Competition in Banking: Implications for Stability and Regulation

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Abstract

We assess the influence of competition and capital regulation on the stability of the banking system, and particularly on the monitoring incentives of banks. We show that competition improves the monitoring incentives of better quality banks and deteriorates the incentives of lower quality banks. Our key result is that precisly for those lower quality banks competition also compromises the effectivess of capital requirements. Our approach deviates from the extant literature in that it recognizes the fixed costs associated with banks' monitoring technologies. We generalize the analysis along a few dimensions. One is where we allow endogenous bank entry, and ask the question how capital regulation affects entry into the industry. In another extension we analyze the effects of asymmetric competition, i.e. one country that opens up its banking system but not vice versa.

1 Introduction

A key public policy issue concerning the banking sector is how competition and regulation affect the functioning of financial institutions, and specifically, what role competition plays when it comes to the effectiveness of regulation. In this paper, we particularly focus on the effects of capital regulation and the competitive environment on the stability of the banking industry.

The importance of these issues is unquestionable. The increasingly competitive and dynamic environment of banking puts severe strains on the viability and effectiveness of regulation. Competition also affects the behavior the players in the industry directly. More competition could induce banks to take more risks, which could undermine the stability of the industry.

We analyze these issues in an industrial organization framework in which we distinguish multiple banks, and we let banks differ in quality. These quality differences will be linked to the banks' abilities in monitoring potential borrowers, and thus affect the profitability of the lending operations of banks. We let banks compete for borrowers and analyze how their choices of monitoring technology, and hence risk, are affected by capital regulation and the intensity of competition. We show that competition improves the monitoring incentives of better quality banks and deteriorates the incentives of lower quality banks. Our key result is that precisely for those lower quality banks competition also compromises the effectiveness of capital requirements.

Our approach deviates from the extant literature in that it recognizes the fixed costs associated with banks' monitoring technologies. These fixed costs give importance to a bank's market share. When good and bad banks compete, good banks will end up giving market share while bad banks lose market share. With the fixed costs, bad banks are now put at a double competitive disadvantage. These issues are partucularly relevant when countries with different quality banking systems open up their markets to competition. Substantial instability could be expected in the weaker countries.

In our model, banks are maximizing shareholder wealth. Due to fixed deposit insurance premium, capital regulation plays a role to contain risk shifting incentives. Higher capital – ceteris paribus – encourages banks to be safer and to invest more in monitoring technology. The investment in monitoring technology involves fixed costs, and has to be taken ex ante. Low quality banks anticipate that they will obtain a smaller market share, particularly when there is more competition. For good banks , competition could help increase market share. As a result, competition increases monitoring incentives of good banks, but decreases those of bad banks.

Key to our analysis are the quality differences between banks, or between banking systems. These differences create an asymmetric impact of competition on the behavior of banks. In the extant literature banking competition has primarily been analyzed in a symmetric context with equally capable banks (see Repullo (2004), Cordella and Levy Yeyati (2002), Allen and Gale (2001) and Boyd and De Nicolo (Forthcoming)).

This approach is highly unsatisfactory. Quality differences between banking institutions and banking systems are of primary concern to regulators, particularly when it comes to encouraging competition. Countries with weak banking systems are reluctant to open up their market to competition because this could undermine their banking system further. Indeed, we do show that competition could indeed have a devastating impact on those weak systems. Possibly, even more troublesome, we show that competition makes capital regulation less effective precisely in those weak banking systems, while it strengthens the effects of capital regulation in high quality banking systems.

We also analyze several extensions. By endogenizing bank entry we analyze explicitely how capital regulation affects the incentives of banks to enter the industry, and hence show how capital regulation itself affects the competitiveness of the industry. In another extension we analyze the effects of asymmetric competition, i.e. one country that opens up its banking system but not vice versa.

The paper is organized as follows. In Section 2 we develop the model, including the specification of the competitive environment. Section 3 presents some basic results. The main results are contained in Section 4. Section 5 discusses the extensions, and Section 6 concludes.

2 The Model

2.1 Preliminaries

There are four players in the model: commercial banks, depositors/investors, the regulator (who sets the capital requirement and provides deposit insurance), and borrowers (companies asking for loans).

Banks specialize in lending and fund themselves with deposits and capital. We assume that banks acquire core expertise in monitoring borrowers, and that this expertise is valuable to the companies that they finance. In particular, we have the monitoring technology of a bank affect the success probability of the project that the bank is financing. This captures the role that banks play in relationship banking: banks invest in borrower-specific knowledge and engage in qualitative asset transformation.[1]

The funding of the banks comes from (liquid) deposits and capital. The liquidity of deposits is rooted in deposit insurance that we assume to be present. The deposit insurance is available at a fixed cost. This potentially introduces moral hazard on the part of banks and helps explain the role of capital requirements; capital requirements may contain asset substitution moral hazard. We assume that bank management is fully aligned with shareholders.

The regulator sets the minimum level of the capital requirement k and provides for deposit insurance. Due to lack of observability and contractability, capital requirements and the deposit insurance premium are fixed across banks.

[1] See Boot (2000) and Ongena and Smith (2000) for reviews of relationship banking.

2.2 Model Details

Preferences and time line: There is universal risk neutrality, with r_f representing the riskless interest factor (one plus the interest rate). There are four dates, $t = 0$, 1, 2 and 3. At $t = 0$ the regulator sets the capital requirement k, and banks decide whether or not to enter the banking industry. At $t = 1$, each borrower is matched with a bank. Banks then decide on their investments in the monitoring technology and their level of capital. We call the initial bank that the borrower is matched with the 'incumbent bank'. This bank makes the borrower an initial offer. At $t = 2$ the borrower might find a second competing bank. If this happens, the initial incumbent bank and competing bank compete as Bertrand competitors. The borrower chooses the best offer, subsequently the winning bank makes the loan, and payoffs are realized at $t = 3$. In Figure 1 we have summarized the sequence of events.

INSERT FIGURE 1

Borrowers: A borrower needs a single-period loan of \$1 to finance a project at $t = 2$ with a payoff at $t = 3$. All borrowers are identical. The borrower's project has a return of either Y or 0 (zero). The probability of success (i.e. the pay-off Y) depends on a bank's investment in monitoring technology ν_j with $j \in \{I, C\}$, where $j = I$ refers to the incumbent bank and $j = C$ is the competing bank. We let the probability of success be equal to the investment ν_j. All other things equal, when the borrower can choose between two competing offers, it will choose the bank with the highest ν_j.[2] The aggregate demand for loans of all borrowers is normalized to 1.

Depositors and providers of capital: Each bank collects a proportion k of the total funds needed from the providers of bank capital and $1 - k$ from depositors. For now, each bank faces a binding capital ratio k.

[2]Actually, we will assume (see later) that the initial bank has an incumbency advantage ϵ, such that the probability of success with an investment in monitoring technology ν_I is $\nu_I + \epsilon$ for the incumbent bank. Thus the competing (second bank) needs to overcome this incumbency advantage.

With complete deposit insurance, depositors are willing to supply their funds at the risk free interest rate r_f. The deposit insurance premium is fixed, and to simplify maters we assume that this premium is included in the gross costs of deposits. Hence, the cost of deposits is $r_D > r_f$.

Capital is costly.[3] We let the cost of capital equal ρ, where $\rho > r_D$.

Commercial banks: Banks choose to enter the banking industry at $t = 0$. All banks are initially (perceived) identical. At $t = 1$ with N banks present, each is matched with $1/N$ of the borrowers. Banks then learn whether their type is good (G) or bad (B), and following this they choose their investments in monitoring technology. The cross-sectional probability of being good (γ) or bad ($1 - \gamma$) are known to all. A good bank faces a cost $C_G(\nu)$ for investing ν in monitoring technology. For a bad bank this is $C_B(\nu)$, with $C_B(\nu) > C_G(\nu) \geq 0$, $C'_B(\nu) > C'_G(\nu) > 0$ and $C''_B(\nu) > C''_G(\nu) > 0$ for all ν. We assume that the borrowers' projects are sufficiently profitable so that lending will take place.

Competitive environment: Competition between banks occurs in two phases. In the first phase (at $t = 1$), all N banks get $1/N$ of the total borrowers,[4] where N is the total number of banks in the banking industry. Each bank then specifies its offer, which is an interest rate R. At $t = 2$, borrowers succeed in locating a competing offer with probability q. With probability $1 - q$, they do not find a competing offer. When this happens borrowers have no choice but to accept the initial offer, provided this gives them a non-negative expected return on the project. When a second bank is found, both the incumbent and the competing bank compete as Bertrand competitors. We assume that at this stage the competing banks and the borrowers can observe the monitoring

[3]The cost of capital is higher than the cost of debt either because bankers' wealth is scarce; see Holmstrom and Tirole (1997) and Diamond and Rajan (2000) for explicit models of why the cost of capital ρ might be higher than the return that depositors would demand. For a similar assumption see Repullo and Suarez (2004).

[4]Since all banks are perceieved identical at that moment, this even distribution of borrowers over all banks is quite natural.

technology adopted by each bank and their types. Each borrower then decides on the bank that gives him the highest expected return on the project net of funding costs.

One important consideration in this competition phase is that the initial (incumbent) bank has an incumbency advantage ϵ. More specifically, we assume that when the incumbent bank has a monitoring technology ν_I, the incumbent borrower's success probability is $\nu_I + \epsilon$, while for the competing second bank this is just its choice of monitoring technology ν_C.

3 Initial Analysis: Some Basic Results

We solve the model using backward induction. We first analyze the optimal interest rate offers that banks grant their borrowers. These offers will depend on whether banks face competition or not at $t = 2$. Subsequently, we compute the optimal investments in monitoring technology ν_j at $t = 1$, anticipating the events at $t = 2$.

3.1 Optimal Bank Interest Rate Offers

At $t = 1$ each borrower is matched with a bank, i.e. the incumbent bank. The initial offer that this bank makes is a monopolistic offer. To see this note that the bank can always improve on its offer when its borrower succeeds in obtaining a competing offer. Hence, setting a monopolistic interest rate is optimal. The bank sets the interest rate equal to the maximum payoff of the borrower. Thus $R^{\max}(\nu_I + \epsilon) = Y$, and in doing so obtains all surplus.

At $t = 2$, the borrower finds with probability q a competing bank; with probability $1 - q$ the borrower only has access to the offer of the incumbent bank. When borrowers have no access to a competing offer, they accept the monopolistic offer and lose all rents. When the borrower has a competing offer, both banks compete for the borrower as Bertrand competitors.

Observe that the incumbent bank will succeed in keeping its borrower if $\nu_I + \epsilon \geq \nu_C$.

In this case the incumbent bank sets the interest rate such that the competing bank cannot outbid it. The lowest interest rate $R^{\min}(\nu_C)$ that the competing bank is (just) willing to offer follows from its zero NPV condition $-k + \frac{\nu_C}{\rho}\{R^{\min} - [1-k]r_D\} = 0$.[5] Hence,

$$R^{\min}(\nu_C) = [1-k]r_D + \frac{k\rho}{\nu_C}. \tag{1}$$

The incumbent bank is able to outbid the competing bank if it can set its interest rate $R(\nu_I + \epsilon|\nu_C)$ such that the borrower obtains a surplus at least equal to what he could obtain with the competing bank's offer $R^{\min}(\nu_C)$.[6] More specifically, the maximum interest rate $R^{\max}(\nu_I+\epsilon|\nu_C)$ that the incumbent bank could set is such that the borrower is indifferent between the offer of his incumbent bank and that of the competing bank. That is,

$$[\nu_I + \epsilon][Y - R^{\max}(\nu_I + \epsilon|\nu_C)] = \nu_C[Y - R^{\min}(\nu_C)].$$

Inserting expression (1) for $R^{\min}(\nu_C)$, we get

$$R^{\max}(\nu_I + \epsilon|\nu_C) = Y[1 - \frac{\nu_C}{\nu_I + \epsilon}] + \frac{\nu_C}{\nu_I + \epsilon}\{[1-k]r_D + k\frac{\rho}{\nu_C}\}. \tag{2}$$

If $\nu_I + \epsilon < \nu_C$, the incumbent bank cannot outbid the competing bank. In that case, the competing bank will prevail. The minimum interest rate that the incumbent bank is willing to offer is such that $-k + \frac{\nu_I+\epsilon}{\rho}\{R^{\min}(\nu_I + \epsilon) - [1-k]r_D\} = 0$. Hence,

$$R^{\min}(\nu_I + \epsilon) = [1-k]r_D + \frac{k\rho}{\nu_I + \epsilon}. \tag{3}$$

In this case, the maximum interest rate $R^{\max}(\nu_C|\nu_I + \epsilon)$ that the competing bank can ask without losing the borrower is such that

$$\nu_C[Y - R^{\max}(\nu_C|\nu_I + \epsilon)] = [\nu_I + \epsilon][Y - R^{\min}(\nu_I + \epsilon)].$$

[5] Note that the cost of investing in monitoring technology incurred at $t = 1$ is sunk once the competition phase is reached at $t = 2$, and thus is not considered when the bank sets the interest rate.

[6] We assume that when the borrower is indifferent between both offers, he chooses the 'better' bank (i.e., the incumbent when $\nu_I + \epsilon \geq \nu_C$, and the competing bank when $\nu_C > \nu_I + \epsilon$).

This gives,

$$R^{\max}(\nu_C|\nu_I+\epsilon) = Y[1-\frac{\nu_I+\epsilon}{\nu_C}] + \frac{\nu_I+\epsilon}{\nu_C}\{[1-k]r_D + k\frac{\rho}{\nu_C}\}. \tag{4}$$

Observe that for any offer $R(\nu_C) \leq R^{\max}(\nu_C|\nu_I+\epsilon)$ the borrower (weakly) prefers the competing offer over that from the incumbent bank.

We can now derive the following proposition.

Proposition 1 *Conditional on the monitoring technologies ν_I and ν_C in place, the interest rate offers available to a borrower equal:*

1. *If the incumbent bank does not face a competitor (this happens with probability $[1-q]$), the borrower is offered,*

$$R^{\max}(\nu_I+\epsilon|\textit{no competition}) = Y \tag{5}$$

2. *If the incumbent bank faces competition (this happens with probability q), it competes as Bertrand competitor:*

   (a) *for $\nu_I+\epsilon \geq \nu_C$, the incumbent bank prevails and the borrower is offered $R^{\max}(\nu_I+\epsilon|\nu_C)$, where $R^{\max}(\nu_I+\epsilon|\nu_C)$ is given in (2).*

   (b) *for $\nu_I+\epsilon < \nu_C$, the competing bank prevails and the borrower is offered $R^{\max}(\nu_C|\nu_I+\epsilon)$, where $R^{\max}(\nu_C|\nu_I+\epsilon)$ is given in (4).*

Proposition 1 summarizes the interest rate offers available to the borrower at $t=2$, conditional on the monitoring technologies ν_I and ν_C. We establish next the optimal investments in monitoring technology at $t=1$, anticipating the events at $t=2$.

3.2 The Choice of Monitoring Technology

The investment that a bank is prepared to make in its monitoring technology depends crucially on the profitability of the lending operation, and hence the competition it anticipates. Recall that all N banks get allocated $1/N$ borrower. For this initial allocation, a bank has a role as incumbent bank. Competition implies that it may lose this borrower (and/or be forced to lower its lending rate), but the bank could also gain new borrowers by challenging other (incumbent) banks. We first derive some preliminaries.

3.2.1 Preliminaries

The value that a bank derives from its initial borrower, conditional on having no competing bank for this borrower, equals $\frac{1}{N}\{-k+[\nu_I+\epsilon]\frac{Y-[1-k]r_D}{\rho}\}$, where Y is the interest rate $R^{\max}(\nu_I+\epsilon|\text{no competition})$ that it charges its borrower, see (5). Hence the bank obtains all surplus. We can write this as (and the superscript *mon* refers to monopoly case)

$$L_I^{mon} = -k/N + [\nu_I + \epsilon]X, \tag{6}$$

where, $X = \{Y - [1-k]r_D\}/N\rho$.

Conditional on a competing bank being present with monitoring technology ν_C, the value that the incumbent bank derives from its initial borrower equals zero if $\nu_I+\epsilon < \nu_C$; that is, it loses the borrower to the competing bank. If $\nu_I+\epsilon \geq \nu_C$, the incumbent bank out bids the competing bank and sets its interest rate equal to $R^{\max}(\nu_I+\epsilon|\nu_C)$ as given in (2). The value that it derives from its initial borrower is now (note that the superscript *comp* refers to the competition it faces)

$$L_{I,\nu_I+\epsilon\geq\nu_C}^{comp} = \frac{1}{N}\left\{-k + [\nu_I+\epsilon]\frac{R^{\max}(\nu_I+\epsilon|\nu_C) - [1-k]r_D}{\rho}\right\}$$

Substituting (2) this gives $L_{I,\nu_I+\epsilon\geq\nu_C}^{comp} = [\nu_I+\epsilon-\nu_C]X$. Hence, summarizing we have,

$$L_I^{comp} = \max\{0, [\nu_I+\epsilon-\nu_C]X\} \tag{7}$$

The incumbent bank can also compete for the borrowers of other banks. Strictly speaking, these other banks are the incumbent banks for those borrowers. To prevent confusion, we will continue to call 'our bank' the incumbent bank, and use ν_I for its technology and ν_C for the technology of the other banks. If the incumbent bank competes for the borrower of another bank with monitoring technology ν_C (and incumbency advantage ϵ), the value that it derives from the possibility of 'getting' this new borrower is

$$L_I^{newbor} = \max\{0, [\nu_I - \nu_C - \epsilon]X\} \tag{8}$$

The expression (8) is very similar to (7), but note that the incumbency advantage now works against 'our bank' (that we will continue to call the incumbent bank). Observe that there are $N-1$ other banks in the economy. The incumbent bank has a probability $q/[N-1]$ that it can compete for the borrowers of any one of these banks.[7] Recall that each of these banks has $1/N$ borrower. Thus the expected number of other borrowers that the incumbent bank can make an offer to is $[N-1] \times \frac{q}{N-1} \times \frac{1}{N} = \frac{q}{N}$. We now have the following lemma.

Lemma 1 *The expected number of other borrowers that the incumbent bank can make an offer to is q/N.*

This lemma highlights that there is a degree of symmetry in our model. That is, the way that we have structured the competition between banks implies that any incumbent bank faces a probability q that others will bid for its $1/N$ borrower. Thus the fraction q/N of its borrower is in expected value sense at risk. However, Lemma 1 shows that the flip side is that this incumbent bank can bid in expect3ed value for the fraction q/N of other banks. The actual outcome will depend on the quality differentials between banks and their potentially different levels of (investment in) monitoring technology.[8]

3.2.2 Optimal Choice of Monitoring Technology

At $t = 1$, the N banks first learn their types, and then individually choose their levels of investment in the monitoring technology. We consider a simultaneous move game,

[7] Note that a borrower gets a competing offer with probability q and there are $[N-1]$ banks that could get the opportunity to make this competing offer.

[8] In section 5.3 we will also analyze how competition will evolve if there is only one-sided competition. What we mean by this is that a bank may face competition from other banks, but the borrowers of these other banks might be shielded from competition (or vice versa).

and derive a separating Nash equilibrium in pure strategies. In choosing their individual levels of investment in monitoring technology, each bank makes a conjecture about the choices of the other banks. In deriving this separating Nash equilibrium we need to put some constraints on the incumbency advantage ϵ. More specifically, we assume,

Assumption 1: $0 < K_d < \epsilon < K_u$, *where* K_d *and* K_u *are defined as*[9]

$$K_d = \max\left(\frac{q[1-\gamma]X}{C''_B(C'^{-1}_B([1-q\gamma]X))}, \frac{q\gamma X}{C''_G(C'^{-1}_G(\{1+q[1-\gamma]\}X))}\right) \quad (9)$$

$$K_u = \min\left(\frac{1}{2}[C'^{-1}_G(\{1+q[1-\gamma]\}X) - C'^{-1}_B([1-q\gamma]X)],\right.$$
$$\left. C'^{-1}_G(\{1+q[1-\gamma]\}X) - C'^{-1}_B(\{1+q[1-2\gamma]\}X)\right). \quad (10)$$

This assumption can be explained as follows. First the condition $K_d < \epsilon$ puts a lower bound on the incumbency advantage. This effectively guarantees that banks of the same type will choose to follow identical strategies, i.e. will choose the same level of investment in monitoring technology. The reason is that the incumbency advantage makes it very difficult to grab market share from a bank of the same type. Hence, a bank has no incentive to increase its investment in monitoring relative to its competitors of the same type. The condition $\epsilon < K_u$ puts an upper bound on the incumbency advantage. This ensures that a better quality bank (i.e. a good bank) can overcome the incumbency advantage of a bad bank, and grab its borrower.

We now proceed as follows. Each bank chooses its investment in monitoring technology ν holding the strategy of other banks fixed. We continue to analyze the problem from the perspective of the incumbent bank. Its investment in monitoring technology is ν_I. The other bank choose ν^i_C, where i refers to one of the other $N-1$ banks.

[9]Observe that $C'^{-1}_\tau(\nu)$ is the inverse of the first derivative of the cost function $C_\tau(\nu)$.

The expected value of the incumbent bank, net of funding costs, is

$$\begin{aligned} V &= [1-q]\{-k/N + [\nu_I + \epsilon]X\} + q\sum_{i=1}^{N-1}\frac{1}{N-1}\max(0,[\nu_I + \epsilon - \nu_C^i]X) + \\ &+ q\sum_{i=1}^{N-1}\frac{1}{N-1}\max(0,[\nu_I - \nu_C^i - \epsilon]X) - C(\nu_I) \end{aligned} \tag{11}$$

In (11), the first expression is the bank's profitability when there is no competition, see (6). This happens with probability $[1-q]$. The second expression is the expected profit on its initial borrower when there is competition (see (7)). The summation is over all $N-1$ competing banks. Finally, the third expression is the incumbent bank's profit from successfully attracting borrowers away from other banks, as given in (8).

Each bank maximizes its analogous expression (11), and recall that each knows its own type when it chooses its level of investment in monitoring technology. We now have the following result.

Proposition 2 *There exists a separating Nash equilibrium consisting of the strategies ν_B^* for the bad bank and ν_G^* for the good bank, where ν_G^* and ν_B^* are*

$$\nu_B^* = C_B'^{-1}([1-q\gamma]X) \tag{12}$$

$$\nu_G^* = C_G'^{-1}(\{1+q[1-\gamma]\}X) \tag{13}$$

From this proposition it follows readily that in equilibrium good banks choose a strictly higher level of monitoring than bad banks. The proposition also implies that when competition materializes good banks will steel borrowers from bad banks, even if those banks have an incumbency advantage. When banks of equal type compete, the incumbent bank prevails.[10]

[10]When banks are very similar to each other and the incumbency advantage is high (note that this would violate Assumption 1), there exists another – pooling – Nash equilibrium in which all banks focus only on their incumbent borrowers. Neither the good nor the bad banks try to win borrowers from other banks, simply because the high incumbency advantage and small cost advantages prevent any type of bank from profiting from non-incumbent borrowers (see Proposition 5). In absence of an incumbency advantage (again a violation of Assumption 1) no equilibrium exists in pure strategies.

A key observation is that the incentives of good and bad banks to invest in monitoring technology crucially depend on the size of the market they expect to capture. We can now analyze a few properties of the equilibrium in Proposition 2.

Corollary 1 *The investments in monitoring technology are strictly decreasing in N, the number of banks.*

This result highlights a critical scale and fixed costs effect. With a larger number of banks, each bank has (on average) a smaller market, and hence faces a lower return on its fixed investment in monitoring technology.

Corollary 2 *An increase in the quality of the banking industry (i.e. higher γ), leads both good and bad type banks to lower their level of investments in monitoring technology, but the* average *level of investment in monitoring technology increases.*

The intuition for the first part of this corollary is related to that of Corollary 1. The higher the quality of the banking market the lower the opportunities for good banks to gain market. Hence these banks effectively utilize their monitoring technologies less, explaining the negative effect of γ on ν_G^*. Similarly, when γ is higher, bad banks are more likely to lose their borrowers, and hence their investments in monitoring technology become less valuable.

The second part of the corollary shows that the average monitoring intensity in a more developed (higher quality) banking system is higher than that in a lower quality banking system. However, the corollary also shows, that all individual banks – holding their types fixed – reduce their monitoring. What this effectively means is that when a banking system restructures such that the number of good banks increases (and the number of bad banks decreases), the improvement that comes from the higher number of good banks (good banks have a strictly higher monitoring level than bad banks) offsets the decline in monitoring in individual banks, holding their type fixed. Thus the positive effect of the former dominates and the average monitoring intensity in the banking industry increases.[11]

The next property relates to the effectiveness of capital regulation.

Corollary 3 *Higher capital requirements improve the monitoring incentives of both good and bad type banks. The positive impact of capital requirements is smaller in a higher quality banking industry (higher γ).*

The intuition for this result is that capital forces banks to internalize risk, and therefore reduces risk-taking incentives, implying more monitoring. The second part of the corollary follows because there is effectively more competition in a higher quality banking industry (higher γ). This anticipated competition reduces the value of costly monitoring since the advantages of monitoring are competed away. As a consequence, the positive effects of capital requirements on monitoring are less pronounced in such high quality banking systems.

4 Further Analysis

4.1 Introduction

For now we continue to hold the number of banks N fixed. Our focus here is on the competition between banks in geographically (partially) segmented markets. The key question analyzed is how relaxing geographic barriers (which has an impact on the competitive environment of banks) affects the strategies of banks and the effectiveness of regulation.

The type of competition that we analyze in this section could be interpreted as opening up national markets to foreign competitors. Across the globe, we increasingly see that banks are challenged in their own home markets, but also themselves challenge

[11] The level of the incumbency advantage does not affect the monitoring level of the good nor the bad type bank as long as Assumption 1 continues to hold.

other banks in their home markets. The reasons for this include deregulation, globalization and developments in information technology. In particular, the latter could potentially allow banks to enlarge their geographic area of operations without having a local presence in those markets; this possibly reduces the competitive advantages of local players (see for example Petersen and Rajan (2002)).

In our model, these developments positively impact q, the probability that borrowers have access to competing offers. Initially, we will continue to assume symmetry in the structure of competition. That is, in the model that we have developed so far, an incumbent bank faces competition for its borrower with probability q, and might therefore be losing these borrowers, but it also get access to borrowers from other banks. In expected value sense the number of borrowers at risk are equal to those it could gain (see Lemma 1). A bank's actual success with competition depends both on its quality and on its investment in monitoring technology relative to those of its competitors.

4.2 Analysis

We will now analyze how competition affects monitoring incentives and the effectiveness of capital regulation.

We first analyze the effect of competition on monitoring incentives.

Proposition 3 *Increased competition (higher q) decreases the optimal level of monitoring of the bad bank (ν_B^*) and increases the optimal level of monitoring of the good bank (ν_G^*).*

The intuition for this proposition is as follows. Higher competition reduces the probability that bad banks can hang on to their own borrowers. This diminishes their market share and hence lowers their incentives to invest in monitoring technology. Good banks, however, benefit from increasing q in that they can steal more borrowers from bad banks. Hence, they gain market share, effectively increasing the returns on investing in monitoring technology.

This differential impact of competition on monitoring incentives highlights an interesting property in our model. For low quality banks, competition implies losing market share and hence increases the effective (per unit) costs of their operations due to the presence of fixed costs. For good quality banks this is precisely the reverse: competition allows for an increase in market share, and effectively helps to lower the per unit costs.

We will analyze next the effect of competition on the effectiveness of capital regulation.

Proposition 4 *Higher competition (higher q) negatively affects the effectiveness of the capital requirements for bad banks, but it increases the effectiveness of capital regulation for good banks.*

From Corollary 3 we know that capital regulation helps in improving monitoring incentives for both good and bad banks. What this proposition shows is that the positive impact of capital regulation is strenghtened for good banks but weakened for bad banks when competition increases. The intuition for this resembles that of Proposition 3. Competition reduces the marginal benefit of investing in monitoring technology for bad banks but increases that for good banks. Not surprisingly then, the favorable impact that capital regulation has on monitoring incentives is strenghtened for good banks but not for bad banks.

The results so far show that competition has a positive impact on the monitoring incentives of good banks, but undermine those of bad banks. This has profound implications for regulatory policy. Most importantly, the understandable policy of by regulators to increase capital requirements in a more competitive environment is not as effective as one would like it to be. That is, competition undermines the effectiveness of capital regulation precisely for those borrowers for which it is needed most. More specifically, 'bad quality' banks reduce their investment in monitoring technology – contrary to good banks – when competition heats up, and precisely for these banks competition undermines the effectiveness of capital regulation. Thus, for lower quality banks increasing competition has both a direct negative impact on monitoring incentives, and an indirect negative impact via a reduced effectiveness of capital requirements. For higher quality banks the direct and indirect effects both positively impact monitoring incentives.

An important caveat needs to be made. While we show that competition in a more developed banking sector increases monitoring incentives, one could say that we overestimate the positive effects on stability. This is because in our model we have a binary fail vs. success distribution, hence only the success probability matters for stability. And this success probability is positively affected by competition via an increase in monitoring incentives. But competition will generally reduce rents and this could negatively affect stability. In addition, the returns of all borrowers of a given bank are perfectly correlated, and diversification effects are not present.

With a more general distribution, bank stability would not only depend on the failure probability of one borrower, but also on diversification effects and hence the level of rents the bank earns on borrowers that succeed. Since competition reduces rents, the smaller diversification effect mitigates (part of) the favorable effects that competition has on stability for the good banks. What this means is that in a model where diversification effects and continuous return distributions are included competition has smaller positive effect on stability for good banks. For bad banks things would become even worse.

However, our main focus is impact of competition and capital regulation in the presence of borrower heterogeneity. The key insights here are robust: bad banks unequivocally suffer from competition and also become less receptive to capital regulation.

4.3 Further Discussion

The competition that we have analyzed so far involves opening up previously (partially) segmented markets.

In the model this means increasing q, while keeping the number of players N fixed. As we have discussed, this could be interpreted as opening up previously closed domestic markets to foreign competitors. Alternatively, the increase in q could be interpretes as an increase in within market competition, for example due to developments in information technology. In the context of two countries that intorduce cross border competition, our results show that the country with low quality banks will become even riskier and the country with high quality banks becomes safer. The direct consequence is that opening up borders is bad for the stability of low quality banking systems and good for the stability of high quality banking systems.[12] Similarly, from a regulatory point of view, the effectiveness of capital regulation is negatively affected in the low quality system, while favorable affected in the high quality system.

5 Model Extensions

In this section, we discuss several extensions. In the first extension, we allow for entry by endogenizing the number of banks N (see Section 5.1). In Section 5.2 we analyze a variation on this entry decision. In this section, a de novo bank, without current borrowers, seeks to enter an established banking market. De novo bank has no incumbency advantage, but all (existing) competitors have. In Section 5.3, we allow for one-sided competition. What we mean by this is that one country opens up its banking system to banks from another country, but this other country keeps its own market closed. In Section 5.4, we analyze the final extension. In this extension, we no longer assume that bank capital is fixed at the regulatory requirement, but allow it to be chosen endogenously with the regulatory requirements as a minimum.

[12]Strictly speaking, this goes a little further than what we have proved. We showed that competition has a favorable effect on good banks, but negatively affects the monitoring incentives of low quality banks. We can show that for a wide set of specifications for the cost functions $C(\nu)$ competition affects the weighted average (over good and bad banks) investments in monitoring technology negatively if γ is low, and positively for γ sufficiently high. This translates into the conclusion that competition is good in a well developed (high quality) banking system, but bad for a low quality banking system.

5.1 Endogenizing Competition

Now we will allow entry in banking; the number of banks N is no longer fixed. The probability that the borrower finds a competing bank q now also depends on the number of banks N operating in the banking system. In particular, we assume that the probability of finding a competing bank is increasing in N, i.e. $\frac{\partial q}{\partial N} > 0$.[13]

The entry decision is made at $t = 0$. At that moment, each prospective bank does not yet know its own (future) type. Each bank computes whether its expected profits from entering, knowing the (expected) competitive environment (including the number of banks already present), exceeds the cost of entry F.

To prevent complexity due to discontinuity in the number of banks, we let N be a continuous variable, such that N^* is determined by the equilibrium condition:

$$[1-\gamma]V_B(\nu_B^*) + \gamma V_G(\nu_G^*) = F, \tag{14}$$

where $V_B(\nu_B^*)$ is the value of the low quality bank at its equilibrium level of monitoring ν_B^* and $V_G(\nu_G^*)$ is the value of the good type bank at its optimal investment in monitoring technology ν_G^* (both net of funding costs).[14]

[TO BE COMPLETED]

5.2 Asymmetric Competition with Late Entrants

We have built our model in a way that banks initially differ only with respect to their type. The borrowers were initially equally spread between banks. Normally banks are already present in the financial system. A new bank enters late much harder, since it does not have its own pool of borrowers yet, but it has to gain them in the competition process.

[13] We also let $\frac{\partial [q/N]}{\partial N} < 0$. This is quite natural property that implies that the probability that a borrower gets an offer from one particular bank is decreasing in N, see (Boot and Thakor 2000).

[14] We assume that F is sufficiently small such that $N > 0$.

Thinking in the form of our model, we again assume that existing banks are either good or bad. The incumbency advantage and the difference between banks is high enough that banks choose different levels of monitoring as given in the separating Nash equilibrium. The borrowers are equally spread between banks. At this moment another bank is considering whether to enter the banking industry. However, the newly established bank has a large drawback with respect to the existing banks; it does not have its own pool of borrowers. The only possibility to get the borrowers is to persuade existing borrowers to switch from their incumbent banks to the new bank.

We assume that the new bank knows its own type before it enters, otherwise the entry would be practically completely blocked. First, we observe that a bank of bad type has no incentives to enter late. The new bank has exactly the same value as existing one of equal type lowered for the profits of the borrowers having not found a second offer. We know that in the separating Nash equilibrium the existing bad banks do not have any incentives to increase investment in monitoring to grasp additional borrowers from other banks of the same type. Consequently this deviation is not profitable for a late entering bad type bank as well.

Second when the new bank is of the good type it might enter if the difference in the quality between good and bad banks, the competition parameter q, and the proportion of bad banks in the sector are high enough. However, the profits that the new bank makes are considerably smaller than the profits of the other banks of the same type due to the absence of initial borrowers and the incumbency advantage.

To keep the pressure on the bad banks the regulator would like to permit new entry. The new bank enters the banking sector only if it is profitable for it to invest more in monitoring than the bad banks do. This increases the quality of the banking system and the level of monitoring as well (see Corollary 2) especially if we assume that the total number of banks on the market stays the same. Takeovers of domestic banks of bad type by a foreign bank of good type yet not being present in the market therefore improve the stability of the banking sector. In the consolidated financial system the entry costs do not play a mayor role in establishing a prudent banking sector as in the young financial system.

Lemma 2 *As the financial system consolidates, the regulator should lower the costs of entry in the banking industry F.*

5.3 One sided Competition

5.4 Endogenizing the Level of Capital

We now generalize our assumption that the capital requirement is binding. The regulator still sets a capital requirement but this as a minimum, and banks could choose a level of capital in excess of this. We let banks choose their level of capital at $t = 1$, aimultanously with choosing the optimal level of monitoring.[15]

Lemma 3 *Each bank selects as low level of capital as possible, being the regulatory capital requirements.*

Relaxing binding capital requirements to minimal capital requirements does not change our analysis. All banks still select the lowest capital requirements possible. Our result that banks would in any case try to lower their capital level to the lowest level possible corresponds with the theoretical literature (see Repullo (2004), Hellmann, Murdock, and Stiglitz (2000) and Repullo and Suarez (2004)). It is the consequense of the fact that the cost of capital is always higher than the cost of debt. Though the higher level of the monitoring might be profitable, there is no need to finance by higher level of capital. Even when a bank invests a lot in the monitoring technology it is more profitable to lower the level of capital. Even more, at any level of monitoring it is profitable to decrease the level of the capital ratio.

[15]The same results follow even if banks decide for the level of capital before they decide for their monitoring levels.

Now assume that on the market there exist two groups of banks. They are both of the same type meaning that they have the same cost function. However, they are differently regulated. The banks from the first group are bind to stricter capital regulation than the banks from the second group.

Lemma 4 *Increasing the level of capital requirements for one group of banks always increases the profits of the other group of banks. The profits of the first group might increase as well, but never for the same amount as of the other group.*

Lemma 5 *When the difference of the capital regulation between groups is small (CALCULATE CONDITION), banks in competition do not gain additional borrowers. Banks in milder regulatory environment have higher profits, however, they monitor less. When the difference in the capital regulation is high enough (CALCULATE THE CONDITION), the separating equilibrium exists where banks in milder regulatory environment grasp borrowers from the banks bind to stricter capital regulation.*

The last result is very useful to discuss the optimal alignment of the capital regulation among different countries. The banks do not gain an advantage when the capital regulation differs slightly. The national regulators can have free hands when deciding about the details of the capital regulation. They know better the conditions on the national markets and therefore they align the regulation closer to the specific needs of the national banking sector. However, there should be universal agreement on the rough level of the capital requirements to prevent unfair competition due to different capital standards.[16]

The result that banks always select the lowest capital ratio as possible relies on the assumption that the capital is costly. More specifically, the cost of capital is higher than the cost of debt plus the cost of fixed rate deposit insurance $\rho > r_D \nu_\tau$, where $\tau \in \{B, G\}$.

[16] Calomiris and Litan (2000) argue that the regulators should harmonize the certification requirements globally, such as minimal capital standards, however, they should compete on other regulatory objectives. Due to market pressure the banks would decide for the best regulation available.

Interesting further generalization of our model would be to consider the case where the cost of capital is more expensive than debt for a bad bank but less expensive than debt for the good bank, namely $\rho > r_D\nu_B^*$ and $\rho < r_D\nu_G^*$. The Proposition 3 would no longer hold, since the good banks have an incentive to finance only with the capital. The bad banks might try to imitate the good banks and select the same level of capital to prevent different pricing of the deposit insurance or might stick to the same level of capital announcing by that their type. Thus either separating or pooling equilibrium occurs.

6 Conclusion

7 The appendix

Proof of Proposition 1

To prove part *1.* note that at $R^{\max}(\nu_I + \epsilon|\text{no competition}) = Y$ the incumbent bank absorbs all surplus of the borrower, and that for any $R < R^{\max}(\nu_I + \epsilon|\text{no competition})$ the bank's revenue is lower. Hence $R = R^{\max}(\nu_I + \epsilon|\text{no competition})$.

Part *2.* follows directly from the arguments in the text leading up to Proposition 1. For $\nu_I \geq \nu_C + \epsilon$, the incumbent and competing banks will (as Bertrand competitors) compete, where the lowest offer acceptable to the competing bank is given in (1). The incumbent bank needs to offer $R \leq R^{\max}(\nu_I + \epsilon|\nu_C)$, and maximizes its profit at $R = R^{\max}(\nu_I + \epsilon|\nu_C)$, where $R^{\max}(\nu_I + \epsilon|\nu_C)$ is given in (2).

For $\nu_I + \epsilon < \nu_C$, similar arguments lead to $R^{\min}(\nu_I + \epsilon)$ as given in (3) as best offer of the incumbent bank. The competing bank now prevails by offering $R^{\max}(\nu_C|\nu_I + \epsilon)$ as given in (4).

■

Proof of Lemma 1

The proof of this lemma follows readily from the text. Observe that there are $N - 1$

other banks in the economy. The incumbent bank has a probability $q/[N-1]$ that it can compete for borrowers of any one of these banks. Recall that each of these banks has $1/N$ borrower. Thus the expected number of other borrowers that the incumbent bank can make an offer to is $[N-1] \times \frac{q}{N-1} \times \frac{1}{N} = \frac{q}{N}$.

■

Proof of Proposition 2

We prove this proposition in steps. We show: first, neither the bad nor the good bank benefits from deviating from ν_B^* or ν_G^* by extremely small amount; second the bad bank has no incentives to deviate from ν_B^* to $\nu_B \geq \nu_B^* + \epsilon$, where ϵ is the incumbency advantage of the bad banks; third the bad bank has no incentives to deviate from ν_B^* to $\nu_B \geq \nu_G^* - \epsilon$; fourth, the good bank has no incentives to deviate from ν_G^* to $\nu_G \geq \nu_G^* + \epsilon$; and last the bad bank has no incentives to deviate from ν_B^* to $\nu_B \geq \nu_G^* + \epsilon$.

1. First we will compute what are the values of bad and good banks respectively assuming that their investments in monitoring do not deviate from ν_B^* and ν_G^*. Using (12) and (13) note that inequality $\epsilon < K_u$ from Assumption 1 guarantees that $\nu_B^* + \epsilon < \nu_G^* - \epsilon$. Proposition 1 implies that the incumbent good bank can always overbid the bad one even when it is competing for new borrower. The incumbent bad bank,'to the contrary, always loses its borrower in competition with a good bank. In this case, the bad bank maximizes the following value function (see (11))

$$V_B = [1-q]\{-k/N + [\nu_B + \epsilon]X\} + q[1-\gamma][\nu_B + \epsilon - \nu_B^*]X - C_B(\nu_B). \tag{15}$$

Using (11) the value of the good bank is rewritten as

$$V_G = [1-q]\{-k\frac{1-q}{N} + [\nu_G + \epsilon]X\} + q\gamma[\nu_G + \epsilon - \nu_G^*]X + 2q[1-\gamma][\nu_G - \nu_B^*]X - C_G(\nu_G) \tag{16}$$

The bad and good banks decide for monitoring technology to maximize (15) and

(16) given the strategies ν_B^* and ν_G^* fixed:

$$\frac{\partial V_B}{\partial \nu_B} = [1-q]X + q[1-\gamma]X - C_B'(\nu_B^*) = 0 \quad (17)$$

$$\frac{\partial V_G}{\partial \nu_G} = [1-q]X + q\gamma X + 2q[1-\gamma]X - C_G'(\nu_G^*) = 0 \quad (18)$$

Expresing ν_B^* and ν_G^* from above equations we get (12) and (13). To verify that ν_B^* and ν_G^* are indeed maxima of V_G and V_B note also that $\frac{\partial^2 V_B}{\partial \nu_B^2} = -C_B''(\nu_B) < 0$ and similarly $\frac{\partial^2 V_G}{\partial \nu_G^2} = -C_G''(\nu_G) < 0$.

2. Incumbent bad bank might have incentives to increase investment in monitoring technology for ϵ or higher. In this case, it is able to attract new borrowers from all other banks. In spite of that, its value declines as we show now.

   When deviating the value of the bad bank becomes:

$$\hat{V}_B = [1-q]\{-k/N + [\hat{\nu}_B + \epsilon]X\} + 2q[1-\gamma][\hat{\nu}_B - \nu_B^*]X - C_B(\hat{\nu}_B). \quad (19)$$

   The value has increased by the term $q[1-\gamma][\hat{\nu}_B - \nu_B^*]X$ which denotes the expected rents due to gain of a new borrower from the bad bank.

   The bad bank has no incentives to deviate, when the expected value of the non-deviating bank is higher than that of the deviating one. Hence, it is enough to show

$$V_B - \hat{V}_B = [\nu_B^* - \hat{\nu}_B]\{1 + q[1-2\gamma]\}X + q[1-\gamma]\epsilon X + C_B(\hat{\nu}_B) - C(\nu_B^*) > 0$$

   The above inequality holds when

$$q[1-\gamma]\epsilon X > [\hat{\nu}_B - \nu_B^*]\left\{[1 + q[1-2\gamma]]X + \frac{C_B(\hat{\nu}_B) - C(\nu_B^*)}{\hat{\nu}_B - \nu_B^*}\right\},$$

   which is true when

$$\begin{aligned} q[1-\gamma]\epsilon X &> [\hat{\nu}_B - \nu_B^*]\left[\{1 + q[1-2\gamma]\}X - C_B'(\nu_B^*)\right] \\ q[1-\gamma]\epsilon X &> [\hat{\nu}_B - \nu_B^*]\left[\{1 + q[1-2\gamma]\}X - X[1-q\gamma]\right] \\ \epsilon &> \hat{\nu}_B - \nu_B^* \end{aligned}$$

We know that (19) has a maximum value in the level of monitoring $\hat{\nu}_B^*$ defined by

$$\{1 + q[1 - 2\gamma]\}X = C_B'(\hat{\nu}_B^*).$$

It is enough to show that

$$\epsilon > \hat{\nu}_B^* - \nu_B^* \quad (20)$$

Using functions determining $\hat{\nu}_B^*$ and ν_B^* we get

$$\epsilon > \hat{\nu}_B^* - \nu_B^* \quad = \quad \frac{C_B'^{-1}(\{1 + q[1 - 2\gamma]\}X) - C_B'^{-1}([1 - q\gamma]X)}{q[1 - \gamma]X} q[1 - \gamma]X$$

Above inequality is satisfied when

$$\epsilon > \hat{\epsilon}_B = \frac{Xq[1 - \gamma]}{C_B''(\nu_B^*)}.$$

Note that this is guaranteed by the condition $K_d < \epsilon$ from Assumption 1.

3. When the bad bank would invest in monitoring by similar amount as good bank does – $\tilde{\nu}_B \in (\nu_G^* - \epsilon, \nu_G^* + \epsilon)$, it would be able to size new borrowers in competition with bad banks (in similar manner as the good bank does) and keep its borrower in competition with good bank. We show that this strategy is not profitable.

   By deviating, the value of the bad bank would become

$$\tilde{V}_B = [1-q]\{-k/N + [\tilde{\nu}_B + \epsilon]X\} + q\gamma[\tilde{\nu}_B + \epsilon - \nu_G^*]X + 2q[1-\gamma][\tilde{\nu}_B - \nu_B^*]X - C_B(\tilde{\nu}_B). \quad (21)$$

   The optimal level of monitoring that the bad bank with the value function (21) would select we denote by $\tilde{\nu}_B^*$. It is obtained by maximization of (21) with respect to $\tilde{\nu}_B$:

$$\{1 + q[1 - 2\gamma]\}X = C_B'(\tilde{\nu}_B^*), \quad (22)$$

   Inequality $\epsilon < K_u$ in Assumption 1 assures that $\tilde{\nu}_B^* < \nu_G^* - \epsilon$. We know that $\tilde{\nu}_B$ is limited to the interval $\tilde{\nu}_B \in (\nu_G^* - \epsilon, \nu_G^* + \epsilon)$. Due to concavity of (21) it is optimal to select $\tilde{\nu}_B$ as close to $\tilde{\nu}_B^*$. The optimal choice is $\tilde{\nu}_B = \nu_G^* - \epsilon$. However, at this $\tilde{\nu}_B$

the deviating bad bank would gain zero rents from its incumbent borrowers that it would keep from escaping to other good bank. As a consequence, the bad bank would strictly prefer $\hat{\nu}_B$ from $\tilde{\nu}_B$. We have already showed that deviation to $\hat{\nu}_B$ is not profitable.

4. To prove that it is not profitable for a good bank to deviate to $\hat{\nu}_G$ where $\hat{\nu}_G > \nu_G^* + \epsilon$ is very similar to the first point of the proof. The deviating good bank would have a value of

$$\hat{V}_G = [1-q]\{-k/N+[\hat{\nu}_G+\epsilon]X+2q\gamma[\hat{\nu}_G-\nu_G^*]X+2q[1-\gamma][\hat{\nu}_G-\nu_B^*]X-C_G(\hat{\nu}_G). \quad (23)$$

We denote the optimal monitoring technology when deviating by $\hat{\nu}_G$ where

$$[1+q]X = C_G'(\hat{\nu}_G^*). \quad (24)$$

Calculating the difference of (16) and (23) we get

$$V_G-\hat{V}_G = [\nu_G^*-\hat{\nu}_G]X[1-q]+2q[1-\gamma][\nu_G^*-\hat{\nu}_G]X-2q\gamma[\hat{\nu}_G-\nu_G^*]X+\epsilon q\gamma X+C_G(\hat{\nu}_G)-C_G(\nu_G^*).$$

It is enough to prove that deviation to $\hat{\nu}_G^*$ is not value enchancing:

$$\epsilon q\gamma X > [\hat{\nu}_G^* - \nu_G^*]\left\{[1+q]X - \frac{C_G(\hat{\nu}_G^* - C_G(\nu_G^*)}{\hat{\nu}_G^* - \nu_G^*}\right\}$$

Due to convexity of $C_G(\nu_G)$ the above inequality is satisfied when

$$\begin{aligned} \epsilon q\gamma X &> [\hat{\nu}_G^* - \nu_G^*]\left\{[1+q]X - C_G'(\nu_G^*)\right\}, \\ \epsilon q\gamma X &> [\hat{\nu}_G^* - \nu_G^*]\left\{[1+q]X - X[1+q[1-\gamma]]\right\}, \\ \epsilon &> \hat{\nu}_G^* - \nu_G^* \end{aligned}$$

where we have used (18). The above inequality holds when

$$\begin{aligned} \epsilon &> \frac{C_G'^{-1}([1+q]X) - C_G'^{-1}(\{1+q[1-\gamma]\}X)}{q\gamma X} q\gamma X \\ \epsilon &> \frac{Xq\gamma}{C_G''(\nu_G^*)}. \end{aligned}$$

Note by inserting ν_G^* from (13) that this inequality is satisfied due to condition $K_d < \epsilon$ from Assumption 1.

5. Combining the second and the third point above and considering that deviation is more costly for a bad bank than it is for a good bank it is not profitable for a bad to deviate to $\nu_G^* + \epsilon$.

■

Proof of Corollary 1:

We want show that $\frac{\partial \nu_B^*}{\partial N} < 0$ and $\frac{\partial \nu_G^*}{\partial N} < 0$. Instead of derivating (12) and (13) we rather compute the derivative of (17) and (18) with respect to N:

$$\begin{aligned} [1-q\gamma]\frac{\partial X}{\partial N} - C_B''(\nu_B^*)\frac{\partial \nu_B^*}{\partial N} &= 0 \\ \{1+q[1-\gamma]\}\frac{\partial X}{\partial N} - C_G''(\nu_G^*)\frac{\partial \nu_G^*}{\partial N} &= 0 \end{aligned}$$

Considering that $\frac{\partial X}{\partial N} = \frac{\partial}{\partial N}\{Y - [1-k]r_D\}/N\rho = -X/N$ we get by rearanging

$$\begin{aligned} \frac{\partial \nu_B^*}{\partial N} &= \frac{-[1-q\gamma]X}{NC_B''(\nu_B^*)} < 0 \\ \frac{\partial \nu_G^*}{\partial N} &= \frac{-\{1+q[1-\gamma]\}X}{NC_G''(\nu_G^*)} < 0 \end{aligned}$$

■

Proof of Corollary 2:

Again we compute a derivative of (17) and (18) this time with respect to γ:

$$\begin{aligned} -qX - C_B''(\nu_B^*)\frac{\partial \nu_B^*}{\partial \gamma} &= 0 \\ -qX - C_G''(\nu_G^*)\frac{\partial \nu_G^*}{\partial \gamma} &= 0 \end{aligned}$$

Rearanging above equations we see that $\frac{\partial \nu_B^*}{\partial \gamma} < 0$ and $\frac{\partial \nu_G^*}{\partial \gamma} < 0$

The change in the average monitoring is:

$$\frac{\partial}{\partial \gamma}\{[1-\gamma]\nu_B^* + \gamma\nu_G^*\} = \nu_G^* - \nu_B^* - q\gamma X\left[\frac{1}{C_G''(\nu_G^*)} - \frac{1}{C_B''(\nu_B^*)}\right]$$

From Assumption 1 we know that $2\epsilon < \nu_G^* - \nu_B^*$ and that $\epsilon > \frac{q\gamma X}{C_G''(\nu_G^*)}$. From that we deduce

$$\frac{\partial}{\partial \gamma}\{[1-\gamma]\nu_B^* + \gamma\nu_G^*\} > \epsilon - \frac{q\gamma X}{C_G''(\nu_G^*)} > 0.$$

■

Proof of Corollary 3:

Again we compute the derivative of (17) with respect to k:

$$[1-q\gamma]\frac{\partial X}{\partial k} - C_B''(\nu_B^*)\frac{\partial \nu_B^*}{\partial k} = 0$$

By rearanging, we get

$$\frac{\partial \nu_B^*}{\partial k} = \frac{[1-q\gamma]r_D}{2\rho C_B''(\nu_B^*)} > 0 \tag{25}$$

For the good bank we proceed similarly, derivating (18) with respect to k:

$$\{1+q[1-\gamma]\}\frac{\partial X}{\partial k} - C_G''(\nu_G^*)\frac{\partial \nu_G^*}{\partial k} = 0$$

By rearanging, we get

$$\frac{\partial \nu_G^*}{\partial k} = \frac{\{1+q[1-\gamma]\}r_D}{2\rho C_G''(\nu_G^*)} > 0 \tag{26}$$

Note also that $\frac{\partial^2 \nu_B^*}{\partial k \partial \gamma} < 0$ and $\frac{\partial^2 \nu_G^*}{\partial k \partial \gamma} < 0$.

■

Proof of Proposition 3:

For the bad bank we compute the derivative of (17) with respect to q:

$$-\gamma X - C_B''(\nu_B^*)\frac{\partial \nu_B^*}{\partial q} = 0$$

Rearanging we get

$$\frac{\partial \nu_B^*}{\partial q} = -\frac{\gamma X}{C_B''(\nu_B^*)} < 0 \tag{27}$$

For the good bank we similarly compute the derivative of (18) with respect to q:

$$X[1-\gamma] - C_G''(\nu_G^*)\frac{\partial \nu_G^*}{\partial q} = 0$$

Rearanging we get

$$\frac{\partial \nu_G^*}{\partial q} = \frac{X[1-\gamma]}{C_G''(\nu_G^*)} > 0 \tag{28}$$

For both type of banks we used the concavity of the cost functions $C'''_\tau(\nu) > 0$. Note also that $\frac{\partial^2 \nu^*_\tau}{\partial q \partial \gamma} < 0$

■

Proof of Proposition 4:

We derivate (25) and (26) further with respect to q. Note that $\frac{\partial^2 \nu^*_B}{\partial k \partial q} < 0$ and $\frac{\partial^2 \nu^*_G}{\partial k \partial q} > 0$.

■

Proof of Lemma 3:

We show that the rents obtained from the initial borrower and from the borrower who obtains a second offer increase if the incumbent bank decreases capital ratio k_I given that the capital ratio of competing bank on the market stays at the level of k_C. Investments in monitoring technologies of incumbent and competing bank are given by ν_I and ν_C. We show that the value of the incumbent bank conditional on having monopoly, competition for its own borrower or for a new one is always decreasing in the level of capital the bank selects. An optimal strategy for a bank is always to select as low capital as possible.

$$L^{\text{mon}} = -k_I + \frac{\nu_I + \epsilon}{\rho}\{Y - [1 - k_I]r_D\}.$$

We compute $\frac{\partial L^{\text{Monopoly}}}{\partial k_I} = -1 + [\nu_I + \epsilon]\frac{r_D}{\rho} < 0$ since $\nu_I + \epsilon < 1$ and $\frac{r_D}{\rho} < 1$.

Similarly we show that the value of bank conditional of having competition for their initial borrowers is decreasing in the level of capital requirements.

$$L_I^{\text{comp}} = -k_I + k_C + \frac{1}{\rho}\{Y[\nu_I + \epsilon - \nu_C] - r_D[\nu_I + \epsilon - \nu_C]\} + \frac{\{k_I[\nu_I + \epsilon] - k_C\nu_C\}r_D}{\rho}$$

increases if the bank selects lower capital ratio k_I. We compute $\frac{\partial L_I^{\text{Competition}}}{\partial k_I} = -1 + [\nu_I + \epsilon]\frac{r_D}{\rho} < 0$ since $\nu_I + \epsilon < 1$ and $\frac{r_D}{\rho} < 1$. The same applies for L_I^{newbor}.

■

Proof of Lemma 4:

We assume that the capital requirements for both groups are close enough. In this case if the incumbency advantage is high enough the pooling equilibrium exists. The banks values can be written as:

$$\begin{aligned}
V_B &= [1-q]\{-k_B/N + [\nu_B + \epsilon]\}X_B + q[1-\gamma][\nu_B + \epsilon - \nu_B^{**}]X_B + \\
&+ q\gamma\{-\frac{k_B}{N} + \frac{k_G}{N} + [\nu_B + \epsilon]X_B - \nu_G^{**}X_G\} - C(\nu_B) \\
V_G &= [1-q]\{-k_G/N + [\nu_G + \epsilon]X_G\} + q\gamma[\nu_G + \epsilon - \nu_G^{**}]X_G + \\
&+ q[1-\gamma]\{-\frac{k_G}{N} + \frac{k_B}{N} + [\nu_G + \epsilon]X_G - \nu_B^{**}X_B\} - C(\nu_G)
\end{aligned}$$

where, $X_B = \{Y - [1-k_B]r_D\}/N\rho$ and $X_G = \{Y - [1-k_G]r_D\}/N\rho$.

Now we can compute the change of values of both banks when the capital requirements for one group increase. We prove it for the capital requirements of the group of bad banks:

$$\begin{aligned}
\frac{\partial V_B}{\partial k_B} &= -\frac{1-q}{N} + [1-q]\nu_B^{**}\frac{r_D}{N\rho} + [1-q]\epsilon\frac{r_D}{N\rho} - \frac{q\gamma}{N} + \\
&+ \epsilon\gamma[\nu_B^{**} + \epsilon]\frac{r_D}{N\rho} + q[1-\gamma]\epsilon\frac{r_D}{N\rho}
\end{aligned}$$

Rearanging we get:

$$\frac{\partial V_B}{\partial k_B} = \frac{1-q[1-\gamma]}{N}[-1 + \frac{r_D}{\rho}\nu_B^{**}] + \frac{\epsilon}{N}\frac{r_D}{\rho}$$

Similarly we show for the good bank

$$\frac{\partial V_G}{\partial k_B} = \frac{q[1-\gamma]}{N}[1 - \frac{r_D}{\rho}\nu_B^{**}] + \frac{\epsilon}{N}\frac{r_D}{\rho} > 0$$

In addition,

$$\frac{\partial V_G}{\partial k_B} - \frac{\partial V_B}{\partial k_B} = 1 - \frac{r_D}{\rho}[\nu_B^{**} + \epsilon] > 0$$

■

Proof of Lemma 5:

The proof is similar to the proof for Proposition 2 and Proposition 5 and is therefore ommited.

Proposition 5 *A pooling Nash equilibrium of the simultaneous game at $t = 2$ consists of strategies $\{\nu_B^{**}, R_B^{**}\}$ for the bad bank and $\{\nu_G^{**}, R_G^{**}\}$ for the good bank where ν_B^{**} and ν_G^{**} are computed as*

$$\nu_B^{**} = C_B'^{-1}(X) \quad (29)$$

$$\nu_G^{**} = C_G'^{-1}(X) \quad (30)$$

if the following condition is satisfied:

$$\epsilon > C_G'^{-1}([1+q]X) - C_B'^{-1}(X) \quad (31)$$

Proof of Proposition 5:

The proof is similar to proof of Proposition 2.

The condition (31) guarantees that when in the equilibrium the good banks are not able to grasp additional non-incumbent borrowers from the competition from other bad banks due to the small difference in cost function of both type of banks and due to high incumbency advantage. Condition (31) assures that $\nu_G^{**} < \nu_B^{**} + \epsilon$. The values of both banks when neither type can win the non-incumbent borrowers are computed from (11):

$$V_B^{**} = -k\frac{1-q}{N} + [1-q]\nu_B X + q[1-\gamma][\nu_B - \nu_B^{**}]X + q\gamma[\nu_B - \nu_G^{**}]X + \epsilon X - C_B(\nu_B).$$
$$V_G^{**} = -k\frac{1-q}{N} + [1-q]\nu_G X + q\gamma[\nu_G - \nu_G^{**}]X + q[1-\gamma][\nu_G - \nu_B^{**}]X + \epsilon X - C_G(\nu_G).$$

From there we can compute optimal monitoring technologies as given in (29) and (30).

We prove that the good banks have no incentives to try to win the non-incumbent borrowers from other good and bad banks when (31) is satisfied. To see this, note that if the good bank decides to deviate to win the non-incumbent borrowers from other good and bad banks its value becomes the same as in the separating Nash equilibrium when the good bank decides to deviate to win the borrowers of other good banks and is given by (23). Therefore, the optimal monitoring in the case of deviating is the same as given in (24). The bank would not want to deviate as long as its value decreases when deviating:

$$\begin{aligned}\hat{V}_G - V_G^{**} &= [1-q][\hat{\nu}_G - \nu_G^{**}]X + q\gamma[\hat{\nu}_G - \nu_G^{**}]X + 2q[1-\gamma][\hat{\nu}_G - \nu_B^{**}]X - \\ &- q[1-\gamma][\nu_G^{**} - \nu_B^{**}]X + [1-q]\epsilon X - \epsilon X - C_G(\hat{\nu}_G) + C_G(\nu_G^{**}) < 0\end{aligned}$$

Using (30) to get $X[\hat{\nu}_G - \nu_G^{**}] = C_G'(\nu_G^{**})[\hat{\nu}_G - \nu_G^{**}] < C_G(\hat{\nu}_G) - C_G(\nu_G^{**})$ above inequality can be rewritten to

$$-q[1-\gamma][\hat{\nu}_G - \nu_G^{**}]X \quad + \quad 2q[1-\gamma][\hat{\nu}_G - \nu_B^{**}]X - q[1-\gamma][\nu_G^{**} - \nu_B^{**}]X < q\epsilon X$$

Observing that $1-\gamma < 1$ and rearranging a bit above inequality we get (31).

As long as (31) is satisfied the deviation to the optimal level of monitoring for deviant bank ν_G^* is not profitable. Thus deviation to other level of monitoring is even less profitable.

The good bank can yield most when deviating and attracting both borrowers from other bad and good banks. If this deviation is not profitable neither is the deviation to try to reach out and win only the borrowers from other bad banks. In addition, when condition (31) is satisfied, the bad banks do not find the deviation profitable as well.

Since it is not profitable for the good banks to deviate to higher monitoring levels to grasp additional non-incumbent borrowers from the bad banks it is even less possible for the bad banks to increase the level of monitoring to get additional customers from the good banks.

■

The condition (31) guarantees that the incumbency advantage is so high that the good banks do not have incentives to try to win the market of the bad banks. In the pooling equilibrium the competition has no effect on the monitoring levels of the banks since all banks are shielded perfectly with high incumbency advantage from the competition of the other banks. The banks with higher level of monitoring thus do not get any additional market share.

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$t = 0$:

♠ The regulator sets the capital requirements k and the entry costs F.

♠ Banks enter the banking industry (if applicable).

$t = 1$:

♠ Each borrower is matched with a bank.

♠ Each bank discovers its type.

♠ Banks invest in monitoring technology

♠ Banks choose their level of capital (if applicable)

♠ Each borrower gets an initial offer from his bank.

$t = 2$:

♠ Each borrower searches for a competing bank.

♠ If a second bank materializes the incumbent bank and the 'second bank' simultaneously give their competing offers, and the borrower chooses the best offer. If no second bank is available, only the borrower's first offer is available.

♠ Each bank collects the necessary capital and deposits and funds its borrowers.

♠ The borrower undertakes his project.

$t = 3$:

♠ Payoffs are realized.

Figure 1: Time line