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Monitoring and Market Power in Loan Markets

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Abstract

Whether or not banks are engaged in ex ante monitoring of customers may have important consequences for the whole economy. We approach this question via a model in which banks can invest in either information acquisition or market power (product differentiation). The two alternatives generate different predictions, which are tested using panel data on Finnish local banks. We find evidence that banks' investments in branch networks and human capital (personnel) contribute to information acquisition but not to market power. We also find that managing customers' money transactions enhances banks ability to control their lending risks.

JEL: D21, G21, L15

Key words: banks, information acquisition, market power, fixed costs, branch network, default costs

Luottokelpoisuusarvioinnin ja markkinavoiman merkitys luottomarkkinoilla

Suomen Pankin keskustelualoitteita 9/2000

Ari Hyytinen – Otto Toivanen
Rahoitusmarkkinaosasto

Tiivistelmä

Pankkien harjoittamalla asiakkaiden luottokelpoisuusarvioinnilla voi olla merkittäviä kokonaistaloudellisia seuraamuksia. Rakennamme tutkimuksessamme mallin, jossa pankit voivat investoida joko luottokelpoisuusarvioinnissa tarvittavan tiedon kokoamiseen tai hankkia markkinavoimaa nk. tuotedifferentiaatioinvestointien avulla. Nämä investointipäätökset johtavat erilaisiin empiirisiin ennusteisiin, joiden toteutumista arvioidaan käyttämällä ekonometrisessa analyysissa suomalaisista paikallispankeista koottua aineistoa. Tuloksemme osoittavat, että investoinnit konttoriverkoston tiheyteen ja henkiseen pääomaan (henkilöstöön) ovat auttaneet pankkeja niiden informaatiotuotannossa, eivät niinkään markkinavoiman hankinnassa. Myös asiakkaiden maksuliikenne (talletustilit) näyttäisivät tuottavan tietoa, jota pankit voivat hyödyntää luottoriskien vähentämisessä.

Asiasanat: pankit, luottokelpoisuusarviointi, markkinavoima,
kiinteät kustannukset, konttoriverkosto, luottotappiot

Contents

1 Introduction

A great deal of empirical evidence supports the hypothesis that banks earn rents (eg Fama 1985, Cosimano and McDonald 1998, Molyneux et al 1994 and the wave of recent bank mergers). In this paper we contrast - within a unified modeling framework - the two main theoretical explanations for these rents that are presented in the literature and test their empirical validity.

A flood of literature (eg Leland and Pyle 1977, Fama 1985, Broecker 1990, Sharpe 1990) suggests that banks' raison d'etre is to collect and analyze information, an activity that we refer to as 'information acquisition'. Banks could, as eg in Broecker's model, test customers for their creditworthiness in order to avoid adverse selection. Such efforts at learning the customer's type can give the bank an information advantage that can be translated into a larger share of the surplus. An equally old and extensive literature (eg Klein 1971, Degryse 1996) argues that banks' rents derive from industrial organization-type sources relating to a small number of firms (oligopolistic market), product differentiation, and/or price discrimination that is not based on customers' risk characteristics.[1] We refer to these sources of rents collectively as 'market power'.[2]

Whether banks are engaged in one or the other activity may have significant consequences outside the industry itself: a large literature suggests that banks' (in)ability to solve informational problems affects the severity of the effects of macro-level shocks (eg Greenwald and Stiglitz 1993, Holmstrom and Tirole 1997). It is therefore critical to know whether, and through what mechanisms, banks collect and process information. There exists indirect evidence that banks are indeed in the business of acquiring information.[3] The main purpose of this paper is to provide a test of the *means* by which banks acquire information.

A common feature of information acquisition and market power is that they are both likely to require fixed investments (but see Petersen and Rajan 1994 and section 4 below). Notwithstanding recent investments in electronic banking, commercial banks' most obvious of such investments are those in branch networks and employees' human capital. We argue that investments in branches and human capital can serve two basic purposes: information acquisition and/or market power. Information acquisition requires personnel who are able to collect and analyze information, and investments in human capital increase these abilities. Since information is often local, a local presence in the form of a branch may fa-

[1] See Freixas and Rochet (1997) for a comprehensive treatment of both bodies of literature.

[2] There is of course a huge empirically oriented literature on banking. For example, Spiller and Favaro (1984) test the market power hypothesis. However, to the best of our knowledge these empirical papers are not concerned with the questions studied here. A paper by Petersen and Rajan (1994) comes close in that they study the effects of long-term relationship on credit terms.

[3] Petersen and Rajan (1994) find that firms with longer bank relationships have better access to credit. James (1987) finds that the stock market reacts favorably to news about new bank loans. Cressy and Toivanen (1998) cannot reject the Null hypothesis of symmetric information when testing the determinants of loan contracts, and attribute this to bank information acquisition. Mester et al (1998) independently from and concurrently with us, find that checking accounts provide banks with information about the riskiness of loans.

cilitate the collection of information.[4] The idea here is that distance between borrowers and lenders does matter as regards monitoring (Petersen and Rajan 2000). But equally plausibly, one could argue that a large branch network enables the bank, via product differentiation that is either horizontal (providing services close by to a larger clientele) or vertical (providing a denser network of services to a given customer), to increase its price-cost margins. Likewise, a better-trained and educated workforce may result in higher levels of service provision - with similar consequences. A third motivation for fixed costs arises from the deposit side. By offering deposit customers more conveniently located and faster services, a bank may be able to attract deposits at lower interest rates. This is an interesting proposition, which warrants greater attention than can be afforded within the scope of this paper. We do not model the deposit side explicitly, but carefully control for it in the empirical model by including, as endogenous explanatory variables, deposit interest rate(s) and the share of deposits in total bank funding.

Our modeling framework encompasses two alternative models, a monitoring model and a product differentiation model, and is based on earlier work (Williamson 1986, 1987, Shaked and Sutton 1982, 1983). In the monitoring model, a bank can acquire monitoring technology that can be used to test loan applicants for a pay-off relevant characteristic. This allows banks 'to focus their attention on information gathering to a particular set of issues: those associated with the probability of default and the net worth of the firm in those low-return states' (Stiglitz 1985, p. 143). The idea is that banks can spend resources so as to be able to inspect entrepreneurs before granting loans and thereby produce information on the value (eg in terms of liquidity) of a project to a bank in the default state.[5] This can have important ramifications. For example, in the Stiglitz-Weiss-type credit-rationing framework of Rousseau (1998), it leads to a narrower loan-deposit spread and eventually to financial deepening. The recovery rate of loans is also an important input in modern credit risk models, such as J.P. Morgan's CreditMetrics or Credit Suisse's CreditRisk$^+$. The second version of the model is a product differentiation model that is close in spirit to Shaked and Sutton (1982). The differentiation is thought to reflect financial service quality, bank-customer relationships and possible switching costs.

After presenting the two theoretical models, we build an econometric model that encompasses both and test the models' predictions using data from Finnish cooperative banks. These banks are small local banks that operate in geographically distinct, non-overlapping markets. They share several common features like ownership form and a quasi-central bank. As a group, they have by far the largest branch network, suggesting that they have made fixed investments. Although these banks share many features and institutions, they operate independently. Their common features (discussed in more detail in section 3) suggest eg that they use their branches for the same purpose, be it information acquisition or market power. This is important because our model suggests that in equilibrium a bank can be a non-monitor or monitor and of high or low quality. A random sample of banks might lead to an incorrect inference regarding the role of fixed costs. Essentially, having banks that have a common mode of operation and that operate in

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[4] We have been told that in the 1970s and 1980s, a Finnish bank's policy was that its local managers have to become members of either the local Lion's, or Rotary's. Although this can partially be explained by them being able to attract business in this way, an alternative explanation is that they were thus in a position to better gather local information.

[5] Wang and Williamson (1998) argue and provide casual evidence that such ex ante monitoring involves larger investments than ex post monitoring.

separate markets enables us to identify empirically the role of fixed costs.[6] Variation in local conditions across and within regions as well as over time (see section 3) means that the optimal level of such investments is bank- (and period-) specific, which allows us to measure the effects of branches and personnel on bank performance. As discussed below, bank size and certain sample-specific features may cause spurious correlations between our dependent variables and our measures of fixed investment. Therefore we carefully control for such correlations in the empirical analysis.

The remainder of the paper is organized as follows. In the next section, we present and solve the monitoring model. For reasons of space, we only briefly explain the main results of the vertical product differentiation model; a detailed analysis is contained in appendix 2. We wish to emphasize that the models are purposefully rather stylized and are to be regarded as examples of formal models from which the more general hypotheses tested in the empirical part can be generated. For example, it may well be the case that a bank uses its fixed investments for both information acquisition and market power purposes - a possibility excluded from our theoretical models. Our empirical specification is more general and allows for this and other possibilities. In section 3, we present and discuss the data. Section 4 provides our econometric setup and empirical results, and in section 5 we offer some brief concluding remarks.

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[6] One way to deal with this would be to estimate different equations for monitoring and non-monitoring banks using eg switching regressions.

2 The Theoretical Model

2.1 The Modeling Framework

Consider a universally risk-neutral economy with two banks and a continuum of entrepreneurs distributed (with unit density) over a compact subset D of $\Re^2$. Each entrepreneur has an initial endowment of $W > 0$, which he can invest either in a safe project generating a payoff $\hat{W} > W$ or in a risky project requiring an initial investment of size $K > W$. If the risky project is undertaken, it yields a random cash flow X. Neither the size of the project nor the initial endowment vary across entrepreneurs. We therefore normalize the entrepreneur's funding need to unity, ie $K - W \equiv 1$. The two banks are the only source of outside finance for entrepreneurs in this economy. The banks are only willing to buy standard debt contracts, and we let R denote the entrepreneur's payment if the project succeeds. The safe and risky projects are mutually exclusive, and the banks obtain loanable funds at a constant cost, denoted ρ.[7]

We denote by x the realized cash flows generated by the risky projects and by $f(x)$ and $F(x)$ respectively the probability density function (pdf) and cumulative density function (cdf) of the distribution of cash flows. The distribution $f(x)$ is assumed to be positive and differentiable on $(0, \infty)$ and identical for all entrepreneurs. As in Williamson (1986, 1987), a cash flow realization x is costlessly observable to the entrepreneur in question whereas a bank must pay an auditing cost to observe it. We further assume that despite auditing the bank can recover only $x - v$, $v \geq 0$, where v represents a leak to outsiders plus the auditing cost in states where the entrepreneur fails to meet his debt service obligation. The amount of this leak varies by entrepreneur and banks know costlessly only the distribution of v (see below). One may think of v as a determinant of the recovery rate of loans and bankruptcy costs, ie general liquidation costs, legal fees, costs of selling specialized equipment, and other costs that are deducted from proceeds that should go to debtors. Borrowers cannot credibly reveal the value of v to lenders.

We assume that the continuum of observationally identical entrepreneurs consists of types that can be characterized by an ordered pair (v, θ), where $\theta \geq 0$. Thus, firstly, the entrepreneurs differ w.r.t. v, ie the payments made to third parties in bankruptcy states. In particular, v is distributed according to marginal pdf $g(v)$ and cdf $G(v)$, and has support $[0, \bar{v}]$, $\bar{v} > 0$. Secondly, the entrepreneurs value the quality and availability of bank services. The extent to which an entrepreneur values these depends on a characteristic θ, which is a non-negative real number. It is assumed that this parameter is distributed according to marginal pdf $z(\theta)$ and cdf $Z(\theta)$ on $[0, \bar{\theta}]$, $\bar{\theta} > 0$.

The following assumptions hold throughout the analysis:

Assumption A1. *The random cash flows are drawn from an exponential distribution, ie* $X \sim Exp(\lambda)$ *with support* $(0, \infty)$ *and expected value* $E(x) = 1/\lambda$.

[7] Banks' funding costs are treated as an endogenous variable in the econometric model.

Assumption A2. *The characteristics* θ *and* v *are statistically independent. In this economy, all possible values of these two parameters are realized, and* $G(\hat{v})$ *and* $Z(\hat{\theta})$ *are the respective fractions of entrepreneurs with* v *and* θ *parameter values such that* $v \leq \hat{v}$ *and* $\theta \leq \hat{\theta}$. *The marginal distributions of both* θ *and* v *are uniform distribution, ie* $\theta \sim \mathrm{U}[0, \overline{\theta}\,]$ *and* $v \sim \mathrm{U}[0, \overline{v}]$.[8]

To complete the description of our general modeling framework, we model a two-stage game. In the first stage, banks enter simultaneously and each can make a costly investment of fixed size. If made, this investment allows the bank to either test customers for their v or to produce a high(er) quality service. In the second stage, banks compete for entrepreneurs by announcing independently but sequentially their loan interest rates. It has been suggested that the identity of the Stackelberg leader may depend eg on the size of firms, distribution of information and characteristics of customer bases, or it may be a result of non-cooperative timing competition. To allow for variation in leader-follower roles, we assume that they are randomly determined. The probability that bank i gets to move first and announce its interest rates(s) is ½. The other bank is then able to observe these, takes them as given, and chooses its own interest rate(s). With the complementary probability the roles are reversed. As we will see, the realization of these leader-follower roles will play a major part in the banks' equilibrium strategies. Sequential second stage competition is adopted because no pure strategy Nash equilibrium exists in a simultaneous move loan pricing game with (asymmetrically) monitoring banks (for a model exhibiting a similar feature with partially overlapping customer classifications, see Broecker 1990). We begin with the monitoring model and later analyze the Shaked-Sutton-type model of vertical product differentiation.

2.2 The Monitoring Model

We first describe the nature of the monitoring technology and then derive Nash equilibrium loan pricing strategies as a function of banks' monitoring investments, conditional on the realization of the randomly determined leader-follower roles. Finally, we characterize the subgame perfect monitoring decisions.

The Monitoring Technology: In order to keep the analysis tractable, we will restrict ourselves to a dichotomous monitoring variable, m_i, with $m_i \in \{0,1\}$. When the investment is made by bank i, $m_i = 1$ and two classes of entrepreneurs are created: good (G) and bad (B) entrepreneurs. Specifically, by paying a strictly positive fixed fee M, the bank can ascertain whether an entrepreneur is of a better or of worse type than $\tilde{v}$,[9] implying that the interval $[0, \overline{v}]$ is divided into two

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[8] We would like to emphasize that assumption A1 is imposed for the sake of concreteness. On the one hand, our analysis does not seem to be particularly dependent on the specific postulated form of $f(x)$. On the other hand, the cost of using a general $f(x)$ with certain restrictions is that explicit expressions for equilibrium interest rates cannot be derived. Though the independence assumption (A2) has no relevance in the monitoring model, it does simplify the product differentiation model in the sense that the provision of higher quality banking services does not affect the expected bankruptcy costs in a bank's loan portfolio.

[9] The threshold is common to both banks.

subintervals by the insertion of point $\tilde{v}$ such that $0 < \tilde{v} < \bar{v}$.[10] Let $GB \equiv G \cup B$ and $v(p)$ and $n(p)$ denote the average v and mass of entrepreneurs in category $p \in \{B, G\}$, respectively. Clearly, for $\tilde{v} > 0$, we have $v(G) < v(GB) < v(B)$ and $n(B) = (1-G(\tilde{v})) > 0$ and $n(G) = G(\tilde{v}) > 0$.

The above implies two possibilities. A bank having no monitoring ability (NM-bank) must treat its customers as a single entity, *GB*, to whom it quotes a single rate R_{NM} whereas a monitoring bank (M-bank) is able to determine whether a given entrepreneur belongs to *G* or *B* and so could quote different interest rates, $R_{M,G}$ and $R_{M,B}$, for the two entrepreneur classes.

We make the following technical assumption to simplify the analysis:

Assumption A3. *If both banks charge an entrepreneur the same interest rate, he will prefer the bank that values his project higher in the default state. If the banks charge an entrepreneur the same interest rate and value his project identically in the default state, he chooses a bank with probability ½.*

The banks are not allowed to cross-subsidize between entrepreneur classes nor can either observe the outcome of its competitor's monitoring activity. An entrepreneur cannot credibly reveal the monitoring outcome of bank *i* to bank *j* because a monitoring report by a rival bank is assumed not to be verifiable. Finally, ex ante monitoring does not reduce the ex post need for auditing nor the associated costs.

By assumption, in this section, no quality difference between banks emerges. We therefore normalize the level of banks' service quality to zero. In what follows we derive equilibrium interest rates under symmetric and asymmetric monitoring investments, conditional on the realization of leader-follower roles.

Loan Pricing Under Symmetric Monitoring Investments: If both banks invest in monitoring ($m_i = m_j = 1$), they are alike. Competition will be Bertrand with homogeneous goods in both entrepreneur classes, *B* and *G*. The follower bank will undercut the leader's offer to entrepreneurs in class *p* provided that this yields non-negative expected profits. Since the expected utility of an entrepreneur is

$$\mu(R) = \int_R^\infty (x-R) f(x) dx = E(x) e^{-\lambda R} = \frac{1}{\lambda} e^{-\lambda R} \tag{1}$$

we have $\mu'(R) = -e^{-\lambda R} < 0$. The most attractive interest rate offer the leader can make to entrepreneurs in class *p* while avoiding undercutting is thus obtained as a solution to

[10] Of course, other assumptions could be made on the nature of monitoring technology. For instance, allowing for more entrepreneur classes (defined similarly by the two banks) would enlarge the strategy space that a bank can consider in setting specific rates for different customer classes. However, this extension would increase the length of the analysis by increasing the number of cases that need to be considered in both stages of the game. Moreover, if in this environment a bank can acquire a technology that allows it to create another class, the analysis would correspond very closely to that pursued in this paper. Another alternative would be to postulate a continuous monitoring variable such that eg all good entrepreneurs with small *v* could be perfectly identified. Not surprisingly, this creates technical problems since a bank no longer chooses a finite number of interest rates but rather designs an optimal interest rate offer function during the second stage of the game. In particular, when acting as the price leader, the design of such an offer function is rather involved and thus beyond the scope of the present paper.

$$\pi(R,v(p)) = n(p)\left[\int_R^{\infty} Rf(x)dx + \int_0^R (x - v(p))f(x)dx - (1+\rho)\right]$$
$$= n(p)\big((E(x) - v(p))(1 - e^{-\lambda R}) - (1+\rho)\big) = 0 \qquad (2)$$

where $p \in \{B, G\}$. The zero profit interest rate for entrepreneur class *p* solving (2) is denoted $R^0_{v(p)}$ and given by

$$R^0_{v(p)} = E(x)\ln\left[\frac{E(x) - v(p)}{E(x) - v(p) - (1+\rho)}\right] \qquad (3)$$

An entrepreneur's participation constraint is satisfied as long as the rate charged is equal to or less than a 'monopoly' rate, R^*, given by

$$R^* = E(x)\ln(E(x)/\hat{W}) \qquad (4)$$

where by assumption $E(x) > \hat{W}$. In order to ensure that the banks' individual rationality constraints are not violated for any entrepreneur class when financed at the monopoly interest rate, we assume that

$$\bar{v} < E(x)\left[1 - \frac{(1+\rho)}{E(x) - \hat{W}}\right]. \qquad (5)$$

This condition ensures also that entry deterrence is not a feasible form of pre-emptive market behavior. Note finally that $\pi'(R, v(p)) > 0$. This property of the banks' payoff functions implies that the model exhibits no credit rationing with some borrowers receiving loans and others not. This differs from Williamson (1987) in which the costs of verifying adverse project outcomes leads to such rationing.

To sum up, both banks announce in equilibrium the zero-profit interest rates for *G* and *B*. As a consequence, the follower has no incentive to undercut the leader's offer. Entrepreneurs, by assumption 3, choose their banks randomly and the banks' expected profits are zero. A similar equilibrium prevails if neither bank invests in monitoring ($m_i = m_j = 0$), the only difference being that in this case each bank offers a single interest rate to all entrepreneurs in *GB*.

Loan Pricing Under Asymmetric Monitoring Investments: If banks have made asymmetric monitoring investments (eg $m_i = 0$ and $m_j = 1$), the M-bank has more competitive instruments than the NM-bank. It remains for us to determine the optimal interest rate setting rule. Not surprisingly, realization of the leader-follower roles determines to what extent the M-bank distinguishes the two customer groups in equilibrium. We establish the following in appendix 1:

Proposition 1. *Consider the sequential interest rate game in the case of asymmetric monitoring investment, conditional on the realization of the leader-follower roles. Then, in the unique Nash equilibrium*

(a) *The M-bank as the (price) leader quotes an 'indifference' rate,* $R_{M,G} = R_G^{ind}$*, for entrepreneurs it classifies as good and prices out entrepreneurs it classifies as bad. The NM-bank sets the monopoly rate,* $R_{NM} = R^*$*, and finances at this rate all entrepreneurs that the M-bank has classified as bad. Both banks make positive expected profits. The interest rates are given by*

$$R_G^{ind} = E(x)\ln\left[\frac{E(x)-v(GB)}{E(x)-v(GB)-(1+\rho)-\pi(R^*,v(B))}\right]$$

$$R^* = E(x)\ln\left[\frac{E(x)}{\hat{W}}\right]$$

where $\pi(R^*,v(B)) = \left((E(x)-v(B))(1-\hat{W}/E(x))-(1+\rho)\right) > 0$ *is the profit that the NM-bank earns from class B at the monopoly rate;*

(b) *as the (price) follower, the M-bank sets* $R_{M,G} = R_{M,B} = R^0_{v(B)}$ *while the NM-bank as the leader quotes* $R_{NM} = R^0_{v(B)}$*. The M-bank extends more loans than the NM-bank, ie it captures all customers it has identified as good and half of those labeled bad. Only the M-bank makes positive expected profits. The equilibrium interest rate is given by equation* (3)*, with p = B.*

The M-bank always earns positive expected profits (only) from the group of good entrepreneurs. Despite this, good borrowers pay on average a lower interest rate for their loans than bad customers. As the leader, the M-bank sets an interest rate schedule that provides a price umbrella under which the NM-bank may set its rate. This softens the undercutting strategy of the non-monitoring follower and leads to pricing out of the group of bad entrepreneurs. The result is close to the finding of Chan and Thakor (1987), who somewhat surprisingly find that *high*-quality borrowers may be priced out of the market but not explicitly denied loan, despite a bank having idle deposits. This way of pricing loans differs sharply from the situation in which the M-bank is the follower. In such a loan market, loan customers are effectively offered a pooling contract despite the bank's ability to discriminate between them. Finally, from the perspective of the NM-bank, there is a positive spillover from the monitoring investment of its rival: despite Bertrand-type competition and homogeneous products, the NM-bank earns positive expected profits in equilibrium.

The Monitoring Investment: In stage one each bank *i* chooses to monitor ($m_i = 1$) or not to monitor ($m_i = 0$) without knowing whether it is the leader or follower in stage 2. Under symmetric investments, the expected profits are zero. Under asymmetric investments they are gross of the fixed monitoring cost *M* (see appendix 1):

$$\pi_i(1,0) = \pi_j(0,1) \equiv \tfrac{1}{2}\pi(R_G^{ind}, v(G)) + \tfrac{1}{2}\pi(R^0_{v(B)}, v(G)) > 0 \qquad (5a)$$

$$\pi_i(0,1) = \pi_j(1,0) \equiv \tfrac{1}{2}\pi(R^*, v(B)) > 0 \qquad (5b)$$

where ½ is the probability of bank *i* becoming the Stackelberg leader. Taking into account *M*, the expected profits of the two banks are as summarized in the following payoff matrix:

Payoff Matrix. Expected equilibrium profits for monitoring choice outcomes.

	$m_j = 0$	$m_j = 1$
$m_i = 0$	0,0	$\pi_i(0,1), (\pi_j(0,1) - M)$
$m_i = 1$	$(\pi_i(1,0) - M), \pi_j(1,0)$	0,0

Consider the simultaneous entry of the banks and assume that the fixed investment generating monitoring service is feasible, ie that $\pi_i(1,0) = \pi_j(0,1) > M$. As long as this assumption holds, the normal form representation of the first stage game reveals

Proposition 2. *The monitoring model has two asymmetric subgame perfect equilibria in which only one bank invests in monitoring.*

Note that the equilibrium is unique up to the reversal of banks' indices. The reason for this result is that identical investments lead to Bertrand competition and zero profits, whereas with one bank investing in monitoring, *both* make strictly positive expected profits.[11]

We can now state the empirical predictions of the monitoring model. Propositions 1 and 2 directly imply that the M-bank finances projects that have higher values in the default state compared to the projects financed by the NM-bank. Depending on the realization of the leader-follower roles, it also charges interest rates that are either strictly lower than or the same as those charged by the NM-bank. We thus have

Proposition 3. *The M-bank charges on average lower interest rates and, conditional on the interest rates charged, faces smaller loan losses relative to the amount of loans extended, than the NM-bank.*[12]

2.3 The Product Differentiation Model

For reasons of brevity, we do not present the detailed analysis of the product differentiation model here in the main text, but refer the reader to appendix 2. The results are also very much in line with standard vertical product differentiation models (eg Shaked and Sutton 1982).

As explained, the basic setup is the same as in the monitoring model. Banks can simultaneously make fixed investments in the first stage. Here the investments are aimed at improving product quality; entrepreneurs value quality but differ in their valuations, θ. Entrepreneurs' valuation of quality is independent of their default costs. In the second stage, conditional on their quality investments, the banks

[11] We have also analyzed the case where banks enter the market sequentially and the entry order is random. In such a case, one can derive a threshold level that determines whether or not the bank entering first/last invests in monitoring.

[12] These empirical predictions are not specific to our model of information acquisition; eg Rousseau's (1998) model predicts that a bank that invests in new technology will at least temporarily charge lower interest rates and have less defaults.

compete by setting interest rates sequentially. As in the monitoring model, the leader-follower roles are determined randomly. Investments in quality do not allow the banks to obtain information about an individual customer's type.

As shown in detail in appendix 2, having both banks investing in quality is not equilibrium, as they would make zero profits. Nor is having neither bank invest in quality equilibrium, as long as the cost of investment in quality are not too high. Under that assumption, an asymmetric market structure emerges. The following summarizes the results for the product differentiation model:

Proposition 4. *The product differentiation model has two asymmetric subgame perfect equilibria in which only one bank invests in product differentiation. In these equilibria,*

(a) *The investing bank charges higher interest rates, and extends more loans than the non-investing bank.*
(b) *Conditional on interest rates charged, the banks' default costs are identical.*

As the investing bank offers higher quality, it can charge a premium in the form of higher interest rates. The higher interest rates naturally imply that, ceteris paribus, it faces higher default costs, but after controlling for that effect, default costs are identical.

In section 4 we will turn to the empirical specification of our model. The next section discusses the market and the data.

3 The Finnish Banking Market and the Cooperative Banks

3.1 The Data and Market Environment

Currently, partly as a result of the severe economic crisis in Finland in the early 1990s, the Finnish banking market is dominated by a few banks/banking groups, one of which consists of over 250 local cooperative banks. Our sample covers almost all of these banks. The other traditional group of local banks, the savings banks, were the most prominent victim of the banking crisis and have been dramatically reduced in size as a consequence of a) a large merger between them and b) a splitting of the merged bank between the remaining banking groups in 1993. As a result of mergers, the three main banking groups in Finland consist of the group of cooperative banks, which we focus on here, and two commercial banks operating on the national level and having a nationwide branch network. Several studies (eg Koskenkylä and Vesala 1994, Nyberg and Vihriälä 1994, Davis 1995) describe the events before and during the crisis, so we will offer only a synopsis here. The volume of lending grew very rapidly, at times by over 30% p.a. in the late 1980s. The growth was partly due to financial market liberalization that took place in the mid-1980s and partly due to an economic boom and lax monetary policy. The boom ended in a collapse of asset values, including real estate, which was a prime source of collateral, and the economy shrank by 8% in 1992 - 1994. Since then, the economy has been growing. The government bailout of banks has officially been estimated to cost approximately FIM 50 billion. Importantly for us, not a single bank was allowed to fail; hence sample selection is not an important issue.[13] Nonetheless, the crisis may affect our results and so we check the robustness of our empirical results in this respect.

A comparison of the nationwide branch networks of different banking groups (see table 1) reveals that as a group the cooperative banks have by far the largest branch network.[14] It is clearly larger than that of the other group of local banks, the savings banks. The size of the branch network of commercial bank Merita is roughly two thirds or less then that of the cooperative banks. This supports our implicit assumption that these are banks that have made (larger) fixed investments.[15]

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[13] During our sample period, all banks were required by law to belong to a security fund. Cooperative banks were members of the cooperative banks' security fund.

[14] Of the comparison banks/banking groups, Savings Bank of Finland (SBF) was created by a merger of most local savings banks, and was dismantled in 1993. Merita is the largest bank in terms of balance sheet total, formed through a merger of the two previously largest commercial banks. The branch networks of the two largest banks have been added together in the table to allow comparisons, and as such Merita's figures represent an upper bound.

[15] The second remaining bank operating nation-wide, besides Merita, is excluded from the table. The reason for this is that it is the government owned former postal savings bank. During our sample period, it had clearly the smallest number of own branches, but did provide some services through post offices.

Table 1. Nationwide branch networks of Finnish banks/banking groups

	Cooperative banks	Merita	Savings banks
1993	977	673	859
1994	993	776	248
1995	960	619	250
1996	893	479	242

Note: The 1993 figure for savings banks includes Savings Bank of Finland, which was dismantled by end-1993. Figures provided by the Finnish Bankers' Association.

Cooperative banks are mostly small local banks that share a common organizational form and certain institutions. For example, they own a 'central bank', have an association that collects and disseminates information, and share other facilities usually found in the headquarters of a bank. Though most decision making power is at the level of individual banks, group coherence and guidelines from the common bodies affect the behavior of individual banks in an essential way. During the boom years of the late 1980s, the cooperative banks were among the more conservative banks. For example, the volume of their lending grew less than that of deposit banks on average. They also experienced a smaller surge in the amount of bad loans during the crisis in the early 1990s (see eg Koskenkylä and Vesala 1994). Compared to other banking groups, cooperative banks are clearly more focused on private customers, agriculture, and small business.[16] As a matter of fact, cooperative banks are the biggest source of loans to agriculture and SMEs.[17] Given the special nature of agricultural loans, one could conjecture that banks with branch networks covering large geographic areas tend to be those that operate in the countryside and that these banks direct a relatively larger proportion of their loans to agriculture. As these loans are guaranteed by the government, we might observe a spurious correlation between branch network size and defaults and interest rates. We address this question in the empirical analysis.

We have data on 250 cooperative banks over the period 1992 - 1996. We use a relatively short and recent panel to exclude the 1980s, as the consensus view is that banks had not yet by the 1980s learned to operate in a liberalized environment. Another reason is to allow time for banks to adjust their branch networks and personnel to levels that are optimal under deregulated conditions; such adjustments necessarily take time. The descriptive statistics for our sample are given in table 2. Although these banks share several features, they are a rather diversified group: The smallest bank's loans amount to just over FIM 6 million, whereas for the largest ones loans amount to almost FIM 4000 million (about EUR 670 m); the mean is FIM 257 million.[18] On average, the banks' deposit totals (mean FIM 284 m) seem to slightly exceed their loans. We have calculated four interest rates,

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[16] The cooperative banks were originally established to channel government loans to small farms that had difficulties in getting loans from established banks. This was their main line of business until the 1950s (personal correspondence with historian Antti Kuusterä). The cooperative banks' joint market share of SME lending has been around 40%.

[17] The prevailing legislation guarantees loans made to farms. Hence these do not expose banks to credit risk.

[18] There has been some consolidation within the cooperative banks. Whenever two or more banks have merged, our data treats them as if they had merged prior to our observation period. A merger dummy did not turn out to be significant in the estimations.

two of which pertain to revenue (customer loans and interbank lending, mainly to other banks), two of which pertain to costs (deposits and interbank borrowing, from other banks). The deposit interest rate is lower than that for interbank borrowing, although there is variation across banks. The reverse applies for loans granted. Banks receive a clearly higher interest rate on customer loans than on interbank lending.

Table 2. Descriptive statistics for bank-level data

Variable definition	Mean	St.Dev
DEP = Amount of deposits in year t, FIM m	293.56	486.47
LOAN = Amount of credit market loans in year t, FIM m	258.47	474.90
R_D = Deposit interest rate in year t, calculated as interest rate expenses/amount of deposits	0.0390	0.0184
R_L = Loan interest rate in year t, calculated as interest rate income/amount of outstanding loans	0.0933	0.0166
R_{DM} = Interbank market deposit interest rate in year t, calculated as interest rate expenses/amount of interbank deposits	0.0650	0.0194
RDEP = Ratio of deposits to total funding	0.8551	0.0851
R_{LM} = Interbank market loan interest rate in year t, calculated as interest rate income/amount of outstanding interbank loans	0.0556	0.0216
DEFR = Net write-offs in year t/amount of outstanding loans in year t. DEF=ln(0.000001+DEFR) is used in the estimations	0.0141	0.0201
BRA = Number of branches at start of year t divided by the size (in square kilometers) of the market area	0.0079	0.0157
PERS = Amount of personnel expenses in year (FIM m) divided by number of branches at start of year t	3.2621	6.2004
INEFF = Ratio of non-interest expenses in year t to non-interest revenues	0.7126	0.3012
SBFD = Dummy variable taking value of 1 for 1993-1995 if the bank bought a part of the dismantled SBF bank in 1993	0.3104	0.4628

NOTE: data provided by the Central Bank of Finnish Cooperative Banks; all data on bank level, period 1992-1996. There are 250 banks in the data.

One of the variables of most interest in this study is the level of default costs. These are measured by net write-offs, ie the difference between write-offs and recoveries. As eg in Angbazo (1997), net writeoffs will proxy for asset quality and expected defaults (relative loan losses), and we have calculated it as a percentage of loans extended (excluding interbank loans). The percentage of default costs ($DEFR_{it}$) varies between 0 and 18.5%, with a mean of 1%.[19] As pointed out earlier, in autumn 1993 the Savings Bank of Finland (SBF) was dismantled through a sale of parts of its balance sheet (loans and deposits) and branches to its rival banks (see eg Vihriälä 1997 for details). In our sample, 97 banks were involved in the operation, and in the estimations we control for it via an SBF dummy (*SBFD*) (see table 2). It is naturally true that such bank-level averages may hide wide variations. For two reasons, this should not be a great concern. First, our sample selection conditions out all but cooperative banks, which, as noted above, are much more homogeneous than banks in general. Second, and even more important, our theoretical predictions are concerned with bank-level averages.

As our main measure of service accessibility (quality) *and* banks' ability to gather local information, we use the number of branches per square kilometer *at the start of the year* (BRA_{it}), which varies between $1.212*10^{-5}$ and 0.154 and has a mean of 0.008. Importantly for us, BRA_{it} should be negatively correlated with average distance between bank and borrowers. The idea behind this definition is that

[19] There are a few observations with negative *DEF*, mainly due to recoveries.

geographical proximity and distance are important determinants of service accessibility and information acquisition. The longer the distance, the higher the costs of acquiring information and monitoring borrowers. This view is supported by Petersen and Rajan (2000) who document, among other things, that distance is a good indicator of creditworthiness. The same argumentation applies for investments in quality: customers may value a large, geographically dense branch network that allows them easier access to services (see in particular Evanoff 1988). Given geographical proximity, a branch is the more effective in providing services and/or acquiring information, the more and better-trained its staff. To take into account the role of staff we use as another measure of fixed costs personnel expenses per branch ($PERS_{it}$). It varies from FIM 0.018 million to FIM 61.014 million per branch. The most obvious alternative way to measure branch density is to use a population-based measure. We test the robustness of our results (see section 4.3) by using as an alternative to BRA_{it} the variable BRA_p, defined as the number of branches per capita.

Because macroeconomic conditions vary markedly over the observation period, we checked the annual descriptive data on the banking variables for anomalies and/or outliers but found none (see appendix 3).

Table 3. Descriptive statistics: market level data

Variable definition	Mean	St.Dev
POPULAT = Total population	18.197	36.575
DENS = Ratio of population to area (in square kilometers)	24.407	62.868
OWNH = Ratio of persons living in their own homes to total population	0.298	0.025
FARM = Number of farms	484.445	516.401
WCAP = Taxable wealth per capita	52.248	11.773
UN = Unemployment rate	0.202	0.047
STUDENT = Ratio of students to total population	0.077	0.013
EDUC = Ratio of persons having a masters or Ph.D degree to total population	0.057	0.018
AGRIC = Ratio of persons employed in farming, fishing or other agricultural industries to total workforce	0.275	0.149
SERCON = Ratio of persons employed in services, construction or manufacturing to total workforce	0.322	0.106
OUTSIDE = Number of persons living in the market area but working outside the area	0.155	0.087

NOTES: data (1992-1995) provided by Statistics Finland

As to the operating environment of cooperative banks, they operate in different, non-overlapping markets. Quite in line with what the banks themselves do, a bank's market is here defined as the counties in which it has branches. Typically, there are very few competitors in the market so that competitive conduct is, along the lines of our theoretical model, essentially duopolistic. Most often the rival is either a savings bank or one of the nationwide commercial banks. Only in the larger cities is this generalization less appropriate. In table 3 we present descriptive statistics on the banking markets. This demographic and socioeconomic data was available to us only for 1992 - 1995. As can be seen, the markets vary in terms of population and density, average wealth, number of farms, unemployment rate, and average education level.

3.2 Cooperative Banks: Profit Maximization vs Managerial Rent-seeking

A special issue concerning our data that should be discussed is banks' ownership forms. One can argue that, contrary to our theoretical model, a cooperative bank may not seek to maximize profits. The danger in this case would be that we observe a spurious correlation between our dependent variables and measures of fixed investment that agrees with predictions of our model but which is due to non-profit maximizing behavior. However, we would argue that, conditional on a break-even assumption, our hypotheses hold even if managers are rent-seekers. Moreover, there are several empirical reasons why the assumption of profit maximization seems to be valid here.

Without attempting to model managerial rent-seeking formally, it seems plausible to assume that even rent-seeking management has to break even, which does leave scope for non-profit maximizing behavior at the margin. However, as stated above, our hypotheses and data are concerned with average interest rates and average default levels, and hence the assumption is justified. If rent-seeking leads to higher fixed investments and to 'empire building', the management still has to ensure a positive price-cost margin. This can happen in two ways. Either the management offers higher quality products to depositors and/or borrowers or it is able to attract borrowers of lower-than-average risk. If management provides higher quality products to depositors only, there is no correlation between our measures of fixed investment and loan interest rates or default costs. If it offers higher quality products to borrowers, this behavior is observationally indistinguishable from a profit maximization with fixed investments aimed at improving the quality of the bank's products. Finally, management may be able to attract low-risk customers. One then has to explain how it is able to do this. If all banks identify their customers by type, they face Bertrand competition with homogeneous goods, and rent-seeking will not result in breaking even. If a bank's management is better at identifying low-risk customers than its rivals and makes fixed investments, this is observationally equivalent to profit maximization with investment in monitoring. We would argue that if the only factors differentiating a rent-seeking bank from other banks are fixed investments and either wider lending margins or lower default rates and interest rates, then management is actually using fixed investments to generate one or the other of the two, ie it is behaving in accord with our hypotheses.

Empirically, only a relatively small portion of these banks' customers are actually members of the cooperative.[20] Treating non-member customers as if the bank was profit-maximizing seems a good first approximation. Secondly, these banks seem to behave no differently toward their customers than other banks, other than being more oriented toward small businesses. Finally, to the extent that managerial rent-seeking at bank level is constant over our relatively short obser-

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[20] In 1998, less than 1/3 of the 2.1 million 'active' customers were members, despite strong growth in the 1990s. The growth was due to active recruiting. The cooperative banks at aiming at 1 million members by 2002. Some 5% of members are firms or societies (eg sport clubs). The one-time membership fee was no less than FIM 500 for 15% of the banks in 1992; currently, it is more than that for 40% of the banks. We were told that there is wide variation between banks. Members have received miscellaneous benefits, the economically most important probably being the right to buy a 'membership credit insurance policy' for use as collateral. No clear policies have existed in terms of giving members loans on more beneficial terms.

vation period, we control for it in our econometric specification by controlling for bank-specific nonobservables.

One could also claim that cooperative banks differ in other respects from other banks. However, as long as such unobserved differences are not correlated with fixed investment, *conditional on a bank being a cooperative bank*, this is not a problem. The reason for this relates to our sample selection strategy: By including only cooperative banks in the sample, we condition out any permanent differences due to organizational form that do not vary between cooperative banks.

The final matter regarding the use of cooperative bank data is that these banks do not necessarily make efficient use of their investments, which might cause a spurious negative correlation between fixed investments and either interest rates and/or default costs. We have four responses to this. Firstly, to the extent that cooperative banks are uniformly inefficient, we control for this by looking only at such banks. Secondly, if such inefficiencies vary over banks but are time-invariant, we control for them through bank-specific effects. Thirdly, an unpublished study on the cost-efficiency of Finnish cooperative banks (Linnosmaa 1993), indicates that inefficiencies are on average 20%, which does not differ greatly from international estimates using data on *profit-maximizing* banks (eg Allen and Anoop 1997). Fourthly, although Berger et al (1993) found that a bank's X-efficiency is size related, with small firms being less efficient, the banks in our sample are all small banks as per their definition. Finally, we explicitly control for inefficiency by using the standard measure: the ratio of non-interest expenses to non-interest income.

4 Empirical Model and Results

4.1 The Empirical Model

The empirical predictions of our theoretical model are expressed in propositions 3 and 4. Our models postulate two types of banks in a given banking market: those that have made a fixed investment and those that have not. Fixed investments may affect, firstly and most importantly for the empirics, the relative amount of defaults (negatively in the case of monitoring, not at all in the case of market power investments), and secondly, the loan interest rate (negatively in the case of monitoring investments, positively in the case of market power investments). If a bank is using its fixed investments for both purposes, their effect on interest rates depends on the relative strengths of the two opposing effects. As market power has no effect on default costs, we would expect a negative relationship between fixed investments and default costs.

A central feature of our identification strategy is that our sample is special in that the banks operate in a similar way, and that they operate in different, non-overlapping markets. Our model predicts that in a given market there will be both banks that invest in fixed costs and banks that do not. Our data (see table 1) supports the assumption that cooperative banks have made fixed investments. The common ownership form and other shared features suggest that they use their fixed investments for the same purpose(s), be it market power, information acquisition, or something else. Having similar banks that operate in different markets enables us to avoid having in the sample non-investing and investing banks, as well as investing banks that use their investments for different purposes.[21] With our model, both of these would be unavoidable if our data covered all banks in a given market.

First off, it would be interesting to compare investing banks (those in our sample) with non-investing banks. Unfortunately, no data is available on the competitor banks at the level of disaggregation that would make such a comparison possible.

We estimate the following dynamic equations for defaults (DEF_{it}) and loan interest rates ($INTL_{it}$):

$$\begin{aligned} DEF_{it} &= \alpha_D DEF_{i,t-1} + \beta_{D1} LOAN_{it} + \beta_{D2} INTL_{it} + \beta_{D3} INEFF_{it} \\ &\quad + \beta_{D4} BRA_{it} + \beta_{D5} PERS_{it} + \mu_{Di} + \gamma_{Dt} + \nu_{Dit} \end{aligned}$$

$$\begin{aligned} INTL_{it} &= \alpha_I INTL_{i,t-1} + \beta_{I1} LOAN_{it} + \beta_{I2} DEF_{it} + \beta_{I3} INEFF_{it} \\ &\quad + \beta_{I4} BRA_{it} + \beta_{I5} PERS_{it} + \beta_{I6} INTD_{it} + \mu_{Ii} + \gamma_{It} + \nu_{Iit} \end{aligned}$$

where t = 1992, …,1996 and i = 1, …, 250. In these equations, the γ_{jt} ($j = D, I$) are time dummies, and ν_{jit} are i.i.d. error terms. The time dummies should capture the effects of any economy-wide shocks on loan pricing and defaults (especially important in the early years of our sample). The μ_{ji} are firm-specific effects, possibly correlated with explanatory variables, which control for bank- and market-specific nonobservables. The most important market- (bank-) specific nonobservables are the (average) riskiness of loan customers and the average expected value of their

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[21] Note that defining empirically a ‘non-investing’ bank is difficult, as any retail bank needs at least one branch and some employees to be operative.

projects, and (possibly) the scope for managerial rent-seeking. To the extent to which behavioral patterns and competitive pressures of the rival banks are time-invariant, μ_{ji} controls also for the competitive situation of the market. As in the company investment application of Bond and Meghir (1994), a further motivation for including bank-specific effects is that our sample is non-random, as it includes only cooperative banks. By allowing for such effects, we can to an extent control for this particular persistent feature.

As to explanatory variables, the variable $LOAN_{it}$ is included to control for the size of a bank (its loan book). This is especially important because size may allow a bank to 1) gain reductions in costs; 2) enjoy economies of scope, eg by facilitating cross-selling of products; 3) better diversify its loan book; 4) achieve lower funding costs (this we control also separately; see below); and 5) increase the likelihood of a bailout by the cooperative banks' security fund.

The once lagged endogenous variables are included to capture any adjustment processes in banks' pricing behavior and gradual realization of loan losses. $INEFF_{it}$ (ratio of non-interest expenses to non-interest revenues) is included as a summary variable to control for i) the (in)efficiency of management, ii) implicit interest rates (possibly) charged in the form of fees on loans and commissions and iii) income smoothing. As these (mixed) effects are all represented by $INEFF_{it}$, and since this summary variable also probably proxies the extent to which banks are engaged in other operations besides traditional loan business, its sign is not predicted. The cost of funding, $INTD_{it}$, (calculated as a weighted average of interest rates on interbank borrowing and deposits) and the proxy for expected defaults, DEF_{it}, are included in the interest rate equation and are predicted to have positive coefficients. We do not model deposit-market related reasons for fixed investments. $INTD_{it}$ controls for such effects where they exist. Our theoretical model drives the inclusion of $INTL_{it}$ in the default equation, and its effect on defaults should be positive. The default equation also contains the SBF-dummy.[22]

All variables are in logs, and since there are observations with zero values for $DEFR_{it}$, we use $DEF_{it} = \ln(.000001+DEFR_{it})$. We experimented with different definitions of DEF_{it} (linear, $\ln(1+DEFR_{it})$), and our results are robust in this sense. The nominal values of variables are used.[23]

4.2 Econometric Methods and Instruments

Because our econometric model is dynamic, we used the Generalized Method of Moments (GMM) designed for dynamic panel data (Arellano and Bond 1991, Blundell and Bond 1998, 1999) in our estimation.[24] We report two different GMM

[22] The SBF-dummy was never significant in the interest rate equation and was therefore dropped. The results are robust to its inclusion in the specification.

[23] The reason for using nominal values is that i) it is not clear what deflator to use (eg real estate values both declined and increased during the observation period), ii) inflation was very low during the (short) observation period. We did however estimate the base specification with variables deflated by the consumer price index and the cost of living index and got the same results.

[24] Estimating a static model with Error Component 2SLS (Baltagi 1981) produced similar results, but autocorrelation tests on the estimated residual gave mixed results. It should however be noted that these estimations were based on a set of covariance restrictions that were somewhat stronger than the ones adopted in this paper. These exogeneity restrictions were made to obtain valid instruments, and we did not test for their validity in that framework.

estimates: 'GMM DIF' is the Arellano-Bond (1991) estimator, and 'GMM SYS' the Blundell and Bond (1998; see also Arellano and Bover 1995) estimator. The first estimator uses on levels (at lags 2 or more) of the endogenous explanatory variables as instruments in first-differenced equations. For predetermined variables, the lag 1 levels are also valid instruments. The second estimator utilizes the assumption that the differences in the explanatory variables are uncorrelated with the firm-specific effect (and a further initial condition assumption). This allows the use of suitable lagged first differences as instruments for the equations in levels. It has been shown (Blundell and Bond 1998, 1999) both in Monte Carlo studies and empirically that especially when the levels are weak instruments for the first differenced variables, considerable efficiency gains and avoidance of finite sample bias can be achieved by adding these extra moment conditions. Such a situation may arise especially when the time series are persistent. This is the case for a number of variables in our data, particularly for $PERS_{it}$, BRA_{it} and $LOAN_{it}$.

In the GMM DIF estimations of the default and loan interest rate equations, we have i) allowed for the fact that the lagged dependent variable is necessarily correlated with the bank-specific effects and ii) assumed that the levels of any other explanatory variable are potentially correlated with the bank-specific effects. In the default equation, the lagged dependent variable and $LOAN_{it}$ are potentially correlated with v_{Dit}, ie endogenous. Since DEF_{it} represents realized loan defaults, the other explanatory variables in this equation are assumed to be predetermined w.r.t. v_{Dit}. For the loan interest rate equation, a more conservative approach was adopted in that all the explanatory variables are treated as endogenous. Based on this classification, the instruments used for GMM DIF are thus the observations on explanatory variables dated t–2 or earlier if the variable is endogenous and t–1 or earlier if it is predetermined.

In the GMM SYS estimations, we initially assumed that the differences of all explanatory variables in both interest rate and default equations are uncorrelated with the bank-specific effects and specifically that the deviations of the initial conditions from the (long-run) mean of the process are uncorrelated with the mean itself (Blundell and Bond 1998, 1999). The instruments used in the levels equations are the observations on the differenced explanatory variables dated t–1 (eg Δx_{t-1}) if the variable is endogenous and t if it is predetermined.

The first observation of our sample is however special. On the one hand, in 1992 the banking crisis was at its worst, with eg defaults for the whole Finnish banking sector reaching their peak (during that year, 4.8% of loans were written off; see Davis 1995). On the other hand, the process of dismantling the SBF bank took place in 1992 and 1993. Interestingly, the default costs for our sample were at their lowest in 1992, relative to loans extended, which also were at their minimum. This casts doubts on the validity of the initial conditions restrictions, at least for the DEF_{it} and $LOANS_{it}$ variables. Indeed, when we tested for all the additional moment conditions used in the levels equations, a difference-Sargan statistic rejected their validity at the 1% level (p-value .0083) in the interest rate equation and resulted in a p-value of .105 in the default equation. There are reasons to suspect that $\Delta LOAN_{i,t-1}$ and $\Delta DEF_{i,t-1}$ are the driving forces behind the rejection (and the marginality of validity). As a matter of fact, the validity of the additional moment conditions used in the levels equations is not rejected when both $\Delta LOAN_{i,t-1}$ and $\Delta DEF_{i,t-1}$ are dropped from the instrument set (the p-values for difference-Sargan tests are .211 and .239 in the default and interest rate equations, respectively). We therefore decided to err on the conservative side and excluded them from the instrument set of both equations in the estimations that follow.

4.3 Empirical Results

The results to be reported are based on one-step GMM estimators.[25] The asymptotic variance matrix for these is more reliable than for the two-step GMM (see eg Blundell and Bond 1998).

4.3.1 Interest Rate Equation

The interest rate estimation results are presented in table 4. Comparing first the coefficients of the lagged dependent variable, we observe that the OLS coefficient (column 1) is the largest, the within-groups coefficient (column 2) the smallest, and the GMM estimates (GMM DIF in column 3, GMM SYS in 4) are in between the others.[26] These follow closely the expected pattern and that reported by Blundell and Bond (1999) in their production function and Monte Carlo studies. Turning to the other parameters, the OLS and within-group estimates differ (sometimes substantially) from the GMM estimates. The GMM DIF and GMM SYS estimates are reasonably close to each other, but the latter seem to be more efficient, as expected. Focusing on the GMM SYS estimates of our base specification (column 4), we find that expected default costs (DEF_{it}) do not affect interest rates but that interest rate costs ($INTD_{it}$) have a positive effect. The long-run cost-of-financing elasticity of loan interest rates is .148. The coefficient of loan book size ($LOAN_{it}$) is positive and has a p-value of 0.09. The summary variable $INEFF_{it}$ obtained a negative and significant coefficient. The variables of greatest interest, BRA_{it} and $PERS_{it}$, both carry negative and significant coefficients, implying that banks with larger branch networks and more human capital at branch level charge lower interest rates. These results are in line with the information acquisition model, and reject the market power model and naturally thereby also the possibility that banks use their fixed investments for both market power and information acquisition.[27] The estimated elasticities for BRA_{it} and $PERS_{it}$ are small, which indicates that the costs of information acquisition in terms of having to offer lower interest rates to attract those customers the bank has identified as 'good' are low.

Turning to the test statistics, the first differenced residuals display first order autocorrelation, as expected, and no second order autocorrelation. The Sargan tests do not reject the overidentifying restrictions in the GMM DIF or GMM SYS estimations. A Wald statistic testing the joint significance of BRA_{it} and $PERS_{it}$ rejects the null hypothesis of their coefficients not being jointly different from zero.

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[25] The estimates have been produced using Arellano-Bond DPD98, kindly provided by Steve Bond. For reference, we also report OLS and within-group estimates. The consistency of these two estimators requires that all explanatory variables be strictly exogenous w.r.t. v_{jit}.

[26] Note that the number of observations varies over estimation methods as GMM DIF loses one year (cross-section) due to lag construction and a second year due to first-differencing. GMM SYS loses only one cross-section.

[27] At the very minimum, it is the case that information acquisition strongly dominates any market power use of fixed investments. It is worth noting that the within-group estimate produces positive and significant coefficients for *BRA* and *PERS* (OLS for *PERS*), which would support the market power hypothesis and reject the information acquisition hypothesis. We have however tested the null hypothesis of *BRA* and *PERS* being predetermined against the alternative of theie being endogenous. Using a difference Sargan test, we rejected the null at the 5% level (p-value .034). Based on this, the consistency of OLS and within-group estimators can be questioned.

Table 4. Interest rate estimation

Variable	(1) OLS (Levels)	(2) WITHIN GROUPS	(3) GMM–DIF	(4) GMM–SYS	(5) GMM–SYS	(6) GMM–SYS	(7) GMM–SYS	(8) GMM–SYS
$INTL_{t-1}$	.4042	-.0857	.2838	.2620	.2503	.2685	.2662	.2639
	(.0542)	(.0464)	(.0635)	(.0567)	(.0544)	(.0748)	(.0699)	(.0748)
LOAN	-.0033	-.1292	.0763	.0323	.0215	.0263	.0261	.0171
	(.0037)	(.0650)	(.0745)	(.0194)	(.0143)	(.0217)	(.0246)	(.0272)
DEF	.0030	-.0013	.0014	.0018	.0039	.0031	.0031	.0030
	(.0008)	(.0010)	(.0030)	(.0027)	(.0025)	(.0031)	(.0032)	(.0031)
INTD	.0821	.1388	.1836	.1091	.1202	.1308	.1794	.1448
	(.0219)	(.0431)	(.0775)	(.0420)	(.0670)	(.0604)	(.0588)	(.0633)
INEFF	-.0805	-.1662	-.1598	-.0893	-.0851	-.1185	-.1220	-.1146
	(.0111)	(.0215)	(.0382)	(.0304)	(.0331)	(.0324)	(.0332)	(.0310)
BRA	-.0008	-.1117	-.1135	-.0343	-.0307	-.0280	-.0557	-.0286
	(.0016)	(.0599)	(.0736)	(.0120)	(.0094)	(.0110)	(.0236)	(.0162)
PERS	.0052	-.1300	-.1233	-.0426	-.0335	-.036	-.0595	-.0329
	(.0020)	(.0626)	(.0745)	(.0185)	(.0145)	(.0196)	(.0299)	(.0254)
RDEP	-	-	-	-	.0427	-	-	-
					(.1049)			-
DENS	-	-	-	-	-	-	-.0844	-
							(.0384)	
EDUC	-	-	-	-	-	-	.0483	-
							(.0199)	
OWNH	-	-	-	-	-	-	.0998	-
							(.0790)	
UE	-	-	-	-	-	-	-	-.0342
								(.0330)
WCAP	-	-	-	-	-	-	-	-.0011
								(.0173)
AGRIC	-	-	-	-	-	-	-	-.0123
								(.0082)
Nobs.	1000	1000	750	1000	1000	750	750	750
Sargan	-	-	.605	.448	.251	.128	.130	.138
m1	-.669	-1.929	-5.309	-5.420	-5.918	-5.136	-5.167	-5.011
	(.503)	(.054)	(.000)	(.000)	(.000)	(.000)	(.000)	(.000)
m2	1.605	-.340	.641	.500	.393	-	-	-
	(.108)	(.734)	(.521)	(.617)	(.695)			
Wald1	360.227	76.242	52.771	38.080	43.598	49.195	51.680	54.679
	(.000)	(.000)	(.000)	(.000)	(.000)	(.000)	(.000)	(.000)
Wald2	589.97	198.505	182.918	410.077	435.767	27.103	27.607	22.580
	(.000)	(.000)	(.000)	(.000)	(.000)	(.000)	(.000)	(.000)
Wald3	-	-	-	8.141	10.590	6.620	5.716	3.496
				(.017)	(.005)	(.037)	(.057)	(.174)

NOTES: All GMM estimates are one-step. Numbers reported are coefficient and asymptotic standard errors (s.e.). Reported standard errors are robust to general cross-section and time-series heteroscedasticity. Nobs is the number of useable observations. All estimations include time dummies.

– Sargan is a test of the overidentifying restrictions for the GMM estimators. Reported numbers are p-values.

– m1 and m2 are tests for 1^{st} and 2^{nd} order autocorrelation in the first differenced residuals (except for OLS and within-group estimations, for which the tests are for levels residuals); they are asymptotically distributed N(0,1); (p-values)

– Wald1 = Wald test of joint significance of explanatory variables (p-value)

– Wald2 = Wald test of joint significance of time dummies (p-value)

– Wald3 = Wald test of joint significance of BRA and PERS terms (p-value)

Robustness tests

We conducted a number of robustness tests. Firstly, as the time period covered by our data starts with a recession and ends with a period of strong growth, we tested our coefficients for stability over time. This was done by introducing an indicator variable for the years 95-96 (years of positive GDP growth) and interacted it with other variables. We could not reject the null that the coefficients are stable over time (p-value .137). Secondly, as the banks differ substantially in size, we tested whether our coefficients for central variables, ie BRA_{it}, $PERS_{it}$, $INTL_{i,t\text{-}1}$ and DEF_{it}, are sensitive to the size of the banks. We introduced an indicator variable that took the value unity if the sum of $LOAN_{it}$ and interbank lending (eg total loans) was above mean (and as an alternative, median) and zero otherwise, and interacted it with the aforementioned variables. Again, the null hypothesis could not be rejected at conventional levels (p-value .270). Thirdly, earlier literature (Fama 1985 and Vale 1993 in particular) has suggested that banks can use deposits to monitor their loan customers' cash flows and thereby gain information on the riskiness of loans. We tested whether this affects loan interest rates by including the variable $RDEP_{it}$, defined as the ratio of deposits made by customers to the sum of customer deposits and interbank borrowing. Treating $RDEP_{it}$ as endogenous, we find that it has no effect on bank's loan interest rates. Fourthly, notwithstanding our arguments favoring a geography-based definition of the branch variable, we estimated the model using the number of branches divided by population. These estimations can be found in appendix 4 and verify our main results. Finally, one could argue that the effect of fixed investments, especially that of $PERS_{it}$ is nonlinear. We thus re-estimated the model including the squared (log of) $PERS_{it}$ (see appendix 4). Again, our results are confirmed as both the linear and the squared $PERS_{it}$ terms obtain negative coefficients, with the former being statistically significant.

The estimates using the whole panel do not include exogenous variables, as market characteristics are currently available only up to 1995. Thus column 6 reproduces the estimation of column 4 (GMM SYS), using 1992 - 1995 data. As the column reveals, our results are robust to exclusion of 1996, a year of strong economic growth. In columns 7 and 8 we add different market characteristics to the model. In these exercises, market level variables are treated as strictly exogenous (and they are only used to instrument themselves). Adding a group of demographic variables (population density $DENS_{it;}$ see table 3 for definitions), education ($EDUC_{it}$) and home ownership ($OWNH_{it}$)) leads to higher absolute values for the BRA_{it} and $PERS_{it}$ coefficients. Two of the three market characteristics obtain statistically significant coefficients. Adding controls for unemployment (UE_{it}), wealth per capita ($WCAP_{it}$) and agriculture ($AGRIC_{it}$) causes $PERS_{it}$ to become insignificant, and BRA_{it} is only marginally significant. However, none of these three controls gets a statistically significant coefficient. We conclude that our results for the negative effects of branch network density and bank human capital on loan interest rates are robust.

To further address the issue of a potentially spurious relationship between our measures of fixed investment and dependent variable(s) due to agriculture, we introduced two further controls: the number of farms in the market, and the average size of a farm. Using all three agricultural controls showed that although they rendered both $PERS_{it}$ and BRA_{it} insignificant, the controls were jointly highly insignificant (p-value 0.724). Introducing them individually showed that $AGRIC_{it}$ is the one that affects our measures of fixed investments, albeit its coefficient was very imprecisely measured (p-value 0.361). With the two other controls, at least the coefficient of BRA_{it} remained significant. One should also keep in mind that the level of agricultural activity over our relatively short observation period is largely constant, and therefore controlled by the market- (bank-) specific effect. We conclude that our results are not due to spurious correlation between our measures of fixed investment and agricultural loans (see also the robustness tests pertaining to the estimated default equation).

4.3.2 Default Equation

Turning now to the results for the default equation in table 5 (column order as in table 4), we find that the coefficients of the lagged dependent variable generated by different estimation methods follow the expected pattern, with the GMM SYS estimate being 0.19. Again concentrating on the GMM SYS estimates (base specification in column 4), we find first of all that an increase in the loan interest rate ($INTL_{it}$) increases the amount of defaults significantly (long-run interest rate elasticity of defaults 8.126). This is in line with our (and other) theoretical models. Even after controlling for this effect, banks with larger loan books have larger relative default costs. This could reflect the specificity of our sample period and more careful choice of customers on the part of small banks. However, it is also possible that the result is not period-specific. This implies that, conditional on the level of fixed investment, a larger loan book (implying a greater number of loans extended) leads to larger default costs. Decreasing returns to scale in the information acquisition technology would lead to this result. The summary variable $INEFF_{it}$ has no effect on default costs, but we find that banks into which former savings banks' branches have been merged have lower loan losses. A possible explanation for this is that only the healthier cooperative banks (SBF dismantlement occurred in 1992 - 1993, in the midst of the banking crisis) were willing (or allowed by the government) to take on former savings bank branches. Also, as a part of SBF dismantlement, the worst loans were transferred to a government-run asset management company while the buying banks took on their books only loans that were considered healthy. Most significantly, we find that both variables capturing fixed costs have significant negative effects on defaults, which supports the information acquisition hypothesis.

The estimated long-run elasticities are –2.15 for branch density and –4.08 for personnel costs. These results reject the market power model (as well as the managerial rents hypotheses).

Turning briefly to the test statistics, these are similar to those of the interest rate equation. In particular, the Sargan tests do not reject the overidentifying restrictions in the GMM DIF or GMM SYS estimations and a Wald statistic rejects the null of BRA_{it} and $PERS_{it}$ being not jointly different from zero.

Table 5. Default cost estimation

Variable	(1) OLS (Levels)	(2) WITHIN GROUPS	(3) GMM DIF	(4) GMM SYS	(5) GMM SYS	(6) GMM SYS	(7) GMM SYS	(8) GMM SYS
DEF_{t-1}	.3597	-.0676	.2062	.1874	.1864	.1691	.1805	.1744
	(.0432)	(.0415)	(.0645)	(.0586)	(.0590)	(.0759)	(.0777)	(.0766)
LOAN	.8075	.9424	1.7024	3.7453	2.6333	2.7800	3.2025	2.7991
	(.1505)	(1.4133)	(3.7771)	(.7300)	(.6069)	(.6899)	(.8311)	(.8369)
INTL	4.8798	3.8350	8.7792	6.6033	4.3394	5.3234	5.4560	5.3366
	(1.8183)	(2.5887)	(3.0866)	(2.8105)	(2.7927)	(2.8791)	(2.9362)	(3.0813)
INEFF	1.7917	-1.2155	.1381	-.0133	-1.0459	-.6972	-.2317	-.1519
	(.3763)	(0.8235)	(1.1478)	(1.1657)	(1.1714)	(1.3052)	(1.2875)	(1.3086)
BRA	-.0816	-.4618	-8.3117	-1.7526	-.9105	-.9589	-1.5315	-.5968
	(.0871)	(1.6473)	(4.3744)	(.6883)	(.4830)	(.5282)	(.9922)	(.6700)
PERS	-.3318	-.9108	-10.1814	-3.3185	-2.3859	-2.4946	-3.1466	-2.0503
	(.1117)	(1.6092)	(4.4300)	(.9000)	(.7332)	(.8032)	(1.2863)	(.9521)
SBFD	-	-	-	-1.2651	-1.1486	-1.1676	-1.2964	-1.0320
				(.5088)	(.4733)	(.5202)	(.5965)	(0.4988)
RDEP	-	-	-	-	-8.3351	-8.6013	-7.4997	-7.3036
					(3.2574)	(4.1885)	(3.8598)	(4.4642)
DENS	-	-	-	-	-	-	-2.8371	-
							(1.6670)	
EDUC	-	-	-	-	-	-	.9744	-
							(.9063)	
OWNH	-	-	-	-	-	-	7.0733	-
							(3.3794)	
UE	-	-	-	-	-	-	-	.1693
								(1.3596)
WCAP	-	-	-	-	-	-	-	1.5145
								(.8060)
AGRIC	-	-	-	-	-	-	-	.4435
								(.3559)
Nobs.	1000	1000	750	1000	1000	750	750	750
Sargan	-	-	.281	.195	.278	.556	.479	.430
m1	.467	-5.016	-5.302	-5.053	-4.963	-3.877	-3.903	-3.897
	(.640)	(.000)	(.000)	(.000)	(.000)	(.000)	(.000)	(.000)
m2	.801	-1.539	-.393	.270	.418	-	-	-
	(.423)	(.124)	(.695)	(.788)	(.676)			
Wald1	342.643	12.826	21.206	54.881	84.384	77.291	75.018	98.562
	(.000)	(.046)	(.002)	(.000)	(.000)	(.000)	(.000)	(.000)
Wald2	10.488	8.433	9.850	7.144	9.987	13.164	18.475	4.558
	(.015)	(.038)	(.020)	(.067)	(.019)	(.001)	(.000)	(.102)
Wald3	-	-	9.463	13.968	10.827	9.872	7.760	6.850
			(.009)	(.001)	(.004)	(.007)	(.021)	(.033)

NOTES: All GMM estimates are one-step. Numbers reported are coefficient and asymptotic standard errors (s.e.). Reported standard errors are robust to general cross-section and time-series heteroscedasticity. Nobs is the number of useable observations. All estimations include time dummies.

– Sargan is a test of the overidentifying restrictions for the GMM estimators. Reported numbers are p-values.

– m1 and m2 are tests for 1st and 2nd order autocorrelation in the first differenced residuals (except for OLS and within-group estimations, for which the tests are for levels residuals); they are asymptotically distributed N(0,1); (p-values)

– Wald1 = Wald test of joint significance of explanatory variables (p-value)

– Wald2 = Wald test of joint significance of time dummies (p-value)

– Wald3 = Wald test of joint significance of BRA and PERS terms (p-value)

Robustness Tests

We conducted the same robustness tests as with the interest rate equation and the results were similar, with one exception. The $RDEP_{it}$ variable (see column 5) obtained a negative and significant coefficient (-8.34) when added to the specification and treated as being endogenous and correlated in levels with the bank-specific effects. This provides evidence that banks can indeed use information obtained from monitoring customers' cash flows to reduce loan losses. Concurrently and independently, Mester et al (1998) obtained a similar result using data on US checking accounts. Adding $RDEP_{it}$ reduces the absolute size of the BRA_{it} and $PERS_{it}$ coefficients to -0.91 and –2.38, respectively. They do remain statistically significant, however.

Excluding the 1996 data does not materially affect the results (column 6). Adding exogenous control variables to the specification changes slightly the BRA_{it} and $PERS_{it}$ coefficients. However, only two of the six exogenous regressors ($OWNH_{it}$ and $AGRIC_{it}$ respectively in columns 7 and 8) obtain statistically significant coefficients. Adding $DENS_{it}$, $EDUC_{it}$ and $OWNH_{it}$ renders the BRA_{it} coefficient significant at only the 12% level; BRA_{it} and $PERS_{it}$ are still jointly significant. Adding UE_{it}, $WCAP_{it}$ and $AGRIC_{it}$ results in an insignificant BRA_{it} coefficient, but BRA_{it} and $PERS_{it}$ are still jointly significant.

As with the interest rate equation, we conducted separate tests to check for the effects of agriculture on defaults. BRA_{it} and $PERS_{it}$ remained jointly significant (though only $PERS_{it}$ individually) when we included all three controls. They were jointly and individually insignificant (p-value of joint significance 0.432). Introducing the controls individually, we found that only when the number of farms was introduced was it not the case the both BRA_{it} and $PERS_{it}$ obtained significant coefficients and, even then, they were jointly significant (though only $PERS_{it}$ individually). The level of agricultural activity (proxy for the level of agricultural loans) thus does not cause a spurious correlation between defaults and our measures of fixed investment.

As a last robustness check, we tested whether future default costs (above and beyond one year) are affected by current values of BRA_{it} and $PERS_{it}$. The aim is to control for the definition of $DEF_{it,}$ which is calculated using net writeoffs (default costs) for the current period, in line with our theoretical model. However, banks in fact incur default costs from loans made in earlier periods, since it takes time before loan risks are realized and loans are written off. The assumption in our monitoring model is that fixed costs are investments that improve a bank's ability to ex ante identify projects with small liquidation costs and/or high resale value. It could be that fixed costs are instead used to improve banks' interim and ex post monitoring ability (costly state verification). To some extent, we control for this in all estimations by using the number of branches at the start of the year in computing BRA_{it}. One could however argue that if only current levels of BRA_{it} and $PERS_{it}$ (as defined) affected DEF_{it} negatively, it would not be clear which of the two phenomena generates the results. Finding that lagged values of *BRA* and *PERS* affect current values of DEF_{it} negatively would provide additional support for our assumption of ex ante monitoring.

The results of the estimations are reported in table 6, where we have used the GMM SYS estimator and the same instruments as above. The first column reproduces our base specification on 1992–1996 data. Column 2 replaces the current values of BRA_{it} and $PERS_{it}$ with once lagged values ($BRA_{i,t\text{-}1}$ and $PERS_{i,t\text{-}1}$). In column 3, BRA_{it} and $PERS_{it}$ have been lagged two years, and column 4 reflects a specification with both current and once lagged values of *BRA* and *PERS*. The idea behind including them is that in any given year, DEF_{it} consists of defaulted loans extended in different years. As the relationship between these explanatory variables and DEF_{it} could well be nonlinear, and because the current and lagged levels of BRA_{it} and $PERS_{it}$ are fairly strongly autocorrelated, we experimented with inclusion of the squared logs of lagged *BRA* and *PERS* (column 5).

Using the once lagged values, we find that both $BRA_{i,t\text{-}1}$ and $PERS_{i,t\text{-}1}$ carry imprecisely measured negative coefficients. The *p*-value of a test of joint significance is 0.138. Lagging the variables twice results in negative coefficients; that of $BRA_{i,t\text{-}2}$ is significant, and they are also jointly significant. In column 4 we find that the current values of BRA_{it} and $PERS_{it}$ obtain negative and significant coefficients, and lagged values positive and insignificant coefficients. Column 5 shows that both current values and the lagged squared values of *PERS* carry negative and significant coefficients. The coefficient of lagged squared *BRA* is positive but insignificant. Though not as strong as those reported in table 5, these results support the assumption of out theoretical model that fixed costs contribute to the ex ante information acquisition ability of banks.

Table 6. Default cost estimations (1992–1996) with lagged BRA and PERS

Variable	(1)	(2)	(3)	(4)	(5)
DEF_{t-1}	.1874	.1926	.278370	.1937	.1885
	(.0586)	(.0595)	(.0849)	(.0567)	(.0568)
LOAN	3.7453	1.5720	1.4900	3.5924	3.6233
	(.7300)	(.5476)	(.5252)	(.7379)	(.6539)
INTL	6.6033	4.1526	6.7225	6.9403	6.5391
	(2.8104)	(2.5040)	(4.0099)	(2.7583)	(2.6596)
INEFF	-.0132	3885	-.6718	.2371	.2304
	(1.1656)	(0.9628)	(1.3835)	(1.1142)	(1.0641)
BRA	-1.7526	-	-	-2.4266	-.9591
	(.6882)			(1.0670)	(.3745)
PERS	-3.3185	-	-	-4.0592	-2.7016
	(.9001)			(1.2874)	(.6555)
BRA_{t-1}	-	-1.1159	-	1.1981	-
		(.6984)		(1.2122)	
$PERS_{t-1}$	-	-.6880	-	1.0709	-
		(.6869)		(1.1101)	
BRA_{t-2}	-	-	-1.4877	-	-
			(.6666)		
$PERS_{t-2}$	-	-	-.9144	-	-
			(.6795)		
$(BRA_{t-1})^2$	-	-	-	-	.0031
					(.0214)
$(PERS_{t-1})^2$	-	-	-	-	-.305673
					(.1158)
Nobs.	1000	1000	750	1000	1000
Sargan	.195	.057	.241	.142	.186
m1	-5.053	-5.116	-3.957	-5.063	-5.248
	(.000)	(.000)	(.000)	(.000)	(.000)
m2	.270	.191	-	.254	.192
	(.788)	(.849)		(.800)	(.848)
Wald1	54.881	65.363	52.607	64.871	96.906
	(.000)	(.000)	(.000)	(.000)	(.000)
Wald2	7.1438	11.441	2.679	5.578	11.532
	(.067)	(.010)	(.262)	(.134)	(.009)
Wald3	-13.968	4.016	8.252	15.054	18.551
	(.001)	(.138)	(.016)	(.005)	(.001)

NOTES: NOTES: All GMM estimates are one-step. Numbers reported are coefficient and asymptotic standard errors (s.e.). Reported standard errors are robust to general cross-section and time-series heteroscedasticity. Nobs is the number of useable observations. All estimations include the SBF dummy;

– Sargan is a test of the overidentifying restrictions for the GMM estimators. Reported numbers are p-values.

– m1 and m2 are tests for 1st and 2nd order autocorrelation in the first differenced residuals (except for OLS and within-group estimations, for which the tests are for levels residuals); they are asymptotically distributed N(0,1); (p-values)

– Wald1 = Wald test of joint significance of explanatory variables (p-value)

– Wald2 = Wald test of joint significance of time dummies (p-value)

– Wald3 = a Wald test of joint significance of all BRAs and PERSs, including lagged ones, in the equation (p-value).

5 Conclusions

The main objective of this paper was to shed light on whether banks use their fixed investments for information acquisition or obtaining market power. Our theoretical model allows us to study such investments within a common modeling framework. Different types of fixed investments have very different empirical implications. Our main interest was on the effects of fixed investment on banks' lending quality and the interest rate charged by the bank. Our theoretical prediction is that information acquisition leads to a lower amount of defaults and a lower interest rate margin. Market power investments, in contrast, have no direct effect on default costs (an indirect positive effect through the interest rate) and lead to higher interest rates.

We tested these theories using panel data covering 250 Finnish local banks over a five-year period. The fact that these banks operate in non-overlapping regional markets means that the equilibrium level of investments varies over banks, thus allowing us to identify the effects of fixed investment on bank performance. The non-random nature of the sample and the shared features and institutions of the cooperative banks allowed us to assume that they use their fixed investments for the same purpose. This also enabled us to avoid the problem (predicted by our theory) of having both investing and non-investing banks in our sample.

We found persistence in both loan interest rates and default costs. Loan interest rates are an increasing function of deposit interest rates. Unsurprisingly, higher interest rates increase default costs. Banks with larger loan books have higher (relative) default costs. We found that banks' investments in both branch network density and human capital (personnel) contribute to the information acquisition ability of banks, as both loan interest rates and default costs are decreasing in these variables. In addition, we find evidence supporting the hypothesis (Fama 1985) that banks use deposits to monitor customers' cash flows and are thereby able to reduce the amount of loan losses. These results were robust to a number of experiments. In particular, we found that lagged values of branch network density and personnel have a similar effect on current default costs. These findings support the assumption of our theoretical model that banks use fixed investments for ex ante information acquisition, rather than for ex post monitoring.

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Appendix 1.

PROOF OF PROPOSITION 1, PART (a): To begin with, note that the no-cross-substitution assumption implies that $R_{M,p} \geq R^0_{v(p)}$ holds for $p \in \{G, B\}$. Then, for a Stackelberg solution, consider the follower. Whenever feasible, the non-monitoring follower will optimally undercut either both offers or the higher offer of the leader, depending on which action yields higher profits. If this strategy is not feasible, the follower tries to at least match one of the offers so as to split the entrepreneurs in this category, just to remain in business. We can now turn to the leader's strategy:

Claim 1. The monitoring leader cannot earn strictly positive expected profits from both entrepreneur categories in equilibrium.

To prove the claim (by contradiction), suppose that the opposite holds. Then it must be the case that $R_{M,p} > R^0_{v(p)}$ holds for $p \in \{G, B\}$. But for any such interest rate pair, the follower will optimally undercut either both offers or the higher offer, depending on which action yields higher profits and capture all the entrepreneurs or those to whom the higher rate was quoted, thus contradicting the assumption. Only when $R_{M,G} \leq R^0_{v(GB)}$ and $R_{M,B} = R^0_{v(B)}$ does there not exist any such strictly profitable undercutting opportunity for the non-monitoring follower. To see this, note that should the follower undercut either loan rate, it would make non-positive expected profits. In this case, however, zero-profits are earned by the leader from the customers labeled bad, which again contradicts the assumption. Thus claim 1 holds.

The implication of the above is that the optimal strategy of the monitoring leader involves pricing to maximize profits from the borrower class from which it can potentially earn strictly positive profits. Given the undercutting option of the follower, the leader can compute and announce an indifference rate at which the follower is indifferent between trying to become the sole financier of *GB* (by undercutting both of the leader's offers) and financing solely those entrepreneurs to whom the leader quotes a higher interest rate. Consider a strategy where such an indifference rate, R_p^{ind} , is quoted for the class $p \in \{G, B\}$ and where the other category, *p´ ≠ p,* is priced out, ie 'rationed' by quoting an interest rate that is strictly higher than the monopoly rate, R^*. If such an interest rate pair were observed by the follower, its optimal response would be to quote $R_{NM} = R^*$, since by construction it has no profit incentive to undercut the offer made by the leader for *p*. The follower would end up financing category *p´* at rate R^*. This implies that if the category to which *no* interest rate is quoted by the leader is *B* (ie if *p´* = *B*), the indifference rate, R_G^{ind} (quoted for the good by the monitoring leader) is found by solving the equation

$$(E(x) - v(GB))(1 - \exp(-\lambda R_G^{ind}) - (1+\rho) = \pi(R^*, v(B)) \tag{1.1}$$

where $\pi(R^*, v(B)) = (1 - G(\tilde{v}))\big((E(x) - v(B))(1 - \hat{W} / E(x)) - (1+\rho)\big)$ is positive by inequality (5) of the main text.

Alternatively, if $p' = G$, the relevant indifference rate, R_B^{ind}, is solved from the equation

$$(E(x) - v(GB))(1 - \exp(-\lambda R_B^{ind}) - (1+\rho) = \pi(R^*, v(G)) \qquad (1.2)$$

where $\pi(R^*, v(G)) = G(\tilde{v})\big((E(x) - v(G))(1 - \hat{W} / E(x)) - (1+\rho)\big) > 0$. In the above equations, $\pi(R^*, v(B))$ and $\pi(R^*, v(G))$ are the expected profits for the follower from cases $p' = B$ and $p' = G$, respectively.

Since banks' expected profits are increasing in the loan interest rate within any given entrepreneur class, in either case the monitoring leader's profit from p is the higher, the higher the indifference interest rate at which it provides financing for p. The observation that the indifference interest rates are the higher, the higher the expected profits of the follower from cases $p' = B$ and $p' = G$, allows us to write

Claim 2. It is optimal for the monitoring leader to price out p', since this maximizes the follower's profit from this entrepreneur class and hence also the associated indifference interest rate that the monitoring bank can charge p.

Note in particular, that if the leader were to quote the monopoly interest rate for class p', the associated indifference interest rate would be strictly lower than it would be if a marginally higher interest rate were quoted.

Claim 3. The optimal pricing by the monitoring leader involves pricing out bad entrepreneurs ($p' = B$) and quoting the indifference rate defined by equation (1.1) for good entrepreneurs ($p = G$). The best response by the follower to such an interest rate schedule is to quote the monopoly interest rate.

To prove the claim, note that the expected profits for the monitoring leader for the case where the indifference rate is quoted for good entrepreneurs, ie $p = G$, are

$$\pi(R_G^{ind}, v(G)) = G(\tilde{v})\left[\frac{(E(x) - v(G))\pi(R^*, v(B)) + (1+\rho)(v(GB) - v(G))}{E(x) - v(GB)}\right] \qquad (1.3)$$

and, from the alternative case, $p = B$,

$$\pi(R_B^{ind}, v(B)) = (1 - G(\tilde{v}))\left[\frac{(E(x) - v(B))\pi(R^*, v(G)) + (1+\rho)(v(GB) - v(B))}{E(x) - v(GB)}\right] \qquad (1.4)$$

Since v is uniformly distributed, it is easy to verify that
$v(G) = \tfrac{1}{2}\tilde{v}$, $v(B) = \tfrac{1}{2}(\tilde{v} + \bar{v})$, $v(GB) = \tfrac{1}{2}\bar{v}$ and $G(\tilde{v}) = \tilde{v} / \bar{v}$
and then that
$\pi(R_G^{ind}, v(G)) > \pi(R_B^{ind}, v(B))$ for $0 < \tilde{v} < \bar{v}$.
Since the best response by the follower to R_G^{ind} is to quote the monopoly rate, claim 3 follows.

Thus, in equilibrium, the leader ends up financing entrepreneurs it classified good at the indifference rate defined in (1.1) whereas the follower provides financing at the monopoly rate for entrepreneurs classified bad by the monitoring leader. The expected profits are $\pi(R_G^{ind}, v(G))$ and $\pi(R^*, v(B))$ for the monitoring leader and non-monitoring follower, respectively. This completes the proof of part (a) of proposition 1. **QED**

PROOF OF PROPOSITION 1, PART (b): Recall that the no-cross-substitution assumption implies that $R_{M,B} \geq R^0_{v(B)}$. We begin by claiming that the non-monitoring leader cannot announce an interest rate (strictly) below $R^0_{v(B)}$. To prove this, suppose the non-monitoring leader were to offer an interest rate marginally below $R^0_{v(B)}$. The follower's best response would clearly be to offer exactly the same interest rate for all good entrepreneurs and any rate higher than or equal to $R^0_{v(B)}$ to those it labeled bad. From this and assumption A3, it follows that all the good entrepreneurs (in class *G*) will prefer the monitoring follower to the leader. This means that at any rate below $R^0_{v(B)}$ the leader finances only those allocated to *B* by the monitoring bank at an interest rate implying negative expected profits for it. Hence the claim must hold in equilibrium.

Note that if the non-monitoring leader tried to set an interest rate higher than $R^0_{v(B)}$ it would provide an incentive for the follower to undercut the offer and thus the leader would end up funding no entrepreneurs. From this it follows that the leader cannot do better than to offer $R_{NM} = R^0_{v(B)}$. The optimal strategy for the follower is then to charge the very same interest rate to all the entrepreneurs, namely $R_{M,G} = R_{M,B} = R^0_{v(B)}$. This implies that $R^0_{v(B)}$ is quoted by both banks and to each entrepreneur category in equilibrium and that *B* is split between the two banks, whereas the monitoring leader finances *G*. It follows that both banks earn zero expected profits from lending to *B* while the monitoring bank earns positive profits from lending to *G*, ie $\pi(R^0_{v(B)}, v(G)) > 0$. **QED**

Appendix 2.

THE PRODUCT DIFFERENTIATION MODEL: In the following we present the details of the product differentiation model. The fixed investment changes the way loan customers perceive the services provided by a banking firm. Both for simplicity and comparability with the monitoring model, we let the quality and availability of services of a bank, s_i, be a dichotomous variable, with $s_i \in \{0,1\}$. The cost of this investment is fixed, $S > 0$. None of the results in this section are due to the constrained choice set that the banks face but rather can also be derived for a continuous quality variable.

For comparability, the timing of events is the same as in the monitoring model. Banks enter simultaneously and decide s_i in stage one. In the second stage, the leader-follower roles are randomly determined, and conditional on their realization, the banks compete in interest rates sequentially.

We next derive Nash equilibrium loan pricing strategies of banks as a function of service quality investments and conditional on realization of the leader-follower roles. Finally, we find the sub-game perfect quality investments.

Loan Pricing Under Symmetric Quality Investments: Since in this section no monitoring is involved, the banks can observe neither v nor θ characterizing the entrepreneurs and each bank can quote only one interest rate, which will apply to all entrepreneurs. It follows that if both ($s_i = s_j = 1$) or neither ($s_i = s_j = 0$) of the banks have made the fixed quality investment, there is no difference in customers' quality perceptions. Given the realization of the leader-follower roles, the analysis then corresponds to the case of standard Stackelberg-competition with identical firms and homogeneous goods. By the standard undercutting argument, banks charge the zero-profit interest rate $R^0_{v(GB)}$ in equilibrium.

Loan Pricing Under Asymmetric Quality Investments: In this subsection, we consider the asymmetric case in which only one bank has made the quality related fixed investment (eg $s_i = 0$ and $s_j = 1$). To begin with, let R_H and R_L denote the rates charged by the high-quality (H-bank) and low-quality bank (L-bank), respectively. An entrepreneur with characteristics (v, θ) patronizing the H-bank has expected utility

$$\mu(R_H) + \theta \tag{2.1}$$

where $\mu(R_H) = E(x)e^{-\lambda R_H}$. Given the normalization of the quality variable, the expected utility for customers of the L-bank is simply $\mu(R_L) = E(x)e^{-\lambda R_L}$. A marginal entrepreneur type (θ^*), who is indifferent between patronizing the two banks, is given by

$$\theta^* \equiv \mu(R_L) - \mu(R_H) \tag{2.2}$$

For the L-bank to attract any customers, $R_L < R_H$ must hold. Since $\theta \sim U[0, \overline{\theta}]$, the demands that the banks face are $D_H(R_H, R_L) = 1 - \theta^* / \overline{\theta}$ and $D_L(R_H, R_L) = \theta^* / \overline{\theta}$ for the H-bank and L-bank, respectively.

Bank *i*'s expected profits are given by

$$\pi(R_i, v(GB)) = D_i(R_i, R_j)\Big((E(x) - v(GB))(1 - e^{-\lambda R_i}) - (1+\rho)\Big) \qquad (2.3)$$

where $i = H, L, i \neq j$.

Due to the assumed sequential structure in interest rate setting, we have two asymmetric cases to consider: the cases of H-bank as leader and follower. The derivation of the Nash equilibrium loan rates is standard, ie one first solves the follower's problem as a function of the leader's interest rate and then utilizes the derived best response function in solving the leader's maximization problem. We omit the details for brevity and present directly

Proposition A2.1. *Consider the sequential interest rate game in the case of asymmetric quality investment and conditional on the realization of the leader-follower roles. Then, in the unique Nash equilibrium*

(a) *the H-bank as the* (*price*) *leader quotes*

$$R_H = E(x) * \ln\left[\frac{E(x) - v(GB)}{E(x) - v(GB) - (1+\rho) - (1 - v(GB)(E(x))^{-1})\overline{\overline{\theta}}}\right]$$

while the L-bank (as the follower) quotes

$$R_L = E(x) * \ln\left[\frac{E(x) - v(GB)}{E(x) - v(GB) - (1+\rho) - \frac{1}{2}(1 - v(GB)(E(x))^{-1})\overline{\overline{\theta}}}\right].$$

The associated loan demands are $D_H = \frac{1}{2}$ *and* $D_L = \frac{1}{2}$ *for the H-bank and the L-bank, respectively.*

(b) *the H-bank as the* (*price*) *follower quotes*

$$\overline{R}_H = E(x) * \ln\left[\frac{E(x) - v(GB)}{E(x) - v(GB) - (1+\rho) - \frac{3}{4}(1 - v(GB)(E(x))^{-1})\overline{\overline{\theta}}}\right]$$

while the L-bank (as the leader) quotes

$$\overline{R}_L = E(x) * \ln\left[\frac{E(x) - v(GB)}{E(x) - v(GB) - (1+\rho) - \frac{1}{2}(1 - v(GB)(E(x))^{-1})\overline{\overline{\theta}}}\right]$$

The associated loan demands are $\overline{D}_H = \frac{3}{4}$ *and* $\overline{D}_L = \frac{1}{4}$ *for the high-quality follower and the low-quality leader, respectively.*

The equilibrium demands were found by computing the identity of the marginal type at the equilibrium interest rates.

To check that banks earn positive expected profits in equilibrium, we use the equilibrium interest rates and demands to find that the profits for part (a) are

$$\pi(R_H, v(GB)) = \tfrac{1}{2}\left(1 - \frac{v(GB)}{E(x)}\right)\overline{\theta} \quad (2.4)$$

$$\pi(R_L, v(GB)) = (\tfrac{1}{2})^2\left(1 - \frac{v(GB)}{E(x)}\right)\overline{\theta} \quad (2.5)$$

and for part (b)

$$\pi(\overline{R}_H, v(GB)) = (\tfrac{3}{4})^2\left(1 - \frac{v(GB)}{E(x)}\right)\overline{\theta} \quad (2.6)$$

$$\pi(\overline{R}_L, v(GB)) = (\tfrac{1}{2})^3\left(1 - \frac{v(GB)}{E(x)}\right)\overline{\theta} \quad (2.7)$$

The Quality Investment: The analysis of the first stage of the vertical product differentiation game closely parallels that of the monitoring game. The expected profits of each bank under asymmetric quality investments are

$$\pi_i(1{,}0) = \pi_j(0{,}1) \equiv \tfrac{1}{2}\pi(R_H, v(GB)) + \tfrac{1}{2}\pi(\overline{R}_H, v(GB)) > 0 \quad (2.8)$$

$$\pi_i(0{,}1) = \pi_j(1{,}0) \equiv \tfrac{1}{2}\pi(R_L, v(GB)) + \tfrac{1}{2}\pi(\overline{R}_L, v(GB)) > 0 \quad (2.9)$$

Taking into account the fixed quality cost, we can summarize the expected profits in payoff matrix A2.1:

Payoff Matrix A2.1. Expected equilibrium profits for quality choice outcomes.

	$s_j = 0$	$s_j = 1$
$s_i = 0$	0,0	$\pi_i(0{,}1), (\pi_j(0{,}1) - S)$
$s_i = 1$	$(\pi_i(1{,}0) - S), \pi_j(1{,}0)$	0,0

We again assume that the fixed investment generating customer services is feasible, ie that its fixed cost, *S,* is low enough to induce one bank to invest in quality. Because the two banks want to avoid entering price competition in Bertrand fashion in homogeneous goods, it is easy, using the payoff matrix, to verify that with simultaneous entry the following obtains:

Proposition A2.2. *The vertical product differentiation model has two asymmetric subgame perfect equilibria in which only one bank invests in quality.*

As in the monitoring model, had we allowed for sequential entry, a threshold could be derived that determines whether the bank entering first invests in quality.

We can now turn to the empirical predictions of the market power version of our model. As in the information acquisition version, the equilibrium structure of a given banking market is asymmetric with one bank investing in high(er) loan customer convenience. By proposition A2.1, the H-bank on average ends up extending more loans and financing entrepreneurs at a higher interest rate than the L-bank. Since the average *v* in the loan portfolios of both banks is *v*(*GB*), expected bankruptcy costs (relative loan losses) are identical for the two banks, *after* controlling for interest rates. Let us collect these empirical predictions into

Corollary A2.1. *The H-bank charges higher interest rates and extends more loans than the L-bank. Conditional on interest rates charged, both banks face identical loan losses relative to the amount of loans extended.*

Proposition 4 of the main text sums up propositions A2.1 and A2.2 as well as corollary A2.1.

Appendix 3.

YEAR-WISE DESCRIPTIVE STATISTICS: In table A.3.1. we report mean, median, standard deviation, and minimum and maximum value for each year and variable. All figures are in FIM in nominal terms.

The mean amount of loans extended was lowest in 1992 and increased thereafter. The same applies for deposits. All four interest rates (loan, interbank loan, deposit, and interbank deposit) decrease each year. The mean loan interest rate goes from 12.03% in 1992 to 7.39% in 1996. Our calculated cost of funds (*INTD*) decreases from 7.43% to 2.49%. Interestingly, and contradicting industry figures, the default costs bottomed in 1992; default costs for the whole banking industry peaked in that year. At their highest (in 1994), the mean default costs were 1.77% of loans extended. This however masks wide bank-level variation. For each year, some banks reported zero default costs. At the same time, the maximum default costs vary between 8.65% (in 1996) and 17.05% (in 1993) of loans extended.

During the observation period, banks' branch networks and numbers of employees were changing. The cooperative banks are generally felt to have been the slowest to make such adjustments, and our numbers bear that out. The mean number of branches declines from 3.6 in 1992 to 2.9 in 1996, but first increases in the interim. Personnel costs are very stable, with a mean of some FIM 5.5 million. Unsurprisingly therefore, personnel costs per branch exhibit an increasing trend.

Checking the year-wise minima and maxima for each bank-level variable revealed no outliers in the sense that the year-to-year changes were roughly proportional to the changes in sample first moments. The only extreme value that changes markedly is that of *INEFF*: whereas the sample moments are stable, the maximum decreases from 3.09 in 1993 to 1.52 in 1994. Sample second moments of all bank-level variables are remarkably stable over the observation period, especially in light of the changing macroeconomic conditions.

Table A3.1 Yearly descriptive statistics of bank variables

Year	Mean	Med.	S.d.	Min.	Max.
Deposits, FIM million					
1992	241.5775	123.641	384.2059	11.0846	2969.309
1993	258.4518	131.3481	416.6836	12.6948	3244.395
1994	314.6419	159.4877	524.9837	13.6927	4194.973
1995	324.3661	162.7845	535.9779	13.8813	4226.674
1996	328.7691	160.7896	544.3834	14.1277	4285.681
LOAN					
1992	242.4031	108.1146	439.4923	6.3583	3296.819
1993	247.7302	111.2777	451.8151	7.0851	3358.258
1994	275.5024	122.9388	515.3931	7.8430	3875.546
1995	264.1695	119.7953	485.1355	7.7068	3734.778
1996	262.5445	119.4842	481.9306	7.2394	3800.051
Deposit interest rate (for customers only)					
1992	0.070867	0.0707	0.004618	0.0565	0.0831
1993	0.047007	0.0463	0.004034	0.0365	0.0611
1994	0.028483	0.0284	0.002412	0.0225	0.0364
1995	0.027876	0.0277	0.002588	0.0210	0.0377
1996	0.020888	0.0207	0.001649	0.0178	0.0288
Loan interest rate (for customers only)					
1992	0.1203	0.1207	0.005476	0.1011	0.1344
1993	0.0996	0.1004	0.007272	0.0558	0.1164
1994	0.0853	0.0852	0.004791	0.0708	0.1059
1995	0.0874	0.0873	0.004120	0.0742	0.1005
1996	0.0739	0.0736	0.004211	0.0636	0.0990
Interbank lending interest rate					
1992	0.0818	0.0789	0.025919	0.0297	0.1333
1993	0.0716	0.0721	0.018423	0.0254	0.1163
1994	0.0581	0.0580	0.011537	0.0294	0.0912
1995	0.0573	0.0571	0.011230	0.0319	0.0970
1996	0.0559	0.0561	0.009925	0.0277	0.0885

Appendix 4.

MEASURING BANK SERVICES AND MONITORING: In this appendix, we discuss the measurement of bank service accessibility/quality and monitoring ability. In addition, we report a set of estimation results demonstrating the robustness of our empirical findings to changes in the definition and functional form of the *BRA* and *PERS* variables.

Measuring Service Accessibility and Monitoring Ability: In attempting to draw an empirical distinction between information acquisition and market power motives, we need personnel and branch measures that capture simultaneously banking service accessibility/quality and banks' monitoring capability.[1] Otherwise, the testing set-up would favor one of the hypotheses over the other. Moreover, we need to incorporate the chosen set of measures simultaneously into the econometric equations, since if there is a role for branches, eg in banking service accessibility, then one cannot test for a similar role for personnel without having the branch variable in the equations. Such an omission would imply misspecified regression equations and an improper testing situation. It then follows that the branch variable, however defined, needs to be valid, given that the economic functions of personnel are controlled for in the equation. The same applies vice versa to the personnel variable. A degree of mutual compatibility is therefore imposed on the definitions of *BRA* and *PERS*.

Geographical proximity and the definition of *BRA* variable: In his study of the determinants of banking service quality, Evanoff (1988) argues that service accessibility and customer convenience are mainly a function of the time, distance and cost required to obtain banking services. As direct measures for these are not available, a measure of average distance traveled might well serve as a proxy. Time spent and cost incurred should correlate positively with distance. Then, assuming that numbers of banks' branches and customers are approximately uniformly distributed, the average distance traveled would correlate negatively with the number of branches per unit of area (*BRA*). Accessibility could therefore be measured using *BRA*.

The same argument applies in attempting to capture banks' ability to gather local information. Monitoring requires the acquisition and verification of information and hence geographic proximity. The shorter the distance between a bank and its borrowers, the more effectively the bank can obtain and authenticate information about their payoff-relevant attributes. This is also the argument of Petersen and Rajan (2000), who provide supporting evidence on the role of distance in determining the quality of bank lending. Assuming again a uniform distribution of customers and branches, *BRA,* as defined, should capture these considerations.

Of course, if either branches or customers or both, are not evenly distributed within the relevant geographical area, *BRA* is weaker as a measure of service ac-

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[1] Recall also that our empirical identification strategy rests on the homogeneity of conduct of cooperative banks. In addition, we hypothesize that the cooperative banks are 'investing banks', as defined in our theoretical setup. We envisage thus that there should not be variation in the strategies that banks choose. Instead, we are assuming that banks adjust their branch and personnel investments optimally according to the type of the regions in which they operate. Therefore, having similar banks that operate in different markets in time and place enables us to identify empirically the role of branches and personnel. Identification thus stems from the optimal investment being different for each bank and year. Basically, we are jointly evaluating the hypothesis of sufficient homogeneity of behavior across cooperative banks and the role of branches and personnel.

cessibility and monitoring ability. However, Evanoff (1988) points out that such distribution problems can be alleviated if one can control for spatially concentrated population, or branching. As the spatial concentration, and other regional features, are likely to be persistent features of the banking market, the bank-specific (market area-specific) effects in our empirical specifications account for these deficiencies. Moreover, a measure of population density is another way to control for the distribution of customers, and such a measure is used in the empirical analysis. To sum up, there are several reasons to presume that geographic proximity, as measured by *BRA*, is capable of capturing and proxying for bank service accessibility and monitoring ability, once the type of region where the bank is active is controlled for.

Additional Robustness Tests (*BRA*): It is clear that even though we feel that we have good reasons for our definitions of variables, a case can be made for other definitions. We therefore consider an alternative branch variable, BRA_P, defined as the number of branches per capita.[2] We have re-estimated base equations using BRA_P (with 1992 - 1995 data, since the population variable is not available to us for 1996). The tenor of our qualitative results remains unchanged: BRA_P and *PERS* are negative and jointly significant in both *INTL* and *DEF* equations (for more precise estimation results, see table A4.1).

As an additional experiment, one could use the number of branches per number of borrowers, BRA_C, instead of BRA. This would probably give an indication of monitoring intensity for the current borrower base. One could however argue that it is the potential customer base that is monitored in ex ante monitoring models. Otherwise the bank is not able to distinguish between the more and less creditworthy; in our theoretical monitoring model, the monitoring bank is able to do just that. The practical problem with BRA_C is that we do not have data on the number of bank customers. However, BRA_C is likely to correlate positively with BRA_P. The reason is that the larger the potential customer population, the larger the actual customer base. This is of course a crude approximation. In any case, the results obtained using BRA_P are at the very least indicative in this respect and they suggest that our results ought not to be materially affected if BRA_C were used.

Branch-level service/monitoring ability and the definition of *PERS*: *PERS* is defined as personnel expenses divided by the number of branches. The purpose of this variable is to capture the role of personnel in either banking service quality or information acquisition, given the definition of *BRA*. It is thus designed to proxy for the quality (and amount) of personnel at branch-level. Given that banks' geographic proximity is accounted for, it is the organization and function of individual branches that is relevant from the viewpoint of service quality and monitoring ability. A more qualified and trained personnel at the branch level should correlate positively with these, and the current *PERS* variable is an average measure of them. It obviously reflects also the average size of the personnel per branch. The role of bank-specific effects in the empirical equations is to account for heterogeneity, eg in number of employees working at the headquarters.

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[2] Note however that though BRA_P has been used in some studies examining bank service accessibility (see eg the references in Evanoff 1988), it is precisely the inverse of the measure that Evanoff has criticized for being an inadequate measure of service accessibility. The criticism stems from the view that urban areas are likely to have a low BRA_P. It is however difficult to argue that service accessibility is low in these areas. This would be the case only if congestion were an issue. The reverse argument applies to rural areas. Whether BRA_P is a good proxy for monitoring ability is more difficult to evaluate.

Additional Robustness Tests (*PERS*): Activities unrelated to lending might increase the level of *PERS*. To account for these effects, we included $(PERS)^2$ in the regression equations. They obtained negative but insignificant coefficients in both the *INTL* and *DEF* equations (for results see the attached table). In these estimations, the linear *PERS* variable obtained negative and significant coefficients; thus our results hold eg in the presence of fixed personnel costs.

Table A4.1. BRA_P and Squared *PERS*

Variable	(1a) INTL (GMM SYS)	Variable	(1b) INTL (GMM SYS)	Variable	(2a) DEF (GMM SYS)	Variable	(2b) DEF (GMM SYS)
$INTL_{t-1}$	.2797	$INTL_{t-1}$	.2543	DEF_{t-1}	.1514	DEF_{t-1}	0.1525
	(.0789)		(.0551)		(.0783)		(0.0595)
LOAN	-.0017	LOAN	.0212	LOAN	2.6229	LOAN	2.6522
	(.0188)		(.0195)		(0.6890)		(0.5329)
DEF	.0052	DEF	.0024	INTL	4.8652	INTL	4.2871
	(.0028)		(.0025)		(2.8393)		(2.7183)
INTD	.2281	INTD	.1086	INEFF	-.9188	INEFF	-0.8624
	(.0713)		(.0274)		(.0775)		(1.1252)
INEFF	-.1255	INEFF	-.0807	BRA_P	-.8548	BRA	-1.1110
	(.0304)		(0.0274)		(.8037)		(.4448)
BRA_P	-.0591	BRA	-.0273	PERS	-2.5749	PERS	-2.0466
	(.0260)		(.0098)		(1.073)		(.5418)
PERS	-.0558	PERS	-.0261	RDEP	-9.2156	RDEP	-6.9254
	(.0297)		(.0148)		(3.9710)		(3.0993)
		$PERS^2$	-.0029			$PERS^2$	-0.1420
			(.0032)				(.1153)
Nobs.	750		1000		750		1000
Sargan	.343		.361		.622		0.117
m1	-5.395		-5.424		-3.861		-5.114
	(.000)		(.000)		(.000)		(.000)
m2	-		.422		-		0.233
			(.673)				(.816)
Wald1	50.312		44.337		77.865		91.681
	(.000)		(.000)		(.000)		(.000)
Wald2	18.691		444.874		13.810		9.874
	(.000)		(.000)		(.001)		(.020)
Wald3	5.250		8.004		8.648		14.552
	(.072)		(.018)		(.013)		(.001)

NOTES: All GMM estimates are one-step. Numbers reported are coefficient and asymptotic standard errors (s.e.). Reported standard errors are robust to general cross-section and time-series heteroscedasticity. Nobs is the number of useable observations. All estimations include time dummies.

– Sargan is a test of the overidentifying restrictions for the GMM estimators. Reported numbers are p-values.

– m1 and m2 are tests for 1st and 2nd order autocorrelation in the first differenced residuals (except for OLS and within-group estimations, for which the tests are for levels residuals); they are asymptotically distributed N(0,1); (p-values)

– Wald1 = Wald test of joint significance of explanatory variables (p-value)

– Wald2 = Wald test of joint significance of time dummies (p-value)

– Wald3 = Wald test of joint significance of BRA and PERS terms (p-value)