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Risky Debt, Investment Incentives, and Reputation in a Sequential Equilibrium

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ABSTRACT

The agency relationship of corporate insiders and bondholders is modeled as a dynamic game with asymmetric information. The incentive effect of risky debt on the investment policy of a levered firm is studied in this context. In a sequential equilibrium of the model, a concept of reputation arises endogenously resulting in a partial resolution of the classic agency problem of underinvestment. The incentive of the firm to underinvest is curtailed by anticipation of favorable rating of its bonds by the market. This anticipated pricing of debt is consistent with rational expectations pricing by a competitive bond market and is realized in equilibrium. Some empirical implications of the model for bond rating, debt covenants, and bond price response to investment announcements are explored.

IN THIS PAPER, WE study the agency relationship between corporate insiders and external claimholders in a dynamic setting. In particular, we examine the investment incentives of a firm with risky debt outstanding when (it is common knowledge that) the firm has to return to the debt market for future financing. A "reputation" effect which arises endogenously as a part of the equilibrium is shown to involve the curtailment of the underinvestment incentives of the levered firm. Although the focus of this paper is on the underinvestment problem, it is hoped that the framework of this paper will be useful for studying reputation in financial models of other phenomena in a multiperiod setting—e.g., patterns of corporate dividend payments, ratings of corporate bonds, discipling of managers by labor markets, strategies in the market for corporate control, and reputation capital in investment banking.[1]

The adverse incentive effects of risky debt on the investment policy of a levered firm in a one-period model are well-known.[2] One of these incentive problems is

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[1] Models of reputation effects in repeated games with asymmetric information have been very useful in economics for studying issues such as predatory pricing below cost and incentives for high product quality. For an introduction and discussion of reputations in finitely repeated games, see the first three papers in *Journal of Economic Theory 27* (August 1982), 245–312.

[2] The distortion in the investment incentives of a firm when there are external outstanding claims (equity or debt claims) has been the subject of many studies (Jensen and Meckling [6], Myers [19], John and Kalay [7, 8], John and Williams [9], Green [3] are a few examples). When some aspect of investment (e.g., its level, its riskiness, the split between risky and safe investments) is a discretionary private decision by the insiders of the firm which is not observed or perfectly monitored by outside claimants, it has been shown that insiders have incentives to deviate from investment policies which maximize the total value of the firm.

that of underinvestment, i.e., passing up positive net present value projects. Jensen and Meckling [6] and Myers [19] have shown that a firm with risky debt outstanding will underinvest. Of course, with the proper pricing of bonds by a debt market which rationally anticipates the incentive effect, the insiders of the firm bear all the costs of their own distorted investment policy. Mechanisms to resolve or ameliorate the problem which have been studied include the role of debt covenants and optimal monitoring and auditing.[3]

Although it has been conjectured that a multiperiod horizon with repeated entry into the market will somehow ameliorate the incentive problems, such a situation has not been analyzed. We model the agency relationship of insiders and bondholders as a dynamic game with asymmetric information in a framework consistent with sequentially rational and competitive behavior. We establish the existence of a sequential equilibrium and examine its properties and the nature of the optimal strategies of insiders and bondholders. For the prescribed investment opportunity sets, it is shown that the concept of "reputation" can be endogenized (and related to the availability of good investment opportunity sets) in an equilibrium where the "reputable" firms optimally curtail their incentives to underinvest in response to anticipated (and realized) higher rating in the pricing of their bonds by the market. It should be emphasized that the bond market is given no monopoly or bargaining power at any point in time. Its favorable pricing of the bonds of the "reputable" firm is entirely consistent with rational expectations pricing in a competitive market. The equilibrium concept that we use is the sequential equilibrium (see Kreps and Wilson [14]).

Our basic model consists of an agency relationship between the insiders of the firm and the outside claimants (here, debt holders). The investment decision is modeled as "private" action on the part of the insiders, i.e., outside claimants would find it too costly to monitor the investment policy. In such an environment, it is well-known that there will be underinvestment (i.e., insiders will invest less than the full-information Pareto optimal levels). It is easy to show that a simple repeating of this relationship a finite number of times *does not* ameliorate the agency costs of the relationship.[4] In other words, if the multiperiod relationship simply involves replication of otherwise independent situations with no intertemporal linkage, full agency costs of the one-period setting will persist. Asymmetry of information between insiders and the market about the evolution of the firm's investment opportunities introduces in a natural way the needed intertemporal

[3] John and Kalay [7] examine the role of debt covenants where stockholders precommit minimum future investment levels by self-imposing optimally specified payout constraints. Bondholders price the debt incorporating the effects of these constraints on the ex-post investment choices of the insiders, thereby passing on the "saved" agency costs to the insiders. Other related solutions have been for the insiders to undertake optimal levels of monitoring and auditing so as to minimize the deviation of their ex post actions from total-value-maximizing levels.

[4] This is consistent with the results of recent literature on finitely repeated versions of the prisoner's dilemma (Kreps et al. [13]), and Selten's chain store paradox (Kreps and Wilson [15] and Milgrom and Roberts [16]). The intuition is that in the last game, the insiders will underinvest since their incentives are no different from that in a one-shot game. Then a process of backward induction repeats the same strategies for the insiders as being optimal with appropriate pricing by the market. Thus, with no intertemporal linkage, the Nash equilibrium of the overall game involves the same strategies in each one of the component games as in a one-shot same. Clearly, the full agency costs persist.

link. The insiders of different firms are assumed to know more about the quality of their investment opportunity set than do the market participants (including the bond market).

The equilibrium in the resulting dynamic game is interesting. In the equilibrium which obtains, the insiders' current optimal investment policy (and resulting ability to repay) is influenced by the quality of the investment opportunities they will have in the future. Firms expecting better investment opportunities optimally curtail the degree of underinvestment, moving closer towards the Pareto optimal levels, anticipating higher pricing of their bonds in the debt market. The bond market would find it rational to price the new issue of bonds conditional on what they know about the past investment policy of the firms. The equilibrium is such that the beliefs of the insiders and the market and their optimal actions (investment policy by insiders and pricing of bonds by the markets) are mutually rational and consistent. Since the market is modeled as competitive, it cannot impose any deliberate punishment to discipline past deviations from optimal investment. Thus, the results are driven by sequential optimality and informational consistency of the equilibrium rather than any monopoly power on the part of the bond market. In other words, the pricing by the market, given its information set (incuding the investment policies of firms), is such that issuing debt is a zero net present value transaction. The equilibrium is characterized by less underinvestment and agency costs than that in the equilibrium of the single-period game. In addition, firms with better investment and repayment records obtain gains to maintaining reputation and higher pricing of their bonds. The higher the quality differential between the low and high quality technologies, the better is the resolution of the underinvestment problem.

This research is closely related to several strands in the literature. The literature on reputation effects in repeated games with incomplete information is now fairly extensive (see Wilson [29]). The endogenous incentive to maintain reputation has been studied in finitely repeated games (see, e.g., Kreps and Wilson [15], Milgrom and Roberts [16], Kreps et al. [13], Rogerson [20], and Sobel [23]) or in infinite horizon models (see, e.g., Dybvig and Spatt [1] and Holmstrom [5]). The paper which is probably the closest to our paper is Spatt [24]. Spatt studies the bank-borrower relationship in a setting of asymmetry of information about the current realized return. This enables the borrower to misreport the realized cash flows and repay only if he chooses to. In the equilibrium obtained, firms with good draws voluntarily repay, demonstrating their future credit worthiness, while firms with low current returns default (despite adequate liquidity). But Spatt [24] does not study the underinvestment problem and its resolution through reputation effects.[5]

John and Nachman [10] study the effect of endogenous reputation considerations on the investment incentives of firms when they are allowed to use the optimal mix of external and internal funds (retained earnings from the past) to finance their investments. With reduced dependence on external markets, the need to maintain reputation is less. The repayment behavior, as well as the new

[5] Adverse selection and moral hazard issues in credit markets have been explored extensively (see, e.g., Stiglitz and Weiss [25, 26]). Eaton and Gersovitz [2] examine credit reputation in international borrowing, but exogenously assume that those who default are indefinitely denied credit.

amount borrowed, conveys information to the bond market. The equilibrium here is also characterized by reputation effects on underinvestment incentives, leading to reduced agency costs. The rating of the bonds are higher with better investment (and repayment) record and lower the amount borrowed.

In the next section, we present the basic model of the agency relationship and the resulting incentives to underinvest. In Section II, we establish the existence of an equilibrium and its properties in the context of the multiperiod model where there is asymmetry of information about the quality of the future technology of the firm between the insiders and the bond market. Conclusions, extensions, and empirical implications are discussed in Section III.

I. The Basic Model

In this section, we will characterize the features of the basic model for the one-period (two-date) setting. We will use it to illustrate the incentive effects of risky debt which we show will *not* be ameliorated in finite repetitions of the game. Augmented versions of the basic model presented here will be used as components of the dynamic game studied in Section II.

Since the characterizations of equilibria in these dynamic games are complex and tend to get intractable, one of the main considerations in the choice of the technology is its simplicity and tractability. In the related literature, researchers have used two-state discrete probability models (see Spatt [24], Kreps and Wilson [15]), mainly motivated by simplicity. Our framework is also selected for its simplicity, while retaining the essential features which give rise to the agency costs of underinvestment: (1) discretionary investment choices on the part of corporate insiders and (2) agency relationship between creditors and insiders (in general, external claimants and insiders who control investment choices). The salient features of the model (in its one-period version) are given below in the context of a representative firm. To a great extent, we have preserved and extended Myers' [19] original model of the underinvestment problem.

In this two-date ($t = 0$ and $t = 1$) model, insiders of each firm control the investment, financing, and dividend decisions of the firm, and act in the interests of current shareholders.[6] The eventual states of the world to be realized at $t = 1$ are indexed by $s_1 \in [0, \bar{s}]$. A pair $\{R(s_1), I\}$ denotes investment opportunities available to the representative firm at $t = 1$. These technologies are the only asset the firm possesses, and they have the following interpretation. The insiders of the firm observe the realized state s_1 at $t = 1$ and choose to invest either zero or an amount I in the technology. If zero is invested, the investment opportunity lapses and the firm is worthless; if I is invested, $R(s_1)$ is the total realized cash flow. For convenience, let the states be ordered such that $R(s_1)$ is monotonically increasing in s_1 (see Figure 1). At $t = 0$, the insiders issue a pure discount bond with a payment F_1 promised at maturity $t = 1$. The usual priority rule applies such that min $\{F_1, C(s_1)\}$ is pledged the bondholders, where $C(s_1)$ is the total

[6] For simplicity, no distinction is made between inside equity and outside equity. However, as argued in Section I, outside equity induces underinvestment incentives similar to that of risky debt. See also footnote 8.

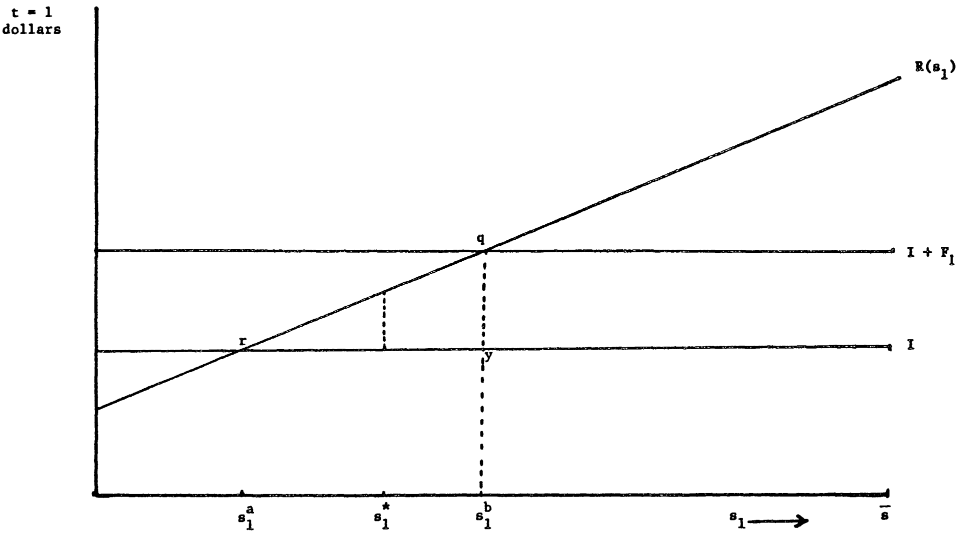

Figure 1. Agency Costs of Risky Debt (s_1^b, cutoff investment state in one-shot game; s_1^*, cutoff investment state in sequential equilibrium)

cash flows resulting from the investment decision. (Here, $C(s_1) = R(s_1)$ if investment I is made; otherwise, $C(s_1) = 0$.

A crucial feature of the model is that the external claimants cannot write forcing contracts on the investment decision of the insiders. A sufficient condition for this to be true is that the outsiders would find it prohibitively costly to verify the realized $s_1 \in [0, \bar{s}]$ so that mutually verifiable state-contingent contracts cannot be written or enforced. Once the debt is issued, the insiders take the investment decisions which maximize the value of equity.

The pricing of claims will be done, as is customary, by taking conditional expectations of the random cash flow with respect to the appropriate unique state-price density function, say $q(s_1)$. For simplicity, we will assume that $q(s_1)$ is a uniform density function over $[0, \bar{s}]$. This enables claim values to be related to areas in the figures used. All taxes (corporate and personal) are zero; similarly, the bankruptcy costs are assumed to be zero.

The insider's overall objective is to maximize the value accruing to equity holders from the available investment opportunity. If the firm were all-equity financed, their optimal investment rule would be simple: observe the realized state s_1 and invest I if $R(s_1) \geq I$; in other words, invest in nonnegative net present value projects. Define s_1^a such that $R(s_1^a) = I$. Then the all-equity investment rule can be equivalently stated as follows: invest I if $s_1 \geq s_1^a$.

The incentive of the insiders (who take investment decisions on behalf of the shareholders) change when the firm has risky debt outstanding. At $t = 0$, the insiders have collected a price B_1 from the bondholders, promising to pay the minimum of F_1 or the available cash flow $C(s_1) = 0$ or $R(s_1)$ at $t = 1$. After observing the realized state s_1 at $t = 1$, the insiders will invest I or zero based on which results in higher (net) return to equity holders. It is easy to see that they will invest I only in states s_1 such that $R(s_1) - I - F_1 \geq 0$. Define s_1^b such that

$R(s_1^b) = I + F_1$. Then the investment is only undertaken in the levered firm for $s_1 \geq s_1^b$. Positive net present value projects are foregone in states $s_1 \in (s_1^a, s_1^b)$. The resulting loss in value is given by

$$A = \int_{s_1^a}^{s_1^b} [R(s_1) - I]q(s_1)\, ds_1 \tag{1}$$

where A is porportional to the area of triangle qry in Figure 1. This loss in value, called agency cost of risky debt, results from the incentives of the insiders to underinvest in the technology when risky debt is outstanding.

A. Agency Costs of Equity

In the above discussion, we are only considering risky debt as the means of raising the required external funds for investment. This is done for ease of modeling and exposition. It should not leave the reader with the impression that the whole problem can be solved by issuing external equity as the means of raising funds. With external equity outstanding, the resulting fractional ownership of the technology by insiders gives rise to distortion in investment similar to the case of risky debt (see John and Williams [9]).[7] To motivate this claim in the framework of this section, see Figure 2. Here, the insiders have issued external equity equal to a fraction $(1 - \alpha)$ of the value of the firm, with corresponding claim to $(1 - \alpha)$ of all cash flows, $R(s_1)$ or zero. As in the case of risky debt, assume that outside claimants do not perfectly monitor the state s_1 realized or the amount I which is invested in the productive assets of the firm; i.e., out of total investable funds I, the insiders have the discretionary choice of investing either the amount I (as before) or the amount zero and consuming the remainder as perquisites. In this setting, it is easy to show that insiders will invest only in states such that $-I + \alpha R(s_1) \geq 0$. Let s_1^e be defined as the value of s_1 such that $-I + \alpha R(s_1^e) = 0$. Insiders will only invest when $s_1 \geq s_1^e$, leading to loss in value (agency costs of external equity) denoted by area $1mn$ in Figure 2.[8]

Even when the firm has issued an optimal mix of risky debt and external equity, there are distortions in investment policy and resulting agency costs. We expect reputation effects to be an important determinant of the trade-off between debt and equity. Interesting issues of optimal capital structure in the presence of reputation effects will be pursued in future work (see John and Nachman [10]). In this paper, however, our focus is limited to the existence and character of an endogenous reputation in the context of underinvestment incentives.

[7] Jensen and Meckling [6] also model agency costs of equity. Their argument is related, but the focus is not on underinvestment. Their insiders consume perquisities from the realized value of the firm which is private information. Myers and Majluf [28] also model costs associated with external equity in an environment of asymmetry of information about the realized value of the new and old assets of the firm. Myers and Majluf [28] show that firms' insiders might choose to underinvest (pass up positive net present value projects) rather than issue external equity to finance them.

[8] This is simply to motivate that the problems of underinvestment are general to external claims, risky debt, or external equity. More importantly, by comparing Figures 1 and 2, the astute reader can see that the partial resolution of the underinvestment problem in the equilibrium of this paper can be made to apply to the case of external equity as well as that of risky debt. However, for expositional ease, we will explicitly model only risky debt.

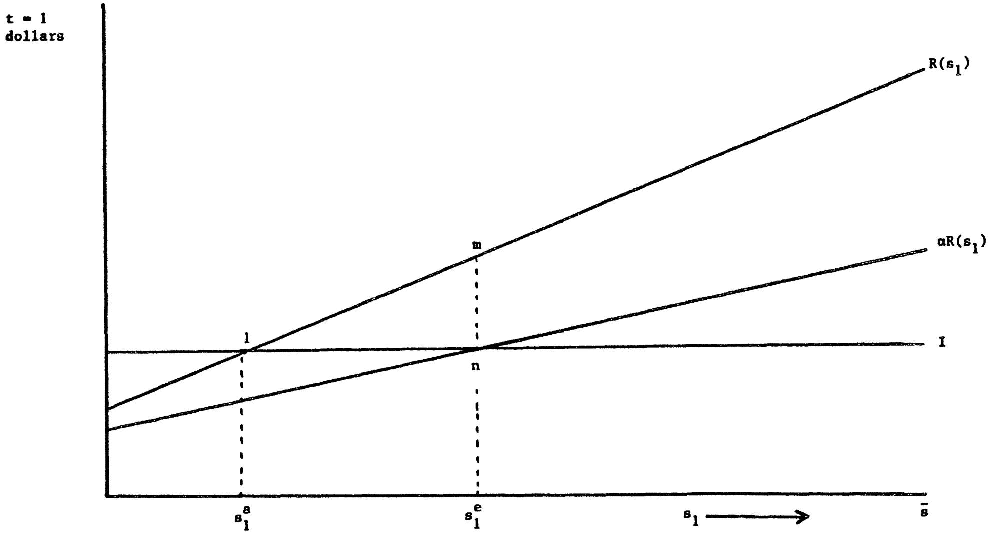

Figure 2. Agency Cost of External Equity (s_1^e, cutoff investment state in one-shot game)

B. Finite Repetitions

Several researchers (e.g., Jensen and Meckling [6], Fama [27], Myers [19]) suggest that the agency problems would be ameliorated in a multiperiod setting where the agency relationship is repeated. Although such an argument is intuitively appealing, its fine structure has to be examined closely. As noted earlier (see also footnote 4), if the repeated agency relationship involves simply replicating independent one-period relationships with no intertemporal linkage, there is no mitigation of agency costs in the repeated scenario. In other words, in each time period i, the firm invests only in states $s_i \geq s_i^b$ and the market prices the bonds appropriately. The full agency costs of underinvestment persist in each time period.

One way out of this deadlock is to introduce some exogenous uncertainty as to the identity ("type") of one of the players (see Kreps and Wilson [15] and Milgrom and Roberts [16]). The resulting asymmetry of information gives rise to equilibria in which the component subgame strategies of players might take on a cooperative flavor. In the context of our model, an asymmetry of information between insiders of the representative firm and the bond market arises in a natural way. The agency problem of underinvestment exists because of private information of insiders. This private information could quite naturally include more precise probabilistic information about the future investment opportunities of the firm. Given this private information about their future technology, the insiders might find it optimal to curtail underinvestment, which results in better repayment behavior. In the equilibrium, the market, which prices future bond issues at favorable terms, would find their conjectured beliefs to be verified. In other words, we will show that in the equilibrium of our model firms with better future investments underinvest less in the current period, resulting in a reduction in the agency costs. Interestingly, introduction of asymmetry of information about the future technologies results in a partial solution to the original agency problem.[9] The properties of the equilibrium will be examined in detail in Section II.

C. Role of Debt Convenants

It has been suggested that debt covenants could provide another solution to the underinvestment problem (see Myers [19], Smith and Warner [22], and John and Kalay [7, 8]). The idea is that it would pay insiders to self-impose constraints on their own future investment decisions. Bondholders who price their claims incorporating the rationally anticipated effect of these constraints pass on to the insiders the value of any saving in agency costs. In our model, we have chosen not to include the debt covenants for the following reasons: as John and Kalay [7] demonstrate based on the information structures of insiders and the market, there is an optimal set of such constraints. However, even under the best possible set of contracts, there is some residual agency costs of suboptimal investments. It is this residual problem that we are addressing. In our model, clearly the only contract which is enforceable (given that outsiders do not observe the realized state s_1) is to pledge to invest in all states. Such a contract involves large agency costs of overinvestment. Our mechanism can be viewed as a self-enforcing, implicit contract. The details of the equilibrium will make this interpretation clearer.

In the next section we study the nature of the equilibrium and its properties in the context of a two-period three-date model.

II. The Equilibrium with Reputation

In this section, we will set up a simple version of the sequential game of two periods with incomplete information which underlies our arguments. We will also study the equilibrium of the game which endogenizes a form of "reputation" in the debt markets. The mathematical construct, roughly interpretable as reputation, arises naturally as a part of the specification of the equilibrium of our sequential game.

As we discussed earlier, simply repeating the game (agency relationship) of the basic model twice does not change the behavior of either the firm (its investment policy) or the bond market (its beliefs used in pricing the bonds). In this section, we will introduce some informational asymmetry between the firm's insiders and the bond market about the probability of obtaining a superior quality investment opportunity set. This in turn brings about a role for "reputation" which will

[9] Another way to view this feature of our model is that it seems to integrate the paradigms of agency and signalling. (See John and Williams [9] for another example). First we have a model of agency resulting from investment being a "private" action. When we introduce additional asymmetry of information about the technology, then the optimal srategy of insiders involve deviating from agency levels of investment because investment (and the observable repayment behavior) acts as a credible signaling device in equilibrium. In other words, investment plays also the role of a signaling mechanism. This, in turn, has a favorable effect on their underinvestment incentives. Thus, when we have asymmetry of information about both the private action of insiders and about the quality of the technology, the underinvestment incentives resulting from the first effect (agency effect) is partially off set by the second effect (signaling effect).

account for intertemporal linkages between the first and the second play of the game. Moreover, such a linkage can produce strategic and market behavior that are different from that predicted from analysis of a sequence of independent games.

In a sequential game, a player's strategy is a function that assigns the action to be taken in each situation (i.e., each possible information condition) in which he might make a choice. If the player has some private information (e.g., his technology), then the choices of actions may depend on this information. In this case, the other player can interpret his past actions as signals about what his private information might have been. More specifically, observers can use Bayes' rule to infer from the history of his observed actions, and from a supposition about what his strategy is, a conditional probability assessment about what it is that he knows. These inferences about the private information can be used to improve predictions of the player's future behavior. This type of an argument brings about the role of reputation in sequential games.

Now we describe the sequential game, with the basic features of each component subgame described in Section I. The additional feature is that in the second period, the technology which becomes available to firms is of two types—high quality and low quality. Private observation of the realized state in period 1 will give the insiders "better" probabilistic information about their future technology. This private information will influence their investment decisions in a manner which will be characterized by the equilibrium.

A. Some Notation

The essential features of the model and the timing of the crucial events and decisions are as follows: the model is a three-date ($t = 0$, $t = 1$, and $t = 2$) two-period model. $s_1 \in S_1 = [0, \bar{s}]$ indexes the state of the world to be realized at $t = 1$. This realization is privately observed by insiders. $s_2 = (s_{21}, s_{22})$ where $s_{21} = +1$ or -1 as the firm's cash flow type is of the high or low type, and s_{22} is the state realized at $t = 2$. Clearly, $s_2 \in S_{21} \times S_{22}$, where $S_{21} = \{+1, -1\}$; $S_{22} = [0, \bar{s}]$.

$R(s) = b + cs$, $s \in [0, \bar{s}]$ is the basic cash flow technology specifying the cash flows obtained if a fixed amount $I > 0$ is invested. More specifically, $R_1(s_1) = R(s_1)$ is the cash flow obtained at time $t = 1$ if the realized state is s_1 and the firm invests. Similarly, $R_2(s_2) = R_2(s_{21}, s_{22}) = (1 + s_{21}\delta)R(s_{22})$ is the cash flow at time $t = 2$ if the firm invests at $t = 2$ when s_{21} is the quality of the technology, where $0 < \delta < 1$ is a given parameter. Assume that the firm has an initial capital Q at $t = 0$, where $0 < Q < I$.

B_1 is the amount borrowed by the firm at $t = 0$ to finance its investment at the end of the period $t = 1$. The firm raises this amount by issuing a pure discount bond of promised payment F_1 to be paid at $t = 1$, from the cash flows obtained from the technology. I_1 is the amount invested in period 1 technology at $t = 1$ by the insiders after observing state s_1. The invested amount is equal to zero or I, where $I > 0$ is the amount required to undertake the firm's period 1 investment opportunities. D_1 is the dividend paid at $t = 1$, a decision made contemporaneously with I_1. If $I_1 = 0$, $D_1 = B_1 + Q$, and if $I_1 = I$, $D_1 = B_1 + Q - I + R(s_1) - F_1$; i.e., all the uninvested funds are paid out as well as the cash flow from the technology after debt service. Here we are making a "no retention" assumption, i.e., cash from the current period cannot be carried over to finance the investment in the next period. Clearly, retention (if allowed) would reduce the dependence of the firm on the external market. This "no retention" assumption is made purely for ease of exposition. The main results are not dependent on this assumption (see John and Nachman [10]).

B_2 is the amount borrowed at $t = 1$ (and is allowed to depend on s_1, but not s_2) by promising an amount F_2 due to be paid at $t = 2$. I_2 is the amount invested at $t = 2$, after the insiders have observed both s_1 and s_2. I_2 can be zero or I, with the same interpretation as that for I_1. The required investment for undertaking period 2 technology can be different than for period 1 technology without changing anything. We assume equality for convenience. D_2 is the dividend paid at $t = 2$, contemporaneously with I_2. If $I_2 = 0$, $D_2 = B_2$. If $I_2 = I$, then $D_2 = B_2 - I + R_2(s_2) - F_2$. D_1 and D_2 are required to be nonnegative, since we do not allow financing with outside equity. Further, for period 1, we will assume that if the firm invests, they are able to repay the promised payment, i.e., $R_1(s_1^a) > F_1$ (there exists $\beta < 1$, determined exogenously, such that $Q > \beta I$ implies this condition holds). The risk-free interest rates are assumed to be zero in both time periods for convenience.

Distributional Assumptions. s_1 and s_{21} are distributed independently of s_{22}. s_1 and s_{22} are uniformly distributed over $[0, \bar{s}]$. $P_0(s_1) = 1/\bar{s}$, $P_0(s_{22}) = 1/\bar{s}$ denotes the density function of s_1 and s_{22}, respectively. Moreover, $P_0(s_{21} = +1 \mid s_1) = s_1/\bar{s}$ gives the conditional probability of $s_{21} = +1$ given s_1. This information about the distributions of s_1 and s_2 is common knowledge.

B. Strategies and Beliefs

The firm makes its borrowing decisions B_1 and B_2 and its investment decisions I_1 and I_2 (which in turn specifies dividends D_1 and D_2). At $t = 0$, the firm's insiders have the same information as the market. At $t = 1$, the insiders privately observe the state realization s_1 which gives them some probabilistic information about their future investment opportunities. The investment decision they take knowing s_1 and the resulting (observed) repayment behavior is used by the market to compute $P_1(s_{21} = +1 \mid I_1) \equiv P_1(+ \mid I_1)$, i.e., the posterior probability of a superior technology based on their observed repayment behavior. Let $P_1(+ \mid I)(P_1(+ \mid 0))$ denote this posterior probability given the firm does (does not) repay its period 1 loan. These posterior probabilities are used, in turn, to price the debt issued in period 2. More precisely, for the same amount B_2 borrowed, the promised payment F_2 would be set such that the market price of a promise F_2 would be B_2. We will use $F_2(I)$ [and $F_2(0)$] to denote the promised payment for the repaying firm (and for the defaulting firm). It will be shown that $F_2(0) > F_2(I)$, which would give the firms incentive to invest and repay. This incentive was not there in the one-shot game or in the complete information, finite repetitions game discussed in Section I.

The following lemma will simplify the characterization of strategies:

LEMMA. *Under the assumptions of our model, the optimal borrowing by the* *representative firm in each time period is the minimum required for the investment, i.e., $B_1 = I - Q$ and $B_2 = I$.*

Proof: See Appendix.[10]

Given the lemma we can characterize the firm's strategies simply in terms of the investment decisions I_1 and I_2, and the market's strategies as simply setting the promised payments F_1 and F_2 based on their beliefs and given all available information in a sequentially rational, competitive manner. The market values the bonds of the representative firm by taking the expected value of the promised payment conditional on their information. Intuitively, the bond market values the securities of the representative firm as if investors were risk-neutral because the firm is negligible relative to aggregate output and uncorrelated with aggregate output. Such an argument for risk-neutral valuation has been made in several contexts in the literature. See Harris and Raviv [4, p. 37–39] for a recent example where this valuation mechanism is formally derived (see also Ross [21]).

Before formalizing the equilibrium, it would be useful to go through the underlying recursive argument. When the investment decision for period 2 is made at $t = 2$, the firm's insiders will know the values of s_{21} and s_{22}. Given a promised payment of F_2, they will invest I if and only if $R_2(s_2) - F_2 \geq I$. Define

$$s_{22}^b(s_{21}, F_2) = \frac{I + F_2 - (1 + s_{21}\delta)b}{(1 + s_{21}\delta)c}. \tag{2}$$

The optimal investment policy for period 2 is

$$\begin{aligned} I_2(s_2, F_2) &= I \quad \text{if} \quad s_{22} \geq s_{22}^b(s_{21}, F_2) \\ &= 0 \quad \text{if} \quad s_{22} < s_{22}^b(s_{21}, F_2). \end{aligned} \tag{3}$$

Now, let us consider the optimal investment decision by insiders at $t = 1$ after they have privately observed the realization of s_1. They will undertake the investment $I_1 = I$ or 0 to maximize the expected value of the cash flows to the shareholders. Let us use $E[D(F_2) \mid s_1]$ to denote the expected value of $D \equiv D_1 + D_2$ when the promised payment is F_2, given state s_1 has occurred. Clearly, the valuation of the period 2 debt borrowed by the firm at $t = 1$ is done by the market incorporating its beliefs at $t = 1$ about the probability of the firm having a high-quality investment opportunity. In the given environment of asymmetric information, the market uses the past actions of the firm (the investment and the resulting observable repayment behavior) to form these beliefs. Then the value of $E[D(F_2(I_1)) \mid s_1]$ is a function of the investment policy I_1 (= 0 or I) of the firm at $t = 1$. Now, for each $s_1 \in [0, \bar{s}]$, the insiders will choose that investment which maximizes the value of dividends, $E[D(F_2(I_1)) \mid s_1]$.

Let $I_1(s_1)$ be the optimal investment policy taken at $t = 1$. Outsiders (the market) will use their anticipation of this investment policy to price the debt borrowed at $t = 0$ (i.e., for the amount B_1 borrowed at $t = 0$, the promised payment F_1 will be set incorporating their anticipation of $I_1(s_1)$). Recall that in

[10] The Appendix containing the complete proof of the lemma and the theorem to follow is available from the authors.

the one-period game or in the complete information repetition of the game, the optimal investment policy is $I_1(s_1) = 0$ for $s_1 < s_1^b$ and $I_1(s_1) = I$ for $s_1 \geq s_1^b$. In the equilibrium of this paper, specified formally below, the optimal investment policy will be $I_1(s_1) = 0$ for $s_1 < s_1^*$ and $I_1(s_1) = I$ for $s_1 \geq s_1^*$, where $s_1^* < s_1^b$. That is, the firm will optimally invest in more states than was the case in the one-period game in order to develop a reputation and get favorable pricing for future issues of debt. This pricing by the debt market will be based on beliefs which are verified in equilibrium.[11]

Equilibrium. An equilibrium of the game described above is: (a) a set of strategies for the firm $\sigma_1(I_1 \mid s_1)$ and $\sigma_2(I_2 \mid s_1, s_2)$ which define the probabilities of investing given the realized states and decisions, and (b), a set of beliefs P_1 by the market which gives the posterior probabilities assigned by investors to s_{21}, given the observed investment-induced repayment behavior, such that:

1. Beliefs of investors are consistent with Bayes' rule, given strategies σ_1 and σ_2 and past decisions I_1 and I_2. That is

$$P_1(s_1, s_{21} \mid I_1) = \frac{\sigma_1(I_1 \mid s_1) P_0(s_{21} \mid s_1) P_0(s_1)}{\int_{S_1} \sigma_1(I_1 \mid s_1') P_0(s_1')\, ds_1'}. \tag{4}$$

   $P_1(s_{21} \mid I_1)$ is computed from (4) and used by the bond market in setting $F_2(I_1)$, the relevant promised payment for the borrowing B_2 at $t = 1$.
2. Firm's insiders maximize the market value of dividends at each stage, given that $F_2(I_1)$ is determined using (4), and given future investment policies of the firm. That is, for any s_1, s_2, $x = \sigma_2(I_2 = I \mid s_1, s_2)$ is chosen to maximize

$$x[-I + R_2(s_2) - \min\{R_2(s_2), F_2\}] + (1 - x)[0], \tag{5}$$

   and for any $s_1 \in [0, \bar{s}]$, $y = \sigma_1(I_1 = I \mid s_1)$ is chosen to maximize

$$yE[D(F_2(I)) \mid s_1] + (1 - y)E[D(F_2(0)) \mid s_1], \tag{6}$$

   where $F_2(I_1)$ is computed using market beliefs in (4) to yield a ($t = 1$) value equal to B_2, and where $D(F_2)$ results from using the solution to Equation (5).

The equilibrium concept used here is the sequential equilibrium (Kreps and Wilson [14]). As seen from the definition above, sequential equilibria invoke the criterion of sequential rationality: in each circumstance, a player chooses an action that is part of an optimal strategy for the remainder of the game, given the strategies and beliefs of the other players. Thus, optimality is checked repeatedly as the game proceeds; or, in reverse, the strategy is computed by backwards recursion using dynamic programming. Players' beliefs are both rational and consistent in that they are calculated according to the assumed strategies of others and the resulting conditional probability satisfying Bayes'

[11] We can specify the exact relationship among the beliefs of the market and strategies of the firm's insiders such that each is rational, given the other. Such a relationship is characterized by the equilibrium of this paper which is a sequential equilibrium in the sense of Kreps and Wilson [14].

rule (whenever the conditioning event has nonzero probability according to the supposed strategies of the other players).[12]

THEOREM. *There is a pure strategy sequential equilibrium in which*

$$I_1(s_1) = \begin{cases} I & \text{for} \quad s_1 \geq s_1^* \\ 0 & \text{for} \quad s_1 < s_1^* \end{cases}$$

and $I_2(s_1, s_2)$ *satisfies* (3) *and* $P_1(s_1, s_{21} \mid I_1)$ *satisfies* (4).[13] *Moreover,* $s_1^* < s_1^b$.

Proof: See Appendix.[14]

The sequential equilibrium in the theorem has the following interpretation. Since the insiders have private information about their future investment technology at $t = 1$ through their observation of s_1, then their investment choices I_1 may depend on their private information. The market interprets investment decisions through the observed repayment behavior as signals about what the private information might have been. The market uses Bayes' rule to infer a conditional probability assessment of the insiders' private information from the insiders' repayment behavior and from a supposition of what the insiders' investment strategy might be. The firm's insiders, who are cognizant of the market's belief formation process, would find it optimal to curtail their under-investment (i.e., $s_1^* < s_1^b$) in order to build a reputation which commands favorable pricing in the market. In equilibrium, the market perceptions are verified by the optimal investment strategies of the insiders. An implication of the theorem is that firms with better future investment opportunities invest larger amounts on their own discretion. An indirect implication could be that investment levels could act as signals of the quality of future investment opportunities. Consequently, investment announcements could elicit a price response by corporate bonds. Empirical evidence in support of these implications have been documented (see Section III).

[12] When the conditioning events have zero probability according to the strategies of other players the consistency requirement is more technical (see Kreps and Wilson [14]). This becomes crucial in the model of John and Nachman [10] and is discussed further there. No serious consistency problems arise in the model of this paper.

[13] The equilibrium described here is interesting and natural from a finance perspective, but there may be other equilibria. In particular we have not studied mixed strategy equilibria in general nor have we been able to prove uniqueness in the pure strategy case. The multiplicity of (even sequential) equilibria is a common difficulty in games of this type. Approaches to this problem have been suggested by Kreps [12] (and references therein) in the context of signaling games and Dybvig and Spatt [1] in the context of an infinite horizon model of product quality.

[14] The Appendix containing the complete proof is available from the authors. A skeletal outline follows: For assumed strategies of insiders (say, parametrized by s_1^d as the cutoff investment state) and given common knowledge of $P_0(s_1)$, $P_0(s_2 \mid s_1)$, the conditional probability of the quality of firm's technology $P_1(+ \mid I_1)$ is determined given the repayment behavior using (4). These are used in pricing the debt claims of the firm in period 2. The firm takes such pricing into account and determines its optimal investment strategy (say, s_1^0 is the cutoff state), i.e., $s_1^0(s_1^d)$. The loop of reasoning is completed by showing that there is an s_1^d, say s_1^*, such that $s_1^0(s_1^*) = s_1^*$ i.e., the optimal response taking into account the creditor's pricing strategy is, in fact, to invest as that strategy assumes. An appropriate fixed point argument establishes the existence of $s_1^* < s_1^b$.

The bond market prices the first period bonds incorporating the effects of reputation and improved investment incentives; i.e., for any amount B_1 borrowed, F_1 will be computed such that $B_1 = F_1(\bar{s} - s_1^*)/\bar{s}$ instead of the single-period version, $B_1 = F_1(\bar{s} - s_1^b)/\bar{s}$ (see Figure 1). This, in turn, implies that there is a saving in the first period agency costs equal to $1/\bar{s} \int_{s_1^*}^{s_1^b} [R_1(s_1) - I]\, ds_1$.

The method of proof employed for the theorem suggests the following conjecture: s_1^* is decreasing in δ, i.e., the larger is the difference between the superior and inferior technologies the less is the underinvestment at $t = 1$. This is a comparative statics result with an appealing interpretation. As the difference between the qualities of the two technologies (parametrized by δ) increases, the stakes in building a reputation increases, providing better incentives for investment at $t = 1$. $(s_1^b - s_1^*)$, which can be taken to be a measure of the reduction in underinvestment, increases with δ. There is some empirical evidence which is consistent with the implications of this conjecture (see Section III).

III. Empirical Implications and Extensions

The model, although simple, has some interesting empirical implications. Like Spatt [24], our model has implications regarding the impact of the credit history of the firm in determining the terms and the interest rate on debt, even in a competitive bond market. Some indirect implications for the investment behavior of firms with different degrees of "growth potential" are perhaps even more interesting. John and Kalay [7] analyze the optimal maximum dividend constraints (and their role to act as minimum-investment restrictions) which are self-imposed by stockholders in covenants of risky debt. Kalay [11] has documented that firms invest on their own initiative more than they have to under these constraints. Moreover, the extent to which they do so is increasing in a measure of the "growth potential" of the firm's technology. Such a result is consistent with the implications of our theorem.

In the equilibrium of our paper, the firms with superior future investment opportunities will curtail current underinvestment without an explicit contract. The mechanism described by our equilibrium acts as an implicit contract for the more reputable firms. Consistent with this implication is the observation that the higher rated debt (bonds of reputable firms) carry less restrictive constraints in the bond covenants on maximal payouts or minimum investment than those of lower rated debt. Another indirect implication of our model is that the current investment decisions of firms lead to a revision of beliefs in the bond market and consequently elicit an appropriate response in bond prices. Mishra [18] documents empirical evidence of bond price reaction to announcements of investments (capital expenditure outlays) consistent with this implication of our model.

This research is at a very preliminary stage and the work can be extended in several directions. In this model, we had only risky debt as the allowed form of external financing. Although external equity has similar incentive problems with regard to underinvestment, it would be useful to model external equity as an alternate source of external financing and examine issues of optimal capital structure in a model with reputation. John and Nachman [10] study some aspects of reputation effects allowing internal as well as external financing. The analysis should also be extended to n period, $n \gg 2$. This would allow examination of the dynamics of building a reputation in the debt markets and possibly milking a reputation with respect to investment strategies. Extensions of such a framework might be useful for studying reputation in financial models of other phenomena in a dynamic setting. For example, stable patterns of corporate dividend payments seem to be inconsistent with one-period signaling models—a multiperiod model with reputation effects might provide some explanation. Similarly, issues of agency and managerial labor markets, market for corporate control, rating of corporate bonds, and reputation in investment banking might be better understood in a multiperiod setting with reputation effects.

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DISCUSSION

CHESTER S. SPATT*: This interesting paper by Professors John and Nachman [5] draws together some central issues in mainstream finance with emerging techniques to examine reputation-based phenomena in a variety of market contexts. The paper is a nice synthesis of several strands in the literature. These include the Kreps and Wilson [6, 7] approach to sequential rationality and reputation, the idea developed in Spatt [10] in studying the reputation aspects of debt contracts and debt repayment that in the presence of correlated opportunities the firm's first period actions can reveal information about second period opportunities, and the Myers [8] analysis of the underinvestment problem that emerges from the incentive conflict between debtholders and equityholders. This paper examines the underinvestment problem studied by Myers [8] in an agency setting by introducing repeated play in a two-period model with correlated investment opportunities by the firm. Reputation incentives reduce the frequency of underinvestment in the first period so that the Myers [8] phenomenon arises in muted form at that date. In the first period underinvestment still occurs, but to a lesser degree than in a single period economy. The equityholders in the first period undertake the project in relatively more states of the world than in a one-period setting, although the project is then still not undertaken in as many states as the full information Pareto outcome. The first-period actions provide the market information about subsequent opportunities. The equityholders favor investment relatively more often than in a single-period model in that the first-period investment signals a more favorable distribution of second-period opportunities.

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