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ABSTRACT

Industry Ownership of Banks and Credit Market Competition

by Michael Tröge*

This paper analyzes the effect of bank participation in the equity of a firm on the competitiveness of the credit market. Using an auction model of bank competition it is shown that an equity stake of one bank is increasing its market power in the market for credits to this firms. The share-owning bank provides credit more often, its profit and the average interest rate increases. If several banks own symmetric stakes, the interest rate decreases. However, if one bank owns an equity stake, no other bank has incentives to own equity of this firm.

ZUSAMMENFASSUNG

Beteiligungsbesitz von Banken und Wettbewerb im Kreditmarkt

Dieser Aufsatz untersucht die Auswirkungen von Bankbeteiligungen im Eigenkapital einer Firma auf die Wettbewerbsintensität im Kreditmarkt. Mit einem Auktionsmodell des Bankenwettbewerbs wird gezeigt, daß ein Aktienanteil einer Bank die Marktmacht dieser Bank im Markt für Kredite dieser Firma vergrößert. Banken, die am Eigenkapital beteiligt sind, vergeben häufiger Kredite an diese Firma, der Profit der Bank und der Zinssatz, den das Unternehmen zahlen muß, steigen. Besitzen mehrere Banken symmetrische Eigenkapitalbeteiligungen an der selben Firma würde der Zinssatz sinken. Allerdings hat, wenn bereits eine Bank Eigenkapital besitzt, keine andere Bank Anreize, sich am Aktienkapital der Firma zu beteiligen.

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1. Introduction

The participation of banks in the equity capital of a firm is one of the most controversial issues in banking regulation. The maximum amount of capital that a bank is allowed to hold in a non financial firm differs widely between countries (OECD 1992). Two well known extremes are Germany and the USA: in Germany banks are free to own non financial firms whereas in the USA the participation of banks in a non financial firm's capital is forbidden since the 1933 Glass-Steagall Act. Interestingly both countries are thinking about changing their legislation. Whereas in Germany the introduction of restrictions on bank ownership is being discussed in the Bundestag[1] (Bundestag (1997)), the US Congress recently started its 10'th attempt since 1933 to abolish the Glass-Steagall Act (Economist 1998).

What are the reasons for restricting bank ownership of firms? Several possible effects have been discussed: For example universal banking is thought to endanger the stability of the financial system, impair the investment bank activitiy and influence the lending activity of the bank.

This paper concentrates on the last aspect. We show that an equity participation of one bank in a firm will lead to a reduced competition in the market for credits to that firm. This is in contradiction to the usual argumentation. So far the impact of bank shareholding on the lending activities of the bank has been used as an argument in favor of universal banking. Most researchers seem to agree that bank holdings of equity tend to benefit the firms. Indeed, it is quite intuitive that a participation in the capital of the firm leads to an alignment of interests between the firm and bank. Banks should be willing to finance riskier projects, obtain better information, and have more incentives for restructuring in case of distress. Neuberger and Neumann (1990) or John et alii. (1995) are presenting models in this spirit. Sometimes the alleged benefits of universal banking have led to an quite enthusiastic view of the German system (Calomiris (1994)).

[1] A law ("Transparenz und Wettbewerbsgesetz") limiting bank participation to 5% has been proposed (Bundestag (1997))

The entirely positive view of the benefits of bank participations has never gained broad acceptance in Germany. Whereas the benefits of a close relationship between banks and firms are generally recognized, suspicions of banks exploiting market power through share possessions have been expressed during the whole of the twentieth century[2]. Nevertheless only recently, after in 1995 a new law imposed the disclosure of participations of more than 5%, it has become possible to underline this suspicion with empirical evidence.

Several studies have estimated the influence of bank participation in a firms capital on the interest rate paid by the firms. Schmid (1996) uses a Herfindahl index to measure the concentration of banks in the firms' capital. He observes a significant interest rising effect of higher concentration[3]. Seger (1998) replicates these results using total bank participation as the explaining variable. In a nonlinear specification, he obtains decreasing interest rates for small participations and only for higher equity stakes a positive effect. Other studies provide complementary evidence. Albach (1998) and Schwiete/Wiegand (1997) observe that firms with higher bank participations have lower debt to equity ratios. The reason could be that debt is more expensive for firms with bank participation. Albach and Elston (1994) use a criterion that includes bank participation in order to define firms with close bank relationships. They cannot confirm that firms with close bank relationships are less liquidity constrained, what would be expected if asymmetric information was the driving force for financial constraints.

The existing economic models of bank participations cannot explain these observations as they do not allow for market power effects. Usually either a monopolistic bank is assumed or perfect Bertrand competition is postulated. Building on the models of Broecker (1990) and Ruckes (1997), we introduce imperfect oligopolistic competition by modelling banking competition as an auction. Thus we are able to show that, indeed, the ownership of a fraction of the firms capital gives a bank market power in the competition for the firm's credits, which leads to higher cost of finance for the firm. In addition, we can derive more precise predictions about the relationship between bank participation and interest rates. If more than one bank has a

[2] Compare Haas (1995) for a historical overview.

[3] It shoud be mentioned that Schmid does not attribute this effect to an increased market power of one bank.

participation in a firm, the interest rate depends on the asymmetry of the banks' participations. Identical stakes of several banks will not increase the interest rate but decrease it compared to the situation in which no bank owns a share of the firm. However a situation in which both banks own equity stakes will not be an equilibrium of a game in which the banks buy shares before competing in the credit market.

These results provide a possibility of testing the proposed mechanism. The cited studies always aggregated the participations of different banks. If our explanation is true, using asymmetry between the banks' equity stakes as explanatory variable should increase the fit of the regression.

Our results rely on very basic payoff structures: a bank that owns shares of a company is not only remunerated by the interest payments, but gets a part of the firm's cash flows through dividends or increased market value of the shares. Hence it is more inclined to lower the interest rate than a non share owning competitor. However, if it is sure to give the credit, it still wants the firm's interest rate to be high because, unless it does not entirely own the firm, it recovers only a part of the cash flows through dividends. Only in case the competitor provides the loan, it will prefer low interest rates. The strategic situation is similar to that of a takeover auction when the bidders already own a fraction of the equity before the start of the bidding. These auctions have been recently studied by Burkart (1995) in a private value setting and by Bulow, Huang and Klemperer (1996) for common values. Whereas the price level rises with private values on average it decreases with common values. Clearly credit auctions have common as well as private value aspects (Tröge 1997). The main source of uncertainty is probably the credit risk which can be modeled as a common value. However, because in credit auctions, unlike in an usual auction, there is no lowest price (highest interest rate) for which the bidders are sure not to make losses, the model of Bulow, Huang and Klemperer is not directly applicable. We use a common value auction with discrete values and solve for an equilibrium in mixed strategies. This model is robust to differences in private values; it can be shown that the mixed equilibrium of the common value auction can be approximated by pure strategy equilibria of an auction with private and common value aspects.

2. The Model

We consider two banks competing for giving a loan to a firm. The size of the loan is normalized to one. Both banks own fractions α_i, $i = 1, 2$ of the firm's equity. Without restriction of generality, we assume that $\alpha_2 \geq \alpha_1 \geq 0$. The firm has an investment project, which is going to succeed with probability λ. If the project succeeds it yields a payoff $X > 1$. Hence the maximum interest rate that a project can support is $X - 1$. We suppose that if the project is successful the credit is paid back and the net profit is distributed to shareholders. With probability $1 - \lambda$ the project fails and has zero return. We assume that $\lambda X < 1$, so that even if the banks ask the highest possible interest rate, it is not profitable to lend without additional information.

With probability q both banks independently receive additional information about the quality of the firm. For simplicity we assume that, having received this information, they know with certainty whether the firm's project is going to succeed or not. As it is not profitable to lend without additional information or after having received negative information, banks only make an offer if they know the project is going to succeed.

This offer consists in the repayment b the firm has to make after the project has succeeded. The interest corresponding to this repayment is $b - 1$. We suppose that both bids are made simultaneously and that the competitor neither observes the offered interest rate nor the fact that a bid has been submitted.

Similar to the usual common value auctions with discrete values, this game has no equilibrium in pure strategies. If one bank was always bidding the same interest rate, the best response of the other bank would be either to slightly undercut this bid or to alwys bid the highest possible amount. Clearly in both cases the first bank's bid is not optimal. However the fact that we consider mixed strategy equilibria does not mean that we really assume that the bank is randomizing when approached by a firm. The mixed equilibria should be understood as an approximation of pure bidding strategies in the Harsanyi (1973) sense. We have shown in Tröge (1998) how in a similar setting the mixed equilibria can be "purified" in a straightforward way by adding continuously distributed private values. Then a bank's bid is not randomly chosen, but a function of its private value. However from the competitor's point of view the bank's bids are still randomly distributed. A possible source of these differences in private values could be different refinancing costs of the two banks.

Let $F_i : [1, X] \to [0, 1]$ be the equilibrium distribution functions for the bid b_i of bank i in the case it has received a positive signal. The expected profit of bank j, having received a positive signal, bidding b and having an equity participation of $\alpha_j \geq 0$ is:

$$\begin{aligned} \pi_j(b) &= (b-1)\left[q\left(1-F_i(b)\right)+(1-q)\right] \\ &\quad +\alpha_j\left[\int_1^b qF_i'(x)\,(X-x)\,dx+\left(q\left(1-F_i(b)\right)+(1-q)\right)(X-b)\right], \end{aligned} \tag{2.1}$$

The first term is the profit on the credit business $(b-1)$ multiplied by the probability of giving the loan. The second brackets contain the profit the bank will make on its equity participation. The integral term are the expected dividends in case the credit goes to the other bank and the other terms describe the dividends in case bank j wins the auction.

In a mixed strategy equilibria both bidders have to choose the distribution of their bids such that the competitor is indifferent between his possible bids. We show in the appendix A.1 how this condition leads to a set of differential equations the solutions of which characterize the equilibrium.

Proposition 2.1. *The following distribution functions F_1, F_2 describe the unique equilibrium of the game:*

$$\begin{aligned} F_1(b) &= \frac{1}{q}-\frac{1}{q}\left(\frac{(1-q)^{\frac{1}{1-\alpha_1}}(X-1)}{b-1}\right)^{1-\alpha_2} \quad \text{for } b\in\left[1+(X-1)(1-q)^{\frac{1}{1-\alpha_1}},X\right), \\ &= 1 \text{ for } b \geqq X, \\ &= 0 \text{ elsewhere}, \end{aligned} \tag{2.2}$$

$$\begin{aligned} F_2(b) &= \frac{1}{q}-\frac{1}{q}\frac{(1-q)(X-1)^{1-\alpha_1}}{(b-1)^{1-\alpha_1}} \quad \text{for } b\in\left[1+(X-1)(1-q)^{\frac{1}{1-\alpha_1}},X\right], \\ &= 1 \text{ for } b \geqq X, \\ &= 0 \text{ elsewhere}. \end{aligned} \tag{2.3}$$

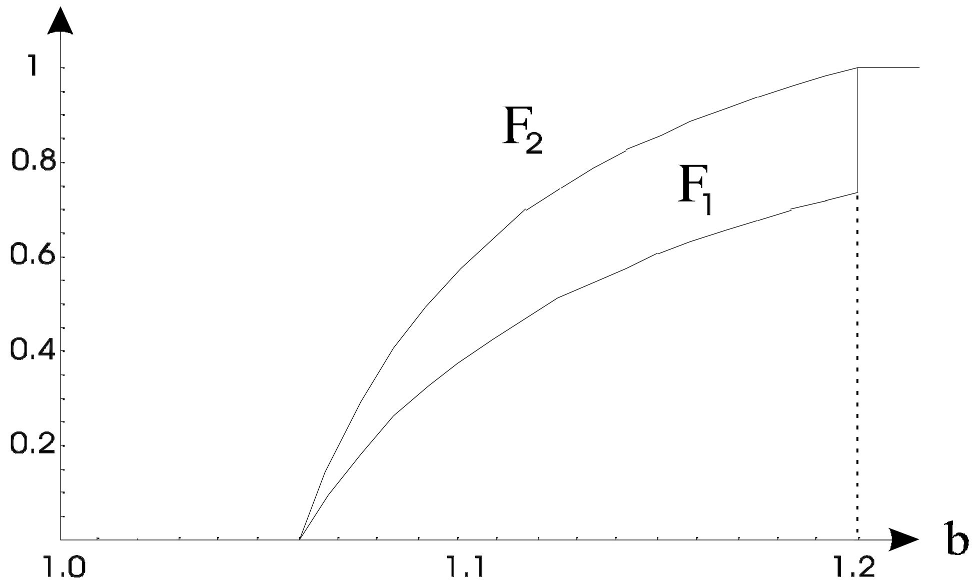

Figure 2.1: Equilibrium distribution functions for $\alpha_1 = 0$, $\alpha_2 = 0.4$, $X = 1.2$, $q = 0.7$.

Proof. See appendix A.1.

The higher one bank's bidding density in a given area, the higher are the competitor's incentives to lower its bid. However, with equal bidding densities the incentives to lower the bid of the bank with the higher shareholdings are always bigger. Therefore, in order to keep the bank with the higher shareholdings indifferent between its bids, the other bank has to bid with a lower density. Because the bank with the smaller shareholdings cannot bid with lower density on the entire support it has to put positive probability on the highest bid X.

Fig.2.1 shows the distribution functions of both bidders for $\alpha_1 = 0$, $\alpha_2 = 0.4$, $X = 1.2$, and $q = 0.7$. It is easy to see that the average bid of the bank with the higher shareholding is lower and that, in case both banks have received a positive signal, the bank with higher shareholding wins with a higher probability

How can this behavior be interpreted? In fact the bank with the smaller equity stake realizes that it is not worthwhile competing with the other bank if both have received a positive signal. Instead it tries to extract the maximum profit in case the other bank as not obtained a signal, by bidding the highest possible amount.

The fact that the shareholding bank is able to bid more successfully than the non shareholder does not yet allow us to judge the overall effect of equity stakes on the average interest rate. Two countervailing forces determine the equilibrium interest rate: On the one hand banks with shareholdings are less averse to placing lower bids, as they are able to recover a part of their losses through the dividend. This will lead to a lower interest rate. On the other hand however, banks with smaller or no shareholdings anticipate this and realize that it is not worthwhile competing with the shareholding bank. This may increase interest rates. In order to decide which one of these effects is determinant we have to do the comparative staticvs of the equilibrium.

We first examine how an increase in the participation of bank 2, the bank with the bigger equity stake, influences the equilibrium outcome.

Proposition 2.2. *A bigger equity stake of bank 2 increases its profit from the credit business and does not decrease the profit of bank 1.*

Proof. We go through the simple case $\alpha_1 = 0$ and refer the reader to appendix A.2 for the quite involved general calculations. With $\alpha_1 = 0$ the profit of bank 1 is easily obtained by inserting the bidding function $F_2(b)$ in 2.1 and multiplying with the probability of receiving a good signal:

$$\begin{aligned} \lambda q \pi_1(b) &= \lambda q (b-1)\left[q(1-F_2(b)) + (1-q)\right] \\ &= \lambda q (1-q)(X-1) \end{aligned}$$

This does not depend on α_2. Not surprisingly this is the same profit it would get by always bidding the highest possible amount and only winning the auction in case the competitor has not received any information. Otherwise the bank would have no reason to bid the highest bid with a positive probability.

When calculating the profit of bank 2's credit department we have to insert $F_1(b)$ in 2.1 leaving out the dividend term:

$$\lambda q (b-1)\left[q(1-F_1(b)) + (1-q)\right] = \lambda q (b-1)^{\alpha_2}\left[(1-q)(X-1)\right]^{1-\alpha_2}$$

As bank 2's credit department is not indifferent between all possible bids we have to integrate this over the distribution of b in order to obtain the expected profit from the credit business:

$$
\begin{aligned}
\Pi_2 &= \int_{1+(X-1)(1-q)}^{X} \lambda q (b-1)^{\alpha_2} \left[(1-q)(X-1)\right]^{1-\alpha_2} F_2'(b)\, db \\
&= \int_{1+(X-1)(1-q)}^{X} \lambda q (b-1)^{\alpha_2} \left[(1-q)(X-1)\right]^{1-\alpha_2} \left[\frac{(1-q)(X-1)}{q(b-1)^2}\right] db \qquad (2.4) \\
&= \lambda \int_{1+(X-1)(1-q)}^{X} \left[\frac{(1-q)(X-1)}{b-1}\right]^{2-\alpha_2} db \qquad (2.5) \\
&= \frac{\lambda}{1-\alpha_2}\left[(1-q)-(1-q)^{2-\alpha_2}\right](X-1) \qquad (2.6)
\end{aligned}
$$

In order to know how this profit changes with the size of the equity stake we take the derivative of this term with respect to α_2:

$$
\frac{\partial}{\partial \alpha_2}\Pi_2 = \frac{(1-q)^{2-\alpha_2}}{(1-\alpha_2)^2}\left[(1-q)^{-(1-\alpha_2)} - 1 + \ln(1-q)^{(1-\alpha_2)}\right]\lambda q (X-1) > 0
$$

As $\ln(x) > 1 - \frac{1}{x}$,this is always positive. ■

In fact perhaps surprisingly with nonzero α_1 the profit of bank 1 also strictly increases with a higher participation of bank 2. In our setting the generated surplus is fixed since the probability of a credit does not change. Hence the increased profit of the banks can only come through an increase in the average interest rate at the disadvantage of the firm's shareholders. More precisely, if Π_1^C and Π_2^C are the expected profits of bank 1 and 2's credit departments, the average interest rate a good firm has to pay conditional on getting a credit is $\frac{\Pi_1^C + \Pi_2^C}{\left[1-(1-q)^2\right]\lambda}$. As the sum of the banks' profits increases we know that:

Corollary 2.3. *The average interest rate the firm has to pay increases with the size of bank 2's equity stake.*

This already provides a strong argument in favor of restricting bank participation in a firm's equity. However it could be argued that the situation we have analyzed is not an equilibrium of a more complete game. It could be suspected that if both banks can decide whether to acquire a participation in the firm, the outcome will be symmetric and no bank will keep an advantage. The next proposition shows that this is not the case.

Proposition 2.4. *A bigger stake of bank 1 in the firm's equity decreases the profit of both banks credit departments.*

Proof. See appendix A.2

This means that a game in which both banks were allowed to buy shares can only have asymmetric equilibria with one bank owning no shares. A situation where both banks own shares cannot be an equilibrium, since selling the (weakly) smaller participation to the bank with the bigger equity stake would increase both banks' profits form the credit business.

It is not easy to determine whether the effect of proposition 1 or the effect of proposition 2 is stronger, i.e. to derive what happens if both stakes are increased simultaneously. In fact only in the symmetric situation we obtain an unambiguous effect:

Proposition 2.5. *If both banks hold symmetric equity stakes the average interest rate decreases with increasing participation.*

This shows that if the proposed competition model is right it does not make much sense to look for a relationship between total bank participation and average interest rates. If for reasons exogenous to this model several noncooperatively acting banks own similar shares the interest rate will not increase but decrease. Perhaps this explains why Seger (1998) observed for low participations decreasing interest rates. We have shown that equity stakes of several banks are not an equilibrium outcome. Hence symmetric participations have probably not been chosen strategically and tend thereforeto be small.

3. Conclusion

We have shown that allowing banks to own equity stakes in firms will reduce the competition in the credit market and drive up the cost of debt for the firms. Thus our model explains recent empirical results obtained with German data. Whereas the original motivation for the Glass Steagall Act and much of the regulaton in other coutries seems to have been unjustified

(Benston (1995), Rajan/Kroszner (1994), Puri (1994)), this effect provides a new argument for limiting bank ownership in non financial firms.

The interest-rising effect of our model relies on very basic payoff structures. The mechanism works with non-voting equity as well as with ordinary shares. The result is only driven by the fact that a bank having an equity participation is interested in high interest rates as long as it is giving the credit itself, but prefers low interest rates in case the other bank is giving the loan. We have derived the interest-rising effect in a possibly unfavorable setting: there is no danger of a winner's curse which drives the similar result in the model of Huang, Bulow and Klemperer (1996). In our framework nobody makes a bid without knowing that the project is good. Introducing a winner's curse by extending the analysis to the case of lending with ínconclusive signals would probably further increase the interest-rising effect. In addition, in this case the shareholding banks will be probably more lenient lenders than the non-shareholding.

There are several other mechanisms, not captured by our model, which could contribute to the interest rising effect in reality. For example the bank could simply influence the management's choice of a credit through its votes on the firm's board. Another reason for reduced credit market competition could be that the share owing banks have access to better information. This can be analyzed with an extension of our model. Better information translates in a higher q, this drives the competitor's equilibrium bid distribution further to the upper limit and increases the expected interest rate. Endogenising the choice of q by introducing an information acquisition technology leads to two asymmetric equilibria, where one bank collects more information than the other. However the shareholding bank makes higher profits as an insider than the non-shareholding bank. Hence shareholding could also be used as a signal to outside banks that information acquisition about this firm is not worthwhile.

However, the most important task is now an empirical test of the two hypothesis we have derived:

1. Asymmetric equity stakes increase the interest rate
2. Symmetric equity stakes decrease the interest rate.

The Herfindahl index used by Schmid (1996) partially captures asymmetry, but doesn't serve our purposes very well, as it does not distinguish between small symmetric participations and higher asymmetric ones which are probably the most common cases. Other measures of asymmetry willl have to be derived. At the moment we are composing an appropriate database in order to test different specifications.

A. Appendix

A.1. Existence and Uniqueness

We need three preliminary properties of any equilibrium in order to show existence and uniqueness:

Lemma A.1. *The bidding supports of both bidders have to be identical*

Proof. Suppose one of the bidders is bidding in a open region where the competitor does not place bids. Then the bidder cannot be indifferent between these bids. Bidding higher would increase the profit in case he wins and not decrease his probability of winning. ■

Lemma A.2. *The bidding supports have to be single intervals including the highest possible bid.*

Proof. Suppose there is a open region U in [1,X] in which the bidders place no bids, but below which the bidders place bids. Define $x := \max\{z | z < U \wedge z \in \mathit{Support}\}$. Then the profit for bidding in U must be bigger than bidding x : The interest rate rises,but the winning probability does not change. Hence the support has to be a single interval including the highest possible bid. ■

Lemma A.3. *One of the distribution functions may be discontinuous at the highest possible bid. Elsewhere the distribution functions are continous. On the open support they are differentiable.*

Proof. For this proof we need measure-theoretic tools. If we can show that each set of measure zero has probability zero we know from the Theorem of Radon-Nikodym that F is differentiable (hence continous).

We prove the lemma in two steps: i) Every set from the interior of the support with measure zero has probability zero. ii) No bidder can put a nonzero weight on the lower bound l, both bidders cannot put a nonzero weight on the higher bound X.

ad i) Sketch: Cover with a countable series of intervals, the measure of which converges to zero. Prove that the bidder cannot be indifferent between upper and lower bound of each interval.

ad ii) Suppose one of the bidders puts nonzero probability on the lower bound. Then the other bidder cannot be indifferent between a bid sufficiently close to l and a bid just below l.

Suppose both bidders put a nonzero weight on the highest bound X. Then one of the bidders could increase his profit by putting the nonzero weight slightly below X. ■

Proof of proposition 2.1:

Let $[l, X]$ be the support of both bidder's distribution functions. In a mixed strategy equilibrium bank j must be indifferent between any bids on the open kernel of the support i.e. $\frac{\partial}{\partial b}\pi_j(b) = 0 \; \forall b \in (l, X), j = 1, 2$.

This condition leads to the following differential equations:

$$(\alpha_j - 1)\left[qF_i(b) - 1\right] - (b-1)\, qF_i'(b) = 0, \; i = 1, 2 \tag{A.1}$$

$$\Rightarrow F_i'(b) = \frac{(1-\alpha_j)}{(b-1)}\left(\frac{1}{q} - F_i(b)\right), \; i = 1, 2 \tag{A.2}$$

Since on the open support, the distribution functions are differentiable they have to be there a solution of this differential equation. One of the distribution functions has also to be continous at $b = X$, Hence we can obtain it as the unique solution of A.2 for the boundary value $F(X) = 1$:

$$F_i(b) = \frac{1}{q} - \frac{1-q}{q}\left(\frac{X-1}{b-1}\right)^{1-\alpha_j} \tag{A.3}$$

F_i is nonzero for

$$b \in \left[1 + (X-1)(1-q)^{\frac{1}{1-\alpha_j}}, X\right]$$

From A.2 we see that for higher α_j the distribution function of bidder i becomes flatter. Both bidders have to randomize on the same support and only one distribution function may be discontinuous at the highest bid. As $\alpha_2 > \alpha_1$ this must be F_1. As its bidding function has to be zero at the lower bound of the support we can calculate it by solving equation A.2 with α_2 and the initial condition $F_1\left(1 + (X-1)(1-q)^{\frac{1}{1-\alpha_2}}\right) = 0$.

We obtain:

$$
\begin{aligned}
F_1(b) &= \frac{1}{q} - \frac{1}{q}\left(\frac{(1-q)^{\frac{1}{1-\alpha_1}}(X-1)}{b-1}\right)^{1-\alpha_2} \quad \text{for } b \in [1+(X-1)(1-q)^{\frac{1}{1-\alpha_1}}, X) \\
&= 1 \text{ for } b \geqq X \qquad \text{(A.4)} \\
&= 0 \text{ elswhere.}
\end{aligned}
$$

The bidding function of the second bank can be obtained with $i = 2$, $j = 1$ form A.3

$$
\begin{aligned}
F_2(b) &= \frac{1}{q} - \frac{1}{q}\frac{(1-q)(X-1)^{1-\alpha_1}}{(b-1)^{1-\alpha_1}} \text{for } b \in \left[1+(X-1)(1-q)^{\frac{1}{1-\alpha_1}}, X\right] \\
&= 1 \text{ for } b \geqq X \qquad \text{(A.5)} \\
&= 0 \text{ elswhere.}
\end{aligned}
$$

■

A.2. Comparative statics

The profit of bank i on the credit business can be calculated as

$$
\pi_i^C(b) = q\lambda(b-1)[q(1-F_j(b)) + 1 - q] = q\lambda(b-1)[1 - qF_j(b)]
$$

The overall profit of a bank is independent of b, but not the profit on the credit business. Hence we have to integrate this over the equilibrium distribution of bank $i's$ bids in order to obtain the expected profit.

For bank 1 we obtain:

$$
\begin{aligned}
\Pi_1^C &= \int_{1+(X-1)(1-q)^{\frac{1}{1-\alpha_1}}}^{X} \pi_1^C(b)\, dF_1(b) \qquad \text{(A.6)} \\
&= \frac{\lambda(X-1)(1-q)^2}{1-\alpha_1-\alpha_2}\left[\alpha_1\left(1-(1-q)^{\frac{\alpha_2-\alpha_1}{1-\alpha_1}}\right) - (1-\alpha_2)\left(1-(1-q)^{\frac{2\alpha_1-1}{1-\alpha_1}}\right)\right]
\end{aligned}
$$

The expected profit of bank 2's credit department is

$$
\begin{aligned}
\Pi_2^C &= \int_{1+(X-1)(1-q)^{\frac{1}{1-\alpha_1}}}^{X} \pi_2^C(b)\, dF_2(b) \qquad \text{(A.7)} \\
&= \frac{\lambda(X-1)(1-\alpha_1)}{1-\alpha_1-\alpha_2}\left[(1-q)^{\frac{1}{1-\alpha_1}}\left(1-(1-q)^{\frac{1-\alpha 1-\alpha 2}{1-\alpha_1}}\right)\right]
\end{aligned}
$$

Proof of proposition 2.2

The following proofs are always based on the inequality $\ln(x) < x - 1 \Leftrightarrow \ln(z) > 1 - 1/z$ for $x, z > 0$.

The derivative of A.6 with respect to α_2 is:

$$\begin{aligned} \frac{\partial}{\partial \alpha_2}\Pi_1^C &= \alpha_1 \frac{\lambda (X-1)(1-q)^{\frac{2-\alpha 1-\alpha 2}{1-\alpha_1}}}{(1-\alpha_1-\alpha_2)^2}\left[(1-q)^{-\frac{1-\alpha 1-\alpha 2}{1-\alpha_1}} - 1 + \ln\left((1-q)^{\frac{1-\alpha 1-\alpha 2}{1-\alpha_1}}\right)\right] \\ &> 0 \end{aligned} \tag{A.8}$$

All the factors are positive, if $\alpha_1 > 0$ they are strictly positive.

The derivative of A.7 with respect to α_2 is:

$$\begin{aligned} \frac{\partial}{\partial \alpha_2}\Pi_2^C &= (1-\alpha_1)\frac{\lambda (X-1)(1-q)^{\frac{2-\alpha 1-\alpha 2}{1-\alpha_1}}}{(1-\alpha_1-\alpha_2)^2}\left[(1-q)^{-\frac{1-\alpha 1-\alpha 2}{1-\alpha_1}} - 1 + \ln\left((1-q)^{\frac{1-\alpha 1-\alpha 2}{1-\alpha_1}}\right)\right] \\ &> 0 \end{aligned} \tag{A.9}$$

■

Proof of proposition 2.4:

The derivative of A.6 with respect to α_1 is:

$$\begin{aligned} \frac{\partial}{\partial \alpha_1}\Pi_1^C &= \frac{(1-\alpha_2)}{(1-\alpha_1)}\frac{\lambda (X-1)(1-q)^{\frac{1}{1-\alpha_1}}}{(1-\alpha_1-\alpha_2)^2}\left[(1-\alpha_1)\left[1-(1-q)^{\frac{1-\alpha 1-\alpha 2}{1-\alpha_1}}\right] + \right. \\ &\quad \left. + \left(1-\alpha_1(1-q)^{\frac{1-\alpha 1-\alpha 2}{1-\alpha_1}}\right)\frac{(1-\alpha_1-\alpha_2)}{(1-\alpha 1)}\ln(1-q)\right] \\ &< K\left[(1-\alpha_1)\left[1-(1-q)^{\frac{1-\alpha 1-\alpha 2}{1-\alpha_1}}\right] - \left[1-\alpha_1(1-q)^{\frac{1-\alpha 1-\alpha 2}{1-\alpha_1}}\right]\left(1-(1-q)^{\frac{1-\alpha 1-\alpha 2}{1-\alpha_1}}\right)\right] \\ &= K(-\alpha_1)\left(1-(1-q)^{\frac{1-\alpha 1-\alpha 2}{1-\alpha_1}}\right)^2 < 0 \end{aligned} \tag{A.10}$$

we have used that $\alpha 1 + \alpha 2 < 1$.

The derivative of A.7 with respect to α_1 is:

$$\begin{aligned} \frac{\partial}{\partial \alpha_1}\Pi_2^C &= \frac{\lambda (X-1)(1-q)^{\frac{1}{1-\alpha_1}}}{(1-\alpha_1-\alpha_2)^2}\left[\alpha_2\left(1-(1-q)^{\frac{1-\alpha 1-\alpha 2}{1-\alpha_1}}\right) + \right. \\ &\quad \left. + \left[1-(1-q)^{\frac{1-\alpha 1-\alpha 2}{1-\alpha_1}} + \alpha_2(1-q)^{\frac{1-\alpha 1-\alpha 2}{1-\alpha_1}}\right]\ln\left((1-q)^{\frac{1-\alpha 1-\alpha 2}{1-\alpha_1}}\right)\right] \\ &< K'\alpha_2\left[\left(1-(1-q)^{\frac{1-\alpha 1-\alpha 2}{1-\alpha_1}}\right)\right. \\ &\quad \left. - \left[1-(1-q)^{\frac{1-\alpha 1-\alpha 2}{1-\alpha_1}} + \alpha_2(1-q)^{\frac{1-\alpha 1-\alpha 2}{1-\alpha_1}}\right]\left(1-(1-q)^{\frac{1-\alpha 1-\alpha 2}{1-\alpha_1}}\right)\right] \end{aligned} \tag{A.11}$$

$$
\begin{aligned}
&= K'\left(1-(1-q)^{\frac{1-\alpha 1-\alpha 2}{1-\alpha_1}}\right)\left[\alpha_2 - 1 + (1-q)^{\frac{1-\alpha 1-\alpha 2}{1-\alpha_1}} - \alpha_2 (1-q)^{\frac{1-\alpha 1-\alpha 2}{1-\alpha_1}}\right] \\
&= K'\left(1-(1-q)^{\frac{1-\alpha 1-\alpha 2}{1-\alpha_1}}\right)^2 (\alpha_2 - 1) < 0.
\end{aligned}
$$

■

Proof of proposition 2.5:

For $\alpha_1 = \alpha_2 = \alpha$, the profit of both banks are identical, we can use any of the formulas A.6 or A.7.

$$
\begin{aligned}
\frac{\partial}{\partial \alpha}\Pi^C &= \frac{\partial}{\partial \alpha}\frac{\lambda (X-1)(1-\alpha)}{1-2\alpha}\left[(1-q)^{\frac{1}{1-\alpha}}\left(1-(1-q)^{\frac{1-2\alpha}{1-\alpha}}\right)\right] \\
&= \frac{\lambda (X-1)(1-q)^{\frac{1}{1-\alpha}}}{(1-2\alpha)^2}\left[1-(1-q)^{\frac{1-2\alpha}{1-\alpha}} + \frac{1-2\alpha}{1-\alpha}\ln(1-q)\right] \\
&< 0
\end{aligned}
$$

■

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