THE DESIGN OF BANK LOAN CONTRACTS, COLLATERAL, AND RENEGOTIATION

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(Revision of Working Paper #1-93)

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Latest Revision: January 17,1996

Abstract

We study a model of renegotiation between a borrower and lender in which there is the potential for moral hazard on each side of the relationship. The borrower may add risk to the project, while the lender may opportunistically hold-up the borrower by threatening to demand early payment. The result is a model in which banks play a unique role in monitoring borrowers' activities, and in which risk is endogenous and state-dependent. The model also yields explicit predictions about renegotiation outcomes, and conditions under which bank loans add value to the firm.

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* This is a substantially revised version of a previous paper with the same title. Thanks to Mathias Dewatripont, Douglas Diamond, Oliver Hart, Paul Milgrom, Raghuram Rajan, and David Webb for discussions and to Nils Gottfries, Michel Habib, Leonard Nakamura, two anonymous referees, and seminar participants at the University of Chicago, University of Illinois, Board of Governors, Johns Hopkins, Wayne State, ECARE, the CEPR Meeting at Toulouse, the Stockholm School of Economics, the Penn Macro Lunch Group and the Penn Finance Lunch Group, for suggestions.

I. Introduction

We analyze a model of renegotiation between a borrower and a lender in which there is potential moral hazard on each side of the relationship. Three questions are addressed. First, how are bank loans different from corporate bonds? Or, put differently, what is meant by bank "monitoring" of borrowers? Our goal is to link bank monitoring to specific features of loan contracts and to provide a more realistic notion of monitoring than the extant literature provides. Second, we ask whether the risk of the borrowing firm can vary endogenously in the equilibrium of the model. This question is of interest because time-varying volatility is empirically important for corporate securities, but to date the only models explaining variation in volatility are statistical models. Finally, we investigate the role of debt in the renegotiation between the borrower and the lender. If both parties to a contract know that it will be renegotiated, why does the initial form of the contract it matter? We show that it is important because it balances bargaining power in renegotiation and, consequently, has efficiency considerations.

Empirical work strongly suggests that bank loans are different from corporate bonds.[1] While bank loans and corporate bonds are both debt contracts, bank loan contracts have many features which differentiate them from corporate bonds. Two features stand out. First, the bank is a single lender, making renegotiation practical. Second, loan contracts contain an embedded option giving the bank the right to liquidate ("to call the loan") the loan by seizing collateral. The model of this paper offers an explanation for the advantages of bank debt over corporate bonds which is centered on these distinctions. We show how bank monitoring during the life of the contract depends on these features. Renegotiation of the contract terms is triggered by the arrival of new information which may lead the borrower to seek to add (costly and inefficient) risk to the project. There is also the potential for moral hazard on the part of the bank since the bank may "hold up" the borrower by (credibly) threatening to liquidate the borrower's project and, thereby, extracting a higher interest rate. The interplay between the two moral hazard problems leads to a number of outcomes to renegotiation. The bank may liquidate the project, raise the interest rate, forgive some of the debt, or do nothing. Monitoring the borrower means liquidating inefficient projects and renegotiating lower interest rates to prevent risk-taking.

We show that in renegotiation the bank is not always successful in preventing the borrower from taking on additional risk. That is, the bank allows some loans to continue even though the borrower chooses to add risk to the project. In equilibrium, the variance of the value of the borrowing firm varies endogenously. This results in renegotiated interest rates that are not monotonic in borrower risk-type, that is, moving from the best type to the worst type borrower, the renegotiated interest rate can fall and then rise.

The endogeneity of the mean and, in particular, the variance of firm value, address the second question. Our results are in contrast to Green (1984) who motivates the existence of warrants and convertible bonds as securities which change the incentives of equityholders, enforcing the constancy of firm variance in theory. As a practical matter, however, attempts to price corporate debt using contingent claims methods have led to mixed results at best (e.g., Jones, Mason, and Rosenfeld (1984)). An important problem is that, as an empirical matter, the volatility of firm value is time-varying. Bank loans are even more complicated securities. Thus, we view our results as a step towards providing a theory of how time-varying volatility is the outcome of interaction between economic agents.

In our model the borrower and the lender know that the initial contract will subsequently be renegotiated. The outcome of the renegotiation has efficiency considerations since some projects will be liquidated by the bank, while others will become riskier when borrowers add risk. We show how the form of the initial contract, and the contract terms, affect the balance of these two moral hazards by allocating bargaining power between the two sides to minimize inefficiency. This is the role of the debt contract initially; it is not directly to compensate for default risk in the loan.

The papers most closely related to ours are models of renegotiation in banking, including Rajan (1992), Sharpe (1990), and Detragiache (1994). In the models of Rajan and Sharpe banks learn private information about borrowers and are able to exploit this information to hold-up borrowers. We also include this moral hazard on the part of the banks, but relate it to the liquidation option. We also include moral hazard by the borrower. In Detragiache's model renegotiation is beneficial, but can lead to *ex ante* risk-taking by the borrower. The focus is on alternative bankruptcy regimes.

Our paper is also related to the literature on the role of banks as *ex post* monitors. That is, banks verify reported (and otherwise unobservable) output in settings with costly state verification (e.g., Diamond (1984)). This theory provides a role for banks after the project returns have been realized, but 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.[2] 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.

In model is specified in Section II. Section III provides preliminary results and definitions of payoffs. Section IV looks at the liquidation decision and Section V analyzes the renegotiation outcomes. Section VI examines the initial pricing of the loan and the role of debt. Corporate bonds are compared to bank loans in Section VII. Section VIII contains some final remarks.

II. The Borrowing and Lending Environment

There are four dates, t=0, 1, 2, 3, in the model economy and two representative risk-neutral agents: a borrowing firm and a lending bank. A summary of the model is as follows. The borrowing firm has a project which requires some external financing: at date t=0 the firm obtains funding from a competitive bank. The funding is governed by a contract that matures at date t=2. A t=1, before the contract matures, some news arrives about the firm's future project payoffs. The new information is observed by both the bank and the borrower, but it is not verifiable. Based on this information, in particular if there is bad news, the borrower can choose to take a costly risk-increasing action. Also at t=1, the contract may allow the bank to demand the collateral (or, synonymously, the project liquidation value) instead of waiting for the contract to mature at date t=2. Whether the borrower expends resources to add risk to the project, and whether the bank ends the contract early by seizing the collateral, depends on the outcome of renegotiation. If the project is not liquidated at t=1, then at t=2 the borrower repays the loan or is liquidated. If the borrower's project is not liquidated at t=2, then a final payoff is received at t=3. Figure 1 shows the timing of the model and Table 1 provides a concise summary of notation and definitions for future reference. We now provide the details.

A) Detailed Assumptions

Projects and Borrowers. The borrower's project requires a fixed scale of investment which, without loss of generality, we will set to one. The borrower has an amount $1 - D$ available to invest, but must obtain the remainder, D.

The project generates cash flow realizations at dates t=2, and t=3 of, respectively, $y_2(z)$, and V(z), where z is the borrower type realized at t=1. We refer to V as the project value, ignoring any liquidation possibilities (see below), and usually suppressing the dependence on z. For simplicity we assume a required rate of return of zero. The value V has a probability distribution given by $G(V;z,\alpha)$, where z, interpreted as "news," is a random variable whose value is realized at t=1, and where α indexes the project that the borrower selects at $t=1$ (i.e., whether risk is added to the project).

Assumption A1. $G(V;z,\alpha)$ is continuous and differentiable in V and z and has bounded support, $[V_l,V_h]$.

Assumption A2. Higher values of z represent "good news" in the sense that the conditional distribution of $f(z|V)$ exhibits the Monotone Likelihood Ratio Property (MLRP), i.e., $f(z|V)/f(z|V^*)$ is monotone in z, increasing if $V>V^*$, and decreasing otherwise (see Milgrom (1981)).

The random variable z, realized at $t=1$, has density $h(z)$ and support $[z_l,z_h]$. We will refer to z as the borrower "type."

Banks and Bonds. A bank is distinguished from other providers of funds by:

Assumption A3. Among possible funds providers, only banks can renegotiate at $t=1$.

Other fund providers, in particular, bondholders, are viewed as dispersed and incapable of coordinating renegotiating efforts.[3] Thus, we assume that an agent must be a bank in order to renegotiate, but whether the contract includes the right to seize collateral prior to maturity is a separate issue.

Liquidation values. 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, the "liquidation" value or "collateral" value. 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. For simplicity, we assume:

Assumption A4. Liquidation is all-or-nothing; liquidation values are certain and are observable by both parties.[4]

Assumption A5. $D>L_1>L_2$.[5]

In other words, the project requires outside financing in an amount that exceeds its liquidation value at any point in time so fully secured debt is not feasible.[6]

Asset Substitution by the Borrower. At $t=1$ the borrower having received news, z, has the ability to unilaterally add risk to his project at a cost to the expected return of c. Adding risk is costly because it reduces both V and L_2 by the amount c.[7]

Adding risk, referred to as "asset substitution," is denoted by the discrete variable α (which equals 1 if the additional risk is taken and zero otherwise).

Assumption A6. Additional riskiness takes the form of a mean preserving spread:

$$V_1 = V_0 + \epsilon$$

where V_α is the value of the project given choice α, and where $E(\epsilon | V_0)=0$.

We denote the distribution of ϵ by $H(\epsilon)$ and the density by $h(\epsilon)$. The support of ϵ is $[\epsilon_l,\epsilon_h]$.

Assumption A7. $V_0 + \epsilon_l \geq c$.

The assumption says that the borrower can always pay the cost c out of the project value when $\alpha=1$ is chosen.

Observability and Verifiability. The contracting environment is as follows:

Assumption A8. The borrower's project choice at $t=1$, α, and the project value, V, are the *private information* of the borrower.

Assumption A9. The realization of the borrower type, z, and the realized cash flow $y_2(z)$ are observable, but *not verifiable*.

The realizations of these variables (z and $y_2(z)$) are observable by the borrower and the lender, but they are not observable by any third party contract enforcer or alternative financing source at $t=1$.[8] Consequently, contracts cannot be made contingent on z or on cash flows. Only the $t=1$ liquidation value and payments by the borrower to the lender are observable by all parties, in particular, third party contract enforcers. Hence contracts can be made contingent only on payments and liquidation values.

Contracts. Our focus is on renegotiation at t=1.

Assumption A10. A contract can include a provision allowing for the lender to seize the borrower's collateral at will at t=1.

We will call this contract provision the "liquidation option." Since the lender must decide when to seize the borrower's collateral, only banks would consider including this provision. Exercising the liquidation option is infeasible for other creditors because, by assumption, other lenders cannot renegotiate and, hence, cannot initiate liquidation.

The outcome of renegotiation at t=1 will either be liquidation of the project or a contract specifying a payment to be made at t=2 (either on new terms or at the status quo ante). Because cash flows are not verifiable, they can be consumed by the borrower; they cannot be seized by outside lenders, such as the bank, but may be handed over voluntarily by the borrower. In this setting Kahn (1995) shows that debt is an optimal contract.[9] For the purposes of this paper we assume that:

Assumption A11. Debt is the optimal contract from t=1 to t=2. Failure to repay the debt at t=2 triggers liquidation, i.e, the parties are precommitted to liquidation if there is a default.

Assumption A12. The cash flow at t=2, $y_2(z)$, is sufficiently high, for all z, so that it is feasible to repay the lender at t=2 if the borrower so chooses.

Renegotiation. In order to most simply characterize the renegotiation outcomes at t=1, we assume that:

Assumption A13. The bank can credibly make a take-it-or-leave-it offer at t=1.

Assumption A14. Borrowers have no alternative source of financing at the date of renegotiation, t=1.

Parameter Restrictions. The following assumptions involve an endogenous variable, F, and therefore must be handled with care. Their role is only to ensure that the parameters of the problem are such that the model behaves reasonably. It turns out that for extreme values of F the characterizations of outcomes in the paper are not complete. These additional cases are either implausible or economically uninteresting, and would only burden the paper with additional complexity. The essence of the assumptions is to show that these outcomes can be ruled out by appropriate (and mutually compatible) parameter restrictions.

Let F_0 denote the amount initially specified by the contract to be repaid at t=0. Clearly, F_0 must be in the range $[D, V_h + \epsilon_h]$. At t=1 a different amount, F^N, may be negotiated. Let F denote either of these values. Then:

Assumption A15. $\epsilon_h > c+F$.

In other words, the upper bound of the support of ϵ is sufficiently large that adding risk always results in a positive probability of solvency. This assumption simply makes the problem interesting since it says that when risk is added there is always some chance for the borrower to benefit.

Assumption A16. $L_2 + c/[1 - H(c)] > F$.

(Recall that $H(\epsilon)$ is the distribution function for ϵ.) This assumption says that c is sufficiently large and/or the distribution of ϵ is sufficiently skewed that for a given F, the bank always prefers that the borrower not add risk.

Let $F^\#(\alpha,z) \equiv \text{argmax}_F\ (L_2 - \alpha c)G(F|V;z,\alpha) + FG(1 - G(F|V;z,\alpha))$. This is the bank's maximized expected profit as of t=1 for a borrower of type z. Let $F^\# = \inf\{F^\#(\alpha,z)\}$. Then:

Assumption A17. $F^\#$ is larger than any F_0 or F^N that the bank would consider.

This assumption is designed to ensure that bank profits are increasing in F. It is straightforward to extend the results of this paper to the case where F_0 or F^N is larger than $F^\#$. Lenders can always forgive debt at t=1 in order to ensure that they are on the upward sloping portion of the bank profit function. The assumption allows us to ignore this issue of forgiveness (which has no efficiency considerations). To avoid burdening the paper with additional complexity, in what follows we will always assume that any F under consideration is less than $F^{\#}$.

Assumptions 15, 16 and 17 ensure that, whatever the equilibrium F turns out to be, we can choose parameters that are consistent with the characterizations in the analysis.

Opportunism by the Bank: When the bank has the opportunity to threaten liquidation early (because this contract provision has been included) it may use this threat to simply extract surplus from the borrower. We will call this "opportunism." Bank opportunism will sometimes have efficiency considerations. Let $\pi^R(F^N,z,\alpha)$ be the expected profits of the bank as of $t=1$ after renegotiation has resulted in a new face value for the debt of F^N. (α is a function of F^N and z, but for clarity we include it as an argument of the expected profit function.) F^N could be higher or lower than the initial face value. If the bank can succeed in obtaining a higher rate, it faces a choice: raise the rate to maximize expected profit accepting that the borrower will choose $\alpha=1$ (call this rate F^{++}); or raise the rate to the highest level so that the borrower just chooses $\alpha=0$ (call this rate F^+).

Assumption A18. $\pi^R(F^{++},z,\alpha=1) > \pi^R(F^+,z,\alpha=0)$, for all z.

This means that bank opportunism has efficiency considerations since, if it can, the bank will renegotiate an interest rate which is so high that the borrower will add risk, even if the borrower would not add risk at the initial interest rate. Assumption A18 is not the only case in which bank opportunism will have efficiency considerations. Furthermore, it is not necessary for the analysis, but it is the most interesting case. The alternative assumptions are discussed further below and results for these cases given in Appendix B.

B) Discussion of the Model

Renegotiation occurs when news (z) arrives and is observed by both parties to the contract. Real world bank loans include covenants which require the firm to supply regular accounting information and provide the bank with an opportunity to investigate the firm. Thus we view it as reasonable that the bank can observe z, which should be interpreted as new information about the firm's prospects that is not freely available to (or easily interpretable by) the public.

The timing of the model assumes that news (z) arrives before the cash flows. This is for simplicity. Since the loan cannot mature before sufficient cash flows from the project are realized, there is always potential for renegotiation during the course of the loan. We simply label the arrival of news and the consequent renegotiation as $t=1$, but in principle these events can occur at any time prior to maturity, provided the borrower has time to add risk if he so chooses.

Renegotiation at $t=1$ is complicated by two moral hazard problems. The first moral hazard problem concerns the borrower. The borrower can threaten to add risk to the project in order to transfer value from the bank. Adding risk is costly because it reduces the project value, V, and the liquidation value, L_2, by c. This can be interpreted as a transactions cost; the borrower must pay to modify the existing project so as to increase riskiness.[10] We will show below that our assumptions restrict attention to cases where the added risk is inefficient. Obviously, if the risk is in the interest of both parties, then such an action should, and will, be taken and we do not concern ourselves with it.

The other moral hazard problem is bank opportunism. The bank may opportunistically threaten to liquidate in order to extract surplus from the borrower once news, z, has arrived. If the bank has the power to threaten liquidation and can thereby extract surplus from the borrower, it may behave inefficiently. Indeed, assumption A18 says that the bank will behave this way if it has a credible liquidation threat. Importantly, this opportunism has efficiency considerations since the borrower will choose to add risk ($\alpha=1$) when the bank behaves opportunistically.

But this threat by the bank depends on the design of the contract. The contract design problem involves a number of considerations, each of which we will address. First, there is the question of whether renegotiation is desirable. In other words, is it efficient to obtain funds from a bank, as opposed to obtaining funds from agents who cannot renegotiate? Answering this question involves comparing the outcomes of obtaining funds from a bank versus issuing bonds. Issuing bonds precommits to not renegotiate.

The second design issue concerns the contract with the bank, if funds are obtained from a bank. Here, the question is whether the contract should include a provision which allows the bank to ask for the collateral prior to maturity of the loan. We assume that the contract can feasibly include the liquidation option which allows the bank to "call the loan" at $t=1$ if it so wishes and we ask whether it is optimal to include this provision.[11]

If the liquidation option is included, then the third contract design consideration involves the specification of the initial (t=0) contract form, considering that both parties know that at t=1 the contract will be renegotiated for sure (resulting in liquidation or a debt claim maturing at t=2). While we have assumed that if the project continues at t=1, it must do so under a debt contract which matures at t=2, this does not determine the optimal form of the contract signed at t=0. Knowing that any contract will be renegotiated at t=1, what contract should be signed at t=0? Our analysis attacks this question by asking: What is the gain to specifying the face value of the debt to be paid at t=2, at t=0 (F_0)? In our analysis it is feasible for the parties to specify $F_0=D$ at t=0 (or, for that matter, $F_0=\infty$). Specifying $F_0=D$ would be tantamount to an initial agreement where the lender essentially says to the borrower: "Here's an amount of money, D. I have the right to liquidate at t=1, at which time we'll work out the details of the contract." This specification of the initial contract says that the bank can threaten to liquidate all borrower types at t=1, receiving L_1, unless borrowers agree to the bank's offer of F^N at that date. We will show how renegotiation outcomes are affected by the specification of F_0 at t=0 even though it is common knowledge that renegotiation will occur. The range of borrower types for which the liquidation threat is credible depends on the initial specification of F_0. The size of F_0 will lead to efficiency considerations via its ability to influence the bank's bargaining power at t=1. The costs and benefits of allocating power to the bank will determine the initial F.

Since we have assumed that the borrower has no alternative financing source at t=1, the borrower cannot threaten to refinance from other sources. It will also turn out that the bank's ability to threaten the borrower is limited. Thus it is not obvious how the surplus at t=1 will be split. We have assumed that the bank can credibly make a take-it-or-leave-it offer at t=1 and, hence, can obtain all the surplus. Since banking is competitive at t=0, the possibility of extracting surplus at date t=1 will be priced *ex ante*. The surplus will be split differently if other bargaining games are allowed, but this will not effect our results concerning efficiency.

III. Preliminary Results and Definitions

In this section we provide preliminary results and definitions. We prove a series of lemmas to build understanding of the model. First, we analyze the borrower's decision at date t=1 concerning adding risk. This defines a critical borrower type z^* below which the borrower will add risk in the absence of any bank action. Using this we then define the payoffs relevant to the subsequent analysis. Then we show that adding risk is inefficient. Finally, we outline the possible renegotiation outcomes and provide some intuition before the formal analysis.

A) News Arrival, the Borrower's Project Choice at t=1, and Efficiency

At 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 may have an incentive to switch projects to add risk ("asset substitution"). Borrowers who receive bad news (low z realizations) will be tempted to switch from their initial project, $\alpha=0$, to a higher risk project, $\alpha=1$. By increasing the variance of the project, the value of the firm's equity can be increased at the expense of the bank. But, since it is costly to take this action, only firms with sufficiently bad "news" will choose $\alpha=1$, as the following lemma shows.

> **Lemma 1:** *Given F_0, there exists some z^* such that setting $\alpha=1$ is profitable for the borrower if and only if $z<z^*$.*

Proof: See Appendix A. ‖

The lemma establishes that there is a critical borrower type, z^*, below which borrowers choose to add risk to their projects. z^* is defined by: $\Gamma(z^*;F_0) = 0$. We refer to $z<z^*$ as "bad" borrowers, and to $z>z^*$ as "good" borrowers.

Eventually, we solve for F_0. In this regard, it is important to know how z^* depends on F_0 since lenders will take adverse incentive affects of higher F_0 into account initially and during any renegotiation. The dependence is intuitive: the higher is the borrower's debt burden, the more likely that asset substitution will be appealing. In other words,

> **Lemma 2:** *z^* is increasing in F_0.*

Proof: See Appendix A. ‖

Lemma 1 shows that borrowers of type $z<z^*$ will, *ceteris paribus*, add risk. Our focus is on situations where the risk-taking by the borrower is unprofitable for the bank and socially inefficient. The

next lemma shows that, under our assumptions, this is ensured.

Lemma 3: *The addition of risk by the borrower ($\alpha=1$) is unprofitable for the bank.*

Proof: See Appendix A. ‖

It follows immediately that since asset substitution by the borrower is always bad for the bank, it is socially harmful on the margin, i.e., for some range of $z<z^*$, because a borrower of type z^* is indifferent to adding risk. Figure 2 depicts typical "gain" functions for the borrower and lender. Lemmas 1 and 3 only say that the gain for the borrower crosses zero somewhere from above, while the gain for the lender is always negative under our assumptions. Thus, the sum of the two gains will cross zero to the left of z^*.

B) Payoffs

At $t=1$ the bank may liquidate the project or renegotiate the interest rate. Let F^N be the new face value for the debt to be paid at $t=2$. In general, F^N will depend on z, but this notation is usually suppressed.

Define the <u>total expected payoff</u> to the project as of $t=1$ for given z and choice of α, $\pi^T(F^N,z,\alpha)$, as follows:[12]

$$\pi^T(F^N,z,\alpha) \equiv L_2G(F^N(z) \mid z,\alpha) + \int_{F^N(z)}^{V_h} Vg(V \mid z,\alpha)dV + y_2(z) - \alpha c$$

Note that this is not the first-best total expected value, but the second-best. Define <u>unrenegotiated bank profit</u>, $\pi^U(F_0,z,\alpha)$, to be expected bank profit as of $t=1$, from a borrower of type z, when evaluated at the initial face value of the debt, F_0, given that the borrower chooses α according to whether $z<z^*$:

$$\pi^U(F_0,z,\alpha) \equiv (L_2-\alpha c)G(F_0 \mid z,\alpha)+F_0[1-G(F_0 \mid z,\alpha)]$$

where α is a function of F_0 and z.

To facilitate discussion of liquidation define:

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

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

$z_{IL} = \inf\{z: \text{Max}[\pi^R(F^N,z,\alpha=1),\pi^U(F_0,z,\alpha=1)]=L_1\}.$

These points are indicated in Figure 3 along with the various expected profit functions. The point z_{IL} is defined as the lowest borrower type at which the best the bank can do under any renegotiation strategy (including not renegotiating) is just equal to the liquidation value of the project. 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. The subscript "IL" denotes inefficient or excessive 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.

C) Renegotiated Interest Rates

If the bank does not liquidate the borrower's project, it may seek to renegotiate the interest rate on the loan.[13] In this subsection we outline the possible renegotiation outcomes (to be analyzed subsequently) and provide intuitive some explanation. The intuition follows the case shown in Figure 3.

Define renegotiated bank profits at t=1, when a new interest rate $F^N(z)$ has been agreed to as follows:

$$\pi^R(F^N,z,\alpha)=(L_2-\alpha c)G(F^N(z) \mid z,\alpha)+F^N(z)[1-G(F^N(z) \mid z,\alpha)]$$

Again, α is the same function of F and z. Renegotiated bank profit is the return the bank expects to receive from the project of a borrower of type z, where the borrower of type z chooses project α, and promises to repay $F^N(z)$, the new interest rate agreed upon at date $t=1$.

One possible renegotiation outcome would be a lower interest rate. For example, 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 (switching to $\alpha=1$). 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 $\alpha=0$ would be chosen so 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 borrower, with reduced leverage, chooses not to add risk. But, even if $z>z^*$ the bank may want to forgive debt, simply because it improves expected profit. In any case, define $F^-(z)$ be the highest value of the new, $t=1$, interest rate, $F^N(z)$, such that $\alpha=0$ solves the borrower's $t=1$ problem of maximizing the (expected) gain to adding risk. Note that it need not be the case that $F^-(z)<F_0$.

For some range of borrowers in the interval $z_1<z<z^*$, the bank may want to forgive debt. But, pursuing the above example, at some borrower type, 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 (F_0) and allowed the borrower to add risk ($\alpha=1$). Define z^{**} to be the borrower type at which the bank is indifferent between these two choices: $\pi^R(F^-,z=z^{**},\alpha=0) = \pi^U(F_0,z=z^{**},\alpha=1)$, where π^R is the bank's expected profit as of $t=1$ when the renegotiated interest rate is decreased (π^R will indicate expected bank profit when the renegotiated interest rate is increased). Note that by definition it is always the case that $z^{**}<z^*$; 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 $\alpha=1$. See Figure 3.

Since z^{**} defines the point at which borrowers add risk, it will be important to know how this point varies with F_0. The answer is given by:

Lemma 4: *z^{**} is increasing in F_0.*

Proof: Note that $\pi^R(F^N,z,\alpha)$ is independent of F_0, but $\partial\pi^U/\partial F_0 > 0$ for $F_0 < F^\#$, by A17. Since z^{**} is defined as the point where $\pi^R(F^-,z=z^{**},\alpha=0) = \pi^U(F_0,z=z^{**},\alpha=1)$ the lemma follows. ‖

If forgiving debt to induce the borrower to choose $\alpha=0$ is not profitable, then the bank may seek to raise the interest rate, provided it has a credible (i.e., subgame perfect) threat to liquidate. Define z_{RN} to be the borrower type at which unrenegotiated bank profits equal the value of the collateral, L_1. Formally, z_{RN} solves $\max[\pi^U(F_0,z_{RN},\alpha), \pi^R(F^-,z_{RN},\alpha)]$ and if $\pi^U > L_1$, for all z, then $z_{RN}=z_l$. 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. If the bank can credibly threaten the borrower, then the higher interest rate (assuming no partial liquidation) is given by:

$$F^{++}(z) = Argmax_{F^N} \ (L_2-\alpha c)G(F^N \mid z,\alpha)+F^N[1-G(F^N \mid z,\alpha)]$$

Recall that under assumption A18, the bank's expected profit is higher if it raises the interest rate so much that the borrower adds risk, as opposed to raising it to $F^+(z)$ and receiving $\pi^R(F^+(z),z,\alpha=0)$.

As shown in Figure 3, as the type of the borrower declines, there comes a point where raising the interest rate cannot raise the expected value of the loan to the bank above the liquidation value, L_1. As defined above, at z_{IL}, $\pi^R(F^{++},z_{IL},\alpha=1)=L_1$. Again, however, it is good to keep in mind that there can be other cases where the bank can profitably raise the interest rate.

As with the other critical z-values, z_{RN} depends on F_0.

Lemma 5: *z_{RN} is decreasing in F_0.*

Proof: When $F_0<F^\#$, $\partial\pi^U/\partial F_0>0$, by A17. ‖

D) Definition of Equilibrium at t=1 and Specification of Cases

At t=1 the bank and the borrower know L_1, observe z, and choose a new contract, F^N, or liquidation, subject to constraints imposed by the existing contract, F_0. The existing contract and the borrower's type determine $\pi^U(F_0,z,\alpha)$, i.e., the unrenegotiated expected bank profit. 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 new contract, $F^N(z)$ (assuming liquidation does not occur); and (2), a choice of (new) interest rate, $F^N(z)$, or liquidation, by the bank, given the borrower's type, z, and choice of α, which maximizes the bank's expected profit. The resulting bank profit function, which we will denote by $\pi^B(F^N,z,\alpha)$, is the upper envelope of the four profit functions based on the different renegotiation outcomes, i.e.,

$$\pi^B(F,z,\alpha) = \text{Max}\{\pi^R(F^{++},z,\alpha),\ \pi^R(F^-,z,\alpha),\ \pi^U(F_0,z,\alpha),\ L_1\},$$

given the optimal choice of risk, α, by the borrower.

The precise pattern of renegotiation outcomes as a function of z depends on the location of z_{RN} relative to z^{**} and z^*. These in turn depend on F_0 and L_1. We treat L_1 as fixed and let F_0 trace out all of the possibilities, although of course ultimately F_0 will be determined by equilibrium conditions. Lemmas 2, 4, and 5 imply that there are three scenarios to consider (as depicted in Figure 4) corresponding to low, intermediate, and high values of F_0.[14] At low values of F (the bottom panel of Figure 4 the bank has a credible threat to renegotiate over a wide range of z, so $z_{RN} > z^*$ and there is never any issue of forgiving debt. The bank just "holds up" everyone with $z \leq z_{RN}$, even knowing that they will add risk as a consequence.

At intermediate and high values of F we have $z_{RN} < z^*$, so there is a range of forgiveness. The difference between the two is that with high F_0, $z_{RN} < z^{**}$ so there is a range in which risk-taking occurs because it is not in the bank's interest to forgive. The loan is still profitable, though, so the bank has no credible threat that would allow it to increase F either, and it just leaves it at F_0. In the intermediate case the forgiveness range runs into the "hold-up" range, so risk-taking coincides with the bank's increasing F.

It will turn out that the equilibrium value of F_0 corresponds to the boundary between the intermediate and high F_0 cases, with $z^{**} = z_{RN}$. This is because, as Figure 4 makes clear, the range of risk-taking (which occurs for $z < \text{Max}[z^{**}, z_{RN}]$) is thereby minimized. In the next section we will go into more detail on the high F_0 case, and relegate the other cases to Appendix B.

IV. The Liquidation Decision at t = 1

What triggers liquidation? By definition of z_{IL}, projects of borrowers of type $z<z_{IL}$ are liquidated. In the Intermediate F_0 Case, liquidation begins at the point where $\pi^R(F^+,z_{IL},\alpha=1)=L_1$. If $\pi^T(z_{IL},\alpha=1) = \pi^R(F^+,z_{IL},\alpha=1) = L_1$, (i.e., $z_{EL2}=z_{IL}$) then the projects liquidated in the range $z_{EL1}<z<z_{IL}$ are second-best liquidated since total expected profits are positive if the borrower did not choose $\alpha=1$. However, if $\pi^T(z_{IL},\alpha=1) > \pi^R(F^+,z_{IL},\alpha=1) = L_1$, then $z_{IL}>z_{EL2}$ and even more projects are liquidated, inefficient (or excessive) liquidation ("IL") beyond the second-best. This inefficient liquidation (relative to second-best) can happen because there is no way for the bank 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. (We discuss the issue of side payments below.)

Liquidation of socially wasteful projects will be an important role for the bank to play. But, by giving the bank the power to liquidate there is also the possibility that the bank liquidates projects inefficiently. This cost will have to be weighed against the benefits of liquidating efficiently.

V. Renegotiation of Loan Contracts at t=1

We now turn to renegotiation with borrowers who are not liquidated, maintaining the focus on the Intermediate F_0 Case.

A) Renegotiation Outcomes

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, $\pi^R(F^{++},z,\alpha=1)$; renegotiated profit when debt is forgiven (i.e., the interest rate is lowered), $\pi^R(F^-,z,\alpha=0)$; unrenegotiated profit, $\pi^U(F_0,z,\alpha)$; and liquidation. Figure 3 graphically portrays the four bank profit curves in the Intermediate F_0 Case. 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 1: *In the Intermediate F_0 Case, renegotiation results in:*

1) $F^N(z) = F^{++}(z) > F_0$ *for all* $z \in [z_{IL},z_{RN}]$*, i.e., raise the interest rate and let the borrower choose* $\alpha=1$*.*

2) $F^N(z) = F_0$ *for all* $z \in [z_{RN},z^{**}]$*, i.e., no change in the interest rate. The borrower chooses* $\alpha=1$*.*

3) $F^N(z) = F^-(z) < F_0$ *for all* $z \in [z^{**},z^*]$*, i.e., forgive debt (lower the rate) so that the borrower chooses* $\alpha=0$*.*

4) $F^N(z) = F_0$ *or all* $z > z^*$*, i.e., no change in the interest rate. The borrower chooses* $\alpha=0$*.*

Proof: Part (1): First, we must show that $[z_{IL},z_{RN}]$ exists. For $z>z_{IL}$, $\Gamma(z) > 0$ implies $Prob(V>F_0)>0$, i.e., $\pi^T(z,\alpha=1)>L_1$. That implies $\pi^U(F_0,z,\alpha=1)>0$. As $z \rightarrow z_{IL}$, $\pi^T(z,\alpha=1) \rightarrow L_1$ and $\pi^U(F_0,z,\alpha=1)<L_1$. Thus, $[z_{IL},z_{RN}]$ exists. In the interval $[z_{IL},z_{RN}]$, $\pi^T(F^N,z,\alpha=1)>L_1$, so the project should not be liquidated, but $\pi^U(F_0,z_{RN},\alpha=1)<L_1$, that is, at the unrenegotiated contract the bank would be better off liquidating the project. Thus, $F^N=F_0$ is not optimal. The fact that $z_{RN}<z^{**}$ means that $\pi^R(F^-,z,\alpha=0)<\pi^U(F_0,z,\alpha=1)$. 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 $F^N=F^{++}(z)$, 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 $z>z_{RN}$. $\pi^R(F^-,\alpha=0,z)<\pi^U(F_0,\alpha=1,z)$ because $z<z^{**}$, so debt forgiveness is not optimal. Since $\pi^U(F_0,\alpha=1,z)>L_1$, 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 $\pi^R(F^-,z,\alpha=0)>\pi^U(F_0,z,\alpha=1)$. 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 3. Starting with the highest type borrowers, those with $z > z^*$ unrenegotiated bank profits are given by $\pi^U(F_0,z,\alpha=0)$ since these borrowers do not switch projects. The bank cannot credibly threaten these borrowers to extract a higher rate because in this range, $\pi^U(F_0,z,\alpha=0) > L_1$ (that is, $z_{RN} < z^*$). The bank may or may not forgive debt for these borrower types (we assume that there is no forgiveness by assumption A17), but in any case these borrowers choose $\alpha=0$. Therefore, these borrowers continue their projects and the bank maintains the initial interest rate F_0. This is shown in the lower panel of the figure.

Borrowers with types below z^* will choose to add risk to their projects, *ceteris paribus*. 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 ($F^-(z) < F_0$), is higher than unrenegotiated bank profits given that borrowers choose $\alpha=1$. (The interval $[z^{**},z^*]$ may not exist.)

Debt forgiveness is optimal as long as $\pi^R(F^-,z,\alpha=0) > \pi^U(F_0,z,\alpha=1)$, that is, until the bank must forgive so much debt that it prefers to stay with the initial contract and allow the borrower to add risk. At the point z^{**}, $\pi^R(F^-,z^{**},\alpha=0)=\pi^U(F_0,z^{**},\alpha=1)$, 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 best 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. 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 of the figure where these borrowers continue with an interest rate of F_0.

For borrowers of type $z_{IL} < z < z_{RN}$ 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 (since $\pi^U(F_0,z,\alpha=1) < L_1$ in this range). Finally, at z_{IL}, $\pi^R(F^{++},z_{IL},\alpha=1)=L_1$ so borrowers of lower type than this are liquidated.

Proposition 1 covers the case assumed by A18, that it is always more profitable for the bank to raise the rate to F^{++} and let the borrower add risk, if the bank can credibly threaten liquidation. Appendix B analyses the alternatives to A18 as well as the High F_0 and Low F_0 cases.

B) Discussion

Two features of Proposition 1 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 projects. Thus, in equilibrium, borrower risk varies endogenously. Second, renegotiated interest rates are not monotonic in borrower type as can be seen in the lower panel of Figure 3. 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. We discuss the implications of these results in Section VIII.

We have allowed for the possibility that the bank may increase F if it has a credible threat to liquidate -- regardless of whether the borrower will choose to add risk or not. We have postponed until now the possibility of debt forgiveness simply as the result of new information being received at $t=1$, namely z. Even absent any moral hazard problem, the bank may be able to increase its expected profits by lowering F for some borrowers. This possibility would only change the shape of the π^U functions monotonically without qualitatively changing Figure 3 or any of the results described above. In particular, without the moral hazard problem, these reoptimized interest rates would introduce no new nonmonotonicity in the pattern of renegotiated interest rates as a function of borrower type, z.

VI. Initial Loan Pricing and the Role of Debt

The renegotiation outcomes at $t=1$ were determined above assuming that the contract contained the liquidation option and assuming a given F_0 that had been determined earlier at $t=0$. If the liquidation option is not included in the contract, then the bank, being a single agent, can renegotiate, but cannot threaten liquidation. Before considering the optimality of the liquidation option, which is done in Section VII, we turn to the determination of F_0 in the case where the liquidation option is included in the contract.

In this case, both parties to the contract know that renegotiation can occur. Then, what role does F_0 play? Why bother specifying F_0, at all, given that it is renegotiated after news arrives? To answer these questions we proceed in two steps. First, we demonstrate how efficiency considerations determine F_0 by affecting the bargaining power of the bank. This will determine the F_0 that is socially optimal (in the second-best sense). Then we inquire as to how the (second-best) efficient F_0 can be implemented when lenders act competitively and earn zero expected profits.

A) The Socially Optimal Initial Interest Rate

The socially optimal (second-best) F_0, call it F^*_0, will minimize inefficient risk-taking subject to the moral hazards. To determine F^*_0 we first need to decide which of the three cases defined above, High F_0, Low F_0, or Intermediate F_0, is most efficient. We can summarize the analysis so far, with respect to which borrowers will add risk to their projects, by combining the results of Proposition 1 with the results in Appendix B:

Low F_0 Case: For $z_{IL} < z < z_{RN}$, $\alpha = 1$, while for $z_{RN} \leq z \leq z_h$, $\alpha = 0$.

Intermediate F_0 Case: For $z_{IL} < z < z_{RN}$, $\alpha = 1$, while for $z_{RN} \leq z \leq z_h$, $\alpha = 0$.

High F_0 Case: For $z_{IL} < z < z^{**}$, $\alpha = 1$, while for $z^{**} \leq z \leq z_h$, $\alpha = 0$.

In the Intermediate and Low F_0 cases, the inefficient risk-taking begins at z_{RN}, while in the High F_0 Case it begins at z^{**}. The next two lemmas show how these risk-taking ranges vary with F_0.

Lemma 6: *In the High F_0 Case, the risk-taking range is shrinking as F_0 decreases.*

Proof: By Lemma 4, $\partial z^{**}/\partial F_0 < 0$. ‖

Lemma 7: *In the Intermediate and Low F_0 Cases, the risk-taking range is increasing as F_0 decreases.*

Proof: By Lemma 5, z_{RN} is rising as F_0 decreases. ‖

As F_0 decreases, the risk-taking range decreases in the Intermediate Case, but increases in the High and Low Cases. It is immediate that:

Proposition 2: *The constrained socially optimal F_0 is such that $z^{**} = z_{RN}$.*

Figure 5 depicts the optimal configuration. The following corollary helps explain the proposition.

Corollary 2.1: *Any reduction in asset substitution brought about through renegotiation is welfare-improving.*

Proof: Since the bank forgives (and thereby eliminates asset substitution) over the range $[z^{**},z^{*}]$, that range of borrowers is indifferent to adding risk given the renegotiated F, whereas the bank still strictly prefers that they not add risk. ‖

B) Implementation of the Socially Optimal F_0

Let F^*_0 denote the optimal value of F_0. Given the nature of bank loans, it should be clear that linear pricing is not necessary. Thus if banks make non-negative profits, they can still price loans F^*_0 and compete by offering other goods or services for free, up to the point that they make zero profits on the whole package. This is the case depicted in Figure 6. Note that bank profits are the same at extreme values of F because the range of risk-taking is broad and the renegotiated F is high in either case.

On the other hand, it may be the case that at F^*_0, banks make negative expected profits, $F_0^* < F_c$. In this case, competitive banks would charge origination fees to make up the difference, if that were feasible. Under our assumptions, however, the borrower has no surplus liquidity at $t=0$, so competitive banking cannot implement the social optimum. In this case, the bank must loan the borrower additional money, so he can pay the fee. But, then the borrower has borrowed more than D, and must repay more than F^*_0 -- leading to a new F^*_0 corresponding to the higher amount lent. Alternatively, a suitably designed monopoly banking system allowing banks to charge a monopolistic F_0 could make lending feasible, but not the social optimum.

Note that even if banks happen to make zero profits at this optimal F_0, its value reflects much more than default risk. It also incorporates the various renegotiation outcomes, including the possibility of the bank opportunistically increasing the rate, or lowering the rate to induce good behavior by the borrower.

VII. Bank Loans, the Option to Liquidate, and Corporate Bonds

We now turn to questions about the desirability and of bank loans versus bonds, and the desirability of the liquidation option in bank loans. The first issue, concerning loans versus bonds, asks whether renegotiation is desirable. We can address this first issue by comparing the bank contract (with or without the liquidation option) to a bond contract which, by definition, cannot be renegotiated (because the bondholders are dispersed). The second issue, of the optimality of the liquidation option can be analyzed by comparing the outcomes from the bank contract with the liquidation option to the outcomes from a contract without this option to address this issue.

The corporate bond contract that we consider is the standard debt contract under which the firm borrows the amount D at date $t=0$ with the promise to pay back F_0 at $t=2$. The contract is not subject to renegotiation and pays off L_2 at $t=2$ if the borrower defaults.[15] Since there is no interest payment at $t=1$ the borrower never defaults at this date.

A) Contract Choice

We begin by comparing a bank contract with the liquidation option to the bond contract, holding fixed the amount borrowed and the face value of the debt, F_0. Borrowing from a bank allows for renegotiation and this makes bank loans valuable because: (i) bank loan contracts prevent continuation of projects that are socially inefficient; and (ii), banks can prevent some (costly) risk-taking by forgiving debt to induce the borrower to not add risk. Against these benefits must be weighed the costs associated with excessive (i.e., beyond second-best) liquidation which occurs if the bank liquidates projects in the range $z_{EL2} < z < z_{IL}$. Corporate bonds cannot be renegotiated (by definition) and so cannot prevent inefficient projects from continuing nor can bondholders prevent excessive risk-taking. But, the advantage of bonds is that projects are not excessively liquidate (since no projects are liquidated). Whether bank loans or corporate bonds are more valuable depends on the relative sizes of these costs and benefits.

Proposition 3: *Bank loans with the liquidation option are more valuable to a borrowing firm than are corporate bonds of the same face value if:*

$$\int_{z_l}^{z_{EL2}} [L_1 - \pi^T(F_0, z, 1)]\, h(z)dz + \int_{z^{EL2}}^{z^{IL}} [L_1 - \pi^T(F_0, z, 1)]\, h(z)dz$$

$$+ \int_{z_{IL}}^{z_{RN}} [\pi^T(F^+, z, 1) - \pi^T(F_0, z, 1)]\, h(z)dz + \int_{z^{**}}^{z^*} [\pi^T(F^-, z, 0) - \pi^T(F_0, z, 1)]\, h(z)dz \quad > \quad 0.$$

Proof: See Appendix A. ‖

The first two terms of the above expression concern liquidation. The first term is positive: over the range $z_l < z < z_{EL2}$, L_1 exceeds the total expected value of the project when the borrower chooses to add risk. The bank loan is more valuable since the bank efficiently ends the project while the bonds allow excessive continuation of the project. The second term, however, is negative because in the range $z_{EL2} < z < z_{IL}$, the bank inefficiently liquidates projects (relative to second-best). Over this range, bonds are superior to loans.

The third and fourth terms capture the effects of renegotiation. The third term is negative (by Lemma 4). Over this range the bank is behaving opportunistically, raising the interest rate which, while in its interest, reduces the total expected value of the project. The fourth term is positive since over the range $z^{*} < z < z^{**}$, the bank forgives debt, raising the project value because the cost, c, is avoided.

We can understand Proposition 3 by considering the case of when no liquidation option is included in the bank loan contract. Then:

Corollary 3.1: *Bank loans* <u>*without the liquidation option*</u> *are always more valuable to a borrowing firm than are corporate bonds of the same face value since:*

$$\int_{z^{**}}^{z^{*}} [\pi^{T}(F^{-},z,0) - \pi^{T}(F_{0},z,0)]\, h(z)dz \quad > \quad 0.$$

The ability to forgive debt is valuable (and can only occur when there is a single agent, the bank, to make the decision) and can be separated from the question of whether the liquidation option is valuable. This means that bank loans unambiguously dominate corporate bonds because the liquidation option need not be included in the loan contract.

Now consider whether the liquidation option is valuable.

Corollary 3.2: *The liquidation option is valuable if:*

$$\int_{z_{I}}^{z_{EL2}} [L_{1} - \pi^{T}(F_{0},z,1)] h(z)dz + \int_{z_{EL2}}^{z_{IL}} [L_{1} - \pi^{T}(F_{0},z,1)] h(z)dz$$

$$+ \int_{z_{IL}}^{z_{RN}} [\pi^{T}(F^{+},z,1) - \pi^{T}(F_{0},z,1)] h(z)dz \quad > \quad 0.$$

The trade-off is clear. Bank loans with the liquidation option dominate bonds if the bank's ability to prevent inefficient continuation of projects via liquidation and its ability to reduce risk-taking via forgiveness outweigh the costs of inefficient liquidation and opportunism. Put another way, if a bank can offer a sufficiently lower interest rate by adding the liquidation option, bank borrowing will be attractive to the firm.

B) Extensions

In the case of bonds, we did not allow for the possibility of borrower-initiated forgiveness. Borrowers can receive forgiveness via an exchange offer in which the borrowing firm offers the existing debtholders a new security (or securities) in exchange for each existing bond. Typically, the exchange allows the firm to reduce its debt obligations (see Asquith, Mullins and Wolff (1989)). Exchange offers allow for the possibility of forgiveness and consequently the renegotiation outcomes achieved when the bank loan does not contain the liquidation option. The possibility of exchange offers means that loans do not unambiguously dominate bonds.

Another contract feature which we did not consider works in favor of bank loans. A prepayment option allowing the borrower to prepay debt at date $t=1$ can reduce the cost of excessive liquidation by the bank, increasing the benefits of loans over bonds. Then, as shown by Gorton and Kahn (1994), inefficient liquidation can be reduced or eliminated and borrowers might never want to add risk.

VIII. Final Remarks

In this section we briefly discuss our results with respect to: (i) the importance of endogenous firm volatility; and (ii), the role of seniority for bank monitoring.

A) Endogenous Volatility

Our model shows how the volatility of corporate securities is not constant. The firm sometimes has an incentive to increase volatility. The outside claimant that is in a position to prevent this, the bank, only imperfectly controls borrower risk-taking. 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 so 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, is not constant, a result at odds with the existing literature on pricing corporate securities based on option pricing.

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. Then firm risk is not increased and Black-Scholes option methods can be applied to pricing corporate securities.

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 the liquidation option 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, is neither observable nor verifiable. If instead of a bank loan, the firm issued bonds and warrants, the warrants would be of no value because the outside equityholders (in this case the bank which obtains equity via warrants) would never earn a dividend since they can not observe V. 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 (interim) asset substitution problem.

B) The Importance of Collateral and Seniority

In the model analyzed above there is no distinction between seniority of debt and collateralized claims since there is only one lender. For the sake of brevity we do not extend the model to include junior corporate debt, though this is straightforward. Nevertheless 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 (in a costly state verification setting), as Fama (1985) has argued. Yet firms often have both bank loans and publicly-issued and traded bonds.

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.

Our view is that, as senior claimants, banks have the unique ability to engage in (relatively) efficient liquidation of bad projects. 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 an incentive to force liquidation, possibly excessively liquidating. If the likelihood of excessive liquidation can be reduced via prepayment options, as discussed above, then bank loans dominate other forms of debt because the prospect of relatively efficient liquidation raises the value of the firm *ex ante* by lowering the cost of debt.[16]

Fama (1985) also argues that bank debtors bear the incidence of the reserve tax, since bank Certificates of Deposit 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.

Appendix A

Proof of Lemma 1: The lemma 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 assume that the conditional distribution of z given V has the MLRP property. Let $\psi: R \rightarrow R$ be some continuous function that crosses zero only once, and from above. Then the function $\xi: R \rightarrow R$, $\xi(z) = E_V[\psi(V,F)|z]$ crosses zero at most once, and from above.*

Proof: See Karlin (1968).

Recall that $\psi(V,F_0) \equiv E_\epsilon[\pi^F(V+\epsilon-c,F_0) - \pi^F(V,F_0)]$, where $\pi^F(w) = \max[w-F_0,0]$ is the profit to the borrowing firm. We denoted the expected gain to a borrower of type z from switching from project $\alpha=0$ to $\alpha=1$ by $\Gamma(z)$. Hence $\Gamma(z) = E_V[\psi(V,F_0)|z]$. At t=1, having observed z, the borrower chooses α to maximize profits. To prove Lemma 2 we apply the Lemma A1 and need only show that $\psi(V,F_0)$ crosses zero only once, and from above. By assumption A15, the upper bound of the support of ϵ is greater than $c+F_0$. We have

$$\psi(V,F_0) = \int_{c+F_0-V}^{\epsilon_h} [e-(c+F_0-V)]h(e)de - \max[V-F_0,0].$$

We know that $V \leq F_0$ implies $\psi(V,F_0) > 0$. Further, since for $V > F_0$

$$\psi(V,F_0) = \int_{c+F_0-V}^{\epsilon_h} eh(e)\,de - (c+F_0-V)(1-H(c+F_0-V)) - (V-F_0),$$

we have

$$\lim_{V\rightarrow\infty} \psi(V,F_0) = \lim_{V\rightarrow\infty} -VH(c+F_0-V) - c < 0.$$

We also have, for $V > F_0$,

$$\frac{\partial \psi}{\partial V} = -H(c+F_0-V) \leq 0.$$

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

Proof of Lemma 2: We have $\Gamma(z^*,F_0)=0$ implicitly defining $z^*(F_0)$. To prove that z^* is increasing in F_0, it suffices to show that:

$$-\frac{\partial \Gamma}{\partial F_0} / \frac{\partial \Gamma}{\partial z} > 0$$

evaluated at z^* and F_0. By the Proof of Lemma 1, we already know that $\partial\Gamma(z^*)/\partial z < 0$, since at z^* the function Γ crosses zero from above. So it remains to show that $\partial\Gamma(z^*,F_0)/\partial F_0 > 0$. For this we need to see how $\psi(V,F_0)$ depends on F_0. We have from before,

$$\psi(V,F_0) = \int_{c+F_0-V}^{e_h} [e-(c+F_0-V)]h(e)de - \max[V-F_0,0]$$

which we now want to consider as a function of F_0 holding V fixed. But, it is straightforward to verify that $\partial\psi/\partial F_0 > 0$. Hence $\partial\Gamma(z^*,F_0)/\partial F_0 = E[\partial\psi(V,F_0)/\partial F_0 \mid z^*] > 0$. ‖

Proof of Lemma 3: Define the <u>gain</u> to the bank from the borrower of type adding risk to be: $\Gamma_B(z;F) = E_V[\omega(V) \mid z]$, where:

$$\omega(V,F) = -c+[1-H(F+c-V)](F-L_2) \qquad \text{if } V<F$$

$$= -H(F+c-V)(F-L_2+c) \qquad \text{if } V \geq F.$$

$\omega(V)$ is discontinuous at $V=F$. Also $\omega(V)$ can be positive for $V<F$ in the vicinity of F. But, for given F, $\omega(V)<0$, for all V, if $F<L_2 + c/[1-H(c)]$. This cannot be true for all possible values of F, but any given value it suffices that c or H(c) be sufficiently large. But A15 states that: $\epsilon_h > c+F$, and A16 states that: $L_2 + c/[1-H(c)] > F$. Thus, $\omega(V)$ is assured of lying everywhere below zero. Recalling that ψ is the gain to the borrower, we have shown that $\psi+\omega$, which is the social gain, lies everywhere below ψ. ‖

Proof of Proposition 3: The total expected value of the project at $t=0$ if it is financed with a bank loan is:

$$\Pi^T(bankloan) = \int_{z_l}^{z_{LL}} L_1 h(z)dz + \int_{z_{LL}}^{z_{RN}} \pi^T(F^+, z, \alpha=1) h(z)dz$$

$$+ \int_{z_{RN}}^{z^{**}} \pi^T(F_0, z, \alpha=1)\, h(z)dz + \int_{z^{**}}^{z^*} \pi^T(F^-, z, \alpha=0) h(z)dz$$

$$+ \int_{z^*}^{z_h} \pi^T(F_0, z, \alpha=0)\, h(z)dz$$

If the project is financed with a public bond issuance, then its expected value at $t=0$ is:

$$\Pi^T(bond) = \int_{z_l}^{z^*} \pi^T(F_0, z, \alpha=1)\, h(z)dz + \int_{z^*}^{z_h} \pi^T(F_0, z, \alpha=0)\, h(z)dz.$$

The difference between the expected value of the project when financed by a bank loan and when financed by corporate (public) debt is the expression provided by the proposition. ‖

Appendix B

Renegotiation Outcomes for the Intermediate F_0 Case

The Intermediate F_0 Case is the situation where $z^{**}<z_{RN}<z^*$. Liquidation occurs for $z<z_{IL}$.

Proposition B1: *If $z^{**}<z_{RN}<z^*$, then renegotiation results in:*

1) $F^N(z) = F^+(z) > F_0$, for all $z \in [z_{IL},z_{RN}]$, i.e, raise rate; borrower chooses $\alpha=1$.

2) $F^N(z) = F^-(z) < F_0$, for all $z>z_{RN}$ forgive debt; borrower chooses $\alpha=0$.

Proof: Part (1): For $z \in [z_{IL},z_{RN}]$ the borrower will choose $\alpha=1$, *ceteris paribus*. Liquidation is not optimal for these borrowers since $z>z_{IL}$. Also, because $z<z_{RN}$, $\pi^U(F,z,\alpha=1)<L_1$, so maintenance of the initial contract is not optimal. Since $z<z_{RN}$ the bank can credibly threaten the borrower. By A18, $\pi^R(F^{++},z,\alpha=1)>\pi^R(F^+,z,\alpha=0)$, that is, it is more profitable for the bank to raise the rate by so much that the borrower chooses $\alpha=1$, rather than raise the rate to the point where the maximum surplus is extracted and the borrower chooses $\alpha=0$. So the bank raises the interest rate and the borrower chooses $\alpha=1$. Part (2): For $z>z^*$ the project is profitable and the borrower will choose $\alpha=0$, *ceteris paribus*. The bank cannot threaten the borrower since $z_{RN}<z^*$, so the initial contract is maintained. ‖

Renegotiation Outcomes for the Low F_0 Case

The Low Case is the situation where $z^{**}<z^*<z_{RN}$, 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. 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 B2: *If $z^{**}<z^*<z_{RN}$, then renegotiation results in the following outcomes:*

(1) $F^N(z) = F^+(z) > F_0$ for all $z \in [z_{IL},z_{RN}]$, i.e., raise the rate; the borrower chooses $\alpha=1$;

(2) $F^N(z) = F_0$ for all $z>z_{RN}$, i.e., no change; the borrower chooses $\alpha=0$.

Proof: Similar to Proposition B1. ‖

Alternatives to Assumption A18

Assumption A18 assumed that $\pi^R(F^N,z,1) > \pi^R(F^N,z,0)$ for all z and F. We now briefly reconsider Propositions 1, B1, and B2, when A18 is not assumed. The first alternative to A18, Subcase 1, occurs when $\pi^R(F^N,z,1)$ cuts $\pi^R(F^N,z,0)$ from above at a point $\underline{\hat{z}}$ such that $z_{IL}<\underline{\hat{z}}<z_{RN}$. For this case:

Proposition B3: *If $z_{RN}<z^{**}<z^{*}$, and Subcase 1, then renegotiation results in:*

1) $F^N(z) = F^{++}(z) > F_0$, for all $z \in [z_{IL},\underline{\hat{z}}]$, i.e, raise rate and let the borrower choose $\alpha=1$.

2) $F^N(z) = F^{+}(z) < F_0$, for all $z \in [\underline{\hat{z}},z_{RN}]$, i.e., raise the rate but such that the borrower chooses $\alpha=0$.

3) $F^N(z) = F_0$, for all $z \in [z_{RN},z^{**}]$, i.e., no change; borrower chooses $\alpha=1$.

4) $F^N(z) = F^{-}(z)$, for all $z \in [z^{**},z^{*}]$, i.e., forgive debt; borrower chooses $\alpha=0$.

5) $F^N(z) = F_0$, for all $z>z^{*}$, i.e., no change; the borrower chooses $\alpha=0$.

Proof: Part (1): For $z \in [z_{IL},\underline{\hat{z}}]$ the borrower is choosing $\alpha=1$. Liquidation is not optimal since $z>z_{IL}$. Since $\underline{\hat{z}}<z_{RN}$, $\pi^U(F,z,\alpha=1)<L_1$, so maintenance of the initial contract is not optimal. By the definition of subcase 1 $\pi^R(F^{++},z,\alpha=1)>\pi^R(F^{+},z,\alpha=0)$ so the bank raises the interest rate. Part (2): As above, neither liquidation nor maintenance of the initial contract is optimal. But, in this range, by the definition of subcase 1, $\pi^R(F^{++},z,\alpha=1)<\pi^R(F^{+},z,\alpha=0)$ so the bank raises the rate as far as possible while maintaining the incentive for the borrower to choose $\alpha=1$. Part (3): In this range the bank can no longer credibly threaten the borrower so raising the rate is not feasible. Forgiveness is not profitable for the bank (by definition of z^{**}). So, the rate does not change and the borrower chooses $\alpha=1$. Part (4): Now it is profitable to forgive debt so that the borrower chooses $\alpha=0$. Part (5): In this range the borrower will choose $\alpha=0$, *ceteris paribus*. The bank has no credible threat to liquidate and cannot raise the rate. The rate stays the same and the borrower chooses $\alpha=0$. ‖

Subcase 2 is the situation where $z_{RN}<\underline{\hat{z}}<z^{**}<z^{*}$. In this case, the result is the same as above since the bank cannot threaten to liquidate borrowers of type $z \in [\underline{\hat{z}},z_{RN}]$. Subcase 3 is: $z_{RN}<z^{**}<\underline{\hat{z}}<z^{*}$. Again, there is no change, for the same reason. The same is true for the case where $z_{RN}<z^{**}<z^{*}<\underline{\hat{z}}$. The final possibility is the case where $\pi^R(F^N,z,1) < \pi^R(F^N,z,0)$ for all z and F, the opposite assumption of A18. In this case, it can easily be shown that the borrower never adds risk since it is always profitable for the bank to forgive rather than raise the rate.

For the Intermediate and Low F_0 Cases there are similar, straightforward, variations when we deviate from A18. These are omitted for the sake of space.

Footnotes

1. For example, James (1987) finds a positive and significant abnormal stock response to firms announcing the signing of bank loan agreements. Also see Lummer and McConnell (1989). Hoshi, Kashyap, and Scharfstein (1990) find that Japanese firms in financial distress that are members of a "main-bank" coalition (*keiretsu*) invest and sell more after the onset of distress than do distressed firms that are not members of a bank coalition. Other evidence includes Gilson, Lang and John (1990) and Slovin, Sushka, and Polonchek (1993).

2. In costly state verification models the value of the borrower is not known until monitoring takes place. Thus, even if the bank's junior claim is worthless, the bank does not know this until it monitors.

3. Thus, 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 Motors Acceptance Corporation.

4. The assumption that liquidation is all-or-nothing is without loss of generality since partial liquidation is never optimal in any case. We prove this in Gorton and Kahn (1992).

5. Note that if $L_1=L_2$, 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 $L_1>L_2$ implies that at earlier stages of the project liquidation is less costly, i.e., more can be recovered.

6. We also assume that there is no choice concerning collateral; the borrower uses all the collateral that the project provides and has no other collateralizable resources.

7. The assumption that the liquidation value, L_2, is also reduced by the amount c if risk is added ($\alpha=1$) is not necessary, but appears (to us) to be realistic.

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

9. Bolton and Scharfstein (1990) and Hart and Moore (1989) show the optimality of debt in similar settings.

10. At $t=1$ we assume that costless, or extremely inexpensive, ways of adding risk can be prevented costlessly by the bank through covenant restrictions.

11. The interpretation of this is that while borrower type, z, is not verifiable, a contract can contain verifiable provisions (covenants) which are always triggered by the arrival of the news, z. Loan covenants are written in terms of variables measurable according to accounting procedures, e.g., net worth, leverage, etc., and consequently are verifiable, though violations may be forgiven by the bank. See Zimmerman (1975), Quill, Cresci, and Shuter (1977), and Morsman (1986). 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.

12. Note that this definition of $\pi^T(z,\alpha)$ presumes no partial liquidation at $t=1$ (i.e., $\lambda=0$) so $x_1=1$. We will show in the next section that partial liquidation is never optimal and will, therefore, impose it now to simplify notation.

13. In fact, even absent the moral hazard problem of asset substitution, it would be in the bank's interest to change F upon learning z simply to increase expected payoffs. We will postpone discussion of this until Section V.

14. In Figure 4 the curve labelled $\pi^R(F^-)$ is $\pi^R(F^+)$ for $z<z^*$ and $\pi^R(F^-)$ for $z<z^*$. To avoid complicating the figure we only include one label.

15. Corporate bond contracts sometimes contain covenants which are monitored by a bond trustee. Our view is that this arrangement is not equivalent to a bank contract since the incentives the trustee faces are not the same as those a bank faces. Thus, it appears to be rare for a trustee to renegotiate the contract in any substantial way. Moreover, there is a well-known hold-out problem in renegotiating bonds. In the U.S. the Trust Indenture Act requires unanimous agreement of bondholders to renegotiate interest or principal payments (though bond covenants usually can be renegotiated by a two thirds majority, or plurality).

16. 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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Table 1: Summary of Some Notation

$y_2(z)$	Cash flow from the project at t=2 for borrower type z
x_t	Scale of the project at time t ($t=0, 1; x_0 = 1$)
D	Initial amount borrowed
F_0	Initial face value of the debt
V	Value of the project to the entrepreneur as of t = 2
L_t	Liquidation value of the project to the lender (t=1, 2)
F^N	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 the riskier project
π^T	Total expected value of the project at t=1
π^R	Expected bank profit with renegotiation
π^U	Expected bank profit absent renegotiation
z^*	$\inf\{z \mid \Gamma(z) \geq$, given $F\}$, i.e., threshold for switching to risky project given initial contract
z^{**}	$\inf\{z \mid \Gamma(z) \geq F^N\}$, i.e., threshold for switching projects given renegotiated contract
z_{RN}	$\inf\{z \mid \pi^U \geq L_1$, for all $F^N \leq F\}$, 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 projects
z_{EL2}	$\inf\{z \mid \pi^T \geq L_1, \alpha=1\}$, threshold for efficient liquidation given switching to the riskier project
z_{IL}	$\inf\{z \mid \pi^R \geq L_1\}$, threshold for liquidation to be profit-maximizing for the bank
$F^{++}(z)$	value of $F^N(z)$ that maximizes $\pi^R(F^{++},z,\alpha=1)$
$F^{-}(z)$	value of $F^N(z) > F$ that maximizes π^R given $\alpha=1$

Figure 1: Sequence of Events

– Date 0

Firm borrows D to finance project, agreeing to repay F at date 2;

– Date 1

z is realized and observed by the firm and the bank;

Bank and firm renegotiate the loan terms; bank may liquidate project;

Firm chooses whether to increase risk ($\alpha = 1$) or not ($\alpha = 0$) at a cost of c (if not liquidates);

– Date 2

V is realized; firm pays off loan if solvent; otherwise, bank receives liquidation value of firm;

– Date 3

Final cash flow from firm project is realized.

Figure 2

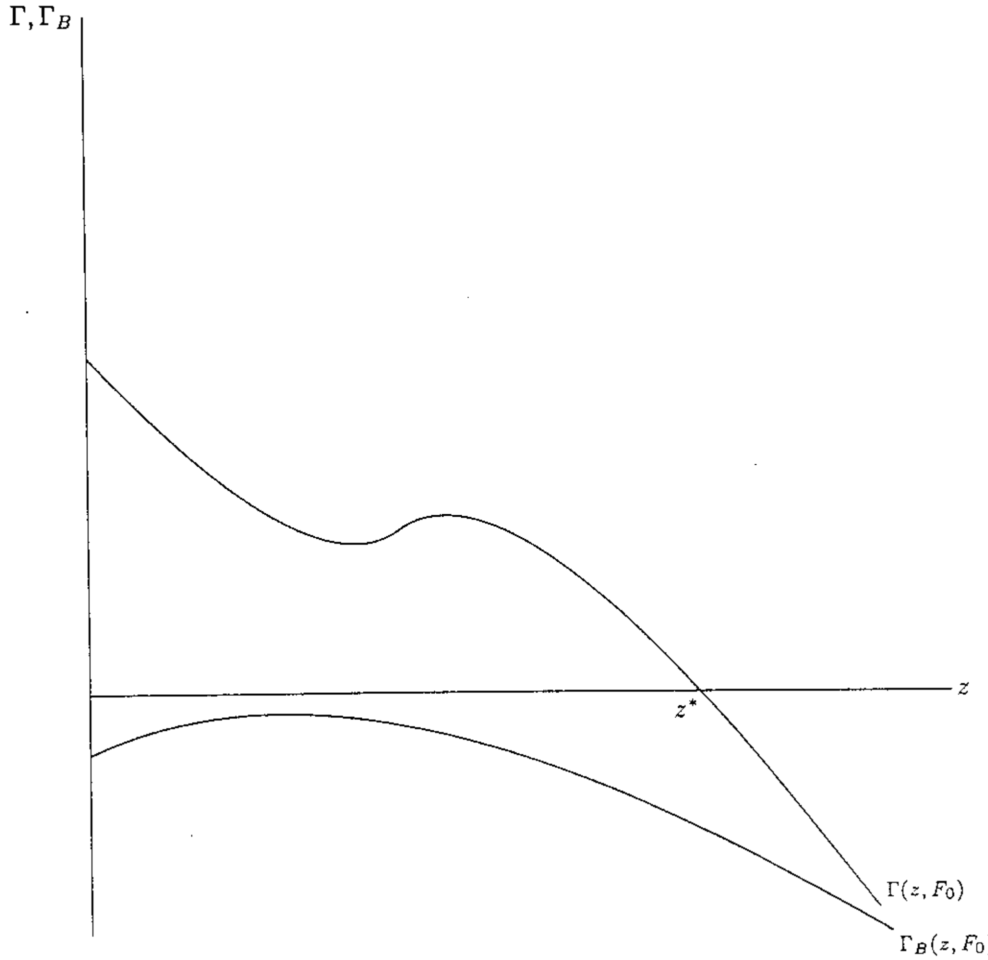
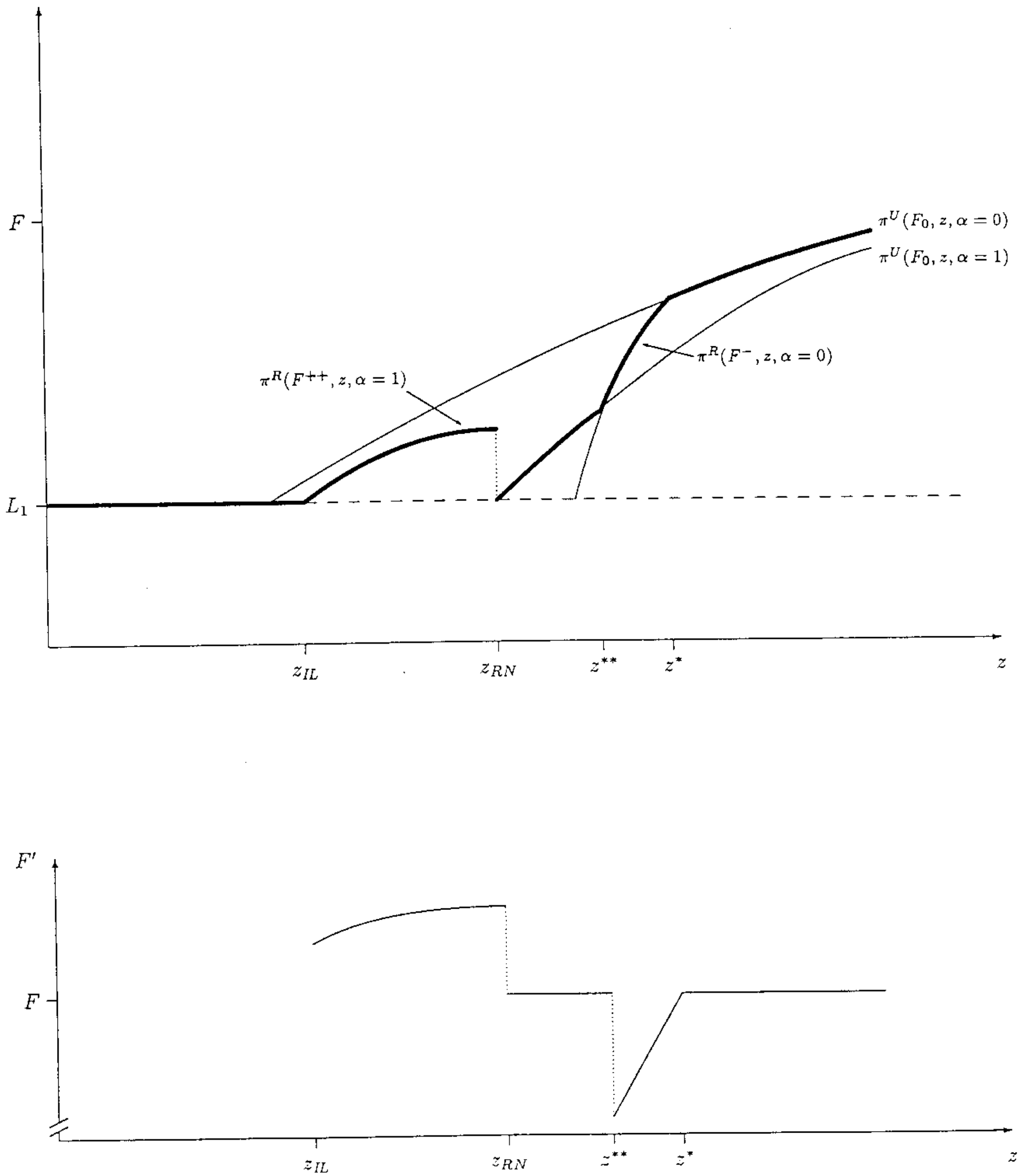
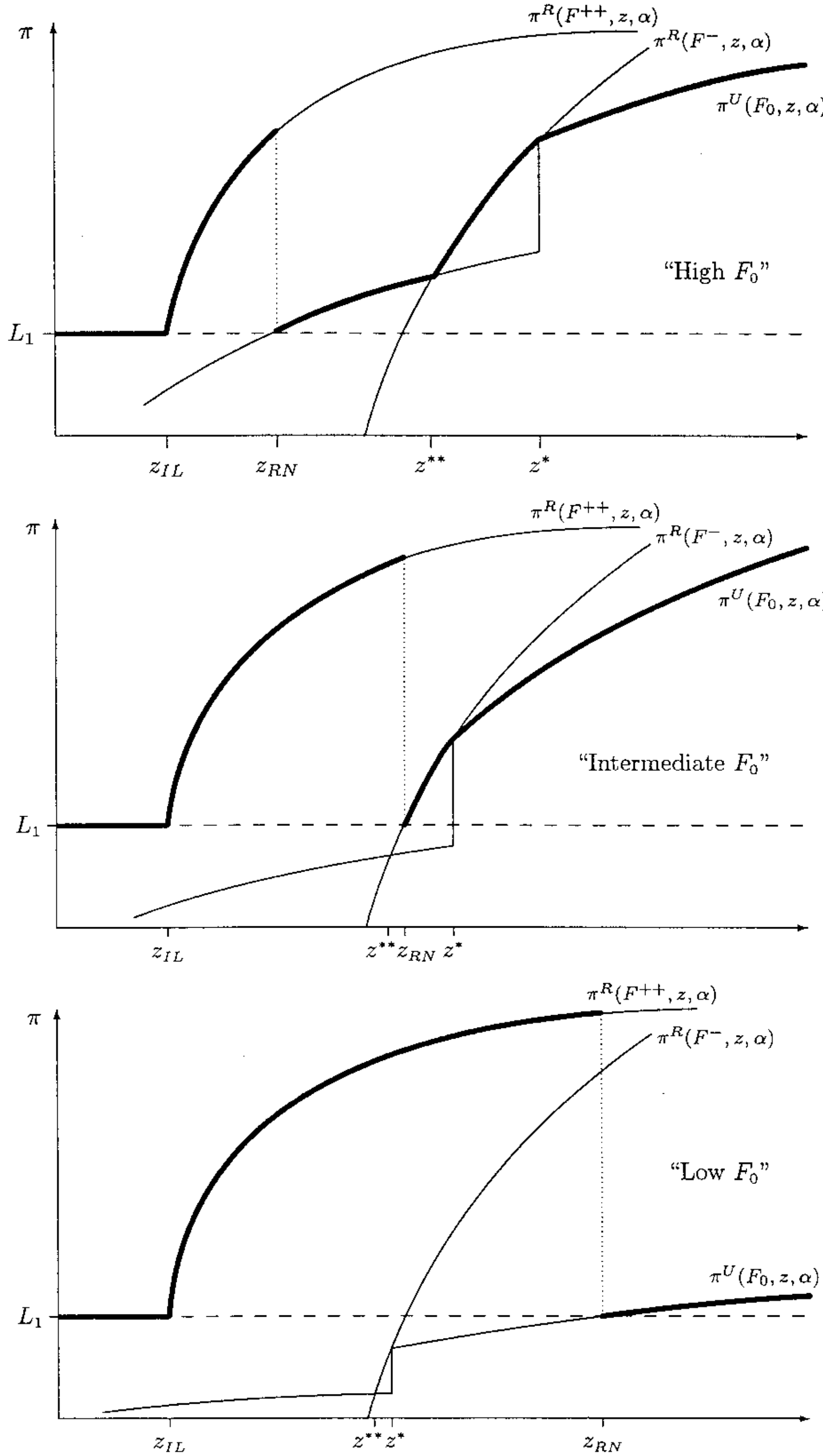


Figure 3



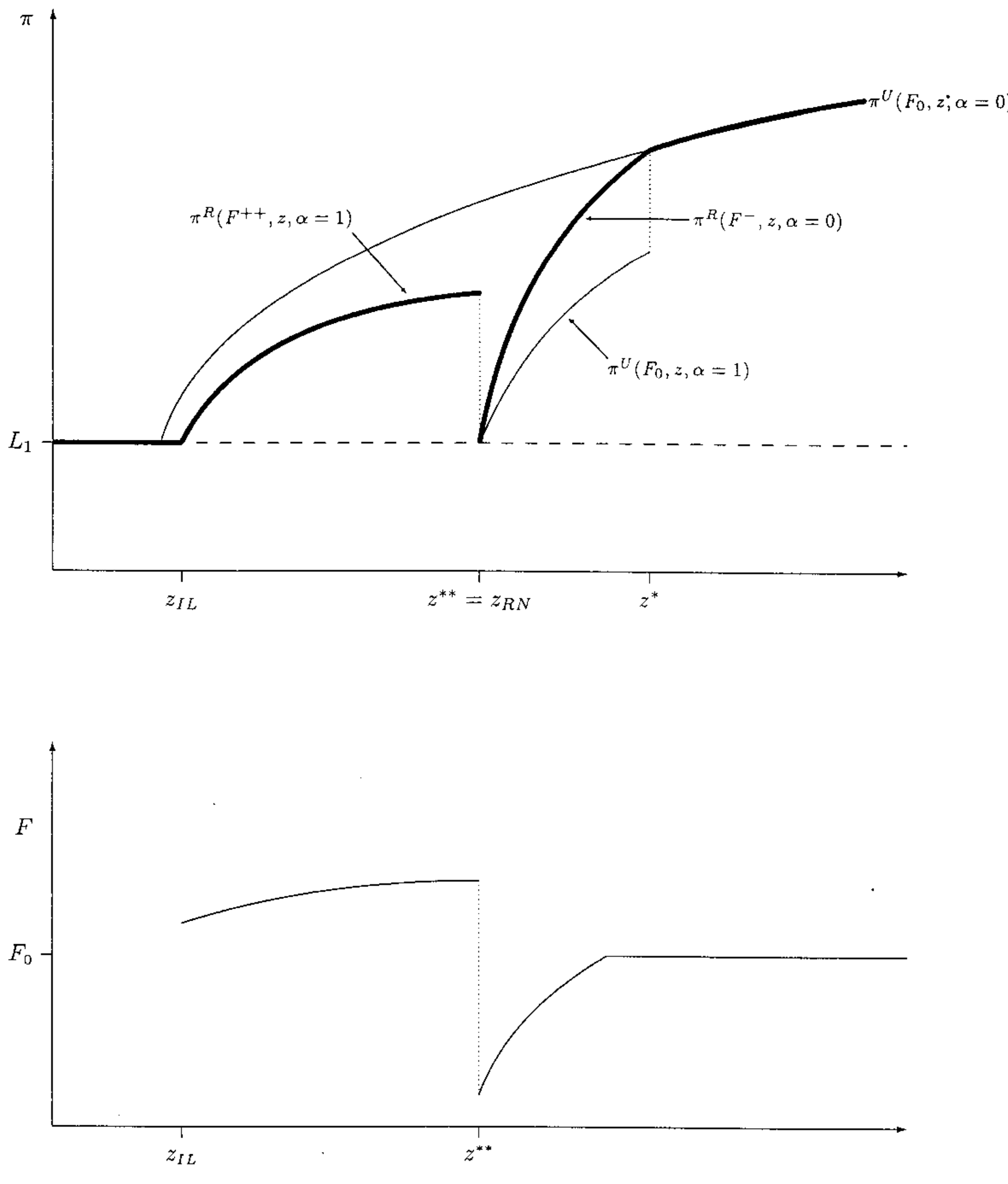
F
L_1
$\pi^U(F_0, z, \alpha = 0)$
$\pi^U(F_0, z, \alpha = 1)$
$\pi^R(F^{-}, z, \alpha = 0)$
$\pi^R(F^{++}, z, \alpha = 1)$
z_{IL}
z_{RN}
z^{**}
z^{*}
z
F'
F
z_{IL}
z_{RN}
z^{**}
z^{*}
z

Figure 4



indicates $\pi^B(F, z, \alpha) \equiv \max\{\pi^R(F^{++}, z, \alpha), \pi^R(F^{-}, z, \alpha), \pi^U(F_0, z, \alpha), L_1\}$.

Figure 5



π
$\pi^U(F_0, z; \alpha = 0)$
$\pi^R(F^{++}, z, \alpha = 1)$
$\pi^R(F^-, z, \alpha = 0)$
$\pi^U(F_0, z, \alpha = 1)$
L_1
z_{IL}
$z^{**} = z_{RN}$
z^*
F
F_0
z_{IL}
z^{**}

Figure 6