Information Acquisition and Market Power in Credit Markets

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January, 2003

ABSTRACT

Investment in information acquisition can be used strategically by banks as a commitment device to augment market power. A static two-period economy with informationally heterogeneous banks is analyzed. Information acquisition limits asymmetries of information and competitors' rents *ex post.* If projects yield insufficient returns in the first period, competitors' *ex ante* break even constraints are tightened, and competition inhibited. Market power can thereby be substantially augmented, and monopoly rents obtained. Welfare is lower with information acquisition, while banks are better off. With more than two banks, information acquisition is characterized by strategic complementarities: hence, multiple equilibria may exist.

Information Acquisition and Market Power in Credit Markets

An important function of banking is to acquire information to separate creditworthy from non-creditworthy borrowers. Indeed, credit risk is the primary financial risk in the banking system and selection and management of credit risk is critically important to bank performance over time (Office of the Comptroller of the Currency (OCC) 2001). Information acquisition facilitates the identification and rating of creditworthiness and is thus a critical feature of the banking industry.

Banks routinely invest significant amounts of resources to collect information. Information collection takes different forms. Most institutions have large loan approval and underwriting departments which evaluate applications. Evaluation takes the form of physical verification, use of statistical criteria and credit risk analysis software etc. Specialized brokers such as credit bureaus and credit rating agencies also constitute a source of information about past behavior of potential borrowers. Information can also be obtained through the process of lending; established relationships can give incumbent lenders information about borrowers not necessarily available to all outside players.

This paper analyzes information acquisition in the banking industry. The issue assumes importance because information gathering is a costly activity. There are substantial costs of operating and upgrading loan approval and underwriting departments, and information brokers charge fees to issue reports. Obtaining information through lending also imposes screening costs on banks. As the theory of customer relationships argues, the incentive to acquire information is therefore predicated on the ability to recover such costs through *ex post* rent appropriation.[1] Rents can arise endogenously through the process of lending. Lenders are usually not fully cognizant of all relevant borrower characteristics *ex ante*.[2] Relationships between banks and borrowers permit the collection of proprietary information, which can mitigate *ex ante* costs through the use of *ex post* market power. Market power arises because of the 'lemons' problem: the presence of inside information with the incumbent implies that any applicant accepting an outside bank's contract must be of inferior quality. This forces up the price of outside offers, allowing the insider to earn information rents. The theory has received support from the recent empirical literature on loan pricing.

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[1] See Greenbaum, Kanatas and Venezia (1989), Sharpe (1990), Petersen and Rajan (1995), Berger and Mester (2002) etc.

[2] Information asymmetries and gaps have been identified as the defining characteristics of credit markets. See Bhattacharya and Thakor (1993) for a survey.

D'Auria, Foglia and Reedtz (1999) and Kerr (2002) show that inside banks offer credit at lower interest rates due to informational superiority.

If loan products and the opportunity cost of funds are common across banks, the above line of reasoning leads to the following conclusions. First, competition can dampen the incentive to acquire information. Credit market competition can influence the leakage of proprietary information and therefore erode the ability to exercise market power.[3] Consequently, financial market deregulation can reduce the acquisition of information, as Allen *et al* (2001) have suggested.[4] However, available evidence does not seem to support this argument. Financial industries have seen a series of rapid and interconnected competition enhancing technological, institutional and regulatory changes over the last two decades.[5] There does not seem to have been a concomitant decline in the information gathering activity of banks.[6]

Second, banks will never have an incentive to expend resources to gather information on firms which are seeking funds for project refinancing. Suppose the loan approval departments of banks can distinguish between firms seeking funds for new projects and those seeking funds for continuing projects. For the latter category, previous lenders must possess information at least as good as that possessed by outside banks. Therefore, if it is profitable for an outside bank to offer a loan to such a firm, it must be profitable for a prior lender to do so as well. Competition then exhausts all rents accruing to an outside lender, thereby removing any incentive to invest in information collection. This conclusion is also at odds with available evidence: banks routinely receive applications for project refinancing and expend resources to investigate such applications.[7]

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[3] Berger and Mester (2002) argue that deregulation in credit markets has been associated with an improved ability to evaluate creditworthiness, thereby reducing incumbent lenders' informational advantages.

[4] It has also been argued that some kind of oligopolistic industry structure may be required to preserve appropriate incentives: see Anand and Galetovic (2000).

[5] Banks were the largest providers of credit to nonfinancial companies two decades ago. They were also relatively protected from competition in local markets by virtue of restrictions on entry, price competition etc. The changing competitive environment has reduced the importance of banks in the provision of credit. The removal of entry restrictions has also increased competition amongst banks. See Bergstresser (2001) and Black and Strahan (2001).

[6] See Bank for International Settlements (BIS) (2000) and White (2001) for evidence that the information brokerage industry has been growing steadily over the past decade or so.

[7] A possible resolution lies in the assumption that banks cannnot distinguish between 'old' firms and 'new' firms: see Dell'Ariccia, Friedman and Marquez (1999), Dell'Ariccia (2001) and Marquez (2001). Since loan applications are often carefully scrutnized by lenders, we discard this line of reasoning. We also rule out any role for liquidity shocks, as large, persistent and idiosyncratic liquidity shocks are seldom observed. In any case, a liquidity shock forcing borrowers to seek outside financing does not remove the adverse selection problem.

This paper provides a resolution by arguing that information acquisition has strategic dimensions. Information collection by any bank reduces *ex post* market power of other banks by limiting informational asymmetries. In turn the erosion of *ex post* market power inhibits their *ex ante* competitive ability. If banks are asymmetric in terms of their ability to acquire information *ex post*, investment in information acquisition acts as a commitment device which augments market power. The idea rests on public information being incomplete. Banks can then exploit their asymmetric ability to gather private information to protect market power by strategically investing in information acquisition. The argument lays a foundation for justifying acquisition of information on firms seeking project refinancing. It also shows that increased competition or the absence of an oligopolistic market structure need not diminish incentives for investing in information acquisition.[8]

We analyze a stylized model to address these issues. We consider a static economy in which projects last for two periods. Projects and borrowers are identical *ex ante* but are heterogeneous *ex post*: some projects are unproductive in the second period, while the distribution of returns of productive projects is dependent on borrower type. All projects yield insufficient revenue (relative to the cost of funds) in the first period. A bank which lends to a borrower in period 1 learns borrower and project type at the end of the period, while every non-lending bank obtains a signal for such a borrower. *Ex ante* investment in information acquisition enhances signal quality. Finally, banks are informationally heterogeneous: each bank has superior *ex post* observational ability for some group of borrowers relative to all other banks.[9]

We fully characterize pure strategy subgame perfect equilibria of the model and show that such equilibria always exist. Although there is aggregate symmetry across banks *ex ante*, symmetric equilibria are not guaranteed to exist. Asymmetric equilibria can exist for intermediate costs of information collection. Investing banks obtain monopoly rents *ex ante*, and have higher payoffs than non-investing banks. Strategic commitment by the former group precludes investment by the

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[8] Dinc (2000) argues that the impact of competition on bank incentives to commit to long-term relationships with borrowers depends on whether competition arises from credit or bond markets. We focus purely on credit market competition and show that the incentives to collect information can be preserved irrespective of the degree of competition.

[9] Variation in informational expertise is a central feature of modern financial markets. Banks can have asymmetric access to outside information for a number of reasons: locational heterogeneity, past lending relationships, non-market interactions, industry specialization, diffusion of personnel etc. The distributed location of banks in 'information space' generates heterogeneity amongst lenders and gives rise to the possibility of *ex ante* market power. See also Hauswald and Marquez (2002).

latter.[10] No bank invests if the cost of investment is high, or if investment is relatively unproductive (in terms of improved signal quality), while all banks invest if the cost is low and investment is sufficiently productive.

The intuition behind a bank's incentive to invest in information acquisition is as follows. Let any bank j have observational superiority for some group of borrowers called its *local borrowers*. Suppose j invests. At the end of period 1, it has a higher probability of receiving signals on borrowers it did not lend to. Consider another bank k competing for one of j's local borrowers in period 1. Information collection by j reduces period 2 rents accruing to k from the relationship. k has to break even over its lifetime from any loan offer it makes to j's local borrower in period 1. Thus, j's investment forces k to raise period 1 interest rates on the loan offer. Since period 1 returns are insufficient to cover the cost of funds, there is an *ex ante* payment constraint. If the payment constraint binds, k is no longer able to offer a loan in period 1, and so j obtains monopoly rents. Therefore, if investment is sufficiently productive, the incentive to acquire information is generated provided the added monopoly payoff outweighs the cost of investment.

The analysis further shows there may be strategic complementarities in information acquisition. Investment by j tightens the *ex ante* payment constraints for all other banks $l \neq j$ when they are bidding for j's borrowers in period 1. However, it also tightens other banks' $l \neq j, k$ *ex ante* payment constraints when bidding for bank k's borrowers in period 1. The existence of a spillover implies that information collection may be characterized by strategic complementarities and therefore, multiple equilibria could exist. We derive necessary and sufficient conditions for the existence of multiple symmetric equilibria.[11] Interestingly, multiple equilibria cannot exist if there are only two banks in the economy. To see that, suppose j and k are the two banks. j's investment tightens k's *ex ante* payment constraint when bidding for j's borrowers in period 1. However, it does not improve k's position by tightening j's *ex ante* payment constraint when bidding for k's borrowers in period 1. Therefore, no strategic complementarities are generated.

Focussing on symmetric equilibria, we finally show that welfare is lower if banks invest than if they do not. This arises because we consider only the commitment value of information acquisition. Investment then merely serves to augment market power of banks, and acts as a dead-weight loss. Banks are better off when they collect information, while borrowers are worse off. Since

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[10] In the relevent zone of the parameter space, asymmetric equilibria arise as the resolution of a multi-player 'hawk-dove' game.

[11] Symmetric and asymmetric equilibria may coexist as well: see Proposition 2.

information collection increases *ex post* competition amongst banks, we obtain the result that investment increases the number of offers received by borrowers seeking to refinance projects, while simultaneously reducing their lifetime payoffs.

Other authors have recently studied information acquisition in financial markets. Boadway and Sato (1999) study how information collected by one lender may dissipate to another through the contracting process. Their analysis of the allocation of resources to different kinds of information collection shows that dissipation induces distortions and that government intervention through information provision may increase welfare. Hauswald and Marquez (2002) study allocation distortions arising from increased competition. They show that intermediate competition leads to a diminution of resources allocated to information acquisition while excess competition leads to banks specializing in information acquisition in core at the expense of peripheral markets. By contrast, we study the strategic role of information acquisition as a commitment device and the complementarities associated with information collection.

This study is also related to literature on incentive problems in credit markets. Since lending generates privileged information, banks get rents *ex post* from borrowers, thereby adversely affecting entrepreneurial incentives. Rajan (1992) and Padilla and Pagano (1997) apply results from the hold-up literature to study how incentive problems may be mitigated. Rajan (1992) shows that firms may borrow from multiple banks to induce competition amongst banks and thereby reduce informational asymmetries. Closer to our paper, Padilla and Pagano (1997) argue that banks may commit to sharing information *ex ante* to restore incentives.[12] By contrast, we study costly information gathering, rather than dynamic information sharing agreements. Our study complements theirs by investigating information acquisition as a market power manipulation device, rather than examining incentive issues.

The rest of the paper is as follows. The model is constructed in the Section 1. Section 2 analyzes the model with only two banks, to develop the intuition. Section 3 presents a preliminary analysis of the general model, while Section 4 characterizes equilibrium. Section 5 focusses on symmetric equilibria, and also studies strategic complementarities. Section 6 concludes, and Section 7 contains proofs.

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[12]Pagano and Japelli (1993) show that information sharing may also arise in credit markets characterized by extreme borrower mobility.

1 Model

The economy runs for two periods and consists of two types of risk-neutral decision makers: *entrepreneurs* (or *borrowers*) and *banks*. In period 1, each borrower is endowed with an indivisible investment project which requires 1 unit of funds. Entrepreneurs have no resources and must borrow in order to operate the project. Projects can be of *high (H)* or *low (L) quality*. All projects yield a cash flow y in period 1. Period 1 output cannot be saved, so an entrepreneur needs to borrow to operate the project in period 2. A project can be operated in period 2 only if it receives funding in period 1. For simplicity, we assume all borrowers apply for loans in every period.

L projects generate 0 cash flow in period 2. H projects may *succeed* or *fail* in the second period. In the event of failure, the output is 0. In the event of success, the cash flow is $Y > y$. Project quality is realized at the end of period 1. The *ex ante* probability of an borrower possessing a high quality project is s.

There is borrower *heterogeneity*, with the probability of success of a H project in period 2 depending on borrower *type*. The type space is a compact interval $[\underline{i}, \overline{i}]$ on the real line and borrowers are uniformly distributed over this space.[13] A borrower of type i succeeds with probability $\sigma_i \in [\underline{\sigma}, \overline{\sigma}] \subset (0, 1)$. Let $\sigma_i Y = \beta_i$, with $\underline{\beta}$ and $\overline{\beta}$ defined appropriately. Also define $\sigma = \frac{\underline{\sigma} + \overline{\sigma}}{2}$ and $\beta = \frac{\underline{\beta} + \overline{\beta}}{2}$. Like project quality, borrower ability is realized at the end of period 1.

There are $N \geq 2$ banks, each with a local market. There is a continuum of borrowers, with the total measure of borrowers equal to M. All borrowers in the economy are symmetrically distributed across the local markets, with any given borrower belonging exclusively to a single market. The measure of borrowers in any given local market is therefore $\frac{M}{N} = \mu$. Banks engage in interest rate competition for loans to borrowers. An entrepreneur can only borrow from a single bank in any period. The model of competition between banks is asymmetric: each bank has informational superiority over other banks as far as its local market is concerned (see below).[14] Every bank always knows the identity of any given borrower's local bank.

A bank can obtain information about project quality and borrower type through the process of lending. Consider a bank B and a borrower E. If B lends to E in period 1, it perfectly observes

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[13]Uniformity simplifies the analysis and has no qualitative implications.

[14]The idea is that local banks have incumbency or location advantages because of the informational distance between local borrowers and the outside banks. For example, in a recent empirical study, Berger, Klapper and Udell (2001) show that home banks persistently enjoy informational superiority over foreign banks for home borrowers.

her type and the quality of her project at the end of the period.[15] If B does not lend to E in period 1, it receives a signal about her ability and project quality at the beginning of period 2. Suppose E is not from B's local market. Then the signal contains information only about her project quality and never her type. However, if E is from B's local market, the signal contains information about her project quality as well as her type. This assumption is meant to capture the stylized notion that information about projects can become public through some detection mechanism, whereas information about borrowers themselves has a more local character and is inherently more difficult to obtain. The fundamental idea is that public information is incomplete, while banks have differential ability to gather private information.

We assume each bank receives a signal for every borrower it does not lend to in period 1. Signals for each borrower are independent across banks. The signal process is as follows. For a given bank, conditional on a borrower not receiving a loan in period 1 or her project being of low quality, the signal always yields L with probability 1. Conditional on her project being of high quality, the signal is correct with some probability p, *i.e.*, yields H with probability p and L with probability $1 - p$. For the local bank, the signal also always identifies her type correctly.

p is therefore a measure of signal quality, or the accuracy of information received by a bank. We assume that a bank can control the quality of the signals it receives through its investment in information acquisition. Specifically, at the beginning of period 1 each bank has to choose whether or not to invest in an *information acquisition technology*. We assume a discrete set-up for simplicity, and note that extension to an environment with a continuous menu of technologies is straightforward. Investment costs a flat amount c and results in a signal quality $p_c \in (0, 1)$. Otherwise, the bank invests nothing and has signal quality $p_u = 0$.[16] Investment decisions are publicly observable.[17]

Each bank has an unlimited supply of funds in every period at a constant opportunity cost which is normalized to 0. To make the problem interesting, assume only single-period contracts can be written or enforced. The following parameter restrictions are imposed: $y \in (0, 1)$, with

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[15] Inside banks are therefore assumed to be fully informed at the end of period 1. The results are robust to perturbations of this assumption. The reason is that even if inside banks have imperfect information at the end of period 1, the adverse selection problem remains as long as its information is superior to those of outside banks.

[16] Qualitative results are hold for $p_u < p_c$. Putting $p_u = 0$ simplifies the calculations.

[17] In order for information acquisition to have potential commitment value, we assume that resources are sunk prior to period 1 decisions. The underlying idea behind the assumption is the observation that information collection is typically a continuing process; banks need to monitor and analyze economic environments, industry trends and market conditions on an ongoing basis in order to better scrutinize loan applications and evaluate creditworthiness.

$1 - y = \alpha.$[18] Since the opportunity cost of funds is non-negative, if a borrower is discovered at the end of period 1 to possess a low quality project, she will not be offered a loan by her prior lending bank in period 2. The net lifetime expected output from a project of unknown quality operated by a borrower of type i is therefore $s(\beta_i - 1) - \alpha$. We assume any borrower's project, conditional on type, is *ex ante* efficient. Therefore, we have

$$Assumption\ 1\colon\ s(\underline{\beta} - 1) - \alpha > 0$$

We study pure strategy subgame perfect equilibria of the model above. Although there are two periods, a number of events occur within each period. The following sequence lays out the exact timing of events within each period.

Period 1:

1. Each borrower is endowed with a project.

2. Banks simultaneously make investment decisions.

3. They simultaneously decide on contract offers for outside borrowers.

4. Then, taking current and future outside contracts as given, they simultaneously decide on contract offers for borrowers in their local market.

5. Borrowers make acceptance or rejection decisions. Output is realized, information is revealed and contracts are settled.

Period 2:

1. Banks receive a signal for all borrowers with whom they have had no prior lending relationship.

2. They then simultaneously decide on contract offers for such borrowers.

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[18] All projects are therefore assumed to lose money in the initial phase. The assumption is motivated by the stylized notion that cash flows are often meagre in the early phase of the project. High quality projects have long gestation periods, with most cash flows accruing later in the project lifespan.

3. Taking outside interest rates as given, they simultaneously decide on contract offers for their prior borrowers.

4. Borrowers make acceptance or rejection decisions. Output is realized, contracts are settled and the game ends.

2 The model with two banks

To clarify the intuition, we first analyze the model when $N = 2$. The discussion is extended in the next section to the general model. Important differences are examined in the following sections.

2.1 Preliminaries

We use backward induction to solve the model. This subsection first examines optimal decisions and payoff functions in the second period, taking period 1 actions as given. It then studies the first period game taking investment decisions as given. The results derived here are used to investigate equilibrium in the economy.

Let j and k be the two banks. Consider a borrower E from j's local market. Suppose j did not lend to E in period 1. Suppose also j receives signal L from E at the beginning of period 2, and that E is of type i. There are three mutually exclusive and exhaustive possibilities: (i) E did not receive a loan in period 1, (ii) E received a loan in period 1 and has a L project, and (iii) E received a loan in period 1 and has a H project.

In order for j to offer E a loan, it has to first assign probabilities to these three events. Let the respective assessed probabilities be π_n^a, π_l^a and π_h^a, with $\pi_n^a + \pi_l^a + \pi_h^a = 1$. Since the signal is L, π_l^a must be positive. Therefore, $\pi_h^a < 1$. E can generate revenues only under the third event. At the beginning of period 2, k knows E's type as well as the quality of her project. j knows her type, but does not know her project quality with certainty. j must therefore break even from any loan offer it makes to E. Let r_l be the break even interest factor given this probability assessment. Then

$$\pi_h^a \sigma_i r_l = 1$$
$$\text{or, } r_l = \frac{1}{\pi_h^a \sigma_i} > \frac{1}{\sigma_i}$$

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Given r_l, k can always retain E by offering her a loan interest factor $r_l - \epsilon$. Also, k makes has a positive net expected payoff at that interest factor. On the other hand, k will never lend to E if she has a L project. Then if j offers E a loan at interest factor r_l, k will retain her if she has a H project, and release her if she has a L project. Thus, if j offers a contract to a borrower who generates signal L, it will attract her either if she received a loan in period 1 and has a L project, or if she did not receive a loan in period 1 at all. Either way, it cannot break even and therefore will not offer her a loan, due to adverse selection.

Now suppose E is not from j's local market. Suppose j did not lend to E in period 1, and that it receives signal L from E at the beginning of period 2. Extending the above argument, it is obvious that j cannot break even on such a borrower if it offers her a loan in period 2, and will therefore not offer her a loan.

Borrowers who did not receive a loan in period 1 will always generate the signal L, as will borrowers who received a loan in period 1, and have L projects. Obviously, the latter category will not be offered a loan in period 2 by their prior lending bank. However, consider a borrower who received a loan in period 1 and has a H project. She will always be offered a loan in period 2 by her prior lending bank. Will she receive outside contract offers? The analysis above establishes the following result:

Claim 1 *Consider a borrower who received a loan in period 1 and has a H project. If all non-lending banks receive the signal L from her, she does not get an outside contract offer in period 2.*

Now suppose a borrower of type i receives an outside loan offer in period 2. Let r be the interest factor on the outside offer. If the outside offer is received from her local bank, clearly the interest factor equals $\frac{1}{\sigma_i}$. Otherwise, let r satisfy feasibility, *i.e.*, $r \leq Y$, and consistency, *i.e.*, $r \geq \frac{1}{\sigma_i}$, for any type i receiving a loan in period 1.

Converse to the claim above, if the non-lending bank receives signal H for a borrower at the beginning of period 2, she will receive an outside contract offer. However, the terms of the offer will depend on the identity of the offering bank. Consider borrower E of type i who received a loan in period 1, and has a H project. Let j be E's local bank. There are two possibilities: either E received a loan in 1 from j, or she received a loan from k.

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We now derive the expected payoffs in period 2 to banks and borrowers under these alternative events. Suppose a borrower received a loan in period 1. If she has a L project, her lending bank will not offer her a loan in period 2. Moreover, non-lending banks receive signal L. Therefore, she will not get an outside contract offer. Since a borrower who did not receive a loan in period 1 will always generate signal L, she will not receive a loan in period 2 either. Focus therefore on borrowers who received a loan in period 1 and have H projects. What are the period 2 payoffs accruing to such a borrower and her lending bank from the relationship? Assume she accepts the contract from her lending bank in the event of indifference and let $p_l, l = j, k$ be the signal strength of bank l.

First suppose E receives a loan from j in period 1. Any outside offer she receives in period 2 carries an interest factor r. The probability she receives an outside offer in period 2 is p_k. j has superior information about E. Therefore, if k, conditional on receiving signal H, offers E a loan at interest factor r, j can always match it. In such an event, the respective payoffs of E and j are

$$(1 - \sigma_i).0 + \sigma_i(Y - r) = \beta_i - \sigma_i r, \text{ and}$$
$$(1 - \sigma_i).0 + \sigma_i r - 1 = \sigma_i r - 1$$

On the other hand, if E does not receive an outside offer in period 2, j is a monopolist and can extract all the rents from her, leaving her with 0 payoff. The respective payoffs are therefore,

$$P_{2,i}^b(p_j, p_k) = p_k(\beta_i - \sigma_i r) \tag{1}$$
$$P_{2,i}^j(p_j, p_k) = p_k(\sigma_i r - 1) + (1 - p_k)(\beta_i - 1) \tag{2}$$

Now suppose she receives a period 1 loan from k. With probability $1 - p_j$, she does not receive an outside offer, in which case k is a monopolist and extracts all rents from her. Suppose she receives an outside offer from j (the probability of receiving such an offer is p_j). Since j makes her an offer if and only if it receives the signal H, k and j are then symmetrically informed about E. Therefore, k must break even from lending to her, while she gets the entire net output from the project. We have

$$P_{2,i}^b(p_j, p_k) = p_j(\beta_i - 1) \tag{3}$$

$$P_{2,i}^k(p_j, p_k) = (1 - p_j)(\beta_i - 1) \tag{4}$$

We now move to an analysis of the first period. Consider a borrower E in bank j's local market. Neither her type nor the quality of her project are known at the beginning of period 1. Suppose she receives a loan offer from k, giving her a lifetime net expected payoff v_0. j then has the option of offering her a loan, taking v_0 and r as given. Finally, E makes borrowing decisions based on her available offers. In the event of indifference, she accepts her local bank's contract.

j and k are *ex ante* symmetrically informed about E, while has j an *ex post* observational advantage over k. Therefore, k has to break even in expected terms from the contract it offers E. It is also possible that E does not receive any outside offers at all, in which case her outside option gives her payoff 0. We first analyze the game under the assumption that she receives an outside offer at the beginning of period 1. Later, we examine bank actions when local market borrowers receive no outside offers.

As before, let the signal quality of any bank l be p_l. Denote by ρ_{0jk} the interest factor on a period 1 outside loan offer from bank k to bank j's borrowers. For convenience, we drop the letter subscripts: the meaning should be clear from the context. Let k offer E a loan in period 1 with an interest factor ρ_0. Clearly, it has to be the case that $\rho_0 \leq y$. Let E's and k's payoffs from this contract be denoted as $v_0(\rho_0; p_j, p_k)$ and $u_0(\rho_0; p_j, p_k)$ respectively. Using (3) and (4), we have

$$\begin{aligned} v_0(\rho_0; p_j, p_k) &= (y - \rho_0) + s \int_{\underline{\sigma}}^{\overline{\sigma}} \frac{p_j(\beta_i - 1)}{(\overline{\sigma} - \underline{\sigma})} d\sigma_i \\ &= (y - \rho_0) + s p_j(\beta - 1) \end{aligned} \tag{5}$$

$$\begin{aligned} u_0(\rho_0; p_j, p_k) &= (\rho_0 - 1) + s \int_{\underline{\sigma}}^{\overline{\sigma}} \frac{(1 - p_j)(\beta_i - 1)}{(\overline{\sigma} - \underline{\sigma})} d\sigma_i \\ &= (\rho_0 - 1) + s(1 - p_j)(\beta - 1) \end{aligned} \tag{6}$$

s is the probability of the project being H, and β is the conditional expected gross output in period 2. Now suppose j offers E a loan contract with interest factor ρ. Let E's and j's payoffs from this contract be denoted as $v(\rho)$ and $u(\rho)$ respectively. From (1) and (2), we get

$$v(\rho; p_j, p_k) = (y - \rho) + s \int_{\underline{\sigma}}^{\overline{\sigma}} \frac{p_k(\beta_i - \sigma_i r)}{(\overline{\sigma} - \underline{\sigma})} d\sigma_i$$
$$= (y - \rho) + sp_k(\beta - \sigma r) \tag{7}$$

$$u(\rho; p_j, p_k) = (\rho - 1) + s \int_{\underline{\sigma}}^{\overline{\sigma}} \frac{p_k(\sigma_i r - 1) + (1 - p_k)(\beta_i - 1)}{(\overline{\sigma} - \underline{\sigma})} d\sigma_i$$
$$= (\rho - 1) + s\{p_k(\sigma r - 1) + (1 - p_k)(\beta - 1)\} \tag{8}$$

σ is the expected probability of success in period 2. Suppose ρ is designed to make E indifferent between the local and the best outside offer, *i.e.*, $v(\rho) = v_0(\rho_0)$. j cannot offer E a contract which gives her less than $v_0(\rho_0)$, while offering her a contract which gives her more is suboptimal. Using (5) and (7), we have

$$(y - \rho) + sp_k(\beta - \sigma r) = (y - \rho_0) + sp_j(\beta - 1)$$
$$i.e., \ \rho(p_j, p_k) = \rho_0(p_j, p_k) - s\{p_j(\beta - 1) + p_k(\beta - \sigma r)\} \tag{9}$$

Now, given any feasible outside contract offered to E, j can always make a counteroffer to retain E, provided it at least breaks even in the process. Since competition ensures that k must offer E a 0 profit contract, the contract must satisfy

$$\rho_0(p_j, p_k) = 1 - s(1 - p_j)(\beta - 1), \text{ by (6)} \tag{10}$$

E's payoff from this contract, *i.e.*, her outside option is, using (5) and (10)

$$v_0(p_j, p_k) = (y - 1) + s(1 - p_j)(\beta - 1) + sp_j(\beta - 1)$$
$$\text{or, } v_0(p_j, p_k) = s(\beta - 1) - \alpha \tag{11}$$

Given $v_0(p_j, p_k)$, if j wants to retain her, it has to offer her a contract ρ such that she is indifferent, where ρ is given by (9). Using (8) through (10), the local bank's payoff from a borrower when the payoff she receives from her best outside option is given by (11), can be obtained as

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$$u(p_j, p_k) = 0 \tag{12}$$

Competition therefore leaves the bank with 0 profits. If its *ex post* observational advantage does not prevent k from a offering competitive contract *ex ante*, the borrower must get the entire net expected output from the project. j is forced to match this payoff, and therefore makes 0 profits. We now turn to an analysis of the behavior of a bank in the first period when its local borrowers have no outside offers, *i.e.*, when $v_0 = 0$. The bank is then an effective monopolist. Suppose the bank offers a local borrower a loan contract in period 1 with interest factor ρ. It is clear that $\rho = y$. We then have, using (1) and (2)

$$
\begin{aligned}
v(p_j, p_k) &= s \int_{\underline{\sigma}}^{\overline{\sigma}} \frac{p_k(\beta_i - \sigma_i r)}{(\overline{\sigma} - \underline{\sigma})} d\sigma_i \\
v(p_j, p_k) &= s p_k(\beta - \sigma r)
\end{aligned}
\tag{13}
$$

$$
\begin{aligned}
u(p_j, p_k) &= s \int_{\underline{\sigma}}^{\overline{\sigma}} \frac{p_k(\sigma_i r - 1) + (1 - p_k)(\beta_i - 1)}{(\overline{\sigma} - \underline{\sigma})} d\sigma_i - \alpha \\
u(p_j, p_k) &= s\{p_k(\sigma r - 1) + (1 - p_k)(\beta - 1)\} - \alpha
\end{aligned}
\tag{14}
$$

Since j is a monopolist in period 1, the borrower's period 1 payoff is 0. Provided she has a H project, her lifetime net expected payoff is given by (13) and is her expected payoff in period 2, provided she receives a period 1 loan from her local bank. The bank extracts all rents from the borrower in period 1. Its lifetime net expected payoff from her is then $(y - 1)$ in period 1, plus her expected payoff in period 2, conditional on the borrower having a H project.

Consider any bank l. Before describing equilibrium, define the indicator variable λ_l, which takes the value 1 if borrowers of bank l receive an outside loan offer in period 1, and 0 otherwise. Also define the set I_l to be the set of types of local borrowers to whom bank l makes loan offers in period 1. Symmetry implies that $I_j = I_k$ in equilibrium. Since information is not available *ex ante*, either $I_l = [\underline{i}, \overline{i}]$ or I_l is null.

Suppose I_l is not null. Consider the period 2 outside interest factor r. In equilibrium, borrowers get period 1 loans from their local banks, if they get loans at all. If a borrower gets a period 1 loan from an outside bank, it must be the case that lending to her is profitable, given interest rates. But

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then, if an outside bank can make non-negative payoffs by lending to her, so can her local bank. Therefore, rational expectations imply that the outside interest factor offered by an uninformed bank in period 2, conditional on receiving a signal H, is $\frac{1}{\underline{\sigma}}$. A larger interest factor would can be undercut, while a smaller interest factor would result in negative payoffs, due to adverse selection. The equilibrium interest factor thus satisfies feasibility and consistency, as defined earlier. We now investigate the determination of λ_l. The following result gives λ_l as a function of p_j and p_k.

Claim 2 *Suppose I_l is non-null. Given p_j and p_k, $\lambda_l = 1 \Leftrightarrow s(1 - p_l)(\beta - 1) \geq \alpha$.*

Proof. See Section 7. ∎

Outside banks can only make a period 1 offer if the interest rate on such an offer is feasible. Feasibility implies that the interest factor that allows the outside bank to break even must be less than the first period cash flow. We see that whether $\lambda_l, l = j, k$ equals 1 or 0 is determined entirely by the parameters, p_j and p_k. We also see that if $y \geq 1$, $\alpha \leq 0$, and hence λ_l is always 1, since $\beta > 1$.

2.2 Equilibrium

Equilibrium can now be defined as a 2-vector (p_j^*, p_k^*), with $p_l^* \in \{0, p_c\}$. There are two candidate symmetric equilibria: one where neither bank invests in information collection, and one where both invest in information collection. We call the former the U equilibrium, and the latter the C equilibrium. There are also two candidate asymmetric equilibria: one where j invests, while k does not, and another where k invests, while j does not. We call these the A equilibria. The banks are symmetric *ex ante*. Therefore, whenever an equilibrium with j investing and k not investing exists, so will an equilibrium with j not investing and k investing.

Under Assumption 1, a pure strategy equilibrium with lending always exists in the model. The logic behind the existence of a U equilibrium is as follows. Suppose a bank does not acquire information. The only reason it would deviate and acquire information is if it could force competitors to stop offering contracts to its local borrowers in period 1. If p_c is low, *ex post* information dissipation is low, and hence competitors are able to cover *ex ante* losses through *ex post* information rents. The bank then has no incentive to invest in information acquisition.

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Now, by deviating, bank l raises its information collection *ex post*. It thereby reduces the rents its competitor can earn *ex post* from l's local borrowers. Hence the competitor has to charge a higher interest *ex ante* in order to break even. If $p_c > 1 - \frac{\alpha}{s(\beta-1)}$, deviation causes the *ex ante* payment constraint to bind, and l earns monopoly rents on its local borrowers in period 1. Then it has an incentive to deviate as long as the cost of investing is sufficiently low. Therefore, a U equilibrium exists for $p_c > 1 - \frac{\alpha}{s(\beta-1)}$ as long as the cost of investment is high.

A similar argument shows that a C equilibrium exists if and only if $p_c > 1 - \frac{\alpha}{s(\beta-1)}$, provided the cost of investment is sufficiently low. Moreover, an asymmetric equilibrium exists for this parameter range if the cost of investment is in the intermediate range. In an asymmetric equilibrium, the investing bank makes monopoly rents *ex ante*, as the competitor cannot offer its borrowers any contracts in the first period. It has no incentive to deviate in spite of the positive cost of investment because the other bank is not investing which raises the rents it earns on its own local borrowers *ex post*. The other bank makes 0 profits however. Switching to an investment strategy is not profitable because c is sufficiently high and because *ex post* rents on its borrowers are limited given that the other bank is investing.[19] Interestingly, the equilibrium payoffs and strategies are asymmetric in spite of the two players being symmetric.

Asymmetry in banks' ability to gather private information on mature borrowers can therefore lead to the commitment value of information acquisition. This property arises because public information, if available, is not fully revealing. Local banks have access to private information *ex post* which allows them to credibly use information acquisition as a strategy to protect local markets. Information acquisition, by generating rents, can therefore lead to a loss in social welfare, as discussed in Section 5.

The following result completely characterizes pure strategy equilibria. In the discussion of asymmetric equilibria below, assume without loss of generality that j invests, while k does not. We have

Proposition 1 *A pure strategy equilibrium always exists.*

Suppose $p_c \leq 1 - \frac{\alpha}{s(\beta-1)}$. Then the unique equilibrium is the U equilibrium.

Otherwise, suppose $p_c > 1 - \frac{\alpha}{s(\beta-1)}$.

Then if $\mu s(\beta - 1) \leq \mu\alpha + c$, the unique equilibrium is the U equilibrium.

If $\mu\alpha + c \in [\mu s\{p_c(\frac{\sigma}{\underline{\sigma}} - 1) + (1 - p_c)(\beta - 1)\}, \mu s(\beta - 1)]$, we have two asymmetric equilibria.

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[19] There is a similarity here with the celebrated 'Hawk-Dove' game.

If $\mu s\{p_c(\frac{\sigma}{\underline{\sigma}} - 1) + (1 - p_c)(\beta - 1)\} \geq \mu\alpha + c$, the unique equilibrium is the C equilibrium.

Proof. See Section 7. ■

We now move to the analysis of the general model, with $N \geq 3$. As in the analysis above, we find that symmetric as well as asymmetric equilibria can exist. The most important difference in the general model is that strategic complementarities in information acquisition may exist with more than 2 banks.

3   Analysis of the general model

The first subsection examines optimal decisions and payoff functions in the second period, taking period 1 actions as given. The following subsection studies the first period game. We then use the results derived in this section to investigate equilibrium in the economy.

3.1   The second period

Note first that Claim 1 established above continues to hold. Borrowers who did not get a loan in period 1, or those who did but have L projects will not get outside loan offers in period 2. Borrowers who got a loan and have a H project will not get any outside loan offer if all non-lending banks receive a L signal from her. We now introduce some terminology. Consider a bank j. Suppose a borrower from its local market with a H project received a loan in period 1. Suppose she is offered a loan in period 2 by a bank which does not know her type. Such a bank is termed an *uninformed bank*. Clearly, all uninformed banks which make her an offer will make her the same offer. The interest factor on such offers is termed the *period 2 outside interest factor*, and is denoted by r_j. If the context is clear, we will drop the subscript j. r is taken as exogenous for now. We assume feasibility, *i.e.*, $r \leq Y$, and consistency, *i.e.*, $r \geq \frac{1}{\sigma_i}$, for any type i receiving a loan in period 1.

As argued above, if at least one non-lending bank receives signal H for a borrower at the beginning of period 2, she will receive an outside contract offer. However, the terms of the offer will depend on the identity of the offering bank. Consider borrower E of type i who received a loan in period 1, and has a H project. Let l be E's local bank. There are two possibilities: either E received a loan in 1 from l, or she received a loan from some other bank j.

If E took a loan from l in period 1, any outside offer she receives in period 2 will necessarily be from an uninformed bank at the period 2 outside interest factor r. However, if she took a period 1 loan from some other bank j, she could receive a period 2 offer from l, at interest factor $\frac{1}{\sigma_i}$, or she could receive at least one outside offer from an uninformed bank without receiving an offer from l. The following lemma derives the probabilities with which she receives these different offers.

Lemma 1 *Let the signal quality of any bank j be p_j. Suppose a borrower E has a H project. If E received a loan in period 1 from l, her local bank, the probability she receives at least one outside offer in period 2 is $\pi_l = 1 - \prod_{j \neq l}(1 - p_j)$. If she received a loan in period 1 from some other bank j, the probability she receives at least one outside offer in period 2 from an uninformed bank without receiving an offer from l is*

$$\pi_o^u = (1 - p_l)\left[\sum_{M=1}^{N-2}\left\{\sum_{\substack{k_1,..k_M \neq j,l}} \prod_{\substack{k_n \\ n=1,..,M}} p_{k_n} \prod_{m \neq j,k_n,l}(1 - p_m)\right\}\right]$$

while the probability she receives a period 2 outside offer from l is

$$\pi_o^l = 1 - (1 - p_l)\left[\sum_{M=0}^{N-2}\left\{\sum_{\substack{k_1,..k_M \neq j,l}} \prod_{\substack{k_n \\ n=1,..,M}} p_{k_n} \prod_{m \neq j,k_n,l}(1 - p_m)\right\}\right]$$

Proof. See Section 7. ∎

We now derive the payoffs in period 2 to banks and borrowers under these alternative events. Without loss of generality, consider borrowers who received a loan in period 1 and have H projects. What are the period 2 payoffs accruing to such a borrower and her lending bank from the relationship? Assume she accepts the contract from her lending bank in the event of indifference. Let $\overrightarrow{p}$ be the vector $(p_1, .., p_j, .., p_N)$.

First suppose E receives a loan from l in period 1. Any outside offer she receives in period 2 is necessarily from an uninformed bank. The interest factor on such an offer is r. The probability she receives an outside offer in period 2 is π_l, by Lemma 1. Since l has superior information about E, the respective payoffs are

$$P_{2,i}^b(\overrightarrow{p}) = \pi_l(\beta_i - \sigma_i r) \tag{15}$$

$$P_{2,i}^l(\overrightarrow{p}) = \pi_l(\sigma_i r - 1) + (1 - \pi_l)(\beta_i - 1) \tag{16}$$

Now suppose she receives a period 1 loan from some other bank j. With probability $1 - \pi_o^u - \pi_o^l$, she does not receive an outside offer, in which case j is a monopolist and extracts all rents from her. Suppose she receives an outside offer from l (the probability of receiving such an offer is π_o^l). Since l makes her an offer if and only if it receives the signal H, l and j are then symmetrically informed about E. Therefore, j must break even from lending to her, while she gets the entire net output from the project. Finally, suppose she receives outside offers only from uninformed banks (the probability of which is π_o^u). j is now superiorly informed about E compared to any such bank. E and j therefore have payoffs $\beta_i - \sigma_i r$, and $\sigma_i r - 1$ respectively. We have

$$P_{2,i}^b(\overrightarrow{p}) = \pi_o^l(\beta_i - 1) + \pi_o^u(\beta_i - \sigma_i r) \tag{17}$$

$$P_{2,i}^j(\overrightarrow{p}) = \pi_o^u(\sigma_i r - 1) + (1 - \pi_o^u - \pi_o^l)(\beta_i - 1) \tag{18}$$

Summing up the discussion, if a borrower receives a loan in period 1, and has a H project, she may face monopoly exploitation if information about the quality of her project is not correctly received by outside lenders. If outside banks receive the signal L for her project, they will not offer her a contract, even though they know their perception is wrong with positive probability. Her prior lending bank can then extract monopoly rents because it can differentiate between projects of differing quality while outsiders cannot. Even if outside banks do offer her contracts in period 2, some rents may accrue to her prior lending bank because of its superior information. A borrower may also earn the entire net product of the project in period 2. This outcome obtains if she receives a period 1 loan some bank j different from her local bank l. Then, if l offers her a contract in period 2, competition takes away all rents from j, because of the informational symmetry between l and j at this stage.

3.2   The first period

We now use the results of the previous section to analyze the game in the first period. We derive optimal actions and payoffs taking investment decisions as given.

Suppose E receives at least one outside contract offer, and let her best outside offer (from some bank C) give her a payoff v_0. C has to break even in expected terms from the contract it offers E. We first derive payoffs under the assumption that she receives at least one outside offer at the

beginning of period 1. Later, we examine bank actions when local market borrowers receive no outside offers.

As before, let the signal quality of any bank j be p_j and let $\overrightarrow{p} = (p_1, .., p_j, .., p_N)$. We eschew a detailed analysis and note that the discussion parallels the arguments of Section 3.1. Therefore, if E receives at least one outside contract offer in period 1, her payoff, *i.e.*, her outside option is, from (17)

$$v_0(\overrightarrow{p}) = s(\beta - 1) - \alpha \tag{19}$$

Therefore, using (18), her local bank's payoff from her is

$$u(\overrightarrow{p}) = 0 \tag{20}$$

On the other hand, suppose a bank's local borrowers have no outside offers in period 1, *i.e.*, $v_0 = 0$. Suppose the bank offers a local borrower a loan contract in period 1 with interest factor $\rho = y$. We then have, using (15) and (16)

$$v(\overrightarrow{p}) = s\pi_l(\beta - \sigma r) \tag{21}$$

$$u(\overrightarrow{p}) = s\{\pi_l(\sigma r - 1) + (1 - \pi_l)(\beta - 1)\} - \alpha \tag{22}$$

If the borrower has a H project, her lifetime net expected payoff is given by (21) and is her expected payoff in period 2, provided she receives a period 1 loan from her local bank. The bank extracts all rents from the borrower in period 1. Its lifetime net expected payoff from her is then $(y - 1)$ in period 1, plus her expected payoff in period 2, conditional on the borrower having a H project.

In summary, since a bank's borrowers cannot be differentiated in period 1, if borrowers from a local market receive outside contracts in period 1, all such borrowers have to receive the same offers. If some bank's local market borrowers do not receive outside offers in period 1, it is a monopolist. It then extracts all rents, leaving borrowers with 0 payoff in period 1. Borrowers who are offered loans by the local bank then receive their period 2 payoff, provided they have a H project. On

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the other hand, they may receive outside contract offers in period 1. Such contracts have to leave the offering banks with 0 lifetime net expected payoffs. The local bank also then has to receive 0 profits from lending to such borrowers.

Before describing equilibrium, define the indicator variable λ_j, as before, which takes the value 1 if borrowers of bank j receive at least one outside loan offer in period 1, and 0 otherwise. In a symmetric equilibrium, either the borrowers of a bank will receive period 1 outside loan offers from all non-local banks, or they will not receive any offers at all. Define the set I_j to be the set of types of local borrowers to whom bank j makes loan offers in period 1. $I_j = I_k, \forall j, k$, in equilibrium and either $I_j = [\underline{i}, \overline{i}]$ or I_j is null. If I_j is not null, the period 2 outside interest factor r_j.is $\frac{1}{\underline{\sigma}}$, which satisfies feasibility and consistency as before. The following result gives λ_j as a function of $\overrightarrow{p}$.

Lemma 2 *Suppose I_j is non-null. Given $\overrightarrow{p}$, $\lambda_j = 1 \Leftrightarrow s\{\pi_o^u(\frac{\underline{\sigma}}{\underline{\sigma}} - 1) + (1 - \pi_o^u - \pi_o^l)(\beta - 1)\} \geq \alpha$.*

    Proof. See Section 7. ∎

Feasibility implies that the interest factor that allows the outside bank to break even must be less than the first period cash flow. Recall π_o^u and π_o^l are uniquely determined by $\overrightarrow{p}$ (see Lemma 1). Therefore, given $\overrightarrow{p}$, whether λ_j equals 1 or 0 is determined entirely by the parameters. We also see that if $y \geq 1$, $\alpha \leq 0$, and hence λ_j is always 1, since $\beta > 1$, and $\overline{\sigma} > \underline{\sigma}$.

4   Equilibrium with $N \geq 3$ banks

We use the results of the previous sections to establish the existence of pure strategy equilibrium in this section. The next section studies symmetric equilibria in greater detail and investigates some properties of equilibrium. The intuition for the existence of different kinds of equilibria is similar to that discussed in the 2 bank model. Equilibrium always exists, with U equilibrium existing if p_c is low or the cost of investment is high. A C equilibrium exists if c is low, provided p_c is not too low. In general, asymmetric equilibria exist for intermediate costs of investment.

Equilibrium is the N vector $(p_j^*)_{j=1}^N$. We first define an n-equilibrium, $0 \leq n \leq N$ as an equilibrium with n banks investing in information acquisition and $N - n$ banks not investing. A *0*-equilibrium is then equivalent to a U equilibrium where no bank invests in information collection, while an N-equilibrium is equivalent to a C equilibrium, with all banks investing. For ease of

exposition, we assume that *ex post* expected information rents, which is a function of the degree of heterogeneity in borrower type $(\overline{\sigma} - \underline{\sigma})$ is higher than period 1 losses.

$$\text{Assumption 2: } s(\frac{\overline{\sigma} - \underline{\sigma}}{2\underline{\sigma}}) > \alpha$$

We now show that a pure strategy equilibrium always exists. The following result completely characterizes pure strategy equilibria in the N-bank model. We have

Proposition 2 *A pure strategy equilibrium exists given Assumptions 1 and 2.*

Proof. See Section 7. ■

To augment our understanding, Figures 1 and 2 draw on the proposition above to present a graphical picture of how different equilibria exist in different parts of the parameter space. Figure 1 considers the case of $N = 3$, while Figure 2 considers the case of $N = 4$. For the purpose of drawing the figures, we put $\frac{\sigma}{\underline{\sigma}} = \sigma^*$. The following corollary is immediate.

Corollary 1 *In an n-equilibrium, $0 < n < N$, the payoff to the investing banks is higher than the payoff to the non-investing banks.*

Proof. See Section 7. ■

The logic is as before. In an asymmetric equilibrium, investing banks make monopoly rents *ex ante*, while non-investing banks are forced to give their local borrowers the entire net expected product of the projects. Investment precludes competitors from offering period 1 loans to investing banks' local borrowers, and also acts as a commitment device to prevent some banks from investing themselves. Investing banks have no incentive to deviate in spite of the positive cost of investment because some banks are not investing which raises the rents earned on local borrowers *ex post*. For non-investing banks, switching to an investment strategy is not profitable because c is sufficiently high and because *ex post* rents on own borrowers are limited given that the presence of some investing banks.

5   Symmetric equilibrium

We use the results derived so far to investigate symmetric pure strategy equilibria in this section. The model predicts there may be multiple equilibria. We derive conditions under which multiple symmetric equilibria exist. An interesting prediction of the general N-bank model, when $N \geq 3$, is that there may be strategic complementarities in information acquisition. Recall from the discussion in Proposition 1, strategic complementarities and hence multiple equilibria do not exist in the 2-bank model.

The argument is as follows. When $N \geq 3$, a bank j's investment in information acquisition tightens the *ex ante* payment constraints of all other banks $l \neq j$ when they are bidding for j's borrowers in period 1. However, investment improves j's *ex post* signal quality in general and thus also tightens other banks' $l \neq j, k$ *ex ante* payment constraints when bidding for bank k's borrowers in period 1. For some parameter values, j's action therefore can induce other banks to invest, which in turn can raise j's incentive to invest.

Notice, this argument does not work when there are only 2 banks in the economy. If j and k are the two banks, investment by j tightens k's *ex ante* payment constraint when bidding for j's borrowers in period 1. But since it does not improve k's position by tightening j's *ex ante* payment constraint when bidding for k's borrowers in period 1, strategic complementarities are not generated.

Proposition 3 *Multiple symmetric equilibria exist if and only if*

$$a) \ s[(\frac{\sigma}{\underline{\sigma}} - 1) + (1 - p_c)^{N-1}(\beta - \frac{\sigma}{\underline{\sigma}})] - \alpha \ \in \ [\frac{c}{\mu}, sp_c(\frac{\sigma}{\underline{\sigma}} - 1)) \ and$$
$$b) \ s(1 - p_c)(\beta - 1) \ \geq \ \alpha$$

Proof. See Section 7. ∎

We now study welfare when multiple symmetric equilibria exist. Let welfare be measured by the sum of payoffs of all agents, banks and borrowers, in the economy. The following result shows that welfare is strictly lower in a C equilibrium, *i.e.*, when all banks invest in information collection. The argument is simple. Since information on borrowers and projects are not known in period 1, all borrowers always get loans. In a C equilibrium however, banks also expend resources to

acquire information. In the model, the only role information collection has is to augment market power. Investment acts as commitment device: investing increases *ex post* competitiveness and hence generates monopoly rents *ex ante*. It is thus a deadweight loss on society, arising from the presence of informational asymmetries. The banks are better off however: their payoffs are higher in a C equilibrium than in a U equilibrium. Interestingly, compared to a U equilibrium, a C equilibrium has lower welfare and borrower payoff even though *ex post* competition as measured by the expected number of offers received by any borrower is higher.

Proposition 4 *Suppose a C equilibrium and a U equilibrium exist simultaneously. Relative to a U equilibrium, a C equilibrium has lower welfare, higher payoff for banks, lower payoff for borrowers, and higher ex post competition as measured by the expected number of offers received by borrowers with H projects in period 2.*

Proof. See Section 7. ∎

6   Conclusions

Optimal allocation of investment funds is contingent on the appropriate evaluation of credit risk. By being central to the determination and rating of creditworthiness, efficient information acquisition is critical to the proper functioning of credit markets. Existing literature has suggested that the nature of information as a 'soft' good over which property rights are difficult to define or enforce acts as an impediment to information production. Competition then diminishes the incentives for information collection. Furthermore, since privileged information is obtained through the process of lending, banks will never invest in gathering information on firms seeking funds for project refinancing.

This paper has shown that there may be other strategic dimensions to information acquisition. With informationally heterogeneous banks, investment in information acquisition acts as a commitment device. By reducing competitors' *ex post* rents, banks lower the level of competition faced *ex ante*. If the reduction in competition is sufficiently large, banks may obtain monopoly rents. The incentive to invest in information collection then depends on the trade-off between increased payoffs stemming from limited competition and the cost of investment. If the cost is sufficiently low, and investment is sufficiently productive, the unique equilibrium has all banks investing in

information acquisition. By contrast, if the cost is sufficiently high, and investment is sufficiently unproductive, the no bank invests in information acquisition.

Asymmetric equilibria exist with intermediate costs of investment: in such an equilibrium, investing banks obtain higher payoff than non-investing banks. The analysis also shows that with more than two banks, information acquisition is characterized by strategic complementarities. Thus, multiple equilibria may exist. Banks invest in information acquisition to augment market power and limit competition; information collection therefore represents a dead-weight loss and leads to reduced welfare. Since more information becomes available about borrowers *ex post*, increased competition for continuing projects may actually signal higher market power for banks.

The results of the paper have implications for deregulation policy. Welfare is reduced because of the exercise of market power by informationally superior banks through the use of strategic commitment. Competitors cannot break even from period 1 offers because reduced period 2 rents cannot compensate for the losses borne *ex ante*. In the absence of enforceability of long-term contracts, welfare could be augmented by imposing 'no-refinancing' penalties on borrowers. Borrowers then face switching costs of moving to another lender in period 2. Since incumbent lenders are therefore able to extract higher *ex post* rents, their ability to subsidize period 1 losses is enhanced. Penalties thus weaken the commitment value of information acquisition. Borrowers get the same lifetime payoffs however, as competition ensures they get the entire net expected output from their projects.

The commitment value of information acquisition is generated by the asymmetries in banks' abilities to gather private information *ex post* and the incompleteness of public information. In this context, regulatory changes designed to increase information acquisition through heightened use of public credit rating information, as envisioned in the Basel Accord (see BIS (2000)), may have negative consequences. The results of this paper suggest that such a policy should be complemented with one designed to minimize the discrepancy between public and private information.

Although the discussion has been framed with reference to credit markets, the arguments extend to more general contexts. Suppose privileged information arises in the course of a relationship and vendors are informationally heterogeneous. Investment in information acquisition limits asymmetries of information and therefore competitors' rents *ex post.* By tightening competitors' *ex ante* break even constraints, competition is inhibited. Under some circumstances, market power is substantially augmented, and monopoly rents may be obtained. Such issues may be important in merchant banking, insurance, human capital, housing and other markets.

Several directions for further research could be pursued. In the model, all banks are symmetrically uninformed *ex ante*. With asymmetries, strategic information manipulation becomes an issue. Observation of each bank's behavior then becomes a conditioning variable *ex post*, with implications for portfolio risk, volume of lending and social welfare. The issue of entrepreneurial incentives could also be studied. Information acquisition increases competition *ex post*, while reducing it *ex ante*. The impact on incentives then depends on the relative productivity of the project in the first vis-à-vis the second period. In imperfectly competitive economies, the nature of surplus sharing between banks and borrowers will also influence the impact of information acquisition on incentives, and thereby on social welfare. These questions are left for future research.

7 Proofs

Proof of Claim 2.   Suppose $\lambda_l = 1$, for some l. Let the best period 1 outside offer faced by l's local borrowers be ρ_{0l}. Since $\lambda_l = 1$, ρ_{0l} must satisfy feasibility, *i.e.*, $\rho_{0l} \leq y$. Applying (10), we have

$$\rho_{0l}(p_j, p_k) = 1 - s(1 - p_l)(\beta - 1) \leq y$$
$$\text{or,} \ \alpha \leq s(1 - p_l)(\beta - 1)$$

For the converse, suppose $\alpha \leq s(1 - p_l)(\beta - 1)$. Then, a loan offer $\rho_0 = 1 - s(1 - p_l)(\beta - 1)$ is feasible. Making such an offer allows the outside bank to break even, and makes borrowers indifferent between this and their local bank's offer. ∎

Proof of Proposition 1.   We first look at asymmetric equilibria. First of all, we note that since $s(\underline{\beta} - 1) - \alpha > 0$, $\beta > \frac{\sigma}{\underline{\sigma}}$. Suppose j invests while k does not. Consider j's payoffs first. Define λ_{li}^a as the value of the indicator variable for bank l, $l = j, k$ in an asymmetric equilibrium when l's action is i, $i = u, c$, given that bank l conforms to its prescribed action. $i = u$ indicates the bank does not acquire information, while $i = c$ indicates the bank collects information. Also define λ_{li}^{ad} as the value of the indicator variable for bank l, $l = j, k$ in an asymmetric equilibrium when l's action is i, $i = u, c$, given that bank l deviates. λ_{li}^u, λ_{li}^c, λ_{li}^{ud} and λ_{li}^{cd} are defined similarly.

In equilibrium, if $\lambda_{jc}^a = 1$, the payoff is $-c$, by (12). Otherwise, by (14), the payoff is

$$\mu s(\beta - 1) - \mu\alpha - c$$

By Claim 2,

$$\lambda_{jc}^a = 1 \Leftrightarrow s(1 - p_c)(\beta - 1) \geq \alpha$$

Suppose j deviates. Then, if $\lambda_{jc}^{ad} = 1$, the payoff is 0. Otherwise, the payoff is

$$\mu\{s(\beta - 1) - \alpha\}$$

Finally,

$$\lambda_{jc}^{ad} = 1 \Leftrightarrow s(\beta - 1) \geq \alpha, \text{ which is always true.}$$

Since $p_c > 0$, we have $\lambda_{jc}^{ad} = 0 \Rightarrow \lambda_{jc}^a = 0$ and $\lambda_{jc}^a = 1 \Rightarrow \lambda_{jc}^{ad} = 1$. Clearly, j deviates if both λ_{jc}^a and λ_{jc}^{ad} equal 1 or if they both equal 0. Suppose therefore $\lambda_{jc}^{ad} = 1$, and $\lambda_{jc}^a = 0$. In other words, suppose $p_c > 1 - \frac{\alpha}{s(\beta-1)}$. Then, j does not deviate if and only if

$$\mu s(\beta - 1) - \mu\alpha - c \geq 0$$

Next, consider k's payoffs. In equilibrium, if $\lambda_{ku}^a = 1$, the payoff is 0. Otherwise, the payoff is

$$\mu s[p_c(\frac{\sigma}{\underline{\sigma}} - 1) + (1 - p_c)(\beta - 1)] - \mu\alpha$$

By Assumption 1 and Claim 2, λ_{ku}^a is always 1 as $s(\beta - 1) > \alpha$. Now suppose k deviates. Then, if $\lambda_{ku}^{ad} = 1$, the payoff is $-c$. Otherwise, the payoff is

$$\mu s[p_c(\frac{\sigma}{\underline{\sigma}} - 1) + (1 - p_c)(\beta - 1)] - \mu\alpha - c$$

Finally,

$$\lambda_{ku}^{ad} = 1 \Leftrightarrow s(1 - p_c)(\beta - 1) \geq \alpha$$

By the earlier logic, k does not deviate if both λ_{ku}^a and λ_{ku}^{ad} equal 1 or if they both equal 0. Suppose therefore $\lambda_{ku}^{ad} = 0$, and $\lambda_{ku}^a = 1$. In other words, suppose $p_c > 1 - \frac{\alpha}{s(\beta-1)}$. Then, k deviates if and only if

$$\mu s[p_c(\frac{\sigma}{\underline{\sigma}} - 1) + (1 - p_c)(\beta - 1)] - \mu\alpha - c > 0$$

Therefore, given j invests, k does not invest if and only if

$$\text{a) } p_c \leq 1 - \frac{\alpha}{s(\beta - 1)}$$

$$\text{or c) } p_c > 1 - \frac{\alpha}{s(\beta - 1)}$$
$$\text{and } \mu\alpha + c \geq \mu s[p_c(\frac{\sigma}{\underline{\sigma}} - 1) + (1 - p_c)(\beta - 1)]$$

Therefore, asymmetric equilibria exist if and only if

$$p_c > 1 - \frac{\alpha}{s(\beta - 1)}$$
$$\text{and } \mu\alpha + c \in [\mu s\{p_c(\frac{\sigma}{\underline{\sigma}} - 1) + (1 - p_c)(\beta - 1)\}, \mu s(\beta - 1)]$$

We now look at the existence of the C equilibrium. Suppose both banks invest. Then, for any bank l, in equilibrium, if $\lambda_l^c = 1$, the payoff is $-c$, by (12). Otherwise, using (14), the payoff is

$$\mu s[p_c(\frac{\sigma}{\underline{\sigma}} - 1) + (1 - p_c)(\beta - 1)] - \mu\alpha - c$$

Moreover, using Claim 2

$$\lambda_l^c = 1 \Leftrightarrow s(1 - p_c)(\beta - 1) \geq \alpha$$

Suppose bank l deviates. Then, if $\lambda_l^{cd} = 1$, the payoff is 0. Otherwise, the payoff is

$$\mu s[p_c(\frac{\sigma}{\underline{\sigma}} - 1) + (1 - p_c)(\beta - 1)] - \mu\alpha$$

Finally, λ_l^{cd} equals 1 by Assumption 1. Since $p_c > 0$, we have $\lambda_l^{cd} = 0 \Rightarrow \lambda_l^c = 0$ and $\lambda_l^c = 1 \Rightarrow \lambda_l^{cd} = 1$. Suppose therefore $\lambda_l^{cd} = 1$, and $\lambda_l^c = 0$. In other words, suppose $p_c > 1 - \frac{\alpha}{s(\beta-1)}$. Then a C equilibrium exists if and only if

$$\mu s[p_c(\frac{\sigma}{\underline{\sigma}} - 1) + (1 - p_c)(\beta - 1)] \geq \mu\alpha + c$$

Finally, we study the U equilibrium. Suppose neither bank invests. Then, for any bank l, in equilibrium, if $\lambda_l^u = 1$, the payoff is 0, by (12). Otherwise, using (14), the payoff is

$$\mu\{s(\beta - 1) - \alpha\}$$

Moreover, $\lambda_l^u = 1$, by Assumption 1. Suppose bank l deviates and collects information. Then, if $\lambda_l^{ud} = 1$, the payoff is $-c$. Otherwise, the payoff is

$$\mu s(\beta - 1) - \mu\alpha - c$$

Finally,

$$\lambda_l^{ud} = 1 \Leftrightarrow s(1 - p_c)(\beta - 1) \geq \alpha$$

Since c is positive, no deviation occurs if $\lambda_l^u = \lambda_l^{ud} = 1$, or if $\lambda_l^u = \lambda_l^{ud} = 0$. Also, $\lambda_l^{ud} = 1 \Rightarrow$ $\lambda_l^u = 1$ and $\lambda_l^u = 0 \Rightarrow \lambda_l^{ud} = 0$. Suppose therefore $\lambda_l^{ud} = 0$ and $\lambda_l^u = 1$. In other words, suppose $p_c > 1 - \frac{\alpha}{s(\beta-1)}$. Then a U equilibrium does not exist if and only if $\mu s(\beta - 1) > \mu\alpha + c$. ■

Proof of Lemma 1. First suppose E received a loan in period 1 from l. In period 2 uninformed banks receive signals about her project quality. She will not receive an outside contract offer if and only if all uninformed banks receive signal L. By independence, the probability of that event is

$$\prod_{j \neq l}(1 - p_j)$$

Therefore, the probability she receives at least one outside offer is the complementary event, *i.e.*,

$$\pi_l = 1 - \prod_{j \neq l}(1 - p_j), \ ^{20}$$

_____

[20]It is easy to show that the probability she receives exactly M outside offers is

$$[\sum_{\substack{k_1,..k_M \neq l}} \prod_{\substack{k_n \\ n=1,..,M}} p_{k_n} \prod_{m \neq k_n, l}(1 - p_m)], 0 \leq M < N - 1$$

while the probability she receives $N - 1$ outside offers is

$$\prod_{k \neq l} p_k$$

Now suppose she received a loan in period 1 from some other bank j. Define the three following events: A - l receives a signal H, B - l receives a signal L, as do all other non-lending banks, and C - l receives a signal L, while at least one other non-lending bank receives a signal H.

Event B occurs if and only if all non-lending banks receive signal L. The probability of event B is therefore

$$\prod_{k \neq j}(1 - p_k) = (1 - p_l) \prod_{k \neq j,l}(1 - p_k)$$

In order for event C to occur, it must be the case that l draws signal L. In addition at least one of the other non-lending banks must draw signal H. The probability that exactly M of the non-lending banks (apart from l) draw signal H is

$$\{\sum_{\substack{k_1,..k_M \neq j,l}} \prod_{\substack{k_n \\ n=1,..,M}} p_{k_n} \prod_{m \neq j,k_n,l}(1 - p_m)\}, 0 < M < N - 1$$

Therefore, the probability that E receives at least one outside offer in period 2 from an uninformed bank without receiving an offer from l is

$$\pi_o^u = (1 - p_l)[\sum_{M=1}^{N-2}\{\sum_{\substack{k_1,..k_M \neq j,l}} \prod_{\substack{k_n \\ n=1,..,M}} p_{k_n} \prod_{m \neq j,k_n,l}(1 - p_m)\}]$$

Finally, the probability that E receives an offer from l is the residual. Therefore,

$$\pi_o^l = 1 - \pi_o^u - (1 - p_l)\prod_{k \neq j,l}(1 - p_k)$$

$$\text{Therefore, } \pi_o^l = 1 - (1 - p_l)[\sum_{M=0}^{N-2}\{\sum_{\substack{k_1,..k_M \neq j,l}} \prod_{\substack{k_n \\ n=1,..,M}} p_{k_n} \prod_{m \neq j,k_n,l}(1 - p_m)\}]$$

∎

Proof of Lemma 2. Suppose $\lambda_j = 1$, for some j. Let the best period 1 outside offer faced by j's local borrowers be ρ_{0j}. Since $\lambda_j = 1$, ρ_{0j} must satisfy feasibility, *i.e.*, $\rho_{0j} \leq y$. Dropping the subscript j, and applying (10), we have

$$\rho_0(\overrightarrow{p}) = 1 - s\{\pi_o^u(\frac{\sigma}{\underline{\sigma}} - 1) + (1 - \pi_o^u - \pi_o^l)(\beta - 1)\} \leq y$$

$$\text{or, } \alpha \leq s\{\pi_o^u(\frac{\sigma}{\underline{\sigma}} - 1) + (1 - \pi_o^u - \pi_o^l)(\beta - 1)\}$$

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For the converse, suppose $\alpha \leq s\{\pi_o^u(\frac{\sigma}{\underline{\sigma}} - 1) + (1 - \pi_o^u - \pi_o^l)(\beta - 1)\}$. Then, a loan offer $\rho_0 = 1 - s\{\pi_o^u(\frac{\sigma}{\underline{\sigma}} - 1) + (1 - \pi_o^u - \pi_o^l)(\beta - 1)\}$ is feasible. Making such an offer allows the outside bank to break even, and makes borrowers indifferent between this and their local bank's offer. ∎

Proof of Proposition 2. Define λ_{li}^n as the value of the indicator variable for bank l, $l = j, k$ in an n-equilibrium when l's action is i, $i = u, c$, given that bank l conforms to its prescribed action. $i = u$ indicates the bank does not acquire information, while $i = c$ indicates the bank collects information. Also define λ_{li}^{nd} as the value of the indicator variable for bank l, $l = j, k$ in an n-equilibrium when l's action is i, $i = u, c$, given that bank l deviates.

Notice, whenever an n-equilibrium exists, with n banks investing and $N - n$ not investing, we also have $^N C_n - 1$ other equivalent equilibria because of the symmetry across banks. We ignore such multiplicity in the following discussion. Also, the U equilibrium and the C equilibrium are unique in the sense described here as $^N C_0 = ^N C_N = 1$.

We use Lemmata 1 and 2, and equations (20) and (22) to derive payoff functions. First consider a U equilibrium. Consider an arbitrary bank l. In equilibrium, $\pi_l = \pi_o^u = 0$, and $1 - \pi_o^u - \pi_o^l = 1$. Therefore, its payoff is 0 if $\lambda_{lu}^0 = 1$, and, by Assumption 1, $\lambda_{lu}^0 = 1$.

If l deviates, $\pi_l = \pi_o^u = 0$, and $1 - \pi_o^u - \pi_o^l = 1 - p_c$. Also its payoff is $-c$ if $\lambda_{lu}^{0d} = 1$, and $\mu s(\beta - 1) - \mu\alpha - c$ if $\lambda_{lu}^{0d} = 0$. We have $\lambda_{lu}^{0d} = 1 \Leftrightarrow s(1 - p_c)(\beta - 1) \geq \alpha$.

Clearly then, if $\lambda_{lu}^0 = \lambda_{lu}^{0d} = m$, $m = 0, 1$, l does not deviate. Let $\lambda_{lu}^0 = 1$ and $\lambda_{lu}^{0d} = 0$, $i.e.$, let

$$p_c > 1 - \frac{\alpha}{s(\beta - 1)}$$

Then, l conforms if and only if

$$\mu\alpha + c \geq \mu s(\beta - 1)$$

Therefore a U equilibrium exists if and only if a) $p_c \leq 1 - \frac{\alpha}{s[(\frac{\sigma}{\underline{\sigma}} - 1) + (\beta - \frac{\sigma}{\underline{\sigma}})]}$ or b) (i) $p_c > 1 - \frac{\alpha}{s[(\frac{\sigma}{\underline{\sigma}} - 1) + (\beta - \frac{\sigma}{\underline{\sigma}})]}$ and (ii) $\mu\alpha + c \geq \mu s[(\frac{\sigma}{\underline{\sigma}} - 1) + (\beta - \frac{\sigma}{\underline{\sigma}})]$.

We now consider a 1-equilibrium, $i.e.$, an equilibrium where only 1 bank invests, while the others do not. Consider an arbitrary non-investing bank l. We have $\pi_l = p_c$. Now consider offers received by l's local borrowers in period 1. Offers could come from other non-investing banks, with all such offers identical to each other. An offer could also come from the investing bank. Since all period 1 offers leave the borrowers with the same payoff $s(\beta - 1) - \alpha$, entrepreneurs are indifferent amongst outside offers, irrespective of the investment decision of the offering bank. However such

an offer, if accepted, leaves an investing bank with higher rents *ex post*, when compared to an accepted offer made by a non-investing bank as $p_c > 0$. The *ex ante* payment constraint of a non-investing bank is then tighter. Thus, if a non-investing bank finds it feasible to make an offer, so does the investing bank. Hence, without loss of generality, consider an offer from the investing bank.

In equilibrium therefore, $\pi_o^u = 0$, and $1 - \pi_o^u - \pi_o^l = 1$. Its payoff is 0 if $\lambda_{lu}^1 = 1$. By Assumption 1, λ_{lu}^1 is always 1. If l deviates, $\pi_o^u = 0$, and $1 - \pi_o^u - \pi_o^l = 1 - p_c$. Also its payoff is $-c$ if $\lambda_{lu}^{1d} = 1$, and $\mu s[p_c(\frac{\sigma}{\underline{\sigma}} - 1) + (1 - p_c)(\beta - 1)] - \mu\alpha - c$ if $\lambda_{lu}^{1d} = 0$. We have $\lambda_{lu}^{1d} = 1 \Leftrightarrow s(1 - p_c)(\beta - 1) \geq \alpha$.

Clearly, l conforms if $\lambda_{lu}^{1d} = 1$. Therefore, let $\lambda_{lu}^1 = 1$ and $\lambda_{lu}^{1d} = 0$. Then,

$$p_c > 1 - \frac{\alpha}{s(\beta - 1)}$$

Then, l conforms if and only if

$$\mu\alpha + c \geq \mu s[p_c(\frac{\sigma}{\underline{\sigma}} - 1) + (1 - p_c)(\beta - 1)]$$

Now consider the investing bank l'. In equilibrium, $\pi_{l'} = \pi_o^u = 0$, and $1 - \pi_o^u - \pi_o^{l'} = 1 - p_c$. Moreover, its payoff is $-c$ if $\lambda_{l'c}^1 = 1$ and $\mu s(\beta - 1) - \mu\alpha - c$ if $\lambda_{l'c}^1 = 0$. Finally, $\lambda_{l'c}^1 = 1$ if and only if $s(1 - p_c)(\beta - 1) \geq \alpha$.

If l' deviates, $\pi_{l'} = \pi_o^u = 0$, and $1 - \pi_o^u - \pi_o^{l'} = 1$. Its payoff is 0 if $\lambda_{l'c}^{1d} = 1$ and $\mu s(\beta - 1) - \mu\alpha$ if $\lambda_{l'c}^{1d} = 0$. Also, $\lambda_{l'c}^{1d} = 1$ if and only if $s(\beta - 1) \geq \alpha$, which is always true. Since l' always deviates if $\lambda_{l'c}^1 = \lambda_{l'c}^{1d}$, suppose $\lambda_{l'c}^1 = 0$ and $\lambda_{l'c}^{1d} = 1$. We have,

$$p_c > 1 - \frac{\alpha}{s(\beta - 1)}$$

l' invests if and only if

$$\mu\alpha + c \leq \mu s(\beta - 1)$$

Collecting together the results then, a *1*-equilibrium exists if and only if

$$\text{a) } p_c > 1 - \frac{\alpha}{s[(\frac{\sigma}{\underline{\sigma}} - 1) + (\beta - \frac{\sigma}{\underline{\sigma}})]} \text{ and}$$

$$\text{b) } \mu\alpha + c \in [\mu s[(\frac{\sigma}{\underline{\sigma}} - 1) + (1 - p_c)(\beta - \frac{\sigma}{\underline{\sigma}})], \mu s[(\frac{\sigma}{\underline{\sigma}} - 1) + (\beta - \frac{\sigma}{\underline{\sigma}})]]$$

Now consider an arbitrary n-equilibrium, with $2 \leq n < N$. Let l and l' be representative non-investing and investing banks respectively. Consider l's decision to deviate. $\pi_l = 1 - (1 - p_c)^n$. As before, suppose outside offers to its local borrowers come from investing banks, without loss of generality. Then

$$
\begin{aligned}
\pi_o^u &= p_c^{n-1} + {}^{n-1}C_{n-2}p_c^{n-2}(1 - p_c) + \dots + {}^{n-1}C_1 p_c (1 - p_c)^{n-2} \\
&= \sum_{M=1}^{n-1} \{{}^{n-1}C_M p_c^M (1 - p_c)^{n-1-M}\}
\end{aligned}
$$

Similarly,

$$
\begin{aligned}
\pi_o^l &= 1 - \sum_{M=0}^{n-1} \{{}^{n-1}C_M p_c^M (1 - p_c)^{n-1-M}\} \text{ and} \\
1 - \pi_o^u - \pi_o^l &= (1 - p_c)^{n-1}
\end{aligned}
$$

If $\lambda_{lu}^n = 1$, its payoff is 0, while its payoff is $\mu s[\{1 - (1 - p_c)^n\}(\frac{\sigma}{\underline{\sigma}} - 1) + (1 - p_c)^n(\beta - 1)] - \mu\alpha$ if $\lambda_{lu}^n = 0$. We have

$$
\lambda_{lu}^n = 1 \Leftrightarrow s[\{\sum_{M=1}^{n-1} \{{}^{n-1}C_M p_c^M (1 - p_c)^{n-1-M}\}\}(\frac{\sigma}{\underline{\sigma}} - 1) + (1 - p_c)^{n-1}(\beta - 1)] \geq \alpha
$$

On the other hand, if l deviates,

$$
\begin{aligned}
\pi_o^u &= (1 - p_c) \sum_{M=1}^{n-1} \{{}^{n-1}C_M p_c^M (1 - p_c)^{n-1-M}\} \text{ and} \\
1 - \pi_o^u - \pi_o^l &= (1 - p_c)^n
\end{aligned}
$$

If $\lambda_{lu}^{nd} = 1$, its payoff is $-c$, while its payoff is $\mu s[\{1 - (1 - p_c)^n\}(\frac{\sigma}{\underline{\sigma}} - 1) + (1 - p_c)^n(\beta - 1)] - \mu\alpha - c$ if $\lambda_{lu}^{nd} = 0$. We have

$$
\lambda_{lu}^{nd} = 1 \Leftrightarrow s(1 - p_c)[\{\sum_{M=1}^{n-1} \{{}^{n-1}C_M p_c^M (1 - p_c)^{n-1-M}\}\}(\frac{\sigma}{\underline{\sigma}} - 1) + (1 - p_c)^{n-1}(\beta - 1)] \geq \alpha
$$

Since $\lambda_{lu}^n = \lambda_{lu}^{nd}$ implies that l does not deviate, let $\lambda_{lu}^{nd} = 0$ and $\lambda_{lu}^n = 1$. We have

$$p_c \;>\; 1 - \frac{\alpha}{s[\{\displaystyle\sum_{M=1}^{n-1}\{^{n-1}C_M p_c^M (1-p_c)^{n-1-M}\}\}(\frac{\sigma}{\underline{\sigma}}-1)+(1-p_c)^{n-1}(\beta-1)]}$$

$$i.e.,\; p_c \;>\; 1 - \frac{\alpha}{s[(\frac{\sigma}{\underline{\sigma}}-1)+(1-p_c)^{n-1}(\beta-\frac{\sigma}{\underline{\sigma}})]}$$

Then, l conforms if and only if

$$\mu\alpha + c \geq \mu s[\{1-(1-p_c)^n\}(\frac{\sigma}{\underline{\sigma}}-1)+(1-p_c)^n(\beta-1)]$$

Now consider l''s decision to invest. $\pi_l = 1-(1-p_c)^{n-1}$. We have

$$\pi_o^u \;=\; (1-p_c)\sum_{M=1}^{n-2}\{^{n-2}C_M p_c^M (1-p_c)^{n-2-M}\} \text{ and}$$

$$1-\pi_o^u-\pi_o^l \;=\; (1-p_c)^{n-1}$$

If $\lambda_{l'c}^n = 1$, its payoff is $-c$, while its payoff is $\mu s[\{1-(1-p_c)^{n-1}\}(\frac{\sigma}{\underline{\sigma}}-1)+(1-p_c)^{n-1}(\beta-1)]-\mu\alpha-c$ if $\lambda_{l'c}^n = 0$. We have

$$\lambda_{l'c}^n = 1 \Leftrightarrow s(1-p_c)[\{\sum_{M=1}^{n-2}\{^{n-2}C_M p_c^M (1-p_c)^{n-2-M}\}\}(\frac{\sigma}{\underline{\sigma}}-1)+(1-p_c)^{n-2}(\beta-1)] \geq \alpha$$

If l' deviates,

$$\pi_o^u \;=\; \sum_{M=1}^{n-2}\{^{n-2}C_M p_c^M (1-p_c)^{n-2-M}\} \text{ and}$$

$$1-\pi_o^u-\pi_o^l \;=\; (1-p_c)^{n-2}$$

If $\lambda_{l'c}^{nd} = 1$, its payoff is 0, while its payoff is $\mu s[\{1-(1-p_c)^{n-1}\}(\frac{\sigma}{\underline{\sigma}}-1)+(1-p_c)^{n-1}(\beta-1)]-\mu\alpha$ if $\lambda_{l'c}^{nd} = 0$. We have

$$\lambda_{l'c}^{nd} = 1 \Leftrightarrow s[\{\sum_{M=1}^{n-2}\{^{n-2}C_M p_c^M (1-p_c)^{n-2-M}\}\}(\frac{\sigma}{\underline{\sigma}}-1)+(1-p_c)^{n-2}(\beta-1)] \geq \alpha$$

Since $\lambda_{l'c}^n = \lambda_{l'c}^{nd}$ implies that l does not deviate, let $\lambda_{l'c}^{nd} = 1$ and $\lambda_{l'c}^n = 0$. We have

$$p_c > 1 - \frac{\alpha}{s[(\frac{\sigma}{\underline{\sigma}}-1)+(1-p_c)^{n-2}(\beta-\frac{\sigma}{\underline{\sigma}})]}$$

Then, l' invests if and only if

$$\mu\alpha + c \le \mu s[\{1 - (1 - p_c)^{n-1}\}(\frac{\sigma}{\underline{\sigma}} - 1) + (1 - p_c)^{n-1}(\beta - 1)]$$

Therefore, an n-equilibrium exists if and only if

a) $p_c > 1 - \dfrac{\alpha}{s[(\frac{\sigma}{\underline{\sigma}} - 1) + (1 - p_c)^{n-2}(\beta - \frac{\sigma}{\underline{\sigma}})]}$ and

b) $\mu\alpha + c \in [\mu s[(\frac{\sigma}{\underline{\sigma}} - 1) + (1 - p_c)^{n}(\beta - \frac{\sigma}{\underline{\sigma}})], \mu s[(\frac{\sigma}{\underline{\sigma}} - 1) + (1 - p_c)^{n-1}(\beta - \frac{\sigma}{\underline{\sigma}})]]$

We note that $s[(\frac{\sigma}{\underline{\sigma}} - 1) + (1 - p_c)^{m}(\beta - \frac{\sigma}{\underline{\sigma}})]$ and therefore $1 - \frac{\alpha}{s[(\frac{\sigma}{\underline{\sigma}}-1)+(1-p_c)^{m}(\beta-\frac{\sigma}{\underline{\sigma}})]}$ are decreasing functions of m, where m is a positive integer.

We finally turn to the C equilibrium. Consider an arbitrary bank l. $\pi_l = 1 - (1 - p_c)^{N-1}$. In equilibrium,

$$\pi_o^u = (1 - p_c) \sum_{M=1}^{N-2} \{^{N-2}C_M p_c^M (1 - p_c)^{N-2-M}\} \text{ and}$$

$$1 - \pi_o^u - \pi_o^l = (1 - p_c)^{N-1}$$

Therefore, its payoff is $-c$ if $\lambda_{lc}^N = 1$, and, $\mu s[\{1 - (1 - p_c)^{N-1}\}(\frac{\sigma}{\underline{\sigma}} - 1) + (1 - p_c)^{N-1}(\beta - 1)] - \mu\alpha - c$ if $\lambda_{lc}^N = 0$. We have

$$\lambda_{lc}^N = 1 \Leftrightarrow s(1 - p_c)[\{\sum_{M=1}^{N-2} \{^{N-2}C_M p_c^M (1 - p_c)^{N-2-M}\}\}(\frac{\sigma}{\underline{\sigma}} - 1) + (1 - p_c)^{N-2}(\beta - 1)] \ge \alpha$$

If l deviates,

$$\pi_o^u = \sum_{M=1}^{N-2} \{^{N-2}C_M p_c^M (1 - p_c)^{N-2-M}\} \text{ and}$$

$$1 - \pi_o^u - \pi_o^l = (1 - p_c)^{N-2}$$

Also its payoff is 0 if $\lambda_{lc}^{Nd} = 1$, and $\mu s[\{1 - (1 - p_c)^{N-1}\}(\frac{\sigma}{\underline{\sigma}} - 1) + (1 - p_c)^{N-1}(\beta - 1)] - \mu\alpha$ if $\lambda_{lc}^{Nd} = 0$. We have

$$\lambda_{lc}^{Nd} = 1 \Leftrightarrow s[\{\sum_{M=1}^{N-2} \{^{N-2}C_M p_c^M (1 - p_c)^{N-2-M}\}\}(\frac{\sigma}{\underline{\sigma}} - 1) + (1 - p_c)^{N-2}(\beta - 1)] \ge \alpha$$

It is easy to see then that a C equilibrium exists if and only if

$$a)\ p_c\ >\ 1 - \frac{\alpha}{s[(\frac{\sigma}{\underline{\sigma}} - 1) + (1 - p_c)^{N-2}(\beta - \frac{\sigma}{\underline{\sigma}})]}\ \text{and}$$

$$b)\ \mu\alpha + c\ \leq\ \mu s[(\frac{\sigma}{\underline{\sigma}} - 1) + (1 - p_c)^{N-1}(\beta - \frac{\sigma}{\underline{\sigma}})]$$

Collecting together the results, we see that a pure strategy equilibrium exists always. ∎

Proof of Corollary 1. Consider an n-equilibrium, $0 < n < N$. For an arbitrary non-investing bank l, $\lambda_{lu}^n = 1$, while for an arbitrary investing bank l', $\lambda_{l'c}^n = 0$. Therefore l's payoff is 0, while l''s payoff is $\mu s[\{1 - (1 - p_c)^{n-1}\}(\frac{\sigma}{\underline{\sigma}} - 1) + (1 - p_c)^{n-1}(\beta - 1)] - \mu\alpha - c \geq 0$. ∎

Proof of Proposition 3. From Proposition 2, a C equilibrium exists if and only if

$$a)\ p_c\ >\ 1 - \frac{\alpha}{s[(\frac{\sigma}{\underline{\sigma}} - 1) + (1 - p_c)^{N-2}(\beta - \frac{\sigma}{\underline{\sigma}})]}\ \text{and}$$

$$b)\ \mu\alpha + c\ \leq\ \mu s[(\frac{\sigma}{\underline{\sigma}} - 1) + (1 - p_c)^{N-1}(\beta - \frac{\sigma}{\underline{\sigma}})]$$

(a) is equivalent to $\mu s[(\frac{\sigma}{\underline{\sigma}} - 1) + (1 - p_c)^{N-1}(\beta - \frac{\sigma}{\underline{\sigma}})] < \mu\alpha + \mu s p_c(\frac{\sigma}{\underline{\sigma}} - 1)$, while (b) is equivalent to $\mu s[(\frac{\sigma}{\underline{\sigma}} - 1) + (1 - p_c)^{N-1}(\beta - \frac{\sigma}{\underline{\sigma}})] \geq \mu\alpha + c$.

Consider a U equilibrium. From Proposition 2, a U equilibrium exists if and only if

$$a)\ p_c\ \leq\ 1 - \frac{\alpha}{s(\beta - 1)}\ \text{or}$$

$$b)\ (i)\ p_c\ >\ 1 - \frac{\alpha}{s(\beta - 1)}\ \text{and}$$

$$(ii)\ \mu\alpha + c\ \geq\ \mu s(\beta - 1)$$

If $p_c > 1 - \frac{\alpha}{s(\beta-1)}$, a U equilibrium exists if and only if $\mu s(\beta - 1) \leq \mu\alpha + c$. Since $s(\beta - 1) > s[(\frac{\sigma}{\underline{\sigma}} - 1) + (1 - p_c)^{N-1}(\beta - \frac{\sigma}{\underline{\sigma}})]$, we focus on $p_c \leq 1 - \frac{\alpha}{s(\beta-1)}$, without loss of generality. Now, $p_c \leq 1 - \frac{\alpha}{s(\beta-1)}$ is equivalent to $s(1 - p_c)(\beta - 1) \geq \alpha$.

Therefore, multiple symmetric equilibria exist if and only if

$$a)\ s[(\frac{\sigma}{\underline{\sigma}} - 1) + (1 - p_c)^{N-1}(\beta - \frac{\sigma}{\underline{\sigma}})] - \alpha\ \in\ [\frac{c}{\mu}, s p_c(\frac{\sigma}{\underline{\sigma}} - 1)]\ \text{and}$$

$$b)\ s(1 - p_c)(\beta - 1)\ \geq\ \alpha$$

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■

Proof of Proposition 4. From Proposition 2, in a C equilibrium, each bank's payoff is given by

$$\mu s[(\frac{\sigma}{\underline{\sigma}} - 1) + (1 - p_c)^{N-1}(\beta - \frac{\sigma}{\underline{\sigma}})] - \mu\alpha - c \geq 0$$

while the payoff of each bank in a U equilibrium is 0. Using (19), total welfare in a U equilibrium is given by $M[s(\beta - 1) - \alpha]$. In a C equilibrium, total welfare is, using (21)

$$
\begin{aligned}
&N[\mu s\{(\frac{\sigma}{\underline{\sigma}} - 1) + (1 - p_c)^{N-1}(\beta - \frac{\sigma}{\underline{\sigma}})\} - \mu\alpha - c] + M[s\{1 - (1 - p_c)^{N-1}\}(\beta - \frac{\sigma}{\underline{\sigma}})] \\
= \ &M[s(\beta - 1) - \alpha] - Nc
\end{aligned}
$$

Therefore, welfare and borrower payoffs are lower, while bank payoffs are higher, in a C equilibrium when compared to a U equilibrium.

We now turn to *ex post* competition. Consider a borrower with a H project from bank l's local market. From Lemma 1, the probability she receives $N - 1$ offers in period 2 is $\prod_{k\neq l} p_k$, while the probability she receives exactly M offers, $0 \leq M < N - 1$ is

$$\sum_{k_1,..k_M\neq l} \prod_{\substack{k_n \\ n=1,..,M}} p_{k_n} \prod_{m\neq k_n,l} (1 - p_m)$$

Therefore, her expected number of offers in period 2, conditional on her project being H is 0 in a U equilibrium, while in a C equilibrium it is

$$\sum_{M=0}^{N-1} M^{N-1}C_M p_c^M (1 - p_c)^{N-1-M} = \sum_{M=1}^{N-2} M^{N-1}C_M p_c^M (1 - p_c)^{N-1-M} + (N-1)p_c^{N-1}$$

$$= (N-1)p_c[\sum_{K=0}^{N-3}\{^{N-2}C_K p_c^K (1 - p_c)^{N-2-K}\}] + (N-1)p_c^{N-1}$$

$$= (N-1)p_c(1 - p_c^{N-2}) + (N-1)p_c^{N-1} = (N-1)p_c > 0$$

Therefore, a C equilibrium has higher *ex post* competition than a U equilibrium. ■

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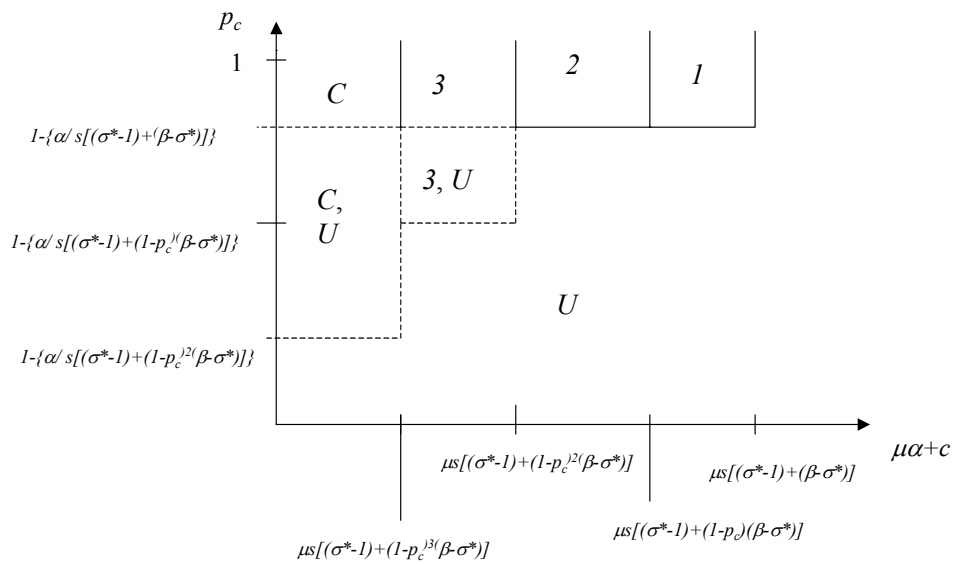
Equilibrium existence: $N = 3$
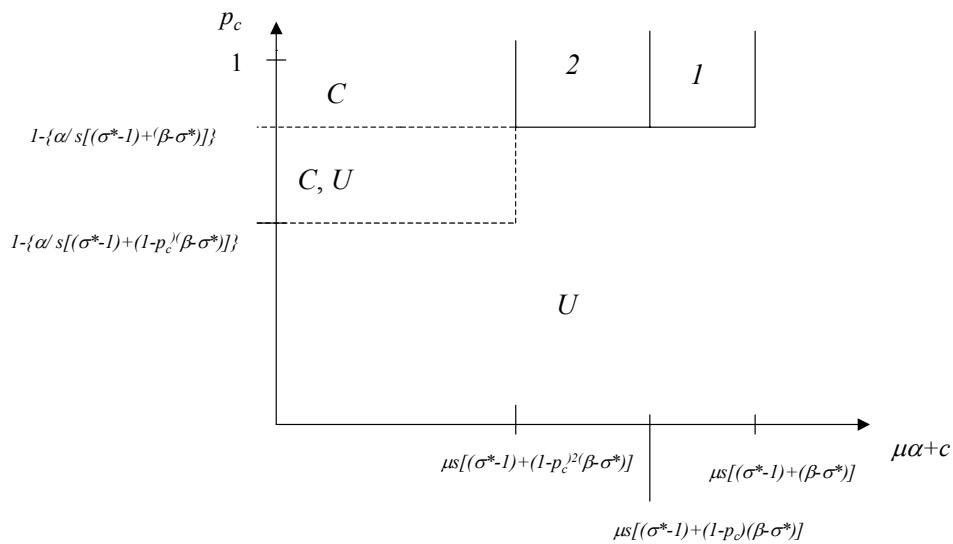
The numbers and letters in the graph refer to the type of equilibrium. For example, (C, U) means that in the relevant zone, both C and U are equilibria.

Figure 1:

Equilibrium existence: $N = 4$

The numbers and letters in the graph refer to the type of equilibrium. For example, (3, U) means that in the relevant zone, both $n=3$ and U are equilibria.

Figure 2: