Monitoring and Reputation: The Choice between Bank Loans and Directly Placed Debt

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This paper determines when a debt contract will be monitored by lenders. This is the choice between borrowing directly (issuing a bond, without monitoring) and borrowing through a bank that monitors to alleviate moral hazard. This provides a theory of bank loan demand and of the role of monitoring in circumstances in which reputation effects are important. A key result is that borrowers with credit ratings toward the middle of the spectrum rely on bank loans, and in periods of high interest rates or low future profitability, higher-rated borrowers choose to borrow from banks.

I. Introduction

This paper analyzes the conditions under which a borrower's debt contract will be monitored by lenders. This is interpreted as the choice between borrowing directly (issuing publicly traded bonds or commercial paper, without monitoring) and borrowing through a bank that monitors to alleviate moral hazard. There are few existing theories of bank loan demand and its changes over time. The analysis

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provides a theory of individual and aggregate bank loan demand. More generally, the model explores the role of monitoring of self-interested actions to deal with moral hazard in circumstances in which reputation effects are important. Monitoring of actions interacts with reputation (long-lived information about an agent's type).

There is a "life cycle" effect in the use of borrowing through intermediaries. New borrowers borrow from banks initially but may later issue debt directly, without using an intermediary. A borrower's credit record acquired when monitored by a bank serves to predict future actions of the borrower when not monitored.

To focus on the interaction of borrower reputation and monitoring, the model abstracts from long-term contracting and lender reputation. The only intertemporal linkage is the information in a borrower's track record. Borrowers want to borrow repeatedly, and they take into account the effects of future information generated by their actions. This role for reputation is similar to that in Kreps and Wilson (1982) and Milgrom and Roberts (1982).

Directly placed debt (commercial paper) is a contract with terms (covenants) and loan-granting decisions that depend only on public information (including the borrower's track record).[1] The contract I call a bank loan uses this information plus information from costly monitoring of a borrower's actions to condition the decision to grant a loan or to condition the loan's covenants. A justification for this interpretation is that monitoring of private information is most efficiently delegated to a financial intermediary rather than collected directly by many investors (see Diamond 1984). The contract structure to provide incentives for the financial intermediary to do this monitoring is not present, but costs generated by such a structure (and other costs, such as reserve requirements) are consistent with the setup.

A key result is that borrowers with credit ratings toward the middle of the spectrum rely on bank loans. Reputation effects eliminate the need for monitoring when the value of future profits lost because of the information revealed by defaulting on debt is large. Borrowers with higher credit ratings have a lower cost of capital, and such a rating needs to be maintained to retain this source of higher present value of future profits. These high-rated borrowers do not need monitoring. Very low rated borrowers have less to lose if they reveal bad news about themselves by defaulting, but also less to lose if they reveal bad news about themselves by being caught when monitored. As a result, monitoring will not provide incentives for these very low rated

[1] The model does not make a distinction between short- and long-term debt. See Diamond (1991) for some analysis of maturity choice of directly placed debt.

borrowers; instead monitoring will serve to screen out some borrowers who are caught taking self-interested actions. Monitoring that only screens borrowers is less useful, and it may not be worth its cost for these lower-rated borrowers.

The model has the following additional implications. (1) The demand for monitoring is higher during periods of high interest rates or lower future economywide profitability because higher-rated borrowers then need monitoring: this implies a higher fraction of bank loans to commercial paper issues than when rates are lower. (2) The need for monitoring by higher-rated borrowers when real rates are high or future profits are low makes the quality of the average new loan made during such periods increase (default probability decrease) if moral hazard is sufficiently widespread. This makes the rates charged on average new bank loans increase less than one for one with real riskless market rates. (3) The initial periods of a borrower's reputation will typically be acquired by repaying loans from a bank that monitors, but a good track record from this monitored borrowing will allow the borrower to issue debt directly without monitoring. (4) Monitoring of new, low-rated borrowers will not provide them with incentives to avoid such actions. Many new borrowers will be turned down for credit because monitoring does not provide incentives for cooperative actions but will instead act as a screening device.

The balance of the paper proceeds as follows. Sections II–IV analyze the basic model. Section V describes the time series of choices of type of borrowing (monitored vs. direct) and type of project (safe vs. risky). Section VI, which is a bit technical, analyzes an alternative monitoring cost structure and shows that the results are very similar to those in the balance of the paper. Section VII discusses implications about determinants of bank loan demand, and Section VIII concludes the paper.

II. The Basic Model of Reputation without Monitoring

All borrowers and lenders are risk neutral. Each lender receives an endowment of inputs at the beginning of a period, and borrowers receive no endowment. Borrowers and lenders have access to a constant returns to scale technology for storing endowment within a period, converting it to a perishable consumption good that must be consumed at the end of a period. This technology returns R units of output at the end of a period per unit of input at the beginning of the period. Each period, borrowers face a new set of lenders that live for a single period. Because borrowers must borrow endowment and offer an expected return of at least R, they never use the storage technology. There are three sorts of projects, and the set of projects available to each borrower is the borrower's private information. Projects are in short supply (they do not exhaust any period's endowment), implying that storage is always in use, and a borrower can borrow by offering lenders an expected return of R.

There are three types of borrowers:

Type G: Borrowers that have one safe, positive net present value project each period. They can invest one (dollar) and receive $G > R$ at the end of the period.

Type B: Borrowers that have one risky, negative net present value project each period. They can invest one, and with probability $\pi < 1$, the project returns B (where $\pi B < R$ and $B > G$); with probability $1 - \pi$, it returns zero.

Type BG: Borrowers that have their choice each period of an action, denoted by a_t, between either one of two mutually exclusive projects. By taking action $a_t = g$, they select a safe project in period t that is identical to that of type G's; by taking action $a_t = b$, they select a risky project in period t that is identical to that of type B's.

The initial population of borrowers contains a proportion f_{G} of type G's, f_{B} of type B's, and f_{BG} of type BG's. The proportions are public information. A borrower's type, action, and the realized output of his project are private information observed only by the borrower. At periods other than $t = 1$, there will be a track record, Ω_t, of each borrower that will condition lenders' beliefs about type. The track record of a borrower consists of the dates on which the borrower repaid the face value of debt, defaulted on debt, and the outcome of all past monitoring of the borrower. To rule out certain "money-burning" equilibria (which I could rule out on other grounds) that involve borrowers that pay unnecessarily high interest rates, assume that the face value of debt offered in the past is not part of the track record. The probability or proportion of each type θ of borrower at the beginning of period t in the group of borrowers with track record Ω_t, $P(\theta | \Omega_t)$, is denoted by $f_t^{\theta\Omega}$. I use f_t^{θ}, with no explicit Ω_t, to denote the type probabilities given a "perfect" track record at date t: never a default or an instance of being caught taking risky projects when monitored.

Borrowers offer debt contracts to lenders. Because I assume that cash flows from projects are not observed (and that consumption cannot be negative), no other contract form dominates the debt contract. To explain why the debt contracts are enforceable, make the following assumption. There is a liquidation technology, use of which can be included as a contingency in financial contracts. One interpretation of liquidation is a highly inefficient bankruptcy court. Projects have a zero liquidation value at the end of a period, but liquidation destroys all profits from a project, including those that the borrower does not pay to lenders, preventing the borrower from consuming them. This implies that lenders and borrowers each receive zero when there is liquidation. Liquidation does not destroy the borrower's ability to invest in the future and induces no other pain for the borrower. The threat of liquidation implies that borrowers will pay the face value of debt whenever their projects deliver sufficient return. Liquidation produces no information about the project's return (in contrast to the costly state verification in Townsend [1979]), but in equilibrium there is liquidation only when the value of the project's cash flow is zero.

There are T time periods, where $T < \infty$, but I use limiting behavior as $T \rightarrow \infty$ for most results. Finite T allows use of backward induction arguments and of results from finitely repeated game theory in the selection of equilibria. There may be additional equilibria if T is infinite, but I have not analyzed these. The future is discounted: the present value of a unit of consumption at the end of a period is $d \leq 1$.

Borrowers with a given track record offer lenders the lowest face value each period that offers lenders an expected return of R, net of monitoring costs. The proof of lemma 1 below shows why this is reasonable. The idea is as follows. At the final date, T, a borrower would offer a face value higher than this minimum only if there was a reduced probability of receiving a loan at the lower face value, that is, only if lenders draw inferences from lower rates that lead to a reduced probability that the loan will be granted. It is a sequential equilibrium for all borrowers to offer the lowest face value that gives lenders a net expected return of R, supported by lenders' beliefs that borrower type is not a function of the face value r_T offered. This equilibrium is reasonable (satisfies the usual refinements of sequential equilibrium) because borrowers with risky projects (to whom lenders would not knowingly lend) have a smaller benefit from paying a lower rate because they pay the rate with probability $\pi < 1$; those with a safe project pay the rate for sure. If anything, the action that could indicate that one was not worth lending to (and has a stigma) would be to offer a higher rate. It is a dominated strategy for type G's to offer a higher rate given that they receive funding for sure at the lower rate, because they then pay more than necessary for the same financing: there is no lender response to the higher rate that would make type G's choose to offer a high rate of interest.

The offering of the lowest possible rate of interest holds for all dates t because past interest rate offers are not part of the track record. As a result, there is no benefit of influencing future lenders' beliefs from overpaying interest. If all other borrowers are offering the lowest rate, then a deviant would increase the current cost of borrowing and have no effect on the future costs. The assumption of unobservable face value offers is not necessary: the identical outcomes are generated by observable rates and the belief that the rate offered is independent of type.

LEMMA 1. On each date all borrowers offer the lowest face value that provides lenders a net expected return of R.

Proof. See the Appendix.

Let r_t be the face value of a debt contract in period t. The amount loaned to all borrowers at the beginning of a period is one unit, the scale of each project. The debt contract specifies liquidation if a borrower pays less than r_t and no liquidation if he pays r_t.

III. Project Choice without Monitoring

This section introduces the incentive problem faced by type BG borrowers, initially assuming that monitored lending (such as a bank loan) is not available.

At the final period, $t = T$, unmonitored type BG borrowers will select risky projects if and only if the expected end-of-period payoff from selecting risky projects, $\pi(B - r_T)$, exceeds the payoff from safe projects, $G - r_T$. Safe projects are selected if and only if the face value r_T is low enough: $r_T < (G - \pi B)/(1 - \pi) \equiv A_T$. The face value of the debt is a decreasing function of the borrower's credit rating because it must contain a default premium. Higher-rated borrowers have lower face values r_T and are thus less subject to the moral hazard.

I assume that even at the riskless rate of interest, $r_T = R$, type BG borrowers with a single-period horizon would select risky projects, implying that $A_T > R$. Reputation effects of multiple borrowing opportunities are then important to provide incentives to select the proper project. Because type BG and type B borrowers will select risky projects at the final date T, no one will lend without monitoring at date T unless borrowers have a sufficiently high probability of being type G, given their track record. Because type G borrowers do not default, this implies that without monitoring, a single default results in a cutoff of credit because successively earlier periods become the "last" opportunity to borrow. Repaying a loan at a date before T has the short-run cost of r_t minus the long-run benefit of the rents from borrowing in the future from dates $t + 1$ to T. Let V_{t+1} denote the value to a type BG of borrowing making optimal project decisions over these dates. The payoff from choosing a safe project at t is $G - r_t + V_{t+1}$; the payoff from choosing a risky project is $\pi(B - r_t + V_{t+1})$, implying that safe projects are selected if and only if $r_t < A_T + V_{t+1} \equiv A_t$. The reputation capital that is lost on a default is V_{T+1}. The present value of future rents, V_{t+1}, is increasing in the credit rating (e.g., in $1 - f_{Bt}$). This implies that a sufficiently good credit rating, as well as a long horizon, is required for there to be incentives to choose safe projects (see Diamond 1989). Lemma 2 states the lower limit on present and future rents for reputation to eliminate moral hazard.

LEMMA 2. Safe projects are the optimal choice without monitoring at date t ($a_t = g$) if and only if the net cost of repaying a loan is sufficiently low ($r_t - V_{t+1} \leq [G - \pi B]/[1 - \pi] \equiv A_T$) or, equivalently, the value of choosing a safe project at t (and making optimal decisions thereafter) is sufficiently high ($V_t^g \equiv d[G - r_t + V_{t+1}] \geq d[\pi(B - G)/(1 - \pi)] \equiv VA$). Risky projects are the optimal choice if and only if the reverse inequalities hold.

Proof. The first condition was established above. If $a_t = g$, the second follows from substituting into $V_t^g = d(G - r_t + V_{t+1})$. Q.E.D.

The technology of monitoring is introduced in the next section.

IV. Monitoring

A lender monitors to detect the selection of a risky project: the action $a_t = b$. Only type BG borrowers are subject to moral hazard because the other types do not have profitable opportunities for such actions. This implies that monitoring will catch a borrower taking action $a_t = b$ only if he is a type BG and that being caught will reveal his type.

For a fixed cost, a period t lender can monitor the random variable $\tilde{m}_t$ that might catch a borrower choosing the risky project. With probability $1 - P$, such monitoring produces an "uninformative" report, $m_t = 0$, on the borrower, independent of the action or type of the borrower. With probability P, monitoring will detect the choice of risky projects (action $a_t = b$, selected by a type BG) without error, delivering the report $m_t = b$. If the borrower did not take an action to select risky projects (because he was type B or G, or if safe projects are selected by a type BG), the monitoring delivers the "uninformative" report $m_t = 0$.

If the borrower is a type B or G or is a type BG choosing safe projects, monitoring delivers the realization $m_t = 0$ for sure (because the action $a_t = b$ is not taken by these types). The distribution of $\tilde{m}_t$ given a type BG borrower who has selected risky projects, $a_t = b$, is $m_t = b$ with probability P and $m_t = 0$ with probability $1 - P$.

The cost of monitoring in date 2 units is $C \geq 0$. The action of monitoring by the lender is observed by the borrower, and the commitment to monitor can be made before the borrowers choose their actions. The ability to commit to monitoring is important because it can provide incentives that remove the uncertainty about the action monitored. Note that the cost C can include costs of providing incentives to delegate the monitoring to a bank (see Diamond 1984) and costs of being a bank, such as reserve requirements and operating costs. Because loan size is a constant, fixed and variable monitoring costs are not distinguished.

There are two specifications of the timing of monitoring that turn out to provide the same incentives to borrowers, and each has some claim to being realistic. The first assumes that lenders monitor actions before a loan is granted but incur the costs even if it is not granted. The second assumes that the loan must be granted and production undertaken before it is possible to observe actions, but that the lender can enforce a loan covenant allowing early liquidation contingent on the outcome of the monitoring. Results below are stated for the case of monitoring before loan origination, and they are identical to those of the second case if the early liquidation yields the initial capital lent.[2]

The timing of the moves and the arrival of information from monitoring when monitoring comes before loans are advanced are shown in the first time line in figure 1 (time goes left to right). Borrowers offer a contract, lenders begin to monitor, type BG borrowers choose an action, and on the basis of the monitoring of the action, the lender decides whether to grant the loan. If $a_t = b$ is detected, no loan is made. If a loan is made, the borrower then observes the project's outcome and makes a repayment, with liquidation if the payment is less than face value.

The equivalent alternative structure is shown in the second time line in figure 1. In this case, each borrower chooses an interest rate to offer to lenders. The lenders then decide whether to accept the offer and advance capital and whether to monitor. If the loan is granted, the borrower invests the capital; if he is a type BG, he chooses an action, a_t. Lenders that choose to monitor then observe m_t.[3] The lender includes a loan covenant providing the right to liquidate early if risky projects are detected, $m_t = b$. This early liquidation yields the lender the present value of the one dollar loaned and yields

[2] If liquidation yields less than 100 percent of the present value of initial capital, the value for C for which lenders will monitor is reduced. Being caught still reduces the borrower's return to zero in the current period.

[3] The reason the alternative technology provides identical incentives is that the optimal covenant sets the face value of debt to B when $m_t = b$ is observed and provides a zero return to a borrower caught with $a_t = b$. This is identical to the borrower's return if no loan is granted. The current-period effects of monitoring on a borrower's payoff are identical in the two cases.

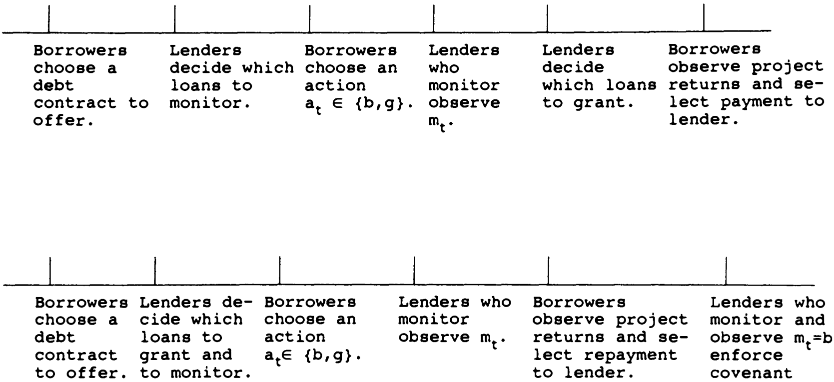

FIG. 1.—Time lines

the borrower zero, and thus provides the exact same information and cash flows as in the previous case. Liquidation at the end of a period given a default still is assumed to yield zero. This case is not discussed further.

Given a face value r_t selected by a borrower, a lender decides whether to monitor on the basis of maximizing expected return net of monitoring costs. A lender will monitor in period t if and only if monitoring is profitable and monitored lending is feasible: the first requires that the increase in expected return from monitoring is at least the monitoring cost, C, and the second requires that the monitored loan offers an expected return of at least $R + C$. Lenders lend for a single period: their monitoring decision depends on the one-period expected profit.

Monitoring has no direct effect on borrowers that are not of type BG. It can serve one of two functions: incentives or screening. Monitoring provides incentives if it induces type BG borrowers to select safe projects. It screens if it does not provide incentives but instead catches some type BG's choosing risky projects (allowing the loan not to be made). The value of monitoring to the lender is greater when it provides incentives. When it does provide incentives, it increases the probability of receiving the face value r_t (which exceeds R) from π to one when the borrower is a type BG (increases the expected payment from πr_t to r_t). A borrower with a perfect track record is a type BG with probability f_{BGt}, implying that the lender's expected return from investing C in monitoring that provides incentives is $f_{BGt}(1 - \pi)r_t$. The effect of screening a BG is to allow the capital to be invested elsewhere at an expected return of R, and this increases the expected payment from πr_t to R. The expected return from investing C in monitoring that screens is $f_{BGt}P(R - \pi r_t)$, which is strictly less than when monitoring provides incentives because $P \leq 1$ and $r_t > R$.

Lenders will not monitor if there is no moral hazard (type BG borrowers select safe projects without monitoring) because neither their actions of granting loans conditioned on the outcome nor the borrowers' actions are affected by monitoring. One necessary condition for monitoring to be used is that monitoring is needed.

A. *Actions and Monitoring*

In any period in which a borrower is caught choosing risky projects, no one will advance a loan because it would be a negative net present value investment. The borrower's return that period is zero. Selecting risky projects, $a_t = b$, when monitored implies a probability $1 - P$ of receiving a loan that period; selecting safe projects, $a_t = g$, implies a loan for sure. There may also be an effect on future treatment by lenders. The next subsection examines the last period, T, where this second effect is absent.

1. The Final Period T Payoffs with Monitoring

The borrower's payoff at the end of period T, as a function of the action a_T, is (multiply each by d to get the beginning-of-period value) $G - r_T$ if $a_T = g$ and $(1 - P)\pi(B - r_T)$ if $a_T = b$.

Monitoring will provide incentives to select $a_T = g$ if and only if

$$r_T \leq \frac{G - \pi(1 - P)B}{1 - \pi(1 - P)} \equiv I_T.$$

Monitoring reduces the probability of receiving $B - r_T$ when $a_T = b$ from π to $\pi(1 - P)$. If $P = 1$, monitoring will provide incentives at T. Because the face value with monitoring must be at least $R + C$, a necessary condition for monitoring to provide incentives at T is $P \geq 1 - [(G - R - C)/(B - R - C)]$.

B. *Monitoring and Reputation*

Assume that without some reputation effects, monitoring cannot induce type BG borrowers to select safe projects. The other case, which is more complicated but produces similar results, is discussed in Section VI. Even if borrowing at the riskless rate that covers monitoring costs (a face value of $R + C$), type BG borrowers will select risky projects if monitored (both $A_T < R$ and $I_T < R + C$). Because only type G borrowers would select safe projects at date T, lenders will lend only to borrowers with a sufficiently large probability of being a type G.[4] Borrowers that default at any date or are caught selecting risky projects (and reveal that they are not type G) have their credit permanently cut off. If no one will lend to them at the last period, backward induction implies that each earlier period is the "last" period. Only a borrower with a perfect record of never defaulting or being caught when monitored can borrow on a given date. All borrowers that are caught when monitored are revealed to be type BG, and a fraction π of the remaining types B and BG (if $a_t = b$) default each period.

1. The Decision of a Type BG, with Monitoring

Let V_{t+1} denote the present value of rents of a type BG that makes optimal decisions from $t + 1$ to T given a record up to date t of never defaulting or being caught when monitored. The future value of all other track records is zero.

If a risky project is selected, the borrower is caught with probability P, and he cannot borrow in the current period or in any future period: the payoff is zero. With probability $1 - P$, monitoring is uninformative, and $m_t = 0$. Conditional on $m_t = 0$, the borrower has a probability of repayment of π and of default of $1 - \pi$. The expected end-of-period payoff from a risky project, $a_t = b$, is $(1 - P)[\pi(B - r_t + V_{t+1})]$.

If a safe project, $a_t = g$, is selected, then the borrower will neither default nor have monitoring reveal $m_t = b$: the payoff at the end of the period is $G - r_t + V_{t+1}$.

The type BG will select $a_t = g$ if and only if

$$(1 - P)[\pi(B - r_t + V_{t+1})] \leq G - r_t + V_{t+1}$$

or

$$r_t \leq \frac{G - \pi(1 - P)B}{1 - \pi(1 - P)} + V_{t+1} = I_T + V_{t+1} \equiv I_t.$$

In this case, reputation reinforces and strengthens monitoring: $I_t > I_T$. Monitoring provides incentives for lower-rated borrowers (higher value of r_t) when there is a reputation effect and future borrowing opportunities, because of the lost future rents when monitoring catches a borrower.

The value of current and future rents, $V_t^g = d(G - r_t + V_{t+1})$,

[4] If the probability of being a type G were zero, screening would allow lenders to avoid some bad loans, but not to make profitable loans that cover the cost of monitoring.

must exceed $\pi(1 - P)(B - G)/[1 - \pi(1 - P)] \equiv VI$ for monitoring to provide incentives.

C. *Lenders' Monitoring Choice with Endogenous* r_t

The face values of debt at a date t that provide a net expected return of R in the following conditions are as follows: With no monitoring and $a_t = g$,

$$r_t^g = \frac{R}{f_{Gt} + f_{BGt} + \pi f_{Bt}}.$$

With monitoring that provides incentives ($a_t = g$),

$$r_t^I = \frac{R + C}{f_{Gt} + f_{BGt} + \pi f_{Bt}}.$$

With no monitoring and $a_t = b$,

$$r_t^b = \frac{R}{f_{Gt} + \pi(f_{BGt} + f_{Bt})}.$$

With monitoring that screens ($a_t = b$),

$$r_t^S = \frac{C + R(1 - Pf_{BGt})}{f_{Gt} + \pi[f_{Bt} + (1 - P)f_{BGt}]}.$$

Because borrowers offer the lowest feasible face value each period, all borrowers choose the smallest of these four face values that is relevant in the current period. The face value r_t^g is the lowest of the four, and it is offered if and only if safe projects are selected without monitoring. This implies that monitoring is needed if and only if safe projects are not selected at t given the face value r_t^g and thus that it is needed if and only if

$$f_{Bt} \geq \frac{1}{1 - \pi}\left(1 - \frac{R}{A_t}\right).$$

Monitoring provides incentives for safe projects at t if and only if

$$f_{Bt} \leq \frac{1}{1 - \pi}\left(1 - \frac{R + C}{I_t}\right).$$

The requirement that monitoring is profitable, given that borrowers offer the lowest rate that provides a net expected return of R at any date t, implies the following. If $r_t^I \leq r_T^b$, then the lender's monitoring is profitable because borrowers offer r_t^I, providing lenders an expected return of $R + C$; at any rate below r_t^b, their return is less than R. A similar argument implies that if monitoring does not provide incentives, there is screening only if $r_t^S \leq r_t^b$. There is monitoring with incentives only if $r_t^b \geq r_t^I$ or

$$f_{BGt} + f_{Bt}\left(\frac{C}{R + C}\right) \geq C[(R + C)(1 - \pi)]^{-1}.$$

When monitoring only screens, it is profitable if $r_t^S \leq r_t^b$ or

$$\frac{f_{BGt}(1 - f_{BGt})PR - C\{f_{BGt} - [1/(1 - \pi)]\}}{f_{BGt} \cdot P \cdot R - C} - f_{Bt} \geq 0.$$

This condition for screening to be profitable is decreasing in f_{Bt} because increased f_{Bt} increases the face value that type BG borrowers pay with fixed probability when not monitored. The condition requires that f_{BGt} be above a critical positive value, but there can be an upper bound on f_{BGt} because the face value r_t^S is increasing in f_{BGt}. This upper bound on f_{BGt}, as well as that on f_{Bt}, is not relevant if screening is profitable at $r_t^S = G$, its maximum feasible value.

The constraints that face value not exceed G ($r_t < G$) in the cases in which safe projects are selected without monitoring, in which monitoring provides incentives, in which risky projects are selected without monitoring ($a_t = b$), and in which there is screening translate into, respectively, $r_t^I \leq G$, $r_t^g \leq G$, $r_t^b \leq G$, and $r_t^I \leq G$. These "feasibility" constraints are given by

$$f_{Bt} \leq \left(\frac{1}{1 - \pi}\right)\left(1 - \frac{R + C}{G}\right),$$

$$f_{Bt} + f_{BGt} \leq \left(\frac{1}{1 - \pi}\right)\left(1 - \frac{R}{G}\right),$$

$$f_{Bt} \leq \left(\frac{1}{1 - \pi}\right)\left(1 - \frac{R}{G}\right),$$

$$f_{Bt} + f_{BGt}\left[\frac{1 + (R/G)}{1 - \pi} - P\right] \leq \left(\frac{1}{1 - \pi}\right)\left(1 - \frac{R + C}{G}\right).$$

Figure 2 shows the regions of monitoring and credit granting at date T, for a particular set of parameters. The way to interpret it is to view $1 - f_B$ as the borrower's credit rating and f_{BG} as the pervasiveness of moral hazard in the population of borrowers. Holding fixed a value of f_{BG} and changing f_B give the effect of a credit rating on the type of borrowing chosen or, alternatively, on the ability to borrow at all.

The use of monitored bank lending as a function of the credit rating of the borrower is as follows. For a sufficiently high credit

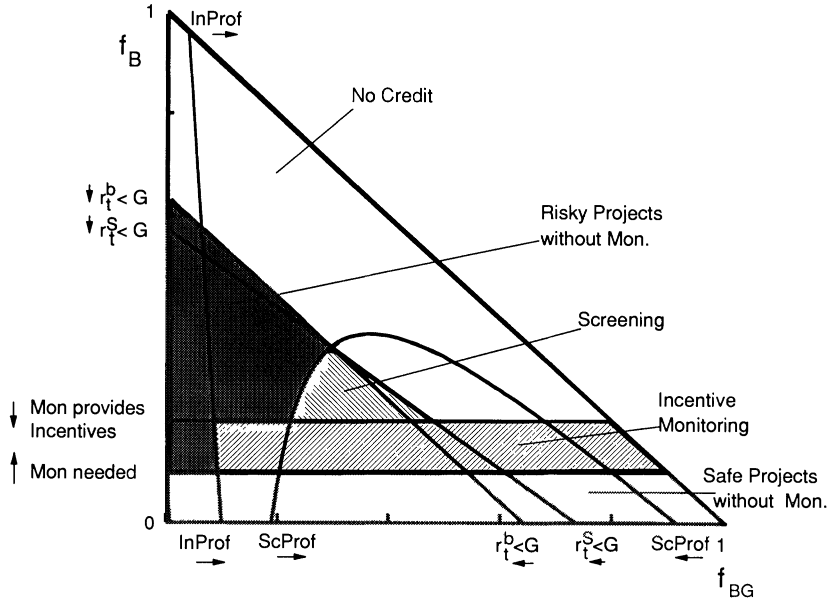

FIG. 2.—Lending, monitoring, and project choices at a date $t < T$, as a function of credit rating (higher f_B is a lower rating) and of the pervasiveness of moral hazard (higher f_{BG} is more pervasive). InProf denotes that incentive monitoring is profitable; ScProf denotes that screening is profitable.

rating (low f_B implying $r_t^g \leq A_t$), there is a direct issue of commercial paper because monitoring has no value since there is no relevant moral hazard: it does not provide incentives or screen. For a somewhat lower credit rating (intermediate values of f_B implying $r_t^g > A_t$ but $r_t^I \leq I_t$), monitoring provides incentives and has its maximum value to lenders. If moral hazard is sufficiently pervasive, borrowers with these ratings will borrow from banks. For lower ratings (higher f_B implying $r_t^I > I_t$), monitoring will only screen and will have a lower value to lenders. If moral hazard is not pervasive (very low f_{BG}), then monitoring will not be worth the cost, and the low-rated borrower will borrow directly. If the cost of monitoring is low, then for somewhat higher values of f_{BG}, borrowers will borrow from banks with screening. With higher monitoring costs, these borrowers will be unable to raise capital from any source.

If monitoring is sufficiently costly, high-rated borrowers will borrow directly (without monitoring), and low-rated borrowers may not be monitored unless they have a good enough rating for monitoring to provide incentives. Many implications of the model, discussed in Section VII, follow from this characterization of the value and use of monitoring as a function of the current credit rating. The dynamics of the time series of action choices by borrowers and lenders are more complicated but are also useful in understanding decisions over a life cycle of a borrower. These are described in Sections V and VI.

V. Equilibrium Path of Actions

As time passes, a borrower's track record and credit rating change. The more times a borrower continues a perfect track record (has borrowed and repaid in full and been monitored and not been caught), the higher conditional probability of being a type G because the number of type G's with a perfect record stays constant and the number of type B's with a perfect record declines; the number of type BG's with a perfect record either declines (if risky projects are selected) or stays constant (if safe projects are selected). The probability of being a type BG, given a perfect record, increases at date $t + 1$ if safe projects are selected (because then all type BG's continue a perfect record and only some type B's do not) and falls if risky projects are selected (because then at least as many BG's lose the perfect record as type B's). A fraction π of type BG's continue a perfect record if they choose risky projects and there is no monitoring; if they choose risky projects and are monitored, a fraction $\pi(1 - P)$ continue a perfect record.

Let Nb denote one plus the number of past periods in which BG's selected risky projects and NS one plus the number of past periods in which there was monitoring that screened ($NS \leq Nb$ because screening requires a choice of risky projects). The number of type BG's with a perfect track record, as a fraction of the initial date 1 number of borrowers of all types, is therefore $f_{\mathrm{BG}}\pi^{Nb-1}(1 - P)^{NS-1}$. Finally, the probability of being a type B given a continuation of a perfect record falls if there is no screening (because the proportion of BG's that end their perfect record is less than or equal to that of type B's) but can rise if there is screening and P and $f_{\mathrm{BG}t}$ are sufficiently high (because the proportional drop in BG's is much larger than the drop in B's).

Formally, this implies that the conditional type probabilities f_t^θ given a perfect track record up to date t, given Nb and NS, are given by

$$f_{\mathrm{G}t}(Nb, NS) = \frac{f_{\mathrm{G}}}{f_{\mathrm{G}} + \pi^{t-1}f_{\mathrm{B}} + \pi^{Nb-1}(1 - P)^{NS-1}f_{\mathrm{BG}}},$$

$$f_{\mathrm{B}t}(Nb, NS) = \frac{\pi^{t-1}f_{\mathrm{B}}}{f_{\mathrm{G}} + \pi^{t-1}f_{\mathrm{B}} + \pi^{Nb-1}(1 - P)^{NS-1}f_{\mathrm{BG}}},$$

$$f_{\mathrm{BG}t}(Nb, NS) = \frac{\pi^{Nb-1}(1 - P)^{NS-1}f_{\mathrm{BG}}}{f_{\mathrm{G}} + \pi^{t-1}f_{\mathrm{B}} + \pi^{Nb-1}(1 - P)^{NS-1}f_{\mathrm{BG}}}.$$

These allow the face values r_t^g, r_t^b, r_t^I, and r_t^S, as well as all constraints that do not depend on V_{t+1}, to be expressed as functions of Nb and NS. Note that at $t = 1$, $Nb = NS = 1$.

Some useful properties of equilibrium follow directly from these dynamics of $f_{\theta t}$ and the definition of the constraints. These are given in lemma 3.

LEMMA 3.

1. If monitored lending is feasible at t (either $r_t^I \leq G$ or $r_t^S \leq G$), then it is feasible at $t + 1$ (r_t^I and r_t^S fall over time).
2. If incentive monitoring is unprofitable at t (increases a lender's expected return by less than C) and a risky project is selected at t, then monitoring is also unprofitable at $t + 1$.
3. If f_{BGt} is sufficiently high—$f_{BGt} > (1 - \pi)/[1 + (C/R)]$—and a safe project is selected at t, then if incentive monitoring is profitable at t, it is profitable at $t + 1$.
4. For fixed $C > 0$, screening is used only for at most a bounded number of periods.
5. If sufficiently far from T, monitoring is not needed at $t + 1$ if it is not needed at t.
6. If sufficiently far from T, monitoring provides incentives at $t + 1$ if it provides incentives at t.
7. There is at most one connected set of dates on which screening is used because if screening was profitable in the past and is not now, it will not be profitable in the future. Further, if screening is profitable given $r_t^S = G$ and is not profitable at $t = 1$, it will never be profitable.

Proof. The lemma is proved by substitution, using $f_{Bt+1} < f_{Bt}$ if there is no screening at t and $f_{BGt+1} > (<) f_{BGt}$ as $a_t = g$ (b) and using $V_t \leq V_{t+1}$ if $T - t$ is sufficiently large; this is proved in the Appendix. Part 1 uses the result that $r_t^S < r_{t-1}^S$ if there is screening at t (proved in the Appendix). Part 2 uses the result that there is no monitoring if incentive monitoring is unprofitable. The condition in part 3 is obtained from the condition for incentive monitoring to be profitable with $f_{Bt} = 0$: the condition provided is sufficient because $f_{Bt+1} > 0$ makes the constraint looser.

A. *The Most General Possible Order of Actions*

The results in lemma 3 put strong restrictions on the possible time series of actions by type BG's and monitoring choices by banks. I assume that $T \to \infty$ to avoid concern with approaching the endgame in which reputation effects break down because of a short horizon (the only discussion of the endgame is in the proof of lemma 2). To avoid repeated formal statements, I shall say that a result is true given a long horizon if it is true for all dates less that τ and that $\tau \to \infty$ as $T \to \infty$. Given a long horizon, the following are true. By part 5 of lemma 3, once monitoring is not needed, it will not be needed again (before τ). By part 6, once monitoring provides incentives, it will provide incentives thereafter. As a result, if monitoring ever screens rather than provides incentives, it occurs toward the beginning of a borrower's credit history. It would not occur at the very beginning only if f_{B} is too high for it to pay and $f_{\mathrm{B}t}$ falls fast enough relative to $f_{\mathrm{BG}t}$ (which is unlikely). Given these results and a long horizon, the most general possible order of actions by BG's and lenders (which occurs if each constraint has at least one period in which it is the only binding constraint) is

1. risky projects without monitoring because screening is unprofitable;
2. risky projects with screening, beginning on date t_{SPa};
3. risky projects without monitoring because screening is unprofitable, beginning on date t_{SPb};
4. safe projects with incentive monitoring, beginning on date t_I;
5. risky projects without monitoring because incentive monitoring is unprofitable, beginning on date t_{IP}; and
6. safe projects without monitoring, beginning on date t_A.

Not all the constraints become individually binding for all parameter values, implying that some of the time intervals identified above may have zero length, including some of the earliest subperiods. For example, it is possible that $t_A = 1$.

Proposition 1 below summarizes the technological conditions that determine whether reputation effects alone or monitoring along with reputation can eventually provide incentives for safe projects ($a_t = g$) to be selected at some date t, given a long horizon: the conditions at which $t_A < T + 1$ and $t_I < T + 1$. These results describe what happens once a borrower has acquired a very good reputation: if there were never a period in which safe projects were selected, then for large enough t, $f_{\mathrm{B}t} \to 0$ and $f_{\mathrm{BG}t} \to 0$, which implies that $r_t^b \to R$ and $r_t^I \to R + C$. The reasoning is as follows. At dates close to T, risky projects will be selected, there will not be monitoring, and the value of maintaining a perfect track record will approach $B - R$ per period. At any date near T on which risky projects are selected thereafter, the value of maintaining a perfect track record will approach from below: $V_{t+1} \to [d\pi/(1 - d\pi)](B - R)$, which is the present value of $B - R$ each period until the first default as $T \to \infty$. This implies that if reputation alone never provides incentives, then $[d\pi/(1 - d\pi)](B - R)$ must be less than $R - A_T$ (otherwise this would be a contradiction). If instead these rents exceed $R - A_T$, then eventually reputation alone provides incentives.

If reputation alone never provides incentives, then monitoring will provide incentives on some date if and only if $[d\pi/(1 - d\pi)](B - R)$ exceeds $R + C - I_T$ because with monitoring r_t must be at least $R + C$, and V_{t+1} approaches this bound if risky projects are selected for a sufficiently large number of previous periods. Proposition 1 states these and related results.

PROPOSITION 1. Given a long horizon, if the loan market does not fail, then the following conditions hold:

1. If and only if $R - A_T < [d\pi/(1 - d\pi)](B - R)$, monitoring is always needed (never a safe project without monitoring): $t_A = \tau$. If this condition is false, then eventually monitoring is not needed.
2. If monitoring is always needed (see pt. 1), then risky projects are selected every period even if there is monitoring ($t_g = t_A = t_I = T + 1$) if and only if $R + C - I_T > [d\pi/(1 - d\pi)](B - R)$.
3. If monitoring is always needed (see pt. 1) and it can provide incentives (the condition in pt. 2 is false), then $t_I < \tau$ and monitoring provides incentives. If monitoring that provides incentives is ever used, it is used and provides incentives up to date τ.
4. If $f_{BGtI} \geq C[(1 - \pi)(C + R)]^{-1}$ (which is satisfied if $C \rightarrow 0$), then $t_{IP} = T + 1$. If monitoring that provides incentives is used, it is used until it is not needed (until the smaller of t_A and τ).
5. If C is sufficiently close to zero, then if there is screening at t, it continues until safe projects are selected: $t_{SPb} = \min\{t_I, t_A\}$.

Proof. The conditions in parts 1–3 for reputation or monitoring not to provide incentives were established above; sufficiency of the reverse conditions for monitoring or reputation to provide incentives is proved in the Appendix. Part 4 is implied by part 3 of lemma 3 and part 5 by part 4 of lemma 3. Q.E.D.

The simplest characterization of equilibrium comes from the implications of borrowers offering the lowest face value that provides lenders a net expected return of R per period. This implies that reputation alone provides incentives on the first date that it is self-fulfilling, t_A, given the current track record, $f_{\theta t}$. Folding back from this date (unless it is date 1 or no such date exists) allows determination of the first self-fulfilling date that monitoring provides incentives, t_I. Determining these two dates requires knowledge of V_{t+1}, the value of future rents, but all other decisions in the model, such as whether monitoring that provides incentives is profitable, depend only on the current track record, $f_{\theta t}$. Given a specified t_A and t_I, one can determine the values of the relevant face values in each period. Because monitoring is used only when needed, if monitoring is ever used to provide incentives, then $t_I \leq t_A$. Define $t_g \equiv \min\{t_I, t_A\}$ as the first date on which the safe projects are selected. Given knowledge of t_g, one knows that risky projects were selected each previous period, and repeatedly evaluating the conditions for screening to be profitable determines whether there was screening on previous dates. This allows the conditional type probabilities given a perfect record at t_g to be calculated, and given these one can determine whether monitoring is needed at t_g. If it is not needed, then $t_g = t_A$, and one knows $r_t = r_t^g$ for all future dates. If monitoring is needed at t_g, the date (if any) on which monitoring is not needed is computed from the type probabilities given from the monitoring conditions after t_g and t_A the smallest self-fulfilling value.

A time series of face values, for an exogenously given value of $t_g = t'$, that satisfies all the requirements that monitoring be profitable, computed according to the procedure of the last paragraph is the τ vector $\mathbf{R}[t']$, with elements $\mathbf{R}_t[t']$, and it is formally defined in the Appendix in the proof of proposition 2.

This conjectured series of face values is used to compute the present value of future rents. Whenever the rents given this face value series and the current and future choice of safe projects are sufficiently high, then safe projects are selected: by lemma 2, the minimum value of these future rents for safe projects to be selected without monitoring is $d\pi(B - G)/(1 - \pi) \equiv VA$, and the minimum value for projects to be selected at t with monitoring is $d[\pi(1 - P)(B - G)]/[1 - \pi(1 - P)]$. Given a conjectured face value series $\mathbf{R}[t']$ and an arbitrarily long horizon, it is straightforward to compute the present value of always selecting a safe project.

Let $W_{\hat{t}}[t']$ denote the present value of choosing safe projects each period from $\hat{t}$ to $\tau \rightarrow \infty$, facing rates $\mathbf{R}[t']$, given by

$$W_{\hat{t}}[t'] \equiv \sum_{t=\hat{t}}^{\infty} (G - \mathbf{R}_t[t'])\, d^{1+t-\hat{t}}.$$

The most general characterization is proposition 2. Because the face value series $\mathbf{R}[t']$ is constructed to satisfy all the model's constraints, choosing the smallest self-fulfilling value of $t' = t_g$ provides the lowest self-fulfilling r_t given the history up to t and is thus the equilibrium value.

PROPOSITION 2. The equilibrium value of t' is the smallest self-fulfilling value: t_g is the smallest t' such that $W_{t'}[t']$, the present value of selecting $a_t = g$ and borrowing with face values given by $\mathbf{R}[t']$ for each period from t' to τ, exceeds either $d\pi(B - G)/(1 - \pi) \equiv VG$ or $d[\pi(1 - P)(B - G)]/[1 - \pi(1 - P)] \equiv VI$. If the first condition is the one first satisfied, then $t' = t_g = t_A$, and monitoring never provides incentives; alternatively, if the second condition is first satisfied, then $t' = t_g = t_I$, and monitoring provides incentives and is used until it is unprofitable or is not needed.

Proposition 3 characterizes the equilibrium actions at $t = 1$. I shall say that monitoring is needed at $t = 1$ if $W_1[1] < VA$ and that monitoring provides incentives if $W_1[1] \geq VI$.

PROPOSITION 3. Given a long horizon, the following conditions are true at $t = 1$:

1. If f_B is low enough that monitoring is not needed and $r_t^g < G$, then *there is never monitoring,* and $t' = N[t'] = t_A = 1$.
2. If f_B is high enough that monitoring is needed, low enough that monitoring provides incentives and $r_1^I \leq G$, and incentive monitoring is profitable:

$$f_{BG} + f_B\left(\frac{C}{R + C}\right) \geq C[(R + C)(1 - \pi)]^{-1},$$

then *monitoring is needed, provides incentives, and is used* at $t = 1$: $t' = t_I = 1$.
3. If f_B is high enough that monitoring is needed but does not provide incentives, f_{BG} is high enough that screening is profitable, and a weighted sum of f_B and f_{BG} is low enough that $r_1^S \leq G$, then *there is monitoring that screens* at $t = 1$: $t_{SPa} = 1$ and $t_g > 1$.
4. If f_B is high enough that monitoring is needed and does not provide incentives, $f_B + f_{BG}$ is low enough that $r_1^b \leq G$, and C is high enough that monitoring is unprofitable at date 1 even if it would provide incentives, then *there is never monitoring* and risky projects are selected at $t = 1$: $t_{SPb} = t_{IP} = 1$.
5. If f_B is high enough that monitoring is needed but does not provide incentives, f_{BG} is either low enough or very high (and possibly f_B is high enough) that screening is unprofitable, and $f_B + f_{BG}$ is low enough that $r_1^b \leq G$, then *there is no monitoring* and *risky projects are selected* at $t = 1$: $t_{SPa} > 1$.
6. If f_B is high enough that $r_1^g > G$, f_B is high enough for monitoring to be needed and both $r_1^I > G$ and $r_t^b > G$ and is low enough to provide incentives, or f_B is high enough for monitoring to be needed but not provide incentives and f_B and f_{BG} are high enough that both $r_1^S > G$ and $r_1^b > G$, then *markets fail* on all $t \leq T$.

The proposition is proved by verification of conditions when $a_t = g$ without monitoring for the remainder of the horizon is self-fulfilling and substitution into the monitoring constraints.

The next section describes the case in which monitoring is so precise that even without reputation it can eliminate moral hazard. This section is a bit technical and concludes that this case is qualitatively similar to the case considered above (with the exception of a single point about the reinforcement effect of reputation on monitoring). Hurried readers can skip to Section VII for a discussion of the empirical implications of the model.

VI. Cheap and Effective Monitoring

Suppose that monitoring is sufficiently precise (P close enough to one) and inexpensive (C close enough to zero) that it can provide incentives at date T (without reputation). Continue to assume that without monitoring the risky project would be taken. Borrowing at date T then requires that the probability of being a type B be low enough, and not the stronger condition that in addition the probability of type G be positive. A borrower known for sure to be a type BG would be able to borrow at T with monitoring. He would need to be monitored each period because once he is known to be a type BG, there is no more information to be revealed. Observed outcomes have no effect on future treatment by lenders, implying that a borrower's decisions always have a one-period horizon.

An interpretation of the distinction between the two cases is that they refer to the monitoring of two different types of information. This section deals with information that, once revealed, produces information that reveals only slightly embarrassing news about a borrower (compared to the best possible news about a borrower); the previous case examined more embarrassing information. There are multiple sequential equilibria in this case, but most of them are not very reasonable. The multiplicity arises because a borrower's choice of projects depends on the response of lenders to a current default, which in turn depends on what lenders believe about a borrower's unobserved choice of projects. The equilibria that I rule out have current lenders believe that type BG borrowers choose risky projects *only* because they believe that future lenders will expect safe projects should the future lenders lend to a borrower that defaults this period. In the Appendix I give a formal argument that the equilibrium described in this section satisfies the usual game-theoretic equilibrium refinements related to the Kolberg-Mertens (1986) notion of strategic stability. Formally, this is a proof that these refinements are satisfied in an equilibrium in which lemma 1 applies, and borrowers always offer the lowest self-fulfilling face value of debt that provides lenders a net expected return of R.

There are two types of ruled-out equilibria. One implies that no one will lend today; the other implies that required interest rates are high today, in each case because of pessimism about BG actions that can be justified only by conjectured future optimism of lenders to these borrowers after they default. Ruling these out is equivalent to assuming that a lower present value of future rents never makes borrowers more concerned about the future, that is, never more willing to choose to reduce rents this period (by selecting safe projects) to preserve their chances of collecting smaller future rents.

This implies that credit is cut off after a default in any period.[5] If safe projects are selected, then the default comes from type B's (to whom no one would lend). If risky projects are selected, then the type BG borrower cannot be induced to select safe projects at t and will not be able to be induced to select safe projects at $t + 1$ (and therefore no one will lend at $t + 1$).

The equilibrium actions and beliefs are as follows. If a borrower is monitored and caught taking risky projects, then there is no loan this period and he is revealed to be a type BG. If the borrower is not caught (including not monitored), then if he defaults, he is believed to be a type B (and credit is cut off forever) unless this belief is not self-fulfilling. If it is not self-fulfilling (i.e., borrowers select risky projects even when credit cutoff is the penalty), then given a default, the inferred proportions of types are the beginning-of-period proportions, subtracting all the type G's and the type BG's that were caught if and when monitored.[6]

Because type BG borrowers are believed to choose safe projects in any period that this belief is self-fulfilling (and have credit cut off if they default), the condition for monitoring to be needed is as before (except for a possibly different value of V_{t+1}, the value of borrowing in the future).

The conditions for monitoring to provide incentives differ from those in the former analysis. If monitored and caught with risky projects, the borrower will not receive a current loan and is revealed to be a type BG, implying that future loans are available. There then can be no more reputation effects once he is known to be a type BG because no further learning from outcomes can occur. This implies that monitoring will be needed every period, and the face value each period will be $R + C$. The present value of future rents for a borrower known to be a type BG is defined as $U_{t'}$ and is given by

$$(G - R - C) \sum_{t=t'}^{T} d^{1+t'-t} \equiv U_{t'}.$$

[5] There is one exception: when monitoring could induce safe projects at date t but is not used because it is unprofitable. After a default in this case, there can be lending with monitoring if it can still induce safe projects.

[6] If type BG's follow a mixed strategy at t, then belief about default includes only the fraction of BG's that select risky projects.

As $T \to \infty$, this converges to $d(G - R - C)/(1 - d) \equiv U$.

The end-of-period payoff from choosing a risky project is $P(U_{t+1}) + (1 - P)[\pi(B - r_t + V_{t+1})]$. The end-of-period payoff from choosing a safe project is $G - r_t + V_{t+1}$. Monitoring provides incentives (safe projects are selected when monitored) if and only if

$$r_t^I \leq I_T + \left[V_{t+1} - \frac{P}{1 - \pi(1 - P)} U_{t+1}\right] \equiv I_t.$$

This implies that the ability to continue to borrow as a known type BG reduces the extent to which reputation strengthens the effect of monitoring. The *stigma from being caught* with risky projects is the difference between the value of future payoffs given a perfect track record and the future payoff once revealed to be a type BG. When one takes account of the chance that one is not caught when monitored, the expected stigma from being caught is $V_{t+1} - \{PU_{t+1}/[1 - \pi(1 - P)]\}$.

Under the conditions assumed in the rest of the model, where monitoring will not provide incentives at T, monitoring is "weak or expensive," and $U_{t+1} = 0$. In that case, reputation always strengthens monitoring. Under the conditions of this section, monitoring is "cheap and effective," and reputation can dilute the value of monitoring. The stigma of being revealed to be a type BG when monitored and caught is small or even negative when cheap, effective future monitoring can help to deal with moral hazard. The "backstop technology" of future monitoring removes the future stigma caused by current monitoring. This can result in the ineffectiveness of monitoring.

Monitoring will not be reinforced by reputation when the current value of maintaining a good reputation, V_{t+1}, is low relative to U_{t+1}, the value of being revealed to be a type BG. For a low-rated borrower who must borrow at high interest rates, it can improve the future terms at which he can borrow if revealed to be a BG: V_{t+1} can be less than U_{T+1}.[7] Lemma 4 provides the condition under which this "negative stigma" from being caught prevents monitoring from providing incentives.

LEMMA 4. Monitoring fails to provide incentives whenever needed

[7] If eventually reputation alone can provide incentives, then once a sufficiently good reputation is acquired, monitoring will be reinforced by reputation. With a good enough reputation, a BG with a perfect track record borrows at a face value approaching R, which is better than revealing oneself to be a type BG and borrowing at $R + C$. Note that as $C \to 0$ there is a weakly negative stigma and no reinforcement by reputation.

if

$$U_{t+1} > \frac{\pi(B - G)}{1 - \pi} - \frac{C[1 - \pi(1 - P)]}{P}.$$

Proof. See the Appendix.

The two terms to the right of the inequality in lemma 4 are attributable to the direct and indirect effects of monitoring, respectively. The direct effect on the payoff from choosing a risky project arises from the chance of being caught; the indirect effect comes from the effect of monitoring costs on the face value of debt. If the indirect effect were absent (e.g., if lenders need not pay for monitoring), then monitoring would be useless if U_{T+1} exceeded the first term. Risky projects are preferred without monitoring only if the end-of-period payoff from a safe project, $G - r_t + V_{t+1}$, is less than $\pi(B - G)/(1 - \pi)$. If the payoff when caught choosing a risky project also exceeds this level, then the return to a risky project exceeds that of a safe project when caught as well as when not caught, and cannot deter this choice.

If the payoff when caught is less than this level, the probability P of being caught makes risky projects less attractive; but monitoring costs increase the face value of debt and tilt the choice toward risky projects. The increased face value due to monitoring costs is at least C, and this increased face value reduces the face value of the safe project by C and that of the risky project by $C\pi(1 - P)$. The difference between these is the second term in the inequality in lemma 4; it is divided by P because the monitoring cost must be paid for sure, but the borrower is caught (and receives the payoff U_{t+1}) only with probability P.

For both types of monitoring, cheap and effective and weak or expensive, the stigma from being caught (which measures the contribution of reputation to the efficacy of monitoring) is a strictly increasing function of V_{t+1}, the value of having the reputation associated with a perfect track record of no defaults and never being caught by monitoring. The stigma is $V_{t+1} - \{P/[1 - \pi(1 - P)]\}U_{t+1}$, where U_{t+1} is a constant. For effective and cheap monitoring, the constant is positive; for weak or expensive monitoring, the constant is zero. A better credit rating (higher V_{t+1}) more strongly reinforces monitoring but also makes it more likely that monitoring is not needed. Except for the fact that reputation reinforces the effect of monitoring, the two cases are the same. All the results of propositions 1–3 are true except that the reduced effect of reputation is reflected in $VI \equiv d\{[\pi(1 - P)(B - G) - PU_{t+1}]/[1 - \pi(1 - P)]\}$, where the value with $U_{t+1} = 0$ was used previously.

Information that is not tremendously embarrassing will be useful and will be reinforced by reputation effects only if the borrower's current reputation is very good. This type of information might not be monitored for borrowers with worse reputations because it would not provide incentives. For borrowers with poor enough reputations, some less precise and higher-cost information could be preferred if it had a greater stigma attached and therefore provided incentives rather than just screened borrowers.

VII. Empirical Implications about Bank Loan Demand

The model has implications about the credit ratings of those borrowers who use banks (or other monitoring intermediaries) and about the portfolios of banks (or other monitoring intermediaries). The discussion above has developed the former implications on which borrowers are included in bank loan demand, summarized in figure 2, with $1 - f_{Bt}$ interpreted as the credit rating: borrowers with high credit ratings will borrow directly without monitoring, lower-rated borrowers will borrow from banks and monitoring will provide incentives, and still lower-rated borrowers (if monitoring costs are not too high) will borrow from banks and will be screened; some of these will be turned down for credit. The last group might appear to receive stochastic credit rationing if one did not observe the information monitored by banks. Section VI describes the life cycle transitions of borrowers between these groups over time.

The implications for the composition of bank loan portfolios come from examining the effect of changes in real interest rates or the profitability of typical investments on the cross-sectional demand for monitored bank loans. The way to interpret this is to imagine that at each date there are borrowers with many different credit ratings, possible overlapping cohorts of borrowers with different dates when they began acquiring their reputation, or borrowers for whom other public information differs. New additions to bank loan portfolios consist of the sum of all borrower credit ratings for which monitoring provides incentives and is profitable, as well as a fraction $1 - Pf_{BGt}$ (those who are not caught) of borrowers with those credit ratings (if any) for which screening is profitable and feasible.

The changes in conditions that I consider are changes in real riskless interest rates and a proportionate change in the payoffs of all projects, both safe and risky. For example, assume a single time period and consider proportional changes in the real riskless return on a one-unit investment: its return is now $\beta \cdot R$. Consider project return changes such that the return on safe projects is αG and the return on risky projects when successful is αB (with expected return $\alpha\pi B$). The ratio α/β is similar to Tobin's q: future rents from investment are high when this ratio is high. Tobin's q could be used as a proxy for α/β. The condition in which monitoring is needed is

$$f_{BT} \geq \frac{1}{1-\pi}\left(1 - \frac{\beta R}{\alpha A_T + V_{t+1}}\right),$$

and V_{t+1} is decreasing in β and increasing in α. When real rates increase relative to future profitability, the future becomes less important and moral hazard becomes more severe: more credit ratings choose to take a chance on ruining their now less valuable reputation. I shall state my results in terms of changes in the present value of future rents: these increase when β falls sufficiently relative to α. Similarly, a sufficient decrease in α relative to β will imply that the minimum credit rating for which monitoring provides incentives will also increase (the maximum face value for monitoring to provide incentives is I_t, which behaves similarly to A_t). In terms of figure 2, the horizontal lines that give the boundary credit ratings such that monitoring is needed and provides incentives both shift down (requiring higher ratings).

A lower present value of future rents (lower q) leads new bank loans to be less risky because borrowers with lower default risk choose to be monitored, and fewer loans are made to lower-rated borrowers because monitoring no longer provides incentives for these borrowers.[8] There are two reasons that fewer bank loans are made to low-rated borrowers: if screening is not profitable for the borrowers with ratings for which monitoring no longer provides incentives, these ratings no longer get new loans; if screening is profitable, a fraction $1 - Pf_{BGt}$ are caught and no longer receive loans. Lower q implies that banks deal on average with safer borrowers. This change in clientele implies that the loan rate charged to the average bank borrower will increase less than one for one with riskless real rates because the default risk premium of the average loan is decreasing in real riskless rates. This would generate bank loan interest rate data that make it appear that bankers are slow to adjust loan rates to changed market interest rates.

If the switch to safer lending when the present value of future profits decreases were sufficiently strong, it would generate what is

[8] Because all loans last one period, as well as all projects, the model says nothing about the effect of these changes on previously made loans. However, reduced future profits could increase the default risk of such old loans, providing a confounding effect.

referred to as a "flight to quality" or "credit crunch" that some would attribute instead to panicky bankers.

The model also has implications for the determinants of the ratio of the value of new bank loans to the value of new commercial paper issues. A decrease in future profitability that will make monitoring needed for higher-rated borrowers can lead to more new bank loans relative to new commercial paper. This presumes that the dominant effect of reduced future profitability is the increased monitoring of higher-rated borrowers, and not reduced monitoring by lower-rated borrowers due to the reduced incentive effect of monitoring.[9]

There is a potential problem in applying this result to U.S. data on new bank loans and commercial paper issues. Until 1986, banks faced regulatory deposit interest rate ceilings that restricted the supply of some deposits to banks, restricting bank lending in periods of high nominal interest rates. This was especially important in 1966–70, when a binding ceiling applied to large certificates of deposit as well; this period would not provide useful data. After 1970, large banks could raise funds at an unregulated interest rate using certificates of deposit of 89-day or shorter maturity, so there is a reasonable hope of measuring the changes in demand for bank loan monitoring by examining the quantities of loans relative to commercial paper issues. Including private placements that are not bank loans as monitored lending would also help reduce problems due to binding rate ceilings. In addition, in the 1980s, the identification of bank loans and other private placements as monitored and commercial paper as unmonitored has been blurred. Bank loans sold in secondary markets may involve much less monitoring, and some commercial paper is guaranteed by bank letters of credit that provide the bank strong incentives to monitor. Before 1980, these considerations are not of significant importance in U.S. banking markets.

The model has ambiguous implications about the effect of increased uncertainty about future interest rates (higher R_t volatility) on the demand for monitoring today. The value of future rents, V_{t+1}, is neither always concave nor always convex in R_{t+1}. As a result, there is no clear prediction about the effect of changes in volatility of future interest rates.

[9] Let f^I_{Bt} be the highest f_B such that monitoring provides incentives and f^A_{Bt} the lowest for which monitoring is not needed. An increase in rates, β, or a decrease in profitability, α, increases f^I_{Bt}/f^A_{Bt} and reduces each of the two. If commercial paper data measure loans to those borrowers that do not need monitoring, the statement follows if the dollar value of loans to those with credit ratings around f^I_{Bt} (that no longer receive loans after β increases) is not too much larger than the dollar value of loans to those with ratings around f^A_{Bt} (that switch to bank loans from commercial paper after β increases).

VIII. Conclusion

The model predicts that if moral hazard is sufficiently widespread, then new borrowers will begin their reputation acquisition by being monitored and later switch to issuing directly placed debt. The favorable track record acquired while being monitored will be useful in predicting future actions without monitoring. Reputation alone can eventually deal with the moral hazard because the better reputation achieved over time implies that adverse selection is then less severe.

The clientele of borrowers who rely on monitored bank loans are the middle-rated borrowers, whose rating is too low for reputation effects to eliminate moral hazard but is high enough for monitoring to eliminate moral hazard.

Monitoring that is very effective and cheap may fail to provide incentives to eliminate moral hazard because it removes the stigma from being known to be subject to moral hazard: future monitoring can deal with the moral hazard effectively. Monitoring can then destroy its own value because reputation effects work against its effectiveness.

In periods of high present or anticipated future real interest rates or low present or future anticipated economywide profitability, a higher credit rating is required to borrow without monitoring, implying that the demand for bank loan monitoring is then high and that the average new bank loan goes to a safer, higher-rated customer.

Appendix

Proof of Lemma 1

Because past face values are not observed, the only effect of a current rate offer on lender beliefs occurs in the current period. If a borrower has a safe project (type G or type BG with $a_t = g$) and the probability of receiving a loan as a function of the offered face value r_t is $\rho(r_t)$, the expected return is $\rho(r_t)(G - r_t)$. If the borrower has a risky project (type B or BG with $a_t = b$), the expected return is $\rho(r_t)\pi(B - r_t)$ without monitoring or $\rho(r_t)\pi(1 - P) \cdot (B - r_t)$ for a BG with monitoring.

Let $\Delta\rho = \rho(r_t + \delta) - \rho(r_t)$. The change in payoff from offering $r_t + \delta$ instead of r_t with a safe project is $\Delta\rho \cdot (G - r_t) - \rho(r_t + \delta) \cdot \delta$; for a type B borrower with a risky project (or an unmonitored BG with a risky project), it is $\Delta\rho \cdot \pi(B - r_t) - \rho(r_t + \delta) \cdot \pi\delta$. A monitored BG with $a_t = b$ has a change in payoff of $\Delta\rho \cdot \pi(1 - P)(B - r_t) - \rho(r_t + \delta) \cdot \pi(1 - P)\delta$. To provide an incentive for either type to select a higher rate requires $\Delta\rho \geq 0$. Given that $\rho(r_t) = 1$, it is a dominated strategy for any type to offer a rate above r_t, for any response of lenders.

Because the one-period profit from risky projects always exceeds that from safe projects, $\pi(B - r_t) > G - r_t$, and the condition for a BG to select $a_t = b$ is $\pi(1 - P)(B - r_t) > G - r_t$, for fixed $\Delta\rho$, borrowers with safe projects have the weakest incentive to offer a higher face value. For any $\Delta\rho$ that implies a weak incentive for a borrower with a safe project to offer the higher rate, a borrower with a risky project has a strict incentive to offer the higher rate. The Banks-Sobel (1987) divinity refinement or independence of inferences that are never a weak best response (see Kolberg and Mertens 1986; Cho and Sobel 1990) allows only the interpretation that offering the higher rate indicates a risky project. The logic is that there are conjectured responses of lenders that might attract those with a risky project to the higher face when borrowers with safe projects would not be attracted, but not vice versa. Therefore, lenders conclude that the higher face indicates risky projects, they will not lend at the higher face value, and $\Delta\rho < 0$. Q.E.D.

Proof of Lemma 3

Result That $r_t^S < r_{t-1}^S$ with Screening at $t - 1$

The face value r_t^S is set such that the investment of R plus a further investment of C on screening is equal to the expected return from receiving r_t^S with probability $f_{Gt} + \pi[f_{Bt} + (1 - P)f_{BGt}] \equiv \Gamma_t$ plus a return of R (from investing in storage) with probability $P \cdot f_{BGt} \equiv \sigma_t$. One period later, r_{t+1}^S is received with probability

$$\Gamma_{t+1} = \frac{f_{Gt} + \pi^2[f_{Bt} + (1 - P)^2 f_{BGt}]}{\Gamma_t} > \Gamma_t,$$

and money is invested in storage with probability $\sigma_{t+1} = P^2(1 - P)\pi f_{BGt}/\Gamma_t < \sigma_t$. Therefore, $r_{t+1}^S < r_t^S$: for all t, $r_{t+1}^S = (C + R\sigma_t)/\Gamma_t$. Q.E.D.

Result That $V_t \leq V_{t+1}$ if $t \ll T$

For a fixed action a_t over time by BG's and by lenders (monitor/do not), r_t is a decreasing function of time because given a longer perfect track record, f_t^G is increasing and f_t^B is decreasing if there is no screening at $t - 1$. If there is screening at $t - 1$, $r_t^S < r_{t-1}^S$, and because screening is feasible at t, $r_t \leq r_t^S$. If the actions were fixed, then for dates sufficiently far from T, V_t is increasing over time. To establish that when an action changes it leads to a rate below that implied by the action at the previous date, note that, given lenders' actions, the only borrower action change that could increase the rate above its previous-period value is a switch to $a_t = b$, which would need to imply that $a_t = g$ was not self-fulfilling. Begin with the case in which the fixed action of lenders is no monitoring. If $a_{t-1} = g$, then by lemma 2, $V_{t-1} \geq d\{G - [(G - \pi B)/(1 - \pi)]\}$ and $V_{t-1} = d(G - r_{t-1}^g + V_t)$. If $a_t = b$, then $V_t < d\{G - [(G - \pi B)/(1 - \pi)]\}$; together these imply $r_{t-1}^g < dG + (1 - d)[(G - \pi B)/(1 - \pi)]$. However, if a_t were fixed at $a_{t'} = g$ in the future, then $r_{t'} \leq r_t^g$ for all $t' > t - 1$; if there remain a sufficient number of periods after t, then $V_t > d\{G - [(G - \pi B)/(1 - \pi)]\}$, and it is a contradiction that $a_t = g$ is not self-fulfilling.

Holding fixed the action "monitor" by lenders at $t - 1$ and $t' > t - 1$ leads to a similar proof, except that on date $t - 1$ where monitoring provided incentives for $a_t = g$, we know $V_{t-1} \geq d(G - \{[G - \pi(1 - P)B]/[1 - \pi(1 - P)]\})$ in place of $d\{G - [(G - \pi B)/(1 - \pi)]\}$, and $a_t = b$ with monitoring implies that with monitoring and $a_t = g$ it must be true that $V_t < d(G - \{[G - \pi(1 - P)B]/[1 - \pi(1 - P)]\})$. This implies that $r_t^l < dG + (1 - d)\{[G - \pi(1 - P)B]/[1 - \pi(1 - P)]\}$ and that if the actions monitor and $a_t = g$ were maintained long enough, then $V_t \geq d(G - \{[G - \pi(1 - P)B]/[1 - \pi(1 - P)]\})$, implying that it is a contradiction that $a_t = g$ is not self-fulfilling at t with lenders' future monitoring actions held constant.

The only lender action change that could increase the rate is a switch to monitoring from not monitoring; however, lenders monitor only when the rate with monitoring is below the one that would prevail without monitoring, and the rate that would prevail without monitoring is less than the one that prevailed without monitoring the previous period. This establishes that r_t is decreasing over time if sufficiently far from t and that any action changes weakly increase V_t above the value for fixed actions, implying that V_t is weakly increasing in t if sufficiently far from T. Q.E.D.

Proof of Proposition 1

The necessary conditions for monitoring or reputation to provide incentives are given in the text. For the details of sufficiency when monitoring is impossible, see Diamond (1989, proposition 1). A sketch of the proof when monitoring is possible is as follows. For sufficiently large $t, f_{Bt} \rightarrow 0$. If the necessary condition for reputation to provide incentives is true, then for an unbounded number of periods after a sufficiently large $t < \infty$,

$$r_t \leq dG + (1 - d)\frac{G - \pi B}{1 - \pi} \equiv \phi$$

because r_t equal to this bound for all t would make type BG's indifferent between $a_t = b$ and $a_t = g$ and reduce f_{BGt} until for all future dates $r_t^b < \phi$. Because borrowers offer the lowest face value each period, $r_t \leq r_t^b$, and an unbounded number of periods with r_t less than ϕ implies that $V_t^g \geq d[\pi(B - G)/(1 - \pi)]$ and that safe projects are selected at t without monitoring.

If reputation alone cannot provide incentives, then there will be monitoring in any period in which safe projects are selected (as well as possibly others in which there is screening). If the necessary condition for monitoring to provide incentives holds, then near T, the future rents will be too small to provide incentives, and there would need to be screening or loans without monitoring with risky projects. If f_{BGt} were too large on that date (and $\min\{r_t^S, r_t^b\} > G$), this could appear to cause market failure. However, as in the case without monitoring, previous periods of monitoring that provided weak incentives for safe projects along with a fraction less than one of BG's choosing risky projects, such that $r_t^I = dG + (1 - d) \cdot \{[G - \pi(1 - P)B]/[1 - \pi(1 - P)]\}$, would reduce f_{BGt} sufficiently by allowing repeated periods of indifference between safe and risky projects given monitoring. These periods in the endgame are of bounded duration and are not further discussed in the text. Q.E.D.

Definition for Proposition 2

Define the τ vector of face values $\mathbf{R}[t']$ with elements given by $\mathbf{R}_t[t'] =$

$r_t^b[Nb = t, NS = 1]$	for $t = 1, \ldots, \min\{\bar{t}_{SPa} - 1, t'\} - 1$,
$r_t^S[t, 1 + t - \bar{t}_{SPa}]$	for $t = \bar{t}_{SPa}, \ldots, \min\{\bar{t}_{SPb}, t'\} - 1$,
$r_t^b[t, 1 + \bar{t}_{SPb} - \bar{t}_{SPa}]$	for $t = \bar{t}_{SPb}, \ldots, t' - 1$,
$r_t^I[t', 1 + \min\{\bar{t}_{SPb}, t'\} - \bar{t}_{SPa}]$	for $t = t', \ldots, \min\{\bar{t}_{IP}[t'], N[t']\} - 1$,
$r_t^b[t' + t - \bar{t}_{IP}[t'], 1 + \min\{\bar{t}_{SPb}, t'\} - \bar{t}_{SPa}]$	for $t = \min\{\bar{t}_{IP}[t'], N[t']\}, \ldots, N[t'] - 1$,
$r_t^g[t' + \min\{0, t' - \bar{t}_{IP}[t']\}, 1 + \min\{\bar{t}_{SPb}, t'\} - \bar{t}_{SPa}]$	for $t = N[t'], \ldots, \tau$,

where $\bar{t}_{SPa}$, $\bar{t}_{SPb}$, $\bar{t}_{IP}[t']$, and $N[t']$ are defined in the next four paragraphs.

Let $\bar{t}_{SPa}$ be the smallest date t such that screening is profitable given loans from dates 1 to $\bar{t}_{SPa}$ with risky projects selected without monitoring (smallest t such that screening is profitable given $Nb = t$ and $NS = 1$).

Let $\bar{t}_{SPb}$ denote the smallest date $t \geq \bar{t}_{SPa}$ such that screening is not profitable, given risky projects without monitoring from dates 1 to $\bar{t}_{SPa} - 1$ and screening from $\bar{t}_{SPa}$ to t (smallest $t \geq \bar{t}_{SPa}$ such that screening is not profitable given $Nb = t$ and $NS = 1 + t - \bar{t}_{SPa}$). If screening is never profitable, $\bar{t}_{SPa} = \bar{t}_{SPb} = 1$.

Define $\bar{t}_{IP}[t']$ as the first date such that the increase in expected return from monitoring that provides incentives is *not* profitable, given monitoring that provides incentives beginning on date t', and such that there is screening from date $\bar{t}_{SPa}$ to the smaller of $\bar{t}_{SPb}$ and t' (smallest t such that incentive monitoring is unprofitable given $Nb = t_I$ and $NS = 1 + \min\{\bar{t}_{SPb}, t'\} - \bar{t}_{SPa}$).

Let $N[t']$ denote the smallest $t'' \geq t'$ such that the present value to a BG of selecting $a_t = g$ each period borrowing at $r_t^g[Nb = t' + \min\{0, t' - \bar{t}_{IP}[t']\}$, $NS = \min\{\bar{t}_{SPb}, t'\} - \bar{t}_{SPa}]$, from t'' to τ, exceeds $d\pi(B - G)/(1 - \pi)$ (the condition for $a_t = g$ without monitoring). This present value is $\Sigma_{t=t''}^{\tau} (G - r_t^g)d^{1+t-t''}$, where r_t^g is given in the text.

Proof

This section proves that, with cheap and effective monitoring, an equilibrium in which lemma 1 is true (borrowers always offer the lowest self-fulfilling face value of debt that provides lenders a net expected return of R) satisfies the Banks-Sobel (1986) divinity refinement. Initially, I hold fixed a monitoring decision of lenders. The best response of future lenders to a current observed default depends on the type of inference they make from a default, which depends on the action a_t they anticipate. Those who default had projects that return zero. The fraction of type G's in the pool of defaulters is zero. If monitoring cannot provide incentives at T, no one would lend to a BG, so no matter what project choice is anticipated, there will be no loans to defaulters. Even if monitoring can provide incentives at T, if the proportion of type B's in the pool of defaulters is sufficiently high, the face value (with safe projects assumed) would exceed G and there will be no loans made to those who have defaulted. There are BG's in the pool of defaulters only if $a_t = b$ is anticipated for some BG's. The possible belief that future lenders might have about the population of defaulters at t is that it includes a fraction $1 - \pi$ of the B's who borrow at t plus a fraction $\alpha_t(1 - \pi)$ of the BG's who borrow at t, where $\alpha_t \in [0, 1]$ is the fraction of BG's believed to have selected $a_t = b$. For a sufficiently high α_t, it can be a best response of future lenders to lend to a borrower who has defaulted.

For the best response of lenders to a belief in [0, 1] about α_t, if the strictly optimal choice of a BG is $a_t = b$, then in any sequential equilibrium, type BG's will select $a_t = b$ (and $\alpha_t = 1$ is the only sequentially rational belief). Instead, for best responses to all $\alpha_t \in [0, 1]$, if BG's prefer $a_t = g$, then in any sequential equilibrium, BG's select $a_t = g$ (and $\alpha_t = 0$ is the only sequentially rational belief). Refinements of sequential equilibrium are needed only if BG's prefer $a_t = b$ for some beliefs α_t and $a_t = g$ for others.

The incentive of type BG's to select $a_t = b$ is increasing in α_t. Any $\alpha_t > \alpha_t'$ will lead future lenders to increase their estimate of the fraction of BG's in the pool of defaulters at t (compared to $\alpha = \alpha'$). If lenders lend to those who default at t, at a date $t^* > t$ the interest rate will be nonincreasing in α_t because monitored BG's are the only such borrowers that can select safe projects. A value of α_t that exceeds α_t' will increase r_t. In addition, because it will raise the probability of being a type BG and reduce that of being a type B, given a default, either it will leave all future interest rates paid by those who default at t unchanged (which leaves the BGs' value of making optimal decisions from $t + 1$ to T unchanged) or it will decrease some of the rates and increase none (which increases the BGs' value of making optimal decisions from $t + 1$ to T). If some future rates are lower for $\alpha_t > \alpha_t'$ (and the value of defaulting at t and making optimal decisions thereafter increases), then if BG's are indifferent for α_t', they strictly prefer $a_t = b$ for $\alpha_t > \alpha_t'$. By a symmetric argument, for $\alpha_t < \alpha_t'$, r_t is lower, and either future rates are weakly higher or (for sufficiently low α_t) there are no loans granted to those who default at t. Therefore, for $\alpha_t < \alpha_t'$, either BG's remain indifferent between their two projects or they strictly prefer $a_t = g$. Therefore, the amount by which BG's prefer $a_t = b$ over $a_t = g$ is weakly increasing in α_t. This implies that if $\alpha_t \in (0, 1)$ is self-fulfilling, then $a_t = 0$ is self-fulfilling.

If BG's prefer $a_t = g$ given the belief that $\alpha_t = 0$, then the belief $\alpha_t = 0$ is the only belief that satisfies the refinements used in the proof of lemma 1. Either the belief is the only sequentially rational belief or there exists a best response to some $\alpha_t' \in [0, 1]$ such that BG's are indifferent between $a_t = b$ and $a_t = g$. The second case implies that any α_t that implies BG weak preference for $a_t = b$ implies B strict preference for risky projects.

If $\alpha_t = 0$, then all defaults come from B's, and lenders cut off credit to those who default. The Banks-Sobel (1986) divinity refinement and the related arguments discussed in the proof of lemma 1 allow only the off-equilibrium belief $a_t = g$ if it is self-fulfilling; this implies that a default indicates that a borrower's type is B. Only if this belief is not self-fulfilling do lenders expect $a_t = b$ and assign positive probability to defaults coming from type BG's in a period. Our previous result—if $\alpha_t \in (0, 1)$ were self-fulfilling, then $a_t = 0$ is self-fulfilling—implies that if $\alpha_t = 0$ is not self-fulfilling, then $\alpha_t = 1$ is the only self-fulfilling value.

The pool of borrowers that default at t when $\alpha_t = 1$ contains the same relative proportions of types B and BG as the group that had never defaulted up to t, and no type G's. Given the pool of borrowers with a track record of zero defaults, if $\alpha_t = 0$ is not self-fulfilling with or without monitoring at t (i.e., $\alpha_t = 1$ is the smallest self-fulfilling value of α_t), then $\alpha_{t+1} = 1$ is also the smallest self-fulfilling value for the pool of defaulters (the original pool with the type G's removed), with or without monitoring at $t + 1$. The defaulters would face higher face values r_t at all future dates because of the lower probability of repayment, implying lower V_{t+1}. Therefore, if the smallest self-fulfilling $\alpha_t = 1$, credit is cut off on a default because then a loan to a defaulter would lead any BG's in the group to select $a_t = b$, and all such borrowers would select the negative net present value project implied by $a_t = b$.

If monitoring that provides incentives would be profitable at t, then if $\alpha_t = 0$ is self-fulfilling for some monitoring decision, zero will be the equilibrium value of α_t. Therefore, the previous paragraph's results imply that if incentive monitoring would be profitable, then credit is cut off on the first default.

If monitoring is needed, incentive monitoring is unprofitable, but monitoring would provide incentives if used at t, then loans will be made to those who default at t. This occurs only when monitoring is needed at t, so $\alpha_t = 0$ without monitoring is not self-fulfilling. The conditions for monitoring to be needed or to provide incentives can therefore be computed correctly assuming that credit is cut off on the first default because this assumption about credit cutoff will be false only when the condition that monitoring is unprofitable is the binding constraint. Q.E.D.

Proof of Lemma 4

The condition for monitoring not to work when needed is $A^t \leq r_t^g \Rightarrow I^t < r_t^I$, or $A_t \geq I_t + (r_t^I - r_t^g)$. Using $I_t - r_t^g = C/(1 - \pi f_{Bt})$, we get

$$\frac{G - \pi B}{1 - \pi} \geq \frac{G - \pi(1 - P)B - PU_{t+1}}{1 - \pi(1 - P)} - \frac{C}{1 - \pi f_{Bt}}.$$

This is equivalent to

$$(G - \pi B)[1 - \pi(1 - P)] - [G - \pi(1 - P)B](1 - \pi) \geq -(1 - \pi)\left\{PU_{t+1} + \frac{C[1 - \pi(1 - P)]}{1 - \pi f_{Bt}}\right\}$$

or

$$P\pi(G - B) \geq -(1 - \pi)\left\{PU_{t+1} + \frac{C[1 - \pi(1 - P)]}{1 - \pi f_{Bt}}\right\}$$

or

$$U_{t+1} \geq \frac{\pi(B - G)}{1 - \pi} - \frac{C[1 - \pi(1 - P)]}{P(1 - \pi f_{Bt})} \geq \frac{\pi(B - G)}{1 - \pi} - \frac{C[1 - \pi(1 - P)]}{P}.$$

Q.E.D.

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