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discussion papers

FS IV 99 - 23

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October 1999

ISSN Nr. 0722 - 6748

Forschungsschwerpunkt Marktprozeß und Unternehmensentwicklung

Research Area Market Processes and Corporate Development

Zitierweise/Citation:

Michael Tröge, **The Structure of the Banking Sector, Credit Screening and Firm Risk,** Discussion Paper FS IV 99 - 23, Wissenschaftszentrum Berlin, 1999.

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ABSTRACT

The Structure of the Banking Sector, Credit Screening and Firm Risk

by Michael Tröge

With an auction model of bank competition, the relationship between the number of banks in a market, the quality of the firms and the banks' effort to carry out creditworthiness tests is analyzed. It is shown that, if the cost of information acquisition is taken into account, welfare and the firm's profit may decrease with a higher number of banks. In general a high number of banks produces more welfare with a bad sample of firms, whereas a low number of banks is preferable for a sample with a lot of good firms.

ZUSAMMENFASSUNG

Die Struktur des Bankensektors, Kreditwürdigkeitsprüfungen und Firmenrisiko

Der Aufsatz untersucht mit einem Auktionsmodell des Bankenwettbewerbs den Zusammenhang zwischen der Anzahl der im Wettbewerb stehenden Banken, der Qualität der zu finanzierenden Firmen und den Anreizen der Banken, Kreditwürdigkeitsprüfungen durchzuführen. Es wird gezeigt, daß, wenn man die Kosten des Informationserwerbs mit in Betracht zieht, die Wohlfahrt mit der Anzahl der Wettbewerber sinken kann. Im Allgemeinen erzeugt eine höhere Anzahl von Banken mehr Wohlfahrtsgewinn mit Firmen von schlechter Qualität, wohingegen ein engeres Bankenoligopol bessere Ergebnisse mit sehr guten Firmen erzielt.

1 Introduction

What is the optimal number of banks for an economy? This is a question faced by policymakers in very different countries. In most emerging markets and transition economies the banking sector is very dispersed. The apparent overbanking in these countries has been made responsible for the frequent banking crises. Central banks or regulatory agencies have to decide whether to limit the number of banking licences. In contrast to this, the current wave of banking mergers triggered by the relaxation of branching restrictions in the United States and the monetary union in Europe has raised concerns about a too concentrated banking sector. Antitrust authorities face the question whether these mergers will constitute a danger for competition.

This paper argues that in addition to the trade-off between stability and competitiveness, the informational efficiency of the banking sector should be taken into account when deciding about the optimal number of banks. It is shown that the informational efficient number of banks depends on the risk characteristics of the firms in the economy. This may help to explain the different trends in the banking sectors of developed and emerging countries.

Unlike in usual product markets, the allocation of capital is not only determined by its price. Banks choose their customers and play therefore an active role in allocating savings among alternative investment uses. Welfare and growth are only maximized if they direct funds to the firms with the highest returns. The crucial factor determining how efficiently banks can carry out this task is the banks' information about borrowers. This information is not free, banks need to run costly creditworthiness tests, in order to determine which firms to finance. If banks have insufficient incentives to screen borrowers they will either not finance innovative risky firms or they will finance too many risky firms. However, screening may also become excessive, it is inefficient if the same information is acquired several times.

The incentives to carry out costly screening depend on the market structure of the banking sector as well as on the ex ante quality of the firms in the economy. If competition is very strong, freeriding and spillover effects will prevent banks from earning the marginal rent of its information collecting effort and erode screening incentives. If there are only a few good firms in the sample banks have no incentives to screen because they will only finance with a low probability. However, if most firms in an economy are creditworthy, banks will also not run very thorough creditworthiness tests.

In this paper a conceptually simple auction model of oligopolistic banking competition is presented, which allows to endogenize the screening effort of banks. The welfare effects of market concentration can then be calculated for economies or firm samples with different risk characteristics.

We find that, if the firms in the sample are very good, a very narrow banking oligopoly will perform best. Additional banks will make additional unnecessary expenses on information acquisition, which will decrease welfare. If, however, the average quality of the firms to be financed is rather bad, a banking sector with a high number of banks does a better job in identifying the good firms and therefore produces more welfare than a narrow oligopoly.

Hence, disregarding prudential concerns, the high number of banks in risky emerging economies may in fact be an efficient reaction of the market to the characteristics of the economy. Policy should therefore not try to reduce systemic risk by reducing the number of banks[1]. Only after the economy becomes more stable, it makes sense to decrease the number of banks.

Of course risk characteristics are not only different between countries, but also between economic sectors within a country. In this context, the model could be part of an explanation for why different banking systems seem to perform differently for different industries. For example in Germany, where despite a high number of regional banks the banking sector is very concentrated the Monopoly Commission (1998) expresses strong concerns that innovative firms are not able to obtain finance. In the USA with its artificially fragmented market,

[1]Capital requirements, transparency rules and banking supervision are other options to ensure the "safety and soundness" of the banking.

after the experiences with the savings and loan crisis, the main concern is a too expansive and risky lending policy.

The auction approach to banking, used in this paper, has been initiated by Broecker (1989). He models bank competition as a sealed bid common value auction, but does not endogenize the informativeness of the banks' signals. Similarly Riordan (1993) only endogenizes a bank's leniency, but not the informativeness of their creditworthiness test. Gehrig (1998) shows that, the cost of information acquisition may prevent entry in banking monopolies

The complete endogenization of information acquisition in an auction is, in fact, still an unsolved problem in general auction theory. Matthews (1985) has derived some properties of information acquisition in the context of pure common values and closed bidding but he is not able to ensure the existence of an equilibrium in his setting. Hausch and Li (1993) get around the mathematical difficulties by using a discrete information acquisition technology and solving the equilibrium in mixed strategies. The model in this paper builds on Ruckes (1998), who has adapted this method for modeling banking competition.

A range of papers have avoided to model explicitly competition in screening and focussed on how screening will be influenced by other variables. Chan, Greenbaum and Thakor (1986) show that the screening effort of banks decreases with the reusability of information, hence will be low in fast changing, risky environments. Manove, Padilla and Pagano (1998) show that the presence of collateral may lead to an inefficiently low screening level.

In the next section of the paper we present the model and in section three the bidding equilibrium is calculated. Section four endogenizes information acquisition and derives the welfare results. Section four concludes.

2 The Model

The market consists of n banks competing to give a credit to one firm. The size of the loan is normalized to one. The firm has an investment project, which is going to succeed with probability λ. In this case the firm's return is X, whereas the unsuccessful projects return nothing and the firm goes bankrupt.

By taking a close look at the firm, for example by examining the books, analyzing the feasibility of the firm's project and evaluating the quality of the firm's staff, banks are able to get better information about whether the firm is going to be successful. However, this information will not come without cost.

This situation is modeled by assuming that banks are equipped with a costly information production technology. Investing γq^2 in information acquisition, a bank independently receives with probability q a perfect signal about the quality of the firm. This means that with probability q this bank will know with certainty if the firm is going to succeed or not, whereas with probability $1-q$ the bank does not receive additional information. We assume that banks do not observe the effort invested by its competitors in information acquisition.

Depending on their information, the banks may offer the firm a credit, asking for a repayment of b in case of success. As the investment has been normalized to one, this corresponds to an interest rate of $b-1$. The bidding is assumed to be closed i.e. banks do not know the competitor's bids nor the fact that the competitor has made an offer. It is clear that whenever a bank has received the information that the firm is going to fail it will not make a credit offer. Accordingly, when a bank knows that the project is going to succeed it will always offer credit. In case a bank has received no additional information it may or may not offer credit, depending on the ex ante probability of success of a firm.

3 Equilibrium Bidding

Before endogenizing the effort invested in information acquisition, the bidding strategies of banks having information of symmetric quality will be calculated. When deciding about the interest rate, a bank faces a trade-off between a higher profit in the case of winning and a higher probability of winning but a lower interest rate. Similar to other auctions with discrete values, this game has no equilibrium in pure strategies. If one bank were always bidding the same interest rate, the best response of the other bank would be either to slightly undercut this bid or to always bid the highest possible amount. Clearly, in both cases the first bank's bid is not optimal. An equilibrium in mixed strategies can be described by the bidding densities $F_j(b)$ of bank j in case it has received a good signal, the probability μ_j of making an offer in case the bank j has not received a signal and the distribution of the bids $H_j(b)$ in case the bank is bidding without having received a signal. The profit of a bank i, having received a good signal and bidding b, can be calculated as follows:

$$\begin{aligned} \pi^g(b) &= (b-1)\left[\sum_{s=0}^{n-1}\binom{n-1}{s} q^s (1-F(b))^s (1-q)^{n-1-s} \right. \\ &\quad \left. \cdot \left[\sum_{t=0}^{n-1-s}\binom{n-1-s}{t}(1-\mu)^{n-1-s-t}\mu^t (1-H(b))^t\right]\right] \\ &= (b-1)\left[1-qF(b)-(1-q)\mu H(b)\right]^{n-1}. \end{aligned} \tag{1}$$

In case the bank has not received any information, its profit is:

$$\begin{aligned} \pi^0(b) &= \lambda(b-1)\sum_{s=0}^{n-1}\binom{n-1}{s} q^s (1-F(b))^s (1-q)^{n-1-s}\left[1-\mu H(b)\right]^{n-1-s} \\ &\quad -(1-\lambda)\sum_{s=0}^{n-1}\binom{n-1}{s} q^s (1-q)^{n-1-s}\left[1-\mu H(b)\right]^{n-1-s} \\ &= \lambda(b-1)\left[q(1-F(b))+(1-q)\left[1-\mu H(b)\right]\right]^{n-1} \qquad (2) \\ &\quad -(1-\lambda)\left[q^s+(1-q)\left[1-\mu H(b)\right]\right]^{n-1}. \qquad (3) \end{aligned}$$

Equation 1 is the profit on the credit business $(b-1)$ multiplied by the probability of giving the loan. If bank i has received a good signal, the project must be successful. This means that, if one of the competitors j also receives a signal, this must be a good signal. He will therefore make an offer which, with probability $1 - F_j(b)$, will be higher than the offer b made by bank i. With probability $1 - q_j$, bank j will not receive a signal. In this case bank j will make an offer with probability μ_j. This offer will not be accepted with probability $1 - H_j(b)$. Equation 2 can be derived with a similar reasoning, but now, the bank's loss in case the firm is unsucessful has to be subtracted.

Some preliminary definitions will facilitate the exposition of the equilibrium.

Definition 1

$$\hat{a}_n \quad : \quad = 1 + (1-q)^{n-1}(X-1), \tag{4}$$

$$\hat{b}_n \quad : \quad = 1 + \frac{1-\lambda}{\lambda(1-q)^{n-1}}, \tag{5}$$

$$\hat{\mu}_n \quad : \quad = \left[1 - \frac{q}{1-q}\frac{(1-\lambda)^{\frac{1}{n-1}}}{(\lambda(X-1))^{\frac{1}{n-1}} - (1-\lambda)^{\frac{1}{n-1}}}\right]. \tag{6}$$

The equilibrium bidding strategies are summarized in the following proposition

Proposition 2 *The equilibrium strategies are*

a) If $X \leq \hat{b}_n$, banks bid only after having received a good signal:

$$F(b) = \begin{cases} 0 & \text{for } b < \hat{a}_n, \\ \frac{1}{q}\left[1 - (1-q)\left(\frac{X-1}{b-1}\right)^{\frac{1}{n-1}}\right] & \text{for } b \in [\hat{a}_n, 1], \\ 1 & \text{for } b > X. \end{cases} \tag{7}$$

b) In the case $X > \hat{b}_n$, banks bid with good and with probability $\hat{\mu}_n$ with inconclusive signals using the distribution functions

$$F(b) = \begin{cases} 0 & \text{for } b < \frac{1}{\lambda}, \\ \frac{1}{q}\left[1 - \left(\frac{1-\lambda}{\lambda(b-1)}\right)^{\frac{1}{n-1}}\right] & \text{for } b \in \left[\frac{1}{\lambda}, \hat{b}_n\right], \\ 1 & \text{for } b > \hat{b}_n, \end{cases} \tag{8}$$

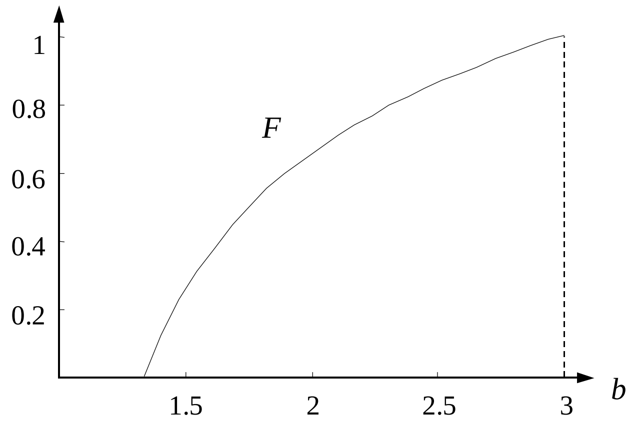

Figure 1: Case a: Bid distributions with $n = 6$, $\lambda = 0.6$, $q = 0.3$ and $X = 3$.

$$H(b) = \begin{cases} 0 & \textit{for } b < \hat{b}_n, \\ \frac{1}{\hat{\mu}_n}\left[1 - \frac{q}{1-q}\frac{(1-\lambda)^{\frac{1}{n-1}}}{(\lambda(b-1))^{\frac{1}{n-1}} - (1-\lambda)^{\frac{1}{n-1}}}\right] & \textit{for } b \in \left[\hat{b}_n, X\right], \\ 1 & \textit{for } b > X. \end{cases} \tag{9}$$

Proof. See Appendix A ■

If $\lambda X < 1$, i.e. if the ex ante expected profit from financing a firm in the sample is negative. In this case because of $\hat{b}_n > \frac{1}{\lambda} > X$, solution a) applies, i.e. banks will not offer credit without having received additional information. Figure 1 shows the cumulative bid distribution function in this situation. For $\lambda X > 1$ the decision to bid without a good signal depends not only on the quality of the firms, but also on the number of potential lenders. For higher n, the value of $\hat{b}_n$ converges to infinity, so that only in relatively narrow markets with firms of good quality, banks offer credit without having received a positive signal. In figure 2 the equilibrium bid distributions for such a situation are plotted.

Inserting the equilibrium strategies into the profit equation results in the following equilibrium profits:

Proposition 3 *The equilibrium profits of a bank are*

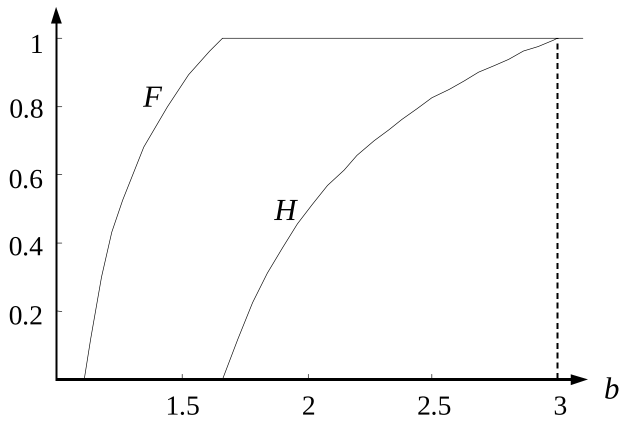

Figure 2: Case b: Equilibrium for $n = 6$, $\lambda = 0.9$, $q = 0.3$ and $X = 3$.

a) $\pi = \lambda q (X - 1) (1 - q)^{n-1}$, *for* $X \leq \hat{b}_n$,

b) $\pi = q (1 - \lambda)$, *for* $X > \hat{b}_n$.

Proof. See Appendix A ■

Perhaps surprisingly, in case b) the profit of each bidder does not depend on the number of competitors. Of course, if there are more banks with symmetric strategies, each bank will receive the credit with a lower probability. However, at the same time all banks are asking higher interest rates. Both effects exactly offset each other.

4 Information Acquisition and Welfare

Having obtained the profits of banks possessing information of a given quality, the amount of information banks will acquire in equilibrium can be calculated. As banks cannot observe the competitors' actions, investment in information acquisition and the decision about the credit offer will be modeled as simultaneous choices in a one-step game. A symmetric equilibrium of this game can be described by (q, F, H, μ), i.e. the probability of receiving information, the distribution functions for bidding with and without information and the probability of bidding without information. In equilibrium, deviating from this strategy while keeping the other players strategies fixed, should not be profitable. However, the profit of bank j is not influenced by its choice of its own distribution functions and μ_j, as it is indifferent between any bids on the support and makes a lower profit out of the support. Once bank j has made the decision about its investment in information acquisition, its profit only depends on the competitors' actions. Therefore, in order to prove that a given symmetric strategy combination is an equilibrium, it remains to check that secretly deviating from the choice of q_j does not increase the bank's profit. If all other banks have invested q, its profit as a function of his own choice of q_i will be in case a)

$$\Pi(q_i, q) = \lambda q_i (X-1)(1-q)^{n-1} - \gamma q_i^2, \tag{10}$$

and in case b)

$$\Pi(q_i, q) = q_i (1-\lambda) - \gamma q_i^2. \tag{11}$$

Deriving with respect to q_i and imposing symmetry leads to the following conditions for an equilibrium in case a)

$$\frac{\partial}{q_i}\Pi(q_i, q) = \lambda (X-1)(1-q)^{n-1} - 2\gamma q_i = 0, \tag{12}$$

$$\Rightarrow \lambda (X-1)(1-q)^{n-1} - 2\gamma q = 0, \tag{13}$$

Unfortunately this equation does not have an analytic solution. In case b) the equilibrium condition is

$$\frac{\partial}{q_i}\Pi(q_i, q) = 1 - \lambda - 2\gamma q_i = 0,$$

which can be solved trivially. Proposition 4 summarizes these results.

Proposition 4 *The equilibrium information acquisition q is*

a) the solution of the equation $\lambda (X-1)(1-q)^{n-1} - 2\gamma q = 0$, if $X \leq \hat{b}_n$,

b) $q_i = \frac{(1-\lambda)}{2\gamma}$, if $X > \hat{b}_n$.

Welfare and consumer surplus (i.e. the firm's profit) can be easily calculated in case a) as no bank bids without having received a signal. If there are n banks, screening with intensity q, the probability of a good project not to be financed is then $(1-q)^n$. Hence the welfare produced is

$$W(q,n) = \lambda (X-1) \left[1-(1-q)^n\right] - n\gamma q^2. \tag{14}$$

Case b) is more complicated, as here the firms may be financed even if no bank gets a signal. The welfare produced is now

$$W(q,n) = \lambda (X-1) \left[1-(1-q)^n (1-\hat{\mu}_n)^n\right] \tag{15}$$

$$-(1-\lambda)\left[1-(1-(1-q)\hat{\mu}_n)^n\right] - n\gamma q^2. \tag{16}$$

The firm's average profit can be obtained by subtracting the banks' profit, which is n times the profit of one bank, given in equation 10, from the total welfare.

Because the equilibrium information acquisition of banks is not analytically solvable, the qualitative results are discussed with a numerical example. Figure 3 shows welfare and consumer surplus for $X = 2, \gamma = 2$ and $\lambda = 0.4$ as a function of the number of banks. This is an ex ante unprofitable sample where without information acquisition, lending is not profitable, therefore only solution a) applies. Under these circumstances welfare and the firm's profit always increase with the number of banks.

This could be interpreted as the situation of firms in emerging economies or innovative sectors. Banks have very bad information about these firms. They know that some of the projects are worthwhile being financed, but they also know that there are a lot of lenders with unreasonable projects, most of which will fail. Without acquiring detailed information about the firms the banks will not be willing to lend. If the number of banks increases, every bank will reduce its spending on information acquisition. Nevertheless, in the aggregate, the probability rises that one of them will recognize the potential of the project and provide finance.

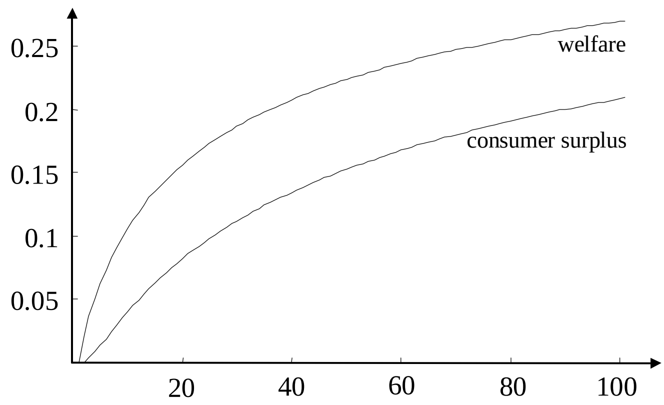

Figure 3: Case a) Welfare and Consumer Surplus for $\lambda = 0.4, \gamma = 2$ and $X = 2$

However, if the sample of firms is ex ante profitable, welfare reacts very differently with respect to changes in the number of banks. As the numerical solution plotted in figure 4 demonstrates, in less concentrated markets, solution b) applies. Banks will bid, even if they have not received a positive signal. In this case welfare will decrease with the number of banks. Intuitively in a situation where lending is possible without additional information, the acquisition of information is less socially valuable. The main reason for banks to collect information is not to be able to finance firms, but rather to get a competitive advantage. An additional bank will increase the overall expenditures on information acquisition without substantially increasing the probability of a firm getting a credit. Only for a large number of banks, $\hat{b}_n$ will again exceed X and we will be back in case a) , where banks do not bid without having received information. This scenario could be interpreted as lending to mature firms in a stable environment. Under these circumstances, banks possess sufficient prior information to select a pool of ex ante profitable firms. Two banks seem then to be sufficient to ensure an informational efficient and reasonably competitive financial market.

In the model, as the number of banks goes to infinity, welfare always increases again and exceeds the initial levels. In order to prove this result we need the following corollary:

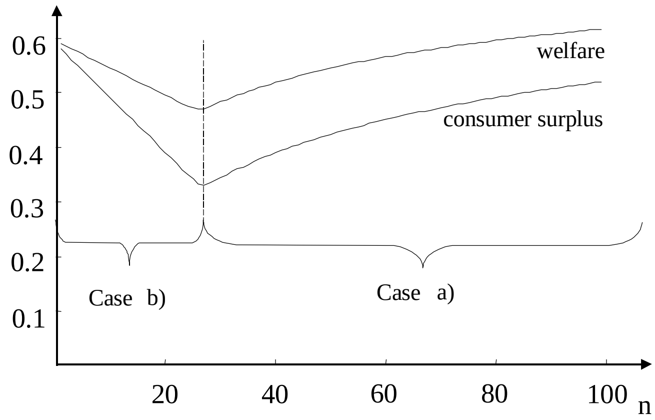

Figure 4: Case a) and b) Welfare and Consumer Surplus for $\lambda = 0.8, \gamma = 2$ and $X = 2$.

Corollary 5 *In case a) the banks choose the welfare maximizing intensity of information acquisition in the equilibrium.*

Proof. The welfare optimal choice of q is solution of

$$\frac{\partial}{\partial q} W(q,n) = 0 \Leftrightarrow \lambda(X-1)(1-q)^{n-1} - 2\gamma q = 0. \tag{17}$$

This first order condition is identical to condition 13, defining the equilibrium intensity of information acquisition. ■

Because for high n only solution a) is relevant we can apply this corollary as n converges to infinity. In fact welfare will converge to the first best level.

Proposition 6 *For $n \to \infty$, welfare converges to $\lambda(X-1)$.*

Proof. It has been shown in proposition 2 that for a sufficiently high number of banks only case a) applies. Define $\alpha < 1$ as the probability that the market accepts a good project. Since $\alpha = 1 - (1-p)^n$, the total cost of achieving α with n banks is $n\gamma\left[1 - \sqrt[n]{1-\alpha}\right]^2$, which converges to zero for $n \to \infty$ with fixed $\alpha < 1$, and to one for fixed n and $\alpha \to \infty$. The total surplus generated is $\alpha\lambda(X-1) - n\gamma\left[1 - \sqrt[n]{1-\alpha}\right]^2$. Assume that for all n the optimal welfare does not exceed a given level $W < \lambda(X-1)$. However, defining $\alpha = \frac{W+\lambda(X-1)}{2\lambda(X-1)} <$

1 and a n_α, such that $n_\alpha \gamma \left[1 - \sqrt[n_\alpha]{1-\alpha}\right]^2 < \frac{1}{2}\left[\lambda(X-1) - W\right]$ can be found.
It follows that $n_\alpha \lambda (X-1) - n_\alpha \gamma \left[1 - \sqrt[n_\alpha]{1-\alpha}\right]^2 > W$. Therefore the optimal welfare level for n_α must be higher than W. As this is true for every $W < \lambda(X-1)$, the optimal welfare level and therefore the level obtained by the market must converge to $\lambda(X-1)$ for $n \to \infty$.
■

The fundamental reason for this result is that we had assumed initial marginal costs of information acquisition to be zero. As the number of banks converges to infinity the market will provide perfect information at no cost. Whereas this result is interesting from an auction theoretic point of view it is probably not very relevant for the banking situation. The numerical solutions show that welfare converges very slowly. However the profit of each bank falls drastically as the number of banks increases. If banks need fixed costs to run their operations they will not be able to survive. If for example in the situation depicted in fig. 4 more than 40 banks cannot survive in the market, the welfare optimal sustainable market structure will be a duopoly rather than the maximum sustainable number of banks. only if the sample is not ex ante profitable the maximum sustainable number of banks will also be the welfare optimal one.

In reality of course a banking system has to finance firms of different quality. If for example one half of the economy consists of firms as in fig 3 and the other half of firms of the type of fig. 4, the optimal sustainable number of banks will not be either two or 40, but some number between the two. As a given banking oligopoly performs differently for different groups of firms the optimization has to weight the benefits for one group against the losses for another. This is visualized on figure 5. The fraction of the maximal surplus $\lambda(X-1)$ realized by the competitive equilibrium has been plotted as a function of the quality of the sample λ. A dispersed banking sector generates more surplus with innovative firms i.e. for low λ, whereas a more concentrated banking sector mainly lends to conservative industries.

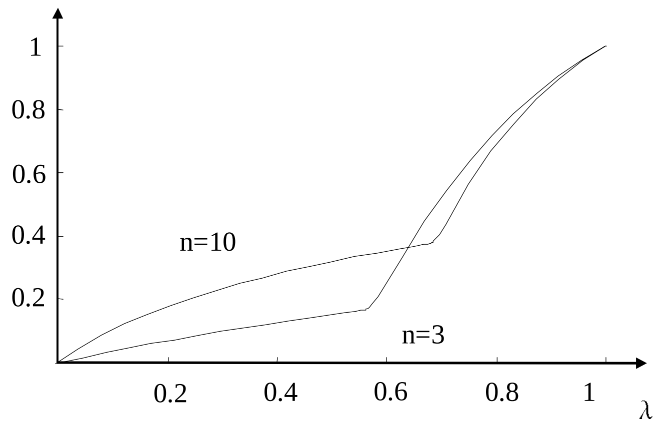

Figure 5: Surplus over $\lambda\left(X-1\right)$ as a function of λ for $X=2,\gamma=2$.

5 Conclusion

The paper has analyzed how banking oligopolies generate the information necessary for an efficient allocation of capital in the economy. This provides an additional criterium for evaluating the efficient number of banks. The results are based on two main insights:

With lot of banks, a lot of money will be spent on information acquisition. However, this will only increase welfare if the information produced is socially valuable i.e. in situations of high uncertainty about the firms creditworthiness. If the sample of firms is very good, so that it could be financed without additional information, screening is socially wasteful and low number of banks is preferable..

One implication of these results is that risky economies need a dispersed banking sector, whereas in stable economies a few banks are sufficient. However, the model can also be used to provide an explanation for, why some financial systems seem to be better suited for certain industries. In particular a more dispersed banking sector will be beneficial for the innovative sectors. Here information acquisition is much more important for producing welfare. A larger number of banks will increase the chance of one bank detecting the value of an innovative project. Therefore regulations such as the Interstate Banking Act, which is responsible for an artificially large number of banks in the USA, may not be necessarily welfare increasing, but will boost the innovative sector of the economy. In Germany the small number of banks may be an efficient reaction to economic stability, however innovative sectors of the economy will be neglected.

The paper is also interesting from a purely auction theoretic view. Bulow and Klemperer (1996) have shown that excluding bidders from an auction will not increase the sellers profit. It has been shown above that this is not true any more when information acquisition is taken into account. This could explain for example, why investment banks typically choose only a small number of potential acquires when selling a company.

Appendix

A Proof of proposition 2 and 3

In order to verify that the distribution functions 7, 8 and 9 constitute an equilibrium it has to be shown that bank with a given information is indifferent on the support and makes lower profits from bidding outside the support. As the proof only requires simple algebraic manipulation it is only sketched in the following.

Case a) bidding only with good signals Inserting the bidding distribution 7 of the $n-1$ competitors in 1, and observing that $H(b)=0$, we obtain as the profit of a bank, having received a good signal and bidding in the interval $\left[\frac{1}{\lambda}, X\right]$:

$$\begin{aligned}
\pi^{g}(b) &= (b-1)\left[1-qF(b)-(1-q)\hat{\mu}_{n}H(b)\right]^{n-1} \\
&= (b-1)\left[(1-q)\left(\frac{X-1}{b-1}\right)^{\frac{1}{n-1}}\right]^{n-1} \qquad (18)\\
&= (X-1)(1-q)^{n-1}. \qquad (19)
\end{aligned}$$

Hence his ex ante expected profit is:

$$\pi=\lambda q(X-1)(1-q)^{n-1},$$

which proves part a) of proposition A.

Bidding lower than $\frac{1}{\lambda}$,will decrease the profit as it will not increase the probability of winning compared to bidding exactly at $\frac{1}{\lambda}$, but decrease the interest rate in the case of winning.

Case b) bidding for good and inconclusive signals: the indifference of a bank having received a good signal can be calculated as above. Plugging the equilibrium distributions 8 and 9 of the competitors into the profit function 2, shows that a bank having received an inconclusive signal is indifferent on the support and making there zero profits. Therefore it is also indifferent between bidding and not bidding. It will make losses from bidding below $\hat{b}_n$.

■

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