GOVERNANCE AND THE EFFICIENCY OF ECONOMIC SYSTEMS
GESY

Discussion Paper No. 244

Bank Competition – When is it Good?

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July 2008

Financial support from the Deutsche Forschungsgemeinschaft through SFB/TR 15 is gratefully acknowledged.

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July 24, 2008

Abstract

The effects of bank competition and institutions on credit markets are usually studied separately although both factors are interdependent. We study the effect of bank competition on the choice of contracts (screening versus collateralized credit contract) and explicitly capture the impact of the institutional environment. Most importantly, we show that the effects of bank competition on collateralization, access to finance, and social welfare depend on the institutional environment. We predict that firms' access to credit increases in bank competition if institutions are weak but bank competition does not matter if they are well-developed.

JEL-Classification: D82, G21, K00

Keywords: Bank competition, collateralization, screening, incentives

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1. Introduction

There is a big debate in the academic literature on whether bank competition is good or bad for efficiency or, more generally, for social welfare. Many theory papers argue that, due to problems of asymmetric information, bank competition has a negative effect on the efficiency of the banking system. However, others argue that bank competition reduces lending rates and thereby benefits borrowers (see Cetorelli, 2001 for a survey). A recent empirical study by Beck, Demirgüc-Kunt, and Maksimovic (2004) demonstrates that when evaluating whether bank competition is good or bad the characteristics of the country must be taken into account. Their study analyses one particular characteristic of a banking market, namely access to credit. It is shown that bank competition increases the access to credit for firms in developing countries but does not matter for firms in countries with well-developed institutions.[1]

The institutional environment influences access to finance through collateralization. One of the most important barriers to getting finance is the availability of sufficient collateral. Institutions determine the payoff the bank receives when it liquidates collateral and whether collateralization is economically viable.

So far, the impact of the institutional environment on the banking sector has hardly been analyzed - neither theoretically nor empirically. We want to know how bank competition determines the type of credit contract offered by the bank and, in particular, its decision to collateralize. How does the contract offered affect access to credit and social welfare? And how does the institutional environment influence the effect of bank competition on the contract offered, access to finance, and social welfare?

To answer these questions, we compare the behavior of a monopolistic bank and competing banks in a theoretical model in which banks must solve the problem of adverse selection before they grant a loan. They can do so by either offering a collateralized contract or by screening applicants. The screening technology provides only an imperfect signal on the applicant's creditworthiness. Through collateralization a firm reveals its type truthfully but

[1] More generally, Eicher and Leukert (2008) show that the impact of economically important institutions is three times as high in developing countries as compared to OECD countries.

it is costly because a deadweight loss arises in the case that the collateralized assets are liquidated. The effect of institutions is captured by the liquidation value of collateral. The better the legal environment (and consequently, the lower the cost of liquidation) and the more liquid the market where the asset is sold, the higher is the liquidation value and the lower is the deadweight loss. Thus, in our model a high (low) liquidation value represents good (poor) institutions.

Our analysis highlights the important role of institutions. Our first result is that competing banks are more likely to collateralize than a monopolistic bank given poor institutions, but that the result is exactly the opposite, namely a monopolistic bank is more likely to collateralize, if institutions are good. In the latter case, the monopolistic bank is better off by offering a collateralized contract. In the case of two banks, each competing bank obtains positive expected profits if one of them offers a screening contract and the other offers a collateralized contract. In this case some degree of asymmetric information prevails as the screening signal is imperfect and this softens competition. However, each competing bank would make zero expected profits if they both offered a collateralized contract. Thus, it is optimal for competing banks to offer different types of contracts and to collateralize less often than a monopolistic bank.

Our second result is that access to credit is easier with bank competition if institutions are poor but that access does not depend on the degree of bank competition if institutions are good. This is confirmed by empirical evidence measuring access to finance (Beck, Demirgüc-Kunt, and Maksimovic, 2004). Thus, our paper gives an explanation for why institutions matter for the effect of bank competition on access to finance: the chance to receive a loan depends on the type of contract offered which, in turn, depends both on the institutional environment and the degree of bank competition.

Our third result is that the optimal degree of bank competition depends on the quality of institutions. For low liquidation values, a monopolistic bank as well as competing banks offer screening contracts. The social planner prefers bank competition because competing banks create independent signals and are more likely to finance good projects. For intermediate liquidation values, there exist parameter ranges in which social welfare is highest with a monopolistic bank. There are two countervailing effects that affect the optimality of the monopolistic bank. On the one hand, the monopolistic bank has first best incentives to switch from one contract to the other because it is the residual claimant. On the other hand, the monopolistic and each competing bank can choose from the same set of contracts. This means that the joint set of contracts competing banks can offer is bigger, which reduces the optimality of a monopolistic bank. Finally, if the liquidation value is high, competing banks as well as a monopolistic bank offer a collateralized credit contract and therefore social welfare does not depend on the degree of bank competition. Generally, our results show that the policy conclusions, in particular how desirable bank competition is, depend on the specific features of the banking sector and the environment in which banks operate.

This paper is related to two strands of literature: bank competition and choice between screening and collateralization. Bank competition reduces the amount of collateral demanded by improving the firm's bargaining position (Berlin and Butler, 2002; Hainz, 2003). At the same time, the possibility of collateralization helps to increase bank competition. Entry barriers which are caused by the information advantage of the incumbent bank (Dell'Ariccia, Friedman and Marquez, 1999; Sharpe, 1990) can be contested by offering collateralized contracts (Sengupta, 2007). In contrast to papers that study the effect of bank competition on collateralization, the majority of (theory) papers conclude that bank competition leads to an inefficient outcome (see Cetorelli, 2001, for a summary). The sources of the inefficiency depend on the set-up of the model. They can be the duplication of screening costs and the winner's curse problem (as in Broecker, 1990).[2] Thereby incentives get distorted and lead to, for instance, insufficient investment in screening by competing banks (as in Schnitzer, 1999). In contrast, we show that by taking into account the impact of the institutional environment bank competition can achieve an efficient allocation in the banking market.

The second strand of literature this paper is related to is the choice of contract by a bank. Both collateralization and screening can be used to solve the adverse selection problem between bank and firm. The seminal paper on screening is Broecker (1999), which analyzes credit contracts when banks receive imperfect and independent signals from screening applicants and show that a winner's curse problem arises. Through collateralization firms can

[2] Endogenizing the screening decisions, Direr (2008) shows that a screening equilibrium is more likely as the number of bank increases.

signal their type. Then banks offer contracts with different combinations of repayment and collateral.[3] As firms with a lower default risk are more inclined to provide collateral, firms reveal their default probability through their choice (Bester, 1985; Besanko and Thakor, 1987).[4]

Although collateral and screening could be complements when information about borrowers is generated (like in Inderst and Müller (2006)), in most papers they are substitutes. What are the trade-offs between different contractual modes? Basically, banks trade off the costs of offering a contract to all applicants (i.e. the risk of financing non-creditworthy customers), a screening contract (i.e. the screening costs if the signal is perfect) and a collateralized contract (i.e. the costs of liquidating assets) (Schnitzer, 1999; Dell'Ariccia and Marquez, 2006).

Our model is most closely related to Manove, Padilla and Pagano (2001) (henceforth MPP) who compare screening and collateralization. In their model, firms know their *type*, i.e., whether they have a high or low probability of success. By pledging collateral they can reveal their type to the bank. However, banks could find out the actual *quality* of a firm, i.e., whether a firm is going to be successful or fail, by screening them. Thus, banks can generate additional information by screening applicants. Suppose screening costs are intermediate. For firms with a high probability of success, it is cheaper to opt for a collateralized credit contract and to subsidize those firms with a high probability of success that in the end fail than to bear the screening costs of all bad firms (with high and low probability of success). At the same time, firms with a low probability of success prefer a screening contract since with a collateralized contract they would have to cover the losses arising from financing the bad firms, which are more numerous in this category of firms. Thus, in this parameter range competing banks offer both a collateralized and a screening contract. However, a screening contract would maximize welfare. Thus, according to MPP, competing banks screen too little.

The result in MPP is based on the assumption that banks can get better information

[3] Collateral is also used to mitigate the moral hazard problem between bank and borrower (*ex ante* as well as *ex post*) by changing the payoff structure (Bester, 1987, 1994).

[4] However, this prediction is not confirmed in the empirical analysis (Booth and Booth, 2006).

about the firm's probability of success than the entrepreneur. This happens, for instance, if firms are overconfident. The evidence whether firms are indeed overconfident is equivocal (for a discussion of the related empirical literature see Wu and Knott (2006)).[5] We make a less restrictive assumption, namely that the bank is not capable of generating additional information but aims to overcome the adverse selection problem. Like MPP, we find that competing banks collateralize more often than a monopolistic bank - provided the liquidation value is low. However, if the liquidation value is higher, we get the opposite result, namely that a monopolistic bank is more likely to collateralize.

The paper is organized as follows: in section 2 we set up the model and derive the contract offered by a monopolistic bank and competing banks. Moreover, we compare how the contract offered depends on the degree of competition in the banking sector and how this influences access to credit. In section 3, we evaluate the contracts offered in the case of bank competition and in the case of a monopolistic bank from a social welfare point of view. Finally, we conclude in section 4.

2. Model

2.1. Set-up

We start by describing the characteristics of the firms and the banking sector. There exists a continuum of firms the number of which is normalized to 1. Firms want to undertake an investment project that costs I. They are endowed with an asset of value $A > I$. However, due to the lack of liquidity, firms need to finance their investment through credit. A fraction μ of the firms are good and a fraction of $(1-\mu)$ are bad. Good firms have a project that is successful with probability p. In the case of success the project's payoff is X, in the case of failure it is 0. Thus, the expected payoff of a good firm is $pX - I$, which we assume to be positive. Bad firms take the money and run. They fail with probability 1. We assume that the average quality of firms is such that banks would not make a loss by offering a pooling contract, i.e. $\mu pX - I > 0$.

We consider two different market structures in the banking sector: there is either a

[5] Banking with overly optimistic entrepreneurs is modeled in Manove and Padilla (1999).

monopolistic bank or a competitive banking sector with two identical banks. Banks have two means to discriminate between good and bad firms: they either offer a collateralized credit contract which induces firms to signal their type, or they screen all firms applying for credit by evaluating their credit proposals.

In our model, we explicitly incorporate different levels of institutional development. It is captured by the liquidation value of collateral, which is denoted by α. In the case of collateralization, the bank gets a payoff from the collateralized assets that are liquidated if the project fails. The liquidation value of each unit of collateral is lower than the continuation value in the firm, i.e., $\alpha < 1$. The better the legal environment and the more liquid the market where the asset is sold, the higher is the liquidation value (World Bank, 2006).[6]

If banks decide to screen, they incur a cost c when screening a firm. By screening they receive a signal which reveals the firm's type correctly with probability s, with $s > 0.5$. In the case with two banks the signals are independent of each other.[7] It is quite realistic to use imperfect and independent signals because the empirical literature shows that banks rate the default risk of a particular borrower differently. In a study on Sweden, the correlation between screening results of different banks varies between 0.75 and 0.8 (Jacobson, Lindé and Roszbach, 2006). In a study on Belgium, a simulation shows that "[...] between sixteen and twenty percent of applicants would find their loan applications rejected by one bank but accepted by the other [...]" (Mitchell and van Roy, 2007, p. 4).

In our model, we rule out that a bank offers both a screening contract and a collateralized contract. A bank might consider offering both types of contracts because it wants firms to self-select themselves (as in MPP). Since bad firms will never opt for a collateralized contract, good firms could reveal their type by choosing this contract. Then, bad firms could apply for a screening contract. But then offering a screening contract would yield a loss for the bank since screening is imperfect. Thus, in our set-up an individual bank does not have an incentive to offer both contracts. Moreover, a bank could offer a screening contract with

[6] According to the Doing Business Report the recovery rate (which depends on the type of assets used and the losses in the case of liquidation) in most regions of the world does not exceed 30 per cent (World Bank, 2006). Secured creditors may get a higher repayment, but even their payoff is still remarkably low in the case of failure.

[7] The set-up of this section is similar to the model by Broecker (1990).

the option to collateralize for all those firms that generated a negative signal. However, in many credit markets banks decide either to accept applicants under the initial conditions or to reject them (Saunders and Thomas, 2001). Therefore, we assume that each bank makes only one offer to a particular firm.

2.2. Monopolistic Bank

The monopolistic bank makes a take-it-or-leave-it credit offer to the firms. We denote repayments demanded by the monopolistic bank by R_M. The timing is as follows: First, the monopolistic bank decides whether to offer a screening contract or a collateralized contract and determines the terms of the contract. Next, firms decide whether to accept the credit offer or not and submit their credit proposals. The monopolistic bank evaluates the credit proposal and decides which firm it offers a loan. Finally, the payoffs are realized and firms repay. We solve the game by backward induction and first study the terms of the different contracts before determining which one is offered.

2.2.1. Collateralized Credit Contract

We first study a collateralized credit contract. Collateralization implies that the firm repays an amount R in the case of success and that it loses collateral in the amount L in the case of failure. The credit contract has to be designed in a way that bad firms have no incentive to demand credit. This is reached through collateralization. The incentive compatibility constraint for a bad firm can be written as:

$$\begin{aligned} I + (A - L) &= A \text{ or} \\ L &= I \end{aligned} \tag{IC-F}$$

If a bad firm receives a loan in the amount of I, it will lose assets in the amount of L as the project fails with certainty. Therefore, it is obvious that the amount of collateral that prevents bad firms from applying for credit is I. The repayment R_M^L (with superscript L for collateral) is determined according to the participation constraint of good firms:

$$\begin{aligned} p(A + X - R) + (1-p)(A - I) &\geq A \text{ or} \\ R_M^L &\leq \frac{pX - (1-p)I}{p} \end{aligned} \tag{PC-F}$$

If the project is successful, the good firms repay R_M^L from the payoff X they generate. In the case of failure, collateralized assets in the amount of I are seized by the bank. The expected payoff when the investment is credit-financed has to be at least as high as the payoff from not investing. Thus, the monopolistic bank can extract the whole rent by demanding $R_M^L = \frac{pX-(1-p)I}{p}$, holding down the firm to a payoff of A.[8]

For the monopolistic bank the collateralized credit contract yields the following profit, denoted by Π_M^L:

Lemma 1. *The expected profit of a monopolistic bank offering a collateralized credit contract is* $\Pi_M^L = \mu(pX - (1-p)(1-\alpha)I - I)$.

As Lemma 1 shows, the monopolistic bank extracts the total rent from the good firms. However, it also has to bear the total costs of collateralization because in the case of failure, which happens with probability $(1-p)$, the collateralized assets yield a payoff of αI. This implies that there is a loss in the case of liquidation in the amount of $(1-\alpha)I$.

2.2.2. Screening Contract

If the monopolistic bank decides to screen its applicants, it has to incur the costs of c for evaluating the credit proposals. As the quality of the signal is imperfect, only a fraction s of the good firms will be financed (all the firms that generated a positive signal). Even more importantly, a fraction $(1-s)$ of bad firms gets credit as the bank (by mistake) receives a positive signal about their quality. Again, the monopolistic bank can extract all rents from the good firms by demanding X as a repayment because it makes a take-it-or-leave-it credit offer. The following lemma states the bank's profit in the case of screening, denoted by Π_M^S:

Lemma 2. *The expected profit of a monopolistic bank offering a screening contract is* $\Pi_M^S = \mu s(pX - I) - (1-\mu)(1-s)I - c$.

[8] Demanding higher collateral and lower repayment would reduce the bank's profit because getting a payoff in the case of failure, in contrast to the repayment in the case of success, means that the bank receives less than the amount that the firm has to give up.

2.2.3. Contract Offered

We can derive which credit contract is optimal for the monopolistic bank by comparing the profit levels. The threshold of the liquidation value where the decision to offer a contract changes is denoted by α_M.

Proposition 1. *The monopolistic bank offers a collateralized credit contract if* $\alpha_M \geq \frac{\mu(1-p)I-(1-s)(\mu(pX-I)+(1-\mu)I)-c}{\mu I(1-p)}$. *Otherwise, it screens all applicants and finances firms with a positive signal.*

Proof: See the Appendix A.

The monopolistic bank faces the following trade-off: in the case of collateralization, the bank must bear the costs associated with the liquidation of the collateralized asset. In the case of screening, the monopolistic bank has to incur screening costs for each applicant. More importantly, it faces the risk of receiving an incorrect signal, which means that it finances bad firms and makes losses, and it misses financing good firms and thereby foregoes extracting rents. Whenever the liquidation value of collateral exceeds the threshold value α_M, it is optimal to offer a collateralized contract.

If the costs of screening c increase, the threshold value α_M decreases. As expected, the critical liquidation value increases as the quality s of the signal and I increase. A higher I means that the costs of liquidation increase as the amount of collateral increases. A better screening technology reduces the losses of financing bad projects and foregoing good ones. Our model shows that the degree of collateralization is influenced not only by the liquidation value of collateral but also by the capability of the bank to generate information through screening.

2.3. Competitive Banking Sector

We capture bank competition in a model with two banks that engage in Bertrand competition.[9] The timing of the game is as follows: First, banks decide simultaneously which type

[9] In order to make our results as clear as possible, we restrict our analysis to only two banks. The same intuition would apply to a banking sector with more banks. The condition on the number n of banks active

of contract they offer. Second, the banks determine simultaneously the terms of the credit contract they offer. Third, firms submit their credit proposals. Firms will apply at both banks because they do not have any costs of submitting credit proposals. Like in MPP, firms can apply for only one contract at each bank because, as argued above, each bank offers only one contract. Then, banks evaluate the credit proposals and decide which firm they offer a loan. There is no information sharing between the banks about the signals of a particular customer. Next, firms decide which offer they accept. Finally, the payoffs are realized and firms repay.

[Table 1]

2.3.1. Both Banks Collateralize

As shown for the monopolistic bank, the incentive compatibility constraint of the bad firm implies that collateral $L = I$. Since banks are competing, they will demand a repayment R that guarantees that they are making zero expected profit from financing good firms. (Note that we do not use subscripts in the case of bank competition to ease notation.) The bank's participation constraint for financing good firms is that the expected profit from the repayment R it gets in the case of success and the liquidation value it gets in the case of failure αI cover the loan I:

$$\begin{aligned} pR + (1-p)\,\alpha I &= I \text{ or} \\ R &= I\frac{1-(1-p)\,\alpha}{p} \end{aligned}$$

The payoff a firm receives with a collateralized credit contract is denoted by P^L, the bank's profit by Π^L. The good firm's participation constraint is always fulfilled because it is the residual claimant and gets the same payoff as the monopolistic bank gets from financing one good firm.

Lemma 3. *If both banks offer a collateralized credit contract, a good firm receives an expected payoff of* $P^L = pX - I\,(1 + (1-\alpha)\,(1-p))$ *and banks make zero expected profits,* $\Pi^L = 0$.

in the market is that the nth signal generated yields a non-negative payoff for the bank which bases its lending decision on this signal (see condition (2.2) for the case of two banks).

2.3.2. Both Banks Screen

Banks demand a repayment of R^S if the firm is successful and they do not get any repayment if the firm fails. We solve the game by backward induction. Firms choose the most favorable credit offer, implying that firms accept any credit contract offered if they receive only one offer. Banks accept those firms with a positive signal. Of course, the banks are aware of the adverse selection problem existing between them because they have applicants with a positive signal that are rejected by their competitor.

The banks determine their repayment as follows. A bank is willing to offer credit with certainty if the expected payoff from demanding the highest repayment X and being undercut with certainty by its competitor is non-negative. We assume that this is indeed the case. Formally, this condition is given by:

$$\overline{\Pi}^S = \mu(1-s)\,s\,(pX-I)-(1-\mu)\,s\,(1-s)\,I-c \qquad (2.1)$$

$$= (1-s)\,s\,(\mu pX-I)-c\geq 0 \qquad (2.2)$$

The expected profit of demanding X consists of the rent, $pX-I$, that a bank can extract from those good firms that generate a positive signal at this bank but a negative signal at the other bank. However, the bank also has to cover the loss made with bad firms that receive a favorable signal at this bank but a negative one at the other bank, i.e., $(1-\mu)\,s\,(1-s)\,I$. Moreover, the evaluation of each credit proposal causes a cost of c since all firms apply at each of the two banks.

There is no equilibrium in pure strategies when the repayment R^S is determined. We denote the repayment that a bank needs to break even when serving the whole market by $\underline{R}^S$. Suppose bank 1 and bank 2 offer the same repayment. Then, applicants with two good signals would go to each bank with equal probability. Suppose that this R^S yields zero expected profit for the banks and that bank 1 marginally reduces the repayment. Thereby, bank 1's profit would increase discontinuously because all applicants with two good signals would apply for credit at bank 1. By undercutting, bank 1 can improve the pool of applicants significantly and therefore makes a non-negative expected profit. This would hold for all $R^S\geq\underline{R}^S$. For bank 2 the optimal answer would be to demand X from all applicants with a positive signal from bank 2 but a negative signal from bank 1. However, in this situation demanding $\underline{R}^S$ is no longer optimal for bank 1. Thus, no equilibrium in pure strategies exists. The mixed strategy equilibrium is described in the following proposition:

Lemma 4. *The mixed strategy equilibrium has the following features: The banks demand a repayment from the range* $\left[\frac{s(\mu pX-I)(1-s)+(1-s(1-\mu)-\mu(1-s))I}{\mu sp}, X\right]$, *according to the following cumulative distribution function* $F(R) = \frac{\mu s^2(pR-I)-\mu s(1-s)p(X-R)-(1-\mu)(1-s)^2 I}{\mu s^2(pR-I)-(1-\mu)(1-s)^2 I}$.

Proof: See the Appendix B.

Note that $F(R)$ and $\underline{R}^S$ decrease in s, which means that the expected repayment a bank demands decreases in the quality of the signal. The reason is that as s increases, the fraction of good firms that receive only one positive signal and are willing to repay X decreases. For the bank this means that the number of firms that are willing to repay up to X decreases and therefore it is optimal to reduce the repayment in order to attract the good firms which receive a positive signal at both banks and therefore choose the lowest repayment. The following lemma shows the firm's expected payoff, denoted by P^S, and the bank's expected profits. $E\left(R^S\right)$ denotes the expected repayment.

Lemma 5. *If both banks offer a screening contract, the expected payoff of a good firm is* $P^S = p\left(X - E\left(R^S\right)\right) s(2-s)$ *and banks make an expected profit of*
$\Pi^S = \mu(1-s)s(pX-I) - (1-\mu)s(1-s)I - c.$

Proof: See the Appendix B.

A good firm receives a loan when at least one of the two signals about its creditworthiness is positive. The probability to receive credit is thus $s(2-s)$. The repayment is influenced by the screening quality of the bank. The repayment determines the extent to which bad firms are subsidized by good firms. It also influences the profit which the banks can earn by serving the good firms with only one positive signal. The latter profit level determines the expected bank profit Π^S. Although there is Bertrand competition banks make positive expected profits because asymmetric information between banks is not fully eliminated after banks conducted their creditworthiness tests.

2.3.3. One Bank Screens, One Bank Collateralizes

Suppose bank 1 offers a collateralized credit contract and bank 2 offers a screening contract. Good firms demand credit from the bank that offers the lowest expected repayment. Bad firms receive a loan offer only from bank 2 which errs with probability $(1-s)$, and they accept this offer. A collateralized credit contract specifies a repayment, denoted by R^{LS} (the first superscript shows the choice of the bank we consider and the second the competitor's choice), and collateral $L(= I$ in order to prevent the bad firm from demanding a loan). The repayment of the screening contract is denoted by R^{SL}. A good firm is indifferent between the collateralized contract and the screening contract (given it receives an offer) if:

$$p\left(X - R^{LS}\right) - (1-p)\, I = p\left(X - R^{SL}\right)$$

or if the collateralized contract offers $L = I$ and $R^{LS} = R^{SL} - \frac{I(1-p)}{p}$.

There is no equilibrium in pure strategies when the contract terms are determined, for the same reason as before. We can use the following condition to determine bank 1's expected profit: suppose bank 1 offers a contract that only those good firms that generated a negative signal at the competing bank will choose, which is a collateralized contract with $L = I$ and the highest repayment possible $R^{LS} = R_M^L$. All other repayments have to generate the same profit level. The equilibrium is in mixed strategies and is shown in the next lemma. We denote the cumulative density function of bank 1 (2) by F (G). At a threshold value $\alpha_2 = \frac{\mu s(1-s)(pX-I)+\mu s^2 I(1-p)-I(1-\mu)(1-s)-c}{\mu s^2 I(1-p)}$ the cumulative density functions of bank 1 and the profit levels of bank 2 change.[10] We denote the repayments accordingly with $\underline{R}_{\alpha\leq\alpha_2}^{LS}$ and $\underline{R}_{\alpha\leq\alpha_2}^{SL}$ $\left(\underline{R}_{\alpha>\alpha_2}^{LS}\right.$ and $\left.\underline{R}_{\alpha>\alpha_2}^{SL}\right)$ for those below (above) the threshold value.

Lemma 6. *The mixed strategy equilibrium has the following features:*
Bank 1 *demands collateral $L = I$ and a repayment R^{LS}*
- from the range $\left[\underline{R}_{\alpha\leq\alpha_2}^{LS}, R_M^L\right]$ according to $F\left(R^{LS}\right) = \frac{(s-1)(pX-I)-s(1-p)(1-\alpha)I+pR^{LS}-pI}{p(R^{LS}-I)}$ and $prob(R^{LS} = X) = \frac{(1-s)(pX-I)+s(1-p)(1-\alpha)I}{p(R^{LS}-I)}$ if $\alpha \leq \alpha_2$,
- and from the range $\left[\underline{R}_{\alpha>\alpha_2}^{LS}, R_M^L\right]$ according to $F\left(R^{LS}\right) = \frac{\mu spR^{LS}-(1-\mu)(1-s)I-\mu spI-c}{\mu sp(R^{LS}-I)}$ and

[10] The threshold value α_2 is denoted this way because it is used for comparisons in the following propositions.

$prob(R^{LS} = X) = \frac{(1-\mu)(1-s)I+c}{\mu sp(R^{LS}-I)}$ if $\alpha > \alpha_2$.
Its expected profit is $\Pi^{LS} = (1-s)\mu(pX - I - I(1-p)(1-\alpha))$.
***Bank 2** offers a screening contract and demands a repayment R^{SL} according to*
$G\left(R^{SL}\right) = \frac{pR^{SL}-(1-s)(pX)-s(1-p)(1-\alpha)I-sI}{s((pR^{SL}-I)-(1-p)(1-\alpha)I)}$
- from the range $\left[\underline{R}^{SL}_{\alpha\leq\alpha_2}, X\right]$ if $\alpha \leq \alpha_2$. Its expected profit is
$\Pi^{SL} = (1-s)(\mu s(pX - I) - (1-\mu)I) + s^2\mu(1-\alpha)(1-p)I - c.$
- and from the range $\left[\underline{R}^{SL}_{\alpha>\alpha_2}, X\right]$ if $\alpha > \alpha_2$. Then its expected profit is $\Pi^{SL} = 0$.

Proof: See the Appendix B.

Bank 1, which offers the collateralized credit contract, can always secure itself a positive payoff of Π^{LS} since it has the outside option of serving all the good firms with a bad signal that do not get a loan offer from bank 2 and demanding X from them. As Lemma 6 shows, bank 1 will demand the repayment X with positive probability. The expected profit of bank 2 also depends on the liquidation value α. For low enough liquidation values bank 2 makes positive profits as well because its screening technology involves comparatively lower costs than collateralization. This, in turn, allows bank 2 to extract rents from the firms whose outside option is a collateralized contract which is - due to the low liquidation value - rather expensive. Bank 2 mixes continuously over the whole range of repayments. If the liquidation value exceeds a certain threshold, collateralizing is more cost-efficient. This reduces bank 2's position in the competitive environment and it thus makes zero expected profits. In this case, bank 2 demands the minimum repayment with positive probability. Moreover, this minimum repayment has to be higher than in the case of $\alpha \leq \alpha_2$ in order to guarantee bank 2 a non-negative profit.

2.3.4. Contract Offered

Solving the game by backward induction, we determine the type of contract which is offered in equilibrium. The banks simultaneously choose the type of contract offered. We assume that banks offer a collateralized credit contract if both contracts generate the same return, since in case of collateralization the number of bad loans is lower. Depending on the parameter values, we obtain the following equilibria.

Proposition 2. *The contracts offered in equilibrium by competing banks depend on the liquidation value:*

- If $\alpha < \alpha_1 = \frac{\mu(2s-1)(pX-I)-s^2(\mu pX-I)+\mu(1-p)(1-s)I-s(1-\mu)I-c}{\mu(1-p)(1-s)I}$, both banks screen.
- If $\alpha_1 \leq \alpha < \alpha_2$, each bank offers a screening contract with probability $t_i = \frac{\Pi^{SL}}{\Pi^{SL}+\Pi^{LS}-\Pi^{S}}$ and a collateralized contract with probability $1 - t_i, i = 1, 2$.
- If $\alpha \geq \alpha_2$, both banks collateralize.

Proof: See the Appendix A.

When deciding which contract to offer banks compare the profits from the different contracts. For very low liquidation values, i.e. $\alpha < \alpha_1$, both banks offer a screening contract. Since screening is relatively cheaper, the profit extracted through this type of contract is high. The reason is that there exist firms which receive an offer from one bank but do not receive an offer from the other bank with certainty as the signals are imperfect and independent. These firms are willing to repay as much as X. Thus, banks react by demanding repayments that exceed the minimum repayment, and they can extract rents.

If the liquidation value increases, banks offer different contracts. There are two effects at work. First, suppose bank 1 offers a screening contract. Then, it is optimal for bank 2 to offer a collateralized contract since it avoids denying credit to good firms. Second, suppose bank 1 offers a collateralized credit contract. In order to avoid the scenario of perfect competition with zero expected profit, bank 2 offers a screening contract. But the profit level depends on the contract offered. If offers were made sequentially, the bank making the offer first would offer the most profitable contract. Since contracts are offered simultaneously, an equilibrium in mixed strategies exists where banks offer a screening (collateralized) credit contract with probability t_i $(1 - t_i)$. Finally, if the liquidation value is above α_2, both banks offer a collateralized credit contract. They both have perfect information about the firm's type and therefore competition is perfect.

2.4. Comparison between Monopolistic Bank and Competing Banks

The crucial question is how the market structure in the banking sector influences the credit contract offered. To answer this question, we compare the threshold values of the liquidation values for which a monopolistic bank and the competing banks, respectively, change the contract offered. Thus, the threshold values for the competitive scenario are α_1 and α_2; for the monopolistic scenario there is only the threshold value α_M, with $\alpha_1 < \alpha_M < \alpha_2$.

Proposition 3. *(i) Suppose that the liquidation value is very low, i.e., $\alpha < \alpha_1$, then the monopolistic bank as well as the competing banks offer a screening contract.*
(ii) Suppose that the liquidation value is low, i.e., $\alpha_1 \leq \alpha < \alpha_M$, then the monopolistic bank offers a screening contract whereas in the case of competition, banks offer a screening contract and a collateralized contract with probability t_i and $(1 - t_i)$, respectively.
(iii) Suppose that the liquidation value is high, i.e., $\alpha_M \leq \alpha < \alpha_2$, then the monopolistic bank offers a collateralized credit contract whereas in the case of competition, again banks offer a screening contract and a collateralized contract with probability t_i and $(1 - t_i)$, respectively.
(iv) Suppose that the liquidation value is very high, i.e., $\alpha \geq \alpha_2$, then the monopolistic as well as the competing banks offer a collateralized credit contract.

Proof: See the Appendix A.

[Table 2]

The monopolistic bank is the residual claimant and therefore has to bear the costs of collateralization. Thus, it always chooses the contract with the lowest costs. As long as the liquidation value is not high, i.e., $\alpha < \alpha_M$, the optimal contract is one with screening. Only if the liquidation value is high or very high does the monopolistic bank offers a collateralized credit contract, because then the expected costs of liquidating collateralized assets are lower than the costs of a screening contract (see Figure 2.2. for an illustration). There are two differences between the offers of a monopolistic bank and competing banks. First, with competing banks both types of contracts can be offered at the same time. Second, the threshold values where the competing banks' choice changes differ as compared to the monopolistic bank. For very low liquidation values, both competing banks offer a screening contract just as the monopolistic bank does. For low liquidation values, the competing banks offer a screening contract and a collateralized credit contract with positive probability whereas the monopolistic bank offers a screening contract. For high liquidation values, competing banks still offer screening and collateralized contracts with positive probability whereas a monopolistic bank offers only a collateralized credit contract. Only if the liquidation value is very high is a collateralized credit contract offered independently of the market structure.

We find that competing banks collateralize either more or less often than a monopolistic bank. For low liquidation values, competing banks collateralize more often than a monopolistic bank. But if liquidation values are high, competing banks collateralize less often than a monopolistic bank. Thus, we obtain the same result as MPP for low liquidation values but the opposite result if the liquidation value is high. Why do competing banks collateralize more often if the liquidation value is low? In this parameter range, a monopolistic bank screens because the costs of collateralization would be too high. If there is bank competition, the banks offer a screening contract and generate two independent signals; each bank thus finances those firms for which it has a positive signal. This also means that each bank finances firms that were rejected by the other bank. This imposes significant costs because, among those rejected by the other bank, there is a large fraction of bad firms. Thus, the competing banks compare the costs of financing firms with a positive signal that were rejected by the competitor and the costs of collateralization. Therefore, they offer the combination of screening and collateralized contract even for low liquidation values.

What is the reason for competing banks to collateralize less often than a monopolistic bank if the liquidation value is high? Competing banks would make zero expected profits if they both offered a collateralized contract. By offering different contracts some degree of asymmetric information prevails as the screening signal is imperfect. Thereby, each of the two competing banks makes positive expected profits. Thus, the banks' aim to maximize their profits and the possibility to offer different types of contracts lead to less collateralization in the case of bank competition.

2.5. Access to Credit

Our analysis allows us to make predictions about the impact of bank competition on access to credit. Limited access to credit is an important obstacle for the operation and growth of firms in many countries and therefore many policy programs are run in order to reduce this obstacle. We measure access to credit as the probability that a firm gets a loan. We first study the impact of bank competition on access to credit for good firms because they should be the ones that receive loans. Most importantly, we find that whether the degree of bank competition affects access to credit depends on the institutional environment as the following proposition shows.

Proposition 4. *The probability that a good firm receives a loan*
- is higher with bank competition if the liquidation value is very low or low, i.e., $\alpha < \alpha_M$,
- but does not depend on the degree of bank competition if the liquidation value is high or very high, i.e., $\alpha \geq \alpha_M$.

Proof: See the Appendix A.

For very low liquidation values, the chances of good firms to receive a loan are higher in the case of bank competition as compared to a monopolistic bank. The reason is that there are two banks that generate independent signals. For low liquidation values, the monopolistic bank screens and finances those good firms with a positive signal whereas in the case of bank competition, one of the two banks offers a collateralized loan which ensures that all good firms receive a loan.

For high and very high liquidation values access to credit is independent of the degree of competition. The monopolistic bank as well as (at least one of) the competing banks offers a collateralized contract. Thus, all good firms have access to credit.

We also study the impact of competition on the access to credit for all firms, including bad firms because, for instance in an empirical study, it might be difficult to control for whether a firm is creditworthy. For very low liquidation values, bank competition increases the probability to get a loan for both the good and the bad firms. Bad firms also benefit from competition because, in sum, competing banks make mistakes more often. For low liquidation values, the bad firms have the chance to get a loan offer independently of the degree of competition because one of the competing banks offers a screening contract and thus makes an offer to a bad firm with the same probability as a monopolistic bank. But, as shown before, good firms are more likely to get loans in the case of bank competition. Thus, for low liquidation values, access to finance is (on average) easier with bank competition. For high liquidation values, bad firms are never financed by a monopolistic bank because it offers only a collateralized contract. However, they obtain loans from the competing bank that offers the screening contract. Here, competition provides easier access for bad firms. For very high liquidation values, only the good firms get access to credit because they are financed by a collateralized credit contract. Therefore, in this case the degree of bank competition does not matter for access to credit.

We can conclude that up to a threshold of the liquidation value, access to finance increases through bank competition (although this threshold differs for good and bad firms). For liquidation values above the threshold, the degree of bank competition does not matter any longer. Our prediction is confirmed by a cross-country study which uses the firms' perception about how much access to finance is an obstacle for a their operations and growth (Beck, Demirgüc-Kunt, and Maksimovic, 2004). It shows that access to finance improves through bank competition in developing countries. However, in countries with well developed institutions, bank competition does not influence access to finance. Thus, we provide an explanation for this observation. The institutional environment and the degree of bank competition in a country determine which type of contract is offered and this offer, in turn, influences access to finance. Once institutions are good enough, i.e. the liquidation value is high, the monopolistic bank and at least one of the competing banks offer a collateralized contract so that all good firms get access to credit - independently of the degree of bank competition.

3. Welfare Analysis

3.1. Optimal Contract

We want to evaluate the contract choice in terms of efficiency. Therefore, we study a social planner that can determine the number of banks. In the context of our model, the costs of financing depend on the degree of bank competition and the type of contract offered (which is denoted by T for contract). Both determinants are influenced by the size of the costs of collateralization relative to the screening costs.[11] In the case of a monopolistic bank social welfare is given by:

$$SW \begin{cases} = \Pi_M^S = \mu s\left(pX - I\right) - \left(1-\mu\right)\left(1-s\right)I - c & \text{if } T = S \\ = \Pi_M^L = \mu\left(pX - I - I\left(1-p\right)\left(1-\alpha\right)\right) & \text{if } T = L \end{cases}$$

Since the profit of the monopolistic bank and social welfare coincide, the monopolistic bank opts for the efficient contract given the menu of contracts it can chose from.

With bank competition the contracts offered change as compared to the case of a monopolistic bank. Social welfare is given by:

$$SW \begin{cases} = s\left(2-s\right)\mu\left(pX-I\right) - \left(1-s^2\right)\left(1-\mu\right)I - 2c & \text{if } T = S \\ \Pi_M^L < SW < \mu\left(pX - I\right) - \left(1-s\right)I\left(\left(1-\mu\right) - \mu\left(1-p\right)\left(1-\alpha\right)\right) - c & \text{if } T = S, L \\ = \mu\left(pX - I - I\left(1-p\right)\left(1-\alpha\right)\right) & \text{if } T = L \end{cases}$$

Social welfare depends on the type of contracts offered. First, if both banks screen, loans are granted to $s\left(2-s\right)$ good firms that contribute to social welfare, and $\left(1-s^2\right)$ bad firms that reduce social welfare. Second, banks offer different types of contract. In order to facilitate the exposition of the social welfare function, we state the lower and the upper bound of social welfare by studying the most extreme combination of contracts. One bound is social welfare when the bank that offers the collateralized credit contract would serve all customers ($SW = \Pi_M^L$). The other bound is social welfare when a bank would finance all firms with a good signal and would offer collateralization to those firms which generate a

[11] Note that in this model the liquidation value represents the proceeds the bank receives as creditor. The social costs from liquidation might well be lower than the deadweight loss from liquidation. The reason is that the buyer of the asset may have a higher willingness to pay than is reflected by the liquidation value.

negative signal. Only the good firms among those with a negative signal accept the offer to pledge collateral. The actual social welfare with competing banks is within these bounds because firms demand credit from the bank with the lowest offer. Since banks mix over repayments, it is not clear which bank wins a customer, i.e. whether a customer that gets two offers is served by the bank with the lowest cost contract. Therefore, the actual social welfare depends on which bank wins the competition and, thus, on the cumulative density functions of both banks. Finally, if both banks collateralize, all good firms contribute to social welfare, which is reduced by the costs of collateralization.

Ultimately, we want to know which market structure in the banking sector maximizes social welfare and, given the optimal market structure, which contracts are offered. Within the parameter ranges of low and high liquidation values there exist threshold values where the optimal market structure changes. We denote these threshold values by α^S_{low} and α^S_{high} and discuss their values later in the text. The following proposition shows the optimal market structure:

Proposition 5. *(i) If the liquidation value is very low, i.e. $\alpha < \alpha_1$,the social planner allows two banks to enter the market. Banks offer screening contracts and produce two independent signals.*

(ii) If the liquidation value is low, there exist two parameter ranges:

- For $\alpha_1 \leq \alpha < \alpha^S_{low}$, the social planner prefers a monopolistic bank that offers a screening contract.

- For $\alpha^S_{low} \leq \alpha < \alpha_M$, the social planner allows two banks that offer a screening and a collateralized contract with probability t_i and $(1 - t_i)$, respectively.

(iii) If the liquidation value is high, there exist two parameter ranges:

- For $\alpha_M \leq \alpha < \alpha^S_{high}$, the social planner allows competing banks to enter the market, which offer a screening and a collateralized contract with probability t_i and $(1 - t_i)$, respectively.

- For $\alpha^S_{high} \leq \alpha < \alpha_2$, the social planner opts for a monopolistic bank that offers a collateralized contract.

(iv) If the liquidation value is very high, i.e. $\alpha_2 \leq \alpha$, then the social planner is indifferent between a banking market with one or two banks since both offer a collateralized credit contract and produce the same social welfare.

Proof: See the Appendix A.

[Table 3]

As part (i) of the proposition states, for very low liquidation values collateralization is very expensive. Both the monopolistic bank and the competing banks offer screening contracts. Note that in the case of competition the banks generate signals on the creditworthiness of a borrower independently of each other and that the second signal is such that financing firms according to this signal increases welfare. Consequently, the allocation in the case of a monopolistic bank is less efficient than that of competing banks (see Figure 3.1.).

For low liquidation values (part (ii)), we can show that there exists a threshold value where the optimal market structure changes. For the ease of exposition we did not calculate social welfare but show its lower and its upper bounds. We know that for the lowest liquidation value in this parameter range, α_1, both the (hypothetically) lowest and highest value of social welfare are below social welfare with a monopolistic bank. And thus, social welfare with a monopolistic bank is higher. For the highest liquidation value in the parameter range, α_M, social welfare with competing banks certainly exceeds the level with a monopolistic bank, because both for the lower and the upper bound social welfare is higher with competing banks. Thus, there must exist a threshold in the parameter range of low liquidation values where the optimal market structure changes from a monopolistic bank to competing banks. The intuition is that for low liquidation values in this parameter range it is rather expensive to collateralize. The trade-off a competing bank faces is between collateralization and screening given that the other bank screens as well. This renders screening more expensive for competing banks and explains why they choose to offer a collateralized credit contract with some probability for these low liquidation values although it is inefficient. For the liquidation values in this parameter range above the threshold competing banks dominate because as a group they have a richer set of contracts to offer.

For high liquidation values (part (iii)), there is a similar reasoning. For low liquidation values in this parameter range, the competing banks generate the higher social welfare (as social welfare at both the lower and the upper bound is higher than in the case of a monopolistic bank). But once the liquidation values exceed α^S_{high}, the monopolistic bank is optimal. The reason is that for these values, collateralization is relatively cheaper than screening. But the competing banks' incentives to offer only collateralized contracts are distorted. If they both offered a collateralized contract, there would be no asymmetric information between banks and perfect competition would drive their profits down to zero. As long as they offer two different contracts, they both make positive expected profits.

Finally, if the liquidation value exceeds the threshold value of α_2 (part (iv)), the terms of a credit contract are independent of the degree of competition. Therefore, a social planner is indifferent between market structures.[12]

4. Discussion and Conclusion

In this paper we ask the question *when* bank competition is good. Thus, we must integrate into our analysis the particular features of the environment in which banks operate. Most importantly the country's institutional environment, in particular the legal system, determines a bank's payoffs. In our model this is captured by the credit contract and, in particular, the liquidation value a bank gets when a project fails and the bank must liquidate the firm's assets. Our model shows that the impact of bank competition on collateralization, access to finance, and social welfare depends on the quality of institutions.

Regarding the use of collateral, our model challenges the results by MPP. They argue that competing banks become lazy and reduce their screening effort if they can collateralize. Indeed, we get the same result if the liquidation value is low; competing banks collateralize more often. But this is detrimental to social welfare only if the liquidation value is in

[12] We give each bank the possibility to offer either a screening or a collateralized contract to an individual customer (which is justified by empirical evidence, see Saunders and Thomas, 2001). However, for the contracts offered on the market this implies that with a monopolistic bank one type of contract is offered but with competing banks it is possible that the two banks offer different types of contracts. We could enrich the menu of contracts a monopolistic bank can choose from to that in the case of bank competition and check how much our results depend on the current specification. In particular, we would give the monopolistic bank a richer set of contracts and thereby allow the monopolistic bank to offer a collateralized contract to those firms that generated a negative signal. The basic insights on the choice of contracts and the effect of bank competition on social welfare hold (although some details change, results are available upon request). Most importantly, social welfare is still highest with bank competition if the liquidation value is relatively low.

the lower range of this parameter range. For liquidation values in the upper range, bank competition delivers higher social welfare. However, for higher liquidation values our result contradicts the one by MPP, namely that competing banks collateralize less often. Here, the impact of social welfare is ambiguous, as well.

With respect to access to credit, we find that in countries with poor institutions (reflected by low liquidation values) bank competition improves a firm's chance to get a loan. However, in countries with proper institutions (reflected by high liquidation values) the degree of bank competition does not matter for access to credit. Empirical evidence supports these predictions (Beck, Demirgüc-Kunt, Maksimovic, 2004). Thus, our paper delivers an explanation for how the institutional environment influences the impact of bank competition on, for instance, access to finance.

Ultimately, we want to evaluate the effect of bank competition on social welfare and show that for very low liquidation values, bank competition maximizes social welfare. For low and high liquidation values there exist parameter ranges in which a monopolistic bank is preferred by a social planner. When the liquidation value is very high, the degree of bank competition no longer influences social welfare.

The welfare analysis clearly shows that social welfare increases in the liquidation values. One obvious reason is that the losses through liquidation decrease. But higher liquidation values have the additional advantage that, independently of the degree of bank competition, the efficient contract is offered. The policy recommendations depend on the source of the costs of liquidation. In developed economies, liquidation values of assets are low if assets are traded on illiquid secondary markets. In particular, in times of financial crises secondary markets can be very illiquid. Banks will take into account such a situation when evaluating the expected liquidation value of collateral. Governments should take actions that help to increase the liquidity of secondary markets. In emerging markets, low liquidation values are in addition caused by the poor legal and institutional environment. Thus, measures should be taken that reduce the costs of collateralization, for example, by speeding up the decision of courts (see also World Bank, 2002).

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6. Appendix A

6.1. Proof of Proposition 1

We want to show that $\Pi_M^S < \Pi_M^L$. Therefore we compare

$$\begin{aligned} \Pi_M^L &= \mu\left(pX - (1-p)(1-\alpha)I - I\right) \\ &\geq \mu s\left(pX - I\right) - (1-\mu)(1-s)I - c = \Pi_M^S \end{aligned}$$

for α_M described in the proposition. Q.E.D.

6.2. Proof of Proposition 2

The profit when a screening contract is offered is Π^S. The profit with a collateralized contract is Π^L. The bank obtains a profit of Π^{SL} if it screens and the competitor collateralizes and a profit of Π^{LS} if it collateralizes when the competitor screens. Banks offer contracts simultaneously.

We derive first an equilibrium in mixed strategies and then argue when this equilibrium is indeed obtained. Suppose bank 1 offers a screening contract with probability t_1 and a collateralized contract with probability $(1-t_1)$. Bank 2 is indifferent between offering a screening and a collateralized contract if

$$\begin{aligned} t_1\Pi^S + (1-t_1)\Pi^{SL} &= t_1\Pi^{LS} + (1-t_1)\,0 \text{ or} \\ t_1 &= \frac{\Pi^{SL}}{\Pi^{SL} + \Pi^{LS} - \Pi^S}. \end{aligned}$$

Since banks are symmetric $t_1 = t_2 = t_i$. Because t_i depends on the liquidation value α, we can show that

- $t_i = 1$ if $\Pi^{LS} = \Pi^S$ or $\alpha = \alpha_1$

$$\Pi^{LS} - \Pi^S = 0 \text{ if}$$

$(1-s)\mu pX - I - I(1-p)(1-\alpha) - (\mu(1-s)(s(pX-I)) - (1-\mu)s((1-s)I) - c) = 0$ or

$$\alpha_1 \equiv \alpha = \frac{\mu(2s-1)(pX-I) + \mu(1-p)(1-s)I - s^2(\mu pX - I) - s(1-\mu)I - c}{\mu(1-p)(1-s)I}$$

Thus, for $\alpha < \alpha_1$, there exists an equilibrium in pure strategies where both banks offer a screening contract.

- $t_i = 0$ if $\Pi^{SL} = 0$ or $\alpha = \alpha_2$

  Thus, for $\alpha > \alpha_2$, there exists an equilibrium in pure strategies where both banks offer a collateralized contract.

- For $\alpha_1 \leq \alpha \leq \alpha_2$, no equilibrium in pure strategies exists. Suppose bank 1 offers a screening contract. Then the best response of bank 2 is to offer a collateralized contract. The best response of bank 1 is to offer a screening contract if bank 2 offers a collateralized contract. Suppose bank 1 offers a collateralized contract, then the best response of bank 2 is to offer a screening contract. Provided that bank 2 offers a screening contract, bank 1's best response is to offer a collateralized contract. The payoff of offering a screening contract is higher if $\alpha < \frac{\mu s^2 I(1-p) - \mu(pX-I)(1-s)^2 - I(1-s)(1-2\mu+\mu p) - c}{(1-p)(1-s+s^2)I\mu}$, otherwise it is lower. For α below this threshold value each bank would like to offer a screening contract. As argued above, this is not an equilibrium. As a result, they choose the screening (collateralized) contract with probability t_i $(1-t_i)$. Q.E.D.

6.3. Proof of Proposition 3

(1) We show that $\alpha_1 < \alpha_M$:

$$\alpha_M - \alpha_1 = \frac{\mu(1-p)I - (1-s)(\mu(pX-I) + (1-\mu)I) - c}{\mu(1-p)I} - \frac{\mu(2s-1)(pX-I) + \mu(1-p)(1-s)I - s^2(\mu pX - I) - s(1-\mu)I - c}{\mu(1-p)(1-s)I} =$$
$$\frac{(2s-1)(1-s)(1-\mu)I + cs}{\mu(1-p)(1-s)I} > 0$$

(2) We show that $\alpha_M < \alpha_2$:

$$\alpha_2 - \alpha_M = \frac{\mu s(1-s)(pX-I) + \mu s^2(1-p)I - (1-\mu)(1-s)I - c}{\mu s^2(1-p)I} - \frac{\mu(1-p)I - (1-s)(\mu(pX-I) + (1-\mu)I) - c}{\mu(1-p)I} =$$
$$(1-s)(s+1)\frac{s\mu(pX-I) - (1-s)(1-\mu)I - c}{\mu s^2(1-p)I}$$

as $s\mu(pX-I) - (1-s)(1-\mu)I - c = \Pi_M^S > 0$

By comparing the threshold values derived in the previous propositions cases (i) to (iv) can be discriminated. Q.E.D.

6.4. Proof of Proposition 4

Probability that a good firm gets a loan:

Liquidation value	Monopolistic bank		Competing banks
very low, $\alpha < \alpha_1$	s	$<$	$s(2-s)$
low, $\alpha_1 \leq \alpha < \alpha_M$	s	$<$	1
high, $\alpha_M \leq \alpha < \alpha_2$	1	$=$	1
very high, $\alpha \geq \alpha_2$	1	$=$	1

Q.E.D.

6.5. Proof of Proposition 5

The social planner compares social welfare for the different values of α.

(i) For a very low liquidation value, i.e. $\alpha < \alpha_1$:

The monopolistic bank as well as the competing banks offer a screening contract.

$$\begin{aligned} & SW_M - SW \\ = \; & (\mu s (pX - I) - (1-\mu)(1-s) I - c) - \left(s(2-s)\mu(pX - I) - \left(1 - s^2\right)(1-\mu) I - 2c\right) \\ = \; & -\overline{\Pi}^S < 0 \end{aligned}$$

(ii) For a low liquidation value, i.e. $\alpha_1 \leq \alpha < \alpha_M$:

The monopolistic bank offers a screening contract whereas the competing banks offer a screening and a collateralized contract with positive probability.

(1) Compare social SW_M with SW when competing banks hypothetically offer a collateralized contract:

$$\begin{aligned} & SW_M - SW(Collat) \\ = \; & (\mu s (pX - I) - (1-\mu)(1-s) I - c) - \mu (pX - (1-p)(1-\alpha) I - I) \\ = \; & (1-s)(-\mu(pX - I) - (1-\mu) I) + \mu (1-\alpha)(1-p) I - c \end{aligned}$$

The sign of this difference depends on α. Since $\frac{\partial((1-s)(-\mu(pX-I)-(1-\mu)I)+\mu(1-\alpha)(1-p)I)}{\partial\alpha} = -\mu(1-p) I < 0$, we know that the difference decreases continuously. We evaluate it at

$\alpha_1 : SW_M - SW(Collat) = \frac{I(2s-1)(1-s)(1-\mu)+cs}{1-s} > 0$

$\alpha_M : SW_M - SW(Collat) = 0$

Thus, there must be some threshold value for which the market structure maximizing social welfare changes.

(2) Compare social SW_M with SW when competing banks hypothetically offer a screening contract and a collateralized contract to all firms with a negative signal:

$$\begin{aligned} & SW_M - SW(Screen + Collat) \\ = \; & (\mu s (pX - I) - (1-\mu)(1-s) I - c) - \\ & (\mu (pX - I) - (1-\mu)(1-s) I - c - (1-s)\mu (1-p)(1-\alpha) I) \\ = \; & -\mu ((pX - I) - (1-\alpha)(1-p) I)(1-s) < 0 \end{aligned}$$

Thus, there exists a threshold value α_{low}^S below which social welfare is highest with a monopolistic bank and above which social welfare is highest with competing banks.

(iii) For a high liquidation value, i.e. $\alpha_M \leq \alpha < \alpha_2$:

The monopolistic bank offers a collateralized contract whereas the competing banks offer a screening and a collateralized contract with positive probability.

(1) Compare social SW_M with SW when competing banks hypothetically offer a collateralized contract. Then the $SW_M - SW(Collat) = 0$ because the monopolistic bank offers a collateralized contract as well.

(2) Compare social SW_M with SW when competing banks hypothetically offer a screening contract and a collateralized contract to all firms with a negative signal:

$$\begin{aligned} & SW_M - SW(Screen + Collat) \\ = \; & (\mu (pX - (1-p)(1-\alpha) I - I)) - (\mu (pX - I) - (1-\mu)(1-s) I - c - (1-s)\mu (1-p)(1-\alpha). \\ = \; & -\mu (1-\alpha)(1-p)(2-s) I + (1-\mu)(1-s) I + c \end{aligned}$$

The sign of this difference depends on α. Since $\frac{\partial(-\mu(1-\alpha)(1-p)(2-s)I+(1-\mu)(1-s)I+c)}{\partial\alpha} = I\mu (2-s)(1-p) > 0$ the difference is increasing continuously in α. We evaluate it at

$\alpha_M : SW_M - SW(Collat) = -(1-s)(s\mu (pX - I) - (1-\mu)(1-s) I - c) < 0$

$\alpha_2 : SW_M - SW(Collat) = (1-s) \frac{s\mu(pX-I)-(1-s)(1-\mu)I-c}{s} > 0$

Thus, there exists an α_{high}^{S} below which social welfare is highest with competing banks and above which social welfare is highest with a monopolistic bank.

(iv) For a very high liquidation value, i.e. $\alpha \geq \alpha_2$:

Then the monopolistic as well as the competing banks offer a collateralized credit contract. In this case $SW = \mu\left(pX - I - (1-p)(1-\alpha) I\right)$, independently of the number of banks. Therefore, the social planner is indifferent between a monopolistic bank and competing banks. Q.E.D.

7. Appendix B (Not intended for publication)

7.1. Proof of Lemma 4

We determine the equilibrium in mixed strategies as described in the lemma.

- If the bank offers the lowest repayment $\underline{R}^S$, it will attract all firms that are offered credit by the competitor and, of course, the firms that do not have an alternative offer. The bank's expected payoff is:

$$\begin{aligned} &\left\{\mu\left(s^2\left(p\underline{R}^S - I\right)\right) - (1-\mu)(1-s)^2 I\right\} + \\ &\left\{\mu(1-s)s\left(p\underline{R}^S - I\right) - (1-\mu)s(1-s)I\right\} - c \\ &= \overline{\Pi}^S \end{aligned}$$

The first brace captures the expected payoff from firms with two positive signals, the second those with a positive signal from this bank only. All firms with two positive signals demand credit from this bank because it demands the lowest repayment. Good firms among the applicants from this group will receive credit with probability s^2. Bad firms are financed with probability $(1-s)^2$. The probabilities s^2 and $(1-s)^2$ are the probabilities with which good and bad firms, respectively, receive offers from both banks. Firms with a positive signal from this bank only are denied credit by the competing bank. Thus, the group of firms with a positive signal from this bank only consists of a share of $\mu(1-s)$ good firms and $(1-\mu)s$ bad firms. The minimum repayment is given by $\underline{R}^S = \frac{s(\mu pX - I)(1-s) + (1 - s(1-\mu) - \mu(1-s))I}{\mu s p}$.

- Consider the profit function $\Pi_i(R_i)$ of bank i $(i \neq j)$ conditional on bank j's offer.

$$\Pi_i(R_i) = (1 - F_j(R_i)) \left(\mu s^2 \left(pR^S - I\right) - (1-\mu)(1-s)^2 I\right) + \left(\mu (1-s) s \left(pR^S - I\right) - (1-\mu) s ((1-s) I)\right) - c \; \forall \; R_i \epsilon \left[\underline{R}^S, X\right).$$

Let us use the fact that $\Pi_i(R_j) = \overline{\Pi}^S$ for each repayment.

- Equivalently, for bank j we determine $F_j(R_i)$ by setting

$$\Pi_i(R_i) = (1 - F_j(R_i)) \left(\mu s^2 \left(pR^S - I\right) - (1-\mu)(1-s)^2 I\right) + \left(\mu (1-s) s \left(pR^S - I\right) - (1-\mu) s (1-s) I\right) - c = \overline{\Pi}^S$$

Since both banks are identical $F_j(R_i) = F_i(R_j) \equiv F(R)$ with $F(R) = \frac{\mu s^2 (pR - I) - (1-\mu)(1-s)^2 I - \mu s (1-s) p (X - R)}{\mu s^2 (pR - I) - (1-\mu)(1-s)^2 I}$. Thus, both banks demand a repayment from the range $\left[\frac{s(\mu p X - I)(1-s) + (1 - s(1-\mu) - \mu(1-s)) I}{\mu s p}, X\right]$ according to $F(R)$. Note that $F(X) = 1$. Q.E.D.

7.2. Proof of Lemma 5

Good firms receive the expected payoff of $p\left(X - E\left(R^S\right)\right)$ with probability $s(2-s)$. The profit of the bank is the expected interest revenue net of the losses from financing bad borrowers and the screening costs. Q.E.D.

7.3. Proof of Lemma 6

Step 0: We argue that there is no equilibrium in pure strategies. Suppose bank 1 offers a collateralized contract and bank 2 a screening contract (payoffs for bank 1 are denoted with superscript LS, for bank 2 with SL). Assume that both banks demand the same expected repayment. Firms with two positive signals would go to each bank with equal probability. Suppose that this repayment yields zero expected profit for bank 1. Bank 2 could marginally undercut this price and would make a positive profit because all applicants with two positive signals would apply for credit at bank 2. However, for bank 1 it would be optimal to serve all those good firms that were denied credit by bank 2 and are willing to pledge collateral. From these firms bank 1 could extract all rents by demanding the highest incentive compatible repayment $R^{LS} = R^L_M = \frac{pX - (1-p)I}{p}$ and $L = I$. Then, the profit of bank 1 is $\Pi^{LS} = \mu(1-s)(pX - I - (1-p)(1-\alpha)I)$. The best response by bank 2 to $\left\{R^{LS} = R_M^L; L = I\right\}$ would be to demand repayment $R^{SL} = X - \varepsilon$. Thus, no equilibrium in pure strategies exists.

Step 1: Determine the expected profit for bank 1 if it demands the highest repayment $R^{LS} = R_M^L = \frac{pX-(1-p)I}{p}$ and collateral $L = I$. Then it is undercut by bank 2 and serves only firms which were denied a loan by bank 2 but have a positive signal at bank 1. Then, the payoff of bank 1 which offers a collateralized contract, provided that bank 2 offers a screening contract, is given by:

$$
\begin{aligned}
\overline{\Pi}^{LS} &= \mu(1-s)\left(p\left(\frac{pX-(1-p)I}{p}\right) + (1-p)\alpha I - I\right) \\
&= \mu(1-s)(pX - I - (1-p)(1-\alpha)I)
\end{aligned}
$$

We assume that $\overline{\Pi}^{LS} > 0$. Now suppose that bank 1 serves the whole market. The lowest repayment bank 1 demands is determined by the expected profit $\overline{\Pi}^{LS}$. Thus, $\underline{R}^{LS}$ is given by

$$
\Pi^{LS} = \mu\left(p\underline{R}^{LS} + (1-p)\alpha I - I\right) = \mu(1-s)(pX - I - (1-p)(1-\alpha)I).
$$

Therefore, the contract with the lowest repayment specifies $\left\{\underline{R}^{LS} = \frac{(1-s)\mu(pX-I)+\mu s(1-p)(1-\alpha)I+\mu pI}{p\mu}, I\right\}$. The debtor is indifferent between this collateralized credit contract and a screening contract if the repayment with a screening contract is $\underline{R}^{SL} = \frac{pX(1-s)+s(1-p)(1-\alpha)I+sI}{p}$.

Step 2: We assume that for bank 1, $\Pi^{LS}\left(\underline{R}^{LS}\right) > 0$, and determine the mixed strategies for bank 2.

The cumulative distribution function for bank 2, denoted by $G(R)$, is given by the following condition:[13]

$$
\begin{aligned}
\overline{\Pi}^{LS} &= (1-G)\left(\mu\left(pR^{SL} + (1-p)\alpha I - I\right)\right) + G(1-s)\left(\mu\left(pR^{SL} + (1-p)\alpha I - I\right)\right) \\
&= \mu(1-s)(pX - I - (1-p)(1-\alpha)I)
\end{aligned}
$$

[13] Note that bank 1 finances only good firms.

As a result, $G\left(R^{SL}\right)=\frac{pR^{SL}-sI-(1-s)(pX)-s(1-p)(1-\alpha)I}{s((pR^{SL}-I)-(1-p)(1-\alpha)I)}$.

Step 3: Suppose $\alpha \leq \alpha_2 = \frac{\mu s(1-s)(pX-I)+\mu s^2(1-p)I-(1-\mu)(1-s)I-c}{\mu s^2(1-p)I}$ implying that bank 2's profit $\Pi^{SL}\left(\underline{R}^{SL}=\frac{pX(1-s)+s(1-p)(1-\alpha)I+sI}{p}\right)>0$. We determine the equilibrium in mixed strategies.

The expected profit of bank 2 demanding $\underline{R}^{SL}=\frac{pX(1-s)+sI(1-p)(1-\alpha)+sI}{p}$ is given by

$$\begin{aligned}\overline{\Pi}^{SL} &= \mu s(1-s)\left(p\left(\frac{pX(1-s)+s(1-p)(1-\alpha)I+sI}{p}\right)-I\right)-(1-s)(1-\mu)I-c\\ &= \mu s(1-s)(pX-I)-(1-s)(1-\mu)I+s^2\mu(1-\alpha)(1-p)I-c\end{aligned}$$

Note that $\Pi^{SL}>0$ if $\alpha \leq \alpha_2$.

The cumulative distribution function for bank 1, denoted by $F(R)$, is determined by:[14]

$$\begin{aligned}\Pi^{SL} &= (1-F)\left(\mu\left(s\left(pR^{LS}-I\right)\right)-(1-\mu)(1-s)I\right)+F\left(-(1-\mu)(1-s)I\right)-c\\ &= \mu s(1-s)(pX-I)-(1-s)(1-\mu)I+s^2\mu(1-\alpha)(1-p)I-c\end{aligned}$$

As as result, $F\left(R^{LS}\right)=\frac{(s-1)(pX-I)-s(1-p)(1-\alpha)I+pR^{LS}-pI}{p(R^{LS}-I)}$. Bank 1 demands collateral $L=I$ and repayments from the range $\left[\underline{R}^{LS},\frac{pX-(1-p)I}{p}\right]$. Note that $F\left(\frac{(1-s)\mu(pX-I)+\mu s(1-p)(1-\alpha)I+\mu pI}{p\mu}\right)=0$ and $F\left(\frac{pX-(1-p)I}{p}\right)<1$. Thus, with probability $1-F\left(\frac{pX-(1-p)I}{p}\right)$ bank 1 demands $\frac{pX-(1-p)I}{p}$ as a repayment.

Bank 2 demands a repayment R^{SL} from the range $\left[\underline{R}^{SL},X\right]$, according to the cumulative distribution function $G\left(R^{SL}\right)=\frac{pR^{SL}-sI-(1-s)(pX)-s(1-p)(1-\alpha)I}{s((pR^{SL}-I)-(1-p)(1-\alpha)I)}$. Note that $G\left(\underline{R}^{SL}\right)=0$ and $G(X)=1$.

Step 4: Suppose $\alpha>\alpha_2$ implying that $\Pi^{LS}\left(\underline{R}^{SL}=\frac{pX(1-s)+s(1-p)(1-\alpha)I+sI}{p}\right)\leq 0$. We determine the equilibrium in mixed strategies.

Thus, bank 2 needs at least a repayment of $\underline{R}^{SL}=\frac{(1-\mu)(1-s)I+\mu sI+c}{\mu sp}$ in order to break-even and get $\Pi^{LS}=0$. A debtor is indifferent between a screening contract determining $R^{SL}=\frac{(1-\mu)(1-s)I+\mu sI+c}{\mu sp}$ and a collateralized credit contract with $\left\{L=I,R^{LS}=\frac{(1-\mu)(1-s)I+\mu spI+c}{\mu ps}\right\}$. The latter condition therefore determines the lower bound of the range from which bank 1 demands its repayment.

[14] Note that all bad firms apply at bank 2.

The cumulative distribution function for bank 1, denoted by $F(R)$, is determined by:

$$\Pi^{SL} = (1-F)\left(\mu\left(s\left(pR^{LS}-I\right)\right)-(1-\mu)\left((1-s)\,I\right)\right)+F\left(-(1-\mu)\left((1-s)\,I\right)\right)-c=0$$

As a result, $F\left(R^{LS}\right)=\frac{\mu spR^{LS}-\mu sI-\mu sIp-I+Is+I\mu-c}{\mu sp\left(R^{LS}-I\right)}$. Bank 1 demands collateral $L=I$ and repayments from the range $\left[\underline{R}^{LS},\frac{pX-(1-p)I}{p}\right]$. Note that $F\left(\underline{R}^{LS}\right)=0$ and $F\left(\frac{pX-(1-p)I}{p}\right)<1$. Thus, with probability $1-F(X)$ bank 1 demands $\frac{pX-(1-p)I}{p}$ as a repayment.

As the payoffs for bank 1 are the same as in the case with $\alpha \leq \alpha_2$, bank 2 demands a repayment R^{SL} from the range $\left[\underline{R}^{SL},X\right]$, according to the following cumulative distribution function $G\left(R^{SL}\right)=\frac{pR^{SL}-sI-(1-s)(pX)-s(1-p)(1-\alpha)I}{s\left(\left(pR^{SL}-I\right)-(1-p)(1-\alpha)I\right)}$.
Note that $G\left(\underline{R}^{SL}\right)>0$ and $G(X)=1$. Q.E.D.

8. List of Figures

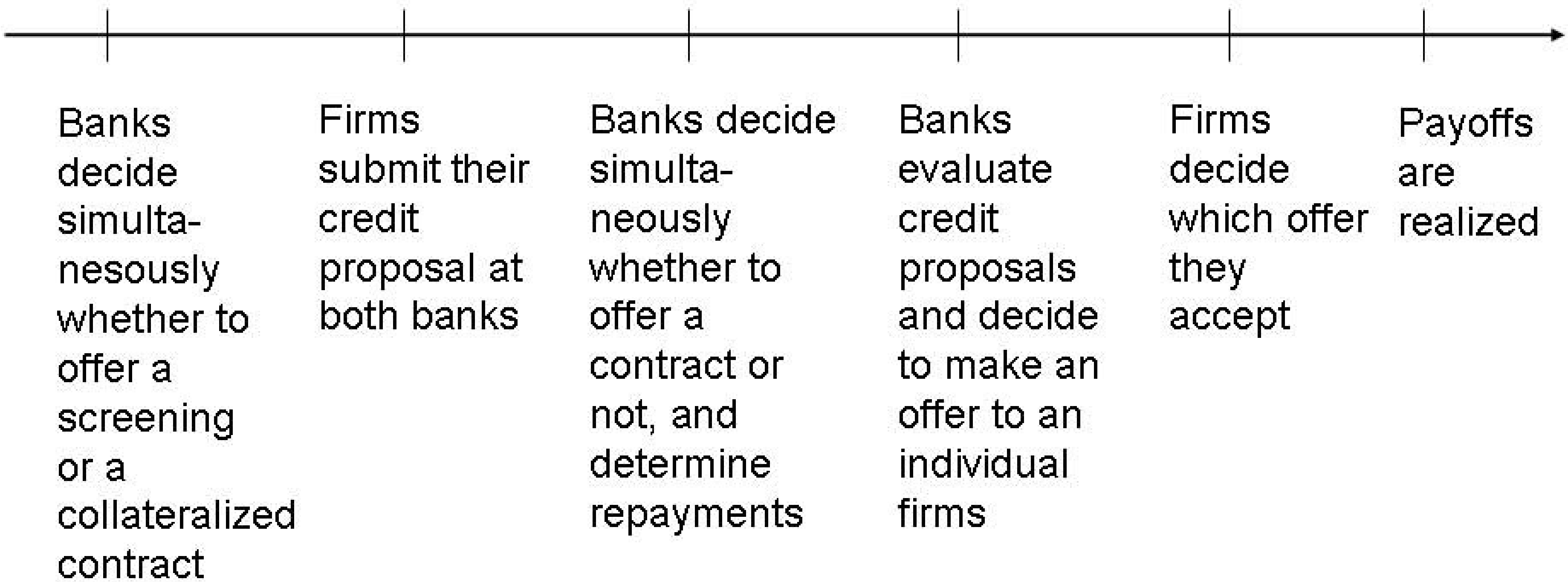

Figure 1: Time line

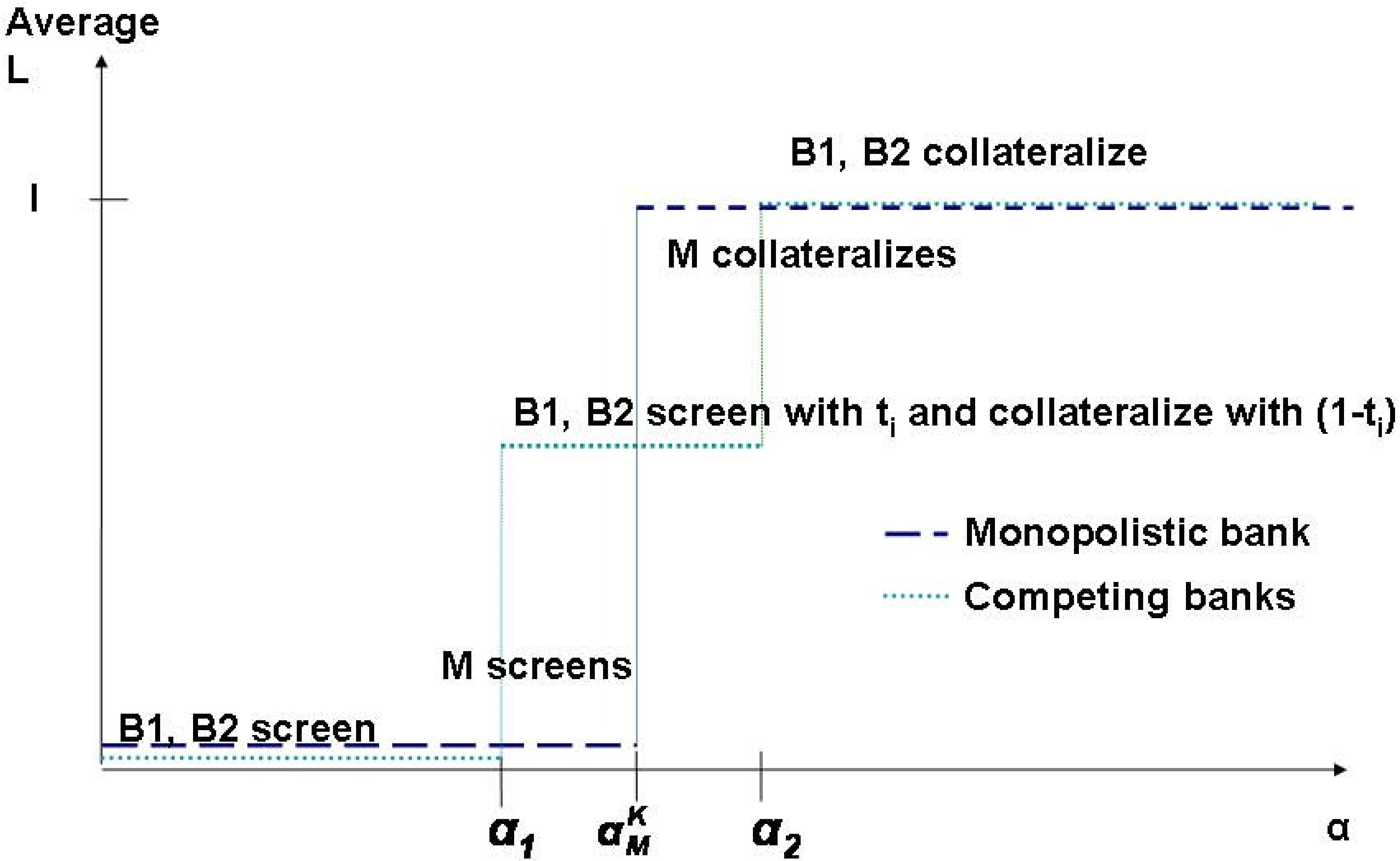

Figure 2: Comparison of contracts offered between monopolistic bank and competing banks

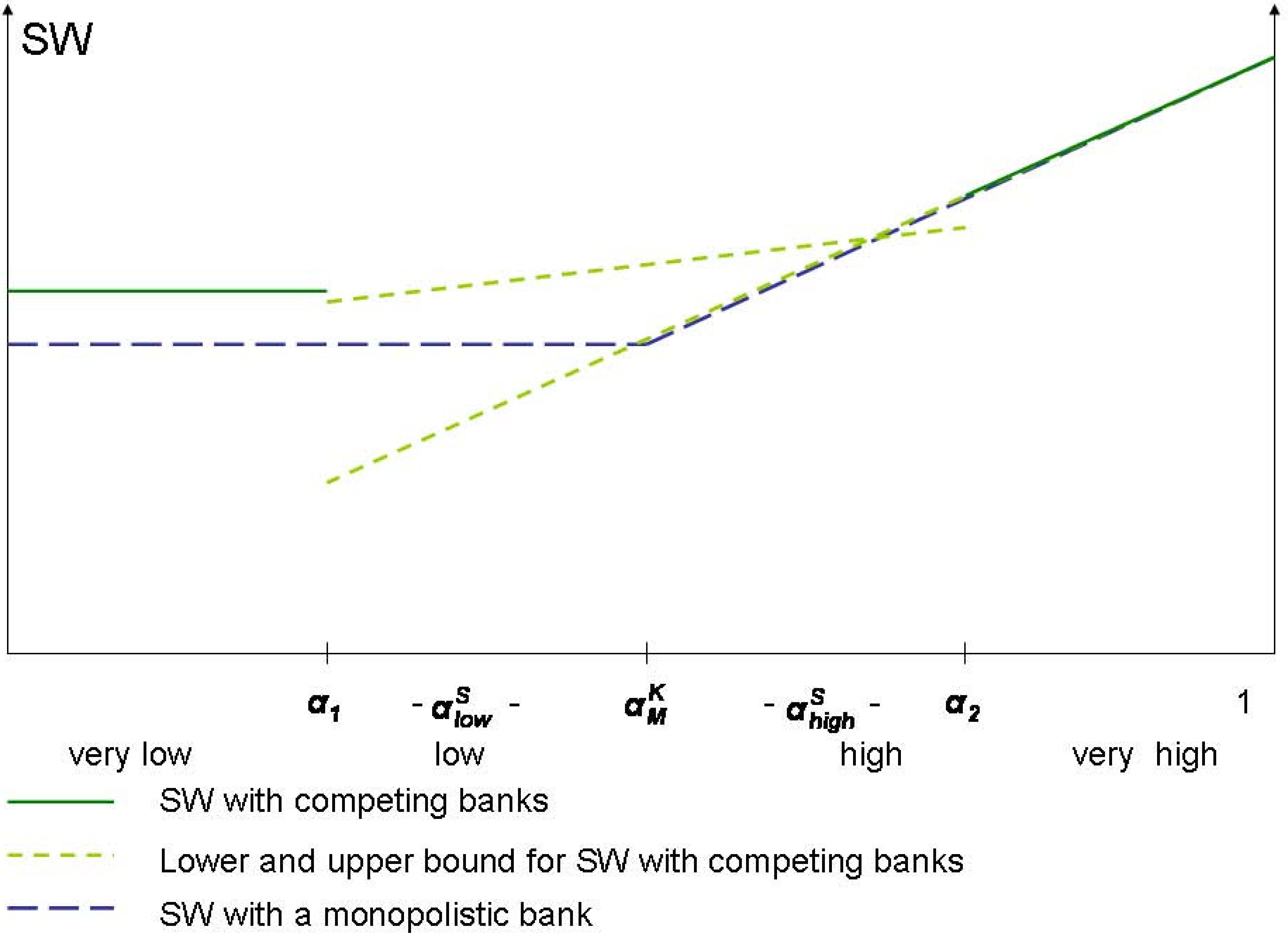

Figure 3: Comparison of social welfare between monopolistic bank and competing banks