WP/05/222

IMF Working Paper

Monitoring and Commitment in Bank Lending Behavior

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INTERNATIONAL MONETARY FUND

 WP/05/222

IMF Working Paper

Western Hemisphere Department

Monitoring and Commitment in Bank Lending Behavior

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November 2005

Abstract

The paper proposes a theoretical argument on the nature of bank lending, based on the idea that, through commitment and monitoring, banks overcome basic informational asymmetries with borrowers. By bringing together loan commitment theories and credit rationing theories, the paper shows that, within a framework of asymmetric information between lenders and borrowers and under costly termination of lending arrangements, commitment may explain the accumulation of nonperforming loans by banks. Two additional results follow: (i) that banks favor borrowers with well-known production functions and long-term credit history; and (ii) that interest rate spreads may be large if significant market imperfections prevail.

JEL Classification Numbers: D45, D82, E44, G21

Keywords: Bank, credit, monitoring, commitment, asymmetry of information

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[1] I would like to thank Michael Kuczynski, Elena Loukoianova, Giovanni dell'Ariccia, Douglas Diamond, Phillip Schellekens, Trevor Alleyne, Mwanza Nkusu, Richard Blavy, Pablo Druck, Enrique Flores, and Ryan Hammond for their helpful comments and suggestions; and Kate Jonah and Lourdes Cuadro for editorial assistance.

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I. Introduction

One of the focuses of the vast literature on credit and bank behavior has been financial intermediation as a major explanation for the existence of banks. The debt contract emerges as key to the bank-borrower relationship. Restrictions on full information and perfect information environments are introduced to explain specific characteristics of that relationship. Seminal works on these issues include Benston and Smith (1976) on transaction costs; Leland and Pyle (1977), Stiglitz and Weiss (1981), Diamond (1984), and Fama (1985) on asymmetric information, credit rationing, and signaling; and Diamond and Dybvig (1983) on liquidity insurance.

This paper purports that the monitoring process undertaken by banks may determine the nature of their lending behavior, in particular in economies where information about borrowers is scarce and the costs of exiting a lending relationship are high. The accumulation of nonperforming loans on the balance sheets of banks is shown to be a plausible result of high exit costs. Two additional characteristics emerge under the proposed framework, both commonly accepted results in the bank lending literature. The first is that banks prefer to finance companies in the formal sector with rare and small deviations from historic average returns and with which they have well-established relationships. The second is that the spread between deposit and lending rates may be wide.

These three characteristics result from a theoretical argument based on the idea that banks overcome some basic informational problems through long-term relationships with borrowers and commitment. Transposed into a framework of asymmetric information between lenders and borrowers, the paper shows that under plausible conditions, monitoring of borrowers by banks increases the efficiency of the credit market by lowering the interest rate charged to borrowers and/or increasing the expected profit to the bank, and by potentially increasing the level of credit in the economy toward its first-best level. A multiperiod setting is modeled by focusing on the conditions that induce banks into a reallocation of their portfolio in interim periods. In the environment of the model, banks are assumed to receive, at each interim period, an informal signal from borrowers that reduces asymmetries of information and allows for an increase in the expected return to the bank. However, commitment to unpromising borrowers, necessary for the partial revelation of information at each interim period, is a costly process that reduces gains from monitoring. The bank may therefore prefer to terminate the lending contract if costs of commitment are higher than exit costs.

With this approach, the paper brings together two theories of banking behavior—i.e., loan commitment theories and credit rationing theories. Some of the constraints commonly imposed in modeling both theories are relaxed, notably the restriction of models to a one-period framework and the assumption of costly state verification. An additional contribution is to use a simple and operational definition of the debt contract. The debt contract is a contract that specifies a loan of financial resources from one agent (the lender) to another (the borrower) at an initial period, against payment in the next period of the lent capital plus the interest due. At each period, the lender can reset the price and possibly the other terms, on the understanding that the loan is renewable for an indefinite period of time.[2]

By focusing on an interim period in the life of the contract, the paper attempts to provide a realistic modeling of the monitoring process. The monitoring activity consists of the combination of three elements: the alertness to information signals, the interpretation of signals, and the adjustment of incentives. As a result, the assumption of ex post costly state verification used in models of bank credit and monitoring is not used here. At each interim period, borrowers send new information about the performance of their projects, which informs banks on the borrowers' expected performance in the one period ahead. This framework is adopted to reflect two features of the loan contract: (i) that banks may generally observe ex post the returns realized by borrowers on their projects, and (ii) that loan contracts tend to cover the multiple periods of the life of a project.

The issue of commitment is introduced from a different angle than in previous loan commitment models. These models have explored the reasons for the emergence of multiperiod loan commitments from the point of view of both borrowers and lenders. They have emphasized the role of market imperfections in the emergence of lending commitments, in particular, transaction costs, asymmetry of information, and market dominance.[3] In a context where banks incur costs of termination when liquidating a loan, they are shown to be implicitly committed to some borrowers, even when they expect negative returns from such borrowers. The presence of commitment and exit costs is central to the argument proposed in this paper. Commitment costs correspond to the reduction in the bank's expected revenue due to commitment to unpromising borrowers. In other terms, they are the bank's investment in the process of information acquisition. Exit costs are, for simplicity, assumed to be related to a number of imperfections in the functioning of the banking firm. These imperfections range from institutional and administrative rigidities, agency problems (notably, a divergence of interests between the agent contracting the loan and the management of the bank), to weaknesses in the judicial and law enforcement systems.

[2] Banks are defined, following Freixas and Rochet (1998), as "institutions whose current operations consist in granting loans and receiving deposits from the public" (p. 1).

[3] James (1982) argued that transaction costs associated with the search for and selection of new borrowers are higher than costs of continuing a preexisting lending relationship, and hence a motive for loan commitment. Melnik and Plaut (1986) develop a model where lending is more efficient under loan commitment contracts than in the spot market. Their results are dependent on the assumption that while the loan rate is fixed under loan commitments, it varies in line with a loan-size risk premium in the spot market. Boot and others (1991) also present a model where loan commitment yields a more efficient allocation of credit than contracting directly in the spot market. In the environment of their model, moral hazard due to asymmetric information leads to investment in second-best projects or to credit rationing. Loan commitments, because they are based on an up-front commitment fee that compensates for below-market interest rates, reduce the distortions associated with moral hazard. Morgan (1994) obtains comparable results in a model where commitments reduce the default risk of borrowers and hence reduce credit rationing.

The key results are as follows.

- At each period, the monitoring of information signals by the bank allows it to sort borrowers into two categories—promising and unpromising borrowers—with the bank expecting positive returns from the former and negative from the latter. The bank consequently maximizes its one-period-ahead expected profit by reallocating its portfolio away from unpromising borrowers to borrowers in the spot market. However, because the bank incurs costs of contract termination when interrupting a lending relationship, it is constrained in its ability to reallocate its portfolio and remains committed to a number of unpromising borrowers. This result provides a first justification for the fact that bank lending tends to be in the form of multiperiod implicit debt contracts.

- Commitment to unpromising borrowers, by reducing the expected profit to the bank, limits its ability to reduce interest rates on promising borrowers and incites the bank to pass on the cost to depositors, in the form of lower deposit interest rates.[4] The model suggests that spreads between lending and deposit interest rates will be large in an environment where the bank suffers from important agency problems, has weak internal control systems, and where the legal system is weak and contract enforcement and termination difficult and costly, because costs of contract termination will be high and so will commitment to unpromising borrowers.

- The possibility for the bank to establish a credit history of borrowers introduces into the model an additional characteristic of bank lending: that the process of information interpretation is mostly backward-looking. In the context of the model, this characteristic is shown to make the bank resilient to noise in information signals and to prevent undue and costly termination of loan contracts. However, backward-looking information interpretation reduces the ability of the bank to detect structural changes in the quality of borrowers, with the potential of a substantial deterioration in its overall portfolio.

The remainder of the paper is organized in four sections. Section II discusses concepts and definitions in light of the existing literature. Section III presents the framework of our model. Section IV develops a model of monitoring and commitment in banks' lending behavior without credit history, which is extended in Section V to allow for the constitution of credit histories by banks. Finally, Section VI provides a summary and conclusion.

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[4] This result of the model may run counter to empirical evidence that banks with high nonperforming loan ratios may actually offer higher deposit rates. In effect, the risk of insolvency provides incentives to increase deposit collection, even at a high cost. This aspect is not modeled in the paper. The result presented here follows notably from the assumptions that the bank has a fixed pool of deposits that does not vary from period to period and that the bank operates in a monopolistic environment.

II. Concepts, Definitions, and Theoretical Framework

The debt contract is at the core of the bank-borrower relationship in the banking literature. In a full information framework, both parties would specify in the contract every possible future contingency (or state of nature) and their resulting obligations in each of them, including the amount of repayment or of additional loan, the interest charge for the next period, any adjustment in the collateral required by the lender, and the set of actions required from the borrower. In a multiperiod setting, a complete contingent contract would be very lengthy and could be prohibitively costly. For this reason and because of uncertainty about future contingencies, debt contracts usually define repayment obligations and collateral for the whole duration of the contract, whereas actions to be undertaken by the borrower are left to its own appreciation (see, for example, Freixas and Rocher, 1998).

The definition of the debt contract adopted in this paper retains some flexibility in the adjustment of the terms of the contract in the various states of nature, while monitoring provides the bank with the ability to influence the actions of the borrowers over time. The debt contract is defined as a contract between a lender and a borrower, renewable for an indefinite period of time, where the lender can reset the price and possibly the other terms. The lender retains the ability to terminate the contract and renegotiate its terms—for simplicity, renegotiation is through the possibility of changing interest rates over time. We assume that this ability is limited partially by implicit costs of contract termination, including (i) institutional and administrative rigidities (for example, the costs of processing the changes in the terms of the contract), (ii) agency problems (notably a divergence of interests between the agent contracting the loan and the management of the bank), and (iii) weaknesses in the judicial and law enforcement systems. The model focuses on the ability of financial intermediaries to monitor borrowers throughout the life of the contract, in the presence of costs of contract termination.

The monitoring activity consists of the combination of three elements: the alertness to information signals, the interpretation of signals, and the adjustment of incentives. The first two elements correspond to the bank's efforts in reducing asymmetries of information with borrowers. The third element represents the ability to modify the terms of the contract to ensure good performance of the borrower. An alternative definition has commonly been defined in the banking literature, where monitoring is a process of outcome discovery, in which the lender has to monitor the borrower in order to have some indications on the realized returns on the projects undertaken. This definition of monitoring is central to the costly state verification paradigm first developed by Townsend (1979) and later extended by Gale and Hellwig (1985) and Williamson (1987). Costly state verification models assume that lenders cannot observe returns on projects undertaken by borrowers unless costly audits are performed. Borrowers, to maximize their returns, may falsify their realized returns in order to lower repayments to the bank, if they can profitably do so. Contracts with ex post asymmetry of information generally specify a high enough penalty to prevent successful borrowers from declaring failed returns. Audits only take place when cash flows are too low for borrowers to repay capital and interest to the bank, since penalties prevent cheating in all other states of nature. For successful states, repayment to the bank is independent of the return on the project. Williamson (1987) showed that this environment endogenously defines the optimal contract as being the debt contract.[5]

Some multiperiod models have imposed stricter restrictions on ex post asymmetry of information, by assuming that ex post audit of returns by the bank is not possible.[6] The borrower only repays the lender if he is provided with incentives to do so. In Bolton and Scharfstein (1990), the threat of contract termination induces the repayment of the loan in a repeated borrower-lender relationship. In a one-period model, there would be no lending because the borrower would always declare failure of its project and inability to repay the loan. Under the assumption that the bank is unable to audit returns ex post, its expected profit would always be negative. In a multiperiod setting,[7] the bank may commit to renew the loan if the firm repays the contractual amount in the interim period. While borrowers will always default on the last payment when the incentive to repay is removed, the bank may yield sufficient profit from interim payments to compensate for the ultimate loss. Stiglitz and Weiss (1983) also developed a model where contract termination and renegotiation are used as incentive mechanisms. Haubrich (1989) extended the models in Bolton and Scharfstein (1990) and Diamond (1984) by combining the two incentive devices in an infinite horizon model: with dynamic contracting, cheating borrowers are identified and punished, either through contract termination or renegotiation of the contract terms—that is, higher interest rates. The assumption of ex post costly state verification is not used in the model proposed here.

Formally, monitoring is undertaken as follows.

Imagine an economic environment where agents are risk neutral and composed of a bank operating in a monopolistic environment and a group of undistinguishable borrowers.

The life of a debt contract is simplified to three stages: the allocation of capital to the new borrower, interim periods during which the loan is renewed, and the termination of the contract. The model focuses on interim periods, denoted t. Assume that the initial allocation of capital has been made under conditions of ex ante asymmetry of information. Under such conditions, the bank has limited information about borrowers. The bank may observe only

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[5] The same result was obtained by Diamond (1984) in a model where cash flows are not observable and mechanisms of truthful revelation establish the optimality of the debt contract. Diamond expanded the model to show that, with a nonpecuniary cost associated with untruthful revelation of returns, a standard debt contract is still obtained.

[6] The impossibility to observe returns ex post is shared with the Diamond (1984) model. However, Diamond's solution was to impose nonpecuniary costs of failed borrowers, and effectively to remove the limited liability constraint.

[7] Gromb (1994) extended the two-period model of Bolton and Scharfstein (1990) to a multiperiod setting (see also Dewatripont and Maskin, 1995).

the average characteristics of a group of borrowers—average probability of success and average expected returns—but not the specific characteristics of individual borrowers.

Assume further that the bank initially allocates all its financial resources to borrowers. The bank's total financial resources are a fixed pool of deposits that do not vary during interim periods. It follows that the bank may enter new loan arrangements in the spot market if and only if it terminates some contracts with its current borrowers in the same period. As a result, if the bank decides to terminate some contracts in an interim period, it frees resources to enter into new loan arrangements with borrowers with which it has no previous lending relationship.

At any given period, the bank reassesses its loan portfolio, after receiving an information signal from borrowers. The signal is emitted at each period. In effect, under the assumption that loans are renewed every period for an infinite number of times, each period corresponds to the repayment of interest and capital by the borrowers and to the renewal decision by the bank. On the basis of the newly accumulated information, the bank decides whether to modify the structure of incentives to borrowers. Changes in the conditions of loans provide incentives to borrowers to perform according to the initial terms of the contract. Among an array of possible changes to the contract, only two are retained, for simplicity: (i) the interest rate may be modified because good borrowers may be offered better terms; and/or (ii) the volume of credit allocated may be modified, either by termination of the contract or by increased credit rationing in the case of unpromising borrowers or loan renewal in the case of promising borrowers.

The model follows the formulation proposed by Stiglitz and Weiss (1981), with borrowers undertaking two-outcome projects. Assumptions about the characteristics of borrowers are as follows:

- For simplicity, each borrower has a single project. There is no adverse selection. Borrowers and projects have the same risk-return characteristics, and the two terms are used interchangeably.
- The individual probability of success, p_i, and the corresponding successful return of the i^{th} borrower, R_i^s, are unobservable to lenders;
- R^f is the return on a failed project and is constant across borrowers, under the assumption that a failed project yields a return equal to the liquidating value of the firm. The value of net assets minus bankruptcy costs, independently of the riskiness of the project itself, is constant for all borrowers;

- $\overline{R}$ is the average expected return on borrowers' projects. $\overline{R}$ is observable to the bank and is constant across borrowers: $p_i R_i^s + (1-p_i)R^f = \overline{R}$. It follows that risky projects yield higher returns in case of success than safer ones.[8]

- The average probability of success of borrowers, $\overline{p}$, together with the average distribution of returns $G(p)$ with density function $g(p)$, are observable by the bank.

In this environment, borrowers have no initial wealth and seek finance for their projects. Without loss of generality, the initial investment required for each project is normalized to 1. A standard debt contract is issued, with repayment of capital and interest ($\hat{r}$) in nonbankruptcy states and maximum recovery of debt in bankruptcy states (R^f). The model assumes that the bank may not fully protect itself against bankruptcy and obtains a negative return in case of failure of the borrower. Formally, the borrowers' failed return is inferior to the loan repayment: $R^f \leq (1+\hat{r})$.

If the project is successful, the borrower receives the payoff of the project net of repayments to the bank. If the project fails, the borrower pays the failed return to the bank and receives no payoff. The return to the i^{th} borrower is $\pi_i = \max\left[R_i^s - (1+\hat{r}); 0\right]$.

Given the probability p_i that the project is successful, the expected return to the i^{th} borrower, net of debt repayment to the bank, is:

$$E(\pi_i) = p_i\left[R_i^s - (1+\hat{r})\right].$$

The expected return to the borrower is a decreasing function of the probability of success.[9] The result that expected net returns to the borrower are higher for riskier projects can be explained by the fact that for riskier projects, "the expected interest payments are lower because the loan is repaid less often" (English, 1986, p. 7). In the model, this is the case because average expected returns ($\overline{R}$) are held constant and because R_i^s is assumed to increase with the degree of risk.

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[8] Given $p_i R_i^s + (1-p_i)R^f = \overline{R}$, and $\overline{R}$ and R^f constant across borrowers, if $p_1 > p_2$,

$$R_1^s = \frac{\overline{R} - (1-p_1)R^f}{p_1} < \frac{\overline{R} - (1-p_2)R^f}{p_2} = R_2^s.$$

[9] The result is obtained by deriving the profit function of the borrower with respect to the probability of success. We obtain: $\frac{\partial E(\pi_i)}{\partial p_i} = \left[R^f - (1+\hat{r})\right] \leq 0$. The derivative function is negative if failed returns are inferior to the loan repayment, which is true under the assumptions of the model.

A risk-neutral entrepreneur is willing to undertake its project, financed by a debt contract, if and only if $E(\pi_i) \geq 0$. Borrowers choose to apply for loans if and only if their project yields sufficiently high returns, which, given the inverse relationship between returns and probability of success, means that borrowers apply for loans only if their projects are sufficiently risky to yield a minimum successful return that ensures nonnegative expected returns. There is a limit probability of success, p^*, above which the entrepreneur decides not to borrow, such that:

$$p^* = \frac{\overline{R} - R^f}{(1+\hat{r}) - R^f}.$$ [10]

The limit probability of success p^* is decreasing with the interest rate. The quality of the pool of borrowers hence worsens as the bank raises interest rates. As in Stiglitz and Weiss (1981), borrowers with high probability of success progressively drop out of the pool of borrowers as the bank raises the lending interest rate. The initial allocation of capital is determined by the expected return to the bank from lending to that group of borrowers at interest rate $\hat{r}$, formally:

$$\Im(\hat{r}) = \int_0^{p^*(\hat{r})} \left[(1+\hat{r})p + (1-p)R^f\right] g(p)dp - (1+b)\int_0^{p^*(\hat{r})} g(p)dp \quad , \tag{1}$$ [11]

where b is the interest rate paid to depositors by the bank. Equation (1) represents the return to the bank from loan applicants given the interest rate $\hat{r}$. Within the subset of loan applicants with probability of success below $p^*(\hat{r})$, the first part of the equation represents the average return from both successful and failed projects. The second part of the equation corresponds to the obligations of the bank to its depositors, since $\int_0^{p^*(\hat{r})} g(p)dp$ is the total value of granted loans. Stiglitz and Weiss (1981) have shown that a credit-rationing

[10] p^* is such that $E(\pi_i) = p^*_i\left[R_i^s - (1+\hat{r})\right] = 0$. From $p_i R_i^s + (1-p_i)R^f = \overline{R}$, it follows that $p^* R_i^s = \overline{R} - (1-p^*)R^f$. Replacing for $p^* R_i^s$ into $E(\pi_i)$ and solving for $E(\pi_i) = 0$, gives $p^* = \dfrac{\overline{R} - R^f}{(1+\hat{r}) - R^f}$.

[11] In the remainder of the paper, $\Im(\hat{r})$ is denoted $\Im$ for conciseness.

equilibrium may exist when some borrowers with positive expected returns are excluded from the credit market.[12]

Once the bank has entered a lending relationship with borrowers, it periodically receives information signals and monitors borrowers.[13] Promising borrowers send a positive signal that suggests that they have a higher probability than the average (undistinguishable) borrower of performing well in the next period. Unpromising borrowers, on the other hand, send a negative signal and have a lower probability of success in the next period.[14] The bank is therefore able to reassess the quality of its credit portfolio after reception of a signal. With additional information, the characteristics of borrowers as observed by the bank at time *t* change. The reception and interpretation of information by the bank is formalized as follows:

- The information signal $\varepsilon_{t,i}$ is emitted at time *t* by borrower *i*.
- A positive signal is such that $\varepsilon_{t,i} \geq 0$. A negative signal is such that $-1 \leq \varepsilon_{t,i} \leq 0$.
- Information is only partially revealed to the bank. The bank observes only whether the signal is positive ε^{+} or negative ε^{-}. The bank may distinguish among previously undistinguishable borrowers two separate groups. Promising borrowers, which send a positive information signal, constitute the first group; and unpromising borrowers the second one.

[12] The existence of a credit-rationing equilibrium is related to the worsening of the pool of borrowers as the interest rate rises. Suppose that, at some interest rate $\hat{r}'$, the bank's revenues from the increase in the interest rate are more than offset by the moral hazard effect, the bank will not lend at interest rates above $\hat{r}'$. If $\hat{r}'$ is such that the expected profit to borrowers is positive, credit rationing follows. Formally, the result is obtained by showing that equation (1) is a nonmonotonic function of the interest rate. By deriving equation (1) with respect to $\hat{r}$, and showing that the limit of the derivative as the interest rate tends to infinity is negative, nonmonotonicity follows.

[13] One possible formulation of information signals is to relate them to the performance of borrowers in the previous period, observed by the bank during monitoring. Performance could, for example, be defined as the ability for borrowers to pay debt service due in a given period.

[14] The model assumes here that the average probability of success for the pool of borrowers remains unchanged at each interim period.

- The reception of the signal modifies the bank's perception of the probability of success of borrowers. At interim period *t*, the observed probability of success is: $\overline{p}(1+\varepsilon_{t,i})$.[15] Hence, $\overline{p}(1+\varepsilon^{+}_{t,i}) \geq \overline{p}$ if the signal is positive and $\overline{p}(1+\varepsilon^{-}_{t,i}) < \overline{p}$ if the signal is negative.

- The information signal is a function of the probability of success of borrowers, consistent with the fact that the signal reveals information about the quality of borrowers. Hence, $\varepsilon_{t,i}$ is denoted $\varepsilon_{t,i}(p)$.

- The average expected return on the projects of borrowers and their average probability of success remain constant. The individual probability of success, p_i, and the associated successful return, R_i^s, remain unobservable to lenders.

III. Monitoring and Bank Lending

In this section, the impact of borrowers' information signals on bank lending is examined in a context where information signals are uncorrelated across periods, which prevents the bank from establishing a credit history of its borrowers. The results provide theoretical support to the idea that the bank benefits from repeated lending to borrowers and develops an expertise that allows it to allocate credit more efficiently than in a typical one-period model.

The decision of the bank to renew or suspend credit to borrowers is modeled within the framework established in Section II. The argument proceeds by analyzing the impact of information on the expected profit to the bank and on credit allocation, successively. The equations presented in Section II are rewritten and modified to take into account the additional information available to the bank in the form of the information signal.[16]

As the bank receives information about borrowers, it can sort previously undistinguishable borrowers into two subgroups, promising and unpromising. The bank adjusts its expectations of profit from borrowers. Promising borrowers are expected to yield higher expected returns than unpromising ones.

PROOF. The expected return to the bank from a single borrower, net of interest payments to depositors, is:

$$\Im_{\varepsilon_{t,i}} = p_i(1+\varepsilon_{t,i})(1+\hat{r}) + (1-p_i(1+\varepsilon_{t,i}))R^f - (1+b). \tag{2}$$

[15] A positive signal is such that $\frac{1-p_i}{p_i} \geq \varepsilon_{t,i}$. This restriction ensures that the probability of success is not superior to 1.

[16] The borrower does not modify its behavior following the signal because the information released with the signal was available to it ex ante.

The expected return to the bank from lending to that group of borrowers at interest rate $\hat{r}$ may be written as:

$$\Im_{\varepsilon_t} = \int_0^{p^*(\hat{r})} \left[(1+\hat{r})p(1+\varepsilon_t(p)) + (1-p\ \ (1+\varepsilon_t(p)))R^f - (1+b)\right] g(p)dp\,. \tag{3}$$

The reception of the information signal modifies the expected return to the bank by (subtracting (1) from (3)):

$$\Delta\Im = \Im_{\varepsilon_t} - \Im = \left[(1+\hat{r}) - R^f\right] \int_0^{p^*(\hat{r})} p\varepsilon_t(p)g(p)dp\,. \tag{4}$$

The sign of the difference will depend on the sign of ε_t. For promising borrowers, the bank will expect higher returns than for the initial group of borrowers. For unpromising borrowers, expected returns will be lower. ■

Proposition 1. Period to period sorting of borrowers allows the bank to modify its credit portfolio to maximize its expected profit. Concurrently, the bank monitors borrowers, providing performance incentives to borrowers in the form of contract termination or continuation and/or changes in the interest rate.

At any given period *t*, with no modification of the bank's portfolio, the expected return for the next period is the average between expected profits from promising borrowers and failed returns from unpromising borrowers. After receiving the signal, the bank may maximize its expected profit by keeping promising borrowers in its portfolio, terminating contracts with unpromising borrowers, and reallocating its portfolio to borrowers for which it has no private information but which yield higher average expected returns, equal to $\Im$ (see equation (4)). Because the overall size of the bank's loan portfolio does not change in interim periods,[17] the bank can expand new loans only if it replaces current borrowers by new borrowers, hence the substitution of unpromising borrowers by undistinguishable borrowers. Depending on its profit objectives, the bank may also decide to keep interest rates constant, increasing its profit further by generating excess returns from promising borrowers, or reduce interest rates on promising borrowers, providing them with a performance incentive.[18]

PROOF. If the bank decides not to modify its loan portfolio, its expected profit is unchanged compared with the previous period. By assumption, the average probability of success remains constant, and the average expected return to the bank is unchanged.

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[17] This is true under the assumption that the bank has a fixed stock of deposits and under the additional assumption that any profit generated by the bank is not reinvested but paid of as dividend to shareholders.

[18] The bank does not charge individual borrowers with differentiated interest rates because of partial revelation of information. It does not distinguish individual borrowers among the two groups of promising and unpromising borrowers.

The share of promising borrowers in the bank's loan portfolio is denoted α. By keeping its interest rate constant on promising borrowers, the bank increases its profit on those borrowers by

$$\alpha\left[(1+\hat{r})-R^f\right]\int_0^{p^*(\hat{r})} p\,\varepsilon_t(p)g(p)\,dp .$$

This situation may be observed if promising borrowers are captive borrowers, i.e., if the information signal is only observable by the bank that has financed those borrowers initially, or, as is the case in the model proposed here, if the bank operates in a monopolistic environment. The bank may also opt to lower the interest rate in order to reward promising borrowers and reinforce incentives for good performance.

The share of unpromising borrowers being $(1-\alpha)$, the expected profit to the bank from those borrowers is equal to:

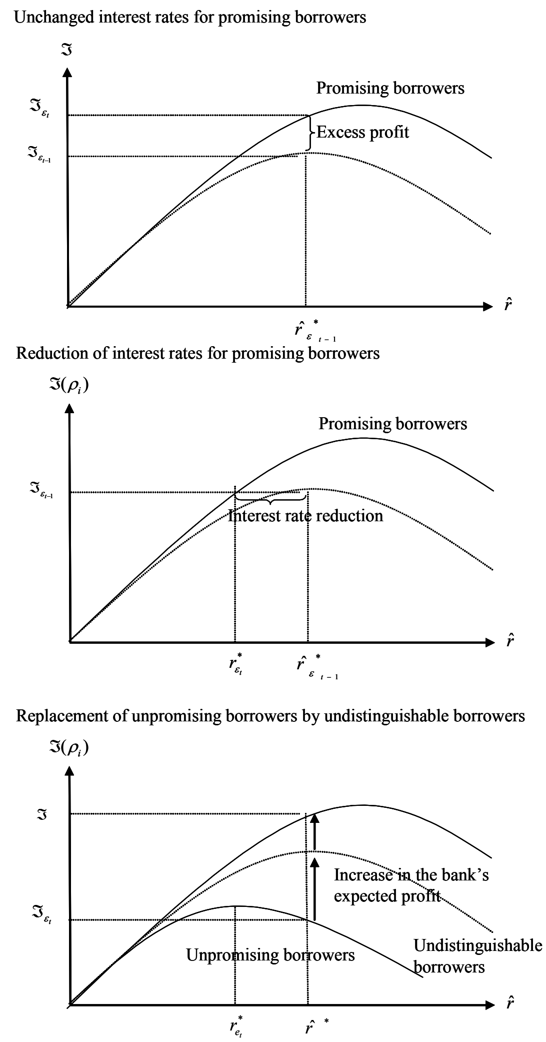
$$(1-\alpha)\int_0^{p^*(\hat{r})}\left[p\,(1+\varepsilon_t(p))(1+\hat{r})+(1-p(1+\varepsilon_t(p)))R^f-(1+b)\right]g(p)\,dp .$$

Following reception of the information signal, the bank leaves interest rates unchanged, keeps promising borrowers, and replaces unpromising borrowers by indistinguishable borrowers. The bank generates an excess profit equal to

$$\alpha\left[(1+\hat{r})-R^f\right]\int_0^{p^*(\hat{r})} p\,\varepsilon_t(p)g(p)\,dp .$$[19] ■

Figure 1 illustrates the outcome of interim monitoring.

Figure 1. Impact of Monitoring on the Expected Profit to the Bank and on Credit Allocation



[19] In this environment, the bank generates excess expected profit at each interim period. The result is a direct consequence of its monopolistic situation. It allows it to extract a rent from promising borrowers, unless the bank decides to lower interest rates to provide them performance incentives.

IV. Termination Costs and Commitment in Bank Lending

This section looks at how the ability of the lender to reallocate its portfolio in order to maximize its profit and monitor borrowers is constrained by the existence of costs associated with the termination of loans. For institutional, administrative, and reputation reasons, it is costly for the bank to exit a loan contract that is performing poorly. As a result, the bank may decide not to act on mixed information signals, but rather accommodate them over time, and act only on very negative signals.

Costs of contract termination are exogenous and denoted *C*. At any period *t*, the bank terminates a loan contract if and only if the cost of termination is smaller than the profit loss, *PL,* incurred by the bank from committing to unpromising borrowers; that is, if and only if $PL \leq C$. The profit loss results from the inability of the bank to reallocate its portfolio away from unpromising borrowers to undistinguishable borrowers due to implicit commitment. The profit loss corresponds to the "investment" undertaken by the bank to acquire private information about borrowers at each interim period. The exit cost at which $PL = C$ is the maximum investment the bank is willing to undertake to obtain information about borrowers.

The profit loss *PL* is calculated as the difference between the expected returns to the bank from undistinguishable borrowers and the expected return from unpromising borrowers. In other words, the profit loss is equal to the change in the expected profit after reception of a negative signal by the bank, as formalized in equation (4):

$$PL = -\left[\Im_{\varepsilon_t} - \Im\right] = -\left[(1+\hat{r}) - R^f\right] \int_0^{p^*(\hat{r})} \varepsilon_t(p) p \; g(p) dp \quad .$$

Proposition 2. Commitment by the bank to unpromising borrowers will depend on the relative magnitude of implicit costs of contract termination and of the information signals received from borrowers at interim period *t*.

Proof. The decision taken by the bank to terminate contracts is subject to $PL \leq C$, or:

$$C \int_0^{p^*(\hat{r})} g(p) dp \geq -\left[(1+\hat{r}) - R^f\right] \int_0^{p^*(\hat{r})} \varepsilon_t(p) p \; g(p) dp \, . \tag{8}$$

There is a threshold for information signals below which the bank does not commit to borrowers. For those borrowers, private information about the probability of success in the period ahead is so negative that the bank prefers to incur the termination cost, liquidate its loans, and lend to finance the projects of undistinguishable borrowers. The threshold ε^* is such that equation (8) holds with equality: $C \int_0^{p^*(\hat{r})} g(p) dp = -\varepsilon^* \left[(1+\hat{r}) - R^f\right] \int_0^{p^*(\hat{r})} p \; g(p) dp$. The threshold is calculated by solving for ε^*:

$$\varepsilon^* = -\frac{C \int_0^{p^*(\hat{r})} g(p)dp}{\left[(1+\hat{r}) - R^f\right] \int_0^{p^*(\hat{r})} pg(p)dp}. \tag{9}$$

The threshold is negative, since the bank will only terminate contracts with unpromising borrowers. The magnitude of the threshold signal leading to contract termination is a positive function of *C*, and a negative function of the return to the bank from undistinguishable borrowers.[20] ■

In a banking environment where banks suffer important agency problems, have weak internal control systems, where the legal system is weak and enforcement of contract termination difficult and costly, and where the bank's reputation is assessed on its ability to retain customers and allocate credit efficiently, implicit costs of contract termination will be high. As a result, only if the bank receives convincing evidence that the expected returns for a borrower are very low will it proceed to terminate a loan contract. For information signals such that $\varepsilon_{t,i} > \varepsilon^*$, the bank will prefer to remain committed to borrowers, even if it incurs a profit loss in the form of forgone revenues.

Proposition 3. By committing to unpromising borrowers, the bank accepts a reduction in its expected profit at each period *t*, however inferior to the profit loss it would incur by terminating its loans on all unpromising borrowers.

PROOF. Denote α_1 as the share of borrowers sending a positive signal $\varepsilon^+_{t,i}$; the share of borrowers sending a negative signal $\varepsilon^-_{t,i}$ such that $0 > \varepsilon^-_{t,i} > \varepsilon^*$ is α_2, and the share of borrowers sending a negative signal $\varepsilon^{--}_{t,i}$ such that $\varepsilon^* > \varepsilon^{--}_{t,i}$ is α_3, with $\alpha_1 + \alpha_2 + \alpha_3 = 1$. The last group of borrowers is designated as "very unpromising borrowers" in the remainder of the paper.

In the presence of costs of contract termination, the bank will renew loans to promising and unpromising borrowers (as shown in proposition 2) and terminate loans with very unpromising borrowers to replace them with undistinguishable borrowers. The expected profit to the bank, $\Im_1$, is compared with two theoretical alternative situations to assess the impact of both the reception of the information signal and of the costs of contract termination. The alternative situations are when the bank replaces all unpromising and very

[20] The information signal threshold is independent of interest payments to depositors. Interest payments remain constant whether the bank commits to unpromising borrowers or relocates to undistinguishable borrowers because the total size of the loan portfolio remains unchanged.

unpromising borrowers by undistinguishable borrowers (i) in the absence of costs of contract termination ($\Im_2$) and (ii) in the presence of costs of contract termination ($\Im_3$).

In the presence of costs of termination and of a threshold ε^* below which the bank decides to terminate loans, the expected profit to the bank is equal to:

$$\Im_1 = \alpha_1 \int_0^{p^*(\hat{r})} \left[(1+\hat{r}) p \left(1+\varepsilon_t^+(p)\right) + \left(1-p\left(1+\varepsilon_t^+(p)\right)\right) R^f - (1+b) \right] g(p)\, dp +$$

$$\alpha_2 \int_0^{p^*(\hat{r})} \left[(1+\hat{r}) p \left(1+\varepsilon_t^-(p)\right) + \left(1-p\left(1+\varepsilon_t^-(p)\right)\right) R^f - (1+b) \right] g(p)\, dp + \alpha_3 \int_0^{p^*(\hat{r})} \left[(1+\hat{r}) p + (1-p) R^f - (1+b) - C \right] g(p)\, dp$$

$$\Im_1 = \int_0^{p^*(\hat{r})} \left[(1+\hat{r}) p \left(1+\alpha_1\varepsilon_{t,i}^+ + \alpha_2\varepsilon_t^-(p)\right) + \left((1-p) - p\left(\alpha_1\varepsilon_t^+(p) + \alpha_2\varepsilon_t^-(p)\right)\right) R^f \right] g(p)\, dp - \int_0^{p^*(\hat{r})} \alpha_3 C + (1+b) g(p)\, dp$$

$$\Im_1 = \int_0^{p^*(\hat{r})} \left[(1+\hat{r}) p + (1-p) R^f - (1+b) \right] g(p)\, dp + \int_0^{p^*(\hat{r})} \left[\left(\alpha_1\varepsilon_t^+(p) + \alpha_2\varepsilon_t^-(p)\right)\left[(1+\hat{r}) - R^f\right] p - \alpha_3 C \right] g(p)\, dp$$

$$\Im_1 = \Im + \int_0^{p^*(\hat{r})} \left[\left(\alpha_1\varepsilon_t^+(p) + \alpha_2\varepsilon_t^-(p)\right)\left[(1+\hat{r}) - R^f\right] p - \alpha_3 C \right] g(p)\, dp . \tag{10}$$

The expected profit to the bank is equal to the expected profit from undistinguishable borrowers plus the excess profit the bank yields from promising borrowers, minus the lower profit it yields from unpromising borrowers to which it commits and minus the termination costs incurred for the share α_3 of borrowers for which it terminates contracts.

In the absence of costs of contract termination, the bank terminates all loans with unpromising and very unpromising borrowers and relocates its portfolio to undistinguishable borrowers. The expected return for the bank is:

$$\Im_2 = \alpha_1 \int_0^{p^*(\hat{r})} \left[(1+\hat{r}) p \left(1+\varepsilon_t^+(p)\right) + \left(1-p\left(1+\varepsilon_t^+(p)\right)\right) R^f - (1+b) \right] g(p)\, dp$$

$$+ (1-\alpha_1) \int_0^{p^*(\hat{r})} \left[(1+\hat{r}) p + (1-p) R^f - (1+b) \right] g(p)\, dp$$

$$\Im_2 = \int_0^{p^*(\hat{r})} \left[(1+\hat{r}) p \left(1+\alpha_1\varepsilon_t^+(p)\right) + \left(1-p - p\alpha_1\varepsilon_t^+(p)\right) R^f \right] g(p)\, dp - \int_0^{p^*(\hat{r})} (1+b) g(p)\, dp$$

$$\Im_2 = \int_0^{p^*(\hat{r})} \left[(1+\hat{r}) p + (1-p) R^f - (1+b) \right] g(p)\, dp + \int_0^{p^*(\hat{r})} \alpha_1\varepsilon_t^+(p)\left[(1+\hat{r}) - R^f\right] p \; g(p)\, dp$$

$$\Im_2 = \Im + \alpha_1\left[(1+\hat{r}) - R^f\right]\int_0^{p^*(\hat{r})} \varepsilon_t^+(p)p\; g(p)dp\,. \tag{11}$$

By keeping promising borrowers and substituting unpromising ones by undistinguishable borrowers, the bank generates an excess profit for the share α of borrowers that are promising.

If the bank were to terminate contracts with all unpromising borrowers, its expected profit from lending in period *t* would be equal to:

$$\Im_3 = \alpha_1 \int_0^{p^*(\hat{r})}\left[(1+\hat{r})p\,(1+\varepsilon_t^+(p)) + (1-p\,(1+\varepsilon_t^+(p)))R^f - (1+b)\right]g(p)dp + (1-\alpha_1)\int_0^{p^*(\hat{r})}\left[(1+\hat{r})p + (1-p)R^f - (1+b) - C\right]g(p)dp$$

$$\Im_3 = \int_0^{p^*(\hat{r})}\left[(1+\hat{r})p\,(1+\alpha_1\varepsilon_t^+(p)) + ((1-p) - p\,\alpha_1\varepsilon_t^+(p))R^f\right]g(p)dp - \int_0^{p^*(\hat{r})}(1-\alpha_1)C + (1+b)g(p)dp$$

$$\Im_3 = \int_0^{p^*(\hat{r})}\left[(1+\hat{r})p + (1-p)R^f - (1+b)\right]g(p)dp + \int_0^{p^*(\hat{r})}\left[\alpha_1\varepsilon_t^+(p)\left[(1+\hat{r}) - R^f\right]p - (1-\alpha_1)C\right]g(p)dp$$

$$\Im_3 = \Im + \int_0^{p^*(\hat{r})}\left[\alpha_1\varepsilon_t^+(p)\left[(1+\hat{r}) - R^f\right]p - (1-\alpha_1)C\right]g(p)dp\,. \tag{12}$$

The expected profits to the bank vary depending on whether it decides to terminate loans with unpromising borrowers. The differences between $\Im_1$, $\Im_2$, and $\Im_3$ are computed as follows:

$$\Im_2 - \Im_1 = \Im + \int_0^{p^*(\hat{r})}\alpha_1\varepsilon_t^+(p)\left[(1+\hat{r}) - R^f\right]p\; g(p)dp - \Im$$

$$- \int_0^{p^*(\hat{r})}\left[(\alpha_1\varepsilon_t^+(p) + \alpha_2\varepsilon_t^-(p))\left[(1+\hat{r}) - R^f\right]p - \alpha_3 C\right]g(p)dp;$$

rearranging yields:

$$\Im_1 - \Im_2 = \alpha_2\int_0^{p^*(\hat{r})} p\;\varepsilon_t^-(p)\left[(1+\hat{r}) + R^f\right]g(p)dp - \int_0^{p^*(\hat{r})}\alpha_3 C g(p)dp\,. \tag{13}$$

Commitment and termination costs affect the expected profit to the bank in two ways, as formalized in equation (13). First, the bank forgoes revenues for the share α_2 of borrowers that it could replace by more profitable undistinguishable ones. Second, the bank incurs costs of contract termination for the share α_3 of borrowers.

However, the bank, through commitment, saves on termination costs and yields higher profits than if it had terminated contracts with all unpromising and very unpromising borrowers, as shown in equation (14):

$$\Im_1 - \Im_3 = \Im + \int_0^{p^*(\hat{r})} \left[\left(\alpha_1 \varepsilon_t^+(p) + \alpha_2 \varepsilon_t^-(p) \right) \left[(1+\hat{r}) - R^f \right] p \; - \alpha_3 C \right] g(p) dp$$

$$- \Im - \int_0^{p^*(\hat{r})} \left[\alpha_1 \varepsilon_t^+(p) \left[(1+\hat{r}) - R^f \right] p \; - (1-\alpha_1) C \right] g(p) dp \;\; ;$$

rearranging yields:

$$\Im_1 - \Im_3 = \alpha_2 \int_0^{p^*(\hat{r})} p \varepsilon_t^-(p) \left[(1+\hat{r}) - R^f \right] g(p) dp \; + \int_0^{p^*(\hat{r})} \alpha_2 C g(p) dp \qquad (14)$$

By terminating all contracts and not committing to α_2 unpromising borrowers, the bank incurs an additional termination cost (the second term of equation (14)) and generates a superior revenue by switching to undistinguishable borrowers (the first term of equation (14)). The superior revenue generated from portfolio reallocation is, however, insufficient to compensate for the termination costs incurred.[21] The bank would therefore expect lower revenues from terminating all contracts compared with committing to those unpromising borrowers who did not send such bad signals. ■

Proposition 4. The ability of the bank to monitor borrowers is constrained by the magnitude of implicit costs of contract termination and by the proportions of promising, unpromising and very unpromising borrowers. The bank may alleviate this constraint by passing part of the costs of implicit commitment to depositors.

Assume that the bank follows an explicit objective for its expected profit. As shown under proposition 1, the bank may generate an excess profit after reception of the information signal. The excess profit may then be used in three ways: (i) to increase the total expected profit to the bank; (ii) to reduce the lending rates on promising borrowers; and (iii) to increase interest rates paid to depositors, thereby fostering financial intermediation. However, the size of the excess expected profit is reduced by the costs of contract termination because the bank needs to generate enough excess returns to compensate for the expected profit loss from unpromising borrowers. This reduces the ability of the bank to monitor borrowers by reducing the threat of contract termination and lowering interest rates on promising borrowers. Hence, commitment results in promising borrowers implicitly subsidizing unpromising borrowers.

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[21] This follows from the fact that, for α_2 borrowers, costs of contract termination are higher than costs of commitment, as demonstrated with equation (9).

In a captive environment where the bank maintains lending and deposit interest rates constant, the bank realizes an excess profit following reception of the information signal. Promising borrowers are charged a constant interest rate in spite of their lower probability of failure, generating an excess profit sufficient to compensate from the profit losses related to implicit commitment and contract termination.

PROOF. Under the assumptions of the model, the reception of the information signal does not affect the average expected profit to the bank but only provides information about the distribution of borrowers. It follows that:

$$\Im_t = \alpha_1 \int_0^{p^*(\hat{r})} \left[(1+\hat{r})p\left(1+\varepsilon_t^{+}(p)\right)+\left(1-p\left(1+\varepsilon_t^{+}(p)\right)\right)R^f\right]g(p)dp + \alpha_2 \int_0^{p^*(\hat{r})} \left[(1+\hat{r})p\left(1+\varepsilon_t^{-}(p)\right)+\left(1-p\left(1+\varepsilon_t^{--}(p)\right)\right)R^f\right]g(p)dp$$
$$+\alpha_3 \int_0^{p^*(\hat{r})} \left[(1+\hat{r})p\left(1+\varepsilon_t^{--}(p)\right)+\left(1-p\left(1+\varepsilon_t^{--}(p)\right)\right)R^f\right]g(p)dp - (1+b)\int_0^{p^*(\hat{r})} g(p)dp = \int_0^{p^*(\hat{r})}\left[(1+\hat{r})p + (1-p)R^f - (1+b)\right]g(p)dp;$$

given $\alpha_1 + \alpha_2 + \alpha_3 = 1$, and re-arranging, yields:

$$\alpha_1 \int_0^{p^*(\hat{r})} \left[(1+\hat{r})p\left(1+\varepsilon_t^{+}(p)\right)+\left(1-p\left(1+\varepsilon_t^{+}(p)\right)\right)R^f\right]g(p)dp + \alpha_2 \int_0^{p^*(\hat{r})} \left[(1+\hat{r})p\left(1+\varepsilon_t^{-}(p)\right)+\left(1-p\left(1+\varepsilon_t^{-}(p)\right)\right)R^f\right]g(p)dp$$
$$+\alpha_3 \int_0^{p^*(\hat{r})} \left[(1+\hat{r})p\left(1+\varepsilon_t^{--}(p)\right)+\left(1-p\left(1+\varepsilon_t^{--}(p)\right)\right)R^f\right]g(p)dp - (1+b)\int_0^{p^*(\hat{r})} g(p)dp = \alpha_1\int_0^{p^*(\hat{r})}\left[(1+\hat{r})p + (1-p)R^f - (1+b)\right]g(p)dp$$
$$+\alpha_2\int_0^{p^*(\hat{r})}\left[(1+\hat{r})p + (1-p)R^f - (1+b)\right]g(p)dp + \alpha_3\int_0^{p^*(\hat{r})}\left[(1+\hat{r})p + (1-p)R^f - (1+b)\right]g(p)dp$$

$$\begin{aligned}&\alpha_1\left[(1+\hat{r})-R^f\right]\int_0^{p^*(\hat{r})} p\,\varepsilon_t^{+}(p)g(p)dp + \alpha_2\left[(1+\hat{r})-R^f\right]\int_0^{p^*(\hat{r})} p\,\varepsilon_t^{-}(p)g(p)dp \\ &+\alpha_3\left[(1+\hat{r})-R^f\right]\int_0^{p^*(\hat{r})} p\,\varepsilon_t^{--}(p)g(p)dp = 0.\end{aligned} \tag{15}$$

Equation (15) formalizes the fact that when the bank leaves its portfolio unchanged after reception of the information signal, its expected profit remains unchanged. The excess profit generated by promising borrowers, the first part of equation (15), compensates exactly for the lower expected profit from unpromising and very unpromising borrowers, the second and third parts of equation (15), respectively.

However, as suggested in the above discussion, the bank modifies its portfolio when it receives information from borrowers, by keeping promising borrowers, committing to unpromising borrowers, and replacing very unpromising borrowers by undistinguishable borrowers. The difference, Δ, between the initial expected profit and the expected profit after reallocation of the bank's credit portfolio is equal to:

$$\Delta = \alpha_1 \int_0^{p^*(\hat{r})} \left[(1+\hat{r}) p \left(1+\varepsilon_t^+(p)\right) + \left(1 - p_i\left(1+\varepsilon_t^+(p)\right)\right) R^f \right] g(p)\, dp + \alpha_2 \int_0^{p^*(\hat{r})} \left[(1+\hat{r}) p \left(1+\varepsilon_t^-(p)\right) + \left(1 - p\left(1+\varepsilon_t^-(p)\right)\right) R^f \right] g(p)\, dp$$
$$+ \alpha_3 \int_0^{p^*(\hat{r})} \left[(1+\hat{r}) p + (1-p) R^f - C \right] g(p)\, dp - (1+b) \int_0^{p^*(\hat{r})} g(p)\, dp - \int_0^{p^*(\hat{r})} \left[(1+\hat{r}) p + (1-p) R^f - (1+b) \right] g(p)\, dp \,;$$

rearranging yields:

$$\Delta = \alpha_1 \left[(1+\hat{r}) - R^f \right] \int_0^{p^*(\hat{r})} p\, \varepsilon_t^+(p) g(p)\, dp + \alpha_2 \left[(1+\hat{r}) - R^f \right] \int_0^{p^*(\hat{r})} p\, \varepsilon_t^-(p) g(p)\, dp - \alpha_3 C \int_0^{p^*(\hat{r})} g(p)\, dp \qquad (16)$$

Rearranging (16) using (15), one obtains

$$\Delta = \alpha_3 C \int_0^{p^*(\hat{r})} g(p)\, dp - \alpha_3 \left[(1+\hat{r}) - R^f \right] \int_0^{p^*(\hat{r})} p\, \varepsilon_t^{--}(p) g(p)\, dp$$

$$\Delta = \alpha_3 \left[C \int_0^{p^*(\hat{r})} g(p)\, dp - \left[(1+\hat{r}) - R^f \right] \int_0^{p^*(\hat{r})} p\, \varepsilon_t^{--}(p) g(p)\, dp \right]. \qquad (17)$$

As shown in proposition 2 and given the definition of very unpromising borrowers, $-C \int_0^{p^*(\hat{r})} g(p)\, dp \geq \left[(1+\hat{r}) - R^f \right] \int_0^{p^*(\hat{r})} p\, \varepsilon_t^{--}(p) g(p)\, dp$. Equation (17) is therefore positive, suggesting that the bank expects an excess profit in the interim period due to portfolio reallocation. The magnitude of the excess profit will determine the extent to which the bank may reduce interest rates on promising borrowers. If costs of contract termination are low and/or the proportion of very unpromising borrowers is high, the bank will have more leeway to reduce such interest rates.

Depending on the flexibility of deposit interest rates, the bank may pass part or all of the cost of implicit commitment to depositors.

By lowering deposit interest rates, the bank modifies its expected excess profit:

$$\hat{\Delta} = \alpha_1 \int_0^{p^*(\hat{r})} \left[(1+\hat{r}) p \left(1+\varepsilon_t^+(p)\right) + \left(1 - p\left(1+\varepsilon_t^+(p)\right)\right) R^f \right] g(p)\, dp + \alpha_2 \int_0^{p^*(\hat{r})} \left[(1+\hat{r}) p \left(1+\varepsilon_t^-(p)\right) + \left(1 - p\left(1+\varepsilon_t^-(p)\right)\right) R^f \right] g(p)\, dp$$
$$+ \alpha_3 \int_0^{p^*(\hat{r})} \left[(1+\hat{r}) p + (1-p) R^f - (1+b) \right] g(p)\, dp - \alpha_3 C \int_0^{p^*(\hat{r})} g(p)\, dp - (1+b_t) \int_0^{p^*(\hat{r})} g(p)\, dp - \int_0^{p^*(\hat{r})} \left[(1+\hat{r}) p + (1-p) R^f - (1+b) \right] g(p)\, dp$$

Given $\alpha_1 + \alpha_2 + \alpha_3 = 1$, and re-arranging, one has:

$$\hat{\Delta} = \alpha_1\left[(1+\hat{r}) - R^f\right]\int_0^{p^*(\hat{r})} p\,\varepsilon_t^+(p)g(p)dp + \alpha_2\left[(1+\hat{r}) - R^f\right]\int_0^{p^*(\hat{r})} p\,\varepsilon_t^-(p)g(p)dp - \alpha_3 C\int_0^{p^*(\hat{r})} g(p)dp - (b_t - b)\int_0^{p^*(\hat{r})} g(p)dp$$

$$\hat{\Delta} = \Delta - (b_t - b)\int_0^{p^*(\hat{r})} g(p)dp \quad . \tag{18}$$

$\hat{\Delta}$ is superior to Δ when the bank may lower the deposit interest rate, hence providing the bank with more leeway to reduce rates on promising borrowers without modifying its expected profit objective. The result provides an explanation for large spreads between lending and deposit rates, in an economic environment where costs of contract termination are high. ■

Following on the argument developed in this section, a different interpretation of the threshold ε^* and the related implicit costs of termination *C* may be provided, as the maximum tolerance of promising borrowers for compensating unpromising borrowers, and of depositors for bearing the costs of the bank's commitment to its credit portfolio, respectively.

V. MONITORING AND COMMITMENT WITH CREDIT HISTORY

In this section, the impact of implicit commitment on the lending behavior of the bank is investigated further, by looking at the process of accumulation over time of information signals received at each period. The assumption used in section IV that information signals are not serially correlated is abandoned, allowing the bank to establish a "credit history" for each borrower, denoted $e_{t,i}$. Commitment to borrowers over time allows the bank to partially palliate the asymmetry of information it faces when lending and to allocate credit more efficiently than in the absence of credit history. Monitoring by the bank is determined by a process of backward-looking accumulation and interpretation of information based on implicit commitment to borrowers.

The decision of the bank to renew or suspend credit to borrowers is modeled within the framework established in section II and, again, the equations in section II are rewritten and modified to take into account the information accumulated by the bank.

The process of information accumulation is formalized as follows. Successive information signals build the bank's expertise with regards to individual borrowers. The definition of promising and unpromising borrowers is amended to account for accumulated information, and promising/unpromising borrowers are borrowers who have a history of positive/negative information signals.

- The informal signal $\varepsilon_{t,i}$ is received at time t. The information signal has the same characteristics as in the previous section;
- Accumulated information is denoted $e_{t,i}$. $\varepsilon_{t,i}$ is aggregated with past information through averaging: $e_{t,i} = e_{t-1,i} + \frac{\varepsilon_{t,i}}{t}$, with $e_{t,i} \subset \left[1; \frac{1}{p}\right]$ if the accumulation of signals is positive, and $0 < e_{t,i} < 1$ if the accumulation is negative. Promising / unpromising borrowers have a higher / lower probability of success than the group as a whole, respectively;
- The average probability of success of the borrowers is remains unchanged at $\overline{p}$. For each subgroup of borrowers, the bank estimates their specific probability of success as $e_{t,i}\overline{p}$, with $\sum_{i=1}^{N} e_{t,i} = 1$, where N is the total number of borrowers in the bank's portfolio. p_i and R_i^s, the individual probability of success and the associated successful return are unobservable by lenders.

One characteristic of the information accumulation process emerges from the specification of $e_{t,i}$: as the bank-borrower relationship extends over time, past information dominates over the signal itself.

The bank is able to reassess the quality of its credit portfolio at each interim period, after it aggregates the new signal with past information. At each interim period *t*, the bank can sort previously undistinguishable borrowers into two subgroups, promising and unpromising. Over time, the bank may improve its interim sorting of borrowers thanks to the successive reception of information signals. Promising borrowers yield higher expected returns than unpromising ones. The bank maximizes its profit by replacing unpromising borrowers by undistinguishable borrowers. The formalization and proofs follow exactly section IV and are presented in appendix 1.

Proposition 5. As a result of both backward-looking information interpretation and implicit commitment to borrowers, information signals have an asymmetric impact on the bank's lending behavior, depending on the nature of the signal and on the borrowers' credit histories.

First, the bank acts differently if the signal received is positive or negative. When the bank receives a positive signal from borrowers, there is no change in its lending behavior: borrowers having sent the signal are retained within the bank's portfolio. The only potential change follows from the fact that the bank may want to lower interest rates on such promising borrowers to provide performance incentives. The impact of a negative information signal may, on the other hand, prompt the bank into action—termination of the lending relationship. Second, the impact of the information signal depends on the credit history of borrowers. Borrowers with a long history of negative information signals will be more exposed to the risk of contract termination than borrowers with a long positive history. This asymmetry is due to backward-looking information interpretation. Through averaging, the bank reduces the magnitude of each new information signal, with the following implications.

- The process of accumulation of information reduces the magnitude of each individual interim information signal through averaging, and reduces the impact of the signal on the expected profit to the bank.

PROOF. At reception of the signal ε_t, the bank revises its assessment of the quality of borrowers by incorporating the signal into past information. As defined earlier, the information used by the bank follows from this incorporation of the signal as $e_{t,i} = e_{t-1,i} + \frac{\varepsilon_{t,i}}{t}$, which is superior to $e_{t-1,i}$ if the signal is positive and inferior to $e_{t-1,i}$ if it is negative. The information signal modifies the profit to the bank by:

$$\Delta\Im_{\varepsilon} = \left[(1+\hat{r}) - R^f\right] \int_0^{p^*(\hat{r})} \frac{\varepsilon_t(p)}{t} p\, g(p)dp . \tag{19}$$

The change in expected profit is smaller by a factor of *t* compared with what it is in the absence of information accumulation (equation (4)). ■

- The borrowers benefit from their long-term relationship with the bank. (i) The threat of contract termination diminishes over time for promising borrowers. (ii) The disciplinary role of monitoring becomes more relevant for unpromising borrowers because the threat of termination is more binding.

PROOF. The emission of a negative signal from borrowers will have a distinct impact depending on the nature of accumulated information. For borrowers with a statistical history of bad news, a small signal may suffice to induce contract termination. For promising borrowers, a succession of negative signals may be needed before the bank decides to act. Formally, the bank will act under an information signal $\varepsilon_{t,i}$ if the signal is such that $\left(e_{t-1,i} + \frac{\varepsilon_{t,i}}{t}\right) < e^*$ or $\varepsilon_{t,i} < \left(e^* - e_{t-1,i}\right) \times t$, where e^* is the threshold that determines whether the bank continues or not to lend to a specific borrower. The magnitude of the signal required for the bank to act will be small if e_{t-1} is close to e^*—that is, if past information has consistently pointed toward the unpromising nature of the borrowers—and large if e_{t-1} is significantly higher to e^*; large if the bank-borrower relationship extends over a long period of time. ■

- With its institutional memory, the bank is less subject to volatility in information signals. For example, the bank would commit to a promising borrower even if that borrower is going through difficult times. The bank also revises only progressively its assessment of unpromising borrowers when good news are received. Because contract termination is costly, the bank's institutional memory has the positive implication of preventing undue contract termination and increasing the expected profit to the bank.

PROOF. In the absence of credit history, the expected profit to the bank would suffer from high volatility of information signals, as it would prompt the bank into regularly terminating contracts on promising borrowers due to occurrences of bad news. With no credit history, the bank terminates its contract with a borrower if the interim information signal is such that $\varepsilon_{t,i} < \varepsilon^*$. However, if the borrower has a promising credit history, with $e_{t-1,i} > 1$, the information signal might represent an exceptional occurrence. The borrower's credit history may be strong enough for the bank to continue to commit to the borrower in spite of the negative signal. As shown above, the signal would have to be such that $\varepsilon_{t,i} < (e^* - e_{t-1,i}) \times t$. Denoting β as the share of borrowers that send such negative signals, the bank would realize higher expected profits from committing to the borrowers equal to:

$$\beta\left[\int_0^{p_i^*(\hat{r})}\left[(1+\hat{r})p_i e_t(p) + (1 - p_i e_t(p))R^f\right]g(p_i)dp_i - \int_0^{p_i^*(\hat{r})}\left[(1+\hat{r})p_i + (1-p_i)R^f\right]g(p_i)dp_i + C\int_0^{p_i^*(\hat{r})} g(p_i)dp_i\right]. \blacksquare$$

- The other consequence of the process of backward-looking information interpretation and implicit commitment is the inability of the bank to detect structural changes in the characteristics of borrowers, whether promising or unpromising.

PROOF. Assume that the quality of a borrower with a promising credit history deteriorates suddenly at period *T*, so that the borrower consistently sends signals $\varepsilon_{t,i}$ such that $\varepsilon_{t,i} \le \varepsilon^*$. With no credit history, the bank would immediately terminate its lending relationship with the borrower. However, due to the process of information accumulation through averaging, it may take a substantial number of periods before the bank decides to act on the negative signals. Specifically, the bank will act when $e_{t,i} \le e^*$. The number *M* of periods is:

$$M = \frac{e^* - e_{T,i}}{\sum_{i=1}^{M} \frac{\varepsilon^*}{T+i}}. \blacksquare$$

VI. CONCLUSIONS

In a framework of information asymmetry between lenders and borrowers, the model presented in this paper shows that a number of features of the debt contract are central in explaining the nature of bank monitoring. Those features include the progressive revelation of the quality of borrowers through successive information signals; the backward-looking process of information accumulation and interpretation; the presence of costs of contract termination for the bank; and, finally, the implicit commitment of the bank to renew the debt contract over time.

Several characteristics of the bank lending process are shown to emerge under the assumptions of the model. The need to commit to borrowers to alleviate problems of asymmetric information and the presence of high costs of contract termination provide an explanation for the accumulation of nonperforming loans on the balance sheets of banks. In an environment with poor information dissemination, high institutional and administrative rigidities, and agency problems, the model shows that costs of contract termination may be so high that banks prefer to keep nonperforming borrowers on their balance sheets. This behavior would be amplified if reasons for commitment are noneconomic, such as red tape and connected lending. Further, these costs explain the preference of banks for borrowers with well-known production functions and little variability in returns over time. Finally, in the environment of the model, the existence of a spread between deposit and lending rates follows from commitment to unpromising borrowers. In effect, the bank may only sustain commitment if it expects excess profit from other borrowers. As a result, it will maintain high interest on promising borrowers, and low interest rates paid to depositors, widening the spread between the two rates. It may do so more easily if competition in the banking sector is limited, as is the case in a monopolistic environment.

The model opens avenues for further research. An immediate extension would be to consider a competitive banking environment. Competition would affect the argument in two ways. First, the bank's market power with depositors would subside, reducing the ability of banks to pass the cost of commitment to depositors. Second, the impact on lending will depend on the ability of borrowers to credibly signal interim status (promising or unpromising) to competing banks. If this information is private to the bank with which the borrower has a preexisting lending relationship, the results of the model are unchanged. It is optimal for the borrower to remain loyal to its bank. The bank creates an ex post informational monopoly, for which it pays the costs of committing to unpromising borrowers. If information is partially or totally available to competing banks, promising borrowers may obtain lower lending rates, which prevent banks from compensating commitment costs by excess returns on promising borrowers. With information publicly available, banks would lose the benefits of commitment.

On a broader macroeconomic level, the paper shows that, when distortions to the functioning of the credit market are high—high asymmetry of information between lenders and borrowers, little competition in the banking sector, high implicit costs of contract termination—the economic costs associated with bank lending may be high. First, the soundness of banks may be at risk due to large volumes of nonperforming loans. Second, the financing of economic growth may be concentrated to a few well-established industries. Third, the volume of credit may be constrained by high interest rates on borrowers, and low interest rates to depositors.

Appendix. Implicit Commitment with Credit History: Formalization

The process of information accumulation and implicit commitment is modeled following closely the formalization in Section IV.

First, with accumulated information, the bank reduces the asymmetry of information between itself and the borrowers and may sort the later into groups of promising and unpromising borrowers.

The expected return to the bank from a single borrower, net of interest payments to depositors, is:

$$E_{e_{t,i}} = e_{t,i}(p)p_i(1+\hat{r}) + (1 - e_{t,i}(p)p_i)R^f - (1+b). \tag{A1}$$

The expected return to the bank from lending to that class of borrowers at interest rate $\hat{r}$ may be written as:

$$\Im_{e_t} = \int_0^{p^*(\hat{r})} \left[(1+\hat{r})e_t(p)p + (1 - e_t(p)p)R^f\right] g(p)dp - (1+b)\int_0^{p^*(\hat{r})} g(p)dp \ . \tag{A2}$$

The accumulation of information modifies the expected return to the bank by:

$$\Delta\Im = \Im_{e_t} - \Im = \left[(1+\hat{r}) - R^f\right] \int_0^{p^*(\hat{r})} p\ (e_t(p) - 1)g(p)dp \ . \tag{A3}$$

The sign of the difference will depend on the sign of $(e_t - 1)$. For promising borrowers, the bank will expect higher returns than for the initial group of borrowers. For unpromising borrowers, expected returns will be lower.

Second, the bank modifies its loan portfolio to maximize its expected profit. The bank maximizes profit by keeping promising borrowers in its portfolio, and reallocating its portfolio away from unpromising borrowers, to borrowers for which it has no private information, as those yield higher average expected returns than unpromising borrowers.

The share of promising borrowers in the bank's loan portfolio is denoted α. By keeping its interest rate constant on promising borrowers and replacing unpromising borrowers by undistinguishable borrowers, the bank increases its profit by

$\alpha\Delta\Im_t = \alpha\left[(1+\hat{r}) - R^f\right] \int_0^{p^*(\hat{r})} (e_t(p) - 1)p\ g(p)dp$. On the share $(1-\alpha)$ of undistinguishable borrowers that replace unpromising ones, the expected profit to the bank is equal to the initial expected profit, so the increase in profit is due to the excess return made on promising borrowers.

Third, the bank has to incur costs of contract termination when exiting a contract with a borrower. Costs of contract termination, denoted C, are assessed relatively to the profit loss PL the bank faces when it commits to unpromising borrowers. The profit loss is estimated as the difference between expected profit from undistinguishable borrowers and expected profit from unpromising borrowers: $PL = -\left[(1+\hat{r}) - R^f\right] \int_0^{p^*(\hat{r})} (e_t(p) - 1)p \; g(p)dp$, which follows from equation (A3).

There exists a threshold based on the accumulated information below which the bank does not commit to borrowers. The threshold, denoted e_t^*, is such that $C = PL$, or $C \int_0^{p^*(\hat{r})} g(p)dp = -\left[(1+\hat{r}) - R^f\right] \int_0^{p^*(\hat{r})} (e^* - 1)p \; g(p)dp$. The threshold is calculated by solving for e_t^*:

$$e^* = 1 - \frac{C \int_0^{p^*(\hat{r})} g(p)dp}{\left[(1+\hat{r}) - R^f\right] \int_0^{p^*(\hat{r})} p \; g(p)dp} . \qquad \text{(A4)}$$

The threshold is inferior to 1, consistent with the fact that the bank will only terminate contracts with unpromising borrowers. The magnitude of the institutional memory leading to contract termination is a positive function of *C*, and a negative function of the return to the bank from undistinguishable borrowers.

Fourth, commitment to unpromising borrowers lowers the expected profit to the bank, but not as much as the termination of contracts on all unpromising borrowers would.

The share of borrowers with a positive credit history is denoted α_1, and the accumulated information e_t^+; the share of borrowers with negative credit history e_t^- such that $0 > e_t > e^*$ is α_2; and the share of borrowers with very negative credit history e_t^{--} such that $\varepsilon^* > \varepsilon_t$ is α_3; with $\alpha_1 + \alpha_2 + \alpha_3 = 1$.

1. In the presence of costs of termination and of a threshold e^* below which the bank decides to terminate loans, the expected profit to the bank is equal to:

$$\Im_1 = \alpha_1 \int_0^{p^*(\hat{r})} \left[(1+\hat{r})p \; e_t^+(p) + (1 - p \; e_t^+(p))R^f - (1+b)\right] g(p)dp \; +$$

$$\alpha_2 \int_0^{p^*(\hat{r})} \left[(1+\hat{r})p \; e_t^-(p) + (1 - p \; e_t^-(p))R^f - (1+b)\right] g(p)dp \; + \alpha_3 \int_0^{p^*(\hat{r})} \left[(1+\hat{r})p + (1-p)R^f - (1+b) - C\right] g(p)dp$$

$$\Im_1 = \Im + \left[(1+\hat{r}) - R^f\right] \int_0^{p^*(\hat{r})} p \left[\alpha_1 (e_t^+(p) - 1) + \alpha_2 (e_t^+(p) - 1)\right] g(p)dp \; - \alpha_3 C \int_0^{p^*(\hat{r})} g(p)dp .$$

The expected profit to the bank is equal to the expected profit from undistinguishable borrowers plus the excess profit the bank yields from promising borrowers, minus the lower profit it yields from unpromising borrowers to which it commits, and minus the termination costs incurred for the share α_3 of borrowers for which it terminates contracts.

2. In the absence of costs of contract termination, the bank terminates all loans with unpromising borrowers and relocates its portfolio to undistinguishable borrowers. The expected return for the bank is:

$$\Im_2 = \alpha_1 \int_0^{p^*(\hat{r})} \left[(1+\hat{r}) p\, e_t^+(p) + \left(1 - p e_t^+(p)\right) R^f - (1+b) \right] g(p)\, dp$$
$$+ (1-\alpha_1) \int_0^{p^*(\hat{r})} \left[(1+\hat{r}) p + (1-p) R^f - (1+b) \right] g(p)\, dp$$
$$\Im_2 = \Im + \left[(1+\hat{r}) - R^f \right] \alpha_1 \int_0^{p^*(\hat{r})} p \left(e_t^+(p) - 1 \right) g(p)\, dp \ .$$

By keeping promising borrowers and substituting unpromising ones by undistinguishable borrowers, the bank generates an excess profit for the share α_1 of borrowers that are promising.

3. If the bank were to terminate contracts with all unpromising borrowers, its expected profit from lending in period *t* would be equal to:

$$\Im_3 = \alpha_1 \int_0^{p^*(\hat{r})} \left[(1+\hat{r}) p\, e_t^+(p) + \left(1 - p e_t^+(p)\right) R^f - (1+b) \right] g(p)\, dp + (1-\alpha_1) \int_0^{p^*(\hat{r})} \left[(1+\hat{r}) p + (1-p) R^f - (1+b) - C \right] g(p)\, dp$$
$$\Im_3 = \Im + \left[(1+\hat{r}) - R^f \right] \alpha_1 \int_0^{p^*(\hat{r})} p \left(e_t^+(p) - 1 \right) g(p)\, dp - (1-\alpha_1) C \int_0^{p^*(\hat{r})} g(p)\, dp \ .$$

The expected profit to the bank varies depending on whether it decides to terminate loans with unpromising borrowers. The differences between $\Im_1$, $\Im_2$, and $\Im_3$ are computed as follows:

$$\Im_1 - \Im_2 = \alpha_2 \left[(1+\hat{r}) + R^f \right] \int_0^{p^*(\hat{r})} p \left(e_t^-(p) - 1 \right) g(p)\, dp - \alpha_3 C \int_0^{p^*(\hat{r})} g(p)\, dp \ . \qquad \text{(A5)}$$

Commitment and costs of contract termination affect the expected profit to the bank in two ways, as described in equation (A5). First, the bank foregoes revenues for the share α_2 of borrowers that it could replace by more profitable undistinguishable. Second, the bank terminates contracts for the share α_3 of borrowers, and incurs costs of contract termination.

However, the bank, through commitment, saves on termination costs and yields higher profits than if it had terminated contracts with all unpromising borrowers, as shown in equation (A6).

$$\Im_1 - \Im_3 = \alpha_2 \left[(1+\hat{r}) - R^f\right] \int_0^{p^*(\hat{r})} p \left(1 - e_t^-(p)\right) g(p)\, dp + \alpha_2 C \int_0^{p^*(\hat{r})} g(p)\, dp \ . \qquad \text{(A6)}$$

By terminating all contracts and not committing to α_2 unpromising borrowers, the bank incurs an additional termination cost (the second term of equation (A6)), and generate a superior revenue by switching to undistinguishable borrowers (the first term of equation (A6)). The superior revenue generated from portfolio reallocation is however insufficient to compensate for the termination costs incurred. The bank would therefore expect lower revenues from terminating all contracts compared to committing to those unpromising borrowers who did not send such bad signals, as indicated by the positive sign of equation (A6).

Fifth, the impact of the credit history of borrowers depends on the proportions of promising, unpromising and very unpromising borrowers and on the magnitude of the implicit costs of termination.

The impact of the reception of the information signal on the expected profit to the bank is computed as the difference between its expected profit in the absence of private information and the expected profit after reception of information signals:

$$\Im_1 - \Im = \Im + \left[(1+\hat{r}) - R^f\right] \int_0^{p^*(\hat{r})} p \left[\alpha_1\left(e_t^+(p) - 1\right) + \alpha_2\left(e_t^+(p) - 1\right)\right] g(p)\, dp - \alpha_3 C \int_0^{p^*(\hat{r})} g(p)\, dp - \Im \, ;$$

rearranging yields:

$$\Im_1 - \Im = \left[(1+\hat{r}) - R^f\right] \int_0^{p^*(\hat{r})} p \left[\alpha_1\left(e_t^+(p) - 1\right) + \alpha_2\left(e_t^+(p) - 1\right)\right] g(p)\, dp - \alpha_3 C \int_0^{p^*(\hat{r})} g(p)\, dp \ . \qquad \text{(A7)}$$

The first term in equation (A7) is positive. $\alpha_1\left(e_t^+(p) - 1\right) + \alpha_2\left(e_t^-(p) - 1\right) \geq 0$ under the assumptions that the average return for the pool of borrowers remains unchanged after reception of the information signal and that $(1+\hat{r}) \geq R^f$.

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