Information Acquisition and Market Power in Credit Markets

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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 analysed. 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 characterised by strategic complementarities: hence, multiple equilibria may exist.

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Credit risk is an important 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 invest significant resources to collect information. Most institutions have large loan approval and underwriting departments which evaluate applications through physical verification, use of statistical criteria and credit risk analysis software etc. Specialised brokers such as credit rating agencies also constitute a source of information about past behaviour 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 analyses costly information acquisition in the banking industry. There are substantial costs of operating loan approval departments, and information brokers charge fees to issue reports. Obtaining information through lending also imposes screening costs. As the theory of customer relationships argues, the incentive to acquire information is therefore predicated on the ability to recover such costs through future rent appropriation.[1] Rents can arise endogenously through the process of lending. Lenders are usually not fully cognisant of all relevant characteristics of a new borrower.[2] Relationships between banks and borrowers permit the collection of proprietary information, which can mitigate screening costs through the use of future 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.[3]

If loan products and the cost of funds are common across banks, the above reasoning leads to two conclusions. First, competition can dampen the incentive to acquire information. Credit market competition can erode the ability to exercise market power and thereby influence the leakage

[1] See Greenbaum, Kanatas and Venezia (1989), Sharpe (1990), Petersen and Rajan (1995), Berger and Mester (2003) etc.

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

[3] The theory has received support from the recent empirical literature on loan pricing. D'Auria, Foglia and Reedtz (1999) and Kerr (2002) show that inside banks offer credit at lower interest rates due to informational superiority.

of proprietary information.[4] Consequently, financial market deregulation can reduce information acquisition.[5] However, available evidence suggests that while financial industries have seen a series of competition enhancing technological, institutional and regulatory changes over the last two decades, there has not been a concomitant decline in the information gathering activity of banks.[6]

Second, banks will never have an incentive to gather costly information on firms seeking project refinancing. Suppose banks can distinguish between firms seeking funds for new projects and those seeking funds for continuing projects. For the latter, the quality of information possessed by previous lenders must at least meet that of outside banks. Thus, if it is profitable for an outside bank to offer a loan, it must be profitable for a prior lender to do so as well. Competition then exhausts all rents accruing to an outside lender, 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]

This paper provides a resolution by arguing that information acquisition has strategic dimensions. Information collection by any bank reduces future informational asymmetries and thereby competitors' market power. In turn the erosion of future market power inhibits their current competitive ability. If banks have asymmetric ability to acquire information in the future, investment in information acquisition acts as a commitment device which augments market power. Banks can then exploit their asymmetric ability to gather private information to protect market power by

[4] Berger and Mester (2003) argue that deregulation in credit markets has been associated with an improved ability to evaluate creditworthiness, thereby reducing incumbent lenders' informational advantages.

[5] See Allen *et al* (2001). It has also been argued that some kind of oligopolistic industry structure may be required to preserve appropriate incentives: see Anand and Galetovic (2000).

[6] 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 (2002). See also 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 (2002). 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 fully remove the adverse selection problem.

strategically investing in information acquisition. The argument lays a foundation for justifying acquisition of information on firms seeking project refinancing. The theory of information acquisition offered in this paper also shows, in contrast to previous theoretical literature which has suggested that competition will force a decline in information acquisition, that increased competition or the absence of an oligopolistic market structure need not diminish information acquisition.[8]

In our stylized model, we consider a static economy in which projects last for two periods. Projects and borrowers are identical in period 1. Some projects are unproductive in the second period, while the period 2 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. Investment in information acquisition at the beginning of period 1 enhances signal quality. Finally, banks are informationally heterogeneous: each bank has superior observational ability for some group of borrowers relative to all other banks.[9]

We characterise pure strategy subgame perfect equilibria of the model. No bank invests if the cost of investment is high, or if investment is relatively unproductive, while all banks invest if the cost is low and investment is sufficiently productive. Symmetric equilibria are not guaranteed to exist. Asymmetric equilibria can exist for intermediate costs of information collection. Investing banks obtain monopoly rents in period 1, and have higher payoffs than non-investing banks. Strategic commitment by the former group precludes investment by the latter.[10]

To understand the intuition, let any bank j have observational superiority for some group of

[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 market power. See also Hauswald and Marquez (2006).

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

borrowers called its *local* borrowers. By investing, j reduces the information gap between itself and its competitors, and consequently the rent a competing bank k can extract from a borrower. If k competes for j's local borrowers in period 1, it has to break even over its lifetime. In this setting, j's investment forces k to raise period 1 interest rates on the 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.

There may also be strategic complementarities in information acquisition. Investment by j tightens *ex ante* payment constraints for all banks $l \neq j$ when they are bidding for j's local borrowers in period 1. However, it also tightens other banks' $l \neq j, k$ constraints when bidding for bank k's borrowers in period 1. This spillover can lead to 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.

Comparing symmetric equilibria, we show that welfare is lower, banks are better off and borrowers are worse off if banks invest than if they do not. Since we only consider the commitment value of information acquisition, investment merely serves to augment market power of banks, and acts as a dead-weight loss. Since 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. In Boadway and Sato's (1999) analysis of the role of government intervention, information collected by one lender may dissipate through the contracting process; thus, competition can diminish incentives to acquire information. The differences with this article stem from the different role of information acquisition which in our paper acts as a device to augment market power by changing the nature

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

of intertemporal payment constraints. The focus on intertemporal trade-offs also differentiates this paper from Hauswald and Marquez (2006), who study allocation distortions arising from increased competition. They show that intermediate competition reduces resources allocated to information acquisition while excess competition leads to banks specialising 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 the 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) study how such incentive problems may be mitigated. Rajan (1992) shows that firms may borrow from multiple banks to induce competition amongst banks and 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 next section constructs the model. Section 2 analyses the model with only two banks, to develop the intuition. Section 3 presents a preliminary analysis of the general model, while Section 4 characterises equilibrium. Section 5 focusses on symmetric equilibria, and also studies strategic complementarities. Section 6 concludes, and the Appendix contains proofs.

1 Model

The two-period economy comprises of *entrepreneurs/borrowers* and *banks*. Entrepreneurs have a project requiring 1 unit of funds every period of operation. Projects are of *high (H)* (with probability s) or *low (L) quality*. All projects yield a cash flow y in period 1, with project quality realised at the end of the period. Borrowers have no resources and savings are not allowed. A project can be operated in period 2 only if it receives funding in period 1. In period 2, H projects may *succeed* (the cash flow is $Y > y$) or *fail* (the output is 0), while L projects fail.

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

The probability of success of a H project in period 2 depends on borrower *type* (realised at the end of period 1). The type space is an interval $[\underline{i}, \overline{i}]$ 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 $\beta = \frac{\underline{\beta}+\overline{\beta}}{2}$.

There are $N \geq 2$ banks, each with a local market. There is a continuum of borrowers of total measure M. All borrowers 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 $\frac{M}{N} = \mu$. Banks engage in interest rate competition for 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. If a borrower does not belong to a particular bank's local market, she will be referred to as a *foreign* borrower for that bank, and the bank will referred to as a foreign bank for that borrower.

We will use the following terminology. Suppose a bank B lends to a borrower E in period 1. Then at the end of period 1, B is the *inside* bank for E, while other banks are *outside* banks. Similarly, E is an inside borrower for B, while borrowers to whom B did not lend in period 1 are outside borrowers. A bank can obtain information about project quality and borrower type through the process of lending. If B lends to E in period 1, it perfectly observes her type and the quality of her project.[15] If B does not lend to E in period 1, it receives a signal about her 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. However, if E is from B's local market, the signal contains information about her project quality as well as her type.

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

[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.

[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.

quality, the signal always yields L with probability 1.[16] 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.[17]

p is therefore a measure of signal quality, or the accuracy of information. We assume that a bank can control its signal quality through investment in information acquisition: at the beginning of period 1 each bank has to choose whether to invest in an *information acquisition technology*. 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 $p_u = 0$. Investment decisions are publicly observable.[18]

Banks have an unlimited supply of funds at 0 opportunity cost every period. We allow only single-period contracts. Let $y \in (0,1)$, with $1-y=\alpha$.[19] If a borrower is discovered at the end of period 1 to possess an L project, she will not be offered a loan by her inside 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.

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

We study pure strategy subgame perfect equilibria of the model above. Although there are two periods, a number of events occur within each period. Figure 1 lays out the exact timing of events

[16] The assumption that only high quality projects yield the signal H is made for expositional purposes. Qualitative results would be largely unaffected if low quality projects could also yield the H signal, as long as high quality projects were more likely to yield the H signal than low quality projects.

[17] The assumption that borrowers are identical at the beginning of period 1 and signals are only received at the beginning of period 2 is for simplicity. Our results hold as long as there is sufficient uncertainty about borrowers at the beginning of period 1.

[18] 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 analyse economic environments, industry trends and market conditions on an ongoing basis in order to better scrutinise loan applications and evaluate creditworthiness.

[19] All projects are therefore assumed to lose money in the initial phase. The assumption is motivated by the stylised 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.

within each period.[20]

[Figure 1 about here]

2 The model with two banks

To clarify the intuition, we first briefly analyse the model when $N = 2$. Some of the arguments are used in the next section as well, where the discussion is extended to the general model.

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. The results derived here are used to investigate equilibrium in the economy.

Let j and k be the two banks. Consider a borrower E and suppose j did not lend to E in period 1. Suppose j receives signal L from E in period 2. If j offers E a period 2 loan, it must break even. Let j offer a loan at the break even interest factor r_l. If E received a loan in period 1, the lending bank k knows the quality of her project. k can therefore undercut j's offer and yet make a positive net payoff. However, k will not lend to E in period 2 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 otherwise. Adverse selection therefore implies that j will not offer E a loan.

Borrowers who received a loan in period 1, and have L projects, as well as those who did not receive a loan in period 1 will not receive any loan offers in period 2. 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 inside bank. The analysis above establishes the following result:

[20] The assumption that foreign contracts are offered before local borrowers are offered contracts is meant to reflect an incumbency advantage, which allows a bank the option to offer terms preventing a borrower from switching to the competition.

Claim 1 *Consider a borrower receiving a loan in period 1 with a H project. If all outside banks receive the signal L from her, she does not get an outside contract offer in period 2.*

We now derive the expected period 2 payoffs. Let $p_l, l = j, k$ be the signal strength of bank l and assume a borrower with multiple offers accepts the contract from her inside bank in the event of indifference and also that a borrower will take a loan if her net expected payoff from doing so is 0. 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. E will receive an outside contract offer in period 2 if the outside bank receives signal H. Let r be the interest factor on such an offer. If the outside offer is received from j, the interest factor equals $\frac{1}{\sigma_i}$. Otherwise, let r satisfy feasibility ($r \leq Y$) and consistency ($r \geq \frac{1}{\sigma_i}$).

Suppose E gets a loan from j in period 1. Since j has superior information, if k offers E a loan, j can match it. E receives a period 2 outside offer with probability p_k. If E does not receive an outside offer in period 2, j extracts all rents from her. The respective payoffs of E and j are, using Assumption 1:

$$P^b_{2,i}(p_j, p_k) = p_k(\beta_i - \sigma_i \frac{1}{\underline{\sigma}}) \quad (1)$$

$$P^j_{2,i}(p_j, p_k) = p_k(\sigma_i \frac{1}{\underline{\sigma}} - 1) + (1 - p_k)(\beta_i - 1) \quad (2)$$

The expressions use the fact that r must be $\frac{1}{\underline{\sigma}}$. Since information is not available *ex ante*, either a bank offers a period 1 contract to all its local borrowers, or none of them. Suppose a bank offers a period 1 contract to its local borrowers. Rational expectations imply that r is $\frac{1}{\underline{\sigma}}$.

Now suppose E gets a period 1 loan from k. If she does not receive an outside offer in period 2, k extracts all rents. Otherwise, E gets the entire net output. The payoffs of E and k are:

$$P^b_{2,i}(p_j, p_k) = p_j(\beta_i - 1) \quad (3)$$

$$P^k_{2,i}(p_j, p_k) = (1 - p_j)(\beta_i - 1) \quad (4)$$

We now analyse the first period. Consider a borrower E in j's local market. First suppose she receives an offer from a foreign bank in period 1. Suppose she receives an 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. j and k are *ex ante* symmetrically informed about E, while j has an *ex post* observational advantage. Therefore, k has to break even in expected terms from the contract it offers E.

Let k offer E a period 1 loan at interest factor ρ_{0jk}. For convenience, we drop the letter subscripts referring to banks j and k. E's (k's) lifetime payoff from this contract is the period 1 payoff $y - \rho_0$ ($\rho_0 - 1$) plus the expected period 2 payoff given by (3) (given by (4)).

Now suppose j offers E a loan contract with interest factor ρ. E's (j's) lifetime payoff from this contract is the period 1 payoff $y - \rho$ ($\rho - 1$) plus the expected period 2 payoff given by (1) (given by (2)).

Suppose k (the foreign bank) offers E a 0 profit contract in period 1 whenever it is feasible, *i.e.*, if j's *ex post* observational advantage does not prevent k from offering a contract *ex ante*. Since j is forced to match this payoff, it is immediate that j's payoff is

$$u(p_j, p_k) = 0 \tag{5}$$

We now analyse the first period when a bank j's local borrowers have no offers from the foreign bank. Suppose j offers a local borrower E a loan contract in period 1 with interest factor $\rho = y$. Using (1) and (2), the respective lifetime payoffs of E and j are,

$$v(p_j, p_k) = sp_k(\beta - \sigma\frac{1}{\underline{\sigma}}) \tag{6}$$

$$u(p_j, p_k) = s\{p_k(\sigma\frac{1}{\underline{\sigma}} - 1) + (1 - p_k)(\beta - 1)\} - \alpha \tag{7}$$

Define the indicator variable λ_l for any bank l, which takes the value 1 if local borrowers of bank l receive an offer from the foreign bank in period 1, and 0 otherwise. Clearly, either all borrowers receive such an offer, or no borrower does. The following result gives λ_l as a function of p_j and p_k.

Claim 2 *Suppose a bank offer loans to all its local borrowers in period 1. Given p_j and p_k, $\lambda_l = 1 \Leftrightarrow s(1 - p_l)(\beta - 1) \geq \alpha$.*

Proof. See the Appendix. ■

Foreign banks can only make a period 1 offer if the break even interest factor on such an offer is less than the first period cash flow. We see that whether $\lambda_l, l = j, k$ equals 1 or 0 is determined entirely by p_j and p_k. We also see that if $y \geq 1$, $\alpha \leq 0$, and hence λ_l is always 1, since $\beta > 1$. We use this result below to show that if the first period cash flow is sufficiently small, *i.e.*, if α is sufficiently llarge, a local bank can use investment in information acquisition to reduce the competition it faces.

2.2 Equilibrium

Equilibrium can now be defined as a 2-vector (p_j^*, p_k^*), with $p_l^* \in \{0, p_c\}$. In a symmetric equilibrium, either both banks invest in information collection, or neither does. We call the former the C equilibrium, and the latter the U equilibrium. There are also two (equivalent) 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.

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. It would deviate if it could force competitors to stop offering contracts to its local borrowers in period 1. By deviating, the bank raises its information collection *ex post.* It thereby reduces the rents its competitor can earn *ex post* from its local borrowers. Hence the competitor has to charge a higher interest *ex ante* in order to break even. 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. But if p_c is high, deviation causes the *ex ante* payment constraint to bind, and the bank 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.

A similar argument shows that a C equilibrium exists if and only if p_c is high, provided the cost of investment is sufficiently low. Moreover, asymmetric equilibria exist for this parameter range if the cost of investment is in the intermediate range. In an asymmetric equilibrium, the investing bank makes monopoly rents in period 1, as the competitor cannot offer its local 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 in period

2. The other bank makes 0 profits however. Switching to an investment strategy is not profitable because c is sufficiently high and because period 2 rents on its borrowers are limited given that the other bank is investing.

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 outside information is typically less revealing than inside information. Local banks have access to private information *ex post* which allows them to credibly use information acquisition as a strategy to protect local markets. The following result completely characterises pure strategy equilibria.

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

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

Proof. See the Appendix. ■

Thus, information acquisition can arise in credit markets as a strategic device to augment market power. We now move to the analysis of the general model, with $N \geq 3$, to study the impact of increased competition on the incentive to acquire information. 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, leading to the possibility of multiple equilibria. Information acquisition, by generating rents, can therefore lead to a loss in social welfare, as discussed in Section 5.

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.

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 in period 2 if all outside 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 an outside loan in period 2 by a bank which does not know her type. Such a bank is termed an *uninformed bank*. 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. As before, it is easy to see that $r = \frac{1}{\underline{\sigma}}$. Now 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. Either E received a loan in 1 from l, or she received a loan from some foreign 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 a foreign 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. What are the probabilities with which she receives these different offers?

Let the signal quality of any bank j be p_j, and 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 a foreign bank j, the probability she receives a period 2 outside offer from l is $\pi_o^l = p_l$, while the probability she receives at least one outside offer in period 2 from an uninformed bank without receiving an offer from l is $\pi_o^u = (1 - p_l)[1 - \prod_{k \neq j,l}(1 - p_k)]$.

We now derive period 2 payoffs 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 inside bank from the relationship? Assume she accepts the contract from her inside bank in the event of indifference. Let $\overrightarrow{p}$ be the vector $(p_1, .., p_j, .., p_N)$.

First suppose E gets a loan from l (her local bank) in period 1. Any outside offer she receives in period 2 is from an uninformed bank at interest factor r. The probability she obtains a period 2 outside offer is π_l, from above. Since l has superior information on E, the respective payoffs are

$$P^b_{2,i}(\overrightarrow{p}) = \pi_l(\beta_i - \sigma_i \frac{1}{\underline{\sigma}}) \tag{8}$$

$$P^l_{2,i}(\overrightarrow{p}) = \pi_l(\sigma_i \frac{1}{\underline{\sigma}} - 1) + (1 - \pi_l)(\beta_i - 1) \tag{9}$$

Now suppose she receives a period 1 loan from a foreign bank j. With probability $1 - \pi^u_o - \pi^l_o$, she does not receive an outside offer in period 2, in which case j extracts all rents from her. Suppose she receives an outside offer from l (with probability π^l_o). 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, E gets the entire net output from the project. Finally, suppose she receives outside offers only from uninformed banks (the probability of which is π^u_o). 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

$$P^b_{2,i}(\overrightarrow{p}) = \pi^l_o(\beta_i - 1) + \pi^u_o(\beta_i - \sigma_i \frac{1}{\underline{\sigma}}) \tag{10}$$

$$P^j_{2,i}(\overrightarrow{p}) = \pi^u_o(\sigma_i \frac{1}{\underline{\sigma}} - 1) + (1 - \pi^u_o - \pi^l_o)(\beta_i - 1) \tag{11}$$

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 inside bank can then extract monopoly rents. Even if outside banks do offer her contracts in period 2, some rents may accrue to her inside 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 from a foreign bank j (where her local bank is 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 analyse the game in the first period. Suppose E receives at least one foreign contract offer, and let her best foreign offer (from some bank B) give her a payoff v_0. B has to break even in expected terms from the contract it offers E. 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 2.1. Therefore, if E receives at least one foreign contract offer in period 1, her payoff and her local bank's payoff from her are respectively, from (8) and (9)

$$v_0(\overrightarrow{p}) = s(\beta - 1) - \alpha \tag{12}$$

$$u(\overrightarrow{p}) = 0 \tag{13}$$

On the other hand, suppose a bank's local borrowers have no foreign 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 (8) and (9)

$$v(\overrightarrow{p}) = s\pi_l(\beta - \sigma\frac{1}{\underline{\sigma}}) \tag{14}$$

$$u(\overrightarrow{p}) = s\{\pi_l(\sigma\frac{1}{\underline{\sigma}} - 1) + (1 - \pi_l)(\beta - 1)\} - \alpha \tag{15}$$

If the borrower has a H project, her lifetime net 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 her 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, if borrowers from a local market receive foreign contracts in period 1, all such borrowers have to receive the same offers. If some bank's local market borrowers do not receive foreign 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 the other hand, they may receive foreign 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 local borrowers of bank j receive at least one foreign loan offer in period 1, and 0 otherwise. Since information is not available *ex ante*, either all borrowers receive such an offer, or no borrower does and either the local borrowers of a bank will receive period 1 loan offers from all foreign banks, or they will not receive any offers at all. The following result gives λ_j as a function of $\overrightarrow{p}$.

Claim 3 *Suppose a bank offer loans to all its local borrowers in period 1. Given* $\overrightarrow{p}$*,* $\lambda_j = 1 \Leftrightarrow s\{\pi_o^u(\frac{\sigma}{\underline{\sigma}} - 1) + (1 - \pi_o^u - \pi_o^l)(\beta - 1)\} \geq \alpha$*.*

Proof. See the Appendix. ■

Feasibility implies that the interest factor that allows a foreign 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 $\overrightarrow{p}$. 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 $\overline{\sigma} > \underline{\sigma}$. This result is used below to demonstrate that a local bank can use investment in information acquisition to reduce the competition it faces in the first period, provided the *ex ante* payment constraint for a foreign bank is sufficiently tight.

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.

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

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

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

Proof. See the Appendix. ■

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

[Figure 2 about here]

[Figure 3 about here]

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 the Appendix. ■

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 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 local borrowers are limited given the presence of some investing banks.

Similar to the 2-bank case explored earlier, information acquisition can help augment market power by limiting competition in the local market. However, with more than two banks, the information acquisition game is characterised by strategic complementarities and can have multiple equilibria, as the next section shows. There, we also explore whether the incentive to acquire information can survive increased competition.

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 competing 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 competing 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*

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

Proof. See the Appendix. ■

The results derived above show that different outcomes may occur in the information acquisition game, depending on parameter values. It is possible that no bank collects information. It is also possible that some or all banks do. Multiple equilibria may also coexist. In particular, we see that information acquisition incentives can be preserved irrespective of the degree of competition. To see that most directly, suppose parameters satisfy the following restrictions: (a) $p_c > 1 - \frac{\alpha}{s(\beta-1)}$, and (b) $c < \mu[s(\frac{\sigma}{\underline{\sigma}}-1)-\alpha]$, which together imply that the unique equilibrium is for all banks to acquire information. We also see that the conditions above are independent of N, the number of banks. Consequently, if the degree of competition is measured by the number of banks present, the incentives to acquire information may be preserved regardless of the extent of such competition. At the same time, information acquisition itself changes the nature of competition by affecting a local bank's ability to extract rents from immature borrowers. Using the number of banks as the sole proxy for the degree of competition therefore may present an incomplete picture.

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 use 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. Bank payoffs are are higher in a C equilibrium than in a

U equilibrium. 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 involves 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 the Appendix. ■

In the model, information acquisition generates no value (for example, by improving *ex ante* risk categorisation, as in Banerjee (2005)) and is used purely as a commitment device to augment market power. The inefficiency stems from the presence of local market power and the generation of inside information. Policies relaxing financial institutions' product-line and geographic constraints, by reducing incumbency advantages in local markets, can therefore be beneficial, as can policies encouraging dispersal of lending among multiple parties, such as through syndication.

6 Conclusions

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 in credit markets. 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. Investment in period 1 reduces the future rents that can possibly accrue to a competitor, lowering the level of competition faced by the investing bank in period 1. If the reduction in competition is sufficiently large, banks may obtain monopoly rents. Thus, information acquisition acts as a strategic device to gain market power. 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. The theory shows why banks may engage in the costly acquisition of information on firms seeking project refinancing and also indicates that information acquisition incentives may be undiminished in the face of increased competition. The analysis also shows that multiple equilibria may exist in the information acquisition game if there are at least three banks and that increased competition for continuing projects may actually signal higher market power for banks.

Although the discussion has been framed with reference to credit markets, the arguments extend to more general contexts. If privileged information arises within relationships and vendors are informationally heterogeneous, investment in information acquisition limits asymmetries of information. 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.

7 Appendix

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

$$\begin{aligned}(\rho_{0l}(p_j, p_k) - 1) + s(1-p_l)(\beta - 1) &= 0 \\ \text{or, } 1 - s(1-p_l)(\beta - 1) &= \rho_{0l}(p_j, p_k) \\ \text{By feasibility, } s(1-p_l)(\beta - 1) &\geq \alpha\end{aligned}$$

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 foreign bank to break even, and makes borrowers indifferent between this and their local bank's offer. ∎

Proof of Proposition 1. First of all, we note that since $s(\underline{\beta}-1)-\alpha>0$, $\beta>\frac{\sigma}{\underline{\sigma}}$. 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. Define also λ_l^u (λ_l^{ud}) as the value of the indicator variable for bank l, $l=j,k$ in a U equilibrium, given that bank l conforms (deviates). λ_l^c and λ_l^{cd} are defined similarly.

We now proceed with the analysis of equilibrium. In the derivations, we repeatedly use equations (5) and (7). We first determine the conditions under asymmetric equilibria exist.

I - Asymmetric equilibrium: Since the banks are symmetric, whenever we have an asymmetric equilibrium with j investing and k not investing, we shall have another asymmetric equilibrium with j not investing and k investing. Suppose without loss of generality j invests while k does not. Consider j's payoffs first.

Conformation by j: In equilibrium, if $\lambda_{jc}^{a}=1$, the payoff is $-c$. Otherwise, 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. A *necessary condition* for j to conform is therefore $\lambda_{jc}^{ad}=1$, and $\lambda_{jc}^{a}=0$, *i.e.*, $p_c>1-\frac{\alpha}{s(\beta-1)}$. Then, j does not deviate if and only if

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

Conformation by k: Next, consider k's payoffs. In equilibrium, if $\lambda^a_{ku} = 1$, 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^a_{ku} is always 1 as $s(\beta - 1) > \alpha$. Now suppose k deviates. Then, if $\lambda^{ad}_{ku} = 1$, the payoff is $-c$. Otherwise, the payoff is

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

We have established that a necessary condition for an asymmetric equilibrium to exist is $p_c > 1 - \frac{\alpha}{s(\beta-1)}$, *i.e.*, $\lambda^{ad}_{ku} = 0$, and $\lambda^a_{ku} = 1$. Then, k deviates if and only if

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

Existence of asymmetric equilibrium: Summarising the above, asymmetric equilibria exist if and only if

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

II - C equilibrium: We omit some details for brevity and note that the arguments are similar to those used in the study of asymmetric equilibria above.

Conformation in a C equilibrium:. Suppose both banks invest. By Assumption 1, λ^{cd}_l equals 1. Then, a necessary condition for a bank not to unilaterally deviate is $p_c > 1 - \frac{\alpha}{s(\beta-1)}$, *i.e.*, $\lambda^c_l = 0$. Given this necessary condition is satisfied, a bank will conform if and only if

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

Existence of a C equilibrium: Summarising the above, a C equilibrium exists if and only if

$$\begin{aligned} p_c &> 1 - \frac{\alpha}{s(\beta-1)} \\ \text{and } \mu\alpha + c &\leq \mu s[p_c(\frac{\sigma}{\underline{\sigma}} - 1) + (1-p_c)(\beta-1)] \end{aligned}$$

III - U equilibrium:

Conformation in a U equilibrium: Suppose neither bank invests. By Assumption 1, $\lambda_l^u = 1$. Then, for any bank l, the payoff is 0. 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,

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

Thus, if $p_c \leq 1 - \frac{\alpha}{s(\beta-1)}$, a bank does not unilaterally deviate. Otherwise, suppose $p_c > 1 - \frac{\alpha}{s(\beta-1)}$, *i.e.*, $\lambda_l^{ud} = 0$ and $\lambda_l^u = 1$. Then each bank conforms if and only if $\mu s(\beta-1) \leq \mu\alpha + c$.

Existence of a U equilibrium: Summarising the above, a U equilibrium exists if and only if either

$$\begin{aligned} \text{a} &: \quad p_c \leq 1 - \frac{\alpha}{s(\beta-1)}, \text{ or} \\ \text{b-i} &: \quad p_c > 1 - \frac{\alpha}{s(\beta-1)} \\ \text{and b-ii} &: \quad \mu\alpha + c \geq \mu s(\beta-1) \end{aligned}$$

■

Proof of Claim 3. Suppose $\lambda_j = 1$, for some j. Let the best period 1 foreign 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, we have since the foreign bank must break even,

$$
\begin{aligned}
(\rho_0(\overrightarrow{p}) - 1) + s\{\pi_o^u(\frac{\sigma}{\underline{\sigma}} - 1) + (1 - \pi_o^u - \pi_o^l)(\beta - 1)\} &= 0 \\
\text{or, } 1 - s\{\pi_o^u(\frac{\sigma}{\underline{\sigma}} - 1) + (1 - \pi_o^u - \pi_o^l)(\beta - 1)\} &= \rho_0(\overrightarrow{p}) \\
\text{By feasibility, } s\{\pi_o^u(\frac{\sigma}{\underline{\sigma}} - 1) + (1 - \pi_o^u - \pi_o^l)(\beta - 1)\} &\geq \alpha
\end{aligned}
$$

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 foreign 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 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 in an n-equilibrium when l's prescribed 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 Claim 3 and equations (12) and (14) to derive payoff functions.

I - U equilibrium: We first consider a U equilibrium.

Conformation in 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 $\lambda_{lu}^0 = \lambda_{lu}^{0d} = 1$, *i.e.*, if $p_c \leq 1 - \frac{\alpha}{s(\beta-1)}$, l does not deviate. Otherwise, let $p_c > 1 - \frac{\alpha}{s(\beta-1)}$, *i.e.*, $\lambda_{lu}^0 = 1$ and $\lambda_{lu}^{0d} = 0$.

Then, l conforms if and only if

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

Existence of a U equilibrium: Summarising the above, a U equilibrium exists if and only if either

$$\begin{aligned} \text{a:} \quad & p_c \leq 1 - \frac{\alpha}{s[(\frac{\sigma}{\underline{\sigma}} - 1) + (\beta - \frac{\sigma}{\underline{\sigma}})]}, \text{ or} \\ \text{b-i:} \quad & p_c > 1 - \frac{\alpha}{s[(\frac{\sigma}{\underline{\sigma}} - 1) + (\beta - \frac{\sigma}{\underline{\sigma}})]} \\ \text{and b-ii:} \quad & \mu\alpha + c \geq \mu s[(\frac{\sigma}{\underline{\sigma}} - 1) + (\beta - \frac{\sigma}{\underline{\sigma}})] \end{aligned}$$

II - 1-equilibrium: 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 foreign offers received by l's local borrowers in period 1. Such 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 foreign 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.

Conformation by a non-investing bank: In equilibrium, $\pi_o^u = 0$, and $1 - \pi_o^u - \pi_o^l = 1$. Bank l's 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 $\lambda_{lu}^{1d} = 1$. Otherwise, let $\lambda_{lu}^{1d} = 0$, *i.e.*, $p_c > 1 - \frac{\alpha}{s(\beta-1)}$. Then, l conforms if and only if

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

Conformation by the investing bank: 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 $s(1 - p_c)(\beta - 1) \geq \alpha$. A necessary condition for l' to conform is therefore $p_c > 1 - \frac{\alpha}{s(\beta-1)}$.

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. Given $p_c > 1 - \frac{\alpha}{s(\beta-1)}$, therefore, $\lambda_{l'c}^{1} = 0$ and $\lambda_{l'c}^{1d} = 1$. Then, l' invests if and only if

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

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

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

III - n-equilibrium: Now consider an arbitrary n-equilibrium, with $2 \leq n < N$. Let l and l' be representative non-investing and investing banks respectively.

Conformation by a non-investing bank: Consider l's decision to deviate. $\pi_l = 1 - (1 - p_c)^n$. As before, suppose foreign offers to its local borrowers come from investing banks, without loss of generality. Then

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

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

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

which is true by Assumption 2. 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, and $\lambda_{lu}^n=1$, let $\lambda_{lu}^{nd}=0$. We have

$$\begin{aligned}p_c &> 1-\frac{\alpha}{s[\{\sum_{M=1}^{n-1}\{{}^{n-1}C_M p_c^M(1-p_c)^{n-1-M}\}\}(\frac{\sigma}{\underline{\sigma}}-1)+(1-p_c)^{n-1}(\beta-1)]} \\ i.e., p_c &> 1-\frac{\alpha}{s[(\frac{\sigma}{\underline{\sigma}}-1)+(1-p_c)^{n-1}(\beta-\frac{\sigma}{\underline{\sigma}})]}\end{aligned}$$

Then, l conforms if and only if

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

Conformation by an investing bank: Now consider l''s decision to invest. $\pi_{l'}=1-(1-p_c)^{n-1}$. We have

$$\begin{aligned}\pi_o^u &= (1-p_c)\sum_{M=1}^{n-2}\{{}^{n-2}C_M p_c^M (1-p_c)^{n-2-M}\} \text{ and} \\ 1-\pi_o^u-\pi_o^{l'} &= (1-p_c)^{n-1}\end{aligned}$$

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

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

Thus, a necessary condition for l' not to deviate is

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

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.

If l' deviates,

$$\begin{aligned} \pi_o^u &= \sum_{M=1}^{n-2} \{^{n-2}C_M p_c^M (1 - p_c)^{n-2-M}\} \text{ and} \\ 1 - \pi_o^u - \pi_o^{l'} &= (1 - p_c)^{n-2} \end{aligned}$$

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

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

which is true by Assumption 2. Thus, given the necessary condition derived above, l' invests if and only if

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

Existence of an n-equilibrium: The analysis above implies that an n-equilibrium exists if and only if

$$\begin{aligned} \text{a) } p_c &> 1 - \frac{\alpha}{s[(\frac{\sigma}{\underline{\sigma}} - 1) + (1 - p_c)^{n-2}(\beta - \frac{\sigma}{\underline{\sigma}})]} \text{ and} \\ \text{b) } \mu\alpha + c &\in [\mu s[(\frac{\sigma}{\underline{\sigma}} - 1) + (1 - p_c)^n(\beta - \frac{\sigma}{\underline{\sigma}})], \mu s[(\frac{\sigma}{\underline{\sigma}} - 1) + (1 - p_c)^{n-1}(\beta - \frac{\sigma}{\underline{\sigma}})]] \end{aligned}$$

IV - C-equilibrium: We finally turn to the C equilibrium. We omit the details as the arguments are similar to those used above.

Conformation in a C equilibrium: Suppose all banks invest. Consider an arbitrary bank l. $\pi_l = 1 - (1 - p_c)^{N-1}$. In equilibrium, 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 $\lambda_{lc}^N = 0$. Further, a necessary condition for l to conform is

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

Also, Assumption 2 implies that $\lambda_{lc}^{Nd} = 1$.

Existence of a C equilibrium: It is easy to show from the above results that a C equilibrium exists if and only if

$$\begin{aligned} \text{a) } p_c &> 1 - \frac{\alpha}{s[(\frac{\sigma}{\underline{\sigma}} - 1) + (1-p_c)^{N-2}(\beta - \frac{\sigma}{\underline{\sigma}})]} \text{ and} \\ \text{b) } \mu\alpha + c &\leq \mu s[(\frac{\sigma}{\underline{\sigma}} - 1) + (1-p_c)^{N-1}(\beta - \frac{\sigma}{\underline{\sigma}})] \end{aligned}$$

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 the two following conditions are satisfied.

$$\begin{aligned} \text{a) } \mu s[(\frac{\sigma}{\underline{\sigma}} - 1) + (1-p_c)^{N-1}(\beta - \frac{\sigma}{\underline{\sigma}})] &< \mu\alpha + \mu s p_c(\frac{\sigma}{\underline{\sigma}} - 1) \\ \text{b) } \mu s[(\frac{\sigma}{\underline{\sigma}} - 1) + (1-p_c)^{N-1}(\beta - \frac{\sigma}{\underline{\sigma}})] &\geq \mu\alpha + c \end{aligned}$$

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

$$\begin{aligned} \text{a) } p_c &\leq 1 - \frac{\alpha}{s(\beta - 1)} \text{ or} \\ \text{b) (i) } p_c &> 1 - \frac{\alpha}{s(\beta - 1)} \text{ and} \\ \text{(ii) } \mu\alpha + c &\geq \mu s(\beta - 1) \end{aligned}$$

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

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

■

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 (11), total welfare in a U equilibrium is given by $M[s(\beta-1) - \alpha]$. In a C equilibrium, total welfare is, using (13)

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

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. The probability she receives $N-1$ outside 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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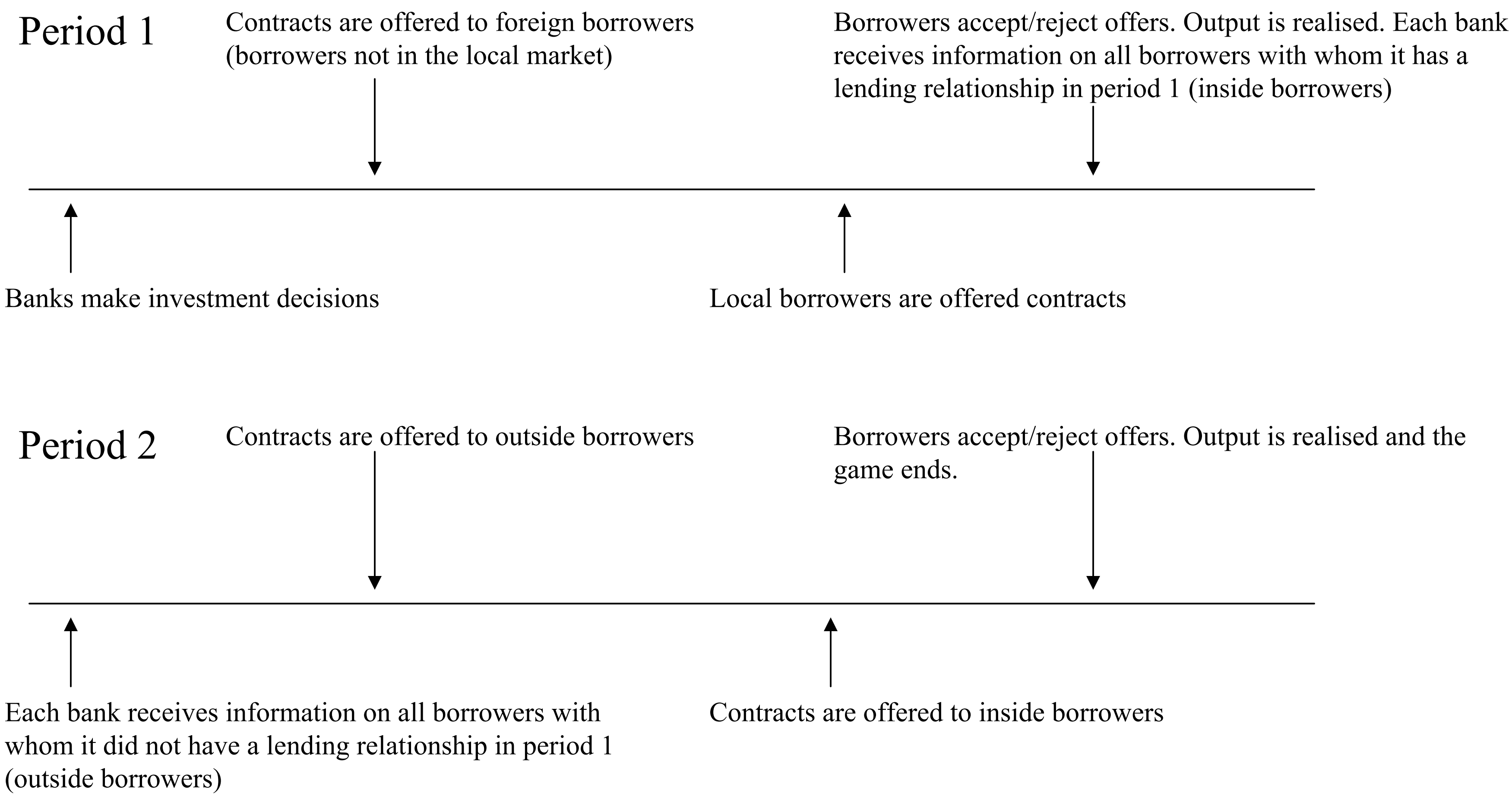
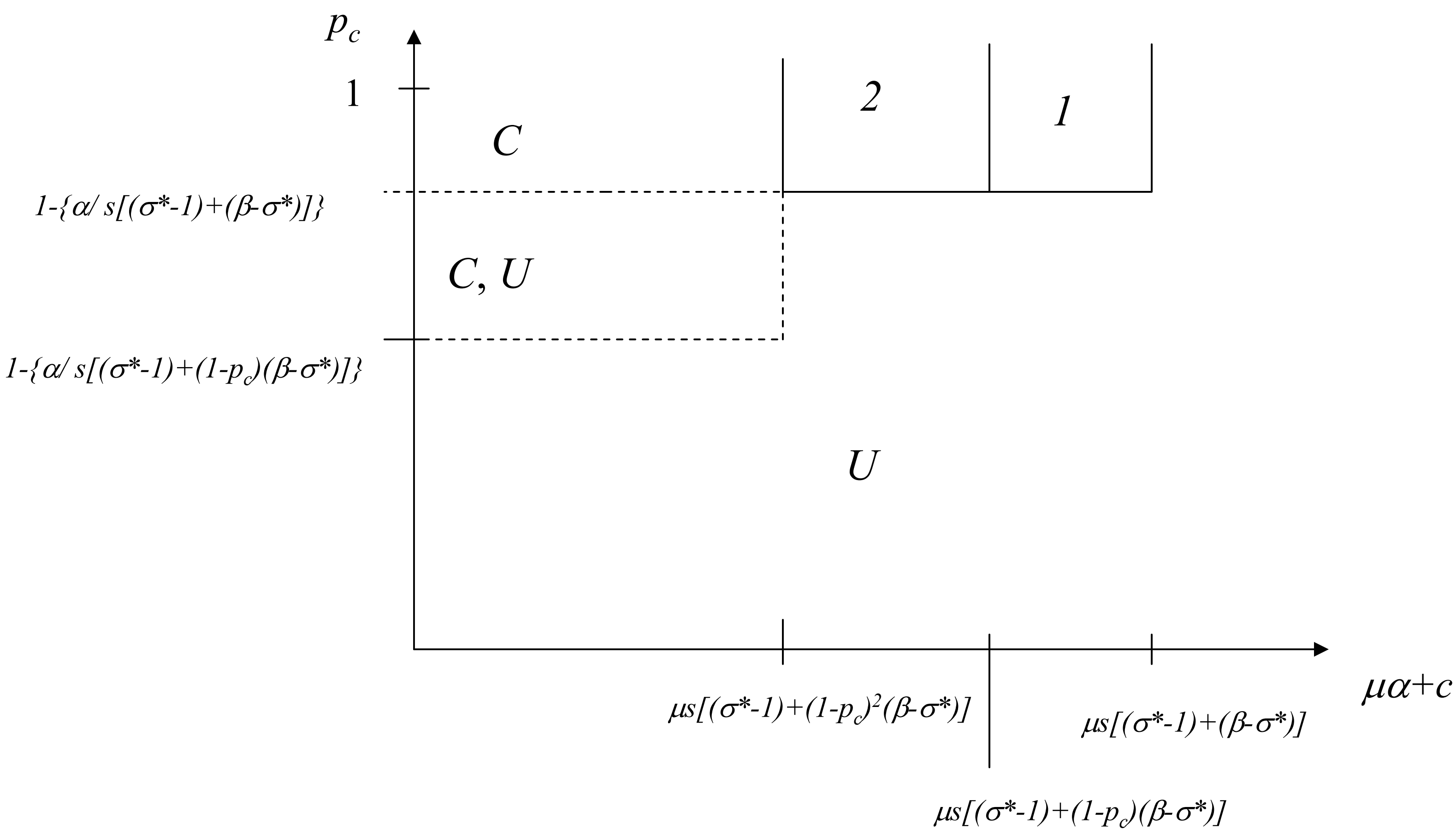


The Timing of Events

Figure 1

Figure 2

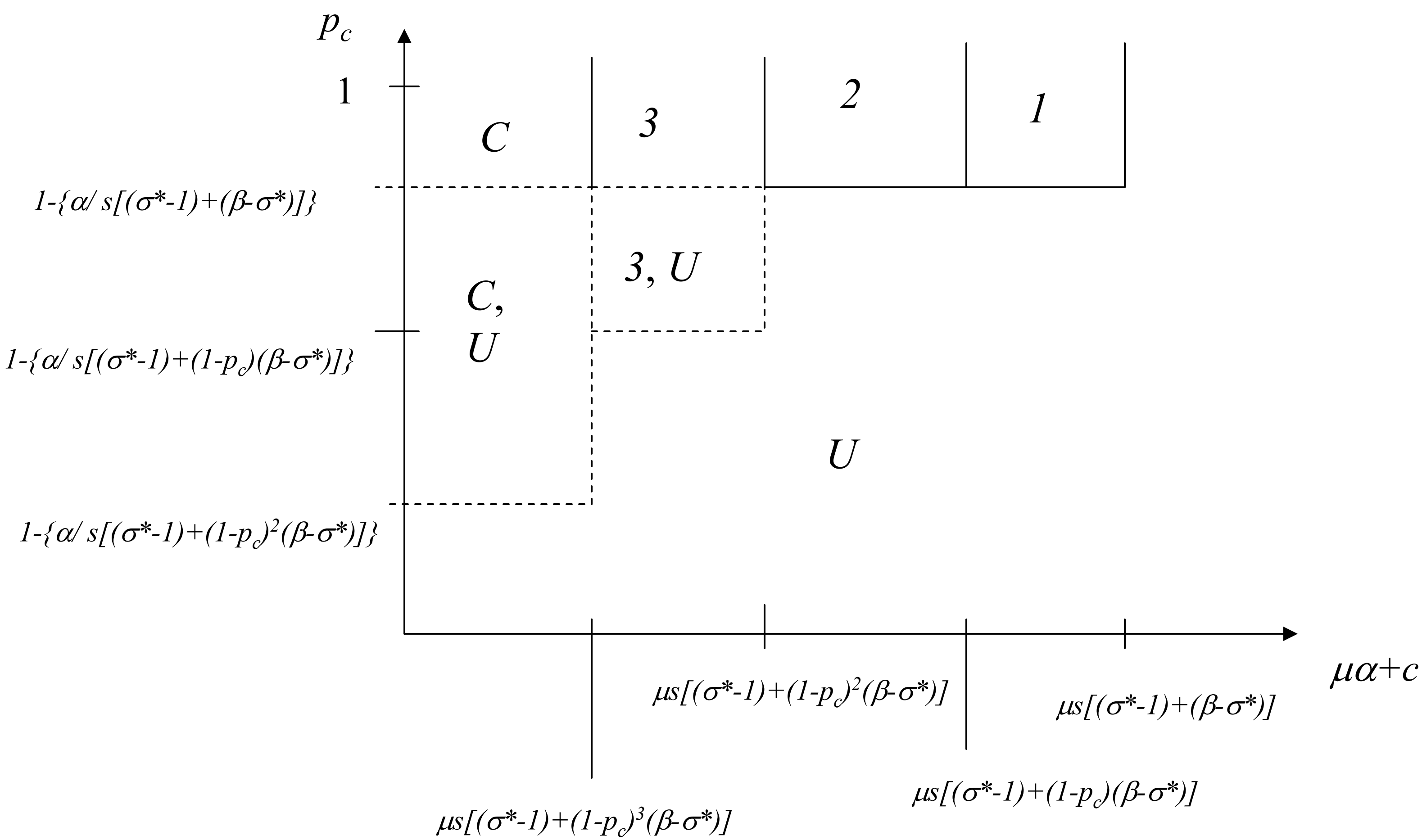
Equilibrium existence: $N = 3$



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 3

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.