Competition and Entry in Banking: Implications for Capital Regulation*

Arnoud W. A. Boot[†]   and   Matej Marinč[‡]

January 18, 2009

[†]Amsterdam Center for Law & Economics (ACLE), University of Amsterdam, and CEPR, Roetersstraat 11, 1018WB Amsterdam, The Netherlands, *email*: a.w.a.boot@uva.nl.

[‡]University of Ljubljana, Kardeljeva ploščad 17, 1000 Ljubljana, Slovenia, *email*: matej.marinc@ef.uni-lj.si, and Amsterdam Center for Law & Economics (ACLE), University of Amsterdam, Roetersstraat 11, 1018WB Amsterdam, The Netherlands, *email*: m.marinc@uva.nl.

Competition and Entry in Banking: Implications for Capital Regulation

Abstract

We assess how capital regulation interacts with the degree of competitiveness of the banking industry. In particular, we ask two questions: i) how does capital regulation affect endogenous entry; and ii) how do changes in the competitive environment affect bank monitoring choices and the effectiveness of capital regulation? In an environment where banks are heterogeneous in quality and compete for market share, we show that increasing costly capital requirements leads to *more* entry into banking, essentially by reducing the competitive strength of lower quality banks. We show that an implication of this is that banks may want the regulator to impose a higher capital requirement on the industry than is socially optimal. We also show that competition improves the monitoring incentives of better quality banks and deteriorates the incentives of lower quality banks; and that precisely for those lower quality banks competition typically compromises the effectiveness of capital requirements.

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 the interaction is between competition and the effectiveness of regulation. In this paper, we particularly ask two questions: i) how does capital regulation affect endogenous entry; and ii) how do changes in the competitive environment affect bank monitoring choices and the effectiveness of capital regulation?

The importance of these issues is unquestionable. The increasingly dynamic environment of banking puts severe strains on the viability and effectiveness of regulation. Competition also affects the behavior of the players in the industry directly. More competition could induce banks to take more risks, which could undermine the stability of the industry (see Vives (2001) for a review). Simultaneously, there is a concern about the impact of capital regulation on the competitive dynamics, including level playing field issues.

We analyze these issues in an industrial organization framework in which we distinguish multiple banks and let banks differ in quality. These quality differences are linked to the banks' abilities in monitoring borrowers and affect the profitability and riskiness of their lending operations. 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 increasing interbank competition – that is, opening up locally segmented markets for cross-market competition (holding the total number of banks fixed) – improves the monitoring incentives of better quality banks and deteriorates the incentives of lower quality banks, and that precisely for those lower quality banks competition typically also compromises the effectiveness of capital requirements. These results point at the difficulty of introducing more competition in protected markets when the local banking system is of low(er) quality.[1]

When we permit endogenous entry, we get arguably the most striking result of our

---

analysis. We show that existing work has overlooked a key benefit of increasing capital requirements in that it reduces the competitive strength of lower quality banks vis-a-vis high(er) quality banks, and in doing so could encourage entry. These insights complement observations by practitioners and policymakers who have sometimes argued that the real contribution of the existing Basel I capital requirements is that it has improved the stability of the financial system by discouraging 'fly-by-night operators'. This cleansing effect of capital regulation also gives a moment of pause for the ambitions of the new Basel II capital requirements. Trying to differentiate capital requirements between banks and tailor them to the exact risks taken by these institutions might truly be of secondary importance if raising capital requirements across the board has had such favorable effect on the industry.

While increasing (costly) capital requirements always has a cleansing effect on the industry by discouraging weaker banks, the net effect on entry is positive only when there are sufficiently many lower quality banks in the economy *and* local banking markets are not fully segmented, i.e. interbank competition should be feasible such that market share can be captured from lower quality banks. In such an environment there is a distinct benefit to discouraging lower quality banks that exceeds the direct cost that costly capital requirements impose on the industry.

The reason why capital requirements work against the competitive strength of low quality banks deserves some further discussion. In our analysis, this is a consequence of deposit insurance. As long as the deposit insurance premium cannot be made fully type (and/or risk) dependent, deposit insurance effectively subsidizes low quality banks relative to high(er) quality banks. This makes low quality banks more competitive than they would otherwise have been, and makes it more difficult for good banks to gain market share at their expense. The consequence of this is that lending rates are pushed down by the over-competitive low quality banks, and this discourages entry. Increasing capital requirements mitigates this by reducing the deposit insurance subsidy for lower quality banks, thereby reducing their competitive strength and encouraging entry.[2]

---

[2]Allowing for quality differences introduces effects similar to the ones analyzed in the industrial organization literature that focuses on non-price competition through product differentiation (see for example Shaked and Sutton (1982)). Interfirm reallocations to more productive firms are also analyzed in the trade literature (see Melitz (2003) and Syverson (2004)).

In an extension, we analyze the effects of asymmetric competition, i.e. one country that opens up its banking system to competition but not vice versa. The key result here is that higher capital requirements *always* encourage entry of existing foreign banks in a previously closed low quality (weak) banking market. We also show that the threat of entry has a positive impact on merger incentives in such weak domestic banking market.

We also ask the question how the social welfare maximizing level of capital requirements relates to the banks' privately optimal choices of capital, and particularly to the level of capital requirements that the banks would prefer the regulator to impose on the industry. We show that banks may want to have the regulator impose a level of capital requirements that exceeds the social welfare maximizing level.

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. Section 4 analyzes how interbank competition affects the effectiveness of the capital requirements. In Section 5, we endogenize entry and analyze how entry is affected by changes in capital requirements. Section 6 discusses extensions and robustness issues. The social welfare analysis and empirical predictions are contained in Section 7. Section 8 concludes.

2 The Model

2.1 Preliminaries

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

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

which might be beneficial to their borrowers.[3]

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. 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. Thus our paper is related to studies of the role of capital in reducing risk-taking, see for example Hellmann, Murdock, and Stiglitz (2000).[4] We assume that bank management is aligned with shareholders.

The regulator sets the capital requirement and provides deposit insurance.

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). We have 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, and banks decide on their investments in monitoring technology. 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 collects the necessary capital and deposits, makes the loan, and the borrower invests. 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. A borrower's project has a return of

---

[3]See Boot and Thakor (2000) and Ongena and Smith (2000) for reviews of relationship banking. Relationship lending is a choice for a particular intermediation technology with extensive investments in processing borrower specific information and contrasts to more distant transaction lending.

[4]Allen, Carletti, and Marquez (2007) analyze a related rational for capital. In their analysis institutions choose capital in response to lending market induced market discipline. In Morrison and White (2005) raising capital requirements could be an appropriate response to counter a confidence crises.

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, and hence normalize ν_j to $\nu_j \in [0, 1]$. All other things equal, when a borrower can choose between two competing offers, he will choose the bank with the highest ν_j.[5] The aggregate demand for loans from all borrowers is normalized to 1.

Depositors and providers of capital: 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 matters we assume that this premium is included in the gross costs of deposits. Hence, the cost of deposits is $r_D > r_f$. Banks face a binding capital requirement k. They collect this proportion k of the total funds needed from the providers of bank capital and $[1 - k]$ from depositors.

Capital is costly. We let the cost of capital equal ρ, where $\rho > r_D$.[6]

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 bank is matched with $1/N$ of the borrowers.[7] Banks then learn whether their type τ is good (G) or bad (B), thus $\tau \in \{B, G\}$, 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. Banks have an intrinsic monitoring ability $\underline{\nu}_\tau$, with $0 < \underline{\nu}_B < \underline{\nu}_G$. A bank can increase its monitoring ability to a higher level ν at a cost $\frac{c}{2}[\nu - \underline{\nu}_\tau]^2$.[8]

Competitive environment: Competition between banks occurs in two phases. In the first phase (at $t = 1$), all N banks get allocated $1/N$ of the total borrowers. Each bank specifies an interest rate offer R for its allocated borrowers. At $t = 2$, borrowers succeed in locating

---

[5] Actually, we will assume (see later) that a borrower can only switch at a cost. Consequently, the incumbent bank has an incumbency advantage, and the competing (second) bank needs to overcome this when making its offer.

[6] See Holmstrom and Tirole (1997) and Diamond and Rajan (2000) for explicit models of why the cost of capital might be higher than the return that depositors demand. Note that this assumption bypasses the question *how* capital is raised, including potential adverse selection problems.

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

[8] Using a generalized cost function satisfying the Inada conditions produces similar results but at a cost of substantial complexity.

a competing offer with probability q. With probability $[1-q]$, they do not find a competing offer. When the latter happens, borrowers have no choice but to accept the initial offer, provided this gives them a non-negative expected return. When a second bank is found, both the initial (incumbent) and the second bank compete as Bertrand competitors. We assume that at this stage the borrowers and the competing banks can observe the monitoring technology adopted by each bank and their types. Each borrower then chooses for the bank that gives the highest expected return net of funding costs.[9]

One additional consideration is that if a borrower switches to a competing bank, he incurs a fixed switching cost S. This friction allows the incumbent bank to earn rents even if the competing bank is equally capable. In other words, the incumbent bank effectively has an incumbency advantage vis-a-vis the competing banks.

3   Initial Analysis: Some Basic Results

We solve the model using backward induction. We first determine the strategies and the valuation of the incumbent bank at $t = 2$ conditional on the levels of investment in monitoring technology ν_j. Subsequently, we compute the optimal investments in monitoring technology ν_j at $t = 1$, anticipating the events at $t = 2$.

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. The bank can always improve on this offer when its borrower succeeds in obtaining a competing offer. The incumbent bank optimally sets the interest rate equal to the maximum payoff of the borrower such that it obtains all surplus when competition would not materialize; thus

$$R^{\max}(\nu_I | \text{no competition}) = Y. \tag{1}$$

At $t = 2$, the borrower finds with probability q a competing bank; with probability $[1-q]$

---

[9]This formulation is qualitatively identical to a Hotelling framework. It gives us rents in the banking system that are decreasing in the level of interbank competition q, similar to a Hotelling-type specification with transaction costs that are decreasing in q. Actually choosing a Hotelling framework would have complicated our analysis substantially given the heterogeneity across banks that we have.

the borrower only has access to the offer of the incumbent bank. When the borrower has no access to a competing offer, he accepts the monopolistic offer and loses all rents. When the borrower has a competing offer, both banks compete for the borrower as Bertrand competitors.

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 each of the N banks gets 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.

A bank maximizes its market value of equity, i.e. its expected profits net of costs of debt, discounted by the cost of capital. The value that the incumbent bank derives from its $1/N$ initial borrower, conditional on having no competing offer, equals

$$V(\nu_I|\text{no competition}) = \frac{1}{N}\{-k + \nu_I \frac{R^{\max}(\nu_I|\text{no competition}) - [1-k]r_D}{\rho}\}.$$

The bank then obtains all surplus. Inserting (1), we can write

$$V(\nu_I|\text{no competition}) = \frac{1}{N}\{-k + \frac{\nu_I X}{\rho}\}, \tag{2}$$

where $X \equiv Y - [1-k]r_D$.

The value that the incumbent bank derives from its borrower when he obtains a competing offer is computed as follows. The lowest interest rate $R^{\min}(\nu_C)$ that a competing bank with investment in monitoring technology ν_C is just willing to offer follows from its zero NPV condition[10]

$$-k + \frac{\nu}{\rho}\{R^{\min}(\nu_C) - [1-k]r_D\} = 0. \tag{3}$$

The incumbent bank is able to outbid the competing bank if it can make an offer such that the borrower obtains a surplus at least equal to what he could obtain with the best

---

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

competing bank's offer $R^{\min}(\nu_C)$. We proceed as follows. The maximum interest rate that the incumbent can charge the borrower without losing him to a competitor with $\nu = \nu_C$ is $R^{\max}(\nu_I|\nu_C)$, where $R^{\max}(\nu_I|\nu_C)$ is such that the borrower is indifferent between this offer and the best offer of the competing bank. That is,

$$\nu_I[Y - R^{\max}(\nu_I|\nu_C)] = \nu_C[Y - R^{\min}(\nu_C)] - S, \tag{4}$$

where we have taken into account that the borrower incurs a switching cost S when he switches to the competing bank.

Conditional on a competing bank being present with monitoring technology ν_C, the value that the incumbent bank derives from its initial borrower if it decides to respond with offer $R^{max}(\nu_I|\nu_C)$ is

$$V(\nu_I|\text{competition}, I \text{ responds}) = \frac{1}{N}\{-k + \nu_I \frac{R^{\max}(\nu_I|\nu_C) - [1 - k]r_D}{\rho}\}.$$

Using (3) and (4), we can rewrite this as

$$V(\nu_I|\text{competition}, I \text{ responds}) = \frac{S + [\nu_I - \nu_C]X}{\rho N}.$$

If $S + [\nu_I - \nu_C]X < 0$, the incumbent bank is not willing to respond (i.e. does not offer $R^{\max}(\nu_I|\nu_C)$) and hence the competing bank prevails. The value that the incumbent bank derives from its initial borrower then equals zero. In total,

$$V(\nu_I|\text{competition}) = \max(0, \frac{S + [\nu_I - \nu_C]X}{\rho N}). \tag{5}$$

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, the value that it derives from the possibility

of getting this new borrower is

$$V(\nu_I|\text{new borrower}) = \max(0, \frac{-S + [\nu_I - \nu_C]X}{\rho N}). \tag{6}$$

The expression (6) is very similar to (5), but note that the incumbency advantage now works against 'our bank'.

An useful result relates to the expected number of other borrowers that a bank can make an offer to:

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

To see this, 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 borrower of any one of these banks.[11] 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 $[N-1] \times \frac{q}{N-1} \times \frac{1}{N} = \frac{q}{N}$.

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 any incumbent bank can bid in expected value for the fraction q/N of borrowers of other banks. The actual outcome will depend on the quality differentials between banks and their potentially different levels of (investment in) monitoring technology.

We will now derive the equilibrium investments in monitoring technology. At $t = 1$, the N banks first learn their types, and then individually choose their levels of investment in monitoring technology. We consider a simultaneous move game, 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 S. More specifically, we assume,

---

[11]For this, see 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.

Assumption 1: $\frac{X^2}{c\rho N} < S < [\underline{\nu}_G - \underline{\nu}_B]X.$

This assumption can be explained as follows. The lower bound on the incumbency advantage ensures that when an incumbent bank competes with a bank of equal quality its incumbency advantage prevails. That is, this competing bank of equal quality will not find it optimal to overcome the incumbency disadvantage by choosing a much higher investment in monitoring technology. Without incumbency advantage this could be optimal because capturing the incumbent bank's borrower offers scale advantages justifying the higher investment in monitoring technology. The incumbency advantage makes this strategy too costly and ensures that banks of the same type will choose identical strategies, i.e. they will choose the same level of investment in monitoring technology. Thus banks of the same type will not grab market share at each others expense.

The upper bound on the incumbency advantage ensures that quality matters in competition; 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 banks choose ν_C^j, where j refers to one of the other $[N-1]$ banks. We can now write the expected value of the incumbent bank of type τ, $\tau \in \{B, G\}$, net of funding costs, as

$$V_\tau(\nu_I) = \frac{1-q}{N}[-k + \frac{\nu_I X}{\rho}] + \frac{q}{\rho N}\sum_{j=1}^{N-1}\frac{1}{N-1}\max(0, S + [\nu_I - E(\nu_C^j)]X) +$$

$$+ \frac{q}{\rho N}\sum_{j=1}^{N-1}\frac{1}{N-1}\max(0, -S + [\nu_I - E(\nu_C^j)]X) - c\frac{[\nu_I - \nu_\tau]^2}{2}. \tag{7}$$

In (7), the first expression is the bank's profitability when there is no competition, see (2). This happens with probability $[1-q]$. The second expression is the expected profit on its initial borrower when there is competition, see (5). The summation is over all $[N-1]$ competing banks. The third expression is the incumbent bank's profit from successfully attracting borrowers away from other banks, as given in (6). The last expression is the cost

of investing in monitoring technology.

Each bank maximizes its analogous expression (7). We now have the following result.[12]

Proposition 1. *There exists a separating Nash equilibrium consisting of the strategies ν_B^* for the bad banks and ν_G^* for the good banks, where ν_G^* and ν_B^* equal*

$$\nu_B^* = [1 - q\gamma]\frac{X}{c\rho N} + \underline{\nu}_B, \tag{8}$$

$$\nu_G^* = \{1 + q[1 - \gamma]\}\frac{X}{c\rho N} + \underline{\nu}_G. \tag{9}$$

From this proposition it readily follows that in equilibrium good banks choose a strictly higher level of monitoring than bad banks.[13] That is, when comparing (9) and (8) we see that good banks have a higher intrinsic monitoring ability than bad banks ($\underline{\nu}_G > \underline{\nu}_B$), and invest more in additional monitoring because of their anticipated gains in market share due to competition. To see this, observe that ν_G^* is positively affected by the competition parameter q, while q affects ν_B^* negatively.

We can now derive a corollary that relates to the effect of capital requirements on monitoring incentives.

Corollary 1. *Higher capital requirements improve the monitoring incentives of both good and bad type banks.*

Capital requirements favorably affect monitoring incentives in our model because higher capital forces banks to internalize more risk which in turn reduces risk taking incentives, implying more monitoring.[14] This is a typical result, and follows from the objective function of banks in our analysis; i.e. banks maximize the value of capital.

---

[12]We impose restrictions to guarantee that the monitoring choices are in the interior and the borrowers' projects are sufficiently attractive that all banks are willing to provide funding. These restrictions are shown to be compatible with Assumption 1 (see the proof of Proposition 1).

[13]When good and bad banks are very similar to each other and the incumbency advantage is very 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 prevents any type of bank from profiting from non-incumbent borrowers. In absence of an incumbency advantage (again a violation of Assumption 1), no equilibrium exists in pure strategies.

[14]Recall from the specification of the model in Section 2 that higher monitoring increases the expected returns on the projects. Strictly speaking, it only reduces risks for all $\nu_\tau > 1/2$.

4   Interbank Competition and the Effectiveness of Capital Regulation

We continue to hold the number of banks N fixed; in Section 5, we will allow for entry. Our focus for now is on interbank competition. The key question analyzed is how relaxing barriers between existing banks (inducing more interbank competition) affects the strategies of banks and the effectiveness of capital 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 home markets by foreign players, but also themselves challenge other banks in their home markets. The reasons for this include globalization, developments in information technology and deregulation. In particular, the developments in information technology could potentially allow banks to enlarge their geographic area of operations without having a local presence in those markets; this possibly reduces the competitive advantage 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 a competing second offer. We 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 own $1/N$ borrower with probability q, but it also gets access to an equal number of borrowers (in expectation) from other banks, see Lemma 1. Thus, in expected value sense, the number of borrowers at risk equals the number it could gain. A bank's actual success depends both on its inherent quality and on its investment in monitoring technology relative to that of its competitors.

We will now analyze how relaxing barriers to competition between existing banks, i.e. increasing q, affects monitoring incentives and the effectiveness of capital regulation. Following this, we analyze how capital requirements affect the values of good and bad banks.

We first analyze the effect of competition on monitoring incentives. From Proposition 1 we can directly show that

Corollary 2. *Increasing interbank competition (higher q; holding the number of banks N*

fixed) decreases the optimal level of monitoring of bad banks (ν_B^*) but increases the optimal level of monitoring of good banks (ν_G^*).

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

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

A related question is what happens to the effectiveness of capital requirements when competition heats up. From Corollary 1 we know that higher capital requirements increase the investments in monitoring technology by both types. What we show next is that competition *strengthens* this positive effect for good banks, but weakens it for bad banks.

Proposition 2. *Higher interbank 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.*

The intuition for this is directly related to that of Corollary 2. 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 strengthened 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 undermines those of bad banks both directly (anticipating the smaller market share) and indirectly via reducing the effectiveness of capital regulation. This has implications for regulatory policy. Most importantly, competition undermines the

effectiveness of capital regulation precisely for those banks for which it is needed most, i.e. the bad banks. For higher quality banks competition positively impacts the effect of capital regulation on monitoring incentives. Since elevating interbank competition also has a direct positive effect on monitoring incentives for high quality banks, competition and stability go hand in hand. For bad banks the opposite holds.[15]

The differential impact of capital regulation on good and bad banks is further highlighted when we look at the effect of capital regulation on the values of good and bad banks. We can derive the following proposition.

Proposition 3. *Higher capital requirements* always *reduce the value of a bad bank* $V_B(\nu_B^*)$, *but increase the value of a good bank* $V_G(\nu_G^*)$ *as long as interbank competition is sufficiently strong (high q) and the quality of banking industry is sufficiently low (not too high γ).*

The key to understanding this result is that capital regulation has two effects. The first effect is that capital imposes a cost on each bank because capital is more expensive than deposits. This, in isolation, reduces the value of each bank, and is the result we are familiar with. However, a second more subtle effect is at work as well: capital regulation reduces the deposit insurance subsidy that goes to low quality banks. That is, flat-rate deposit insurance is most valuable to bad banks, and this makes them artificially stronger competitors.[16] Capital regulation mitigates this and helps good banks capture higher rents when competing with bad banks. This has a positive impact on the value of good banks, and reduces the value of bad banks.

Proposition 3 shows that the positive effect of capital regulation on the value of a good bank depends crucially on q and γ. Good banks can only gain from higher (costly) capital requirements when this allows them to gain market share from bad banks. This is the case, when banks can compete for each others borrowers (q high) and enough bad banks to gain

---

[15]A qualification can be made. Diversification effects across banks are not present in our model. Consequently, only the success probability matters for stability. For good banks this success probability is positively affected by competition via an increase in monitoring incentives. But competition generally reduces rents and this could negatively affect stability when we take into account diversification effects. What we then get is that – taking into account diversification effects – competition has a smaller positive effect on stability for good banks. For bad banks things would become even worse.

[16]In a very different analysis Winton (1997) argues that deposit insurance may facilitate entry by effectively underwriting de novo banks that investors are not familiar with.

market share from are present (γ not too high).

To understand this further, let's reexamine the competition between good and bad type banks. We focus on the case where an incumbent good bank faces competition from a bad bank. The rents that the good bank earns equal, see (5), $\frac{1}{\rho N}[S + [\nu_G^* - \nu_B^*]\{Y - [1 - k]r_D\}]$. Observe that these rents are increasing in the capital requirement k. This is the consequence of the negative effect that capital requirements have on the rents that a bad bank derives from the flat-rate deposit insurance; this reduces its competitive strength and benefits the good banks. To see this, note that a good bank faces a net cost of deposits equal to $\nu_G^*[1 - k]r_D$ while this is for a bad bank $\nu_B^*[1 - k]r_D$. Since $\nu_G^* > \nu_B^*$ deposits are effectively subsidized for bad banks. This mispricing of flat-rate deposit insurance thus unfairly helps bad banks, and makes them fiercer competitors for good banks. Higher capital requirements partially eliminate this distortionary effect.

Proposition 3 gives an intriguing perspective on the impact of capital requirements. Capital requirements, despite their costs, could benefit good banks under well defined circumstances. In Section 5 we explore this further, and focus in particular on the impact of capital requirements on entry, i.e. we endogenize N.

The competition that we have analyzed so far focuses on interbank competition. In the model this means that we focus on q, while keeping the number of players N fixed. In the context of two countries that introduce cross border competition, our results show that the country with low quality banks will become even riskier and the country with high quality banks gains and becomes safer. The direct consequence is that opening up borders is bad for the stability of a low quality banking system and good for the stability of a high quality banking system.

Similarly, the effectiveness of capital regulation is typically negatively affected in a low quality system, yet favorably affected in a high quality system. The impact of capital regulation on the valuation of banks is different as well. Low quality banks always lose value while high quality banks gain value as long as the quality of the banking system is sufficiently low and q, the parameter of interbank competition, is sufficiently high.

5 Endogenous Entry

We will now allow for entry in banking by endogenizing the number of banks N. The probability that a 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. $\frac{\partial q}{\partial N} > 0$.[17]

We first analyze how monitoring choices and bank values are affected by N, the number of banks in the economy. Subsequently, we endogenize N.

Lemma 2. *An increase in the number of banks N decreases both the investments in monitoring, ν_G^* and ν_B^*, and the values of banks, $V_G(\nu_G^*)$ and $V_B(\nu_B^*)$.*

This lemma is intuitive. A higher number of banks reduces the anticipated market share of each bank, and this discourages investments in monitoring technology.

We now endogenize N, and hence allow for entry. The entry decision is made at $t = 0$. At that moment, each prospective bank does not yet know its own (future) type, but assesses its expected quality based on the cross sectional probability distribution $\{\gamma, [1-\gamma]\}$. Each bank computes whether its expected profits from entering exceed the cost of entry F, anticipating the competitive environment (including the number of banks already present).[18]

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

$$[1 - \gamma]\bar{V}_B^* + \gamma\bar{V}_G^* = F. \tag{10}$$

The values $\bar{V}_B^*$ and $\bar{V}_G^*$ are the equilibrium valuations of the bad, respectively good banks at the point where $N = N^*$.

We are particularly interested at how capital regulation affects entry. The next proposition shows that higher capital requirements could encourage entry. The competition parame-

---

[17]Observe that q can still be largely determined by local institutional arrangements. We also let $\frac{\partial [q/N]}{\partial N} < 0$. This is a quite natural property that implies that the probability that a borrower gets his competing (second) offer from any one particular bank is decreasing in N.

[18]We consider the following simple entry procedure: banks decide on entering sequentially in random order. Note that the order does not matter because all prospective entering banks are identical, and assess their quality based on the cross sectional probability distribution $\{\gamma, [1 - \gamma]\}$.

ter q is the one that obtains in equilibrium before we change the level of capital requirements.

Proposition 4. *The effect of capital regulation on entry is as follows:*

1. *When competition is low ($q < \bar{q}$), higher capital requirements decrease entry.*

2. *When competition is high ($q \geq \bar{q}$), higher capital requirements:*

   (a) *increase entry for $\gamma \in [\gamma_1(q), \gamma_2(q)]$;*

   (b) *decrease entry for $\gamma \in [0, \gamma_1(q)) \cup (\gamma_2(q), 1]$.*

This proposition points at a striking feature of capital regulation: higher capital requirements induce more entry into the industry when the banking industry is rather heterogeneous, i.e. $\gamma \in [\gamma_1(q), \gamma_2(q)]$, and interbank competition is sufficiently high ($q \geq \bar{q}$). To see this note first that higher capital requirements can only induce more entry when they positively affect the value of good banks (otherwise, following Proposition 3, both the bad and the good banks' valuations would be decreasing in the level of capital requirements which would for sure lead to less entry). Proposition 3 then tells us that the level of interbank competition q should be sufficiently high, and γ should not be too high. What Proposition 4 shows is that for higher capital requirements to induce more entry, we need a lower bound on γ as well. This can be easily understood. If γ is too low, a prospective entering bank believes that it will turn out to be of low quality as well. In that case, it expects its value to be negatively affected by higher capital requirements (see Proposition 3), which discourages it from entering.[19]

We can now analyze what happens to the effectiveness of capital regulation as an instrument to encourage monitoring when entry is endogenous. Observe that in the absence of endogenous entry (see Corollary 1) capital regulation always has a positive impact on monitoring incentives. We are now ready to prove the following corollary that shows that this positive impact could be dampened by endogenous entry.

---

[19]Thus the banking industry needs to be sufficiently heterogeneous; γ close to one or close to zero make the industry effectively rather homogeneous.

Corollary 3. *The effects of capital requirements on the investments in monitoring technology for both good and bad banks are weakened when capital regulation encourages entry and strengthened when capital regulation induces less entry.*

Corollary 3 in combination with Proposition 4 offers some challenges for regulators. Capital regulation has a direct positive effect on the investments in monitoring technology (Corollary 1), but this effect is mitigated by the higher entry that capital regulation could induce (Case 2a in Proposition 4). What this points at is that under circumstances like those in Case 2a restrictions on entry could improve on the effectiveness of capital regulation.

If capital regulation discourages entry (Cases 1 and 2b), the effectiveness of capital regulation is actually enhanced and hence entry restrictions would be redundant.

6   Model Extensions and Robustness Issues

In this section, we first analyze model extensions involving one-sided competition. That is, in the context of two countries we let one country open up its banking system while the other country keeps its banking system closed. We also analyze how domestic merger incentives are affected by cross-border competition. Subsequently, we focus on robustness issues.

6.1   Model Extensions

So far our analysis has focused on symmetric competition. That is, for banks of the same type, the expected gain in market share (stealing borrowers from other banks) equals in expected value sense the potential loss they face in their own market, see the discussion following Lemma 1. We now let one country open its domestic banking market, while the second country keeps its market closed. We seek to answer the question whether countries should single-handedly free up their banking markets or whether this should be done on a reciprocal basis only.

We proceed as follows. The country that opens up its market we call the 'open' country (country O). The country that keeps its banking market closed but whose bank is allowed to enter country O we call the 'attacking' country A. This means that a bank from country

A can enter country O, but not vice versa. Since we also want to analyze later whether domestic mergers are an effective response to the threat of competition from foreign banks, we assume that there are two domestic banks in country O, but just one in country A. To make matters interesting, the bank in country A is good otherwise it would never be able to enter country O. We let all banks be of equal size. We distinguish two cases. In Case 1, both banks in country O are bad; in Case 2, the banks are good.

Proposition 5.

Case 1 – **The domestic banks in country O are good:** *The banks in country O hold on to their market share and do not change their investments in monitoring technology, but their values decrease because of extra competition from opening up the market. For the bank in country A nothing changes.*

Case 2 – **The domestic banks in country O are bad:** *The banks in country O lose market share and value; the good bank from country A now gains market share and value. Anticipating the loss of market shares, the banks in country O reduce their investments in monitoring technology while the bank in country A increases its investment.*

The results in this proposition are quite straightforward. When the domestic banks in the country that opens up are good (Case 1) they can hold on to their market, and also their investments in monitoring technology remain intact. If the banks are bad (Case 2), they will lose out to the foreign competitor and market share is lost. Anticipating this, the domestic banks in country O will reduce their levels of investment in monitoring and hence increase their riskiness (and instability goes up).

Following Corollary 1 (simultaneously) increasing capital requirements could offset the negative impact that entry has on monitoring and risk in country O when banks in that country are bad. We can show however that this will (further) encourage entry.

Corollary 4. *The attractiveness of entering country O when the banks in that country are bad is increasing in the level of the capital requirements.*

This corollary contrasts to the results in Proposition 4. There we showed that higher capital requirements encourage de novo entry only when q is high enough and γ takes on

19

interior values. This corollary shows that an *existing* foreign bank finds it *always* more profitable to enter a new market when capital requirements are higher. Corollary 4 provides the interesting empirical implication that in countries with relatively weak banks increasing capital requirements facilitates entry of foreign banks.[20]

Next, we ask the question whether opening up borders encourages domestic mergers. And if so, are merging incentives elevated more for good than for bad domestic banks? We can prove the following.[21]

Corollary 5. *For any small positive entry cost to the foreign entrant the threat of entry (weakly) increases the value of merging for bad domestic banks, but has no effect on the merger incentives of high quality domestic banks.*

The reason that a threat of entry encourages weak domestic institutions to merge is because of scale economies. Without such threat domestic banks enjoy a relatively high valuation as stand-alone entities. Particularly for weak institutions this value is at risk when entry comes about. While allowing domestic institutions to merge helps them protect market share and preserve monitoring incentives, it simultaneously prevents the influx of higher quality banks. This suggests that opening such domestic market should allow for takeovers of weak domestic institutions by foreign entrants.

6.2 Robustness Issues

There are three main robustness issues to be addressed. The first is the source of the competitive distortion in this paper, i.e. the mispricing of deposit insurance that introduces

---

[20]We do not allow for different capital requirements being imposed on foreign versus domestic banks (see Dell'Ariccia and Marquez (2006)). Note also, that entry in Proposition 4 was analyzed from the perspective of a de novo bank that did not yet know its type, while in Corollary 4 the existing bank knows that it is good. Observe however that if the de novo bank in Proposition 4 knows that it is good for sure, it would be more likely to enter in response to higher capital requirements only when q is high (see also Proposition 3). In Corollary 4 we do not need this restriction. A potentially more important consideration is that we have implicitly assumed that the fixed-cost based monitoring technology of a bank is equally useful across borders. If that is not the case, entry would be complicated and effectively imply de novo entry in the market with a scale disadvantage vis-a-vis existing players.

[21]To simplify the analysis we assume that the foreign bank faces a small positive entry cost. Note that without entry cost even if the foreign entrant would not succeed in obtaining market share upon entry, it would affect the valuations of good domestic banks (see Proposition 5). The latter effect is not present when there is an entry cost.

cross subsidies. Second, the modelling of the monitoring technology of banks, and particularly the fixed cost nature of this technology. And finally, the assumption in the analysis that capital requirements are binding.

Deposit insurance: Lack of contractability generally makes it infeasible to have deposit insurance premiums be fully risk-based (i.e. type and risk dependent) and effectively introduces cross-subsidies. It is important to note that systemic concerns in the banking industry create all kinds of other cross-subsidies and interdependencies. For example, many agree that the functioning of the banking sector depends crucially on the confidence that the public has in the financial system at large. Any of such interdependencies could induce similar competitive distortions as analyzed in this paper.

Monitoring technology: The result on the positive impact of bank capital regulation on entry does not depend on the endogeneity and fixed cost nature of monitoring. Just assuming that the banking system is sufficiently heterogeneous and higher quality banks are better at monitoring (i.e. the ν_j's are exogenous, with $\nu_G > \nu_B$) would have been sufficient. Mispricing of deposit insurance – with implicit subsidies to lower quality banks – would again make weak banks artificially strong competitors and capital regulation would mitigate this.

Where having endogeneity in monitoring does become important is in analyzing the impact of interbank competition (q) and entry on the effectiveness of capital regulation, and more directly where we focus on the impact of interbank competition and entry on monitoring choices. These interactions crucially depend on monitoring being endogeneous.

Another caveat relates to the fixed cost nature of the monitoring technology. This causes scale economies to enter the analysis (including also the need for the incumbency friction S). While scale economies might certainly be present in banking (see Focarelli and Panetta (2003)), we could have done without this feature and have allowed for intertemporal information reusability instead, as in Petersen and Rajan (1995). That is, in monitoring a borrower information might become available that can be used in future periods as well. Since good banks are more likely to be around in the future, we would, as in (8) and (9), have good banks monitor more than bad banks. In such setting, similar results on the effects of capital regulation, interbank competition and entry could have been obtained.

21

Capital requirements: We have assumed that capital requirements are binding. This seems to be in contrast with the empirical findings that banks on average choose levels of capital well above the minimum (see Flannery and Rangan (2004)). However, our analysis shows that capital requirements are really needed to control low quality banks that seek to maximize the deposit insurance subsidy. These banks have little interest in being well capitalized. Thus, key is that what makes capital requirements important is their cleansing effect on low quality 'fly by night operators'. As we will also see in Section 7.1, the industry as a whole might benefit from having capital requirements imposed across the board even if they are redundant for high quality operators.

7 Social Welfare and Empirical Predictions

In this section, we do two things. We first analyze what the optimal capital requirements are from a social welfare point of view and how this relates to the private incentives of banks. Subsequently, we focus on the empirical predictions that are generated by our analysis.

7.1 Social Welfare

In the analysis so far we have assumed that the capital requirements set by the regulator are binding. But what level of capital would banks prefer? Proposition 3 shows that for q sufficiently high and γ relatively low, a good bank wants the regulator to impose a higher capital requirement on the industry. This will elevate its value.[22] This is consistent with the 'cleansing role' of capital that we have identified. However, a bad bank would always prefer capital requirements to be set as low as possible. As Proposition 3 shows, its value is decreasing in the level of the capital requirements. For now we hold the number of banks N fixed.

The question we would like to answer is how the level of capital requirements preferred by good banks compares to the welfare optimal level. Observe that the welfare optimal

---

[22]The regulator imposes a uniform capital standard on the industry which is consistent with the lack of observability of bank type ex ante in our setting. If capital requirements could be made contingent on bank type, good banks would prefer that the regulator imposes capital requirements only on bad banks.

level of capital requirements takes into account the externality that banks impose on the deposit insurer. That is, a failure of a bank typically imposes a loss on the deposit insurer. Since banks do not bear these losses, they would not have an incentive to privately choose capital to reduce this externality. As is well known, in a homogeneous banking industry this will always put the welfare maximizing level of capital above the level that banks choose privately (see Hellmann, Murdock, and Stiglitz (2000) and Repullo (2004)). However, the heterogeneity in banking quality in our analysis gives good banks an incentive to favor high(er) capital because this reduces the competitive strength of bad banks. Actually, in the spirit of Proposition 4, we can prove that a bank that does not know its quality might favor positive capital requirements. That is,

Proposition 6. *For sufficiently high interbank competition q, $q > \hat{q}$, and intermediate values of γ, banks prefer that the regulator imposes a positive level of capital on the industry.*

The intuition is similar to that of Proposition 4. Imposing positive (costly) capital requirements helps banks in that it reduces the competitive strength of bad banks. This holds when interbank competition q is sufficiently high, and 'enough' bad banks are present (γ not too high) and the banks' expectations about their own quality are not too low (lower bound on γ needed).

Proposition 6 offers some interesting insights in that it shows that in a heterogeneous industry capital requirements are desired by the industry itself. This contrasts with a homogeneous industry where banks privately would set capital as low as possible. Observe that this contrast is somewhat subtle. In a heterogeneous industry banks would *individually* choose low capital, but realize that they are better off if the regulator enforces high(er) capital levels across the industry. So banks prefer capital regulation to be present.[23]

What the preceding discussion implies is that we have uncovered a new rational for capital regulation. Banks, realizing that the competitive playing field will be spoiled by

---

[23]In our analysis capital regulation and capital levels are committed to *prior* to banks discovering their type (and borrowers discovering bank type). Hence, the chosen levels of capital do not reveal information about type. If we would allow banks to choose their levels of capital *after* getting to know their own type, this would make bad banks interested at choosing a positive level of capital only if that could prevent borrowers from finding out the banks' low quality (i.e. they then may want to mimic good banks). Observe that this will create a very sophisticated competition game between banks for borrowers because the latter would not know the quality of banks making offers and hence would have difficulty choosing between offers.

some that will turn out to be of low quality later, prefer that capital regulation is put in place to guarantee a more balanced competitive environment.

We have not yet given an answer to the question how the level of capital that the banks want to have imposed relates to the socially optimal level of capital. Recall that the regulator wants to have capital regulation in place to limit the losses to the deposit insurance fund, while banks may desire capital regulation to guarantee a 'balanced' competitive environment. In deciding on the welfare optimal level of capital, the regulator maximizes the total surplus of banks, borrowers and deposit insurance fund.[24] We now establish that the private optimum may exceed the welfare maximizing level of capital requirements.

Proposition 7. *For high values of interbank competition q, $q > \bar{q}$ (with $\bar{q} \geq \hat{q}$), and intermediate values of γ, banks prefer that the regulator imposes capital requirements that are strictly above the welfare optimal level.*

The intuition is that the level of capital that banks would want to have imposed is increasing in the level of interbank competition q; i.e. at higher q it becomes more important to contain the competitive distortion that low quality banks inflict. In the limit (for q high enough), k approaches 1. The regulator's optimum for the level of capital is, however, always strictly less than one. To see this note that for k approaching 1, banks no longer fund themselves with deposits and hence the externality imposed on the deposit insurer vanishes. Thus, the regulator's choice of capital would – given its cost – never approach 1.[25]

7.2   Empirical Predictions

Our analysis produces several predictions that should be brought to the data. Various pieces of existing empirical evidence are available and will be discussed where applicable. An important step in testing the various predictions is distinguishing between the two competition measures, q and N. The measure q reflects the intensity of competition between existing

---

[24]Observe that this implies that the regulator does not care about competition per se (only the total surplus of banks and borrowers matters). In the welfare optimization we have not taken into account the potential externality that bank instability could impose on the economy at large.

[25]We have not analyzed what happens when we allow for entry. Under the conditions of Proposition 6 this will weaken the banks' preferences for positive capital requirements.

banks. The other measure of competition is the number of banks N. Observe that in the model q is the probability with which borrowers can get a competing offer. This is affected by the number of banks N in the market, but is also (or even primarily) determined by institutional factors like the degree of stringency of anti-trust enforcement. The number of banks N also measures bank size and degree of concentration.

The predictions are as follows:

i. Increasing the interbank competition measure q shifts market share from bad to good banks. This follows from the discussion surrounding Proposition 1. Good banks benefit from a higher q and gain market share, while bad banks lose market share. This prediction is supported by Stiroh and Strahan (2003) who observe that competition reallocates assets from badly performing banks to good ones.

ii. Interbank competition (increasing q) undermines stability in a low quality banking market but strengthens it in high quality banking markets. This prediction follows from the results in Corollary 2. There is some supporting evidence for this. In particular Boyd and De Nicolo (2005), and Beck, Demirgüç-Kunt, and Levine (2005) show that competition and stability could go hand in hand. Our analysis points at the importance of the quality of the banking system for this to hold.

iii. The interbank effectiveness of capital regulation in discouraging risk taking is negatively affected by interbank competition (q) for low quality banks but not so for high quality banks. This follows from Proposition 2 that shows that for bad (good) banks capital is less (more) effective in encouraging monitoring when competition heats up.

iv. Raising capital requirements positively affects the values of good banks when interbank competition (q) is sufficiently high and the average quality of the banking system is not too high (see upper bound on γ in Proposition 3). The value of bad banks is always negatively affected. A way of testing this prediction is by looking at the valuation effects of the introduction of higher capital requirements.

v. Strengthening capital requirements encourages entry in banking markets that are

25

rather heterogeneous (i.e. of *intermediate* quality) and sufficiently competitive (high q), otherwise it discourages entry. This follows from Proposition 4.

vi. Increasing the number of players N in the industry (such that average market shares are diluted) reduces investments in monitoring technology and reduces the effectiveness of capital regulation for all banks. This prediction follows from Lemma 2 and Corollary 3 and comes from the scale economies in the monitoring technology. What this prediction implies is that augmenting competition via the number of players N differs radically from augmenting competition via the openness parameter q. As predictions ii. and iii. show, increasing q has a favorable effect on high quality banks.

vii. Strengthening capital requirements helps existing banks enter weak foreign banking markets. This prediction directly follows from the result in Corollary 4, and complements the effects of strengthening capital requirements identified in prediction v.

viii. The threat of foreign entry encourages mergers between domestic institutions in weak banking systems, but not in high quality banking systems. This result follows from Corollary 5.

8   Conclusion

We believe that this paper adds some key insights to understanding the interaction between competition and regulation. Allowing for heterogeneity in bank quality shows that capital regulation has a significant impact on the competitive dynamics. The most striking conclusion from our analysis is that increasing costly capital requirements encourages entry when banking markets are sufficiently heterogeneous and open for interbank competition. This result comes from the distortions that flat-rate deposit insurance introduces in banking. Implicitly such deposit insurance benefits lower quality banks most, and makes them fiercer competitors than they otherwise would have been. Capital requirements are an effective regulatory tool that mitigates this distortion, and in doing so increases the value of entry. This points at a complementarity between capital regulation and deposit insurance that goes

further than the typical insight that capital regulation mitigates the risk taking incentives induced by deposit insurance. Capital requirements have a 'cleansing' effect mitigating the artificial competitive advantage of low quality banks that deposit insurance induces.

This insight also addresses a potential criticism of our analysis. We have assumed that capital requirements are binding, however, in the real world we often see banks operate at levels of capital significantly above the regulatory minimum (see Flannery and Rangan (2004)). Note however that in our analysis capital plays a crucial role in disciplining lower quality banks, and precisely for these riskier banks capital regulation should be expected to be binding. Our analysis shows that capital regulation protects higher quality banks (and the financial system at large) from low quality 'fly by night' operators.

An arguably less surprising insight from our analysis is that competition weakens low quality banking systems even further, including the effectiveness of capital regulation in such systems, while strengthening high quality banking systems. This result confirms the anxiety that regulators may have about opening up their weak domestic banking markets to foreign competition; the stability consequences could be quite negative. However, it would be wrong to use this as an argument against opening up domestic markets. Rather, it points at the way in which domestic markets should be opened to competition. Our paper shows that having low quality domestic banks compete with higher quality foreign banks will cause substantial instability. Anticipating loss in market share, the weak domestic banks will cut back on investments in monitoring and in doing so elevate their riskiness. This may not happen if foreign entry leads to takeovers of domestic institutions. Such takeovers would not cause a reduction in monitoring since market share is no longer at risk.

In future work, the optimality of capital regulation and deposit insurance deserves further study. The optimality of these instruments in face of the even more competitive environment of banking is a key public policy issue. This paper has taken these arrangements as given, and focused on their impact on the competitive dynamics. The good news that we have uncovered is that capital requirements help mitigate the competitive distortions that deposit insurance induces.

Appendix

Proof of Lemma 1

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 1

Conjecture that good banks prevail over incumbent bad banks, and when banks of the same type compete, the incumbency advantage prevails. Using (7) we have

$$V_B = \frac{1-q}{N}[-k + \frac{\nu_B X}{\rho}] + \frac{q}{\rho N}[1-\gamma]\{S + [\nu_B - \nu_B^*]X\} - c\frac{[\nu_B - \underline{\nu}_B]^2}{2}, \tag{11}$$

$$V_G = \frac{1-q}{N}[-k + \frac{\nu_G X}{\rho}] + \frac{q\gamma}{\rho N}\{S + [\nu_G - \nu_G^*]X\} + \frac{2q}{\rho N}[1-\gamma][\nu_G - \nu_B^*]X - c\frac{[\nu_G - \underline{\nu}_G]^2}{2}. \tag{12}$$

The first terms in (11) and (12) represent the profits of the incumbent bank from its borrower without a competing offer. This happens with probability $[1-q]$. With a probability q, the borrower finds a competing bank. A bad incumbent bank only retains its borrower when he gets the second offer from another bad bank. This happens w.p. $q[1-\gamma]$, see the second term in (11). A good bank can retain its incumbent borrower when he gets an offer from another good bank. This occurs w.p. $q\gamma$, see the second term in (12). In addition, a good bank retains its incumbent borrower when he receives an offer from a bad bank. This happens w.p. $q[1-\gamma]$. Moreover, it can grab new borrowers from other bad banks, also with the same probability $q[1-\gamma]$, see the third term in (12).

Implicitly in (7), (11) and (12), we have assumed that the borrowers' projects are sufficiently profitable such that banks are willing to lend. Whether a bank succeeds in holding on to, or acquiring a borrower depends on its own strength (quality and investment in monitoring technology), the strength of its competitor and the incumbency advantage. A sufficient condition for this is

$$-k + \frac{\nu_B X}{\rho} - \frac{S}{\rho} > 0. \tag{13}$$

The condition (13) implies that a bad bank at the minimum monitoring level $\underline{\nu}_B$ can profitably lend to a borrower of another bank. Each type maximizes its own value holding the strategy of the other type fixed. Use (11) and (12) to get

$$\frac{\partial V_B}{\partial \nu_B}(\nu_B^*) = \frac{1-q}{\rho N}X + \frac{q}{\rho N}[1-\gamma]X - c[\nu_B^* - \underline{\nu}_B] = 0, \tag{14}$$

$$\frac{\partial V_G}{\partial \nu_G}(\nu_G^*) = \frac{1-q}{\rho N}X + \frac{q}{\rho N}\gamma X + 2\frac{q}{\rho N}[1-\gamma]X - c[\nu_G^* - \underline{\nu}_G] = 0, \tag{15}$$

which imply (8) and (9). Note from (14) and (15) that $\frac{\partial V_B}{\partial \nu_B}(\nu_B = 0) > 0$ and $\frac{\partial V_G}{\partial \nu_G}(\nu_G = 0) > 0$. This shows that each bank's investment in monitoring technology is positive. Note also that the second order conditions are negative. Thus, the optimal levels of monitoring are (8) and (9). Insert $\nu_B = \nu_B^*$ and $\nu_G = \nu_G^*$ from (8) and (9) in (11) and (12) to get

$$V_B^* = \frac{1-q}{N}[-k + \frac{\underline{\nu}_B X}{\rho}] + q[1 - \gamma]\frac{S}{\rho N} + \frac{X^2}{2c[\rho N]^2}\{1 - 2q + q^2[2 - \gamma]\gamma\}, \tag{16}$$

$$V_G^* = \frac{1-q}{N}[-k + \frac{\underline{\nu}_G X}{\rho}] + q\gamma\frac{S}{\rho N} + \frac{2q[1 - \gamma]}{\rho N}[\underline{\nu}_G - \underline{\nu}_B]X + \frac{X^2}{2c[\rho N]^2}\{[1 - q]^2 - q^2\gamma^2\}. \tag{17}$$

Now we check that (8) and (9) indeed satisfy our conjectures. Assumption 1 guarantees that $[\underline{\nu}_G - \underline{\nu}_B]X > S$. Use this and (8) and (9) to get $[\nu_G^* - \nu_B^*]X > S$, hence

$$\nu_G^* X - S > \nu_B^* X. \tag{18}$$

The expression in (18) implies that a good bank prevails over an incumbent bad bank; an incumbent good bank then prevails over a competing bad bank.

We show next that for a good bank it is not profitable to increase its level of monitoring sufficiently to steal borrowers from other good banks, i.e. to deviate from ν_G^* to $\hat{\nu}_G \gg \nu_G^*$. Use (7) to compute the value of a good bank which chooses the level of monitoring $\hat{\nu}_G$,

$$\hat{V}_G = \frac{1-q}{N}[-k + \frac{\hat{\nu}_G X}{\rho}] + 2\frac{q}{\rho N}\gamma[\hat{\nu}_G - \nu_G^*]X + 2\frac{q}{\rho N}[1 - \gamma][\hat{\nu}_G - \nu_B^*]X - c\frac{[\hat{\nu}_G - \underline{\nu}_G]^2}{2}. \tag{19}$$

Maximizing (19) w.r.t. $\hat{\nu}_G$ gives,

$$\hat{\nu}_G^* = \underline{\nu}_G + [1 + q]X/c\rho N. \tag{20}$$

Insert $\hat{\nu}_G = \hat{\nu}_G^*$ from (20) in (19) and use (8) and (9) to get

$$\hat{V}_G^* = \frac{1-q}{N}\{-k + \frac{\underline{\nu}_G X}{\rho}\} + \frac{2q[1 - \gamma]}{\rho N}[\underline{\nu}_G - \underline{\nu}_B]X + \frac{X^2}{2c[\rho N]^2}[1 - q]^2. \tag{21}$$

To show that the deviation to $\hat{\nu}_G^*$ is not profitable, observe from (21) and (17) that

$$V_G^* - \hat{V}_G^* = \frac{q\gamma}{\rho N}S - \frac{X^2}{2c[\rho N]^2}q^2\gamma^2. \tag{22}$$

Since $\frac{X^2}{c\rho N} < S$ (see Assumption 1), it immediately follows that the expression in (22) is positive, hence a good bank will not steal borrowers from other good banks.

We now show that a bad bank does not have an incentive to increase its investment in moni-

toring from ν_B^* to $\hat{\nu}_B \gg \nu_B^*$ to attract borrowers from other bad banks. From (7) we have

$$\hat{V}_B = \frac{1-q}{N}[-k + \frac{\hat{\nu}_B X}{\rho}] + 2\frac{q}{\rho N}[1 - \gamma][\hat{\nu}_B - \nu_B^*]X - \frac{c}{2}\hat{\nu}_B^2. \tag{23}$$

Maximizing (23) with respect to $\hat{\nu}_B$ gives

$$\hat{\nu}_B^* = \{1 + q[1 - 2\gamma]\}X/c\rho N + \underline{\nu}_B. \tag{24}$$

Insert $\hat{\nu}_B = \hat{\nu}_B^*$ from (24) in (23) and use (8) to get

$$\hat{V}_B^* = \frac{1-q}{N}\{-k + \frac{\underline{\nu}_B X}{\rho}\} + \frac{X^2}{2c[\rho N]^2}[1 - q]^2. \tag{25}$$

Observe that the deviation to $\hat{\nu}_B^*$ is not profitable (use (16) and (25)),

$$V_B^* - \hat{V}_B^* = q[1 - \gamma]\frac{S}{\rho N} - \frac{X^2}{2c[\rho N]^2}q^2[1 - \gamma]^2. \tag{26}$$

Since $\frac{X^2}{c\rho N} < S$ (see Assumption 1), it follows that (26) is positive, and a bad bank will not steal borrowers from other bad banks.

We now show that an incumbent bad bank has no incentive to increase its investment in monitoring technology to $\tilde{\nu}_B \gg \nu_B^*$ to hold on to its borrower when competing with a good bank. If a bad bank chooses $\tilde{\nu}_B$, we have (use (7)),

$$\tilde{V}_B = \frac{1-q}{N}[-k + \frac{\tilde{\nu}_B X}{\rho}] + \frac{q}{\rho N}\gamma\{S + [\tilde{\nu}_B - \nu_G^*]X\} + 2\frac{q}{\rho N}[1 - \gamma][\tilde{\nu}_B - \nu_B^*]X - c\frac{\tilde{\nu}_B^2}{2}. \tag{27}$$

Maximizing (27) with respect to $\tilde{\nu}_B$ gives

$$\tilde{\nu}_B^* = \{1 + q[1 - \gamma]\}X/c\rho N + \underline{\nu}_B. \tag{28}$$

Insert $\tilde{\nu}_B = \tilde{\nu}_B^*$ from (28) in (27) and use (8) and (9) to get

$$\tilde{V}_B^* = \frac{1-q}{N}\{-k + \frac{\underline{\nu}_B X}{\rho}\} + q\gamma\frac{S - [\underline{\nu}_G - \underline{\nu}_B]X}{\rho N} + \frac{X^2}{2c[\rho N]^2}\{[1 - q]^2 - q^2\gamma^2\}. \tag{29}$$

Use (16) and (29) to see that,

$$V_B^* - \tilde{V}_B^* = q\gamma\frac{[\underline{\nu}_G - \underline{\nu}_B]X - S}{\rho N} + q[1 - \gamma]\frac{S}{\rho N} - \frac{X^2}{2c[\rho N]^2}q^2[1 - 2\gamma]. \tag{30}$$

Since $\frac{X^2}{c\rho N} < S$ and $S < [\underline{\nu}_G - \underline{\nu}_B]X$ (see Assumption 1), we see that (30) is positive, and hence an incumbent bad bank will not try to hold on to its borrower when competing with a good bank.

Finally, note from (8) and (9) that the following condition guarantees that ν_G^* and ν_B^* are in

30

the interior for all $q, \gamma \in [0, 1]$,

$$2X/c\rho N + \underline{\nu}_G < 1. \tag{31}$$

The conditions (13), (31) and Assumption 1 are easily simultaneously satisfied (e.g. choose X high enough to satisfy (13), and then choose sufficiently high N to satisfy Assumption 1 and (31)). ■

Proof of Corollary 1

Differentiate (8) and (9) w.r.t. k and recall that $X \equiv Y - [1 - k]r_D$, to get

$$\frac{\partial \nu_B^*}{\partial k} = \frac{[1 - q\gamma]r_D}{c\rho N} \quad \text{and} \quad \frac{\partial \nu_G^*}{\partial k} = \frac{\{1 + q[1 - \gamma]\}r_D}{c\rho N}, \tag{32}$$

which are both positive. ■

Proof of Corollary 2

Differentiate (8) and (9) with respect to q, to get

$$\frac{\partial \nu_B^*}{\partial q} = -\frac{\gamma}{c\rho N}X < 0 \quad \text{and} \quad \frac{\partial \nu_G^*}{\partial q} = \frac{1 - \gamma}{c\rho N}X > 0. \tag{33}$$

Thus, competition increases the investment in monitoring for a good bank, but not for a bad bank.
■

Proof of Proposition 2

Differentiate both expressions in (32) with respect to q to get

$$\frac{\partial^2 \nu_B^*}{\partial q \partial k} = -\frac{\gamma}{c\rho N}r_D < 0 \quad \text{and} \quad \frac{\partial^2 \nu_G^*}{\partial q \partial k} = \frac{1 - \gamma}{c\rho N}r_D > 0.$$

Hence, interbank competition elevates the effectiveness of capital regulation for a good bank, but not for a bad bank. ■

Proof of Proposition 3

Differentiating (16) with respect to k and rearranging gives

$$\frac{\partial V_B^*}{\partial k} = [\underline{\nu}_G - \underline{\nu}_B]\frac{r_D}{\rho N}\{-[1 - q]\alpha - \zeta[1 - q^2[2 - \gamma]\gamma]\}, \tag{34}$$

where we have used the following definitions

$$\alpha \equiv \frac{1 - r_D\underline{\nu}_B/\rho}{[\underline{\nu}_G - \underline{\nu}_B]r_D/\rho} - \frac{2X}{c\rho N[\underline{\nu}_G - \underline{\nu}_B]} \quad \text{and} \quad \zeta \equiv \frac{X}{c\rho N[\underline{\nu}_G - \underline{\nu}_B]} > 0. \tag{35}$$

Rewrite α as $\alpha = 1 + \frac{1 - r_D\underline{\nu}_G/\rho - 2Xr_D/c\rho^2 N}{[\underline{\nu}_G - \underline{\nu}_B]r_D/\rho}$. Substitute for $\underline{\nu}_G$ from (31) to get

$$\alpha > 1 + \frac{1 - \frac{r_D}{\rho}[1 - 2X/c\rho N] - \frac{2Xr_D}{c\rho^2 N}}{[\underline{\nu}_G - \underline{\nu}_B]r_D/\rho}. \tag{36}$$

31

Rearrange (36) to get $\alpha > 1 + \frac{1 - r_D/\rho}{[\nu_G - \nu_B]r_D/\rho} > 1$. Note from the definition of ζ in (35) and the fact that $\frac{X^2}{c\rho N} < [\nu_G - \nu_B]X$ (see Assumption 1) that $\zeta < 1$. Thus,

$$\alpha > 1 \quad \text{and} \quad 0 < \zeta < 1. \tag{37}$$

Note that $\gamma[2 - \gamma]$ is maximized for $\gamma = 1$. Use this and (37) in (34) to see that $-[1 - q]\alpha - \zeta[1 - q^2[2 - \gamma]\gamma] \leq -[1 - q]\alpha - \zeta[1 - q^2] < 0$. This implies that $\frac{\partial V_B^*}{\partial k} < 0$, and proves that the value of a bad bank is always negatively affected by stricter capital requirements.

For a good bank, use (17) to see that

$$\frac{\partial V_G^*}{\partial k} = [\nu_G - \nu_B]\frac{r_D}{\rho N}\{-[1 - q]\alpha + 1 + q[1 - 2\gamma] - \zeta[1 - q^2[1 - \gamma^2]]\}. \tag{38}$$

Observe that for $q = 0$, the expression (38) simplifies to $\frac{\partial V_G^*}{\partial k}\Big|_{q=0} = [\nu_G - \nu_B]\frac{r_D}{\rho N}[-\alpha + 1 - \zeta]$, which (using (37)) is always negative. In addition, note that

$$\frac{\partial V_G^*}{\partial k}\Big|_{q=1,\gamma=0} = 2[\nu_G - \nu_B]\frac{r_D}{\rho} > 0.$$

Observe that $\frac{\partial V_G^*}{\partial k}$ is monotonically increasing in q and decreasing in γ. By continuity, capital regulation increases the value of a good bank for q sufficiently high and γ sufficiently low. ∎

Proof of Lemma 2
We need to show that ν_B^* and ν_G^* are decreasing in N. Differentiate (8) and (9) with respect to N,

$$\frac{\partial \nu_B^*}{\partial N} = -\frac{[1 - q\gamma]X}{c\rho N^2} - \frac{\gamma X}{c\rho N^2}\frac{\partial q}{\partial N}, \tag{39}$$

$$\frac{\partial \nu_G^*}{\partial N} = -\frac{\{1 + q[1 - \gamma]\}X}{c\rho N^2} - \frac{1 - \gamma}{c\rho N}[\frac{q}{N} - \frac{\partial q}{\partial N}]. \tag{40}$$

Note that the ratio q/N is subject to the regularity condition, $\frac{\partial[q/N]}{\partial N} < 0$, implying that the expected number of other borrowers that the incumbent bank can make an offer to is decreasing in N. This should hold because, while q is increasing in N, the market – with a higher N – has to be shared among more competing banks reducing each bank's share. Transform $\frac{\partial[q/N]}{\partial N} < 0$ to get $\frac{q}{N} - \frac{\partial q}{\partial N} > 0$. Use this and $\frac{\partial q}{\partial N} > 0$ together with (39) and (40) to see that $\frac{\partial \nu_B^*}{\partial N} < 0$ and $\frac{\partial \nu_G^*}{\partial N} < 0$.

Now we prove that V_B^* and V_G^* are decreasing in N. Differentiate (16) and (17) w.r.t. N to get

$$\frac{\partial V_B^*}{\partial N} = -\frac{1 - q}{N^2}[-k + \frac{\nu_B X - S}{\rho}] - [1 - q\gamma]\frac{S}{\rho N^2} - \frac{X^2}{2c\rho^2 N^3}\{1 - 2q + q^2[2 - \gamma]\gamma\}, \tag{41}$$

$$\frac{\partial V_G^*}{\partial N} = -\frac{1 - q}{N^2}[-k + \frac{\nu_G X - S}{\rho}] - \{1 - q[1 - \gamma]\}\frac{S}{\rho N^2} - \frac{\{2q[1 - \gamma]\}}{\rho N^2}[\nu_G - \nu_B]X$$
$$- \frac{X^2}{2c\rho^2 N^3}\{1 - 2q + q^2[1 - \gamma^2]\}. \tag{42}$$

32

We make the following substitutions in (41) and (42). First, recall from (13) that $S < -\rho k + \underline{\nu}_B X$. Second, use Assumption 1, i.e. substitute for S and $[\underline{\nu}_G - \underline{\nu}_B]X$ the expression $\frac{X^2}{c\rho N}$. This gives

$$\frac{\partial V_B^*}{\partial N} < -\frac{X^2}{2c\rho^2 N^3}\{2[1 - q\gamma] + 1 - 2q + q^2[2 - \gamma]\gamma,$$

$$\frac{\partial V_G^*}{\partial N} < -\frac{X^2}{2c\rho^2 N^3}\{2[1 - q[1 - \gamma]] + 1 + q[1 - 2\gamma] + 1 - 2q + q^2[1 - \gamma^2]\}.$$

This can be further rearranged to

$$\frac{\partial V_B^*}{\partial N} < -\frac{X^2}{2c\rho^2 N^3}\{1 - q\gamma + [1 - q][2 - q\gamma] + q^2\gamma[1 - \gamma]\}, \tag{43}$$

$$\frac{\partial V_G^*}{\partial N} < -\frac{X^2}{2c\rho^2 N^3}\{1 - q[1 - \gamma] + 1 - q\gamma + 2[1 - q] + q^2[1 - \gamma^2]\}. \tag{44}$$

Since q and γ are limited to the interval $[0, 1]$, the RHS of (43) and (44) are always negative. $\blacksquare$

Proof of Proposition 4

Differentiating (10) with respect to k we get

$$-\{[1 - \gamma]\frac{\partial \bar{V}_B^*}{\partial N} + \gamma\frac{\partial \bar{V}_G^*}{\partial N}\}\frac{\partial N}{\partial k} = [1 - \gamma]\frac{\partial \bar{V}_B^*}{\partial k} + \gamma\frac{\partial \bar{V}_G^*}{\partial k}. \tag{45}$$

We know from Lemma 2 that $\frac{\partial \bar{V}_B^*}{\partial N} < 0$ and $\frac{\partial \bar{V}_G^*}{\partial N} < 0$. Hence, the sign of $\frac{\partial N}{\partial k}$ equals the sign of the right hand side of (45), i.e. higher capital induces more entry iff

$$[1 - \gamma]\frac{\partial \bar{V}_B^*}{\partial k} + \gamma\frac{\partial \bar{V}_G^*}{\partial k} > 0. \tag{46}$$

Use (34) and (38) to simplify (46) to get that higher capital induces more entry iff

$$DV(\gamma, q) > 0, \text{ where} \tag{47}$$

$$DV(\gamma, q) \equiv -[1 - q]\alpha + \gamma\{1 + q[1 - 2\gamma]\} + \zeta[-1 + 3q^2\gamma[1 - \gamma]]\}, \tag{48}$$

α and ζ as defined in (35), and conditions in (37).

We first observe what impact higher capital has on entry at a fixed q. Observe that for a fixed q the function $DV(\gamma, q)$ for γ is a downsided parabola. Note that $DV(\gamma = 0, q) = -[1 - q]\alpha - \zeta < 0$. In addition, we have $DV(\gamma = 1, q) = -[1 - q][\alpha - \gamma] - \zeta < 0$. This means that higher capital always reduces entry at $\gamma = 0$ and $\gamma = 1$. This and the parabolic shape of the function $DV(\gamma, q)$ implies the following for the intermediate values of γ. There exist solutions to the equation $DV(\gamma, q) = 0$ denoted by $\gamma_1(q) \in [0, 1]$ and $\gamma_2(q) \in [0, 1]$ iff $DV(\gamma, q) > 0$ for at least one $\gamma \in [0, 1]$.

Now we show that $DV(\gamma, q) > 0$ for at least one $\gamma \in [0, 1]$ iff competition q is high enough, i.e.

$q \geq \bar{q}$. First, note that

$$DV(\gamma, q = 0) < -\alpha + \gamma - \zeta, \tag{49}$$

which is negative for all $\gamma \in [0, 1]$. Second, observe that

$$DV(\gamma = 1/2, q = 1) = 1/2 + \zeta[-1 + 3/4] > 0. \tag{50}$$

These two facts and the monotonicity of $DV(\gamma, q)$, i.e.

$$\frac{\partial DV(\gamma, q)}{\partial q} = \alpha + \gamma[1 - 2\gamma] + 6\zeta q\gamma[1 - \gamma] > 0, \tag{51}$$

imply that there exist a certain $\bar{q}$ such that $DV(\gamma, q) < 0$, i.e. higher capital discourages entry, for all $\gamma \in [0, 1]$ if $q < \bar{q}$. For high competition, i.e. $q \geq \bar{q}$, we have two regions of γ. In the first region, i.e. $\gamma \in [0, \gamma_1(q)) \cup (\gamma_2(q), 1]$, $DV(\gamma, q) < 0$ and higher capital discourages entry. In the second region, i.e. $\gamma \in [\gamma_1(q), \gamma_2(q)]$, $DV(\gamma, q) \geq 0$ and higher capital induces more entry. ∎

Proof of Corollary 3

First, we compute the impact of entry on the monitoring of bad banks. Partially differentiate (8) with respect to k to get

$$\frac{\partial \nu_B^*}{\partial k} = -\frac{X}{c\rho N}[\gamma \frac{\partial q}{\partial N} + \frac{1 - \gamma q}{N}]\frac{\partial N}{\partial k} + \frac{1 - q\gamma}{c\rho N}r_D. \tag{52}$$

Observe that (52) equals (32), except for the additional term

$$-\frac{X}{c\rho N}[\gamma \frac{\partial q}{\partial N} + \frac{1 - \gamma q}{N}]\frac{\partial N}{\partial k}. \tag{53}$$

Observe that $\gamma\frac{\partial q}{\partial N} + \frac{1-q\gamma}{N} > \gamma\left[\frac{\partial q}{\partial N} - \frac{q}{N}\right]$, which is always positive because $\frac{\partial[q/N]}{\partial N} < 0$ (see Lemma 2). This means that (53) is positive as long as $\frac{\partial N}{\partial k} < 0$ and negative if $\frac{\partial N}{\partial k} > 0$. Thus, the monitoring incentives induced by additional capital are strengthened if capital regulation discourages entry, and weakened if capital regulation encourages entry.

We proceed similarly for good banks. Differentiate (9) w.r.t. k, to get

$$\frac{\partial \nu_G^*}{\partial k} = \frac{X}{c\rho N^2}\{[N\frac{\partial q}{\partial N} - q][1 - \gamma] - 1\}\frac{\partial N}{\partial k} + \frac{1 + q[1 - \gamma]}{c\rho N}r_D. \tag{54}$$

The expression in (54) is equal to (32), except for the additional term

$$\frac{X}{c\rho N^2}\{[N\frac{\partial q}{\partial N} - q][1 - \gamma] - 1\}\frac{\partial N}{\partial k}. \tag{55}$$

As in the proof of Lemma 2, $\frac{\partial q/N}{\partial N} < 0$ implies $\frac{q}{N} - \frac{\partial q}{\partial N} > 0$, hence $N\frac{\partial q}{\partial N} - q < 0$. Thus, (55) is positive as long as $\frac{\partial N}{\partial k} < 0$ and negative if $\frac{\partial N}{\partial k} > 0$. This means that the effectiveness of capital

34

requirements increases (decreases) when capital requirements induce less (more) entry. ∎

Proof of Proposition 5

Note that all banks are (initially) of equal size. This implies that country O (with two banks) is twice as big as country A. We have 3 banks, each with $1/N = 1/3$ of total borrowers. We normalize the total borrowers (over both countries) to one to provide symmetry with our earlier analysis.

Case 1: Proposition 1 establishes that banks do not gain market share from banks of equal type. This immediately implies that good banks in country O hold on to their market share. Banks do not change their levels of monitoring. To see this note that because there are only good banks in the market $\gamma = 1$, which implies that the optimal level of monitoring ν_G^* is not a function of q, see (9). One sidedly opening up borders, however, increases the competition parameter in country O. This reduces the value of banks in country O, i.e. observe that (17) is a decreasing function of competition parameter q, for $\gamma = 1$, i.e.

$$\frac{\partial V_G^*}{\partial q}\bigg|_{\gamma=1} = -\frac{1}{N}[-k + \frac{\underline{\nu}_B X}{\rho}] + \frac{S}{\rho N} - \frac{1}{\rho N}[\nu_G - \underline{\nu}_B]X - \frac{X^2}{2c[\rho N]^2}\{2[1-q]q + 2q\},$$

which is always negative (see that Assumption 1 guarantees that $S < [\nu_G - \underline{\nu}_B]X$).

Case 2: Proposition 1 establishes that bad banks lose their market share to good banks. When the borders are closed, there are only bad banks in country O, i.e. $\gamma = 0$, and banks in country O invest $\nu_{BC}^* = X/c\rho N + \underline{\nu}_B$ (see (8)) in the monitoring technology. After opening up borders, a bad bank in country O competes with equal probability with a good or bad bank, this means that $\gamma = 1/2$. Bad banks in country O now invest $\nu_{BO}^* = [1 - q/2]X/c\rho N + \underline{\nu}_B$. Thus, we have,

$$\nu_{BC}^* = X/c\rho N + \underline{\nu}_B, \quad \nu_{BO}^* = [1 - q/2]X/c\rho N + \underline{\nu}_B. \tag{56}$$

Observe that $\nu_{BO}^* < \nu_{BC}^*$. From (16) it follows that opening borders decreases the country O bank values V_B^*, since V_B^* is decreasing in both q and γ; thus $V_{BO}^* < V_{BC}^*$. To compute the monitoring level of the good bank in country A before the borders of country O are opened insert $\gamma = 1$ and $q = 0$ in (9) to get $\nu_{GC}^* = X/c\rho N + \underline{\nu}_G$. After borders are opened the good bank has access to the borrowers from the bad banks in country O. Now $q > 0$ and $\gamma = 0$, from (9) we have $\nu_{GA}^* = [1 + q]X/c\rho N + \underline{\nu}_G$. Summarizing we have,

$$\nu_{GC}^* = X/c\rho N + \underline{\nu}_G, \quad \nu_{GA}^* = [1 + q]X/c\rho N + \underline{\nu}_G. \tag{57}$$

∎

Proof of Corollary 4

Use adapted one-sided competition versions of (7) to compute the values of the good bank in

country A before (V_{GC}^*) and after (V_{GO}^*) it gets access to country O, i.e.,

$$V_{GC}^* = \frac{-k + \nu_{GC}^* X/\rho}{N} - c\frac{[\nu_{GC}^* - \underline{\nu}_G]^2}{2} \qquad (58)$$

and

$$V_{GA}^* = \frac{-k + \nu_{GA}^* X/\rho}{N} + \frac{q}{\rho N}\{-S + [\nu_{GA}^* - \nu_{BO}^*]X\} - c\frac{[\nu_{GA}^* - \underline{\nu}_G]^2}{2}. \qquad (59)$$

Insert ν_{GA}^*, ν_{GC}^* and ν_{BO}^* from (56) and (57) in (58) and (59) to get

$$V_{GC}^* = \frac{-k + \underline{\nu}_G X/\rho}{N} + \frac{X^2}{2c\rho^2 N^2}, \qquad (60)$$

and

$$V_{GA}^* = \frac{-k + \underline{\nu}_G X/\rho}{N} + \frac{[1+q]X^2}{c\rho^2 N^2} + \frac{q}{\rho N}\{-S + [\underline{\nu}_G - \underline{\nu}_B]X\} + \frac{3q^2 X^2}{2c\rho^2 N^2} - \frac{[1+q]^2 X^2}{2c\rho^2 N^2}. \qquad (61)$$

Now compute the difference between (60) and (61) to see what the value of entering country O is to the bank in country A. This gives

$$V_{GA}^* - V_{GC}^* = \frac{q}{\rho N}\{-S + [\underline{\nu}_G - \underline{\nu}_B]X\} + \frac{q^2 X^2}{c\rho^2 N^2}.$$

which is always increasing in X and therefore also increasing in k. This completes the proof. ∎

Proof of Corollary 5

We assume that the domestic banks behave in a closed domestic market as monopolists, i.e. $q = 0$. Opening up the border increases q to the level $q_O > 0$. The value of each domestic bad bank when the border is opened and there is no merger is (see (7))

$$V_{BO} = \frac{1 - q_O}{N}[-k + \frac{\nu_{BO} X}{\rho}] - c\frac{[\nu_{BO} - \underline{\nu}_{BO}]^2}{2}. \qquad (62)$$

Note that a bad bank loses its borrower to the good entering bank with probability q_O. Each bad domestic bank maximizes (62) by selecting the monitoring level $\nu_{BO} = \nu_{BO}^* = \frac{[1-q_O]X^2}{c\rho^2 N^2} + \underline{\nu}_B$. Hence,

$$V_{BO}^* = \frac{1 - q_O}{N}[-k + \frac{\underline{\nu}_B X}{\rho}] + \frac{[1 - q_O]^2}{2}\frac{X^2}{c\rho^2 N^2}. \qquad (63)$$

Observe that the value of a merged bad bank facing $q = 0$ is

$$V_{BOM} = \frac{2}{N}[-k + \frac{\nu_{BOM} X}{\rho}] - c\frac{[\nu_{BOM} - \underline{\nu}_B]^2}{2}. \qquad (64)$$

36

We impose the following restriction on S,

$$S > [\underline{\nu}_G - \underline{\nu}_B]X - [1 - q_0]\frac{X^2}{c\rho N}. \tag{65}$$

The condition in (65) imposes a potentially stricter lower bound on S than Assumption 1 does. A potential entrant will now abstain from entering. To save on the entry cost, it will not even pose any competitive threat. Hence $q = 0$. The merged bank now maximizes (64) by investing $\nu_{BOM} = \nu^*_{BOM} = \frac{2X^2}{c\rho^2 N^2} + \underline{\nu}_B$. Inserting this in (64) gives

$$\frac{V^*_{BOM}}{2} = \frac{1}{N}[-k + \frac{\underline{\nu}_B X}{\rho}] + \frac{X^2}{c\rho^2 N^2}. \tag{66}$$

Compute the benefits of merging from (66) and (63) to get

$$MB_{BO} = \frac{V^*_{BOM}}{2} - V^*_{BO} = \frac{q_O}{N}[-k + \frac{\underline{\nu}_B X}{\rho}] + [1 - \frac{[1 - q_0]^2}{2}]\frac{X^2}{c\rho^2 N^2}. \tag{67}$$

If the borders are closed, the value of a bad bank is

$$V_{BC} = \frac{1}{N}[-k + \frac{\nu_{BC} X}{\rho}] - c\frac{[\nu_{BC} - \underline{\nu}_{BC}]^2}{2}. \tag{68}$$

The optimal monitoring is $\nu^*_{BC} = \frac{X}{c\rho N} + \underline{\nu}_B$. Insert this in (68) to get

$$V^*_{BC} = \frac{1}{N}[-k + \frac{\underline{\nu}_B X}{\rho}] + \frac{1}{2}\frac{X^2}{c\rho^2 N^2}. \tag{69}$$

The value of a merged bad bank is as in (66). The benefits of merging are (use (69) and (66))

$$MB_{BC} = \frac{V^*_{BCM}}{2} - V^*_{BC} = \frac{1}{2}\frac{X^2}{c\rho^2 N^2}. \tag{70}$$

Compute the difference between (70) and (67) to get

$$MB_{BO} - MB_{BC} = \frac{V^*_{BCM}}{2} - V^*_{BC} = \frac{q}{N}[-k + \frac{\underline{\nu}_B X}{\rho}] + \frac{1 - [1 - q_O]^2}{2}\frac{X^2}{c\rho^2 N^2}. \tag{71}$$

This is positive. Thus, for bad banks merging becomes more beneficial when borders are opened.

With good domestic banks, opening up borders has no impact. The entry cost together with anticipating zero market share prevent entry even without a merger, and there is no valuation impact. ∎

Proof of Proposition 6

Assume that Assumption 1 holds for any k and also the condition (31) for an interior optimum. Following Proposition 4, positive capital is desired in two cases. In the first case, $DV(\gamma, q|k = 0) >$

0, where $DV(\gamma, q|k)$ is defined as $DV(\gamma, q)$ in (48) and constants α and ζ are computed at specific k such that the conditions in (37) hold. In the second case, $DV(\gamma, q|k = 0) < 0$, yet positive at higher values of k. Because (16) and (17) are quadratic functions of k, the value of a bank in this case has a maximum either at $k = 0$ or at $k = 1$. In fact, by symmetry of the quadratic functions the value of a bank at $k = 1$ exceeds that at $k = 0$ if $DV(\gamma, q|k = \frac{1}{2}) > 0$. In sum, banks want to have positive capital requirements as long as $DV(\gamma, q|k = 0) > 0$ or $DV(\gamma, q|k = \frac{1}{2}) > 0$. This is the case for a sufficiently high q, i.e. $q > \hat{q}$, and for an intermediate γ (see Proposition 4). ∎

Proof of Proposition 7

First, we show that the welfare optimal level of capital is strictly less than 1. We compute the welfare contribution of a bank by summing together the bank and borrower surplus, the expected loss to the deposit insurance fund and entry costs. We have

$$W_B(\nu_B) = \frac{1 - q\gamma}{N}[-k + \frac{\nu_B X}{\rho}] - c\frac{[\nu_B - \underline{\nu}_B]^2}{2} - \frac{[1 - \nu_B][1 - k]r_D[1 - q\gamma]}{\rho N} - F, \quad (72)$$

$$W_G(\nu_G) = \frac{1 + q[1 - \gamma]}{N}[-k + \frac{\nu_G X}{\rho}] - c\frac{[\nu_G - \underline{\nu}_G]^2}{2} - \frac{[1 - \nu_G][1 - k]r_D\{1 + q[1 - \gamma]\}}{\rho N}$$
$$- F - \frac{q[1 - \gamma]}{\rho N}S. \quad (73)$$

Social welfare is the sum of the welfare contributions of the individual banks, i.e. $TW(\nu_B, \nu_G) = N\{\gamma W_G(\nu_B) + [1 - \gamma]W_B(\nu_G)\}$. Use (72) and (73) and maximize w.r.t. k to get

$$\frac{\partial TW}{\partial k}(k = k_{reg}) = \frac{1}{N}[-1 + \frac{r_D}{\rho}] + \{1 + \gamma[1 - \gamma]q^2\}\frac{[1 - k_{reg}]r_D^2}{c\rho^2 N} = 0.$$

Note that $\frac{\partial^2 TW}{\partial k^2} < 0$. Solve for the welfare optimal capital requirement k_{reg} to get $k_{reg} = \max(0, 1 - \frac{c\rho^2 N[1 - \frac{r_D}{\rho}]}{\{1 + \gamma[1 - \gamma]q^2\}r_D^2})$, which is strictly less than 1.

We now show that the privately optimal capital requirements are increasing in q and reach 1 for a sufficiently high q and intermediate γ. Again Assumption 1 and (31) hold for any k. First, if $DV(\gamma, q|k = 0) > 0$, where $DV(\gamma, q|k)$ is defined in (48), optimal capital requirements are positive. Note from (50) that $DV(\gamma = 1/2, q = 1|k) > 0$ and from (51) that $\frac{\partial DV(\gamma, q|k)}{\partial q} > 0$ for all k. This guarantees that bank values are maximized at capital requirements equal to 1 for sufficiently high q and intermediate γ. Because $k_{reg} < 1$, there exists a $\bar{q} \geq \hat{q}$ such that for $q > \bar{q}$ and intermediate γ banks want the regulator to choose capital requirements equal to 1 which is above the welfare optimal level. Second, if $DV(\gamma, q|k = 0) < 0$ and $DV(\gamma, q|k = \frac{1}{2}) > 0$ banks want the regulator to set capital requirements equal to 1 (see Proposition 6) and $\bar{q} = \hat{q}$. ∎

References

Allen, F., E. Carletti, and R. Marquez, 2007, "Credit Market Competition and Capital Regulation," mimeo, University of Pennsylvania.

Beck, T., A. Demirgüç-Kunt, and R. Levine, 2005, "Bank Concentration and Fragility: Impact and Mechanics," NBER Working Paper 11500.

Boot, A. W. A., and A. V. Thakor, 2000, "Can Relationship Banking Survive Competition?," *Journal of Finance*, 55(2), 679–713.

Boyd, J. H., and G. De Nicolo, 2005, "Bank Risk Taking and Competition Revisited," *Journal of Finance*, 60(3), 1329–1343.

Dell'Ariccia, G., and R. Marquez, 2006, "Competition among Regulators and Credit Market Integration," *Journal of Financial Economics*, 79(2), 401–430.

Diamond, D. W., and R. G. Rajan, 2000, "A Theory of Bank Capital," *Journal of Finance*, 55(6), 2431–2464.

Flannery, M. J., and K. P. Rangan, 2004, "Market Forces at Work in the Banking Industry: Evidence from the Capital Buildup of the 1990s," mimeo, University of Florida.

Focarelli, D., and F. Panetta, 2003, "Are Mergers Beneficial to Consumers? Evidence from the Market for Bank Deposits," *American Economic Review*, 93(4), 1152–1172.

Freixas, X., S. Hurkens, A. D. Morrison, and N. Vulkan, 2004, "Interbank Competition with Costly Screening," Oxford Financial Research Centre Working Paper.

Hellmann, T. F., K. C. Murdock, and J. E. Stiglitz, 2000, "Liberalization, Moral Hazard in Banking, and Prudential Regulation: Are Capital Requirements Enough?," *American Economic Review*, 90(1), 147–165.

Holmstrom, B., and J. Tirole, 1997, "Financial Intermediation, Loanable Funds, and the Real Sector," *Quarterly Journal of Economics*, 112(3), 663–691.

Kopecky, K. J., and D. VanHoose, 2006, "Capital Regulation, Heterogeneous Monitoring Costs, and Aggregate Loan Quality," *Journal of Banking & Finance*, 30(8), 2235–2255.

Melitz, M. J., 2003, "The Impact of Trade on Intra-Industry Reallocations and Aggregate Industry Productivity," *Econometrica*, 71(6), 1695–1725.

Morrison, A. D., and L. White, 2005, "Crises and Capital Requirements in Banking," *American Economic Review*, 95(5), 1548–1572.

Ongena, S., and D. C. Smith, 2000, "Bank Relationships: A Review," in *Performance of Financial Institutions*, ed. by S. A. Zenios, and P. Harker. Cambridge University Press, Cambridge.

Petersen, M. A., and R. G. Rajan, 1995, "The Effect of Credit Market Competition on Lending Relationships," *Quarterly Journal of Economics*, 110(2), 407–443.

——— , 2002, "Does Distance Still Matter? The Information Revolution in Small Business Lending," *Journal of Finance*, 57(6), 2533–2570.

Repullo, R., 2004, "Capital Requirements, Market Power and Risk-Taking in Banking," *Journal of Financial Intermediation*, 13(2), 156–182.

Shaked, A., and J. Sutton, 1982, "Relaxing Price Competition Through Product Differentiation," *The Review of Economic Studies*, 49(1), 3–13.

Stiroh, K. J., and P. E. Strahan, 2003, "Competitive Dynamics of Deregulation: Evidence from U.S. Banking," *Journal of Money, Credit, and Banking*, 35(5), 801–828.

Syverson, C., 2004, "Market Structure and Productivity: A Concrete Example," *Journal of Political Economy*, 112(61), 1181–1222.

Vives, X., 2001, "Competition in the Changing World of Banking," *Oxford Review of Economic Policy*, 17(4), 535–547.

Winton, A., 1997, "Competition among Financial Intermediaries When Diversification Matters," *Journal of Financial Intermediation*, 6(4), 307–346.
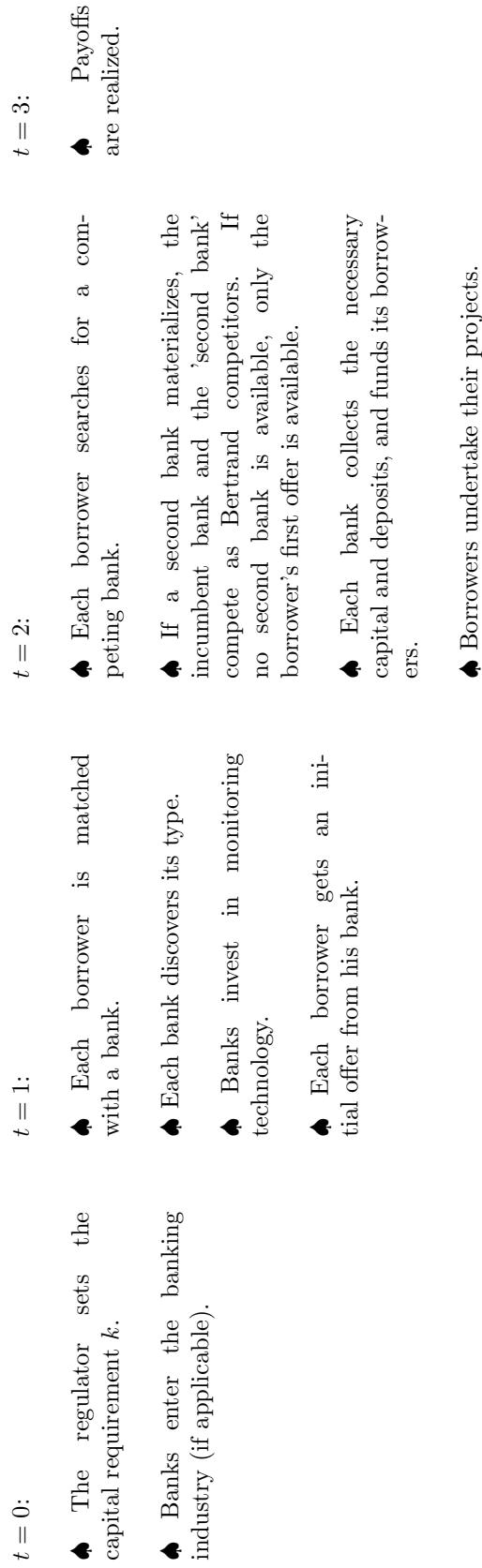
$t = 0$:

♠ The regulator sets the capital requirement k.

♠ 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.

♠ 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' compete as Bertrand competitors. 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.

♠ Borrowers undertake their projects.

$t = 3$:

♠ Payoffs are realized.

Figure 1: Time line