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THE DESIGN OF BANK LOAN CONTRACTS, COLLATERAL, AND RENEGOTIATION*

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Abstract

Empirical evidence suggests that banks play a unique role in the savings-investment process, affecting firms' cost of capital and the level of investment. We argue that bank uniqueness is related to how the design of bank loan contracts allows banks to affect borrowers' choice of project risk. Unlike corporate bonds, bank loans are typically secured senior debt which contain embedded options allowing the bank to "call" the loan. The option allows the bank to control borrowers' risk-taking activity via renegotiation of the loan. We analyze the renegotiation outcomes and show that: (1) debt forgiveness occurs; (2) monitoring by the bank is not always successful in preventing the borrower from increasing risk; (3) renegotiated interest rates are not monotonic in borrower type; (4) inefficient liquidation can occur. In renegotiation seniority and collateral are crucial because they allow the bank to threaten the borrower and liquidate inefficient projects. Pricing these outcomes *ex ante* makes bank debt more valuable to firms than corporate debt.

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I. Introduction

The emergence over the last decade of a large literature on financial intermediation reflects a widespread belief in the importance of banks in the savings-investment process. The thrust of this literature is that banks play a unique role, that other sources of finance are imperfect substitutes for bank loans and, consequently, that developments that affect banks' ability to provide finance affects firms' cost of capital and the level of investment.

Bank loans constitute the overwhelming bulk of (the flow of) firm external finance (see Mayer (1990) and Frankel and Montgomery (1991).) In stock terms, even the largest firms have significant amounts of bank loans.[1] Bank loan contracts contain many features which differentiate them from other kinds of corporate debt. In this essay we study the role of bank loans in corporate finance, focusing on contract features peculiar to bank loans. We show how these contract features allow the bank to monitor borrowers' risk-taking behavior in ways which are not possible with other corporate securities. We then study the pricing of bank loan contracts.

A typical bank loan contract with a firm involves a single lender who is a secured senior debt claimant on the firm.[2] The contract contains a large number of covenants which effectively give the lender the right to force the borrower to repay the loan early if demanded.[3] In contrast, corporate bonds typically involve multiple lenders who are not secured, may not be senior, have less detailed covenants, and have no option to force the borrower to repay. These contract differences, we will argue, stem from the different roles played by these two types of corporate securities.

Empirical work strongly suggests that bank loans are different from corporate bonds. For example, James (1987) finds a positive and significant abnormal stock response to firms announcing the signing of bank loan agreements. The abnormal response to the announcements of other types of security issuance is significantly negative or zero (see Smith (1986)). Further study by Lummer and McConnell (1989) finds that the abnormal response of stock returns occurs for announcements of renegotiated bank loans and not for announcements of new agreements.

There is also evidence that firms with bank loans behave differently than firms without bank loans. Hoshi, Kashyap and Scharfstein (1990) find that Japanese firms in financial distress which are members of a "main-bank" coalition (*keiretsu*) invest and sell more after the onset of distress than do distressed firms which are not members of a bank coalition. Gilson, John, and Lang (1990) report that, in a sample of financially distressed firms, those more likely to restructure their debt privately, rather than through formal bankruptcy procedures, tend to be firms with more bank debt.[4] James and Weir (1991) find that the initial public offerings of firms with bank relationships are not as underpriced as other firms. Finally, that firms find the services entailed by bank loans valuable is suggested by Fama (1985) and James (1987) who argue that borrowers bear the incidence of the reserve tax on bank liabilities.

Previous theoretical research has identified two special or unique roles for banks. First, banks may undertake *ex ante* screening of borrowers, producing information on their credit risks or by offering screening contracts (e.g., Boyd and Prescott (1986)). Collateral is usually viewed as a part of *ex ante* screening (e.g., Bester (1985), Stiglitz and Weiss (1981, 1986)). Second, banks may monitor *ex post*, that is, verify reported (and otherwise unobservable) output in settings with costly state verification (e.g., Townsend (1979), Diamond (1984)).

These explanations for the role of banks are not completely satisfactory. The *ex ante* screening theory is contradicted by the empirical findings of Lummer and McConnell (1989) that there is no announcement effect upon signing a bank loan agreement. While the theory provides a role for collateral, it cannot explain the presence of covenants, the option to call the loan in early, or seniority. Nor can it address the other empirical findings. The monitoring theory provides a role for banks after the project returns have been realized. It cannot explain observed interaction between banks and borrowers during the life of the contract. Moreover, the role of banks as *ex post* monitors suggests that banks should be junior claimants (and perhaps equity claimants) because their incentive to monitor would then be strongest. Fama (1985) argues that this is the case. But, in fact, banks are typically senior, secured, claimants. It seems difficult to reconcile this feature of bank loans with the bank's role as *ex post* monitor.

Our analysis attempts to provide an explanation of how the details of bank loan contracts, such as collateral, the option to liquidate, and seniority, allow the bank to control borrowers during the life of the contract. We assume that *ex ante* screening corresponds to the design of covenants which provide information about the borrower's subsequent state.[5] All borrowers are the same *ex ante*, but at an interim date learn about the state of the distribution function of their project returns. We refer to this state as the borrower "type." The bank also learns this information (implicitly because of the monitoring). At the interim date some borrowers may wish to take a costly risk-increasing action. Since the bank will suffer a capital loss if this action is taken it may engage in prior renegotiation. We assume that there is a single, competitive, bank lender *ex ante*, while if there is corporate debt, there are many lenders.

We focus on the renegotiation outcomes between the bank and the borrower. We show that debt, collateral, and seniority play important roles in the renegotiation process because they define the point at which the bank has a credible threat against the borrower. For a borrower of a given type the face value of the debt determines the bank's expected profit. If the expected profit under the initial contract is less than the value of the collateral, then the bank can credibly threaten the borrower and extract a higher interest rate (if that is optimal). Credible threats depend on the existence of debt, seniority, and the amount of collateral. Unlike the previous literature, which stresses the role of collateral as a screening device, here collateral is important because of the implied threat in bargaining.

There are a number of outcomes to renegotiation. The bank may liquidate the project, raise the interest rate, forgive some of the debt, or do nothing. Liquidation occurs for the worst borrower types, but inefficient liquidation may also occur. In order for efficient liquidation to occur the bank must be in a senior, collateralized, position. We show how the inefficient liquidation can be reduced, and possibly eliminated, by the two parties. For some other borrower types the bank can credibly threaten to liquidate and thereby force a higher interest rate, though the borrower does add risk to the project. For still other borrowers the bank is willing to forgive some of the debt to induce the borrower not to add risk to the project through costly actions. Importantly, renegotiated interest rates are not monotonic in borrower type, that is, moving from the best type to the worst type borrower, the renegotiated interest rate can fall and then rise.

Pricing the loan initially requires determining the renegotiation outcomes as a function of the state of the borrower. This is complicated by the result that renegotiated interest rates are not monotonic in borrower type. An additional complication is that the bank is not always successful in preventing the borrower from taking on risk. The bank allows some loans to continue even though the borrower chooses to add risk to the project. This makes pricing bank loans quite distinct from the standard view of pricing corporate securities.

Theoretically, the pricing of corporate securities has been based on Black-Scholes, though it has been recognized that there may be important differences between pricing derivative securities and pricing corporate securities. While it may seem reasonable to assume a constant volatility for underlying securities in the case of derivatives, the mean and variance of the value of a firm are endogenous and may not be constant. Since equityholders have an incentive to increase firm variance, at the expense of debtholders, it is less clear that the assumption of constant variance is reasonable in the case of corporate securities.

The endogeneity of the mean and variance of firm value is important in the model we study because the bank cannot force the borrower to maintain the same mean and variance in all states of the world. This is in contrast to Green (1984) who motivates the existence of warrants and convertible bonds as securities which change the incentives of equityholders to enforce the constancy of firm variance. In our model it is not possible to change the equityholders incentives by using warrants or convertibles, as we explain below. The bank attempts to prevent the firm from increasing risk, but, importantly, is not always successful.

In Section II the basic setting of the model is detailed. Section III analyzes the borrower's choice of project, that is, whether to add risk or not at the interim date. We then turn to the main focus of attention, analyzing the outcomes at the interim date at which news arrives. Section IV analyzes liquidation and Section V analyzes the renegotiation outcomes for borrowers that are not liquidated. In Section VI we turn to the problem of choosing the initial (t=0) face value of the debt. We show that bank loans are more valuable to the borrower than are corporate bonds. In Section VII we briefly review results of Gorton and Kahn (1992) explaining why debt is the optimal contract from the interim renegotiation date until the end of the contract. In Section VIII we discuss the results and the extant relevant literature. Section IX briefly discusses some extensions and Section X concludes.

II. Borrowing and Lending

There are four dates, t=0, 1, 2, 3, in the model economy and two groups of risk-neutral agents: borrowers (firms) and lenders (banks).[6] Agents within each group are identical *ex ante*. Borrowing firms have projects which require some external financing: at date t=0 firms borrow from banks. The loan matures at date t=2. At date t=1 some information about future project payoffs is realized. Based on this information the borrower may, at this time, take a costly risk-increasing action. But, also at this date the bank may "call" the loan which, as explained in detail below, means that the project may be liquidated or the terms of the loan renegotiated.[7] Projects have final payoffs at t=2 and t=3. For simplicity we assume a required rate of return of zero. Figure 1 shows the timing of the model.

Borrowers' projects require a fixed scale of investment, x_0, which is financed by debt and equity. To ease notation, and without loss of generality, we will set $x_0=1$. (We defer until later a discussion of why debt is the optimal contract.) Initially, the firm borrows an amount D from the bank, promising to pay back an amount F at t=2.[8] The borrower's equity share in the project is 1 - D. We assume that the project requires outside financing in an amount that, with some probability, exceeds its liquidation value at any point in time. Consequently, fully secured debt is not feasible.

At t=0 all borrowers are identical; they have projects which will generate cash flows at dates t=1, t=2, and t=3 of, respectively, $y_1(z)$, $y_2(z)$, and $y_3(z)$. At t=2 the project value, V, is the present value of $y_3(z)$. The value V has a probability distribution given by $G(V;z,\alpha)$, where z is a random variable whose value is realized at t=1, and where α indexes the project the borrower selects at t=1. As explained below, the borrower may choose to add risk to the project ($\alpha=1$) or may continue with the existing project ($\alpha=0$). We assume that V has bounded support, $[0,\bar{V}]$. The random variable z has density h(z) and support $[z_l,z_h]$. We will refer to z as the borrower "type."

The project value as of t=2, V, is to be interpreted as the net present value of the project when it is in the hands of the borrower who is assumed to have some special expertise relative to the bank. If the bank becomes the owner of the project, then it is worth a different value, what we call the "liquidation" value. The interpretation is that this is the value of the project if it is run by the bank. The project liquidation value is L_t per unit of x_t at t=1, 2. Let λ be the proportion of the project liquidated at t=1, so $x_1 = (1-\lambda)x_0 = (1-\lambda)$ (since we have assumed that $x_0=1$). Liquidation at date t means that the project yields L_t at that date in lieu of any future payoffs subsequent to the liquidation date. The t=2 liquidation value, L_2, is uncertain and is assumed to be the *private* information of the borrower. For simplicity the t=1 liquidation value, L_1, is not uncertain and is assumed to be observable by both parties.[9] Assume that $L_1 > E(L_2)$, where "E" indicates expectation.[10]

Given the realization of the t=2 liquidation value, L_2, the project payoff is Max[V, L_2] + y_2, where V is the expected value of y_3 as of t=3. The cash flow can be consumed by the borrower; it cannot be seized by outside lenders, such as the bank, but may be handed over voluntarily by the borrower.

The realization of the borrower type, z, is observable by the borrower and the lender, but is *not verifiable*, that is, it is not observable by any third party contract enforcer.[11] Consequently, contracts cannot be made contingent on z. The borrower's choice of α, and the project value, V, are the *private information* of the borrower, that is, the choice of α and the realization of V are neither observable to the lender nor verifiable. Only the t=1 liquidation value and payments by the borrower to the lender are observable by all parties, and, in particular, verifiable by the contract enforcer.[12] Hence contracts can be made contingent on payments and liquidation values. Failure to make a payment as specified in the contract is referred to as "default."

At t=1 the bank and the borrower may renegotiate the contract. We start by assuming that the optimal contract from t=1 to t=2 is a debt contract. This allows us to proceed to our main focus, studying the renegotiation and liquidation outcomes at t=1. In Section VII we briefly review results of Gorton and Kahn (1992) establishing that debt is the optimal contract from t=1 to t=2. In Section VI we will examine the initial loan pricing at t=0.

III. News Arrival and Project Choice at t=1

We now focus attention on the interim contract date, t=1, at which time the borrower can switch projects and the bank can initiate contract renegotiation or liquidation.

A) Borrowers' Project Choice and the Representation of News at t=1

At date t=1 the borrower and lender observe the realization of borrower type, z. The realization of a low z means that the borrower's equity is worth less than it was *ex ante*. In this situation, as is well-known, the borrower has an incentive to switch projects to add risk. By increasing the variance of the project, the value of the firm's equity can be increased at the expense of the bank. But, it is costly to take this action, as explained below. Borrowers who receive bad news, low z realizations, will be tempted to switch from their initial project, $\alpha=0$, to a higher risk project, $\alpha=1$.

The sequence of events at t=1 is as follows:

(i) z is realized and is observed by the bank and the borrower;

(ii) Renegotiation occurs, possibly leading to a new (higher or lower) interest rate, F'(z), or to liquidation;

(iii) If there is no liquidation, then the borrower chooses $\alpha \in \{0,1\}$.

We proceed by first determining the borrower's optimal choice of project for a given initial interest rate, F. In the next two sections the outcomes of renegotiation are characterized.

At t=1 both the firm and the bank learn the value of the stochastic variable z, the borrower type, which affects the distribution of the borrower's project value, V, according to the density $g(V;z,\alpha)$. We assume that higher values of z represent "good news" in the sense that the conditional distribution of $f(V|z)$ exhibits the Monotone Likelihood Ratio Property (MLRP), as described by Milgrom (1981).

At t=1 the borrower has the ability to unilaterally add risk to his project at a cost to the expected return of c. This choice is denoted by the discrete variable α, which equals 1 if the additional risk is taken, zero otherwise. Since we are assuming risk neutrality, any measures to add risk costlessly which increase the expected return would have been undertaken at t=0 and, in fact, were efficient. Taking this into account, any action taken at t=1 to increase risk is costly. The cost of adding risk can be interpreted as a transactions cost; the borrower must pay to modify the existing project so as to increase riskiness.[13]

Additional riskiness takes the form of a mean preserving spread, which can be represented by:

$$V_1 = V_0 + \epsilon$$

where V_α is the value of project choice α, and where $E(\epsilon | V_0)=0$. We denote the distribution of ϵ by $H(\epsilon)$ and the density by $h(\epsilon)$.

Given this structure, we prove in the Appendix that:

Proposition 1: *Given F, there exists some z^* such that setting $\alpha=1$ is profitable for the borrower if and only if $z<z^*$.*

To understand the proposition, define $\psi(V) \equiv E_{\epsilon,z}[\Pi(V+\epsilon\text{-}c) - \Pi(V) | V]$, where $\Pi(x) = \max[x\text{-}F,0]$ is the profit to the borrower. We denote the expected gain to a borrower of type z from switching from project $\alpha=0$ to $\alpha=1$ by $\Gamma(z)$. Hence $\Gamma(z) = E_V[\psi(V) | z]$. At $t=1$, having observed z, the borrower chooses α to maximize profits. The borrower's solution is to switch to the higher variance project if and only if the gain from switching projects is positive. The proposition establishes that there is a critical borrower type, z^*, below which borrowers choose to add risk to their projects. We refer to $z<z^*$ as "bad" borrowers, and to $z>z^*$ as "good" borrowers.

B) Definitions

Lenders are (implicitly) assumed to have an option to "call" the loan at $t=1$. By "calling the loan" we simply mean that the bank and the borrower can renegotiate the contract. Implicitly we assume that the bank loan covenants allow the bank to learn the borrower's type and verifiably allow the bank to threaten the borrower with liquidation. This is enforceable if the bank can point to covenant violations as justification.[14] Renegotiation may lead to liquidation, ending the contractual relationship at $t=1$. Depending on firm type, liquidation may be optimal. Alternatively, renegotiation may result in an agreement to raise the interest rate on the loan, to forgive some of the debt (by lowering the interest rate), and, possibly, to partial liquidation of the project.[15]

In order to most simply characterize the renegotiation outcomes at $t=1$ we begin by making some simplifying assumptions which will be reconsidered in a subsequent section. We assume that borrowers have no alternative source of financing at the date of renegotiation, $t=1$. In particular, assume that: (i) $y_1=0$, i.e., there is no cash flow from the project at $t=1$; and (ii), borrowers can not approach other lenders at $t=1$. Later we briefly discuss the possibility of borrowers making transfers to lenders when $y_1>0$ and prepaying their loans at $t=1$ by refinancing from alternative sources. Also, we assume that the liquidity constraint at $t=2$ is not binding. In other words, suppose the borrower owes an amount F' at $t=2$, then we assume that $y_2 \geq F'$ whenever $V \geq F'$. This assumption means that if the borrower is solvent, i.e., $V \geq F'$, then the cash is available to repay the loan. Situations where the borrower is solvent, but illiquid are avoided.

At t=1 the bank observes the borrower's type, z, and knows that the borrower will choose $\alpha=1$ if the gain to adding risk by switching projects is positive, i.e., if their type is below z^*. The bank may threaten bad borrowers with liquidation, but, in equilibrium, only credible threats will affect the borrowers' behavior. The resulting renegotiation may allow a project to continue, but with a new face value for the original debt, F', to be paid at t=2. In general, F' will depend on z, but this notation is suppressed. In order to determine which projects are liquidated, the possibility of mutually beneficial renegotiation must be considered.

We do not consider the details of the renegotiation process, that is, we do not specify the rules of a bargaining game. Since we have assumed that borrowers have no alternative financing source, they cannot threaten to refinance from other sources. Hence, the bank can obtain all the surplus at t=1. However, since banking is competitive at t=0, the possibility of extracting surplus at date t=1 will be priced *ex ante*.

At t=1 the bank and the borrower may renegotiate the initial contract, specifying a new debt payment of F', due at t=2, which may be equal to the initially agreed contracted repayment (F) or may be higher or lower depending on the outcome of the t=1 renegotiations. We defer until Section VII a discussion of why debt is the optimal contract from t=1 to t=2. The following additional definitions will be convenient. Define the total expected payoff to the project as of t=1 for given z and choice of α, $\pi^T(z,\alpha)$, as follows:

$$\pi^T(z,\alpha) \equiv \int_0^{\frac{F'(z)}{x_1}} L_2(V)(E+D)g(V \mid z,\alpha)dV$$

$$+\int_{\frac{F'(z)}{x_1}}^{\bar{V}} V(E+D)g(V \mid z,\alpha)dV+y_2(z).$$

Thus, $\pi^T(z,\alpha=0)=\pi^T(z,\alpha=1)+c$, which implies $\pi^T(z,\alpha=0) > \pi^T(z,\alpha=1)$, for each z. Note that this definition of $\pi^T(z,\alpha)$ presumes no liquidation at t=1.

Define unrenegotiated bank profit, $\pi^U(F,z,\alpha)$, to be expected bank profit at t=1, from a borrower of type z, when evaluated at the initial face value of the debt, F, when none of the project is liquidated ($\lambda=0$):

$$\pi^U(F,z,\alpha) \equiv \int_0^F L_2(V)g(V \mid z,\alpha)dV + F[1-G(F \mid z,\alpha)]$$

Finally, define renegotiated bank profits at t=1 (for given z) as follows:

$$\pi^R(F',\alpha,z) \equiv \lambda L_1+(1-\lambda)\langle\int_0^{\frac{F'(z)}{x_1}} L_2(V)g(V \mid z,\alpha)dV$$

$$+\frac{F'}{x_1}[1-G(\frac{F'}{x_1} \mid z,\alpha)]\rangle$$

Renegotiated bank profit is the return the bank expects to receive from the project of a borrower of type z, when λ of the project has been liquidated, and where the borrower of type z chooses project α, and promises to repay F', the new interest rate agreed upon at date t=1.

Feasible bank strategies include liquidation, debt forgiveness (accomplished by lowering the interest rate), raising the interest rate, or keeping the interest rate the same. To facilitate discussion of liquidation define:

$z_{EL1} = \inf\{z: \pi^T(z,\alpha=0)=L_1\};$

$z_{EL2} = \inf\{z: \pi^T(z,\alpha=1)=L_1\};$

$z_{IL} = \inf\{z: \pi^R(F'',z,\alpha=1)=L_1\}.$

where, as will become clear, the subscript "EL1" denotes first-best efficient liquidation because the value of projects of type lower than z_{EL1} are expected to be less than the liquidation value of the project even if the borrower does not add risk. The subscript "EL2" denotes second-best efficient liquidation, indicating that the value of projects of type $z_{EL1}<z<z_{EL2}$ is expected to be less than the liquidation value only if the borrower chooses to add risk. If the borrower does not add risk, then these projects should not be liquidated (from the point of view of a social planner). Note that $z_{EL1}<z_{EL2}$. The reason for this inequality is that switching to $\alpha=1$ reduces the expected return because it costs c to switch projects. This lowers the expected return for each z. (By definition, $z^* \geq z_{EL2}$.) The subscript "IL" denotes inefficient liquidation because, as will be seen, some projects of type $z>z_{EL2}$ may be liquidated. z_{IL} is defined with respect to the bank's expected profit and, thus, will define when liquidation occurs. Consequently, z_{IL} may or may not coincide with Z_{EL2}, as seen below.

If the borrower type is such that the gain to switching projects is positive, i.e., $z<z^*$, then the bank may forgive part of the debt by lowering the interest rate to induce the borrower not to add risk by switching to $\alpha=1$. For $z<z^*$, define $F^*(z)$ be the highest value of the new, t=1, interest rate, F'(z), such that $\alpha=0$ solves the borrower's t=1 problem of maximizing the (expected) gain to adding risk. Note that $F^*(z)<F$.

The possibility of lowering the interest rate to $F^*(z)$ arises as follows. Consider a borrower of type just worse (i.e., lower) than z^*. Such a borrower will choose to add risk,

$\alpha=1$, but is near indifference. If the value of the borrower's equity were a little higher, then $\alpha=1$ would not be chosen and the cost c would not be borne. The bank may find it profitable to raise the value of the borrower's equity by forgiving some debt. While this lowers the face value of what the borrower contracts to repay, the bank's expected profits may rise because the cost, c, is not borne.

At some point, however, lowering the interest rate to induce the borrower not to switch projects will reduce the bank's expected profit below what it would earn if it maintained the initial contract and allowed the borrower to add risk. Define z^{**} to be the borrower type at which the bank is indifferent between these two choices: $\pi^R(F^*,\alpha=0,z=z^{**}) = \pi^U(F,\alpha=1,z=z^{**})$. Note that $z^{**}<z^*$ because the borrower would only be tempted to choose $\alpha=1$ if $z<z^*$, that is, when the gain to switching projects is positive ($\Gamma(z)>0$). Thus, z^{**} is the threshold value of z below which (even with renegotiation) the borrower chooses $\alpha=1$.

If forgiving debt to induce the borrower to choose $\alpha=0$ is not profitable, then the bank may seek to raise the interest rate. In order to renegotiate a higher interest rate the bank must have a credible threat. Define z_{RN} to be the borrower type at which unrenegotiated bank profits equal the value of the collateral, L_1, i.e., $\pi^U(F,z_{RN},\alpha)=L_1$. For $z<z_{RN}$ the bank expects its (unrenegotiated) profit to be less than the current liquidation value and, hence, has a credible threat to liquidate. The subscript "RN" denotes "renegotiation" since for $z<z_{RN}$ the bank can credibly threaten the borrower and demand a higher interest rate, say $F''(z)$. If the bank can credibly threaten the borrower, then the higher interest rate is given by:

$$F''(z) = Argmax \int_0^{\frac{F'}{x_1}} L_2(V) g(F' \mid z,\alpha=1) dV$$

$$+\frac{F'}{x_1}[1-G(\frac{F'}{x_1} \mid z,\alpha=1)]$$

At t=1 the bank and the borrower know L_1, observe z, and choose a new contract, F', or liquidation, subject to constraints imposed by the existing contract, F. The existing contract and the borrower's type determine $\pi^U(F,z,\alpha)$. An equilibrium at t=1 is: (1) a choice of α by a z-type borrower which maximizes the borrower's expected profits, given the contract F' (assuming liquidation does not occur); and (2), a choice of (new) interest rate, F', or liquidation, by the bank given the borrower's type and choice of α which maximizes the bank's expected profit.

In the range $z < z_{RN}$ the bank can credibly threaten the borrower (because $\pi^U(F,z,\alpha) < L_1$) and choose the new interest rate, F', to maximize renegotiated bank profit subject to $\pi^R(F',z,\alpha) > L_1$ otherwise the project is liquidated. The bank is in a position to do this because the borrower, at this point, has no outside financing option, by assumption. In the range $z_{RN} < z$, the bank cannot credibly threaten the borrower and extract a higher interest rate (because $\pi^U(F,z,\alpha) > L_1$). But, the bank can forgive some of the debt by lowering the interest rate if it chooses.

The precise pattern of renegotiation outcomes as a function of z depends on the location of z_{RN} relative to z^{**} and z^*. For sufficiently small L_1, $z_{RN} < z^{**}$. For intermediate values of L_1, $z^{**} < z_{RN} < z^*$, and for larger values of L_1, $z_{RN} > z^*$. In the following sections we will focus on the first case, $z_{RN} < z^{**}$, which we regard as the most plausible and the most straightforward. The other cases are addressed in the Appendix.

Table 1 provides a concise summary of the notation and definitions for future reference.

IV. Liquidation at t = 1

We begin by considering the possibility of partial liquidation by the bank. This turns out to never be optimal so the next step is to consider when full liquidation is optimal.

Lemma 1: *Partial liquidation is never optimal.*

Proof: See Appendix. ‖

According to the lemma, $\lambda \in \{0,1\}$, that is, the bank either completely liquidates the project or liquidates no part of the project. The reason is straightforward. Since expected returns are linear in the fraction liquidated, partial liquidation does not affect the borrower's incentives. The project is either expected to be profitable or not, regardless of scale.

Now we ask when liquidation will occur. Liquidation clearly occurs for $z < z_{EL1}$ because $\pi^T(z,\alpha=0) < L_1$, that is, the total expected project returns do not exceed the current liquidation value. Since no contract revision can make the project profitable to the bank, the project is liquidated. This liquidation is first-best efficient (indicated by the subscript "EL1"--for first-best efficient liquidation).

A more interesting case occurs when $z_{EL1} < z < z_{EL2}$. At z_{EL2}, $\pi^T(z_{EL2},\alpha=1) \geq \pi^R(F'',z_{IL},\alpha=1) = L_1$. Strict inequality occurs if $F''(z) < \infty$ in which case the borrower's expected profit under the renegotiated interest rate, $F''(z)$), is nonzero. In such cases the project is profitable even if the borrower chooses $\alpha=1$, but it may not be profitable for the bank to continue the project. If $F''(z) = \infty$, then $\pi^R(F'',z,\alpha) = E(L_2(R)\,|\,z)$ and equality holds, that is, the bank ensures that it will receive the realized liquidation value of the project at $t=2$ with probability one. But, liquidation with probability one may not be efficient; it may result in less than the return achieved if the borrower can avoid default at $t=2$. Thus, $F''(z)=\infty$ may not be optimal.[16]

Inefficient liquidation will occur if, for types $z_{EL1}<z<z_{EL2}$, the best alternative the bank has is to raise the interest rate (to F''), but that, at that higher interest rate, renegotiated bank profits are below the liquidation value L_1. (The notation "EL2" indicates second-best efficient liquidation.)

Proposition 2: *Projects of borrowers of type $z_{EL1}<z<z_{IL}$ are liquidated.*

Proof: In this range the borrower will choose $\alpha=1$ under the initial contract since $z<z^*$. Since $z^{**}>z_{IL}$ forgiveness of debt cannot be optimal since, for $z<z^{**}$, $\pi^R(F^*,\alpha,z)<L_1$. (F^* is the lower renegotiated interest rate.) The bank can credibly threaten to raise the interest rate, since $z\leq z_{RN}$, to $F''(z)$. But, as $z\rightarrow z_{IL}$ (from above) $\pi^R(F'',z,\alpha=1)\rightarrow L_1$. For $z<z_{IL}$, $\pi^R(F'',z,\alpha=1)<L_1$. Thus, liquidation is optimal. $\|$

Liquidation begins at the point where $\pi^R(F'',z_{IL},\alpha=1)=L_1$. If $\pi^T(z_{EL2},\alpha=1)=\pi^R(F'',z_{IL},\alpha=1)=L_1$, (i.e., $z_{EL2}=z_{IL}$) then the projects liquidated in the range $z_{EL1}<z<z_{IL}$ are inefficiently liquidated since total expected profits are positive if the borrower did not choose $\alpha=1$. The difficulty is that there is no way to overcome the incentive the borrower has to choose more risk. Forgiveness does not increase the bank's expected profit by enough, nor does raising the interest rate. But these projects are inefficiently liquidated in a second-best sense since a social planner, facing the same problem of borrower moral hazard would liquidate these projects. If $\pi^T(z_{EL2},\alpha=1)>\pi^R(F'',z_{IL},\alpha=1)=L_1$, then $z_{IL}>z_{EL2}$ and even more projects are liquidated. (The Appendix considers the other case of a different constellation of the z points.)

Liquidation of socially wasteful projects will be an important role for the bank to play. But, by giving the bank the power to liquidate, by virtue of seniority and collateral, there is also the possibility that the bank liquidates projects inefficiently ($z_{IL} > z_{EL2}$). This cost will have to be weighed against the benefits of liquidating efficiently. However, as we will see below, in Section IX, if the borrower has a cash flow at t=1 ($y_1 > 0$) inefficient liquidation outcomes can be minimized.

V. Renegotiated Contracts at t=1

Now consider borrowers who are not liquidated. Renegotiation outcomes, as a function of borrower type, are characterized by the bank choosing the outer envelope of four expected profit curves: renegotiated profit when the interest rate is raised, $\pi^R(F'',z,\alpha)$; expected profit when debt is forgiven (i.e., the interest rate is lowered), $\pi^R(F^*,z,\alpha)$; unrenegotiated profit, $\pi^U(F,z,\alpha)$; and liquidation.

Figure 2 graphically portrays the situation we are focusing on, the case where $z_{RN} < z^{**} < z^*$. The four profit curves for the bank are shown, as are the total expected profit curves for $\alpha=1$ and $\alpha=0$. The next proposition formalizes the intuition that the bank will choose the outer envelope of these profit curves subject to its ability to extract surplus from the borrowers.

Proposition 3: *If $z_{RN} < z^{**} < z^*$, then renegotiation results in:*

1) $F'(z) = F''(z) > F$ for all $z \in [z_{EL2}, z_{RN}]$, i.e., raise the interest rate;

2) $F'(z) = F$ for all $z \in [z_{RN}, z^{**}]$, i.e., no change;

3) $F'(z) = F^*(z) < F$ for all $z \in [z^{**}, z^*]$, i.e., forgive debt;

4) $F'(z) = F$ or all $z > z^*$, i.e., no change.

Proof: Part (1): First, we must show that $[z_{EL2}, z_{RN}]$ exists. For $z > z_{EL2}$, $\Gamma(z) > 0$ implies $\text{Prob}(V > F) > 0$, i.e., $\pi^T(z, \alpha=1) > L_1$. That implies $\pi^U(F, z, \alpha=1) > 0$. As $z \rightarrow z_{EL2}$, $\pi^T(z, \alpha=1) \rightarrow L_1$ and $\pi^U(F, z, \alpha=1) < L_1$. Thus, $[z_{EL2}, z_{RN}]$ exists. In the interval $[z_{EL2}, z_{RN}]$, $\pi^T(z, \alpha=1) > L_1$, so the project should not be liquidated, but $\pi^U(F, z_{RN}, \alpha=1) < L_1$, that is, at the unrenegotiated contract the bank would be better off liquidating the project. Thus, $F' = F$ is not optimal. $z_{RN} < z^{**}$ implies $\pi^R(F^*, z, \alpha=0) < \pi^U(F, z, \alpha=1)$. Therefore, forgiving some of the debt by lowering the interest rate cannot be optimal. Hence, the project is profitable even if the borrower chooses $\alpha=1$, and the bank sets $F' = F''(z)$, i.e., raises the interest rate.

Part (2): The borrower will choose $\alpha=1$ because $z < z^*$, but the bank cannot raise the interest rate because it has no credible threat since $z > z_{RN}$. $\pi^R(F^*, \alpha=0, z) < \pi^U(F, \alpha=1, z)$ because $z < z^{**}$, so debt forgiveness is not optimal. Since $\pi^U(F, \alpha=1, z) > L_1$, the best the bank can do is maintain the current contract.

Part (3): In this range borrowers choose to add risk, $\alpha=1$, since $z < z^*$, but the bank has no credible liquidation threat since $z_{RN} < z^{**}$. However, assuming the interval $[z^{**}, z^*]$ exists, lowering the interest rate results in $\pi^R(F^*, z, \alpha=0) > \pi^U(F, z, \alpha=1)$.

Part (4): Borrowers in this range do not add risk and the bank has no credible threat. Thus, the best the bank can do is maintain the initial contract. ||

The proposition can best be understood with reference to Figure 2. Starting with the highest type borrowers, those with $z > z^*$ unrenegotiated bank profits are given by $\pi^U(F, z, \alpha=0)$ since these borrowers do not switch projects. The bank cannot credibly threaten these borrowers to extract a higher rate because $\pi^U(F, z, \alpha=0) > L_1$ (that is, $z_{RN} < z^*$). The bank has no reason to forgive debt since these borrowers are choosing $\alpha=0$. Therefore, these borrowers continue their projects maintaining the initial interest rate F. This is shown in the lower panel of the figure.

Borrowers with types below z^* choose to add risk to their projects. But, the bank is not in a position to threaten all of these borrowers with liquidation because the point at which the bank can credibly threaten and force renegotiation, z_{RN}, is below z^* ($z_{RN}<z^*$). However, by providing debt forgiveness to some of these borrowers they can be induced to not add risk. Debt forgiveness raises the value of the borrower's equity by just enough to make taking the costly, risk-increasing, action unprofitable. The question is whether this is profitable for the bank. In the figure it can be seen that the bank's expected profit when debt is forgiven, i.e., the interest rate is lowered ($F^*(z)<F$), is higher than unrenegotiated bank profits given that borrowers choose $\alpha=1$.[17]

Debt forgiveness is optimal as long as $\pi^R(F^*,z,\alpha=0) > \pi^U(F,z,\alpha=1)$, that is, until the bank must forgive so much that it prefers to stay with the initial contract and allow the borrower to add risk. At the point z^{**}, $\pi^R(F^*,z^{**},\alpha=0)=\pi^U(F,z^{**},\alpha=1)$ so debt forgiveness is only provided for borrowers of type $z^{**}<z<z^*$ since they can be induced to not add risk which is in the bank's interest. For borrowers in the range $z_{RN}<z<z^{**}$ there is no change in the interest rate since these borrowers cannot be threatened to get a higher rate and debt forgiveness is not profitable. (The bank can only force renegotiation for $z<z_{RN}$ because for these borrowers $\pi^U(F,z,\alpha=1)<L_1$.) Consequently, borrowers of type $z_{RN}<z<z^{**}$ are allowed to add risk and continue under the old contract. This is shown in the bottom panel where these borrowers continue with an interest rate of F.

For borrowers of type $z_{EL2}<z<z_{RN}$ it is not profitable for the bank to forgive debt (since $z^{**}>z_{RN}$), but the project is worth continuing. The bank can force the borrower to pay a higher interest rate because the threat of liquidation is credible for these borrower types ($\pi^U(F,z,\alpha=1)<L_1$ in this range). Finally, at $z_{EL2}=z_{IL}$, $\pi^R(F'',z,\alpha=1)=L_1$ so borrowers of lower type than this are liquidated.

Two features of Proposition 3 are worth noting. First, the bank is not entirely successful in controlling risk. Borrowers of type $z_{IL} < z < z^{**}$ choose to add risk and are allowed to continue their project.. Thus, in equilibrium borrower risk is not constant; some types will have higher risk projects. Second, renegotiated interest rates are not monotonic in borrower type as can be seen in the lower panel of Figure 2. Starting from z^{*}, the bank first lowers the interest rate to forgive debt (until z^{**} is reached), then maintains the initial rate (until z_{RN} is reached), and then raises the rate (until z_{IL} is reached) after which projects are liquidated. Cases 2 and 3, considered in the Appendix, provide results which are similar, though the pattern of interest rate changes as a function of borrower type is different it is still nonmonotonic in borrower type. We discuss the implications of these results in Section VIII.

VI. Initial Loan Pricing and the Role of Debt

We now turn to examining the $t=0$ problem of choice of F (which for given D will determine the interest rate charged on loans). We maintain the assumption that the optimal contract from $t=1$ to $t=2$ is a debt contract. This is discussed in the next section.

Since all borrowers are the same at $t=0$ the choice of F will be determined by the requirement that lenders act competitively and earn zero expected profits. Since banks are competitive, and take F as given, the only thing to be chosen at $t=0$ is the volume of loans to make.[18] We assume that initially there is no choice concerning collateral. The borrower uses all the collateral that the project provides and has no other resources.

A) The Initial Interest Rate

The above propositions describe the renegotiation and liquidation outcomes for all borrowers at $t=1$. Renegotiation outcomes depend on the constellation of z-cut-offs. For illustration purposes we will continue to focus on the case where $z_l < z_{EL2} < z_{RN} < z^{**} < z^{*} < z_h$.

Let ϕ be the probability the bank is solvent at date t=2, and let the bank finance loans with demand deposits D_d which require a gross return of R^d (which equals one since we have assumed that the required rate of return is zero), given by the market. Since the industry is competitive, an individual bank takes F as given. Let Π be the bank's expected profit at t=0. Then the equilibrium F is that F which solves $\Pi=0$, where:

$$\Pi=\phi\langle\int_{z_l}^{z_{EL2}}\int_0^{F'}L_2(V)g(V;z,\alpha)h(z)dVdz$$

$$+\int_{z_{EL2}}^{z_{RN}}\{[1-G(V;z,1)]F''(z)+[\int_0^{F''}L_2(V)g(V;z,1)dV]\}h(z)dz$$

$$+\int_{z_{RN}}^{z^{**}}\{[1-G(V;z,1)]F+[\int_0^{F}L_2(V)g(V;z,1)dV]\}h(z)dz$$

$$\int_{z^{**}}^{z^{*}}\{[1-G(V;z,0]F^{*}(z)+[\int_0^{F*}L_2(V)g(V;z,0)dV]\}h(z)dz$$

$$+\int_{z^{*}}^{z_h}\{[1-G(V;z,0)]F+[\int_0^{F}L_2(V)g(V;z,0)dV]\}h(z)dz-R^dD_d\rangle$$

The face value of the debt, F, together with L_1, determine the point z^* which splits borrowers into those for which the gain to adding risk is positive (the "bad" types) and those for which the gain is negative (the "good" types). High values of F allow the bank a stronger bargaining position with respect to bad borrowers since the value of unrenegotiated bank profit, π^U, which determines when the bank's threat to liquidate is credible, z_{RN}, depends on F. A more powerful threat point is obtained by setting a high value of F, making π^U very low, and raising z_{RN}, so that the bank is in a strong bargaining position. Also, the point at which forgiveness becomes unprofitable, z^{**}, depends on F. But, high values of F do not affect all good borrowers since that increases the range over which forgiveness occurs, meaning that they do not all pay the higher rate. Nevertheless, some good borrowers do end up with interest rates which overprice their type. Competition limits how high F can be set. In equilibrium each bank chooses an amount of loans to make, taking F as given. The model does not determine the scale of the representative bank.

B) Bank Loans and Corporate Bonds

If the option to renegotiate is valuable to the bank, then the bank should be willing to provide the loan at a lower interest rate than the firm could obtain by issuing corporate bonds which do not contain this option. The lower interest rate raises the value of the borrowing firm. In this section we establish that a bank loan allows a borrower to obtain a lower interest rate than could be obtained by issuing a corporate bond because bondholders cannot renegotiate.

Since there is no interest payment at $t=1$ the borrower never defaults at this date.[19] Suppose that at $t=0$ the firm borrowed an amount D by issuing (pure discount) corporate bonds promising to pay F at $t=2$. The expected return to bondholders from making this loan is:

$$\Pi^B = \int_{z_l}^{z^*}\{[1-G(V;z,1)]F+[\int_0^F L_2(V)g(V;z,0)dV]\}h(z)dz$$

$$\int_{z^*}^{z_h}\{[1-G(V;z,0)]F+[\int_0^F L_2(V)g(V;z,0)]\}h(z)dz$$

Since the corporate bondholders cannot liquidate or renegotiate, the risk that the borrower who receives bad news will add variance must be priced. Consequently, bondholders must require a higher F. Thus:

Proposition 4: *Bank debt is more valuable to a borrowing firm than are corporate bonds of the same face value.*

Proof: We will show that the bank's expected profit is higher than the expected profit to a corporate bondholder for given F (and D). Thus, if both must satisfy a zero profit condition, the face value of the bank loan will be lower. The difference between the bank's expected profit from the loan and the expected return to a bondholder is:

$$\int_{z_l}^{z_{EL2}}\{[L_1-L_2(V)g(V;z,1)]dV\}h(z)dz-\int_{z_l}^{z_{EL2}}\{[1-G(V;z,1)]F\}h(z)dz$$

$$+\int_{z_{EL2}}^{z_{RN}}[1-G(V;z,1)][F''(z)-F]h(z)dz$$

$$+\int_{z^{**}}^{z^{*}}\{[1-G(V;z,0)F^{*}-[1-G(V;z,1)]F+\int_{0}^{F}[g(V;z,0)-g(V;z,1)]L_2(V)dV\}\ h(z)dz$$

Note that the first line of the above expression can be written as:

$$\int_{z_1}^{z_{EL2}}[L_1-\pi^{U}(F,z,\alpha)]h(z)dz$$

which is the difference between the value of the collateral and the bank's expected unrenegotiated profits over the range where the bank liquidates the borrower. For each z in this range, i.e., $z\in[z_1,z_{EL2}]$, this difference is positive. Therefore, the first term is positive. The second term is positive because $F''(z)>F$ for borrower types in this range. Over the range $z^{**}<z<z^{*}$ the bank lowered the interest rate because this was more profitable than allowing the borrower to continue at the initial rate and choose $\alpha=1$. Thus, by revealed preference the last term is positive. ||

VII. The Role of Debt at t=1 and Final Payoffs at t=2

To this point we have proceeded under the assumption that the optimal contract from t=1 to t=2 is a debt contract. We will rely on results of Gorton and Kahn (1992) to show that this is the case. Here we provide only a brief summary.

A t=2 the project's liquidation value, L_2, is realized and the debt matures. The realization of L_2 and the realization of V are the private information of the borrower. At t=2 the borrower has available an amount of cash flow from the project, $y_2(z)$, which (by assumption) exceeds the amount owed the bank. But, there is no way the bank can force this cash to be released by the borrower. Assume that L_2 is a monotonically increasing function of V, $L_2(V)$, and that $V-L_2(V)$ is monotonically increasing in V. These assumptions seem natural since they imply that higher value projects also have higher liquidation values. At t=1 the bank and borrower can sign a contract that specifies repayments and liquidation contingencies as a function of the borrower's *announced* value of V at t=2. The contract chosen must: (i) maximize the expected return to the bank; (ii) be incentive compatible; and (iii), be renegotiation-proof. Kahn (1992) shows that if the realization of L_2 is observable, and no renegotiation is allowed, then debt is the optimal contract. The remaining issue concerns the possibility of renegotiation at t=2.

Allowing renegotiation at t=2 complicates the outcome as follows. If the liquidation value is known, then the bank cannot credibly reject an offer of repayment that is ϵ more than the project's liquidation value. While debt can serve to allow the bank to threaten liquidation, the bank can never obtain more than a tiny amount above the liquidation value. We have, however, assumed that $L_2(V)$ is not known by the bank. This assumption seems natural since the bank has less expertise than the borrower and must rely on appraisals of the project (see Quill, Cresci, and Shuter (1977)). Since $L_2(V)$ is monotonically increasing in V, the function $\phi(q) \equiv E[L_2(V) | V > q]$ is monotonically increasing in q. Let $q^* \equiv \inf\{q | \phi(q) > q\}$. A borrower with a realization of V such that $V < F'$ would like to renegotiate the final payment, offering a payment $F° < V$. (Recall that F' is the amount the borrower agreed to repay.) But, conditional on such an offer, the bank can infer that $E[L_2(V) | F° \text{ offered}] = \phi(F°)$. Since $F° < F' \leq q^*$, the bank knows that $\phi(F°) > F°$ and, therefore, would not accept the offer. The positive correlation between the project's liquidation value and its value to the borrower supports the outcome that the borrower repays more than the value of the collateral to the bank. Gorton and Kahn (1992) formally show that debt is the optimal contract.

VIII. Discussion of the Results

In this section we briefly discuss the above results, focusing on how our model differs from the existing literature.

A) Pricing Bank Loans With Endogenous Firm Volatility

Proposition 3 (and the results for the other cases, given in the Appendix) demonstrates how the bank can control borrower risk-taking, but imperfectly. The bank interacts with the borrower during the course of the contract. It is in a position to do this because by assumption it is a single agent and, hence, can renegotiate higher interest rates, liquidate, or forgive debt. The bank controls risk in two ways: it may liquidate the project or it may change the borrower's incentive to add risk by debt forgiveness. But, importantly, there are borrower types for which the bank cannot prevent risk from being added, but whose projects are allowed to continue. This means that the variance of the value of the firm (and the mean) depend, in equilibrium, on the borrower type and, in particular, are not constant.

The result that the firm's mean and variance are not constant is at odds with the existing literature on pricing corporate securities based on option pricing. Pricing bank loans using option pricing methods which take the value of the underlying asset as exogenous will be wrong in the above context because the mean and variance of the value of the firm are not constant.[20]

The existing literature has recognized the potential problem of the endogeneity of firm mean and variance in the context of pricing corporate securities. As mentioned in the introduction, Green (1984) motivates the existence of warrants and convertible debt on these grounds. In Green's model the firm can invest in two projects, one with a higher variance than the other. The firm's equityholders issue debt initially and, given a price for the debt, have an incentive to invest more in the risky project to increase the value of the equity claims (at the expense of the debtholders). The benefit of increasing risk, however, does not accrue to the equityholders if the debtholders can participate in the gains by exercising warrants or conversion features of their debt. Green shows that properly designed warrants or convertibles can eliminate the incentive of the equityholders to increase risk. Essentially, what happens is that if the equityholders increase risk the stock price rises, but then the warrants are "in the money" and are exercised. Anticipating this response by the debtholders the equityholders never add risk so that the warrants or convertibles are never exercised in equilibrium.

Like Green we seek to motivate the existence of embedded options in corporate securities by appealing to an asset substitution problem, i.e., the potential for equityholders to take on risk at the expense of other claimants. In our case we seek to explain the existence of put options in bank debt. The crucial difference between our model and Green's is that we motivate the existence of debt whereas Green assumes debt. If the firm can issue equity initially, or subsequently via warrants, then it should do so and should not use debt. Clearly, an all equity firm does not suffer from asset substitution problems.

In our model the firm cannot issue equity initially because outside equityholders cannot force cash to be released from the firm since the value of the firm at $t=2$, V, and the liquidation value, L_2, are not observable. If instead of a bank loan, the firm issued bonds and warrants, the warrants would be of no value because the outside equityholders (those obtaining equity via warrants) would never earn a dividend since they can not observe V or L_2. This problem motivates debt in our model. In Green's model there is no reason for debt, so there is no problem faced by outside warrant holders. In our model the threat to exercise warrants would not be credible and, hence, could not prevent the asset substitution problem.[21]

B) The Importance of Collateral and Seniority

Our model sheds light on a puzzle that emerges from the existing literature on financial intermediation: why should banks as senior claimants engage in monitoring the behavior of borrowers more closely than junior claimants do? Junior claimants would seem to have a greater incentive to monitor, as Fama (1985) has argued. Diamond (1984) and others have shown that such monitoring requires centralized lending in part to avoid the free rider problem inherent in monitoring activity. Yet firms often have both bank debt and other publicly-issued debt, Fama

(1985) argues that the benefits of banks' monitoring activities spill over into the corporate debt market as the presence of bank debt on a corporation's balance sheet functions as a sort of "seal of approval" that enables it to issue debt directly. The problem with this scenario is that bank debt is senior to corporate debt. Consequently, banks should have less incentive to monitor borrowers' subsequent behavior than the junior creditors would have.

A natural first response is that although banks might have less incentive to monitor they could have a lower cost of monitoring as well. Banks can avoid the coordination costs facing decentralized creditors and may have more information (e.g., regarding z) than decentralized creditors would have. But, this response does not address the question of why the entity that monitors should be the senior claimant. For example, if coordination problems prevent efficient forgiving of debt by decentralized creditors, then banks could improve the efficiency of the outcome by being junior claimants. As senior claimants banks would not have any incentive to do this for risky actions that only affect more junior claimants' returns.

Thus, two questions emerge: first, why do banks, as senior claimants, undertake monitoring? Second, does this monitoring facilitate the issuance of subordinated debt? Our paper provides a precise answer to the first question, but is less clear regarding the second. Our view is that, as senior claimants, banks have the unique ability to engage in (relatively) efficient liquidation of bad projects.[22] Thus, *ceteris paribus*, a firm that obtains bank financing will have a higher market value than one that does not.

Banks have a clear cut incentive to monitor, and, in fact, their claim on collateral enables them to use the renegotiation process to monitor more efficiently. If banks did not have claims on collateral at $t=1$, they could not liquidate projects. As junior claimants they would have no incentive to liquidate bad projects, since the proceeds would go to others. But, as senior claimants they have every incentive to force liquidation in as efficient a manner as possible.

This prospect of relatively efficient liquidation raises the value of the firm *ex ante* by lowering the cost of debt.[23]

Whether bank loans can facilitate the issuance of junior debt is less clear from the model, however. While some of the benefits of banks' monitoring activities could spill over to junior claimants directly (e.g., reductions in some kinds of risk-taking), in many instances their interests diverge. The main benefit is indirect: banks' monitoring activities give rise to efficient liquidation, which lowers bank loan rates, and therefore, increases demands for additional loans.

Fama (1985) argues that bank debtors bear the incidence of the reserve tax, since bank CD's have to compete with high grade commercial paper in money markets. Our model is consistent with this observation, since banks, as senior creditors, offer unique services that benefit borrowers and enhance efficiency. The only concern is whether some other institution, not subject to the reserve tax, could take over that role. This is a question for future research, since nothing in our analysis identifies banks *per se* as the institution that should be the senior claimant, only that whoever is senior claimant should monitor z.

C) The Role of Debt

There is a large literature on debt which analyzes the role of this contract in allocating rights to control of the firm. (See Hart and Moore (1989) and Dewatripont and Tirole (1992) for brief reviews.) The basic idea is if that the firm's revenue stream is sufficiently correlated with the state of the firm (z, in our model) so that the firm defaults on debt payments in bad states (i.e., low z), then control transfers to the creditors in those states in which it is optimal for control to pass to the debtholders. (See Aghion and Bolton (1988) and Hart and Moore (1989).) Transfer of control need not imply liquidation, so debt serves to partition the state space into states in which debtholders get control and those in which control remains with the equityholders. Thus, the defining feature of these models is that they link rights to the firm's income streams via design of liabilities to rights of control over firm decisions.

Unlike the literature on debt as a mechanism for control rights allocation, since in our model there is not debt payment at date $t=1$, the rationale for the optimality of debt cannot be a link between allocation of control rights and the firm's revenue stream (which itself must be correlated with the firm's state). In fact, it is reasonable to question the desirability of such a link. A not uncommon occurrence in banking is for the bank to lend more when a debt payment is missed, suggesting that the revenue stream and the firm type realization are not highly correlated.

In our model the role of debt is somewhat different. We focus on the case where there can be no default on debt at the interim date (because there is no interim debt payment or no cash flow). Nevertheless, there is a flow of information and, based on that news, the bank can implement a transfer of control via its option to call the loan in early; the bank can liquidate. Moreover, control of the equityholders' (i.e., the borrower's) decisions can occur without the debtholder taking over the firm since the bank can forgive debt, altering the borrower's actions.

IX. Extensions

In this section we briefly discuss some extensions to the model. For the sake of space we do not provide formal analyses but indicate the issues that would be involved. Two extensions are briefly discussed: (1) what happens if the firm receives some revenue, $y_1>0$, at $t=1$ (where y_1 is possibly a function of z); and (2) what happens if borrowers are allowed to prepay loans at $t=1$ and borrower from other sources.

A) Liquidation and Renegotiation When $y_1>0$

Suppose the project yields a cash flow of $y_1>0$ at $t=1$. A positive amount of cash at $t=1$ introduces the possibility of a transfer from the borrower to the bank. In particular, the borrower may be able to make a transfer to the bank which together with a new interest rate allows projects to continue which would otherwise be liquidated. Without the possibility of a transfer from the borrower liquidation occurs inefficiently for some borrower types. If, at $t=1$, the borrower has received a cash flow of y_1, then this amount is available to induce the bank to allow the project to continue. Some projects which would have been liquidated may now continue to the mutual satisfaction of both parties. Also, in cases above where the bank raises the interest rate, the feasibility of a transfer may allow a lower interest rate combined with a transfer. This may be preferred by both the bank and the borrower.

As an example, consider a borrower of type $z_{EL1}<z<z_{EL2}$. If this borrower were to make a transfer to the bank of $y^*\leq y_1$ such that, for some new interest rate F', $\pi^R(F',z,\alpha)+y^*>L_1$, then the bank would find continuation of the project profitable. The transfer, y^*, is profitable for the borrower, as well, if $\pi^B(F',z,\alpha)-y^*>0$, where π^B is the borrower's expected (renegotiated) profit. Since $\pi^T=\pi^R+\pi^B$, the transfer, y^*, (given F'(z)) must satisfy $\pi^T>\pi^R+y^*>L_1$ for both parties to find it agreeable to allow the project to continue. The largest transfer the borrower can make is y_1.

A transfer from the borrower to the bank cannot change the bank's liquidation decision unless the bank can precommit to not liquidating the project following the transfer. Otherwise the bank will accept the transfer and then liquidate the project. But, if the transfer is verifiable, then an outside contract enforcer could prevent liquidation. Suppose this is the case.

The bank will be indifferent between combinations of $\{F',y^*\}$ which maintain a given level of expected profit, the bank's iso-profit curve. The borrower also has an iso-profit curve. A bargaining problem must be specified to determine the equilibrium pair of $\{F',y^*\}$, but the main point is that some inefficient liquidation outcomes would be eliminated.

B) Prepayment

Suppose that other banks also learn the borrower type, z, at t=1 (perhaps at a cost). Then, clearly, the ability of the incumbent bank to extract surplus from the borrower at t=1 is limited because borrowers can credibly threaten to go to competing banks. But, this would then be priced initially. Since the competitor banks know z, no loan from t=1 to t=2 will be mispriced and there are no effects on the efficient allocation of resources. Clearly, if other banks cannot determine z, then the situation is more complicated. But it is still not clear that any efficiency change in the allocation would occur.

X. Conclusion

Bank loan contracts are significantly different than corporate bonds; they are senior, secured, claimants with an option to call the loan in early. Because a bank is a single agent, receiving information about the state of the borrower via covenants, the bank is in a unique position to renegotiate the contract with the borrower or to liquidate the project. We have analyzed how the bank goes about renegotiating and the extent to which the bank can be successful in controlling borrower risk-taking activity.

The bank can successfully liquidate inefficient projects, but may also inefficiently liquidate projects, though this can be mitigated by bargaining when the borrower has a cash flow at the renegotiation date. The other way that the bank can influence the borrower's choice of risk is via debt forgiveness which can change the borrower's incentives to take on risk.

When the bank cannot control the borrower, it can still enforce a higher interest rate in some cases. In these cases, and in some other cases where the bank cannot obtain a higher interest rate, the borrower does increase risk in equilibrium. Equilibrium renegotiation outcomes reveal a pattern which is nonmonotonic in borrower type, reflecting the fact that some borrowers do engage in higher risk projects. This means that pricing bank loans practically cannot be based on standard contingent claims methods.

The role of debt in this model is distinct from the existing literature which has recently linked debt payments to issues of the transfer of control rights. Here there is no such link. Instead, control of the firm occurs via renegotiation directly. Debt serves to define the bank's bargaining power with respect to the borrower, allowing the bank to credibly threaten the borrower with liquidation. This allows the bank to liquidate some borrowers, but also allows the bank to extract a higher interest rate from borrowers who take on more risk. In a competitive banking market it is the good borrowers who benefit from this.

The unique contract features of bank loan contracts make bank loans more valuable than corporate debt. Corporate debt, held by dispersed bondholders, and without sufficiently detailed covenants, cannot achieve the outcomes achieved via bank renegotiation.

Appendix

Proof of Proposition 1: The proposition says that there exists a trigger value of z, which we denote z^*, such that the borrower chooses $\alpha=1$ if and only if $z \leq z^*$. That is, the moral hazard problem is more severe for those who get bad news. In the following discussion we use the notation $E_x[w(x,y)]$, where w is a function of random variables x and y, to indicate that the expectation is with respect to x alone. We first provide the following lemma.

Lemma A1: *Let V and z be two random variables with joint distribution $G(V,z)$ and conditional distribution $F(V|z)$. Assume F has the MLRP property. Let $\psi:R \rightarrow R$ be some continuous function that crosses zero only once, and from above. Then the function $\xi:R \rightarrow R$, $\xi(z) = E_V[\psi(V)|z]$ crosses zero at most once, and from above.*

Proof: See Karlin (1968).

Recall that $\psi(V) \equiv E_{\epsilon,z}[\Pi(V+\epsilon-c) - \Pi(V)|V]$, where $\Pi(x) = \max[x-F,0]$ is the profit to the borrower. We denoted the expected gain to a borrower of type z from switching from project $\alpha=0$ to $\alpha=1$ by $\Gamma(z)$. Hence $\Gamma(z) = E_V[\psi(V)|z]$. At t=1, having observed z, the borrower chooses α to maximize profits. To prove the proposition we apply the lemma and need only show that $\psi(V)$ crosses zero only once, and from above. Assume that the upper bound of the support of ϵ is greater than c+F. We have

$$\psi(V) - \int_{c+F-V}^{\infty}[\epsilon-(c+F-V)]h(\epsilon)d\epsilon - \max[V-F,0]$$

We know that $V \leq F$ implies $\psi(V) > 0$. Further, since for $V > F$

$$\psi(V)=\int_{c+F-V}^{\infty}\epsilon h(\epsilon)-(c+F-V)(1-H(c+F-V))-(V-F),$$

we have

$$\lim_{V\to\infty}\psi(V)=\lim_{V\to\infty}-VH(c+F-V)-c<0.$$

We also have, for V>F,

$$\frac{d\psi}{dV}=-H(c+F-V)\leq 0.$$

Therefore, ψ has the desired properties, and we have proven the proposition. ‖

Proof of Lemma 1: At t=1 the bank's problem is to choose a new interest rate, F'(z), and a fraction of the project to liquidate, λ, to maximize (expected) renegotiated bank profits:

$$\pi^R(\frac{F'}{x_1};\alpha,z)=\lambda L_1+(1-\lambda)\int_0^{\frac{F'}{x_1}}L_2(V)g(V\mid z,\alpha)dVG(\frac{F'/x_1}{(1-\lambda)}\mid z,\alpha)$$

$$+[1-G(\frac{F'/x_1}{(1-\lambda)}\mid z,\alpha)]$$

The first order conditions, with respect to λ and F'(z), respectively are:

$$L_1-\int_0^{F'/x_1}L_2(V)g(\cdot\mid\cdot)dV+\{F'/x_1-(1-\lambda)[L_2(\frac{F'/x_1}{(1-\lambda)})G(\cdot\mid\cdot)+\int_0^{F'/x_1}L_2(V)g(\cdot\mid\cdot)dV]\}$$

$$[\frac{-F'/x_1}{(1-\lambda)^2}]G_1 \geq 0 \tag{A1}$$

$$G_1[L_2(\frac{F'/x_1}{(1-\lambda)})G(\cdot\mid\cdot)+\int_0^{F'/x_1}L_2(V)g(\cdot\mid\cdot)dV-(\frac{F'/x_1}{(1-\lambda)})]=-[1-G(\cdot\mid\cdot)] \tag{A2}$$

where G_1 is the partial derivative with respect to λ. Solving (A2) for G_1 and substituting into (A1) results (after some manipulation) in:

$$L_1 \geq \pi^R$$

In other words, if renegotiated bank profits are greater than the liquidation value of the project, $\pi^R > L_1$, then the bank chooses $\lambda=0$ otherwise renegotiated bank profits do not exceed the liquidation value and the bank chooses to completely liquidate the project, $\lambda=1$. ||

Liquidation When $z_{EL1} \leq z < z^{**} < z_{EL2} \leq z^* < z_{RN}$

Proposition A1: *Projects of borrowers of type $z_{EL1} \leq z < z^{**} < z_{EL2} \leq z^* < z_{RN}$ are liquidated, while borrowers of type $z_{EL1} \leq z^{**} < z < z_{EL2} \leq z^* < z_{RN}$ receive debt forgiveness.*

Proof: Borrowers will choose $\alpha=1$ under the initial contract since $z<z^*$. As $z \rightarrow z^{**}$ from above $\pi^R(F^*,\alpha=0,z) \rightarrow \pi^U(F,\alpha=1,z) \rightarrow L_1$. Thus, for $z>z^{**}$ forgiveness of debt can make the project profitable. For $z<z^{**}$ forgiveness is not profitable and, by the same arguments as in Proposition 2, raising the interest rate cannot make the project profitable. ||

Again, projects in the range $z_{EL1} < z < z^{**}$ are liquidated inefficiently. (Here $z_{IL} = z^{**}$.) Projects in the range $z^{**} < z < z_{EL2}$ are profitable if the borrower chooses $\alpha = 0$. By forgiving some of the debt the bank can induce the borrower to choose $\alpha = 0$ and these projects are allowed to continue.

Renegotiation Outcomes For Cases 2 and 3

Case 2 is the situation where $z_{RN} > z^{*}$, that is, unrenegotiated bank profits are less than the liquidation value starting at borrower types higher than the type at which there is an incentive to switch projects and add risk. (Recall that $\pi^{U}(F,z,\alpha) < L_1$, for all $z < z_{RN}$.) In this situation the bank can credibly threaten to liquidate borrowers who have no intention of switching projects (in addition to those who do).

Proposition A2: *If $z_{RN} > z^{*}$, then renegotiation results in the following outcomes:*

(1) $F' = F''(z) > F$ for all $z \in [z_{EL2}, z^{**}]$, i.e., raise the rate;

(2) $F' = F^{*}(z) < F$ for all $z \in [z^{**}, z^{*}]$, i.e., forgive debt;

(3) $F' = F''(z) > F$ for all $z \in [z^{*}, z_{RN}]$, i.e., raise the rate;

(4) $F' = F$ for all $z > z_{RN}$, i.e., no change.

Proof: Part (1): For $z^{*} > z > z_{EL2}$, $\Gamma(z) > 0$, i.e., the gain is positive so the borrower will add risk, which implies $\text{Prob}(R > F) > 0$, i.e., $\pi^{T}(\alpha=1,z) > L_1$. That implies that $\pi^{U}(F,\alpha=1,z) > 0$. As $z \rightarrow z_{EL2}$, $\pi^{T}(\alpha=1,z) \rightarrow L_1$ and $\pi^{U}(F,\alpha=1,z) < L_1$. Therefore, the interval $[z_{EL2}, z^{**}]$ exists. In this interval liquidation is not optimal because $\pi^{T}(\alpha=1,z) > L_1$, nor is setting $F' = F$ optimal (because $\pi^{U}(F,z,\alpha=1) < L_1$). At z^{**}, $\pi^{R}(F^{*},\alpha=0,z^{**}) = \pi^{U}(F,\alpha=1,z^{**}) < L_1$. Since as $z \rightarrow z_{EL2}$ (from z^{**}), $\pi^{R}(F^{*},\alpha=0,z) < L_1$, lowering the interest rate cannot be optimal. To prevent liquidation the borrower must agree to the higher interest rate, $F''(z)$.

Part (2): First, we must show that the interval $[z^{**},z^{*}]$ exists. By assumption $z_{EL2}<z^{**}$. For $z>z^{*}$, $\pi^{U}(F,\alpha=0,z)>\pi^{R}(F^{*},\alpha=0,z)$ since $F^{*}<F$. For $z<z^{*}$, $\pi^{U}(F,\alpha=1,z)<\pi^{R}(F^{*},\alpha=0,z)$. As $z\rightarrow z^{**}$ from above, $\pi^{R}(F^{*},\alpha=0,z)\rightarrow\pi^{U}(F,\alpha=1,z)$. Therefore, the interval $[z^{**},z^{*}]$ exists. Liquidation cannot be optimal since $\pi^{T}(\alpha=1,z)>L_1$. Since $z^{*}<z_{RN}$, $\pi^{U}(F,z,\alpha=1)<L_1$ for $z\in[z^{**},z^{*}]$, $F'=F$ cannot be optimal. For $z\in[z^{**},z^{*}]$, $\pi^{R}(F'',\alpha=1,z)<\pi^{U}(F,\alpha=1,z)<L_1$ since $F''(z)>F$. But, $\pi^{R}(F^{*},\alpha=0,z)>\pi^{U}(F,\alpha=1,z)$ and as $z\rightarrow z^{**}$ (from z^{*}) $\pi^{R}(F^{*},\alpha=0,z)\rightarrow\pi^{U}(F,\alpha=1,z)$. Therefore, $F'=F^{*}$ is optimal.

Part (3): In this range $\pi^{U}(F,z,\alpha=0)<L_1$ since $z<z_{RN}$. Because $z^{*}<z<z_{RN}$, the borrower is already choosing $\alpha=0$ so there is not point in lowering the interest rate. Liquidation is clearly not optimal. However, the bank can credibly threaten to liquidate and, therefore, raise the rate to $F''(z)$.

Part (4): For $z>z_{RN}$, $\pi^{U}(F,z,\alpha=0)>L_1$ so the bank cannot threaten to liquidate the project or to raise the interest rate. It is not profitable to forgive debt since the borrower is already choosing $\alpha=0$. ‖

In the above case the bank forgives some debt for types in the interval $z^{**}<z<z^{*}$. For bad borrowers in the interval $z_{EL2}<z<z^{**}$ debt forgiveness benefits the borrower, but cannot make the loan profitable to the bank. Since the project is profitable even if the borrower adds risk, i.e., $\pi^{T}(z,\alpha=1)>L_1$, the bank raises the interest rate. The bank also raises the interest rate for borrowers which can be threatened with liquidation, even though they will not choose to add risk, those in the interval $z^{*}<z<z_{RN}$. This possibility would, of course, be priced initially. This outcome is due to the bank's monopoly position since these borrowers might choose to prepay their loan and get financing elsewhere if that were possible, something we consider in Section IX.

Case 3 is the situation where $z^{**} < z_{RN} < z^{*}$. Liquidation occurs for $z < z_{EL2}$. This case is similar to Case 1 except that there is no range between forgiveness of debt and raising the rate where no change occurs.

Proposition A3: *If $z^{**} < z_{RN} < z^{*}$, then renegotiation results in:*

1) $F' = F''(z) > F$, for all $z \in [z_{EL2}, \underline{\hat{z}}]$, i.e, raise rate;

2) $F' = F^{*}(z) < F$, for all $z \in [\underline{\hat{z}}, z^{*}]$, i.e., forgive debt;

3) $F' = F$, for all $z > z^{*}$, i.e., no change.

Proof: We begin with a lemma, then prove the proposition.

Lemma A2: If $\pi^{U}(F,z) < L$ for some $z < z^{**}$, then there exists $\underline{\hat{z}}$, $z^{**} < \underline{\hat{z}} < z_{RN}$ such that $\pi^{R}(F''(z),\alpha=1) > \pi^{R}(F^{*},\alpha=0)$, for $z^{**} < z < \underline{\hat{z}}$.

Proof: As $z \rightarrow z^{**}$ (from above) $\pi^{R}(F',\alpha=0,z) \rightarrow \pi^{U}(F,\alpha=1,z)$. But, $\pi^{R}(F'',\alpha=1,z) > \pi^{U}(F,\alpha=1,z)$. Therefore, $\pi^{R}(F'',\alpha=1,z) > \pi^{R}(F',\alpha=0,z)$. ||

Proof of Proposition A3:

Part (1): For $z \in [z_{EL2}, \underline{\hat{z}}]$ the borrower is choosing $\alpha=1$. Liquidation is not optimal since $z > z_{EL2}$. Since $\underline{\hat{z}} < z_{RN}$, $\pi^{U}(F,\alpha=1,z) < L_1$, so maintenance of the initial contract is not optimal. By the lemma $\pi^{R}(F'',\alpha=1,z) > \pi^{R}(F',\alpha=0,z)$ so the bank raises the interest rate.

Part (2): As above neither liquidation nor maintenance of the initial contract is optimal. In this range, by the lemma, $\pi^{R}(F'',\alpha=1,z) < \pi^{R}(F',\alpha=0,z)$ so the bank forgives some debt.

Part (3): For $z > z^{*}$ the project is profitable and the borrower chooses $\alpha=0$. The bank cannot threaten the borrower since $z_{RN} < z^{*}$, so the initial contract is maintained. ||

Footnotes

1. According to Srini Vasan (1986), over the period 1964-1980, 13.4 percent of the total assets of small firms (under $10 million in total assets) were funded by loans from banks. For medium-sized firms ($10-100 million in total assets) bank loans constituted 12.7 percent of total assets, and 4.9 percent of the total assets of large firms (greater than $100 million) were bank loans.

2. Currently, 70 percent of commercial and industrial loans are made on a secured basis. See Berger and Udell (1990). Often when a loan is made on an unsecured basis, loan covenants forbid the pledging of assets to other agents. Contractual details on bank loans and collateral are provided by Morsman (1986) and Quill, Cresci and Shuter (1977).

3. Zimmerman (1975) discusses bank loan covenants. Smith and Warner (1979) discuss corporate bond covenants.

4. Asquith, Gertner and Scharfstein (1991), however, do not find that this is the case. Gilson, John, and Lang (1990) have a sample of firms in which some firms have no public debt, whereas Asquith, Gertner, and Scharfstein's sample has no such firms.

5. Many covenants require the borrower to maintain balance sheet ratios, such as "times interest earned," "cash flow to current maturities," or "sales to receivables," above or below specified thresholds. Zimmerman (1975) describes these covenants as providing "triggers or early warning signals of trouble, which will allow the bank to take remedial action."

6. The term "bank" is intended to apply to any agent who is the sole lender to the borrowing firm and lends according to the contract we specify in the model. We do not intend the term to strictly apply to institutions chartered by the government, but rather to a broader class of agents, including so-called nonbank banks such as insurance companies and firms such as General Electric Credit Corporation.

7. Formally, the right to "call" the loan is a put option since the bank has the right, but not the obligation, to ask the borrower to buy the loan at a stated exercise price.

8. Thus, the two period interest rate on the loan is $(F - D)/D$. While F will always refer to the face value of the debt to be repaid at $t = 2$, we will often refer to F as "the interest rate."

9. The reasons for the asymmetric treatment of the $t=1$ and $t=2$ liquidation values will become clear. Basically, the $t=1$ liquidation value could also be treated as uncertain and as the private information of the borrower, but at considerable expense without changing the results. Uncertainty and private information about L_2 are needed to support debt as the optimal contract from $t=1$ to $t=2$, but from $t=0$ to $t=1$ these same arguments are not needed.

10. Note that if $L_1 = E(L_2)$, then the bank can never be worse off by allowing the project to continue at $t=1$ and, thus, will never liquidate the project at that date. The assumption that $L_1 > E(L_2)$ implies that at earlier stages of the project liquidation is less costly, i.e., more can be recovered.

11. There is (implicitly) a third party, a contract enforcer, who has less information about relevant state variables than any borrower-lender pair.

12. The values E, D, and F are public information.

13. Essentially costless, or extremely inexpensive, ways of adding risk are assumed to be prevented costlessly by the bank through covenant restrictions.

14. Bank loan contracts are written with a large number of covenants so that small deviations of the state of the firm trigger covenant violations, allowing the firm to "call" the loan. Sometimes the bank excuses such violations. Because of these covenants, the option to "call" is best viewed as always verifiably being "in the money" for bad borrowers.

15. Banks appear to rarely forgive debt directly by forgiving prinicipal. Instead, forgiveness takes the form of deferring principal and interest payments. See Asquith, Gertner and Scharfstein (1991). In order to incorporate this our model we need one more period.

16. Since we have assumed, at this point, that the borrower has not received a cash flow at $t=1$ ($y_1=0$) it is not feasible for the borrower to make a transfer to the bank to induce the bank to allow the project to continue. We take this issue up in a later section.

17. The interval $[z^{**}, z^{*}]$ may not exist.

18. We abstract from how the bank finances itself since that is separable from the problem of choosing the face value of the debt, F, assuming that the problem of depositors monitoring the bank has been solved along the lines suggested by Diamond (1984).

19. Note that the borrowing firm never has an incentive to make an exchange offer at $t=1$ and the bondholders can not force a renegotiation because they are dispersed. Because they are dispersed there is a free riding problem or hold-out problem which prevents them from forgiving debt (outside of bankruptcy proceedings).

20. Attempts to price corporate debt using contingent claims methods have led to mixed results, at best. E.g., Jones, Mason, and Rosenfeld (1984).

21. There are two additional problems with warrants or convertibles. First, even if these securities functioned to prevent asset substitution in our model, their use could not implement efficient liquidation. Second, the design if these securities would be very peculiar in our set-up. In our model all firms are identical *ex ante* and so would all have the same stock price. Subsequently, some firms get bad news when they find that they are of low type; their stock prices would fall. If they add risk, then their stock prices would rise, but there is no reason to

think that they would rise above the initial, t=0, stock price. Thus, for the warrants to deter adding risk, they might have to be designed to be "in the money" at stock prices below the stock price at the date of issuance, something never observed in practice.

22. Diamond (1992) provides a rationale for banks to be the senior, short-term lenders to firms in a setting where there is adverse selection initially and subsequent revelation of information. The argument depends banks being the only agents that learn the relevant information.

23. As junior claimants banks could still forgive debt, while as senior claimants they would not forgive since subordinated debtors would be the beneficiaries. Thus, when junior debt is present, and banks are senior lenders, banks are not likely to forgive principal. This corresponds to the findings of Asquith, Gertner, and Scharfstein (1991) who study distressed junk bond issuers and find that the banks rarely forgave principal, but did defer principal and interest payments.

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Figure 1: Time Line

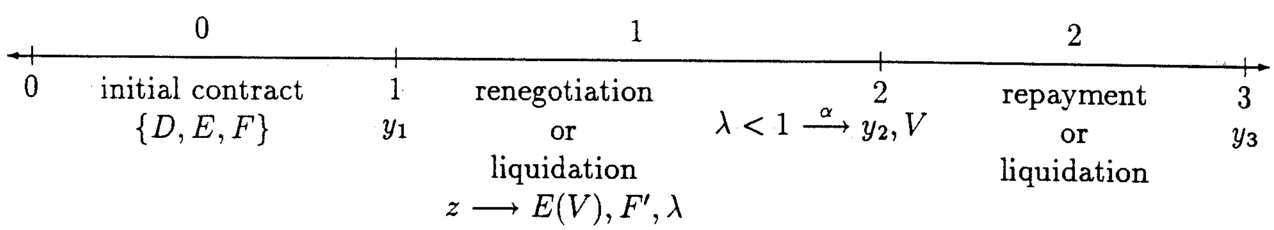
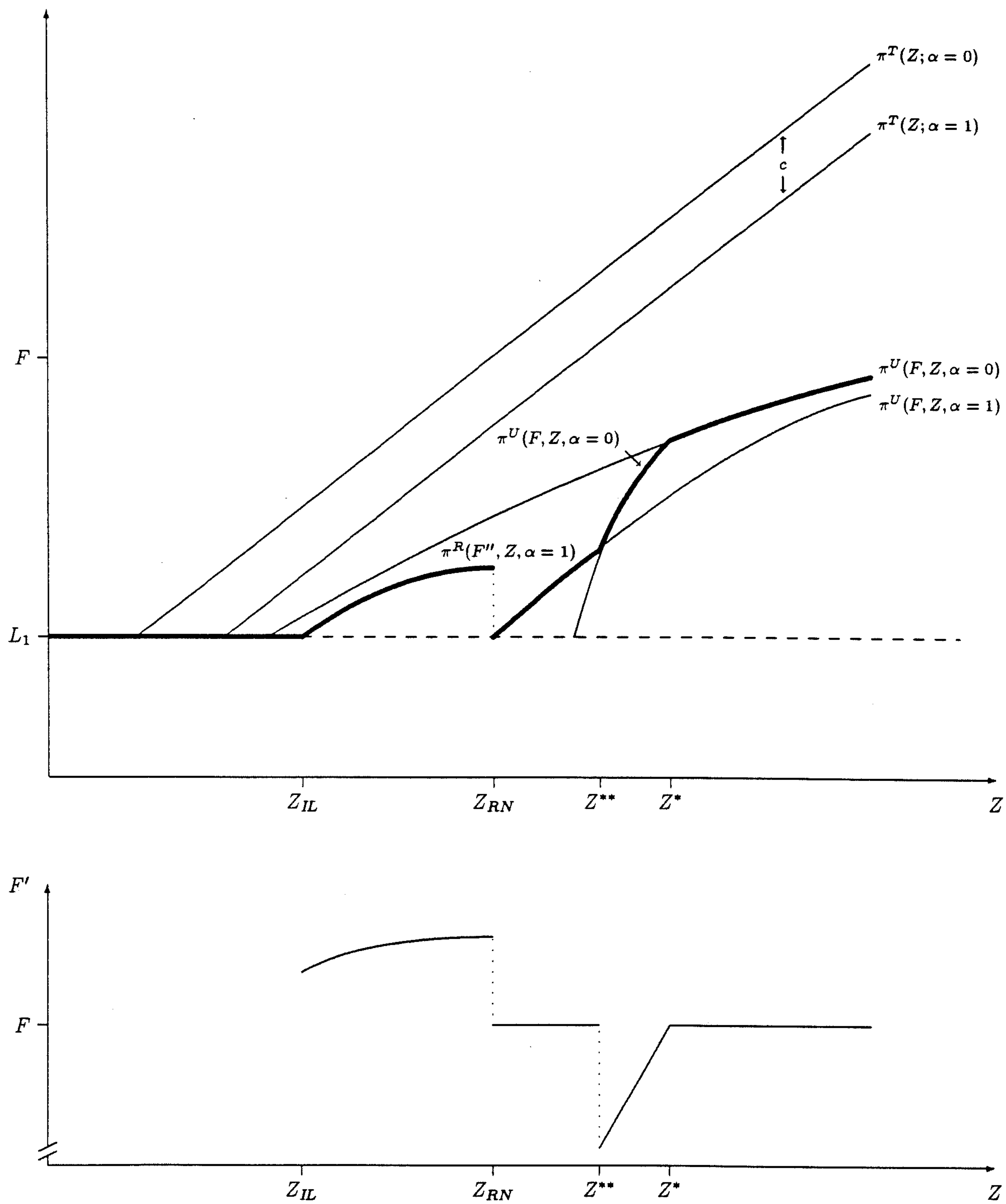


Figure 2



$\pi^T(Z;\alpha=0)$
$\pi^T(Z;\alpha=1)$
c
F
$\pi^U(F,Z,\alpha=0)$
$\pi^U(F,Z,\alpha=1)$
$\pi^U(F,Z,\alpha=0)$
$\pi^R(F'',Z,\alpha=1)$
L_1
Z_{IL}
Z_{RN}
Z^{**}
Z^*
Z
F'
F
Z_{IL}
Z_{RN}
Z^{**}
Z^*
Z

Table 1: Concise Summary of Notation

t	time periods $(0, 1, 2, 3)$
y_t	cash flow from project in period t $(t = 1, 2, 3)$
x_t	scale of project at time t $(t = 0, 2;\ x_0 = 1)$
D	initial debt
E	initial equity $(E + D = 1)$
F	initial face value of debt
V	value of the project to the entrepreneur as of $t = 2$
$G(\cdot)$	distribution function for V, with support $[0, \overline{V}]$ and density $g(\cdot)$
L_t	liquidation value of the project to the lender $(t = 1, 2)$
λ	fraction of the project that is liquidated at $t = 1$
F'	renegotiated face value of debt at $t = 1$
α	indicator variable for switching to riskier project $(\alpha \in \{0, 1\})$
c	cost of switching to riskier project
π^T	total expected value of the project at $t = 1$
π^U	value of bank expected profit absent renegotiation
π^R	value of bank expected profit with renegotiation
z	observable but nonverifiable information at $t = 1$ about project value
$\Gamma(z)$	net gain to borrower from switching to riskier project (i.e., $\alpha = 1$)
z^*	$\inf\{z \mid \Gamma(z) \geq 0$, given $F\}$ (threshold for switching projects given initial contract)
z^{**}	$\inf\{z \mid \Gamma(z) \geq 0$, given $F'\}$ (threshold for switching projects given renegotiation)
$z_{R,N}$	$\inf\{z \mid \pi^U \geq L_1, \forall F' \leq F\}$ (threshold for liquidation to be a credible threat)
z_{EL1}	$\inf\{z \mid \pi^T \geq L_1, \alpha = 0\}$ (threshold for efficient liquidation absent switching)
z_{EL2}	$\inf\{z \mid \pi^T \geq L_1, \alpha = 1\}$ (threshold for efficient liquidation given switching)
z_{1L}	$\inf\{z \mid \pi^R \geq L_1\}$ (threshold for liquidation to be profit-maximizing for bank)
$F^*(z)$	value of $F' < F$ such that $\Gamma(z) = 0$
$F''(z)$	value of $F' > F$ that maximizes π^R given $\alpha = 1$