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ABSTRACT

Project Monitoring and Banking Competition under Adverse Selection

by Vesa Kanniainen and Rune Stenbacka*

We develop an analysis of ex ante monitoring of risky projects in banking. If protected from competition, banks are more concerned about not catching good risk projects when the perceived state of the economy improves, while they are more concerned about being induced to finance bad risk projects when conditions deteriorate. A monopoly bank provides the socially optimal ex ante monitoring of good risks, but is too conservative with regard to bad risks. Competition between banks is shown to undermine the incentives to avoid decision errors regarding both good and bad risk projects providing too limited monitoring effort from society's point of view.

ZUSAMMENFASSUNG

Projektsteuerung und Bankenwettbewerb bei adverser Selektion

In dem Beitrag wird ein Modell zur Auswahl von risikobehafteten Projekten durch Banken entwickelt. Wenn Banken vor Wettbewerb geschützt werden, dann legen sie unter guten wirtschaftlichen Bedingungen mehr Wert darauf sich keine Projekte mit gutem Risiko entgehen zu lassen, wohingegen sie, wenn sich die Bedingungen verschlechtern eher darauf achten keine schlechten Projekte zu finanzieren. Eine monopolistische Bank leistet die sozial-optimale Auswahl guter Risiken, aber die Selektion ist zu konservativ im Hinblick auf schlechte Risiken. Es wird gezeigt, daß Wettbewerb zwischen den Banken dazu führt, daß die Anreize fehlerhafte Entscheidung zu vermeiden sowohl im Hinblick auf Projekte mit guten als auch für Projekte mit schlechten Risiken zu gering sind. Die gesellschaftliche Wohlfahrt sinkt, weil Banken zu wenig in Projektauswahl investieren.

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I. Introduction

In the aftermath of the financial crises, experienced earlier in several western countries and more recently in Southeast Asia, the issue of how the lending market structure affects the banks' risk exposure is at the center of economic discussion. Many observers have questioned the incentives of the private banking industry to adequately evaluate projectholders' risks suggesting that these incentives may be sensitive to the business cycles as well as to the market structure in the banking industry. Such a financial crisis took place in the USA in the 1980s and Japan is facing its crisis in the 1990s without ignoring that many European banks have also experienced financial distress during the last decade. The most severe banking crisis in the monetary history of the Scandinavian countries has recently generated exceptionally high credit losses and bad debts.[1] The crises emerged not long after thoroughgoing deregulation of the banking industries in these countries. In light of this experience, more research effort should evidently be directed to the question whether private banks have sufficient incentives to invest in project-specific *ex ante* monitoring and in what way these incentives are related to the nature of competition in banking. This issue is addressed in the current paper.

One should also ask how the monitoring effort of banks is related to undiversifiable economy-wide risks at the macro level? We should highlight the fact that the seeds of for example the Scandinavian banking crises were laid in the 1980s, during a period which was understood to be a period of steady macroeconomic growth and optimistic expectations of the future states of the economies. Is it thus plausible that optimistic expectations reduce the incentives for banks to defray costly monitoring effort and thereby engage in excessive risk-taking? What exactly is the relationship between the undiversifiable risks and the incentives of banks to become engaged in project-specific monitoring?

In light of the existing theory of banking, explanations are hard to find. It is not sufficiently well understood how risky finance gets allocated through the banking system and in which way banks evaluate economic risks.[2] Our focus in this paper will be on *ex ante* incentives of evaluating risks properly instead of exploring the banking crises from an *ex post* perspective. The ultimate question "what's different about banks?"

continues to be a most fundamental question. This is the question raised by Fama (1985) who suggested that the fundamental output of a banking firm is information. This view should not come as a surprise given the earlier studies dating back to the 1970s which have suggested that informational asymmetries limit banks' ability to sign first-best contracts with their customers. One is tempted to suggest that the failure of banks to produce the required information about private projects lies at the heart of the recent banking crises.

It is an established approach to view banks as financial intermediaries which economize on costs of monitoring on behalf of depositors (Diamond (1984)). In an important branch of the literature, the idea of costly state verification (Townsend (1979), Gale and Hellwig (1985), Williamson (1986)) has pointed to the banks' role in the *ex post* monitoring of contracts which determine the sharing of risky returns. Monitoring of such a type, however, limits the bank's role to the act of finding out whether correct information has been provided by the firm regarding the state of nature after resolution of uncertainty. There are other aspects of monitoring that appear to be important for the theory of financial intermediaries. The *ex ante* costs of information acquisition certainly represent one such aspect. The important question therefore is how successful banks are in screening and monitoring credit applications *ex ante*. Such *ex ante* monitoring is necessary if the projectholders do not have credible means, such as sufficient collateral, of signaling their type to financiers. It is reasonable to view the intermediaries as institutions which possess a comparative advantage in *ex ante* monitoring.

It is reasonable to view projectholders as having private information regarding their projects compared to the information of banks or their depositors. The banks thus face a fundamental problem of adverse selection, first properly analyzed by Stiglitz and Weiss (1981) and subsequently elaborated by Bester (1985), Clemenz (1986) and Milde and Riley (1988) in various directions. To make sure, the literature on banks and credit contracts has not left unrecognized the role of banks in providing *ex ante* monitoring of risky investment projects. Chan, Greenbaum and Thakor (1986) introduced the idea of optimal screening of bank's borrowers suggesting that the probability of loan default is related to screening. Broecker (1990) also introduced the mechanism of credit testing recognizing the fundamental property that competition in lending rates tends to reduce the average quality of loans. However, he assumed costless testing of loan applicants (i.e. requiring no investment) with predetermined chance of evaluating risks correctly, thus abstracting from the banks' monitoring decisions. Similarly, Riordan (1993) has applied auction theory to the bank loan market and demonstrated how more intense competition may damage market performance. Riordan's model, however, also focuses on banks making funding decisions based on signals with exogenous statistical properties. In Diamond (1991), there is a fixed cost of monitoring which provides random information; the monitoring effort is not, however, endogenized. In the presence of costly screening, Wang and Williamson (1994) have examined the optimality of debt contracts and shown how debt contracts can serve as a screening mechanism whereby low-risk customers are separated out from the pool of applicants. In their model, the bank can fully learn the type of the customer. In Holmström and Tirole (1997), moral hazard makes the bank pay a fixed cost of monitoring to reduce the incentives of projectholders for private rent-seeking. Again, monitoring effort is not optimized. The idea of *ex ante* monitoring is also introduced by Caminal and Matutes (1997) in a model of moral hazard where the bank can, but need not, monitor the clients at stochastic cost.[3] In contrast to the previous literature, we introduce costly but imperfect monitoring into a model *where banks optimally determine the classification errors*. The idea of endogenizing lenders' information acquisition and relating it to the market structure in the lending market has earlier *informally* been suggested by Riordan (1993). Our paper introduces a formal analysis of how the monitoring incentives of banks can be explained by structural features such as the lending market structure as well as the state of the economy measured as proportion of creditworthy projects. It also demonstrates an important property of rational customer evaluation in banking: different monitoring intensities are required for the optimal evaluation of good and bad risks. Within the framework of an analysis independent and complementary relative to ours, Gehrig (1998) has recently developed a model where banks can strategically adjust the characteristics of creditworthiness tests by investing in a screening technology. With the screening intensity summarized by one variable capturing signal quality, Gehrig provides conditions under which screening efforts are reduced by competition. In such a case competition would cause the quality of overall loan portfolios to decline making the economy incur higher risks.

The procedures of project-specific monitoring obviously relate to the market structure of the lending market as well as to the internal organization of banks. In a general context, not restricted to loan markets, Sah and Stiglitz (1986) have earlier analyzed alternative ways of organizing the selection of projects to be funded.[4] They compare the quality of project selection within hierarchies and polyarchies from the point of view of the two possible classification errors. There appears to be an analogy between their approach and ours, but our focus is on the relationship between monitoring and the external market structure rather than on issues of internal organization.

The Scandinavian experiences suggest that dilution of banks' interest in *ex ante* monitoring coincides with mistaken beliefs about future economic conditions and the radically changed nature of strategic competition in the post-deregulation period.[5] In the present paper, we first characterize a bank's optimal investment in project-specific *ex ante* monitoring in the absence of competing intermediaries. By monitoring we mean an *ex ante* evaluation of a project intended to classify its future return distribution based on processing information such as the projectholder's history and reputation, the firm's current assets and its perceived competence as well as the nature of the industry in which the projectholder operates. We view monitoring as an instrument for the bank to alleviate the problem of asymmetric information. From the bank's point of view, access to a monitoring technology is equivalent to access to inside information concerning the projectholders. Investment in such a technology is taken to be costly for the bank, but is taken to lead to improved judgement about the credit worthiness of each potential customer. Monitoring is, however, an imperfect instrument in the sense that the bank will always be subject to two kinds of decision errors.

The perceived state of the economy will be shown in our model to be one of the key determinants of banking behavior. We establish some fundamental theorems of *ex ante* monitoring. Firstly, a profit maximizing bank will become more concerned about losing good risk projects when the perceived state of the economy becomes better, while it becomes more concerned about being induced to finance bad risk projects when the perceived state of the economy worsens. Secondly, as commitments to sharing of customer-specific information cannot be regarded as credible, competition between banks undermines the incentives to control both good and bad risks when compared to a bank operating in the absence of competition, subject to the qualification that the lending rate competition is not too intense. Thus, our paper identifies a trade-off between the degree of banking competition and the incentives for banks to acquire information. Competition is detrimental to monitoring incentives, reducing the quality of customers and resulting in higher average failure probability. Thirdly, the normative part of our analysis suggests an important message from the point of view of what constitutes an optimal market structure of the lending industry from the point of view of information acquisition. We will show that a monopoly bank will provide a socially optimal amount of monitoring of good risks, while introduction of competition into the monopoly market will reduce the monitoring incentives. In fact, a banking duopoly will achieve a monitoring intensity which is unambiguously insufficient from the social point of view. However, we find the monopoly bank to be too conservative in its evaluation of bad risks investing too much in detection of bad risks. In contrast, bank duopolists will typically underinvest in monitoring of bad risks relative to the social optimum. Our analysis of competition in monitoring suggests a welfare-improving role for coordination of monitoring activities of competing banks. As a logical consequence, a jointly operated institution for credit evaluation would generate unambiguous welfare gains relative to noncooperative monitoring competition.

Our study first outlines the model and the assumptions used in the analysis. In section III, we provide a motivation for *ex ante* monitoring. In section IV, we focus on optimal investments in monitoring on behalf of a bank operating in the absence of competition. Section V provides an analysis of the impact of banking competition on investment in project-specific monitoring. Section VI reports our welfare analysis. Finally, we summarize and discuss some of the implications of our analysis in Section VII.

II. A Model with Costly and Imperfect Monitoring

We assume that there are N risky projects. They are taken to be of just two types, low-risk (L) or high-risk (H). Each project requires one unit of funding. For our purposes, it is useful to adopt the widely employed tradition by assuming that projectholders do not have access to outside equity capital. The model is built so that banks favor debt contracts and the projects will be fully financed by debt. Debt turns out to be the optimal form of finance in the current context in the sense that there is no other contract type which could improve the outcome. To focus exclusively on the issues of *ex ante* monitoring and selection of customers it is appropriate to abstract from collateral.[6]

The deposit market is taken to be competitive at zero interest. We share the assumption of riskless deposits with most models of lending markets. Alternatively, the deposit insurance premium is assumed constant and taken to be zero.[7] We assume that a project of type i (i=L,H) has a success probability p_i and a corresponding return under success, R_i, satisfying

Assumption 1. $p_L > p_H$; $p_L R_L > 1 > p_H R_H$; R_H ³ $R_L > 1$.

Such a return structure has been widely employed in the banking literature with its focus on asymmetric information. Under failure, both types of projects generate a return of zero and are protected by limited liability. It follows from *Assumption 1* that $p_H R_L < 1$. The expected net social value of an L-project is thus assumed to be positive while that of an H-project is assumed to be negative. If the bank's lending rate is r_B, the participation constraint of an H-firm in terms of its expected profit reads as $E[P_H] = p_H[R_H\text{-}(1+r_B)] \geq 0$. Under this condition, the H-project is privately, though not socially, valuable. However, under the participation constraint of the H-firm, the bank's expected profit from such a firm will be $E[\pi_B^H] = p_H(1+r_B)\text{-}1 \leq p_H R_H\text{-}1 < 0$. It follows that it will be optimal for the bank to finance L-projects only, trying to abstain from financing H-projects. The projectholders of H-type, however, would have an incentive to raise finance; under a failure, the H-types would be protected by the limited liability while under success they would reap part of the upper tail of the probability distribution. Thus, our model exhibits the well-known conflict of interests between the bank and the projectholders of type H. Such a set up serves the purpose of analyzing normative issues related to project-specific information acquisition within the banking industry.

The relative share of L-type loan applicants is assumed to be λ. As the focus of our paper is on project-specific evaluation of clients for idiosyncratic risks rather than on banks' investigation of industry-wide or economy-wide risks, we assume that the bank knows λ.[8] Because of asymmetric information and in the absence of credible signaling, the bank is unable to identify the type of the projectholder unless it invests *ex ante* in a technology facilitating monitoring of the loan applicant. But, even if the bank does so it can hope for no more than imperfect signals in our model and we will work with the key assumption that the precision of the bank's monitoring is an increasing function of the resources directed towards these activities.[9]

We build our model as follows. Initially, the bank obtains N loan applications where λ is the share of L-type applications. Without monitoring effort, the bank cannot do better than assign a "label" to each application resorting only to its knowledge of λ. The bank can, however, do better. It has access to a monitoring technology, though an imperfect and costly one. This means that fully correct classification cannot be achieved except at infinite *ex ante* cost. Therefore, our model has the property that even if the bank processes information, and hence is better able to evaluate risky projects than are its depositors, its information continues to be more limited than that of the projectholders. We will provide a theory of the optimal classification errors α and β which are regarded as the *decision variables of the bank*, therefore telling something about the quality of the bank's monitoring technology.[10]

We define the resulting classification errors through conditional probabilities as

$$(1) \qquad P(H|L) = \alpha\,; \qquad\qquad P(L|H) = \beta.$$

Thus, α denotes the probability that an L-type project will be mis-classified as H while β measures the probability that an H-type applicant gets mis-labelled as L. It follows that the probabilities of correct classifications are $P(L|L) = 1\text{-}\alpha$ and $P(H|H) = 1\text{-}\beta$. To summarize, we have for the pool of projects

$\lambda\alpha N$ projects of type L misclassified as H,

$\lambda(1\text{-}\alpha)N$ projects of type L correctly classified as L,

$(1\text{-}\lambda)\beta N$ projects of type H misclassified as L,

$(1\text{-}\lambda)(1\text{-}\beta)N$ projects of type H correctly classified as H.

The perceived state of the economy, λ, can be expected to interact with the type of classification error the bank is most concerned with. Expecting a good state, the bank might be more concerned about losing good risk projects (the α-error), though it is precisely the misjudgment of bad risks (β-error) which, in the bad state of nature, causes the credit losses. Below we will establish that this intuition is correct.

Costs of monitoring are introduced through

Assumption 2. *A bank can invest ex ante in a monitoring technology. The cost of such an investment, to be called cost of monitoring, is a decreasing, separable and convex function of the classification errors* α, β, *and is given by* $a(\alpha) + b(\beta)$, *satisfying (A1)* $a'(\alpha) < 0$, $a''(\alpha) > 0$ *with the boundary conditions* $a(1-\lambda) = 0$, $\lim_{\alpha \to 0} a(\alpha) = \infty$, $a'(1-\lambda) = 0$; *(A2)* $b'(\beta) < 0$, $b''(\beta) > 0$ *with the boundary conditions* $b(\lambda) = 0$ *and* $\lim_{\beta \to 0} b(\beta) = \infty$, $b'(\lambda) = 0$.

We thus follow Broecker (1990) by introducing test procedures to evaluate the two types of decision errors but we *endogenize* the testing procedure. A natural interpretation of our monitoring technology is that each customer is evaluated through two different tests, one intended to detect α-errors and the other one to detect β-errors. Sah and Stiglitz (1986) have already demonstrated how α- and β-type errors are linked to the organization structure. In our model, the separation of α- and β-errors could be seen as a result of organizational commitments whereby detection of the different errors is assigned to different agencies within the organization. Also, our model will characterize the optimal allocation of resources directed to detecting the two different types of classification errors.

Since, as we will see, it turns out that the classification errors have different marginal impact on the bank's profits, it would not, in general, be optimal for the bank to maintain equal monitoring intensities ($\alpha = \beta$) with respect to both types of classification errors. Our cost of monitoring shares the convexity property with the model of Chan, Greenbaum and Thakor (1986), but in contrast to their analysis we assume that some of the high-risk projects can be successfully screened out *ex ante*.

Assumptions *(A1)-(A2)* imply that perfect monitoring is not feasible, since it would require infinite resources. If the bank assigns the labels randomly, rationally exploiting only its prior information on λ, it will face maximal classification errors satisfying $P(H|L) = \alpha_0 = 1-\lambda$, $P(L|H) = \beta_0 = \lambda$. To see this, note that the bank labels λN

firms as L and $(1-\lambda)N$ as H. However, it understands that some applicants are misclassified. It is rational to conclude that in the sub-group of the λN firms labelled as L there are only $\lambda^2 N$ L-firms and that $(1-\lambda)\lambda N$ are H-firms. It follows that $\lambda(1-\lambda)N$ of the L firms also carry the H-label i.e. get mislabelled. Therefore $(1-\lambda)^2 N$ of the truly H-firms get labelled as H. Consequently, it must hold that $P(L \mid H) = \lambda$.

Given the bank's commitment to a particular monitoring effort (α,β), we define two additional functions:

$$(2) \quad \tau(\alpha,\beta) = \frac{\lambda(1-\alpha)}{\lambda(1-\alpha)+(1-\lambda)\beta}; \quad \rho(\alpha,\beta) = \frac{(1-\lambda)(1-\beta)}{\lambda\alpha+(1-\lambda)(1-\beta)}$$

In (2), $\tau(\alpha,\beta)$ stands for the probability that firms which are classified as type L indeed are of type L and $\rho(\alpha,\beta)$ is the probability that firms classified as type H indeed are of type H respectively, conditional on the stated monitoring effort. It is reasonable to think of $\tau(\alpha,\beta)$ as a measure of the quality relative to L-type classifications, while $\rho(\alpha,\beta)$ denotes the quality applied to H-type classifications. We notice that $\lambda < \tau(\alpha,\beta) < 1$ and $1-\lambda < \rho(\alpha,\beta) < 1$. For subsequent purposes we notice $\partial\tau/\partial\alpha = -\lambda(1-\tau)/[\lambda(1-\alpha)+(1-\lambda)\beta] < 0$, and $\partial\rho/\partial\beta = -(1-\lambda)\tau/[\lambda(1-\alpha)+(1-\lambda)\beta] < 0$; it also holds that $\partial\tau/\partial\beta < 0$, $\partial\rho/\partial\alpha < 0$. It turns out that the τ-function, the ability to classify the good risks correctly, will play a key role in the subsequent analysis; it is therefore important to highlight that α and β enter in a different way in (2).[11] This finding emphasizes the importance of the technological assumptions of our model, i.e. the separation of α- and β-risks.

In the next section we will review the bank's optimal interest rate policy in the absence of monitoring. In particular, we demonstrate how information asymmetries will generate adverse selection phenomena which can possibly make the credit market break down.

III. Why Ex Ante Monitoring?

Consider initially, if only as a benchmark case, the full information equilibrium. Assume for a moment that the bank can fully verify the types of potential projects; there are no informational asymmetries *ex ante* and no *H*-firm would be funded. However, verifying the *ex post* state is assumed to be costly. In such a context, a debt contract dominates over an equity contract because the debt contract provides social benefits arising from economization on verification costs.[12] Since, and trivially, the bank's expected profit is linear in r_B, the interest rate on *L*-projects, it is optimal for the bank to reap all the surplus from each project to itself subject to the participation constraint of the projectholder.

If the projectholders cannot signal their type and if the bank is not engaged in *ex ante* monitoring, there must be a pooling equilibrium under adverse selection meaning a single interest rate. Debt contracts continue to be optimal: no projectholder has an incentive to misreport (cf. Boyd and Smith (1993)). With equity financing, all projects should be monitored *ex post* with a substantial social deadweight loss due to excessive verification costs. If the bank chooses $r_B > R_L$-1, the participation constraint of the good risk projects is violated and they drop out of the pool generating a severe adverse selection problem. Thus, the interest rate serves as a self-selection mechanism, as suggested by Stiglitz and Weiss (1981). It is optimal for the bank to charge the maximum interest rate at which *L*-type projects accept the loan offer, $r_B = R_L$-1. At such an interest rate, the bank will serve the entire market consisting of both types of projects.

Under debt contracts, project failures will be monitored *ex post*. We introduce an *ex post* verification cost of monitoring a project declared to be a failure. Let $c > 0$ denote such a verification cost. In the absence of *ex ante* monitoring, the expected number of failures will be $N[(1-p_L)\lambda + (1-p_H)(1-\lambda)]$. The bank's expected profit will then be

$$(3) \quad E[\pi_B(R_L)] = N[\lambda(p_L R_L - c(1-p_L)) + (1-\lambda)(R_L p_H - c(1-p_H)) - 1].$$

Instead of financing projects by debt, a bank could choose to be an equityholder. In the current framework equity would not, however, provide the efficient transmission of finance, because it would require all projects to be monitored *ex post*. Equity is privately optimal for a bank, however, if the cost of monitoring *ex post* is small. With equity financing, a bank would reap the whole surplus from successful high risk projects providing a trade-off against cost savings in monitoring. It is easy to see from (3) that the precise condition for debt to also privately dominate equity is given by $cn(\lambda,p_L,p_H) > R_H - R_L$, where $n(\lambda,p_L,p_H) = 1 + \lambda p_L/(1-\lambda)p_H$ with the properties that $\partial n/\partial p_L > 0$, $\partial n/\partial p_H < 0$, $\partial n/\partial l > 0$. It seems that such a feature has been left unnoticed in the literature as it has mainly dealt with the verification issue in the absence of adverse selection. From this condition on c, one can see that high return on bad risk projects under success will threaten the optimality of debt contracts under adverse selection by potentially making equity more attractive for the bank than debt. Further, as is well-known from the literature, debt is always optimal if $R_H = R_L$. Below we work with the assumption that the cost of *ex post* monitoring is sufficiently large to make debt privately optimal for the bank. For a bank to be operative, it must hold that $E[\pi_B(R_L)] > 0$ necessitating $\lambda > \lambda^o$, where $\lambda^o = [1-(R_L+c)p_H+c]/[(R_L+c)(p_L-p_H)]$.[13] From the point of view of the bank, the condition $\lambda > \lambda^o$ thus implies that it is better to finance all projects than to withdraw the lending activities from the market. The credit market, however, breaks down if $\lambda < \lambda^o$, since it would not then be worthwhile for the bank to operate. We have

Lemma 1. *If $l < l^o$, the credit market breaks down in the absence of ex ante monitoring.*[14]

If the credit market breaks down, the bank, however, has the option of investing in monitoring. In the next section, we provide an analysis of the optimal monitoring effort of a bank and we show that it will be in the bank's interest to invest in monitoring *ex ante*. Thus, costly monitoring serves the social purpose of rescuing the operation of a credit market dominated by high risk projects. As a matter of fact, the incentive to monitor is linked to the value of λ, as we will see below.

IV. Optimal Investment In Monitoring

Consider *ex ante* monitoring where the bank commits itself to a monitoring technology and where it can therefore condition its interest rate policy on the outcome of its monitoring. If the credit classification were free of costs, the bank would be able to fully separate projects and the credit market would allocate the funds in the first-best manner. However, under costly monitoring, residual classification errors will remain. Through its monitoring technology, α and β are decision variables for the bank. Thus, based on its *ex ante* monitoring the bank can produce privately (and socially) valuable information so that it can condition its decisions not only on λ, but also on the values of $\tau(\alpha,\beta)$ and $\rho(\alpha,\beta)$.

IV.1 Optimal Interest Rate Policy under Monitoring

We consider a risk-neutral bank. It is reasonable to view the bank's decision-making as sequential in the sense that its interest rate decision will be conditioned on the outcome of its monitoring. Given the monitoring investment (the values of α and β), the bank will determine a lending rate which will be charged to projectholders.

Even though the bank would prefer to avoid funding of *H*-projects, it is able to accomplish such a strategy only imperfectly. The bank tries to identify the *L*-firms and screen out the *H*-type applicants, since these are the source of credit losses on average. Because of imperfect monitoring the bank will face both types of classification error. Even with *ex ante* monitoring, the pool of loan applicants consists of (i) the truly *L*-firms labelled as *L*, (ii) some *H*-firms mis-labelled as *L*, (iii) some *L*-firms mis-labelled as *H*, and (iv) the truly *H*-firms labelled as *H*. Groups (iii) and (iv) drop out of the market, not being financed. It is easy to judge that the optimal lending rate for the bank is $r_B = R_L$-1 as the profit function is linear in r_B. Incorporating these effects on loan offers, we write the bank's expected profit as

$$(4) \quad E[\pi_B \mid \alpha,\beta] = N[\lambda(1-\alpha)+(1-\lambda)\beta][(R_L+c)\Gamma - 1 - c] - Na(\alpha) - Nb(\beta),$$

where we have introduced the notation $\Gamma = p_L\tau + p_H(1-\tau)$ for the *posterior* success probability and where $N[\lambda(1-\alpha)+(1-\lambda)\beta]$ gives the number of projects financed, i.e. the number of projects *classified* as *L*-type. The last two terms in (4) represent the costs of monitoring, capturing the idea that all applicants are monitored on an equal basis.

It is clear from (4) that for a bank to be operative, there must be a sufficient proportion of good-risk projects, λ, in the economy and these must generate a sufficiently high expected return R_L under success. Therefore, a monopoly bank which is engaged in costly monitoring will offer a credit contract with lending rate R_L-1 to all projectholders classified as *L*; it will offer no loan contract to those classified as *H*.

IV.2 Optimal Monitoring

Knowledge of the bank's optimal interest rate policy allows us to solve recursively for the optimal monitoring intensity. The solution will thereby satisfy the requirement of time-consistency. Thus the monitoring intensities will be chosen in order to solve $max_{\alpha,\beta}\ E[\pi_B | r_B]$, obtained by substituting the optimal interest rate $r_B = R_L$-1 into the objective function (4). Intuitively, the optimal commitment to a pair of monitoring intensities (α^m,β^m) has the property that the expected marginal returns on monitoring are equated with the corresponding *ex ante* marginal costs.[15]

Consider first the α-decision. A reduction in α will, ceteris paribus, increase the number of good risk projects correctly classified as *L*, $\lambda(1-\alpha)$, as well as τ (and hence Γ), the posterior probability that those classified as *L* are indeed of the *L*-type. *More loans* will be extended through this channel and both these effects tend to *raise* the expected total and marginal return on monitoring effort. A reduction in β, however, will reduce $(1-\lambda)\beta$, the number of bad risk projects misclassified as *L*, but raise τ (hence Γ), the posterior probability that projects classified as L are indeed of type *L*. *Fewer loans* will be extended through this channel, though at better odds. Therefore, the first effect tends to *reduce* the expected total and marginal revenue from the marginal monitoring effort, while the latter effect has the opposite effect in that it tends to raise it. In terms of expected marginal revenue, there is an interesting but natural asymmetry. When the share of bad risks is high, the β-monitoring is more effective than α-monitoring. Straightforward evaluation of expected returns on marginal monitoring effort shows that $MR(\alpha) = \partial TR/\partial\alpha = -N\lambda[p_L(R_L+c)-(1+c)]$, $MR(\beta) = \partial TR/\partial\beta = N(1-\lambda)[p_H(R_L+c)-(1+c)]$. The marginal effect on revenues of β-monitoring is bigger (by absolute value) when $\lambda < \lambda^o$, where λ^o has been characterized above.

Lemma 2. *The relative effectiveness of a- and b-monitoring, typically unequal, depends on the state of the economy. Monitoring effort directed to control for misclassification of bad risks (b-monitoring) is more effective at (the margin) in raising expected marginal revenue than is a monitoring effort directed to reducing misclassification of good risks (a-monitoring), if the perceived state of the economy is weak enough, i.e.* $l < l^o$.

Though the return on monitoring is asymmetric in that it is more effective to try to control the misclassification of bad risks when λ is small, this does not dictate that the bank would necessarily pay less attention to avoiding good risks. The optimal relative monitoring intensities also depend on marginal costs. Indeed, the optimal mix (α^m,β^m) of risk evaluation has to satisfy the first-order conditions given by (5*a*) and (5*b*)

$$(5a) \qquad -\lambda[p_L(R_L + c) - (1+c)] = a'(\alpha^m)$$
$$(5b) \qquad (1-\lambda)[p_H(R_L + c) - (1+c)] = b'(\beta^m).$$

From (5*a*) and (5*b*) one can see that cost savings with respect to *ex post* monitoring add to the returns on *ex ante* monitoring. Our *Assumption 2* rules out the corner solution at $\alpha = 0$, $\beta = 0$. The other corner is also ruled out because at $\alpha = 1-\lambda$, $\beta = \lambda$, marginal returns are positive (for $\lambda < 1$) while marginal costs are zero. We then definitively have an interior solution characterized by (5*a*) and (5*b*). Moreover, the sufficient second-order conditions $-a''(\alpha^m) < 0$, $-b''(\beta^m) < 0$ are satisfied by *Assumption 2*. The optimal pair (α^m,β^m) is thus determined by (5a)-(5b) through equality of marginal costs and expected marginal revenues from monitoring efforts. We notice from (5*a*) and (5*b*) that the combination of optimal monitoring intensities (α^m,β^m) satisfies

$$b'(\beta^m) = a'(\alpha^m) + (1-\lambda)[p_H(R_L+c)-(1+c)] + \lambda[p_L(R_L+c)-(1+c)]$$

$$= a'(\alpha^m) + (R_L + c)(p_L - p_H)[\lambda - \lambda^o].$$

This result provides an insightful characterization of the optimal monitoring intensities α^m and β^m relative to each other. Though it is not yet quite sufficient to rank α^m and β^m without parametrization of the *a*(.)- and *b*(.)-functions, we can see the central determinants of the relative monitoring efforts: the marginal costs and the state of the economy. Even if it were the case that the monitoring technologies, and hence the cost functions *a*(.) and *b*(.), were identical, this would not imply that $\alpha = \beta$, highlighting the importance of introduction of both decision errors independently. We can conclude that for the optimal combination of monitoring intensities it holds that a marginal relaxation of β-monitoring will generate higher cost savings than a relaxation of α-monitoring if $\lambda < \lambda^o$.

If the bank does not monitor, it will finance either *N* projects or none, depending on the value of λ. With investments in project-specific monitoring, the number of projects financed is changed to $N[\lambda(1-\alpha^m) + (1-\lambda)\beta^m]$. We see that with monitoring, the number of projects financed will typically differ from λN unless monitoring provides perfect information. Thus, based on project-specific information arising from monitoring, the bank will typically find it worthwhile to optimally adjust the number of projects financed. There is, however, an asymmetry. The number of projects financed is negatively related to the accepted classification error α^m, but positively to β^m.

We now want to find out more about the interaction between the proportion of low-risk projects (λ) and the optimal filter characteristics for the bank as measured by the pair (α^m,β^m). We raise the question of how a monopoly bank adjusts its behavior with respect to monitoring when its perception of the pool of loan applicants becomes more optimistic. An expected change in the macroeconomic state of the economy, i.e. in the perception of aggregate risks, may underlie such a change. Differentiating the system of first-order conditions (5*a*) and (5*b*) with respect to λ shows that

$$(6) \quad \frac{\partial \alpha^m}{\partial \lambda} = -\frac{(p_L R_L - 1) + (p_L - 1)c}{a''(\alpha^m)} < 0, \text{ if } c < \frac{p_L R_L - 1}{1 - p_L}$$

and

$$(7) \quad \frac{\partial b^m}{\partial l} = -\frac{p_H R_L - 1 + c(p_H - 1)}{b''(b^m)} > 0.$$

Thus, we can state

Proposition 1. *An increased degree of optimism regarding the average quality of loan applicants makes the (monopoly) bank more willing to accept classification errors in the evaluation of bad risks. It makes the bank less willing to accept classification errors in the evaluation of good risks, subject to the qualification that the ex post cost of monitoring is not too high.*

Thus, an increase in the proportion of low-risk applicants will cause the bank to increase its monitoring efforts towards reduction of the probability that a profitable applicant (*L*-type) would be denied credit. For a given value of α, such a misclassification would be more costly when the proportion of good risk applicants increases. When it comes to the positive impact of λ on β an intuitive explanation goes as follows. When the proportion of low-risk applicants increases the marginal expected return on those classified as *L* increases for any given values of α and β. Thus the bank will have less incentives to spend resources intended to reduce the probability of classifying a bad risk applicant as a low-risk one.

Our interpretation of the impact of changes in the proportion of low-risk projects on the monitoring intensities in terms of the business cycle framework is clearly simplistic and somewhat far-fetched. Of course, to be complete and fully consistent with rational expectations with respect to the underlying macroeconomic conditions (outside our model) such interpretations would formally need a genuine dynamic model to exhibit cyclical fluctuations. Our representation is, however, able to capture some of the basic qualitative features which by necessity would also be present in more detailed models. The massive credit expansion during the prolonged boom in the late 1980s seems to have been a striking feature, for example, of the recent banking crises in Scandinavia or the ongoing crisis in Japan. Many observers have linked this to the significant increase in the Scandinavian banks' credit losses with the failure of these banks to screen out bad risk projects from the pool of potential customers. As we have seen, our model has been able to predict and sort out the mechanism for lower monitoring effort during booms. To this extent, a more liberal credit policy during booms in granting loans seems to be fully consistent with rational behavior on behalf of banks. In light of our model, it seems to be an inherent property of risk evaluation through the banking system that credit volumes will be expanded during a boom. Our model will give rise to a testable prediction,

Corollary 1. ***With a switch to more optimistic macroeconomic conditions, the banks find it worthwhile to expand the number of projects financed.***

Proof. An expansion of the credit volume during booms can be shown in the context of our model as follows. The volume of projects financed is measured by $N[\lambda(1-\alpha^{m}) + (1-\lambda)\beta^{m}]$. The marginal impact of a change in λ on the number of projects financed is given by

$$(8) \qquad N[(1-\alpha^{m}-\beta^{m}) + (1-\lambda)\frac{\partial \beta^{m}}{\partial \lambda} - \lambda\frac{\partial \alpha^{m}}{\partial \lambda}] > 0,$$

which is positive in the face of (6) and (7). QED

So far our analysis has produced results on optimal monitoring by a bank which does not face competition ("a monopoly bank"). We now direct our attention to the implications of competition between banks when monitoring investments are used strategically.

V. Competition In Monitoring

Earlier, Riordan (1993) has explored the implications of more competition in loan markets in the context of a screening model of lending suggesting that more competition might make individual banks too conservative damaging market performance.[16] In order to find out the implications of competition[17] in monitoring, we initially consider a banking duopoly operating in an environment characterized as follows: (i) all projectholders apply for funding at both banks (ii) both banks classify all loan applicants, which become labelled as *L* or *H*; (iii) even though both banks would know the monitoring intensity of their competitor, neither of them has access to information on the outcome of monitoring undertaken by the rival. The important point is that competing banks recognize that their *commitments to monitoring will have spillover effects (externalities) on the expected profit of the competitor*. Absence of information sharing between the banks is most natural; if anything, the banks would have incentives to misrepresent their private information to their rival unless there exists an institution for verification of private bank reports. The banks' monitoring decisions $\{\alpha_i, \beta_i\}$ therefore define a noncooperative game. In a banking industry with multiple banks, all banks understand that each projectholder has the option of being simultaneously and independently monitored by each bank. Of course, such multiple monitoring constitutes a potential source of socially wasteful duplication.

Costless mobility of customers between lenders creates spillovers between the banks with respect to the quality of customers. We study strategic monitoring choices of independent banks and we assume that the banks have access to identical monitoring technologies. The banks understand the mechanism that even if they were committed to a relatively high monitoring effort, like that typical of a monopoly bank, *the average quality of their customers will be reduced under competition.* This is inevitable; a positive classification decision by one bank is sufficient for a project to get funded regardless of the outcome of the screening undertaken by the other bank which has been convincingly demonstrated already by Riordan (1993). Analogously, monitoring reduces the probability that profitable projects are refused funding. In such a situation, banks' expected total revenue from risky lending is somewhat more complicated and sensitive to the *nature* of banking competition.

In order to focus exclusively on the consequences of competition in monitoring, we restrict ourselves to a general representation of lending rate competition. If such a lending rate equilibrium *R* exists, it must satisfy

$$(9) \qquad \frac{1 + c(1 - \Gamma_i)}{\Gamma_i} = R_o \leq R \leq R_L .$$

The lower bound of (9), R_o, represents the zero-profit condition at the stage of lending rate competition while the upper bound corresponds to the case where the banks are able to noncooperatively sustain lending rate collusion. In light of (9), our model captures the outcome of a whole spectrum of patterns of lending rate competition. In the context of competition in monitoring there are several justifications for focusing particularly on cases with a high degree of collusion in lending rates. The existing literature, in particular Broecker (1990) and Yanelle (1997), has already quite extensively characterized lending rate equilibria under competition and explored the highly restrictive circumstances under which the existence of an equilibrium can be guaranteed. Moreover, it is reasonable to consider the reaction lags of banks to be short when it comes to lending rate competition, in particular since lending rates, unlike monitoring commitments are typically public and verifiable information. For that reason, banks might be much better able to noncooperatively sustain collusion with respect to lending rates than with respect to monitoring in the context of repeated competition.[18] Actually, both Yanelle (1997) and Caminal and Matutes (1997) suggest reasons for why ruthless lending rate competition may be ruled out. Especially for high degrees of collusion in lending rates, our results are unambiguous. It is, however, a remarkable feature of our model that the results hold even more generally and that they do not seem to be particularly sensitive to the nature of lending rate competition prevailing.

We now proceed to formally analyze how competition in banking interacts with the incentives to commit oneself to *ex ante* monitoring and how the risks the banks accept in terms of misclassification of risky projects are affected by the market structure in the lending market. When both banks are engaged in monitoring, each project will fall into one of the following four categories: (i) those classified as *L* by both banks, (ii) those classified as *L* by bank *i*, but as *H* by bank *j*, (iii) those classified as *H* by bank *i*, but as *L* by bank *j*, and (iv) those classified as *H* by both banks. Bank *i* will not grant finance to projects in groups (iii) or (iv). Further, bank *i* will be the only bank to offer credit to projects belonging to group (ii). Both banks would be interested in funding the projects belonging to group (i).

We first characterize the market share of bank *i* in a symmetric case of lending rate competition

Lemma 3. *In a symmetric equilibrium, the number of projects financed by bank i is given by*

$$q_i(\alpha_i,\beta_i,\alpha_j,\beta_j) = (1/2)N[\lambda(1-\alpha_i)(1+\alpha_j)+(1-\lambda)\beta_i(2-\beta_j)].$$

Proof. In case a projectholder is labelled as *L*, i.e. as a good risk, by both banks, we assume the projectholder chooses a particular bank with a probability of 1/2. Thus, one can find the number of projects financed by bank *i*, $q_i(\alpha_i,\beta_i,\alpha_j,\beta_j)$ by first evaluating the total number of projects classified as good risk by bank *i*, and then subtracting half of those projects classified as good risks by both banks. Thus, $q_i(\alpha_i,\beta_i,\alpha_j,\beta_j) = N[\lambda(1-\alpha_i)+\beta_i(1-\lambda)]-(1/2)N\lambda(1-\alpha_i)(1-\alpha_j)-(1/2)N(1-\lambda)\beta_i\beta_j$. Simple algebra then gives Lemma 3.

QED

We also obtain the results that $\partial q_i/\partial\alpha_i < 0$, $\partial q_i/\partial\alpha_j > 0$, $\partial q_j/\partial\beta_i > 0$, $\partial q_j/\partial\beta_j < 0$. They all appeal to intuition.

In the absence of contractual arrangements between banks on information sharing, the monitoring efforts must constitute best responses to each other. Thus, we focus on the Nash equilibrium with respect to monitoring. Therefore, given $\{\alpha_j,\beta_j\}$, the optimal monitoring effort of bank *i* is obtained from the maximization problem

$$(10)\quad \max_{a_i, b_i} \; \frac{N}{2}[\, l(1-a_i)(1+a_j)+(1-l)b_i(2-b_j)][(R+c)\Gamma_i-(1+c)]-Na(a_i)-N$$

where, to recall, $\Gamma_i = p_L\tau_i + p_H(1-\tau_i)$ stands for the posterior success probability for projects classified as *L* by bank *i*. After some manipulation, the first-order conditions are found to be

$$(11a)\quad -l(\frac{g}{2})[\, p_L(R+c)-(1+c)]$$

$$+\;(\frac{l}{2})(1-l)b_i\frac{1-a_j-b_j}{l(1-a_i)+(1-l)b_i}[\Gamma_i(R+c)-(1+c)] \;=\; a'(a$$

and

$$(11b)\quad (1-l)(\frac{2-b_j}{2})[(R+c)p_H-(1+c)]\;+$$
$$+(\frac{1-l}{2})(p_L-p_H)(R+c)\frac{l(1-a_i)(1-a_j-b_j)}{l(1-a_i)+(1-l)b_i}t_i \;=\; b'(b$$

In (11*a*), we have introduced an auxiliary variable

$$g \;=\; \frac{l(1-a_i)(1+a_j)+(1-l)b_i(2-b_j)}{l(1-a_i)+(1-l)b_i}.$$

We note that conditions (11*a*) and (11*b*), which equate the expected marginal revenues to marginal costs given the subsequent lending rate, *R*, include not only the decision variables of bank *i*, but also those of the competitor *j*. These conditions represent the reaction functions and they thereby constitute the mutually best responses. We have chosen to introduce them in a form which facilitates comparison of the monitoring intensities of a duopoly bank to those of a monopoly bank. From these conditions, one can see in which way monitoring externalities arise when customers are mobile. It is of particular interest to ask whether competition, and the inevitable sharing of markets, reduces the incentives for monitoring when compared with the monitoring decisions of a lender facing no competition. Intuitively, there are good reasons for such a hypothesis. A duopoly bank is unable to capture all the good risk customers it would like to finance, since those which have been detected as good risk projects by both banks will be shared.

Below we provide a comparison of the monitoring incentives of a bank facing competition with those of a bank not subject to competition. We assume throughout that the outcome of monitoring remains private information and that there is no credible way for the bank to commit itself to information sharing in that there is always an incentive to misrepresent the quality of one's customers to the competitor. We state our major results concerning this comparison as follows:

Proposition 2. (α-*monitoring*) *Regardless of the intensity of the lending rate competition prevailing, monitoring competition between banks undermines the incentives to control good risks when compared to a bank operating in the absence of competition.*

Proof. For the proof we compare the reaction function (11*a*) with the first-order condition (5*a*). For a duopoly to monitor less ($\alpha^d > \alpha^m$) it is sufficient and necessary that its expected revenue from a marginal reduction in monitoring effort exceeds that of the monopoly bank given in (5*a*). In proving this claim, the usefulness of our auxiliary variable *g* becomes evident.

Since

$$min(1+a_j, 2-b_j) < g < max(1+a_j, 2-b_j).$$

it holds that $(g/2) < 1$ in (11*a*). Moreover, the second term on the left-hand side of (11*a*) is always positive since otherwise it will not be profitable to finance projects classified as *L* in the first place. The claim $\alpha^d > \alpha^m$ then follows immediately.[19] QED

Proposition 3. (β-*monitoring*) *As long as lending rate competition is not too intensive, monitoring competition between banks undermines the incentives to control bad risks when compared to a bank operating in the absence of competition.*

Proof. For the proof we compare the reaction function (11*b*) with the first-order condition (5*b*). For a duopoly to monitor less ($\beta^d > \beta^m$), it is sufficient and necessary that its expected revenue from a marginal reduction in monitoring effort exceeds that of the monopoly bank given in (5*b*). Subtracting (5*b*) from (11*b*) we find that

$$(\frac{1-l}{2})[(-b_j)((R_L+c)p_H-(1+c)) + R((2-b_j)p_H + H) - R_L(2-b_j)p_H$$

$$- R_L(2-b_j)p_H + cH = b'(b_i) - b'(b^m),$$

where we have denoted $H = (p_L - p_H)(1-\alpha_j-\beta_j)\tau_i^2$. We observe that the left-hand side of this equation is a linear and increasing function of *R*. It can easily be seen that $b^d > b^m$ if and only if $R > \theta$ where θ is defined by the condition

(12) $\theta[(2-\beta_j)p_H + H] = 2p_H R_L - c[H + b_j(1-p_H)] - \beta_j.$

If the lending rate competition is not extremely intense, it always holds that $R > \theta$ which means that $b^d > b^m$. Only with parameter configurations such that $\theta > R_o$ it can happen that $b^d < b^m$ once the additional requirement of sufficiently intense lending rate competition is met. QED

From *Proposition 2*, we can see that there is an unambiguous relationship whereby competition will undermine the incentives for α-monitoring for all feasible intensities of lending rate competition. Moreover, our *Proposition 2* is a strong one in the following sense: *a monopoly bank is more concerned about misclassification of loan applications independently of l, the state of the economy*. Further, from the proof of the *Proposition 3*, and as illustrated in Figures 1(A) and 1(B), we can conclude that the difference between investments in β-monitoring by a lending monopolist and a lending duopolist increases as a linear function of the prevailing duopoly rate. As long as the degree of lending rate collusion of the banking duopoly is sufficiently large we know for sure that a lending monopolist will maintain a higher quality in its β-monitoring than a bank facing competition. In fact, for reasonable parameter configurations, illustrated by Figure 1(A), such a relationship will hold for all feasible lending rates that can be maintained by a banking duopoly. However, under sufficiently intense lending rate competition, there are also plausible parameter combinations, exhibited in Figure 1(B), such that a bank facing competition will sustain more conservative β-monitoring than a lending monopolist. We illustrate these cases numerically below in Table 1.

	θ	θ	R_o
	$R_L = 1.5$	$R_L = 3$	
$c = 0$	0.783	1.623	1.379
$c = 0.1$	0.734	1.573	1.417
$c = 0.2$	0.684	1.524	1.455
$c = 0.4$	0.585	1.424	1.531

Table 1. **Numerical values of the threshold parameter θ defined by (12) and R_o defined by (9). Assumptions: $\lambda = 0.5$, $\beta_i = b_j = 0.05$, $\alpha_i = a_j = 0.05$, $p_L = 0.75$, $p_H = 0.25$.**[20]

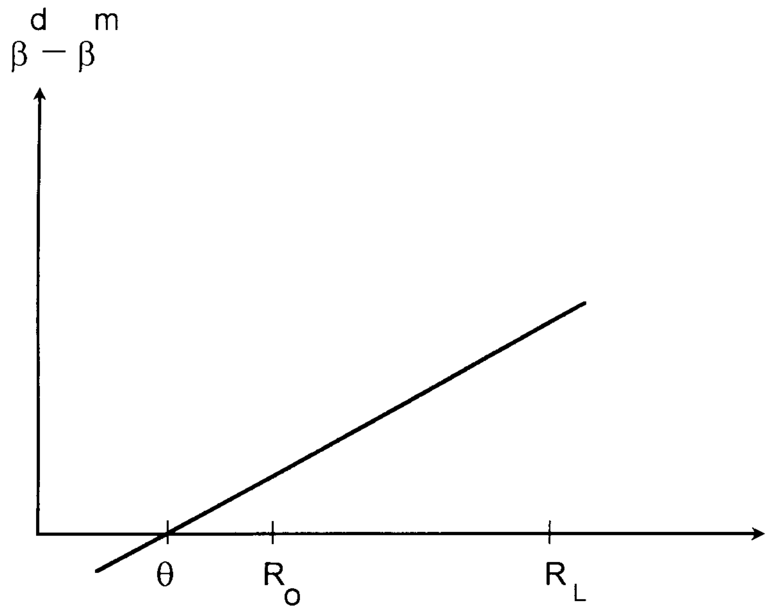

Figure 1 (A) The banking monopoly invests more in β-monitoring for all feasible levels of lending rate competition.

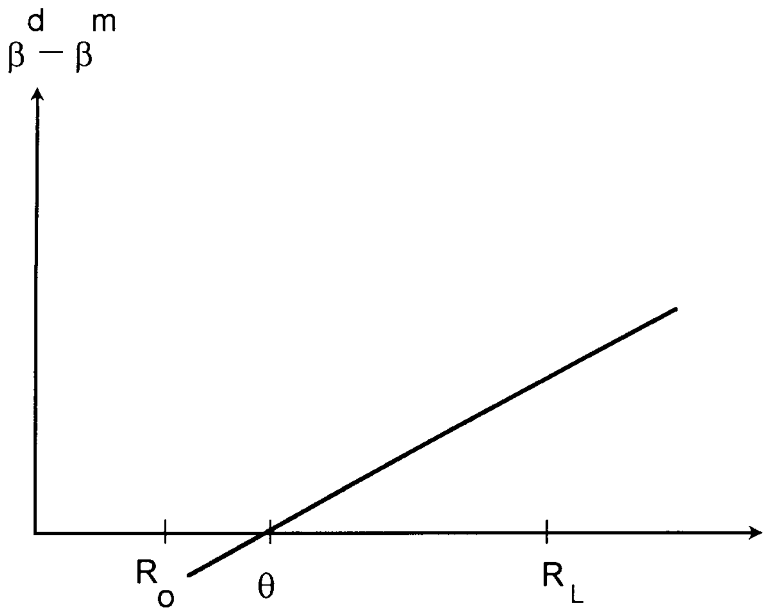

Figure 1 (B) The banking duopolist could invest more in β-monitoring for sufficiently intense lending rate competition

Thus, there will always be less β-monitoring under duopoly banking regardless of the intensity of the lending rate competition when $\theta < R_o$. However, with sufficiently severe interest rate competition, a duopoly bank will invest more in β-monitoring than a monopoly bank if it holds that $\theta > R_o$. Such a case can be intuitively explained as follows. A low lending margin forces the duopolist to carefully screen those projects to be funded. It is not possible for such a duopolist to cover up for careless monitoring based on substantial lending margin in such a way as the monopolist can when R_L is "high". In fact, a large interest rate differential R_L-R_o is a necessary condition for there to be a possibility of $\theta > R_o$ occuring. Interestingly, as illustrated with $R_L = 3$ (see the third column), our calculations show that the *ex post* verification cost has a systematic impact on the relationship between the market structure and monitoring. For example, under high *ex post* verification cost it is the case that a monopoly will monitor more than a duopoly bank.

Consequently, we have identified a non-trivial and somewhat parameter-specific relationship between the incentives for β-monitoring and the prevailing lending market structure. In particular, we have shown how the nature of this relationship is systematically affected by the lending rate competition. Our results thus differ qualitatively from those obtained by Riordan (1993) who found that competition tends to make individual banks more conservative in their lending decisions.

In our model introduction of competition will change the number of loans granted according to

$$N\{\, l\,[a^m - (a^d)^2] + (1 - l)[b^d(2 - b^d) - b^m]\},$$

where α^d and β^d stand for the decisions errors under duopoly. With reasonably small decision errors, a banking duopoly tends to grant more credits than a banking monopoly.

Can we characterize the nature of the strategic interaction with respect to monitoring? From (11*a*) we find, for example, that $\partial\alpha_i/¶a_j < 0$, $\partial\alpha_i/¶b_j > 0$. Therefore, to make the competitor relax the monitoring intensity with respect to good risks, a bank itself has to tighten its α-monitoring. The bank can also induce the competitor to relax its α-monitoring by relaxing its own β-monitoring. In other words, as instruments of strategic competition, evaluations of good risks show up as strategic substitutes while evaluation of bad risks exhibits strategic complementarity relative to the competitor's evaluation of good risks.

To recall, Sah and Stiglitz (1986) have earlier analyzed the internal organization of agencies for project selection. In that respect, they have shown that the screening in a polyarchy is more conservative than that in a hierarchy. In contrast to their model, we have focused on the relationship between monitoring and the external market structure in our characterization how competition typically undermines (with the qualifications stated) the incentives of lenders to avoid decision errors of both types.

VI. Does Monopoly Generate Socially Optimal Monitoring?

Above we have derived a rather strong result concerning the devastating impact of banking competition on the incentives for project-specific monitoring with free mobility of customers subject to the qualification that lending rate competition is not too intense. A striking implication is that the absence of competition in monitoring makes the banking industry better able to finance those projects which are socially valuable while leaving excessively risky projects without financing. Subject to the stated qualification of *Proposition 3,* competition in lending markets systematically deteriorates banks' ability to fulfill the socially fundamental role as producers of project-specific information in risk markets. Thus, the social gains from competition typical of ordinary industries, seem to be more controversial when it comes to considering financial intermediaries. Competition reduces the incentives for *ex ante* monitoring, thereby increasing the risk of funding projects which are not socially valuable.

Thus, it is of substantial interest to address the issue of what type of market structure is *socially optimal from the point of view of the banking industry as a producer of project-specific information in risk markets*. To the best of our knowledge, this important question has not been thoroughly analyzed in the literature. Riordan (1993) has addressed normative issues from a different angle. In the context of an auction for projects, his analysis suggests that an increase in bad loans resulting from more competition may have an overwhelming negative effect on welfare.

We will evaluate the expected social surplus (welfare) generated under different industrial structures of the lending market. Since our model has endogenized the classification errors, minimizing the social costs of both types of errors is not sufficient as a welfare criterion. In our context, the criterion has to be adjusted for the cost of obtaining the desired errors.

A natural welfare measure can thus be obtained by subtracting the initial project investment, the expected cost of project failure, and the *ex ante* monitoring expenditures from the expected return of successful projects. Under a lending market characterized by monopoly, the expected social surplus is given by

$$(13a)\ E[w^m] = N[l(1-a^m)+(1-l)b^m][t^m p_L(R_L+c)+(1-t^m)p_H(R_H+c)-($$

$$-Na(a^m)-Nb(b^m),$$

while the expected social surplus associated with an industry consisting of two identified competing lenders is

$$(13b)\ E[w^d] = 2(\frac{N}{2})[l(1-a^d)(1+a^d)+(1-l)b^d(2-b^d)][t^d p_L(R_L$$

$$+(1-t^d)p_H(R_H+c)-(1+c)] - 2Na(a^d)-2Nb(b^d).$$

Note that (12*b*) takes into account that each project would be evaluated by two independent lenders. As the benchmark for our welfare analysis, we refer to the socially optimal intensities (α^*,β^*) as those solving

$$(13c) \quad \max_{a,b}\ N[\, l(1-a) + (1-l)b\,][\, p_L t(R_L + c) + (1-t)p_H(R_H + c) - (1+$$

$$-\ Na(a)\ -\ Nb(b).$$

Thus, (13*c*) formalizes the objective function of a fictitious "social planner". An important observation is that (4) and (13*c*) are identical except for the feature that R_H replaces R_L in (4). Intuitively, the objective function of the monopoly bank differs from that of the social planner only because in the current context the monopoly bank is concerned about how the surplus generated by the project is *distributed* while the planner need not pay attention to the distribution. We now proceed by asking the unusual question focusing on what "distortions" in *ex ante* monitoring are caused by duopoly competition when compared to monitoring conducted by a lending monopoly. Firstly, with competition there will be duplication of monitoring effort which involves elements of social waste. Secondly, the expected social return on each project financed by a duopoly will be lower than that financed by a monopoly. Namely, the probability that firms classified as *L* indeed are of type *L* is smaller under lending market duopoly than under monopoly, $\tau^d < \tau^m$. Thus, a duopoly finances projects of lower average quality than a monopoly, regardless of the number of projects financed, which typically is increased as we have shown.

We next report the following result which is important from the normative point of view,

Proposition 4. *(i) A monopoly bank provides the socially optimal evaluation of good risk projects (a-monitoring), but it is too conservative in its evaluation of bad risks (b-monitoring), resulting in too few projects being funded. (ii) A duopoly bank always invests too little in evaluation of good risk projects (a-monitoring), and its investment in b-monitoring is also socially insufficient as long as the duopoly banks can exploit a sufficiently large share of the return on high risk projects (R_H/R sufficiently close to one).*

Proof. Using (12*c*), the first-order conditions for socially optimal monitoring read as

$$(14a) \quad - l\,[\,p_L(\,R_L + c) - (1 + c)] - a'(\,a^*) \;=\; 0$$

$$(14b) \quad (1 - l\,)[\,p_H(\,R_H + c) - (1 + c)] - b'(\,b^*) \;=\; 0.$$

Comparing to the conditions (5*a*)-(5*b*) and (11*a*)-(11*b*) proves the claims.

QED

Proposition 4 states that a monopoly bank will provide a socially optimal amount of α-monitoring. The reason for this striking result is that the return on successful bad risk projects does not play any role in the determination of the socially optimal α-monitoring. Consequently, the difference between the objective functions of a monopoly bank and of a planner does not matter for the monitoring intensity of good risks. From *Proposition 2* we already know that introduction of competition into the monopoly market will reduce the monitoring incentives and consequently a banking duopoly will achieve an α-monitoring intensity which is insufficient from the social point of view. Consequently, competition in α-monitoring will lead to a failure of banks to evaluate good risks efficiently.

From *Proposition 4* we find the monopoly bank to be too conservative in its evaluation of bad risks, because, in contrast to the planner, it is not indifferent about the distribution of the project surplus. Introduction of competition into a monopoly lending market gives rise to two types of welfare costs. Firstly, the average quality of funded projects is deteriorated; secondly, each project is subject to multiple monitoring. As long as the return ratio R_H/R is not too far from unity, we know for sure that the β-monitoring undertaken by bank duopolists will be insufficient from the social point of view. Thus, while the monopoly engages in excessive β-monitoring, under the condition stated the duopoly banks underinvest in bad risk evaluation relative to the social optimum.

Importantly, *Proposition 4* suggests a welfare-improving role for coordination of monitoring activities of competing banks. By delegating their monitoring activities to a jointly operated institution for credit evaluation, it would be possible for a banking duopoly to exploit the stronger monitoring incentives of a banking monopoly. By so doing, the banking duopoly would achieve cost savings. Such a jointly operated institution could be organized, for example, in a way analogous to an R&D-cartel (see Kamien, Muller and Zang (1992)). Within the framework of our model, such a jointly operated institution for credit evaluation would generate unambiguous welfare gains relative to noncooperative monitoring competition.

In light of the striking results above, it is obvious that our model has abstracted from some potential benefits of competition in a more general sense. For example, the stylized restriction to two types of fixed-size projects implies that a lower lending rate achieved through competition between banks would not expand the number and size of socially worthwhile projects undertaken.

VII. Concluding Comments

It is one of the key questions in financial economics whether risk markets function efficiently so that funds get allocated to risky projects in the socially optimal way. Our analysis has suggested that banking competition may result in socially inefficient *ex ante* monitoring effort by the banks with regard to screening of risky projects.

The issue of social efficiency is, however, rather complicated when financial intermediaries are concerned. Most of the literature has been based on an implicit assumption of riskless deposits with full insurance or unlimited liability. Moreover, many private projects have external effects. Of course, if projects yield social benefits exceeding the private ones, the monitoring investments also of the monopoly bank would be distorted from the socially optimal levels. Public intervention in controlling the banking industry may be needed, but in light of our analysis, it has to be justified by inefficiencies in banking competition and reasons related to differences between private and social benefits from risky projects. De Meza and Webb (1988) have earlier addressed optimal public intervention in credit markets in the presence of screening costs by concentrating on tax policy applied to interest income. Our model suggests that public intervention in credit markets could also focus on policies applied to the expenditures for project-specific monitoring. In principle, we see no reason for not applying the general principles of industrial policy with respect to banks' investments in project-specific monitoring.

The present model can best be regarded as a step towards understanding the mechanisms and implications of optimal project-specific monitoring. We consider the present model particularly promising as a basis for exploring the relationship between the incentives of banks for costly information acquisition based on *ex ante* monitoring efforts and the market structure of the banking industry. One can expect that competitive pressures lead to underproduction of information so that competition might be socially inefficient from the point of view of information acquisition. There would thus be a trade-off between the degree of banking competition and the incentives for banks to acquire information. Our analysis points to a welfare-improving role of incentive-compatible institutional arrangements making banks share information.

NOTES

1. In Norway, Finland and in Sweden, substantial support from the taxpayers has been inevitable to keep the banking system operating in order to protect depositors from losses. According to Koskenkylä (1995), the credit losses of the Finnish banks amounted on average to 2.2% of GNP during the period 1989-94 and they reached the peak level of 4.6% in 1992. In Sweden and in Norway, the banking crises were only slightly less severe, credit losses as a percentage of GNP reaching on average 2.1% and 1.7%, respectively, during 1989-94.

2. Cf. van Damme's (1994) survey of the area or Freixas and Rochet (1997) suggesting where the limits to the understanding of banks stand today. Dewatripont and Tirole (1994) have extensively developed the implications for regulation of banking.

3. Kanniainen and Södersten (1994) claimed that banks and shareholders share the costs of monitoring whereby the costs born by the bank are taken up in the interest on corporate debt.

4. We are grateful to an anonymous referee for drawing our attention to the relationship between our analysis and that of Sah and Stiglitz (1986).

5. Customers started actively to search for competing credit offers from different banking groups and banks started to compete by the "speed" of customer evaluation.

6. Collateral functions like a substitute for monitoring. Perfect collateral, of course, would completely eliminate completely the need for monitoring *ex ante*, but the need to monitor remains under imperfect collateral. Collateral would, however, interfere with the project choice by the customer. In order to analyze the interaction between imperfect collateral and monitoring, one would need a more complicated return structure (like in Bester (1985)) than what we have introduced here. Such a framework which is in the focus of the promising analysis of Manove, Padilla and Pagano (1998) is, however, unnecessary for the purposes of our paper.

7. The introduction of imperfect deposit insurance would lead to a dramatic change in focus. The depositors would demand a risk-premium and the investment in ex ante monitoring would provide the bank with a costly instrument for signaling its type (risk) to depositors.

8. One could extend the information production of a bank to include evaluation of the aggregate risks, i.e. uncertainty about λ. Such an extension could also provide important elements for a theory of the distinction between local banks with a comparative advantage in monitoring local customer-specific risks and global (national or international) banks with a comparative advantage in the assessment of nondiversifiable aggregate risks.

9. It is natural to view the choice of monitoring technology to be analogous to a choice

under putty-clay conditions. When the investment is made, the bank has the possibility of choosing the average precision of its credit evaluation and this with an increasing cost. After such a commitment has been made, each project evaluation is assumed to take place at zero marginal cost.

10. Of course, all credit applications are in practice subject to *some* review. Monitoring costs amount to the office space, computers, the wage cost of managers and clerks, etc. In addition to the routine review, investment loans are reviewed by specialists, hired by banks for that particular purpose. The degree of *ex ante* monitoring is related to the economic significance of the loan application and the procedure may vary from case to case. Firms often have to release their inside information to the bank including full description of their accounts and their investment plans. The bank then runs a standardized analysis of the quality of the firm based on historical data and evaluates the future of the firm before the decision to finance the project is ultimately made.

11. It follows that in the absence of monitoring, $P(L|L) = \lambda$, $P(H|H) = 1 - \lambda$. Substituting α_0 and β_0 from above into (2) restates this result; without monitoring, the probability that a projectholder classified as good risk, *L*, actually is of type *L* is given by $\tau_0 = \tau(\alpha_0,\beta_0) = \lambda$, while the probability that an applicant classified as bad risk, *H*, actually is of type *H* is given by $\rho_0 = \rho(\alpha_0,\beta_0) = 1\text{-}\lambda$.

12. The result that a standard debt contract is incentive-compatible under costly state verification has been established by Townsend (1979), Gale-Hellwig (1985) and Williamson (1987). For a survey, see also Allen and Winton (1995).

13. In terms of *c*, a precise condition for $\lambda^o < 1$ reads as $c < (R_L p_L\text{-}1)/(1\text{-}p_L)$, which does not contradict with the optimality condition of the debt contract derived above.

14. We note that this type of phenomenon was first identified by Akerlof (1970) in his famous example of the market for lemons.

15. We use the superscript *m* to refer to case of a "monopoly" bank.

16. Riordan's argument follows from the risk of "winner's curse". Riordan models lending competition making use of the Bayesian-Nash equilibrium of a common value auction. Our framework differs from that of Riordan (1993) in several ways: Riordan assumes that the signal is costless while in our model is it costly and its precision is the choice variable.

17. Our model will abstract from several important aspects of lending market characteristics. It is restricted to interbank competition between lenders in the absence of competitive pressure created by external equity markets. For a pioneering analysis in this direction, we refer to the recent work by Boot and Thakor (1997). They also address the issue of "relationship banking" which our paper will not discuss.

18. Note that lending rate regulation has been a prevalent feature of the banking industry until the recent wave of deregulation. As a regulatory instrument, interest rates might be more important than monitoring investments because interest rates represent public and

verifiable information.

19. There are good reasons to highlight that we have been able to prove this qualitative result resorting only to the best response functions of a bank duopolist and without explicitly solving for the actual Nash equilibrium.

20. It should be pointed out that α_i and α_j as well as β_i and β_j are the endogenous variables of our analysis. Through a suitable choice of monitoring technologies (monitoring cost functions) the classification errors which we have selected can always be achieved.

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