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DEPOSIT MARKETS, LENDING MARKETS AND BANK SCREENING INCENTIVES

RINAT MUKMINOV



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Rinat Mukminov
Hanken School of Economics
Department of Economics
P.O.Box 479, 00101 Helsinki, Finland



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PREFACE

I have known since primary school that one day I will defend a doctoral dissertation. Back then though I thought that I would pursue a career in medicine like my mother. I had this plan until I visited medical university's anatomy department where for the first time in my life I saw a real corpse. Moreover, I was told that I would have to deal with corpses on daily basis throughout my first year as a medical student. That was the moment I had to change my plans and pursue instead a career in economics. Even though I am still questioning the wisdom of my somewhat emotional choice, here I am, putting finishing touches to my doctoral dissertation in economics.

Many people and organisations have helped me along this long journey. First, I would like to thank my academic supervisor, Professor Rune Stenbacka, for his help, for his patience, and for the academic freedom that I have enjoyed over these years. I would also like to thank the two pre-examiners of this dissertation: Professor Tuomas Takalo and Professor Juha-Pekka Niinimäki for their insightful comments that helped me to improve the manuscript considerably.

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Before I came to Finland, my knowledge of Finland could have been easily and fully expressed in ten words. Yet when an opportunity presented itself to come to Finland as a guest researcher to Åbo Akademi I gladly took it. I thank Åbo Akademi professors Lars Hassel and Malin Brännback for welcoming me in Finland, and I thank Ufa State Aviation Technical University professors Tatiana Gileva, Larisa Ismagilova, and Viktor Krymsky for sending me to Finland. I would also like to thank Russian Federal Agency for Education for the financial support of my stay at Åbo Akademi.

My work and studies have taken a lot of time and energy. I would have never been able to come this far if I did not have the support and encouragement of my friends and family. I am grateful to my closest friends Laysan Z., Laysan V., Elvira, and Nastya. A very special thank you goes to Panu for his crazy idea that I should pursue a doctorate in economics, instead of an easier discipline, and for his help along the steep and thorny way to it. I would like to thank Martin for showing me the light and warmth in the greyness and cold of this land. Finally, I would like to thank my family. My mother, father, grandmother, and sister have encouraged my doctoral studies since before I could walk. Now it is Daniil's turn!

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1 INTRODUCTION

In the period from 2007 to 2009 the world experienced the deepest financial crisis since the Great Depression. The world economy was in the most severe recession since the Second World War. The financial crisis was followed by a debt crisis in the euro area, which is still, in 2014, far from being resolved. In 2014, the world economy is yet to recover from the crisis.

Acharya (2013) notes that financial crises are “recurring phenomena”. Allen, Babus and Carletti (2009) analyse the theory and evidence of the recurring financial crises. They argue that the most recent financial crisis of 2007-2009 is in many ways similar to the previous crises.

It is widely acknowledged that the financial crisis of 2007-2009 was provoked by the housing bubble in the United States. Sinn (2010) notes that prior to the crisis, in the period from 1996 to 2006 the house prices in the United States increased by 190%. The housing bubble burst in June 2006. Between June 2006 and April 2009 the house prices, measured by the Case-Shiller index¹, declined by 34%. Allen, Babus and Carletti (2009) note that the decline in the house prices “led to a fall in the prices of securitised subprime mortgages, affecting financial markets worldwide”. However, as Hellwig (2010) points out, “the global financial crisis of 2007-2009 was not just a matter of subprime mortgage securitisation in the United States having gone astray”.

Acharya (2013) distinguishes three factors that contributed to the crisis. The first one is the market failures, which are a result of externalities from one bank to another – for example, financial contagion and panic. The second factor is the regulatory failures. Hellwig (2010) argues that lax regulation allowed the financial institutions to be undercapitalised prior to the crisis. Hellwig calls for a substantial increase in the capital requirements. And the third contributing factor is the government failures. Lehman Brothers was allowed to go bankrupt by the Bush Administration on September 15, 2009. Many argue that the Lehman Brothers bankruptcy could have potentially led to a collapse of the global financial system.

But returning to the direct cause of the financial crisis of 2007-2009, namely to the housing bubble in the United States and to the subsequent collapse of the market for securitised subprime mortgages, there have been many questions, as to why banks and other financial institutions failed to – or, refused to – recognise the housing bubble. Keys et al. (2010) find empirical evidence that securitisation leads to a reduction in the screening incentives.

Screening incentives could also be reduced as a result of a change in the macroeconomic conditions. The bank screening literature (see e.g. Ruckes 2004, Hauswald and Marquez 2005) provides the following explanation of the origins of the recurring crises. In boom times, when the majority of loan applications are good, the price competition between the banks intensifies, leading to lower returns from screening loan applicants. As a consequence, screening standards decline and many bad loans end up on the bank balance sheets. Defaults of the bad loans lead to a deterioration of the bank balance sheets, which causes credit crunches and bank crises. Former Federal Reserve Chairman Alan Greenspan contributed to this discussion by

¹ Case-Shiller index is a widely used Standard & Poor’s index. It measures the changes in the house prices in the United States since 1890.

saying: “There is doubtless an unfortunate tendency among some, I hesitate to say most, bankers to lend aggressively at the peak of a cycle and that is when the vast majority of bad loans are made.” (Ruckes 2004)

There is also an emerging finance literature (see e.g. Dell’Arricia et al. 2011) arguing that a lower cost of funds, such as a lower cost of deposits, cheaper credit in the interbank market, a lower discount rate², encourages the banks to take excessive risks. Excessive risk-taking by the banks can also lead to a bank crisis.

These two approaches are interesting because the former one explains excessive risk-taking from the point of view of bank revenues, while the latter approach explains excessive risk-taking from the point of view of bank costs. The aim of this thesis is to build a bridge between these two approaches. This thesis contributes to the screening literature by explicitly introducing the cost of funds into a bank screening model. This is novel, as most previous bank screening literature has assumed the deposit market to be fully competitive with zero interest rate, thus ignoring the impact of the deposit interest rate on bank screening incentives. This thesis also extends the literature, which explores the effects of costs of funds on the bank risk-taking, by explicitly modelling the banks’ investment in screening of potential loan applicants.

This introductory chapter is organised as follows. First, we explain what a bank is, what banks do and why banks are important. Second, we explain why banks exist. Third, we take a look at some of the main contributions to the banking literature. Fourth, we describe the banking risks and provide justifications for banking regulation. Fifth, we explain the asymmetric information problem that exists between the banks and their borrowers. Sixth, we discuss the literature that analyses adverse selection and bank screening. And last, we present the chapters included in the thesis.

1.1 Why Banks Are Important?

A bank is defined as an institution whose current operations consist in granting loans and receiving deposits from the public (Freixas and Rochet 2008). Freixas and Rochet (2008) distinguish the following banking functions. First, a bank offers liquidity and payment services. Second, a bank transforms assets: in size (convenience of denomination), in quality (quality transformation), and in maturity (maturity transformation). Third, a bank manages risks (credit risk, interest rate risk, liquidity risk, and market risk). Fourth, a bank processes information and monitors borrowers.

Many contributions argue that a well-functioning financial system positively affects the economy. Merton (1993) notes: “A well developed smoothly functioning financial system facilitates the efficient life-cycle allocation of household consumption and the efficient allocation of physical capital to its most productive use in the business sector.”

Fisher (1933) argues that an inefficient functioning of the financial markets contributed to the depth of the economic crisis during the Great Depression. Later contributions (see e.g. Gurley and Shaw 1955, Goldsmith 1969) further develop the view that the financial markets have a critical influence on the economy.

More recent contributions examine the link between imperfections in the financial markets and the economic growth. Bernanke and Gertler (1990) argue that higher

² Discount rate is an interest rate on the discount loans. Discount loans are loans made by the central bank to commercial banks.

agency costs (e.g. screening and monitoring costs) resulting from asymmetric information between the lenders and borrowers, lead to lower investment and worse economic performance. (See Levine (2005) for a survey of both theoretical and empirical literature.)

Greenwood and Jovanovic (1990) argue that a better developed financial system promotes the economic growth because it results in a higher rate of return on the invested capital. Economic growth, on the other hand, stimulates the development of an extensive and costly financial system. Jappelli, Pagano, and Bianco (2005) argue that a better organised judicial system improves the efficiency of a financial system and positively affects economic growth prospects. King and Levine (1993) and Guiso, Sapienza and Zingales (2004) confirm the link between the well-functioning of the financial system and the economic growth empirically.

Other authors stress the importance of banks. Gerschenkron (1962) argues that banks have played an important historical role in the economic growth and development of some countries. Hellwig (1991) also argues that banks are instrumental in ensuring economic growth.

Some authors compare the two types of financial systems: the bank-dominated system and the financial market-dominated system. Mayer (1988), comparing data from five countries over the period from 1970 to 1985, finds that well financially developed market-oriented countries like the United Kingdom or the United States are worse at funding the industry than Germany, France or Japan, all the three of which have, in comparison to the UK or the US, less developed bank-dominated financial systems.

Allen and Gale (1995) compare Germany, which has a bank-dominated financial system, and the United States, which have a financial market-dominated system. Allen and Gale find that in market-oriented countries households invest about half of their assets in equity, which allows for better investment in new technologies. In bank-oriented countries, on the other hand, households invest primarily in the safe assets, which serve as a buffer against macroeconomic shocks. Allen and Gale (1997), analysing an overlapping generations model, present a theoretical argument to complement Allen and Gale (1995).

1.2 Why Do Banks Exist?

Freixas and Rochet (2008) distinguish two approaches to the analysis of banking. The first approach is an incomplete financial markets paradigm. It explains why markets are incomplete and why banks exist. Needless to say that in the world of complete markets, the banks would not be needed. The second approach is the industrial organisation approach to banking. This approach views a bank as a firm, which provides services to its customers: gives loans to the borrowers and collects deposits from the depositors. In the analysis of this thesis, we employ the industrial organisation approach. However, in this section, we use the incomplete financial markets paradigm in order to explain why banks exist.

In a world where transaction costs³ exist, a coalition of lenders and borrowers can save on the transaction costs by exploiting the economies of scope and the economies of scale. One example of economies of scale is given by Diamond and Dybvig (1983) who justify the existence of banks by the need for the liquidity insurance. In a world in

³ Transaction costs include monetary costs, as well as costs of search, screening, monitoring, auditing, etc.

which individuals can be affected by random liquidity shocks, the social welfare can be improved by the existence of a bank. Later literature enriches the model of Diamond and Dybvig by allowing for the existence of financial markets (see e.g. Von Thadden 1997).

Another example of economies of scale is the model of Leland and Pyle (1977). Leland and Pyle show that entrepreneurs can signal their quality by investing own wealth. This allows separation of the bad entrepreneurs from the good ones. But when the entrepreneurs are risk averse, this signalling is costly. Leland and Pyle show that a coalition of entrepreneurs can save on the signalling, as the signalling costs increase slower than the size of the coalition. Consistent with other signalling models (see e.g. Spence 1973) Leland and Pyle find a continuum of equilibria. Diamond (1984) later demonstrates that in the model of Leland and Pyle the cost of capital is a decreasing function of the size of the coalition.

Diamond (1984) explains that the banks exist because they can save on the monitoring costs. If lenders are small and costs of delegation are low, Diamond shows that delegated monitoring dominates direct lending. One implication of Diamond's model is that banking is a natural monopoly. Cerasi and Daltung (2000) argue that there is a need for "monitoring the monitors" inside the bank. Cerasi and Daltung show that the cost associated with the inside monitoring is an increasing function in the size of the bank.

Another justification for the existence of banks is that it might be difficult to raise funds directly in the financial market. Diamond (1991) shows that successful firms can build a good reputation that would allow them to issue direct debt, while firms with a worse reputation could end up paying a higher interest rate for a bank loan than the new firms.

Holmström and Tirole (1997) demonstrate that well capitalised firms can issue direct debt, while less well capitalised firms need to seek a bank loan. In times of capital tightening, such as credit crunch, Holmström and Tirole show that the interest rate spread between the direct debt and the bank loans increases significantly, hitting the poorly capitalised firms.

1.3 Some Important Topics in the Banking Literature

In this section we take a look at some of the important contributions to the banking literature. These contributions cover the topics such as banking competition, the relationship between lenders and borrowers, and the equilibrium credit rationing. The section concludes with some empirical results.

1.3.1 Banking Competition

In the Arrow-Debreu world of complete financial markets, a more intense bank competition always leads to greater market efficiency. However, banks do not compete solely on the prices (deposit and lending interest rates). Banks also choose the level of riskiness of their operations, as well as decide on screening, monitoring, etc. So in the real world, greater banking competition might not always be desirable. The theoretical analysis of banking competition using Salop (1979) model shows that free competition leads to too many banks. This makes a case for a regulatory intervention.

Keeley (1990), Suarez (1994) and Matutes and Vives (1996) warn that a more intense bank competition, in an environment where deposits are not insured and the depositors cannot observe the banks' actions, gives the banks incentives to choose the maximum level of riskiness. Moreover, Suarez argues that the possibility of recapitalisation by the bank owners gives the banks greater incentives to engage in risk-taking behaviour.

Carletti (2008) reviews the main contributions in the banking literature that focus on banking competition and regulation. Freixas and Rochet (2008) argue that transparency, capital requirements and relationship banking prevent the banks from taking excessive risks in a competitive environment. The next subsection takes a look at the literature on the relationship banking.

1.3.2 Relationship between Lenders and Borrowers

Sharpe (1990) and Rajan (1992) explore relationship banking. In a multi-period model, monitoring allows a bank to learn the types of its borrowers, while the competing banks suffer from the winner's curse.

Like the banks, credit bureaus and public credit registers also gather information about borrowers. This information could either be positive or negative (Freixas and Rochet 2008). Jappelli and Pagano (2000) argue that the existence of such credit registers leads to lower credit risks, lower lending interest rates, and more extensive loan markets.

Hauswald and Marquez (2003) consider a model of relationship banking, in which there is publicly available information about the borrowers. Hauswald and Marquez argue that the availability of better-quality public information increases the competition and decreases the lending interest rates.

Why do borrowers have incentives to repay the loans? There could be non-pecuniary costs (like reputation) in declaring bankruptcy (Diamond 1984). Relationship banking could also encourage the borrowers to repay their loans, as the threat of termination of the relationship gives the borrowers incentives to repay (Bolton and Scharfstein 1990)

One of the most important contributions to the banking literature explains why in the real world we most often observe a standard debt contract between the bank and the borrower. The reason is costly state verification – in other words, costly audit. Townsend (1979) and Gale and Hellwig (1985) argue that if both lenders and borrowers are risk neutral, then any efficient incentive-compatible debt contract is a standard debt contract.

1.3.3 Equilibrium Credit Rationing

Baltensperger (1978) defines equilibrium credit rationing as a situation in which "a borrower's demand is unfulfilled, although he is willing to pay the ruling market price". Jaffee and Modigliani (1969) study a monopoly bank that is restricted by banking regulation not to use price discrimination. Jaffee and Modigliani argue that the bank has incentives to deny credit to the borrowers against whom the bank would have used price discrimination, if this option were available.

Equilibrium credit rationing could occur because of the asymmetric information problem, as a result of adverse selection (Stiglitz and Weiss 1981), costly state verification (Williamson 1987), and moral hazard (Bester and Hellwig 1987). Bester (1985) argues that no equilibrium credit rationing occurs if a debt contract allows for collateral.

1.3.4 Some Empirical Results

Hannah and Berger (1991) report that the deposit interest rate exhibit price rigidity, especially in more concentrated markets. Berger and Udell (1992) find that also lending interest rates are sticky.

Petersen and Rajan (2002) find that the physical distance between the banks and the borrowers has been increasing in the United States. The median distance between the bank and the borrower has increased from two miles in the 1973-1979 to five miles in 1990-1993. Degryse and Ongena (2005), analysing Belgian data, also report an increase in the distance between the borrower and the lender of about 30% in the period from 1975 to 1997. The median distance is reported to be 2.25 km.

Shaffer (1998) documents “the winner’s curse” in banking. Building on the theoretical work of Broecker (1990), Shaffer empirically shows that the new banks suffer most from the adverse selection problems, as they face the pool of previously rejected loan applicants.

Degryse and Ongena (2008) provide a good review of the empirical evidence on topics such as market concentration, bank-borrower relationship, location, and regulation.

1.4 Risks and Regulation

Freixas and Rochet (2008) distinguish four risks that affect the banks:

- *credit risk*. Credit risk is a risk that a borrower defaults on his loan. It is affected by the banks’ screening and monitoring standards, collateral requirements, legal system, competition policy, information sharing between the banks, etc.

Merton (1974) finds that the lending interest rate increases as a function of a borrowers’ indebtedness, of riskiness of the borrowers’ assets, and of the loan’s maturity. Merton’s model was later improved, most notably by Decamps (1996).

The Basel Accord is an international regulatory response to the credit risk. One of the key requirements of the Accord is for the banks to hold enough capital. Gordy (2003) shows how the ratings-based capital rules of the Basel Accord could be reconciled with the more general credit value-at-risk models.

- *liquidity risk*. Liquidity risk is a risk that the bank is unable to meet its cash obligations. It could occur if, for example, there is an unexpected mass withdrawal of deposits.

Bryant (1980, 1981) and Diamond and Dybvig (1983) argue that in a fractional reserve banking system only patient depositors would not withdraw their deposits early. In the

literature this situation is called an inefficient bank run. A possibility of an inefficient bank run justifies the need for the deposit insurance.

Rochet and Vives (2004) argue that even a solvent bank could be illiquid, as a result of imperfections in the interbank markets. The policy implication of Rochet and Vives is that the central banks should provide liquidity assistance to such banks.

Deposit insurance, emergency liquidity assistance by the central bank and reserve requirements are the policy responses to the liquidity risk. Merton (1977) argues that deposit insurance premiums should be priced based on the arbitrage pricing method and the Black-Scholes (1973) formula. The debate on how to fairly price the deposit insurance premiums continues, see e.g. Merton (1978), Mullins and Pyle (1991), Kerfriden and Rochet (1993). However, Chan, Greenbaum and Thakor (1992) argue that it might be impossible to price the deposit insurance premiums in a fair way.

- *interest rate risk*. Interest rate risk is a result of one of the main functions of the banks: maturity transformation. As the bank transforms short-term deposits into long-term loans, there is a risk that market interest rates could change in an unfavourable way.

Regulation Q was a regulatory response to the interest rate risk. It limited the deposit interest rates in the United States in the 1970s. Regulation Q was abolished in the 1980s, which led to a savings and loans industry's crisis in the late 1980s (Freixas and Rochet 2008).

Hellman, Murdock and Stiglitz (2000) argue that the deposit interest rate regulation could encourage the banks to take less risk and therefore could improve the stability of the banking system. Chiappori, Perez-Castillo, and Verdier (1995) argue that the regulation of deposit interest rates leads to lower lending interest rates.

- *market risk*. Market risk is a risk that the performance of the bank's portfolio falls short of expectations.

Boot and Thakor (1997) argue that a commercial bank has greater incentives to introduce financial innovations than a universal bank, which combines in itself both a commercial and an investment bank. Market risk is addressed by portfolio management. The theory was developed by Sharpe (1964), Lintner (1965), Markowitz (1952), Pyle (1971) and Hart and Jaffee (1974).

The existence of the abovementioned risks justifies the need for banking regulation, as bank failures could be extremely costly for the society. Moreover, there is a risk of contagion and worsening of the asymmetric information problem, as the borrowers of the failed bank would have to look for a new lender. However, in the literature there is a debate whether "imperfectly competitive market" could be actually better than "imperfectly regulated" banking (Freixas and Rochet 2008). Jensen and Meckling (1976) argue that there is a principal-agent problem within the bank, which results in a conflict of interest among various stakeholders. Jensen and Meckling argue that the existence of this problem explains why banks cannot fully regulate their own investment choices.

The existence of the risks is not the only reason why the banks are regulated. Freixas and Santomero (2001) point out that it would be "a naive view of the world" to think

that “regulators act in the best interest of the society” or that the banks “submissively abide by the regulation”.

Reserve requirements, for example, is a source of fiscal revenues. Banking regulation could also help in channelling money to the political projects. Moreover, the regulation could be aimed at preventing criminal activities, like money laundering (Freixas and Rochet 2008).

Carletti and Hartmann (2003) analyse the relationship between competition and stability in banking from the regulatory point of view. Carletti and Hartmann focus on the roles that various regulators played in bank mergers in G7 countries.

1.5 Asymmetric Information Problem in Banking

A bank is a depository institution. One of its main functions in the economy is in collecting deposits, on one hand, and giving out loans, on the other hand. According to the Federal Reserve⁴, in the United States, in October 2013, 78% of bank liabilities were deposits, while loans accounted for 53% of bank assets.

As was noted in the previous section, one of the main risks that a commercial bank faces is credit risk. Credit risk arises because borrowers may default on their loans. If a commercial bank is to be successful in the market and earn profits, it must make successful loans which are paid back fully (Mishkin 2007).

To fully understand the nature of the credit risk, one needs to understand the problem of asymmetric information. Asymmetric information in banking occurs when the bank is less informed than its borrowers about the riskiness of the projects. Asymmetric information leads to the adverse selection problems and to the moral hazard problems.

Adverse selection is an ex ante problem, i.e. it arises before a loan is granted. Those who are least likely to repay the loans could well be the ones who are most eager in seeking loans. In order to filter the good loan applications from the bad ones and to alleviate the adverse selection the banks employ screening. Screening focuses on collecting and evaluating the information about a potential borrower. The more information the bank collects and the higher the quality of the collected information is, the better chances the bank would have in successfully screening out bad loan applications (Mishkin 2007).

Screening is costly. Screening is typically done by loan officers who evaluate the borrowers' ability to repay the loans. It includes conducting of a financial analysis, contacting credit agencies, previous creditors, suppliers, and customers (Ruckes 2004). Also external specialists could be invited to contribute to the screening process.

Moral hazard is an ex post problem, i.e. it arises after a loan is made. Once obtaining a loan, the borrower might engage in higher risk-taking and therefore repayment of the loan might become less likely. In order to alleviate moral hazard problems, the banks employ monitoring. It includes writing restricting covenants into the loan contracts and enforcing them. Monitoring is also costly (Mishkin 2007).

⁴ www.federalreserve.gov/releases/h8/current/

1.6 Adverse Selection and Bank Screening Literature

The seminal work in economics on adverse selection, Akerlof (1970), does not specifically focus on banking. It describes a “lemons problem” in the used-car market⁵. A potential buyer of a used car is less informed about the quality of the car than the seller. In other words, the buyer does not know whether the car is good or whether it is a “lemon”. That is why, a price that the potential buyer is willing to pay for a used car must reflect an average quality of used cars in the market, which would be higher than the price of a lemon but lower than the price of a good-quality used car.

The seller, on the other hand, potentially knows whether his car is good or whether it is a lemon. If it is a lemon, he would be glad to sell the car because the buyer would pay a price, which is higher than what the lemon is worth. But if the car is good, the seller would not be willing to sell it because the buyer would only pay a price that is lower than what the car is worth.

This creates a “lemons problem” – or in other terms, an adverse selection problem. Owners of good used cars would not be willing to sell their cars for low prices, meaning that the used car market would be dominated by lemons. Buyers would anticipate that and the used-car market would break down, i.e. there would be very few used cars being sold.

The beauty of Akerlof’s contribution is that it can be applied not only to the used-car market, but also to many other markets, including the loan market. In the loan market, there are good entrepreneurs, who have good projects, and there are bad entrepreneurs, who have bad projects⁶. Both good and bad entrepreneurs seek bank loans. Clearly, a bank would want to finance only good projects. In the absence of a credible way for a good entrepreneur to signal his type, and in the absence of a screening technology that would allow the bank to assess the quality of loan applications, the loan market would break down. Just like in the used-car market, there would be very few loans being made.

A credible way for a good entrepreneur to signal his type to the bank is to post enough collateral, which would serve as a guarantee for the loan. Sure of his success and sure of the quality of his business plan, a good entrepreneur would be willing to post a large collateral, while a bad entrepreneur, knowing well that his business plan is unlikely to succeed (for example, buying lottery tickets might potentially give huge returns on investment but the chances of winning a jackpot are pretty slim), might be unwilling to post as much collateral as a good entrepreneur. This logic is formalised by Bester (1985). Bester argues that the bank can use collateral to separate risky borrowers from good borrowers. A good borrower is willing to post more collateral in order to reduce the lending interest rate, while a risky borrower would accept a contract with a higher lending interest rate but a lower collateral requirement. In Freixas and Laffont (1990) instead of collateral as in Bester (1985), a loan size is used as a screening device, with the lending interest rate increasing in the size of the loan.

Manove, Padilla and Pagano (2001), in their famous model of “lazy” banks, argue that the use of collateral in loan contracts may induce banks to be “lazy”, i.e. to reduce their screening effort well below the social optimum. If borrowers post enough collateral, banks are unwilling to screen even if the screening costs are low.

⁵ The discussion here is based on the Section II of Akerlof (1970). One of the critical assumptions here is that the used cars have no depreciation.

⁶ By a good (bad) project we mean a project with a positive (negative) expected return

However, in the absence of collateral, there is no way for a good entrepreneur to credibly signal his type. In this environment, if the bank wants the loan market to function properly and wants to earn profits, the bank must develop a screening technology that would allow sorting the good loan applications from the bad ones.

Broecker (1990) analyses the effect of bank competition on the intensity with which the banks screen loan applicants. Screening is done through the use of imperfect, independent and costless creditworthiness tests. Banks compete with each other by offering lending interest rates to the applicants that successfully passed the tests. In this environment, there is no equilibrium in pure strategies. If all banks offer the same lending interest rate, any bank would have an incentive to offer a lower interest rate in order to improve the creditworthiness of its loan portfolio. Furthermore, when loan applicants are able to apply sequentially to different banks, if one bank rejects a loan applicant, it imposes an externality on the other banks by decreasing the quality of the pool of loan applicants. This leads to the conclusion that competition does not necessarily lead to an efficient functioning of the loan market: the more banks there are, the higher the likelihood is that a low-quality loan applicant obtains a loan.

Similarly to Broecker, Riordan (1993) asks the question whether more loan market competition is a good thing. Unlike Broecker, Riordan assumes that the banks receive a continuous signal about the quality of the loan applicant after applying creditworthiness tests, which, like in Broecker's model, are also assumed to have exogenous statistical properties and to be costless. Assuming continuity of the signals allows Riordan to characterise a unique equilibrium in pure strategies. Riordan argues that a bank, which observes a cut-off signal, wins the competition for a loan only if all other banks observe a worse signal. But in winning the competition, the bank suffers from the so called winner's curse. Clearly, the effects of the winner's curse become worse as the number of banks increases. Therefore, increased competition makes the banks more conservative about funding marginal loans. Another reason why competition could damage the market performance is an increase in the number of signals observed as the number of banks increases. This increase could reduce the informativeness of the signals and lead to more bad loans being funded.

Later contributions accounted for the fact that the bank screening activities are costly. Kanninen and Stenbacka (1998) were one of the first to analyse bank incentives to invest in costly screening. In their model, the precision of screening depends on the investment in the screening technology. Kanninen and Stenbacka distinguish between two types of mistakes that a bank can make in its screening decision. Type I mistake occurs when a good loan is misclassified as a bad one, is rejected funding and therefore makes the bank forego a profitable business opportunity. Type II mistake occurs when a bad loan is misclassified as a good one, is funded and therefore increases the bank's credit losses. Kanninen and Stenbacka find that increased competition undermines banks' incentives to invest in reducing both Type I and Type II mistakes. From the social welfare perspective, Kanninen and Stenbacka show that a monopoly bank has the same incentives as the social planner to invest in reducing Type I mistakes, but that it invests too little in reducing Type II mistakes. A duopoly bank, on the other hand, invests too little in reducing both Type I and Type II mistakes.

Gehrig (1998), similarly to Kanninen and Stenbacka (1998), studies banks' incentives to invest in costly screening when the banks have to compete with each other over the potential borrowers. In a sequential-move game – for example, when a foreign bank enters the market dominated by domestic banks – Gehrig analyses a situation in which the incumbent domestic bank has an information advantage over the foreign bank,

because it can offer loans before the foreign bank enters the market and thus leave only the rejected loan applicants to the entrant. The entering foreign bank, on the other hand, is assumed to have a cost advantage over the domestic bank and therefore can offer lower lending interest rates. Foreseeing the entry of a low-cost foreign bank, some potential borrowers could wait for the entry of the new bank. However, if the potential borrowers have even a slight preference for the domestic bank, then they will all apply first to the domestic bank and second to the foreign bank. In this game, the domestic bank has high incentives to screen loan applicants, select the good ones and offer them low lending interest rates. The foreign bank, on the other hand, would not have much incentive to screen but would rather offer loans with a high risk premium. Gehrig characterises the equilibrium in pure strategies in this game. In a simultaneous-move game, Gehrig argues, similarly to Kannianen and Stenbacka (1998), that competition reduces the banks' screening incentives. He also establishes conditions under which the banks do no screening at all in equilibrium.

Later contributions focused on the effects of lending market competition on the bank screening incentives. Ruckes (2004) studies the effect of loan market competition on the bank credit standards. Ruckes models two banks that compete over one borrower. The borrower's creditworthiness is unknown but the banks can employ a costly and imperfect creditworthiness test, which reveals the true type of the borrower with a certain probability. The banks can affect this probability by investing resources in screening. The more the banks invest, the higher the probability is that the test reveals the true type of the borrower. Similar to Broecker (1990), Ruckes establishes non existence of equilibrium in pure strategies, but finds a unique equilibrium in mixed strategies. Ruckes shows that the bank credit standards are low both in deep recessions and in boom times. The bank screening intensity is maximal in uncertain times when the economic outlook is neither bright nor gloomy. Ruckes argues that in deep recessions the banks do not have much incentive to screen, as the vast majority of potential loan applicants are bad, so the banks base their lending decisions on the general economic conditions. As the economic outlook improves, the number of good loan applications increases, which makes screening more profitable, so the banks start to screen more intensely. The bank screening standards increase until a certain point, at which the loan pool quality becomes good enough that more investment in screening becomes unprofitable. Beyond this point the bank screening intensity declines with a further improvement in the general economic conditions. Ruckes argues that the deposit insurance may contribute to this counter-cyclical of the bank credit standards. Higher lending costs discourage bank lending, but if the deposits are insured, the deposit interest rate does not react to the bank lending behaviour, contributing to the risky lending behaviour in boom times.

Hauswald and Marquez (2006) model spatial bank competition in a Salop-style setting, in which a bank's ability to screen borrowers declines as the distance between the bank and the borrower increases. Hauswald and Marquez find that the farther away the borrower is located from the bank, the lower interest rate he enjoys but at the same time the lending decision becomes less efficient. In other words, in pursuit of a bigger market share the banks sacrifice the quality of screening. The implication of this result is that more intense lending rate competition in the loan market reduces the banks' incentives to screen the borrowers. Still, Hauswald and Marquez argue that the banks over-invest in screening in comparison with the social optimum, even though in equilibrium each borrower is screened by at most one bank. From the policy perspective, Hauswald and Marquez argue that bank mergers increase social welfare by cutting wasteful screening.

Gehrig and Stenbacka (2013) analyse the effects of bank competition on the quality of screening. In their model, Gehrig and Stenbacka analyse both Type I and Type II errors. The main result is that competition decreases the industry investment in reducing Type I errors, but increases the industry investment in reducing Type II errors. Gehrig and Stenbacka also show that a centralised screening collaboration leads to more investment in screening than a decentralised collaboration, while a decentralised collaboration in screening leads to lower investment in screening compared with non-cooperative screening. Their welfare analysis shows that the banks under-invest in reducing Type I errors, but over-invest in reducing Type II errors.

Another aspect of lending market competition was analysed by Petersen and Rajan (1995). Petersen and Rajan argue that the lending market competition prevents the bank from forming a long relationship with its borrowers, in which both the bank and its clients could share the surplus. Petersen and Rajan show that a monopoly bank could offer a lower lending interest rate to a young firm in need of external financing in order to be able to extract the rents at a later stage. This theoretical argument is used by Petersen and Rajan to explain an empirical phenomenon in the United States that credit is cheaper and more easily available in less competitive lending markets.

Cao and Shi (2001) seek to explain the phenomenon in the loan market in the United States documented by Petersen and Rajan (1995) that bank loans to small new firms are more easily available and at lower interest rates in areas with fewer banks than in more competitive areas. Cao and Shi focus on one entrepreneur who has a business project of unknown quality. The banks decide with what probability to screen the project. The screening is costly, imperfect and independent. The banks simultaneously decide whether to offer a loan to the entrepreneur and at what interest rate. The entrepreneur chooses the best offer. Cao and Shi find that the loan availability – in line with the results of Petersen and Rajan (1995) – can indeed decrease in the number of competing banks, especially if the screening cost is low. Cao and Shi argue that this happens because of a negative informational externality, in spirit of Broecker (1990) and Riordan (1993). Winning competition is easier when the quality of the business project is bad. The effect of the winner's curse increases in the number of banks. Moreover, as the number of banks increases, the banks screen with lower probability, in order to cover the screening costs, further worsening the informational externality. This leads to the result that more intense competition could lead to loans being less available and more expensive.

Other relevant literature to be discussed in this Section are Banerjee (2005), Gorton and He (2008), and Fishman and Parker (2012). Banerjee (2005) models banks' choice between two screening technologies. One is a less expensive and less precise technology, while the other one is a more expensive and more precise screening technology. The exact precision of the latter technology, however, is not known. In spirit of Broecker (1990), Banerjee shows that a screening technology choice of one bank imposes an externality on the other bank, as the precision of screening by one bank affects the loan pool quality of the other bank.

Gorton and He (2008), analysing a repeated game of bank lending, argue that competition between the banks for the borrowers could lead to periodic variation in the banks' screening intensity, which, in turn, could lead to significant changes in the amount of loans that the banks fund and even to periodic credit crunches. Unlike Ruckes (2004) model, in which exogenous changes in the macroeconomic conditions lead to bank credit cycles, in the model of Gorton and He bank credit cycles are

endogenously generated by banking competition and do not require any changes in the macroeconomic conditions.

Fishman and Parker (2012) consider a model in which ex ante identical but ex post heterogeneous sellers seek to sell future cash payments to investors. Each seller has a fixed reservation value. There are two types of investors. Unsophisticated investors buy the future payments at their expected present discounted values. Sophisticated investors, on the other hand, are able to invest in a screening technology that allows them to imperfectly observe the value of the assets. Fishman and Parker characterise two types of equilibrium. In a pooling equilibrium (which the authors argue is similar to a credit boom) all assets are traded and prices are high. In a valuation equilibrium (which is similar to a credit crunch) unsophisticated investors leave the market, sophisticated investors invest in screening and only the good assets are traded.

1.7 Chapters Included in the Thesis

1.7.1 *To Screen or Not to Screen?*

Chapter 3 is entitled “To Screen or Not to Screen?” In this chapter the research question is whether the banks should invest resources in screening potential borrowers, whether the banks should simply fund loans without performing any screening at all, or whether the bank’s optimal strategy is a combination of the two.

To address this question, we construct a simple theoretical model in which a bank has a choice whether to perform a costly screening of a loan application (and learn whether a given loan application is creditworthy or not) or to grant a loan without screening. The bank has also a possibility to screen some loan applications, while funding others without screening at the same time. We investigate how the bank’s incentives to screen loan applications and to grant loans without screening depend on the economic outlook, on the cost of funds, and on the screening costs. To the best of our knowledge, the effect of costly funds on screening – and on no screening – has not been studied before.

First, let us see how the economic outlook affects the bank’s screening incentives. In a deep recession, when almost all loan applications are high risk, the bank is not active in the market. As the economic outlook improves a little bit, the bank starts screening loan applications, but it does not yet grant any loans without screening. In this situation, a costly screening is profitable, as it detects high-risk loan applications with a high probability, while granting a loan without screening is not profitable at all, as a random loan application is very likely to be bad.

The bank continues to screen more and more loan applications as the economic outlook improves further, but the bank is still unwilling to grant loans without screening. Whether the number of loan applications that the bank screens increases fast or slowly with an improvement in the economic outlook, depends on the cost of funds and on the costs of screening. If both are low, the screening increases very fast.

However, at some point, especially when the screening costs are low and the costs of funds are high, the bank starts to decrease the number of loan applications it screens, as marginal profits from screening start to decline.

At some point, close to the peak of the business cycle, when the economy starts booming, the bank starts granting loans without screening. This has a dramatic effect on the bank's incentives to screen loan applications. The number of loan applications screened declines sharply with further improvements in the economic outlook, while the number of loans funded without screening increases very fast. As the times become better and better, the bank screens fewer and fewer loan applications, but grants more and more loans without screening.

At the peak of the business cycle, the bank screens no loan applications and grants the maximum number of loans without screening. This maximum number depends only on the bank's costs of funds.

Now let us turn our attention to the effect of the cost of funds. The bank's screening incentives depend on the cost of funds before the boom times, i.e. when it is not optimal to fund loans without screening. The bank screens more loan applications when the costs are lower. But in boom times (when the bank starts funding loans without screening) the screening incentives do not react to the changes in the costs of funds. In boom times, the cost of funds has a big effect on the bank's incentives to grant loans without screening. The lower the cost of funds is, the more loans without screening the bank is willing to grant. Why? While the cost of funds has no effect on the performance of good loans, it has a big effect on the losses that the bank incurs from funding bad loans, which are funded alongside good loans when no screening is performed. The costlier the funds are, the more damage the funded bad loans inflict on the bank's balance sheet. This leads us to a result that a lower cost of funds encourages the banks to take more risk in boom times.

We also analyse the effect of the screening costs on screening and on no-screening. The results are intuitive. Lower screening costs encourage the bank to screen more loan applications and to grant fewer loans without screening, and vice versa. Obviously, lower screening costs make screening more attractive.

Further, we analyse how the quality (defined as the probability of detecting a high-risk loan application) of the bank's screening affects the bank's screening incentives and the incentives to fund loans without screening. We find that the economic outlook at which the bank becomes active in the loan market must be better if the quality of screening declines. Moreover, the bank would screen fewer loan applications, while funding more loans without screening.

In Chapter 3, we also perform a welfare analysis. We find that from the social welfare perspective the bank funds too few loans without screening. But whether the bank screens too many or too few loan applications depends crucially on whether it is socially optimal for the bank to engage in funding loans without screening. If it is optimal to fund loans without screening, the bank clearly over-screens. But if it is not optimal to fund loans without screening, the bank under-screens. To the best of our knowledge, this is a novel result that has not been reported by the previous literature.

1.7.2 Costs of Funds and Incentives of Banks to Screen Loan Applicants over the Business Cycle

Chapter 4 is entitled "Costs of Funds and Incentives of Banks to Screen Loan Applicants over the Business Cycle". This chapter focuses on how the cost of funds affects the bank screening incentives over the business cycle.

We construct a simple theoretical model in which a bank has an access to a screening technology which allows it to imperfectly detect high-risk loan applications. The bank can adjust the precision of screening by adjusting its level of investment in the screening technology. Moreover, the bank has a possibility of screening only a fraction of loan applications, by randomly rejecting some loan applications prior to the screening. We investigate how the investment in screening depends on the costs of funds over the business cycle.

At the bottom of the business cycle, the bank is not active in the market. There are too few good loan applications and too many bad ones. As the economic outlook improves, the share of good projects in the economy increases, while the share of the bad ones decreases. The bank enters the loan market when the expected benefits of screening – and potentially funding – one loan application surpass the expected costs. The decision to become active in the market is influenced by the loan pool quality, which determines the expected benefits, and by the screening costs, which determine the expected costs.

Surprisingly, this decision does not depend on the costs of funds. However, as the economic outlook improves further, the number of loan applications that the bank chooses to screen is strongly affected by the costs of funds. The lower they are, the more willing the bank is to screen more loan applications. This happens because the decision to enter the loan market depends only on the costs and benefits of screening one loan application. In this situation, the costs of funds do not play a role. However, when it comes to screening and potentially funding a large number of loan applications, the costs of funds become very significant.

A further improvement in the economic outlook results in a big change in the bank's screening incentives. If at first, the bank screens few loan applications very carefully, as the economy starts booming, the bank screens more and more loan applications less and less carefully. In the end, at the peak of the business cycle, when almost all loan applications are good, the bank invests nothing in the quality of screening, while it screens the maximum number of loan applications. This maximum number depends only on the costs of funds. If they are low enough, the bank has an incentive to grant funding to all applicants.

The quality of screening depends on the screening costs and on the economic outlook. Surprisingly, it does not depend at all on the costs of funds.

From the society's perspective, the bank over-invests in the quality of screening while screening too few loan applications. In other words, the society would prefer the bank to screen more loan applications less carefully.

1.7.3 Competition, Screening, and Lending Volumes over the Business Cycle

Chapter 5 is entitled “Competition, Screening, and Lending Volumes over the Business Cycle”. This chapter investigates how bank competition affects screening and lending volumes over the business cycle.

We construct a theoretical model in which two banks face a pool of loan applicants. The banks compete for customers via screening loan applications. The banks need to decide how many loan applications to screen. Screening is costly but it reveals whether a given loan applicant is creditworthy or not. Unlike in most of the previous screening

literature, the banks need to raise funds in the deposit market at a positive interest rate. We analyse how the banks' screening decisions change as a result of changes in the economic outlook, in the cost of funds and in the costs of screening.

In deep recessions, independently of the costs of funds and of the screening costs, the banks either screen very few loan applications or are not at all active in the market. There are too many bad projects and too few good ones, making lending activity unattractive.

Once the economy picks up, both screening costs and costs of funds start to play a role. If both costs are high, screening – and subsequently lending – remains at a very low level. If either the cost of funds or screening costs decline, the banks start to screen more loan applications, as the economic outlook improves. But the effect of the deposit rate is significantly stronger than that of the screening costs. A small decline in the costs of raising funds results in a big increase in a screening activity. If the cost of funds is sufficiently low, then in boom times both banks screen almost all loan applicants.

When we compare the screening in a duopoly banking industry with a benchmark case of a monopoly banking industry, we find that a monopolist screens more loan applications than either of the two banks in the duopoly industry. However, the two banks in a duopoly industry together screen significantly more than a monopoly bank.

Our welfare analysis produces our most interesting result, which, to the best of our knowledge, has not been documented in the previous literature. From the social welfare perspective, whether the banks under- or over-screen depend on the costs of funds. If the costs are high, the banks under-screen relative to the social optimum, while if the costs are low, the banks over-screen.

1.7.4 Cost of Funds and Bank Competition over Screening Standards

Chapter 6 is entitled “Cost of Funds and Bank Competition over Screening Standards”. This chapter aims to investigate how bank competition affects the quality of the bank screening over the business cycle.

We construct a theoretical model in which two banks compete over the screening standards. Screening is costly and imperfect. It is exclusively aimed at detecting bad loan applications. Given this, the lending interest rates of the banks do not play a role, as screening decisions are not affected by the revenues from making good loans. The choice that the banks have to make is to decide how much to invest in screening out bad loan applications. The more the banks invest in screening, the more precise screening becomes. We find that this decision is strongly influenced by the cost of funds.

When the cost of raising funds is high, the banks invest a significant effort in screening out bad loan applications. But as this cost declines, the banks become less and less willing to spend resources on screening. If the cost of funds is extremely low, the banks are willing to accept a very high classification error in their screening decisions. In other words, the lower the cost of funds is, the more bad loans the banks are willing to fund. This key aspect of bank screening has not been discovered by the previous literature. However, there is evidence in the finance literature that a lower cost of funds encourages risk-taking by the banks (see e.g. Dell’Ariccia et al. 2011). Acharya and Naqvi (2010), analysing a model of bank moral hazard, argue that a low cost of funds leads to excessive lending and results in asset bubbles.

In order for the banks to be extremely cautious in their screening standards, both the economic situation should be tough and the cost of funds should be high. In boom times, independently of the cost of funds, the banks are unwilling to invest much in screening. This result is consistent with the results in Chapters 3 and 4.

When it comes to the effect of competition, we find that competition undermines investment in screening. A monopoly bank screens more intensely than either of the banks in a duopoly banking industry. This result is similar to Gehrig (1998) and to Kanninen and Stenbacka (1998). However, our welfare analysis shows that a monopoly bank over-invests in screening, in comparison with the social optimum. When it comes to a duopoly bank, the story is more complex. Whether the banks in a duopoly banking industry over- or under-screen in comparison with the social optimum depends on the economic outlook, on the costs of funds, and on the screening costs. Banks tend to over-screen in recessions, when the costs of funds are high or when the screening costs are low, while the banks tend to under-screen in boom times, when the costs of funds are low or when the screening costs are high. These welfare results contrast with Hauswald and Marquez (2005) who find that the banks competing for borrowers in a Salop-type setting invest too much in screening of each loan applicant. Gehrig and Stenbacka (2013) also report over-investment in screening intensity relative to the social optimum.

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2 THE BASIC MODEL

In this chapter, we present the main assumptions of the models that are used throughout the thesis. First, we discuss the way we model the lending market. Then we proceed to the discussion of the deposit market.

2.1 Lending Market

In the economy, there is a mass λ of “good” entrepreneurs, who have a low-risk project (L), and there is a mass $1 - \lambda$ of “bad” entrepreneurs, who have a high-risk project (H). Both good and bad entrepreneurs are risk neutral.

A project of either type requires one unit of funding. If realised, a project of type i ($i = L, H$) can either succeed (with probability p_i) or fail (with probability $1 - p_i$). It yields R_i in case of success and zero otherwise. We assume that $p_L > p_H$, $p_L R_L > 1 > p_H R_H$, and $R_H > R_L > 1$.

In order to realise the project, an entrepreneur requires a bank loan. It is assumed that an entrepreneur cannot finance any part of the project himself, nor can he post collateral. Furthermore, an entrepreneur is protected by limited liability. We assume standard debt contracts, as they are most common in the real world.

The banks cannot distinguish between high- and low-risk projects without screening, but they know the share of low-risk projects in the economy, λ , which is a quality measure of the pool of loan applications. Following the literature (see e.g. Ruckes 2004), λ can be seen as a parameter that reflects the state of the economy. An increase in λ could be interpreted that the economy is in expansion, as the share of low-risk projects typically increases in good times and shrinks in bad times.

Even though we employ throughout the thesis the same approach in interpreting the parameter λ as other bank screening literature, we cannot ignore the limitations of this approach and will take a moment to discuss them. Parameter λ simply reflects the loan pool quality. In doing comparative static analysis with respect to λ , this thesis and much of the previous literature assume exogenous changes in the loan pool quality and interpret them as macroeconomic changes⁷.

The lending interest rate is given by $(R_L - 1)$, which is the interest rate that a monopoly bank would be expected to charge. It should be noted that the entrepreneurs cannot affect the success probability of their projects. In other words, we abstract from moral hazard.

Given that the entrepreneurs have no collateral, there is no way in which a “good” entrepreneur can credibly signal his type to the bank. Moreover, a “bad” entrepreneur has no incentive to reveal the type of the project. The expected return of a “bad” entrepreneur from making a loan application is strictly positive: $p_H(R_H - R_L) > 0$. The bank, however, would prefer to finance only the low-risk projects. It follows from our assumptions that the expected revenue from financing a low-risk (high-risk) project is strictly positive (negative):

⁷ For suggestions for future research, refer to Chapter 7: Concluding Comments

$$E[\pi^L] = p_L R_L - 1 > 0, \quad (2.1)$$

$$E[\pi^H] = p_H R_L - 1 < 0. \quad (2.2)$$

The banks have an access to a screening technology. There are differences in the way the screening technology is modelled in each chapter. In Chapters 3 and 4 there is only one bank in the banking industry, which makes decisions over two parameters of the screening technology. In Chapter 3 the bank decides how many loan applications to screen and how many loan applications to fund without screening. In Chapter 4 the bank decides how many loan applications to screen and how well to screen each of these loan applications. In Chapters 5 and 6, on the other hand, there are two banks in the banking industry, which decide over one parameter of the screening technology. In Chapter 5 the banks decide how many loan applications to screen. In Chapter 6 the banks decide how well to screen the pool of loan applicants. Let us now discuss the screening technologies in each chapter in more detail.

In Chapter 3, there is one bank in the industry. The bank has an access to a screening technology, which allows it to perfectly classify the loan applications into low- and high-risk ones. We assume that the two main parameters of the screening technology are M and K . K is a probability – or given out normalisations, fraction, or number – of loan applications that the bank chooses to screen. M , on the other hand, is a probability – or, fraction, or number – of loan applications that the bank chooses to fund without screening. Clearly, it must be that $K \in [0,1]$ and $M \in [0,1]$. Moreover, their sum must be at most one:

$$K + M \leq 1.$$

In Chapter 3 we first present a model in which the screening technology reveals the type of the project with certainty. Then we realistically assume that the screening is imperfect and that there is a probability β with which a high-risk project is misclassified as a low-risk one. β is assumed to be exogenous.

In Chapter 3, the costs of screening are given by

$$K^2 z, \quad (2.3)$$

where z is a parameter that affects the costs of screening, $z \in (0,1)$.

In words, we assume that there are diseconomies of scale; hence the per-project costs of screening are rising in the number of loan applications screened.⁸ Economic motivation for this form of screening costs is based on the idea that the bank has developed a certain expertise in evaluating a certain type of loan applications.

As an example, we can think of a bank that specialises in funding construction firms. Over the years, the loan officers have become experts in screening construction projects. However, if the growth in the construction business slows down, the bank might need to enter a new market, while still funding construction firms. But it is highly likely that screening of a construction project is going to cost less to the bank than screening of a project for developing a new cancer medicine. So the bank might spend less resources on evaluating loan applications that lie in the field of its expertise, while

⁸ This makes it technically possible for the bank to grant some number of loans without screening

it might need to spend considerably more, the further away from the field of its expertise the loan application lies.

In Chapter 4, like in Chapter 3, there is also one bank in the industry. But unlike in Chapter 3, the bank has an access to a screening technology, which allows it to imperfectly classify the loan applications into low- and high-risk ones. We assume that the main parameter of the screening technology is the misclassification error β .⁹ It remains the same across all projects screened. β is a probability that a high-risk project is misclassified as a low-risk one. In our model, the bank regards β as its decision variable. To make things interesting, we assume that a perfect classification (i.e. $\beta = 0$) can only be achieved at unreasonably high cost. The costs of β -screening are given by a function $N(\beta, K)$, where K is the number – or given our normalisations, probability or fraction – of loan applications that the bank chooses to screen ($0 \leq K \leq 1$). We assume this function to exhibit constant returns to scale¹⁰, to be twice continuously differentiable, strictly decreasing ($N_\beta(\beta, K) < 0$), strictly convex ($N''_\beta(\beta, K) > 0$), and to satisfy boundary conditions: $N(1, K) = 0$ and $\lim_{\beta \downarrow 0} N(\beta, K) = \infty$.

Unlike in Chapters 3 and 4, in Chapter 5, there are two banks in the economy, which are denoted by A and B . To simplify the analysis and to focus exclusively on competition in the deposit market, we take the lending interest rate as exogenously given by $(R_L - 1)$. This is a collusive interest rate that a monopoly bank would be expected to charge. This type of collusion has been assumed in the earlier literature (see e.g. Kannianen and Stenbacka, 1998). Gorton and He (2008) show the connection between lending interest rate collusion, screening intensity and the banks' loan portfolio performance.

In Chapter 5, the banks have an access to a screening technology, which allows them to perfectly classify the projects into low- and high-risk ones. The costs of screening are given by

$$K^2 z, \tag{2.4}$$

where z is a parameter that affects the costs of screening, $z \in (0, 1)$, and K is the probability – or, given our normalisations, the fraction or number – of loan applications that the bank chooses to screen, $K \in (0, 1)$. We assume similar diseconomies of scale as in Chapter 3.

Unlike in Chapters 3 and 4, but as in Chapter 5, in Chapter 6 there are two banks in the economy. In Chapter 6, we also take the lending interest rate as exogenously given by $(R_L - 1)$. Even though this assumption might seem extremely restrictive, it does not affect the results. Screening technology in Chapter 6 is aimed only at weeding out high-risk loan applications, so low-risk loan applications drop out from the first-order conditions. The effect of lending interest rate on the payoff of the high-risk loan applications is marginal: it affects the payoff only in the unlikely event that the high-risk loans succeed.

⁹ We have also solved a model that allows the bank's screening technology to have two misclassification errors: α and β . α is a probability that a low-risk project is misclassified as a high-risk one. However, in our model, added value of such analysis is little: whenever it is optimal for the bank to invest more in β -screening, it is optimal to invest less in α -screening, and vice versa. But in the analysis of, for example, venture capital, it might be very important to have both α and β

¹⁰ Screening one loan application costs $N(\beta)$. Screening K loan applications costs $KN(\beta)$

In Chapter 6, like in Chapter 4, the main parameter of the screening technology is the misclassification error β . β is a probability that a high-risk project is misclassified as a low-risk one. In our model, the bank regards β as its decision variable. It remains the same across all projects screened. The costs of screening are given by

$$z(1 - \beta)^2, \tag{2.5}$$

where z is a constant that affects the costs of screening, $z > 0$.

2.2 Deposit Market

In order to finance the projects, the banks need to attract deposits. To simplify the analysis, we assume the supply of deposits of a monopoly bank in Chapter 3 and in Chapter 4 to be given by

$$S = fr, \tag{2.6}$$

where S is the amount of funds raised in the deposit market, f is a parameter that reflects the elasticity of supply of deposits and therefore affects the costs of funds, and r is the deposit interest rate.

The above formula can also be interpreted in another way. Let a unit mass of depositors be evenly distributed on a unit interval. Let each depositor be endowed with one unit of money. A depositor located at x selects the bank, which is located at 0, if

$$1 + r - bx \geq 1.$$

In words, the depositor located at x and endowed with a unit of money, has the benefit of r of going to the bank, which pays a deposit interest rate r . Going to the bank costs b per distance, meaning that the cost of going to the bank for the depositor located at x is bx .

This allows solving for which potential depositors go to the bank as a function of its interest rate:

$$x \leq \frac{r}{b}$$

Therefore, the total deposits that the bank attracts are given by

$$S = \frac{r}{b}.$$

This formula is equivalent to¹¹ Formula 2.6 with $f = 1/b$. This approach reminds of the famous model of Hotelling (1929). However, the original model refers to the product differentiation in a duopoly. Here, we have only one bank in the industry.

¹¹ Matutes and Vives (2000) have a similar formula with the difference that they have one more constant: $S = e + fr$. However, the constant e is tricky to interpret, as it allows the bank to raise deposits at zero interest rate.

In case of a duopoly, in Chapter 5 and in Chapter 6, the supply of deposits of both bank A and bank B is assumed to be given by

$$S_A + S_B = fr, \quad (2.7)$$

where S_A is the deposits raised by bank A , S_B is the deposits raised by bank B , f is a parameter that reflects the elasticity of supply of deposits, and r is the equilibrium deposit interest rate. Given that we are looking for a symmetric equilibrium, S_A equals S_B .

The approach that we employ in this thesis is not limited to the analysis of a deposit market, even though deposits are the main source of funds for commercial banks. Given the above assumptions, we can speak more generally about the costs of raising funds, which include deposit costs¹², interbank loans, discount loans (i.e. borrowings from the central bank), etc.

We make an assumption that there is a competitive market in which the banks raise funds. Moreover, we assume that neither bank can strongly affect the deposit interest rate. This assumption is made in order to exclude the possibility that one of the banks could raise the deposit interest rate enough to shut the other bank out of the market, as in Yanelle (1989).

Costs of funds depend on the competitiveness of the deposit market, which is reflected in the parameter f , which is the elasticity of supply of funds. A large f means that a bank can raise a lot of additional funds by a small increase in the deposit interest rate, r . The larger the parameter f is, the less expensive the funds are. A small f , on the other hand, means that in order to raise additional funds the banks need to increase the deposit interest rate significantly. The smaller the parameter f is, the more expensive the funds are.

It should be noted that the deposit and loan markets are totally separate and do not need to have a similar market structure. In our analysis the deposit market is clearly more competitive than the loan market. This assumption might be also not too far from the reality. In the real world, a small local bank somewhere in the euro area could be an important player in the local loan market, because it developed expertise in granting loans to the local businesses. But this bank does not have to raise funds in the same local market. In fact, the bank can raise funds almost anywhere in the euro area.

Further, throughout the thesis we assume that the banks simultaneously raise funds and grant loans. Alternatively one could have assumed that the banks first take care of one side of their business before taking care of the other side. However, assuming simultaneity is not unrealistic. At the same time one customer could come to a bank, open an account and make a large deposit, while another customer could ask for a large loan. Last, we assume that making a deposit in the banks is risk-free. One could analyse the connection between riskiness of a bank loan portfolio and willingness of depositors to make deposits in the bank. However, in the real world, in many countries, bank deposits are insured, which means that making a deposit up to a certain – rather large – amount in virtually any bank in many countries is risk-free.

¹² Note that deposit costs are not limited to the interest that the bank pays to the depositors. Deposit costs include also the costs of bank services that the depositors enjoy, like nice centrally located offices; customer service at the offices, by telephone and via Internet; payment services; ATM services; etc.

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3 TO SCREEN OR NOT TO SCREEN?

The banks are often criticised for performing very poor screening of loan applications in boom times. Some argue¹³ that poor screening may lead to an accumulation of bad loans on the banks' balance sheets, to a deterioration of loan portfolios, and subsequently to losses, which could result in a credit crunch and an economic downturn.

Understanding why banks could have incentives to be lax in screening in boom times could be a major step in preparing an appropriate policy response, aimed at preventing future crises. Previous bank screening literature explained lax screening in boom times from the point of view of bank competition. Hauswald and Marquez (2005) argue that the main reason for poor screening in boom times is an intense price competition in the lending market. But in this chapter, we argue that even in the absence of a price competition the bank may have an incentive to fund loans without performing any screening at all in boom times.

Unlike in most of the previous bank screening literature, we take into account the fact that a bank faces a positive deposit interest rate, i.e. there is a positive cost of funds. We argue that costly funds are important in explaining why a bank could run a higher credit risk in boom times.

Our analysis focuses on one bank. The bank has two types of decisions to make. First, the bank decides how many loan applications to screen. Second, the bank needs to decide how many loan applications to fund without performing any ex ante screening. The bank can also screen some loan applications while funding others without performing the screening procedure. Screening is realistically assumed to be costly. In Section 3.1.1 we present a model of perfect screening, i.e. if a loan application is screened, the bank learns with certainty whether a given loan application is of good or bad quality. In Section 3.1.2 we make a realistic assumption that the bank's screening is imperfect, i.e. that there exists a probability with which the bank's screening technology misclassifies some high-risk loan applications as good. We analyse how the bank's incentives to perform costly screening of loan applications and to fund loans without screening depend on the economic outlook, on the cost of funds, and on the screening costs. To the best of our knowledge, the effect of the cost of funds on the bank screening incentives has not been studied in the previous literature.

Our findings suggest that the bank has low screening incentives both when the economic outlook is very gloomy and when it is very bright. Both in deep recessions and in boom times, the bank performs costly screening of very few loan applications. However, in boom times – and only in boom times – the bank has an incentive to fund loans without performing any ex ante screening. This result provides a theoretical ground to Alan Greenspan's remark that bankers "lend aggressively at the peak of the business cycle".

Further, we find that a lower cost of funds encourages bank lending. With a low cost of funds the bank screens more loan applications on all the phases of the business cycle aside from the boom. In boom times, a lower cost of funds encourages the bank to fund

¹³ Former Federal Reserve Chairman Alan Greenspan noted: "There is doubtless an unfortunate tendency among some, I hesitate to say most, bankers to lend aggressively at the peak of a cycle and that is when the vast majority of bad loans are made." (Ruckes 2004)

more loans without screening, which means that a lower cost of funds in boom times encourages more risk-taking. This result has important policy implications. Our results suggest that the central bank can stimulate bank lending and help the economic recovery during recessions and crises through lowering of the banks' cost of funds. In boom times, on the other hand, the central bank can discourage the banks from running a high credit risk by increasing the cost of funds.

We also analyse how the screening costs affect the bank screening incentives. We find that a lower screening cost gives the bank incentives to screen more loan applications. Moreover, a lower screening cost encourages the bank to fund fewer loans without performing *ex ante* screening. The quality of screening, the impact of which we analyse in Section 3.1.2, has a similar effect as the screening costs. A lower quality of screening discourages the bank from screening loan applications and encourages the bank to fund more loans without screening.

The welfare analysis, which takes into account the profits of the bank, as well as the welfare of both good and bad entrepreneurs, shows that the bank funds too few loans without screening. However, we also find that on all stages of the business cycle aside from the boom, the bank screens too few loan applications in comparison with the social optimum. But in boom times, when funding loans without screening is optimal, the bank screens too many loan applications. This welfare result has not been reported in the previous literature.

Previous bank screening literature has mostly focused on the lending market competition. Broecker (1990) and Riordan (1993) apply the theory of common value auctions to analyse bank competition. Broecker shows that when banks are charging the same interest rate for loans, any bank has an incentive to offer a lower lending interest rate in order to attract higher-quality borrowers and thus improve the creditworthiness of its loan portfolio. Riordan argues that intensified competition in the loan market may have a negative welfare effect: as the number of banks grows, the probability of mistakenly granting a loan increases. However, both papers unrealistically assume creditworthiness tests to be exogenous and costless. In this chapter, as well as in all other chapters of this thesis, screening decisions are endogenous and costly.

Gehrig (1998) argues that loan market competition may reduce banks' incentives to screen loan applicants. Gehrig derives conditions under which banks may end up performing no screening at all in equilibrium.

In Banerjee (2005) the bank has a choice of two different screening technologies. It can either use a less costly technology that produces a lower-quality credit assessment or use a more expensive technology that produces a higher-quality signal. Banerjee argues that the choice of a screening technology by one bank imposes an externality on the competing bank, which affects the resulting market equilibrium. In contrast with Banerjee, our model allows the bank to choose between two extreme alternatives: to screen a loan application or to fund a loan without screening.

The rest of the chapter is organised as follows. Next section presents the main results. Section 3.2 is dedicated to the welfare analysis. Section 3.3 concludes.

3.1 The Bank's Problem

This section is organised as follows. In 3.1.1 we present the basic model in which the bank's screening is assumed to perfectly reveal the type of the borrower. In 3.1.2 we extend the model by assuming that there is a probability β with which a bad loan application is misclassified as a good one. In 3.1.3 we assume that the good entrepreneurs have a cost of making a loan application, while the bad entrepreneurs do not.

3.1.1 Basic Model

The bank maximises the following profit function with respect to both of its decision variables:

$$\pi(K, M) = K\lambda\pi^L + M[\lambda\pi^L + (1 - \lambda)\pi^H] - rL - K^2z. \quad (3.1)$$

In Formula (3.1), the first term captures the revenue that the bank receives from loan applications that successfully pass the screening. It consists of the number – or, given our normalisations, the probability or fraction – of loan applications that the bank chooses to screen,¹⁴ K , the number of low-risk projects in the economy, λ , and the expected revenue from financing one low-risk loan application, π^L .¹⁵

The second term captures the revenue from financing loan applications that are funded by the bank without screening. The term in the brackets is the sum of the profit from financing low-risk loan applications and of the loss from financing high-risk loan applications. This term, which, given our normalisations, can also be interpreted as the revenue from financing one loan application without screening, is multiplied by the fraction (or number) of loan applications that the bank randomly chooses to finance without screening, M .

The third term is the cost of deposits. It is given by the product of the deposit interest rate, r , and the number of loan applications that the bank decides to finance, L , which is given by:

$$L = K\lambda + M.$$

The first term in the formula above captures the number of loan applications that pass the bank's screening. The second term gives the number of loan applications that are financed without screening.

The deposit interest rate can be found from the formula that gives the supply of deposits:

$$S = fr.$$

Given that it is not optimal for the bank to raise more deposits than it grants loans,

¹⁴ Given our assumptions concerning the form of the screening costs, the bank – for any number of loan applications screened – would screen those loan applications that are least costly to screen.

¹⁵ $\pi^L = p_L R_L - 1$ and $\pi^H = p_H R_L - 1$

$$S = L.$$

So, the third term in the bank's profit function in Formula (3.1) can be expressed in the following way:

$$rL = \frac{(K\lambda + M)^2}{f}.$$

The last term in Formula (3.1) captures the cost of screening. The bank's profit function is subject to the following constraints: $K \in [0,1]$, $M \in [0,1]$, $K + M \leq 1$. The solution to the bank's optimisation problem is given by the following first-order conditions:

$$\frac{\partial \pi(K, M)}{\partial K} = \lambda \pi^L - \frac{2\lambda(K\lambda + M)}{f} - 2Kz = 0,$$

$$\frac{\partial \pi(K, M)}{\partial M} = \lambda \pi^L + (1 - \lambda)\pi^H - \frac{2(K\lambda + M)}{f} = 0.$$

Solving the above first-order conditions as a system of equations, we can find the optimal values of the bank's decision variables, expressed through the exogenous parameters:

$$K^* = \lambda(1 - \lambda) \frac{\pi^L - \pi^H}{2z}, \quad (3.2)$$

$$M^* = \frac{f}{2} [\lambda \pi^L + (1 - \lambda)\pi^H] - \lambda^2(1 - \lambda) \frac{\pi^L - \pi^H}{2z}. \quad (3.3)$$

The above formulas are based on the assumption that both K and M are strictly positive, i.e. there is an interior solution. However, the economic logic would suggest that it is highly likely that M would be zero when the economic times are bad: funding loans without screening could be far from profitable in times when the vast majority of loans are of high risk. That is why we need to also look for a corner solution in which $M = 0$. Then M would drop out from the profit function and Formula 3.1 would take the following form:

$$\pi(K|M = 0) = K\lambda\pi^L - rL - K^2z, \quad (3.4)$$

where

$$rL = \frac{(K\lambda)^2}{f}.$$

The solution is given by the following first-order condition:

$$\frac{\partial \pi(K|M = 0)}{\partial K} = \lambda \pi^L - \frac{2K\lambda^2}{f} - 2Kz = 0.$$

And the optimal number of loan applications screened is given by

$$K^* = \frac{\lambda \pi^L}{\frac{2\lambda^2}{f} + 2z}. \quad (3.5)$$

In order to investigate how a change in the parameter values affects the decision variables of the bank, we proceed to the comparative statics. We are interested in the effects of three parameters on the bank's decision variables: the economic outlook, λ , the cost of funds, f , and the costs of screening, z . Let us start with the comparative static analysis of the interior solution and then proceed to the corner solution.

First, we are interested in the effect of an improvement in the economic outlook, λ , on the bank's decision variables: on the number of loans granted without screening, M , and on the number of loan applications that the bank chooses to screen, K . We can find analytically the effect of λ on K by simply differentiating K^* (Formula 3.2) with respect to λ . But unfortunately the formula for M^* (Formula 3.3) in the interior solution is more complex and in order to investigate the effect of the economic outlook on M^* we will have to resort to numerical analysis. Let us start with the analysis of the interior solution:

$$\frac{dK}{d\lambda} = (1 - 2\lambda) \frac{\pi^L - \pi^H}{2z}.$$

The sign of this expression depends on λ . If λ is larger than $1/2$, the expression is negative. If λ is smaller than $1/2$, the expression is positive. And if λ equals $1/2$, it is zero. These results are intuitive. If the economy is in expansion (λ is increasing) and the majority of the loan applications are low-risk (λ is larger than $1/2$), then it is optimal for the bank to decrease the number of loan applications that it screens, as the economic outlook improves further, because the marginal profits from screening decrease. It is not optimal to look for high-risk projects in a pool where the majority of loan applications are of low-risk and where the share of high-risk loan applications continues to decline.

If, on the other hand, the economy is in expansion (λ is increasing) but the majority of the loan applications are high-risk (λ is smaller than $1/2$), then it is worthwhile for the bank to screen more, as marginal profits from screening increase. In this case, screening is more likely to detect high-risk loan applications.

This result is similar to Ruckes (2004). In his paper, Ruckes argues that the bank's screening incentives increase in expansions until a "certain level" after which the screening incentives decline. We found that this level is at $\lambda = 1/2$. In our model, this is the point below which a random loan application is more likely to be of high-risk and above which a random loan application is more likely to be of low-risk.

However, as we will see in Figures 1 and 2, the crucial condition for the above comparative static analysis is the existence of the interior solution. When looking at Figures 1 and 2 it becomes obvious that the interior solution does not exist for a wide range of parameter values, especially if λ is not high enough. In other words, the interior solution exists only in boom times. Now let us take a look at the comparative static result in the corner solution:

$$\frac{dK}{d\lambda} = 2\pi^L \frac{z - \frac{2\lambda^2}{f}}{\left(\frac{2\lambda^2}{f} + 2z\right)^2}.$$

The sign of the above expression depends on the parameter values. If $zf > 2\lambda^2$ the expression is positive. If $zf < 2\lambda^2$ the expression is negative. And if $zf = 2\lambda^2$ the expression equals zero.

Let us make one more comment on the above expression. Given that the previous literature that assumes the deposit interest rate to be zero implicitly assumes that f tends to infinity, let us take a limit of the above expression, applying l'Hôpital's rule (twice):

$$\lim_{f \rightarrow \infty} \frac{2\pi^L f^2 z - 4\pi^L \lambda^2 f}{(2\lambda^2 + 2zf)^2} = \frac{\pi^L}{2z} > 0.$$

As we can see, the previous literature, in assuming that the deposit interest rate is zero, ignored the fact that the effect of the economic outlook on screening could go either way: a better economic outlook could result both in more and in less screening, depending on the screening costs, on the costs of funds and on the loan pool quality.

Next, let us turn to the effect of the cost of funds on the screening incentives in the interior solution. We find that

$$\frac{dK}{df} = 0.$$

In words, the elasticity of supply of deposits, which determines the cost of raising funds in the deposit market, has no effect on the optimal number of loan applications screened by the bank. This happens because the costly funds have no effect on the profitability of good loans, nor any effect on the bank's lending interest rates, as those are determined in the loan market, not in the deposit market. But this result holds only in the interior solution. In the corner solution the comparative static result is given by:

$$\frac{dK}{df} = \frac{2\pi^L \lambda^3}{(2\lambda^2 + 2zf)^2} > 0.$$

In the corner solution, a lower cost of funds (a higher elasticity of supply of deposits f) encourages the bank to perform more screening. In the corner solution, the bank has no possibility of funding loans without screening, so the only way to increase activity in the loan market is through screening more loan applicants. Lower costs encourage the bank to fund more loans and therefore the bank screens more loan applications.

In the interior solution, we can also take a look at the way the cost of funds influences the bank's incentives to fund loans without screening:

$$\frac{dM}{df} = \frac{\lambda\pi^L + (1 - \lambda)\pi^H}{2} > 0.$$

As the supply of funds becomes more elastic, meaning that raising deposits becomes less expensive, it becomes optimal for the bank to finance more loans without

screening. This is intuitive. While the cost of funds has no effect on the performance of good loans, it has a big effect on the losses that the bank incurs from funding bad loans, which are funded alongside good loans when no ex ante screening of loan applications is performed. The costlier the funds are, the more damage the funded bad loans inflict on the bank's balance sheet. This leads us to a result that a lower cost of funds encourages the bank to take more risk in boom times.

Last, let us analyse the effect of the screening costs on the screening incentives. In the interior solution:

$$\frac{dK}{dz} = -\lambda(1 - \lambda) \frac{\pi^L - \pi^H}{2z^2} < 0,$$

$$\frac{dM}{dz} = \lambda^2(1 - \lambda) \frac{\pi^L - \pi^H}{2z^2} > 0.$$

The mathematical results above are very intuitive. If the screening costs increase, it is natural for the bank to screen fewer loan applications and to grant more loans without screening.

In the corner solution, the result is similar to the one in the interior solution:

$$\frac{dK}{dz} = \frac{-2\lambda\pi^L}{\left(\frac{2\lambda^2}{f} + 2z\right)^2} < 0.$$

Our analytical findings can be summarised in the following proposition:

Proposition 3.1

(a) *When funding loans without screening is optimal, the bank's screening incentives display an inverse U-shape as a function of the economic outlook, with the maximum number of loan applications screened at a point at which a given loan application is equally likely to be high- or low-risk.*

(b) *When funding loans without screening is not optimal, the bank screening incentives depend on the parameter values: on the loan pool quality, on the costs of funds, and on the screening costs.*

(c) *A lower cost of funds encourages the bank to fund more loans without screening.*

(d) *When funding loans without screening is optimal, the cost of funds has no influence on the number of loan applications that the bank screens.*

(e) *When funding loans without screening is not optimal, a lower cost of funds encourages the bank to screen more loan applications.*

(f) *A higher cost of screening encourages the bank to fund more loans without screening. A higher screening cost also encourages the bank to reduce the number of loan applicants screened.*

Aside from the interior and corner solutions that we have described above, there are three more corner solutions that need to be analysed. The first one is the corner

solution in which $M = 1$. Given that the sum of K and M can be at most one, we immediately obtain the result that in case of $M = 1$, $K = 0$. However, $K = 0$ does not make economic sense as long as there are bad projects in the economy that can be detected by the screening technology. Moreover, given the functional form of the screening costs function, the screening costs decline very fast when the number of projects screened declines. This means that as long as $\lambda < 1$ it makes economic sense for the bank to perform at least a little bit of screening. $\lambda = 1$ is a totally uninteresting case to study, as in that case all projects in the economy are high quality.

The second corner solution is the one in which $K = 1$. This automatically means that $M = 0$. Substituting these values into the profit function (3.1) one can calculate the profits of the bank in a straightforward manner.

The third corner solution is the most interesting to study. It is a case in which $K + M = 1$. In order to analyse this corner solution, first note that $M = 1 - K$. Substituting this into Formula 3.1 we obtain the following:

$$\pi(K|M = 1 - K) = K\lambda\pi^L + (1 - K)[\lambda\pi^L + (1 - \lambda)\pi^H] - \frac{(K\lambda + 1 - K)^2}{f} - K^2z.$$

The solution of the bank's problem is given by the following first-order condition:

$$-(1 - \lambda)\pi^H + 2\frac{K\lambda + 1 - K}{f}(1 - \lambda) - 2Kz = 0.$$

From the above formula we obtain the optimal number of loan applications screened:

$$K^* = \frac{(1 - \lambda)}{2} \frac{2 - f\pi^H}{(1 - \lambda)^2 + zf'}$$

$$M^* = 1 - K^*.$$

The numerical illustrations, given in the Appendix 1, have an intuitive form of an X. Moreover, this solution only exists at the higher values of λ , and is, by and large, in line with our Figures 1 and 2.

Let us now turn to our numerical illustrations, which will help us determine how the economic outlook affects the bank's incentives to grant loans without screening. For our numerical analysis, we have assumed the following parameter values: $\pi^L = 0.2$ and $\pi^H = -0.9$.¹⁶ Further, we explored an increase in the cost of funds, which is achieved by decreasing the parameter f from 10 to 5, and an increase in the screening costs, which is achieved by an increase in the parameter z from 0.05 to 0.2. The results of the numerical analysis are presented in Figures 1 and 2.

¹⁶ These are based on assumption that $R_L = 1.25$, $R_H = 2.0$, $p_L = 0.95$, $p_H = 0.1$, and completely satisfy the assumptions of the model in Chapter 2: The Basic Model

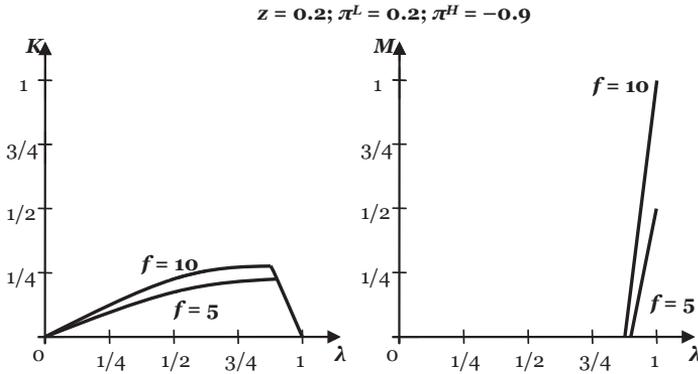


Figure 1 Bank's screening incentives under high screening costs.

As we can see from the Figures 1 and 2, the bank's screening incentives (K) somewhat remind of a U-shaped function of the loan pool quality (λ). It is not a smooth function, as the maximum is attained at the point at which it becomes optimal for the bank to start funding loans without screening. At this point the smooth function of the corner solution meets the smooth function of the interior solution, creating the overall U-shaped function. (See Figures 1 and 2, on the left.)

In the deepest recession (when λ is very small), the bank screens almost nothing, but its activities increase as the economic outlook improves (as λ increases). Whether the number of loan applications that the bank screens increases fast or slowly with an improvement in the loan pool quality, depends on the costs of funds and on the costs of screening. If both are low, the number of loan applications screened increases very fast.

However, at some point, especially when the screening costs are low and the costs of funds are high, the bank starts to decrease the number of loan applications it screens, as marginal profits from screening start to decline. This is clearly visible on the left-hand picture in Figure 2.

At some point, close to the peak of the business cycle, when the economy starts booming, the bank starts granting loans without screening (M , right-hand pictures). This has a dramatic effect on the bank's incentives to screen loan applications. The number of loan applications screened declines sharply with further improvements in the economic outlook (left-hand pictures).

At the peak of the cycle ($\lambda = 1$), the bank does not screen at all and grants the maximum number of loan applications without screening. This maximum number depends only on the bank's costs of funds (parameter f).

The bank's screening incentives (K) depend on the costs of funds before the boom times (in the corner solution). The bank screens more loans when the costs are lower. But in boom times (in the interior solution) the screening incentives do not react to the changes in the costs of funds.

The bank's incentives to grant loans without screening are strongly affected by the costs of funds, which is clearly visible in the right-hand pictures in both Figure 1 and 2. As the costs of funds decline, the bank grants significantly more loans without screening,

though the range of the loan pool quality, λ , at which the bank is willing to grant loans without screening is not affected much: a significant decline in the costs of funds causes only a slight shift of the thick line to the left. The costs of funds affect the marginal profit from granting a loan without screening. So obviously, when the costs of funds are low, the bank grants more loans than when the costs of funds are high.

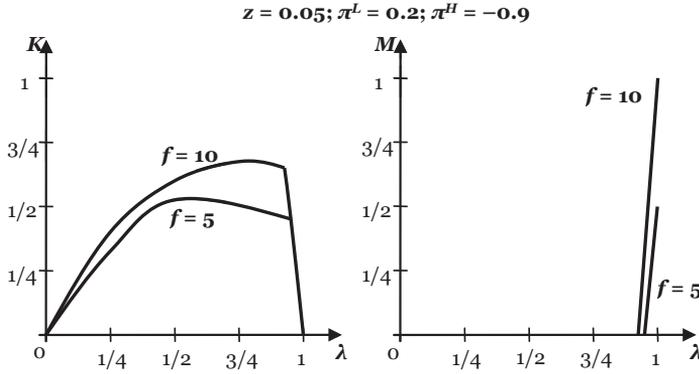


Figure 2 Bank's screening incentives under low screening costs.

3.1.2 Imperfect Screening

In this section, we assume that the bank's screening is not perfect, i.e. that there is a probability β with which a high-risk project is mistakenly classified as a low-risk one. This analysis is more realistic than that of the previous section, as banks do make mistakes in the real world.

There are many reasons why banks make mistakes in their lending decisions. One reason could simply be that some loan officers are more effective than others. If a less competent loan officer is in charge of the screening of a loan application, he or she is more likely to make a mistake. Another reason could be that the bad entrepreneurs differ in their ability in making a convincing loan application. More talented high-risk entrepreneurs are more likely to go undetected – until the failure of their projects.

For technical reasons, we assume the misclassification error β to be exogenous, as solving an optimisation problem over three variables is beyond our abilities. However, in the next chapter, we present a model in which the bank can adjust the precision of screening by choosing the misclassification error and the screening cost associated with it.

In this section, the bank's profit function takes the following form:

$$\pi(K, M) = K[\lambda\pi^L + (1 - \lambda)\beta\pi^H] + M[\lambda\pi^L + (1 - \lambda)\pi^H] - rL - K^2z. \quad (3.6)$$

One change is in the first term, as it accounts for the losses from the high-risk loan applications that are mistakenly classified as the low-risk ones. The other change is in the third term, as the number of loan applications funded changes, to account for the misclassified high-risk projects:

$$L = K[\lambda + (1 - \lambda)\beta] + M.$$

Accordingly, the third term is modified as follows:

$$rL = \frac{(K[\lambda + (1 - \lambda)\beta] + M)^2}{f}.$$

The solution to the optimisation problem is given by the following first-order conditions:

$$\frac{\partial \pi(K, M)}{\partial K} = \lambda\pi^L + (1 - \lambda)\beta\pi^H - \frac{2[\lambda + (1 - \lambda)\beta](K[\lambda + (1 - \lambda)\beta] + M)}{f} - 2Kz = 0,$$

$$\frac{\partial \pi(K, M)}{\partial M} = \lambda\pi^L + (1 - \lambda)\pi^H - \frac{2(K[\lambda + (1 - \lambda)\beta] + M)}{f} = 0.$$

From these we can find the optimal values of the bank's decision variables, expressed through the exogenous parameters:

$$K^* = \frac{\lambda\pi^L + (1 - \lambda)\beta\pi^H - [\lambda + (1 - \lambda)\beta][\lambda\pi^L + (1 - \lambda)\pi^H]}{2z}, \quad (3.7)$$

$$M^* = \frac{f}{2}[\lambda\pi^L + (1 - \lambda)\pi^H] - [\lambda + (1 - \lambda)\beta]K^*. \quad (3.8)$$

As we have seen in the previous section, the above interior solution is only part of the story. There is also a corner solution in which the bank funds no loans without screening, i.e. $M = 0$. Let us find this solution. The profit function takes the following form:

$$\pi(K|M = 0) = K[\lambda\pi^L + (1 - \lambda)\beta\pi^H] - rL - K^2z, \quad (3.9)$$

where

$$rL = \frac{(K[\lambda + (1 - \lambda)\beta])^2}{f}.$$

The first-order condition is given by

$$\frac{\partial \pi(K|M = 0)}{\partial K} = \lambda\pi^L + (1 - \lambda)\beta\pi^H - \frac{2K[\lambda + (1 - \lambda)\beta]^2}{f} - 2Kz = 0.$$

And the optimal number of loan applications screened is given by

$$K^* = \frac{\lambda\pi^L + (1 - \lambda)\beta\pi^H}{\frac{2[\lambda + (1 - \lambda)\beta]^2}{f} + 2z}. \quad (3.10)$$

In this section, we are interested in the effect of a change in the precision of screening, β , on the bank's decision variables, on K and on M . In case of K , we can employ the comparative statics technique only in case of the interior solution, but in case of M in the interior solution and K in the corner solution, we will have to again resort to the numerical analysis.

In case of the interior solution, the comparative static result is given by

$$\frac{dK}{d\beta} = -\frac{\lambda(1-\lambda)[\pi^L - \pi^H]}{2z} < 0.$$

The above expression shows that when the precision of screening improves (as β declines), the bank becomes more willing to increase its screening effort. This is natural: if screening becomes more effective, it is optimal to exert more screening effort.

As in Section 3.1.1 we also performed the analysis of the three corner solutions: $K = 1$, $M = 1$, and $K + M = 1$. This analysis is in Appendix 2.

Let us now take a look at Figure 3. There, the curves of the previous section's analysis (perfect screening) are drawn with thick lines, while the current section's curves (imperfect screening) are drawn with thin lines.

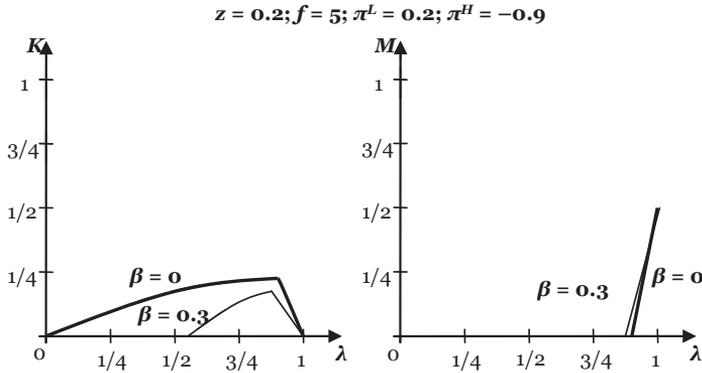


Figure 3 Bank's screening incentives under high screening costs and high costs of funds: perfect screening (thick curves) and imperfect screening (thin curves).

In comparison with the case when the screening was perfect, we see three main changes when the quality of screening is lower. First, the bank screens fewer loan applications. This is intuitive, as with lower screening quality, marginal revenues from screening are lower, making screening less profitable. Second, the bank becomes active in the market at a much higher threshold of the loan pool quality. This is also intuitive. With lower screening quality, the bank could end up mistakenly funding many high-risk loans. In order to avoid such a situation, the bank waits for the loan pool to become sufficiently good before entering the loan market. And third, the bank starts granting loans without screening at a lower loan pool quality: if screening is ineffective, granting loans without screening becomes more profitable.

3.1.3 Costly Loan Applications

If the bank could, it would make so that making a loan application is costly for everyone. An application cost would then act as a screening device: a high enough application cost would deter the bad entrepreneurs from making loan applications. However, in our model that would be an uninteresting solution. Moreover, it could be illegal for the banks to impose a loan application fee.

To make things interesting, in this section, we assume that the bank's screening is perfect but that only a good entrepreneur has a cost of making a loan application, C , while a bad entrepreneur has no cost of making an application. This assumption is realistic and reflects an idea that a good entrepreneur might put a considerable effort into coming up with an idea and into writing his business plan, while a bad entrepreneur could put some numbers into his business plan off the top of his head, without exerting much effort¹⁷.

In this environment, the bank needs to offer attractive enough conditions for the good entrepreneurs to come to the bank, while the bank would prefer the bad entrepreneurs not to come to the bank at all. So the bank would offer a lower lending interest rate (r_l) for loans that successfully pass the screening, while the bank would offer a standard monopoly bank's interest rate for loans that are financed without screening. Unfortunately for the bank, however, given that it is costless for the bad entrepreneurs to come to the bank and submit a loan application, the bad entrepreneurs would still make loan applications, as in the unlikely event that their projects succeed – after being financed without screening – they could pocket the difference $R_H - R_L$.

So, a “good” entrepreneur comes to the bank if

$$p_L(R_L - r_l - 1)K \geq C.$$

The probability of being selected for screening and passing it, K , is multiplied by the probability that the low-risk project succeeds, p_L , and by the entrepreneurs' payoff from a successful realisation of the project. This gives an expected payoff of a good entrepreneur from going to the bank. As the entrepreneur is assumed to be risk neutral, he would go to the bank if this expected payoff is larger than or equal to the cost of making a loan application, C . From this formula, we can find r_l :

$$r_l = (R_L - 1) - \frac{C}{p_L K}.$$

In the previous section, π^L was the profit that the bank received from financing low-risk projects. Here, instead of π^L the bank gets $r_l p_L$. To make the results comparable with the previous sections, let us express $r_l p_L$ through the notation that we used previously:

¹⁷ As an example, consider the problem of plagiarism. The former German Defence Minister Carl-Theodor zu Guttenberg in 2007 was awarded a doctoral title in law. Moreover, his dissertation received the university's highest honour. In 2011, however, it was discovered that the dissertation included numerous copied passages without citation. The doctoral title was subsequently revoked by the university and the minister had to resign from the government. (http://en.wikipedia.org/wiki/Causa_Guttenberg) If it is possible to obtain a doctoral degree with honours by a Copy & Paste method, it is certainly possible to make a convincing loan application using the same method.

$$r_l p_L = \pi^L + (1 - p_L) - \frac{C}{K}.$$

Now, all that we need to do is insert the above expression for $r_l p_L$ into the bank's profit function in Section 3.1.1 instead of π^L . So, the bank's profit function takes the following form:

$$\pi(K, M) = K\lambda\pi^L + K\lambda(1 - p_L) - \lambda C + M\lambda\pi^L + M(1 - \lambda)\pi^H - rL - K^2z. \quad (3.11)$$

The solution is given by the following first-order conditions:

$$\frac{\partial\pi(K, M)}{\partial K} = \lambda\pi^L + \lambda(1 - p_L) - \frac{2\lambda(K\lambda + M)}{f} - 2Kz = 0,$$

$$\frac{\partial\pi(K, M)}{\partial M} = \lambda\pi^L + (1 - \lambda)\pi^H - \frac{2(K\lambda + M)}{f} = 0.$$

Solving the above first-order conditions as a system of equations, we obtain the optimal values of the bank's decision variables, expressed through the exogenous parameters:

$$K^* = \lambda \frac{(1 - \lambda)[\pi^L - \pi^H] + (1 - p_L)}{2z}, \quad (3.12)$$

$$M^* = f \frac{\lambda\pi^L + (1 - \lambda)\pi^H}{2} - \lambda K^*. \quad (3.13)$$

As in the previous sections, the above formulas are the interior solution in which $M > 0$. Let us also find the corner solution in which the bank funds no loans without screening, i.e. $M = 0$. The profit function takes the following form:

$$\pi(K|M = 0) = K\lambda\pi^L + K\lambda(1 - p_L) - \lambda C - rL - K^2z. \quad (3.14)$$

The first-order condition is given by

$$\frac{\partial\pi(K|M = 0)}{\partial K} = \lambda\pi^L + \lambda(1 - p_L) - \frac{2K\lambda^2}{f} - 2Kz = 0.$$

And the optimal number of loan applications screened is given by

$$K^* = \frac{\lambda\pi^L + \lambda(1 - p_L)}{\frac{2\lambda^2}{f} + 2z}. \quad (3.15)$$

Most of the comparative static results of the basic model of Section 3.1.1 hold also in this section.¹⁸ An exception is the effect of the economic outlook, λ , on screening in the interior solution, K :

¹⁸In case of the interior solution:

$$\frac{dK}{d\lambda} = (1 - 2\lambda) \frac{\pi^L - \pi^H}{2z} + \frac{(1 - p_L)}{2z}.$$

The bank screening incentives follow a similar pattern in this section as in the basic model, with three exceptions. The first exception is that the point at which the screening incentives achieve the maximum is slightly lower in this section: in Section 3.1.1 it was $\lambda = 1/2$. Second, the bank clearly screens more loan applications in this section. Third, the bank screens even at $\lambda = 1$. Note that these results hold only in the interior solution in which it is optimal to fund some loans without screening.

The corner solution $K + M = 1$ is analysed in detail in Appendix 3.

As in the previous sections, we shall also do a numerical illustration. It is presented in Figure 4. There, the new results are presented with thin curves, while, for the ease of comparison, the results of Section 3.1.1 are presented in thick curves.

In Figure 4, we see that the bank screens more loan applications than in the standard model and grants fewer loans without screening. An interesting detail is that even at the peak of the business cycle, the bank screens a certain number of loan applications.

This happens because the bank must compensate to the good entrepreneurs the cost of making a loan application. This allows for a certain degree of separation between good and bad entrepreneurs, making the screening (K) somewhat more profitable for the bank than funding loans without screening (M). Even though it costs more to employ the screening technology than simply fund loans without screening, the bank, in comparison with the basic model of Section 3.1.1, screens more loan applications and grants fewer loans without screening.

$$\frac{dK}{df} = 0,$$

$$\frac{dM}{df} = \frac{\lambda\pi^L + (1 - \lambda)\pi^H}{2} > 0,$$

$$\frac{dK}{dz} = -\lambda \frac{(1 - \lambda)[\pi^L - \pi^H] + (1 - p_L)}{2z^2} < 0,$$

$$\frac{dM}{dz} = \lambda^2 \frac{(1 - \lambda)[\pi^L - \pi^H] + (1 - p_L)}{2z^2} > 0.$$

In case of the corner solution:

$$\frac{dK}{d\lambda} = 2(\pi^L + 1 - p_L) \frac{z - \frac{2\lambda^2}{f}}{\left(\frac{2\lambda^2}{f} + 2z\right)^2} \leq 0,$$

$$\frac{dK}{df} = \frac{2\lambda^3(\pi^L + 1 - p_L)}{(2\lambda^2 + 2zf)^2} > 0,$$

$$\frac{dK}{dz} = \frac{-2\lambda(\pi^L + 1 - p_L)}{\left(\frac{2\lambda^2}{f} + 2z\right)^2} < 0.$$

Moreover, as the economic outlook improves (as λ increases), the effect of the separation between good and bad entrepreneurs increases, as the number of good entrepreneurs increases. That is why the difference in screening between the basic model and the model of this section increases as λ increases. This is clearly visible in Figure 4.

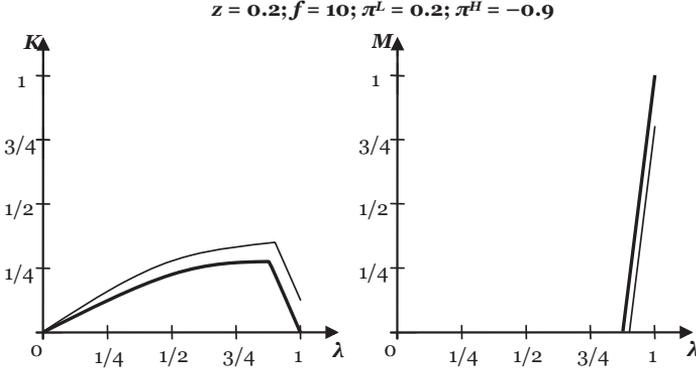


Figure 4 Bank's screening incentives under high screening costs and low costs of funds: costless loan applications (thick curves) and costly loan applications (thin curves).

3.2 The Welfare Analysis

In this section, we perform the welfare analysis that corresponds to the analysis of the bank's problem in the previous section. In 3.2.1 we compare the bank's screening incentives with the social optimum in the basic model, in 3.2.2 in the model of imperfect screening, and in 3.2.3 in the model of costly loan applications.

3.2.1 Basic Model

In the basic model with perfect screening, the society maximises the following social welfare function:

$$W(K, M) = K\lambda\pi^L + M[\lambda\pi^L + (1 - \lambda)\pi^H + (1 - \lambda)p_H(R_H - R_L)] - \frac{S^2}{2f} - K^2z. \quad (3.16)$$

It is assumed that the social welfare function is utilitarian, i.e. the marginal utility of consumption is the same across all individuals. Adopting any other social welfare function could be problematic. For example, if adopting a social welfare function with a stronger inequality aversion, one would need to specify how the gains and losses of the bank are distributed in the society.

The first term in Formula 3.16 captures the social benefit from the loans that are granted by the bank after screening. The term equals the bank's revenue from financing low-risk loan applications.

The second term captures the social benefit from the loans that are granted without screening. The term in the brackets consists of the bank's profits from financing low-risk loan applications, the bank's loss from financing high-risk loan applications, and the surplus of the high-risk entrepreneurs whose loan applications received funding. The term in the brackets is multiplied by the fraction – or number – of loan applications that the bank chooses to finance without screening.

The third term captures the society's costs of deposits. It accounts for the costs of deposits for the bank and for the surplus of the depositors. In order to derive it, first note that the marginal cost of granting a loan equals the deposit interest rate:

$$MC = r = \frac{S}{f}.$$

This means that the total cost can be obtained in the following way:

$$TC = \int_0^S MC(x)dx = \int_0^S \frac{x}{f} dx = \frac{S^2}{2f}.$$

Just like in the bank's problem,

$$S = fr = L.$$

So, the third term in Formula 3.16 equals the following:

$$\frac{S^2}{2f} = \frac{(K\lambda + M)^2}{2f}.$$

The last term in Formula 3.16 captures the cost of screening. The solution to the maximisation problem is given by the following first-order conditions:

$$\frac{\partial W(M, K)}{\partial M} = \lambda\pi^L + (1 - \lambda)\pi^H + (1 - \lambda)p_H(R_H - R_L) - \frac{K\lambda + M}{f} = 0,$$

$$\frac{\partial W(M, K)}{\partial K} = \lambda\pi^L - \lambda \frac{K\lambda + M}{f} - 2Kz = 0.$$

Solving these first-order conditions as a system of equations, we can find socially optimal fraction (or number) of loan applications that are screened, \hat{R} , and the socially optimal fraction (or number) of loan applications that are granted financing without screening, \hat{M} :

$$\hat{M} = f[\lambda\pi^L + (1 - \lambda)\pi^H + (1 - \lambda)p_H(R_H - R_L)] - \lambda\hat{R}, \quad (3.17)$$

$$\hat{R} = \frac{\lambda\pi^L}{2z} - \lambda \frac{\lambda\pi^L + (1 - \lambda)\pi^H + (1 - \lambda)p_H(R_H - R_L)}{2z}. \quad (3.18)$$

As in the bank's problem, in the welfare analysis we need to account for the fact that the socially optimal M might be zero, i.e. from the social welfare perspective funding loans

without screening might be not optimal. Let us find the corner solution. The social welfare function takes the following form:

$$W(K|M = 0) = K\lambda\pi^L - \frac{S^2}{2f} - K^2z. \quad (3.19)$$

The first-order condition is given by

$$\frac{\partial W(K|M = 0)}{\partial K} = \lambda\pi^L - \frac{K\lambda^2}{f} - 2Kz = 0.$$

And the socially optimal number of loan applications screened in the corner solution is

$$\widehat{K} = \frac{\lambda\pi^L}{\frac{\lambda^2}{f} + 2z}. \quad (3.20)$$

In case of the interior solution, comparing \widehat{K} (Formula 3.18) and K^* (Formula 3.2), we find that the bank screens too many loan applications in comparison with the social optimum:

$$K^* - \widehat{K} = \lambda \frac{(1 - \lambda)p_H(R_H - R_L)}{2z} > 0.$$

Moreover, the bank grants too few loans without screening:

$$M^* - \widehat{M} = -\frac{f}{2} [\lambda\pi^L + (1 - \lambda)\pi^H + 2(1 - \lambda)p_H(R_H - R_L)] - \lambda^2 \frac{(1 - \lambda)p_H(R_H - R_L)}{2z} < 0.$$

In this expression, the only term that has an unclear sign is $[\lambda\pi^L + (1 - \lambda)\pi^H]$. However, note that this term equals the revenue that the bank gets from financing loan applications without screening. If this term were negative, the bank would not finance without screening at all.

In case of the corner solution, we see that the denominator of \widehat{K} (Formula 3.20) is smaller than the denominator of K^* (Formula 3.5) while their numerators are identical. This means that $K^* < \widehat{K}$, which means that we arrive at the opposite conclusion to the one in the interior solution: in case of the corner solution, the bank screens too few loan applications.

Our findings can be summarised in the following proposition:

Proposition 3.2

(a) *The bank funds too few loans without screening.*

(b) *When it is socially optimal to fund loans without bank screening, the bank clearly screens too many loan applications.*

(c) *When it is not socially optimal to fund loans without bank screening, the bank screens too few loan applications.*

Points (a) and (b) in the Proposition 3.2 can be explained by the society's care for the welfare of the bad entrepreneurs. If the bad projects are funded by the bank, there is a chance that bad entrepreneurs make profits, which are accounted for in the society's welfare. However, the bank does not care about the welfare of the bad entrepreneurs. The bank only cares about its own profits and therefore engages in costly screening.

Point (c) in the Proposition 3.2 can be explained from different perspectives. First, the bank does not take into account the welfare of the depositors, which means that the bank faces a higher cost of funds than the society. This makes the bank screen fewer loan applications and subsequently fund fewer loans. Second, the bank is a monopoly. Under-production is a standard monopoly result. A monopoly bank chooses its level of production – which is screening in our model – that is below the socially optimal level of production. This is a market failure, which arises as a result of imperfect competition.

3.2.2 Imperfect Screening

In case when the screening is imperfect, the social welfare function takes the following form:

$$W(K, M) = K[\lambda\pi^L + (1 - \lambda)\beta\pi^H + (1 - \lambda)\beta p_H(R_H - R_L)] \quad (3.21) \\ + M[\lambda\pi^L + (1 - \lambda)\pi^H + (1 - \lambda)p_H(R_H - R_L)] - \frac{S^2}{2f} - K^2z.$$

Note that if the screening were perfect, i.e. $\beta = 0$, we get the same social welfare function as in the previous section. Unlike in the previous section, in this section, the society cares for the welfare of the bad entrepreneurs also when it comes to screening (see the difference between Formula 3.16 and Formula 3.21 in the first term), because screening is no longer perfect. The more imperfect the screening is, the more bad entrepreneurs can obtain funding.

Differentiating the social welfare function with respect to both of the decision variables, we get the following first-order conditions:

$$\frac{\partial W(M, K)}{\partial M} = \lambda\pi^L + (1 - \lambda)\pi^H + (1 - \lambda)p_H(R_H - R_L) - \frac{K[\lambda + (1 - \lambda)\beta] + M}{f} = 0,$$

$$\frac{\partial W(M, K)}{\partial K} = \lambda\pi^L + (1 - \lambda)\beta\pi^H + (1 - \lambda)\beta p_H(R_H - R_L) \\ - [\lambda + (1 - \lambda)\beta] \frac{K[\lambda + (1 - \lambda)\beta] + M}{f} - 2Kz = 0.$$

Solving the above first-order conditions as a system of equations, we obtain the socially optimal values of the number of loan applications screened and the number of loans granted without screening, expressed through the exogenous parameters:

$$\hat{M} = f[\lambda\pi^L + (1 - \lambda)\pi^H + (1 - \lambda)p_H(R_H - R_L)] - [\lambda + (1 - \lambda)\beta]\hat{K}, \quad (3.22)$$

$$\widehat{K} = \frac{\lambda\pi^L + (1-\lambda)\beta\pi^H + (1-\lambda)\beta p_H(R_H - R_L)}{2z} - [\lambda + (1-\lambda)\beta] \frac{\lambda\pi^L + (1-\lambda)\pi^H + (1-\lambda)p_H(R_H - R_L)}{2z}. \quad (3.23)$$

As in the previous section, the above is the interior solution in which it is socially optimal to fund loans without ex ante screening. Let us find the corner solution in which $\widehat{M} = 0$. The social welfare function is given by

$$W(K|M=0) = K[\lambda\pi^L + (1-\lambda)\beta\pi^H + (1-\lambda)\beta p_H(R_H - R_L)] - \frac{S^2}{2f} - K^2z. \quad (3.24)$$

The first-order condition is given by

$$\frac{\partial W(K|M=0)}{\partial K} = \lambda\pi^L + (1-\lambda)\beta\pi^H + (1-\lambda)\beta p_H(R_H - R_L) - \frac{K[\lambda + (1-\lambda)\beta]^2}{f} - 2Kz = 0.$$

And the socially optimal number of loan applications screened is given by

$$\widehat{K} = \frac{\lambda\pi^L + (1-\lambda)\beta\pi^H + (1-\lambda)\beta p_H(R_H - R_L)}{\frac{[\lambda + (1-\lambda)\beta]^2}{f} + 2z}. \quad (3.25)$$

Let us now compare the socially and privately optimal screening incentives and incentives to fund loans without screening. We start with the interior solution. Comparing Formula 3.23 with Formula 3.7 we get:

$$\widehat{K} - K^* = \lambda(\beta - 1) \frac{(1-\lambda)p_H(R_H - R_L)}{2z} < 0.$$

The result above is in line with the Proposition 3.2: in case of the interior solution, the bank screens too many loan applications.

If taking a look at the socially optimal \widehat{M} (Formula 3.22) and the privately optimal M^* (Formula 3.8), it becomes obvious that the socially optimal \widehat{M} is larger than the privately optimal M^* . This result is again in line with the Proposition 3.2: from the social welfare perspective, in case of the interior solution, the bank funds too few loans without screening.

Now let us turn to the corner solution and see if the Proposition 3.2 holds in that case too. If we compare in the case of the corner solution, numerators and denominators of the socially optimal \widehat{K} (Formula 3.25) and the privately optimal K^* (Formula 3.10), we will see that the denominator of K^* is larger than that of \widehat{K} , while the numerator of \widehat{K} is larger than that of K^* . This leads us to the conclusion that the socially optimal \widehat{K} is unambiguously larger than the privately optimal K^* . So we arrive to the same result as in the previous section: in case of the corner solution, the bank screens too few loan applications.

3.2.3 Costly Loan Applications

In case when the screening is perfect but the good entrepreneurs have a cost of making a loan application, the social welfare function takes the following form:

$$W(K, M) = K\lambda\pi^L + K\lambda(1 - p_L) - \lambda C \quad (3.26)$$

$$+ M[\lambda\pi^L + (1 - \lambda)\pi^H + (1 - \lambda)p_H(R_H - R_L)] - \frac{S^2}{2f} - K^2z.$$

The solution is given by the following first-order conditions:

$$\frac{\partial W(M, K)}{\partial M} = \lambda\pi^L + (1 - \lambda)\pi^H + (1 - \lambda)p_H(R_H - R_L) - \frac{K\lambda + M}{f} = 0,$$

$$\frac{\partial W(M, K)}{\partial K} = \lambda\pi^L + \lambda(1 - p_L) - \lambda \frac{K\lambda + M}{f} - 2Kz = 0.$$

Solving the above as a system of equations, we obtain the socially optimal values of the number of loan applications screened and the number of loans granted without screening:

$$\widehat{M} = f[\lambda\pi^L + (1 - \lambda)\pi^H + (1 - \lambda)p_H(R_H - R_L)] - \lambda\widehat{K}, \quad (3.27)$$

$$\widehat{K} = \frac{\lambda\pi^L + \lambda(1 - p_L)}{2z} - \lambda \frac{\lambda\pi^L + (1 - \lambda)\pi^H + (1 - \lambda)p_H(R_H - R_L)}{2z}. \quad (3.28)$$

As in the previous sections, let us find also the corner solution, in which it is not socially optimal to fund loans without screening, i.e. $\widehat{M} = 0$. The social welfare function takes the following form:

$$W(K|M = 0) = K\lambda\pi^L + K\lambda(1 - p_L) - C - \frac{S^2}{2f} - K^2z. \quad (3.29)$$

The solution is given by the following first-order condition:

$$\frac{\partial W(K|M = 0)}{\partial K} = \lambda\pi^L + \lambda(1 - p_L) - \frac{K\lambda^2}{f} - 2Kz = 0.$$

And the socially optimal number of loan applications screened is given by

$$\widehat{K} = \frac{\lambda\pi^L + \lambda(1 - p_L)}{\frac{\lambda^2}{f} + 2z}. \quad (3.30)$$

Let us now compare the socially optimal screening incentives with those of the bank. We start with the interior solution. Comparing \widehat{K} (Formula 3.28) and K^* (Formula 3.12), we find that the bank screens too many loan applications in comparison with the social optimum:

$$K^* - \widehat{K} = \lambda \frac{(1 - \lambda)p_H(R_H - R_L)}{2z} > 0.$$

Moreover, the bank grants too few loans without screening:

$$M^* - \widehat{M} = -f \frac{\lambda\pi^L + (1 - \lambda)\pi^H}{2} - f[(1 - \lambda)p_H(R_H - R_L)] + \lambda\widehat{K} - \lambda K^* < 0.$$

Turning to the corner solution, we see that the denominator of \widehat{K} (Formula 3.30) is smaller than that of K^* (Formula 3.15), while their numerators are identical. This leads to the conclusion that the socially optimal \widehat{K} is larger than the privately optimal K^* , meaning that the bank, in case of the corner solution, screens too few loan applications.

All these findings are in line with the Proposition 3.2 in Section 3.2.1.

3.3 Discussion

In this chapter, we have found that a bank has the strongest incentives to perform costly screening of loan applicants when the economic prospects are neither bright nor gloomy. When the times are bad, the bank performs very little screening and subsequently grants very few loans. When the times are good, the bank also performs very little screening. Moreover, in boom times, it has an incentive to fund loans without performing any ex ante screening of loan applications.

The bank's incentives to screen loan applicants depend on the screening costs. The lower the screening costs are, the more loan applicants the bank would screen. When funding loans without screening is not optimal – in other words, on all phases of the business cycle aside from the boom times – the bank's screening incentives also depend on the cost of funds. The lower the cost of funds is, the more loan applications the bank chooses to screen.

The bank's incentives to fund loans without screening, on the other hand, depend both on the cost of funds and on the screening costs. The lower the cost of funds is and the higher the screening costs are, the more loans without screening the bank would grant in boom times. Thus follows our main finding: a lower cost of funds encourages the bank to take more risk in boom times, as the bank grants more loans without screening.

The analysis in this chapter has some policy implications. Our model suggests that if the policy makers would want to encourage the banks to perform more thorough screening of loan applications and to restrict the number of loans that the banks grant without performing screening, the policy should be aimed at reducing the screening costs, for example, through improving the banks' access to information about the potential borrowers.

Moreover, the central bank has the power of affecting the cost of funds through the tools of monetary policy, such as quantitative easing, the interest rate for discount loans, and reserve requirements. The cost of funds affects the allocation of credit because it affects the bank's incentives to grant loans without screening. More expensive funds in boom times would encourage the banks to take less credit risk. Less expensive funds at all other stages of the business cycle would encourage the bank to screen more loan applications, and to subsequently fund more loans.

However, our welfare analysis suggested that in boom times the bank over-screens and grants too few loans without screening. In other words, the model recommends the regulator to give the banks more incentives to be lax in screening in boom times. But at all other stages of the business cycle, aside from the boom times and the very peak of the cycle, the welfare analysis suggested that the bank screens too few loan applications. Encouraging the bank to screen more loan applications can be done by reducing the cost of funds and the screening costs. These measures would increase the welfare – as long as the timing of these measures is appropriate.

However, the welfare analysis has many limitations. Mathematically, the welfare analysis assumes the existence of a social planner, or a benevolent dictator, who cares about maximising the social welfare. In the real world, there are no examples of such benevolent social planners.

The closest thing to a benevolent social planner that exists in the real world is a democratic government. But even democratic governments do not generally care about the welfare of all citizens, but rather about the welfare of the voter groups that are likely to support the government in the next election and ensure its re-election. A leftist government – which typically cares about the equality – could care more about the welfare of high-risk entrepreneurs and might be willing to redistribute the profits of the banks on increasing the welfare of the high-risk entrepreneurs. A right-wing government, on the other hand – which typically rewards the entrepreneurial success – might care more about the bank's profits and the low-risk entrepreneurs, and might be unwilling to support high-risk entrepreneurs. Moreover, different policy makers could have different interests – or even conflicting interests. The central bank, which is typically independent of the government, cares about the stability of the banking system and about the inflation. The central bank typically does not care about high-risk entrepreneurs – as long as they do not threaten financial stability.

The policy that makes economic sense in the setting of our model is a complex of measures aimed at reducing the screening costs on all phases of the business cycle, at reducing the costs of funds in recessions, and at increasing the costs of funds in boom times.

One possible measure to reduce the screening costs is introduction of a loan application cost. Even a small loan application cost could prevent high-risk entrepreneurs from seeking out bank loans, in hopes of banks' low enough screening standards. Therefore a loan application cost can itself act as a screening device that would separate low-risk entrepreneurs from the high-risk ones.

There can also be a separate charge for bank screening. The charge could be in the form of time, which might be somewhat inefficient, as it would lead to time waste, or in the form of money. In Section 3.1.3 we developed a model in which only the low-risk entrepreneurs have to pay a loan application cost. And it well might be true in the real world that a good entrepreneur spends a lot more effort on business planning than a bad entrepreneur. But still a separate charge for the screening or for making a loan application could deter high-risk entrepreneurs from applying, even though the good entrepreneurs could end up paying more for making a loan application than the bad entrepreneurs.

The central bank cares about the stability of the banking system and therefore it is in the central bank's interest to discourage the banks from running a high credit risk. In this chapter we show that the bank has an incentive to lower its screening standards in

boom times. So the appropriate response of the central bank is a more restrictive monetary policy in boom times. This can be achieved, for example, by stopping or reducing the stimulus programmes or by setting a higher interest rate for discount loans. Moreover, the central bank cares about the inflation. Too low costs of funds in boom times could lead to too much lending and therefore to overheating of the economy and to high inflation. Thus, a more restrictive monetary policy by the central bank in boom times could achieve both greater stability of the banking system and meeting of the inflation target.

When it comes to the appropriate response by the central bank in recessions, it is also in the central bank's interest to stimulate lending via lowering of the banks' costs of funds. Too little lending in recessions could lead to a very slow recovery and to too low inflation or even to deflation. In order to meet the inflation target, the central bank should stimulate the lending by commercial banks. The costs of funds can be lowered, for example, through quantitative easing or through setting of a lower interest rate for discount loans.

Any model has many limitations and therefore any possible policy recommendations following from theoretical models should be treated with great caution. The analysis in this chapter is no exception. It did not allow the bank to choose how well to screen the potential borrowers. Rather, the bank in this chapter chose between two extremes: whether to screen the borrower or to grant a loan without screening. This issue will be addressed in Chapter 4. Furthermore, the analysis in this chapter restricted the attention only to one bank in the banking industry and ignored the effects of competition. Banking competition will be studied in Chapters 5 and 6.

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APPENDIX 1

In this appendix, we provide a numerical illustration to the analysis of the corner solution $K + M = 1$ of Section 3.1.1. The illustration is given in Figure 5 below. The numerical illustration has an intuitive form of an X, the width of which seem to be mostly dependent on the screening costs, and only a little bit dependent on the costs of funds. Also note that the X is located at the eastern end of the pictures. This means that the corner solution $K + M = 1$ may exist only when the economy is booming.

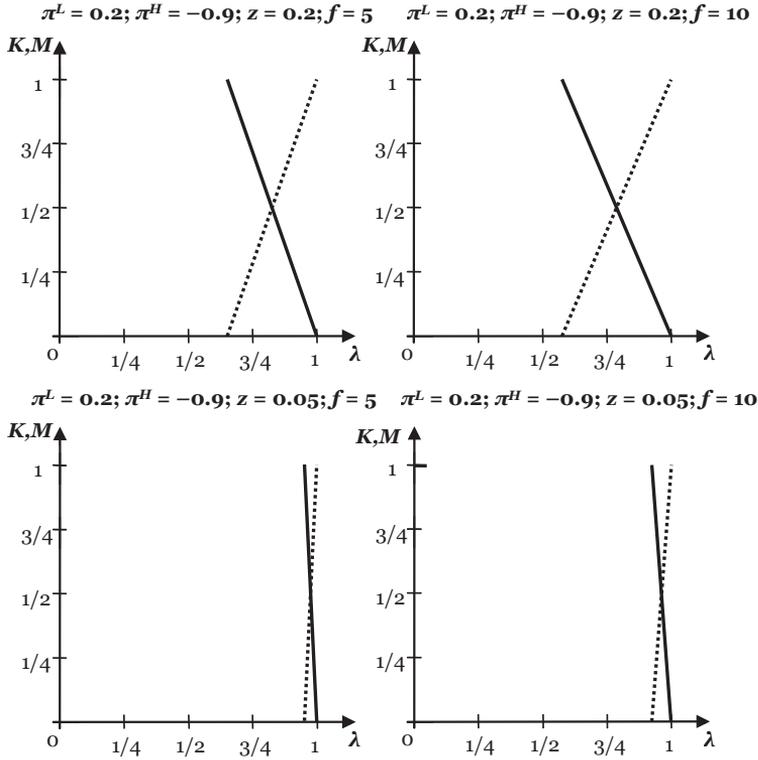


Figure 5 Bank's screening incentives (thick curves) and the bank's incentives to fund loans without screening (dotted curves) under the corner solution

APPENDIX 2

As in Section 3.1.1, we need to take into account the following three corner solutions: $K = 1$, $M = 1$, and $K + M = 1$. The discussion in Section 3.1.1 concerning the first two corner solutions hold also in Section 3.1.2. To remind, the corner solution $M = 1$ does not make economic sense, as it means that $K = 0$, which means that the bank performs no screening at all. The corner solution $K = 1$ is a more interesting case, in which $M = 0$. As in Section 3.1.1 it is straightforward to calculate the bank's profit in case of this corner solution. Let us take a closer look at the corner solution in which $K + M = 1$. In this case, $M = 1 - K$. Substituting this into Formula 3.6 we obtain the following:

$$\pi = K[\lambda\pi^L + (1 - \lambda)\beta\pi^H] + (1 - K)[\lambda\pi^L + (1 - \lambda)\pi^H] - \frac{(K[\lambda + (1 - \lambda)\beta] + (1 - K))^2}{f} - K^2z.$$

The first-order condition is given by

$$-(1 - \lambda)(1 - \beta)\pi^H + \frac{2(K[\lambda + (1 - \lambda)\beta - 1] + 1)(1 - \lambda)(1 - \beta)}{f} - 2Kz = 0.$$

And the optimal K^* is given by

$$K^* = \frac{(1 - \lambda)(1 - \beta)}{2} \frac{2 - f\pi^H}{zf + (1 - \lambda)^2(1 - \beta)^2}$$

$$M^* = 1 - K^*.$$

A numerical illustration is given in Figure 6.

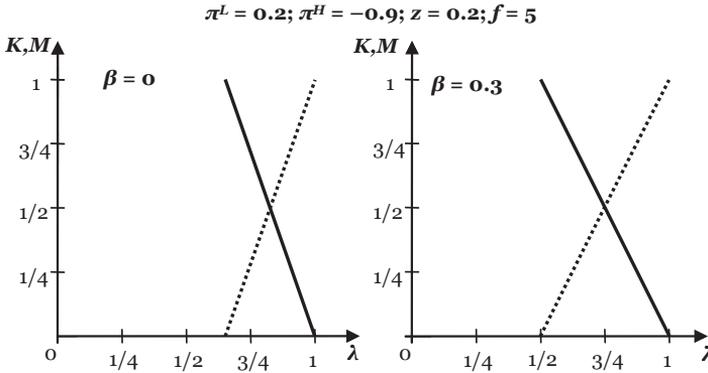


Figure 6 Bank's screening incentives (thick curves) and the bank's incentives to fund loans without screening (dotted curves) under high screening costs and high costs of funds in case of the corner solution: perfect screening (on the left) and imperfect screening (on the right).

As we can clearly see in the figure above, the precision of the bank's screening technology affects the range of λ in which the corner solution $K + M = 1$ exists. The more imprecise the bank's screening is, the more scope the corner solution has.

APPENDIX 3

As in Appendix 2, we take a look at the corner solution in which $K + M = 1$ in Section 3.1.3. In this case, $M = 1 - K$. Substituting this into Formula 3.11 we obtain the following:

$$\pi = K\lambda\pi^L + K\lambda(1 - p_L) - \lambda C + (1 - K)\lambda\pi^H + (1 - K)(1 - \lambda)\pi^H - \frac{(K\lambda + 1 - K)^2}{f} - K^2z.$$

The first-order condition is given by

$$\lambda(1 - p_L) - (1 - \lambda)\pi^H + \frac{2(K\lambda + 1 - K)(1 - \lambda)}{f} - 2Kz = 0.$$

And the optimal K^* is given by

$$K^* = \frac{f\lambda(1 - p_L) + (1 - \lambda)(2 - f\pi^H)}{2(1 - \lambda)^2 + 2fz},$$

$$M^* = 1 - K^*.$$

A numerical illustration is given in Figure 7.

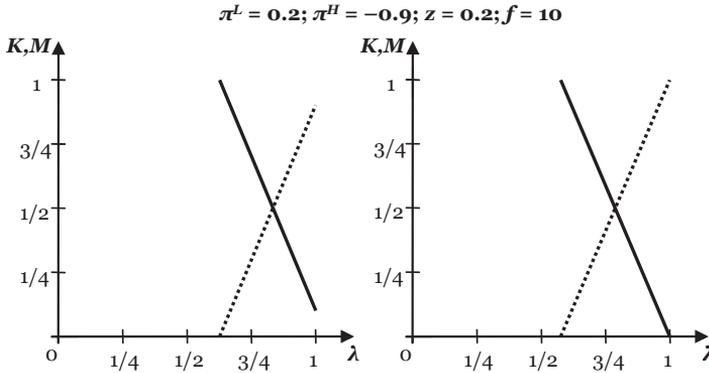


Figure 7 Bank's screening incentives (thick curves) and the bank's incentives to fund loans without screening (dotted curves) under high screening costs and low costs of funds: costless loan applications (on the right) and costly loan applications (on the left).

As we can see, the figure above is in line with our findings in Section 3.1.3.

APPENDIX 4

In this appendix, we analyse whether the bank over- or under-screens in comparison with the social optimum in case of the corner solution in which $K + M = 1$. In this case, $M = 1 - K$. In Section 3.2.1 the social welfare function is given by:

$$W = K\lambda\pi^L + (1 - K)[\lambda\pi^L + (1 - \lambda)\pi^H + (1 - \lambda)p_H(R_H - R_L)] - \frac{(K\lambda + 1 - K)^2}{2f} - K^2z.$$

The first-order condition is

$$-(1 - \lambda)[\pi^H + p_H(R_H - R_L)] - \frac{K(1 - \lambda)^2 - (1 - \lambda)}{f} - 2Kz = 0.$$

And the socially optimal number of loan applications screened is given by

$$\hat{K} = (1 - \lambda) \frac{1 - f\pi^H - fp_H(R_H - R_L)}{(1 - \lambda)^2 + 2zf},$$

$$\hat{M} = 1 - \hat{K}.$$

Unfortunately, we can compare the socially optimal \hat{K} and \hat{M} with the privately optimal K^* and M^* only numerically. This is done in the Figure 8 below. As we can see in this figure, the bank consistently over-screens and funds too few loans without screening. This result holds also in Sections 3.2.2 and 3.2.3.

Also in this appendix we find the socially optimal \hat{K} and \hat{M} in Sections 3.2.2 and 3.2.3. In Section 3.2.2, the social welfare function takes the following form:

$$W = K[\lambda\pi^L + (1 - \lambda)\beta\pi^H + (1 - \lambda)\beta p_H(R_H - R_L)] \\ + (1 - K)[\lambda\pi^L + (1 - \lambda)\pi^H + (1 - \lambda)p_H(R_H - R_L)] \\ - \frac{(K[\lambda + (1 - \lambda)\beta] + (1 - K))^2}{2f} - K^2z.$$

The first-order condition is given by:

$$-(1 - \lambda)(1 - \beta)[\pi^H + p_H(R_H - R_L)] - \frac{K(1 - \lambda)^2(1 - \beta)^2 - (1 - \lambda)(1 - \beta)}{f} - 2Kz = 0.$$

And the socially optimal number of loan applications screened is given by

$$\hat{K} = (1 - \lambda)(1 - \beta) \frac{1 - f\pi^H - fp_H(R_H - R_L)}{(1 - \lambda)^2(1 - \beta)^2 + 2zf},$$

$$\hat{M} = 1 - \hat{K}.$$

In Section 3.2.3 the social welfare function takes the following form:

$$W = K\lambda\pi^L + K\lambda(1 - p_L) - \lambda C + (1 - K)[\lambda\pi^L + (1 - \lambda)\pi^H + (1 - \lambda)p_H(R_H - R_L)] - \frac{(K\lambda + 1 - K)^2}{2f} - K^2z.$$

The first-order condition is given by:

$$\lambda(1 - p_L) - (1 - \lambda)\pi^H - (1 - \lambda)p_H(R_H - R_L) + \frac{(K\lambda + 1 - K)(1 - \lambda)}{f} - 2Kz = 0.$$

And the socially optimal number of loan applications screened is given by:

$$\hat{R} = \frac{f\lambda(1 - p_L) + (1 - \lambda)(1 - f\pi^H - p_H(R_H - R_L))}{(1 - \lambda)^2 + 2fz},$$

$$\hat{M} = 1 - \hat{R}.$$

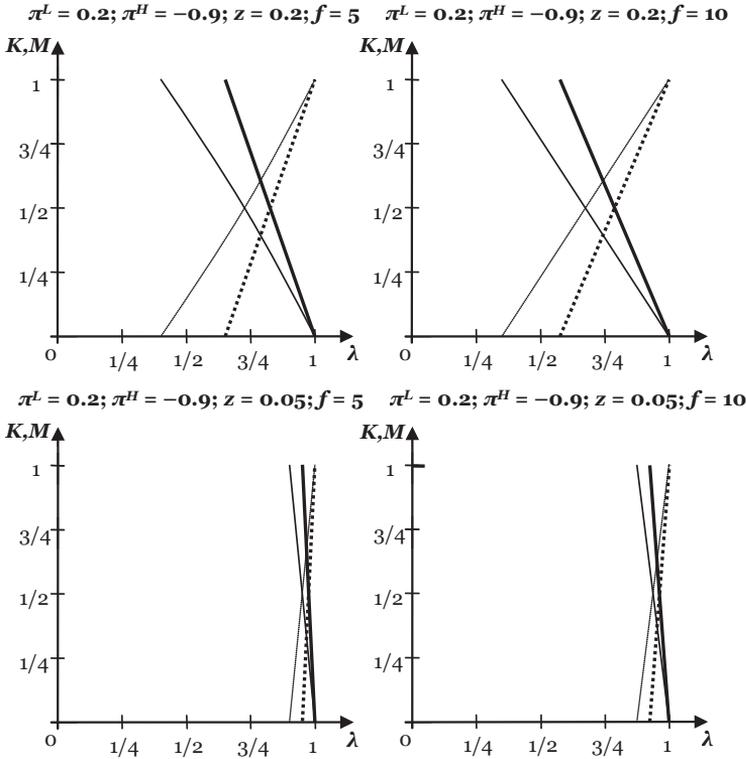


Figure 8 Bank's screening incentives (thick curves) and socially optimal screening (thin curves). The private and social incentives to fund loans without screening in dotted curves.

4 COSTS OF FUNDS AND INCENTIVES OF BANKS TO SCREEN LOAN APPLICANTS OVER THE BUSINESS CYCLE

Much research has been done on how lending market competition affects incentives of the banks to screen loan applicants. Less well understood is how the deposit market – and more generally, the bank's cost of funds – affects the bank screening incentives. Most of the screening literature does not take into account the deposit market, assuming that banks can borrow at a zero interest rate.

In this chapter, we show that the costs of funds affect the banks' screening incentives. As in Chapter 3, we model one bank that makes two types of decisions. First, the bank decides how many loan applications to screen. Second, the bank decides how well to screen each loan application. So, unlike in Chapter 3, in this chapter the bank can adjust the precision – or the quality – of screening by adjusting its investment in the screening technology. The more precise the screening is, the more expensive it is. We investigate how investment in screening depends on the costs of funds over the business cycle.

It has been argued that screening standards vary counter-cyclically (Ruckes 2004). Most bad loans may be granted in boom times. In this chapter, we show that banks indeed have an incentive to perform very poor screening in boom times. This result holds both when it is very costly for the bank to raise funds and when it is very cheap to raise additional funds. Unlike the analysis in Chapter 3, in this chapter the bank does not have a possibility to screen some projects while funding others without screening. But the bank can choose how well it screens each loan application, as well as choose how many loan applications to screen.

This chapter allows studying how the bank's screening incentives change over the course of a business cycle. Understanding how and why the screening incentives change would allow policy makers to come up with better ways of regulating the banks. Unlike the previous literature, this chapter takes into account the cost of funds. This is very significant, especially from the central bank's perspective, as central banks have the power of influencing the cost of funds through the tools of monetary policy.

The analysis in this chapter allows us to study the bank's decision to enter the lending market. We find that the bank's entry decision depends crucially on the screening costs and on the economic outlook. High screening costs and a gloomy economic situation deters the bank from entering the lending market. The bank's entry decision surprisingly does not depend on the cost of funds. However, once the bank enters the market, the cost of funds significantly influences the number of loan applications that the bank screens.

The cost of funds has no effect on the quality with which the bank screens loan applications. Just like the entry decision, the quality of screening depends on the economic outlook and on the cost of screening. The lower the screening costs are and the worse the economic outlook is, the more intensely the bank screens the potential borrowers. Once the bank enters the lending market, it exerts the maximum screening effort and screens the minimum number of loan applications. As the times become better and better, the bank screens more and more loan applications less and less carefully. At the peak of the business cycle, the bank screens the maximum number of loan applications while it invests nothing in the quality of screening. This result is

consistent with Chapter 3, in which we found that the bank has incentives to fund loans without performing any *ex ante* screening in boom times.

The welfare analysis shows that the bank screens too few loan applications too carefully. From the society's perspective, the bank over-invests in the quality of screening while screening too few loan applications. In other words, society would prefer the bank to screen more loan applications less carefully. This result is interesting, as the previous literature pointed out either under-investment (see e.g. Kanninen and Stenbacka 1998) in screening or over-investment in screening (see e.g. Hauswald and Marquez 2005).

Previous literature on banks' incentives to screen loan applicants has mostly focused on how lending market competition affects banks' screening incentives. Kanninen and Stenbacka (1998), analysing a model of costly screening, show that increased competition undermines the banks' incentives to screen loan applications, while Gehrig and Stenbacka (2013) argue that competition increases banking industry's investments in screening of loan applicants. Dell'Ariccia (2000) warns that banks competing for borrowers over screening standards may end up trapped in Prisoner's Dilemma, where the no-screening is the unique equilibrium. Marquez (2002) finds that increased competition among banks leads to an inefficiency, because smaller banks have less information of the market than larger banks, meaning that smaller banks are less effective in screening.

Hauswald and Marquez (2005), on the other hand, find that intensified loan market competition leads to too much screening. Interestingly, they argue that both entry of new banks and consolidation create an incentive for the banks to acquire private information in order to gain market share and maintain profitability. They find that the farther away a borrower is located from the bank, the more the borrower benefits from a lower interest rate, and the less efficient the lending decision becomes.

This chapter is also related to the literature analysing changes in screening standards in response to economic fluctuations in time. Ruckes (2004) shows that banks' screening incentives may exhibit an inverse U-shape as a function of the economic outlook. Ruckes argues that in severe recessions a marginal profit from screening is low and therefore banks base their decisions to finance loans mostly on the general economic conditions rather than on evaluating an individual loan applicant. When the economic outlook improves, the marginal profit from screening increases and hence banks intensify screening. However, as the number of bad loan applications decreases beyond a certain level, marginal benefits from screening decline and hence the banks find it optimal to invest less in screening. Moreover, Ruckes finds that deposit insurance may play a role in countercyclical variation of screening intensity. However, Ruckes does not analyse the banks' decision to enter the loan market, while in this chapter the bank chooses when exactly it wants to enter the market and start screening loan applicants.

The rest of the chapter is organised as follows. Next section presents the main results. Section 4.2 is dedicated to the welfare analysis. Section 4.3 concludes.

4.1 The Bank's Problem

This section is organised as follows. In 4.1.1 we present a simple benchmark model of a bank that can raise deposits at zero interest rate. In 4.1.2 we extend the model by requiring that the bank pay a positive deposit interest rate.

4.1.1 Simple Model of Costless Deposits

In the simplest case of a bank that pays zero interest rate for its deposits, the profit function is given by

$$\pi(\beta) = \lambda\pi^L + (1 - \lambda)\beta\pi^H - N(\beta)^{19}. \quad (4.1)$$

The first two terms in the formula above capture the expected revenues from financing low- and high-risk projects respectively, while the last term gives the costs of screening. The solution to the profit maximisation problem is given by the first-order condition with respect to the screening intensity, β , which is a probability that a bad project is mistakenly classified as a good one:

$$\frac{\partial\pi(\beta)}{\partial\beta} = (1 - \lambda)\pi^H - N'(\beta) = 0.$$

In order to see how screening incentives of the bank change over the business cycle, we proceed to the comparative statics. Total differentiation of $\partial\pi/\partial\beta = 0$ with respect to β and λ gives the following:

$$\frac{\partial^2\pi}{\partial\beta^2}d\beta + \frac{\partial^2\pi}{\partial\beta\partial\lambda}d\lambda = 0.$$

From the formula above we can find the effect of the economic outlook, λ , on the screening intensity, β :

$$\frac{d\beta}{d\lambda} = \frac{\frac{\partial^2\pi}{\partial\beta\partial\lambda}}{-\frac{\partial^2\pi}{\partial\beta^2}}.$$

The denominator of this expression is positive, as profit functions are assumed to be strictly concave²⁰, so the sign of the whole expression depends on the numerator. We find that

$$\frac{\partial^2\pi}{\partial\beta\partial\lambda} = -\pi^H > 0.$$

This means that $d\beta/d\lambda$ is also positive. In words, when the share of low-risk projects increases – which happens at the expansionary phase of the business cycle – the bank finds it optimal to invest less in screening, which is intuitive, as fewer high-risk projects in the economy mean that the marginal profit from screening decreases.

¹⁹ $\pi^L = p_L R_L - 1$ and $\pi^H = p_H R_L - 1$

²⁰ $\partial^2\pi/\partial\beta^2 = -N''(\beta)$. In Section 2.1 we made a reasonable assumption that $N''(\beta) > 0$. This means that $-\partial^2\pi/\partial\beta^2 > 0$

4.1.2 Model of Costly Deposits

Next, we realistically assume that the bank pays a positive interest rate in order to attract deposits. Moreover, the bank has a possibility of randomly rejecting a fraction $1 - K$ of loan applications prior to the screening process. This possibility the bank could use if either – or both – the screening costs or the deposit interest rate is too high. Moreover, one of the key features of a monopolist's behaviour is that it can choose not to meet all of the demand in order to maximise its profit.

This assumption is also similar to credit rationing, which is a rather common strategy used by the banks. Credit rationing takes two forms (Mishkin, 2007). First, the bank could refuse to extend a loan to a certain borrower altogether, even if the borrower is willing to pay a higher interest rate. Second, the bank could offer a loan that is smaller in size than the loan the borrower would like. The second type of credit rationing could be used as a screening device: make a small loan in order to assess the borrower's creditworthiness before extending larger loans. (Equilibrium credit rationing is discussed in greater detail in Section 1.3.3 of the Introduction.)

As an example, imagine a situation in which the economy is deep in recession, with vast majority of loan applications of high-risk. Moreover, both the screening costs and the costs of funds are high. If the bank did not have a say over the number of loan application to screen, K , it would have been forced to screen all loan applications at a high cost, knowing that only a small fraction of them are creditworthy. Being active in the market in this environment is clearly not optimal and our model allows the bank not to engage in such a wasteful behaviour because it can adjust the quality of its screening, as well as choose the number of loan applications to screen.

By assumption, the amount of deposits that the bank collects, S , is given by

$$S = fr.$$

The amount of loans that the bank grants, L , is given by

$$L = K[\lambda + (1 - \lambda)\beta].$$

The first term in the brackets in the formula above captures the number – or given our normalisation, the probability or fraction – of low-risk loan applicants. The second term is the number of high-risk loan applicants multiplied by the misclassification error. Their product gives the number of high-risk loan applications that could pass the screening process, i.e. would be misclassified as low-risk loan applications. Multiplying the term in the brackets by K gives us the number of loan applications that pass the screening and are classified as low-risk.

Note that it does not make sense for the bank to collect more deposits than it grants loans, so it must be so that

$$S = L.$$

The bank's problem is to maximise its profit with respect to both of its decision variables: the misclassification error, β , which captures the intensity (quality) of screening, and the fraction (or, given our normalisations, the number) of loan applications that the bank screens, K :

$$\pi(\beta, K) = \lambda K \pi^L + (1 - \lambda) \beta K \pi^H - rL - N(\beta, K).$$

The first term in the bank's profit function captures the revenues from financing low-risk loan applications, while the second term gives the losses from financing high-risk projects. The third term captures the bank's total payment to the depositors – the cost of funds, in other words. Given our assumptions regarding the supply of deposits, it is easy to see that

$$rL = \frac{L^2}{f} = \frac{K^2[\lambda + (1 - \lambda)\beta]^2}{f}.$$

The last term in the bank's profit function captures the total costs of screening. The solution to the optimisation problem is given by the following first-order conditions:

$$\frac{\partial \pi(\beta, K)}{\partial \beta} = (1 - \lambda) K \pi^H - \frac{2K^2(1 - \lambda)[\lambda + (1 - \lambda)\beta]}{f} - N_\beta(\beta, K) = 0,$$

$$\frac{\partial \pi(\beta, K)}{\partial K} = \lambda \pi^L + (1 - \lambda) \beta \pi^H - \frac{2K[\lambda + (1 - \lambda)\beta]^2}{f} - N_K(\beta, K) = 0.$$

In order to obtain an explicit solution, we make a further assumption that the screening function is given by²¹

$$N(\beta, K) = K \frac{1 - \beta}{z\beta}. \quad (4.2)$$

In this expression, z is a constant that reflects the costs of screening, $z \geq 1$. Substituting this expression into our first-order conditions, we obtain,

$$\frac{\partial \pi(\beta, K)}{\partial \beta} = (1 - \lambda) K \pi^H - \frac{2K^2(1 - \lambda)[\lambda + (1 - \lambda)\beta]}{f} + K \frac{1}{z\beta^2} = 0,$$

$$\frac{\partial \pi(\beta, K)}{\partial K} = \lambda \pi^L + (1 - \lambda) \beta \pi^H - \frac{2K[\lambda + (1 - \lambda)\beta]^2}{f} - \frac{1 - \beta}{z\beta} = 0.$$

Solving the above first-order conditions as a system of equations, we obtain the optimal values of the bank's decision variables expressed through the exogenous parameters. (To save the space, in formula for K^* we used the optimal β^* .)

$$\beta^* = \frac{(1 - \lambda) + \sqrt{(1 - \lambda)^2 + \lambda(1 - \lambda)[1 + \lambda(\pi^L - \pi^H)z]}}{(1 - \lambda)[1 + \lambda(\pi^L - \pi^H)z]}, \quad (4.3)$$

²¹ Note that this function satisfies all the properties listed in Chapter 2: The Basic Model. The function exhibits constant returns to scale, it is twice continuously differentiable, strictly decreasing ($N_\beta(\beta, K) < 0$), strictly convex ($N''_\beta(\beta, K) > 0$), and it satisfies boundary conditions: $N(1, \cdot) = 0$ and $\lim_{\beta \rightarrow 0} N(\beta, \cdot) = \infty$.

$$K^* = \frac{f \left[(1 - \lambda)\pi^H + \frac{1}{z(\beta^*)^2} \right]}{2(1 - \lambda)[\lambda + (1 - \lambda)\beta^*]} \quad (4.4)$$

The uniqueness of the above solution is shown in the Appendix 8.

The above formulas are rather complex to be explored analytically, using traditional comparative static analysis. However, there are two special cases that we can see right away, and there are two comparative static results that we can derive analytically, before proceeding to the numerical analysis.

In Formula 4.3, if $\lambda = 0$ then $\beta^* = 1$. Also in case λ is very close to 0, $\beta^* = 1$. This means that the bank does not invest in the quality of screening in deepest recessions. When it comes to the comparative statics, first, it is easy to see that changes in the elasticity of supply of deposits have no effect on the intensity with which the bank screens each loan application:

$$\frac{d\beta}{df} = 0.$$

But the cost of funds does affect the number of loan applications that the bank chooses to screen:

$$\frac{dK}{df} = \frac{(1 - \lambda)\pi^H + \frac{1}{z\beta^2}}{2(1 - \lambda)[\lambda + (1 - \lambda)\beta]}$$

The sign of the above expression is ambiguous and can go in either direction. If $(1 - \lambda)\pi^H + 1/z\beta^2 > 0$, the expression is positive. If $(1 - \lambda)\pi^H + 1/z\beta^2 < 0$, the expression is negative. And if $(1 - \lambda)\pi^H + 1/z\beta^2 = 0$, the expression is zero. So the sign of the expression depends on the optimal intensity of screening, on the loan pool quality, on the screening costs, and on the expected losses of high-risk loans.

We can summarise our analytical findings in the following proposition:

Proposition 4.1

The cost of funds has no effect on the intensity with which the bank screens the loan applications. However, the cost of funds affects the number of loan applications screened.

Let us now proceed to our numerical analysis, assuming plausible parameter values. This analysis might seem less general than the comparative statics, but in this case it is the only option to proceed. Moreover, as we will see below, the numerical analysis produces reliable and intuitive results.

Let us assume that $\pi^L = 0.2$ and that $\pi^H = -0.9$, which seem rather plausible²², and explore how the bank's incentives to screen loan applicants change, depending on (a)

²² These are based on the assumption that $R_L = 1.25$, $R_H = 2.0$, $p_L = 0.95$, $p_H = 0.1$, and completely satisfy the assumptions of the model. $\pi^L = p_L R_L - 1 \approx 0.2 > 0$ and $\pi^H = p_H R_H - 1 \approx -0.9 < 0$. So, a good entrepreneur is expected to make an expected revenue for the bank of about 0.2 for the investment of one unit, while a bad entrepreneur is expected to lose 90% of the invested one unit of money.

the costs of funds (reflected in the parameter f), on (b) the costs of screening (parameter z), and on (c) the loan pool quality, λ .

Now let us take a look at Figure 9. Here we assume that the costs of screening are high ($z = 20$) and investigate the effects of the loan pool quality and the costs of raising deposits on the bank's decision variables, on β and on K .

The first thing that we notice is that the bank's investment in screening each loan application is independent from the costs of raising funds (the right-hand side): the screening intensity, β , as a function of the economic outlook, λ , does not change in any way when the costs of deposits decrease significantly (parameter f increases from 5 to 10, making deposits a lot cheaper). However, the cost of funds does affect the number of loan applications that the bank chooses to screen, K : as the funds become less expensive, the bank screens significantly more loan applications (the left-hand side).

In other words, if the costs of raising funds increase, the bank does not choose to screen each loan application more carefully – or, invest more in per-project screening. One could have expected that the bank would increase screening intensity to reduce the risk of funding bad projects when the cost of funds increases. Instead, the bank chooses to screen fewer loan applications.

However, this result is intuitive. A change in the cost of funds does not change the distribution of the expected returns from any given randomly screened loan application, because it depends on the quality of the loan pool, λ , and on the expected returns from low- and high-risk projects, π^L and π^H . Hence, the cost of funds does not affect the optimal screening intensity, β . But the cost of funds affects the marginal costs of financing an additional project. Therefore, it affects the optimal number of projects screened, K .

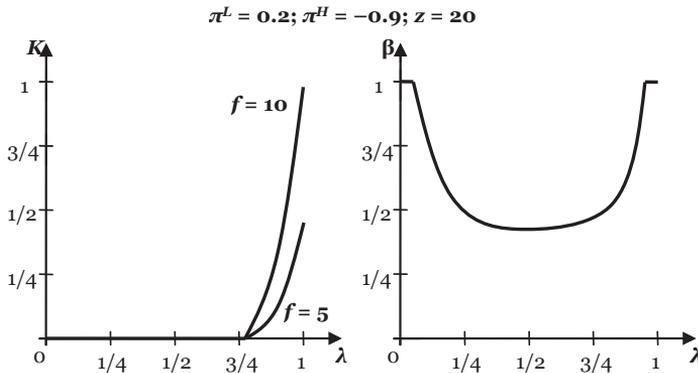


Figure 9 Bank's screening incentives under high screening costs.

The second thing that we notice when we look at Figure 9 is that the bank engages in lending activity both when the costs of funds are low and high in the same range of λ . In fact, the bank enters the loan market at precisely the same level of λ . In other words, the bank's decision to start lending activity is independent from the costs of funds.

The bank enters the loan market ($K > 0$) when screening one random loan application²³ generates an expected profit. This decision depends on the quality of the pool, λ , on the expected returns from low- and high-risk projects, π^L and π^H , and on the costs of screening one loan application. Given that by assumption there are no fixed costs, the costs of funds for screening and potentially funding one loan application are marginal and do not affect the bank's decision. That is why, given the loan pool quality, the bank's decision on when to become active in the lending market is independent of the costs of funds. However, the costs of raising funds affect the slope of K function. If they are marginal for one project, they are not marginal when there are many projects.

And the third observation is that the bank's investment in screening each loan application is low both when the quality of the pool is very low and very high. The investment is highest when the quality of the pool is average. However, the bank is not active in the lower range of λ . So any discussion on why it might have been optimal for the bank to invest very little in screening when all or almost all projects in the economy are high-risk would be pure speculation. But note that the bank's decision to invest less in screening as the loan pool quality improves, follows exactly the same logic as in the model of costless deposits: marginal benefits from screening decline as the number of high-risk projects in the economy declines, making screening less attractive.

Now, let us take a look at Figure 10. The only difference between Figures 9 and 10 is that the costs of screening decrease significantly (parameter z increases from $z = 20$ to $z = 200$). This is a dramatic decline in the screening costs. (See Appendix 7.)

When we compare Figures 9 and 10, we can make two observations. First is that the bank enters the loan market at a much lower threshold of loan pool quality, λ : if in Figure 9 the bank enters the loan market at $\lambda \approx 3/4$, in Figure 10, the bank enters the market at $\lambda \approx 1/2$. In other words, while the entry of the bank into the loan market is independent of the costs of funds, it depends on the costs of screening. The lower the costs of screening are, the more willing the bank is to engage in lending activity.

As was remarked above, the bank enters the loan market when the marginal benefits surpass the marginal costs. Per-project screening costs are the costs of screening of a marginal project. When they decrease, the bank becomes more willing to enter the loan market. Obviously, an increase in π^L and/or decrease in π^H would also make entering the market more attractive.

²³ This is an intuitive way to think about it. Mathematically, this corresponds to a differential with zero screening costs

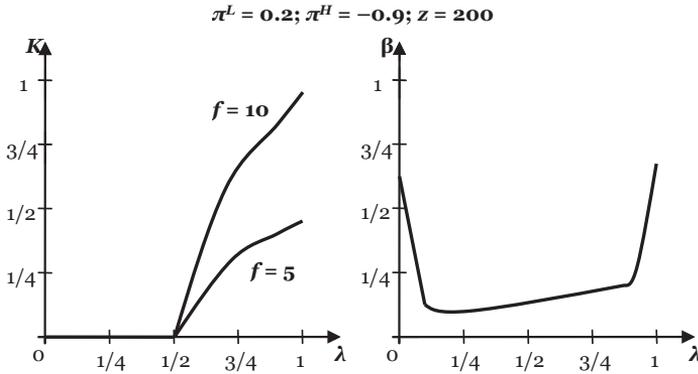


Figure 10 Bank's screening incentives under low screening costs.

And the second observation in Figure 10 is the obvious one: as the costs of screening decline, the per-project screening intensity increases significantly. If the costs of screening decline, then the bank can improve the quality of screening with the same investments or even invest less and achieve a higher quality of screening.

Our findings can be summarised as follows.

Costs of funds do not affect the bank's decision to start its lending, nor do they affect the quality of screening. However, as the costs of funds decrease, the bank has an incentive to screen – and to subsequently fund – more loan applications. Costs of screening, on the other hand, affect both the decision to enter the loan market and the quality of screening. As the costs of screening decline, the bank becomes more willing to enter the loan market and also to increase the quality of screening.

4.2 The Welfare Analysis

In this section, we perform the welfare analysis that corresponds to the analysis of the bank's problem in the previous section. In 4.2.1 we compare the bank's screening incentives with the social optimum in the model of costless deposits, and in 4.2.2 in the model of costly deposits.

4.2.1 Model of Costless Deposits

In the basic model of costless deposits, the society maximises the following social welfare function:

$$W(\beta) = \lambda\pi^L + (1 - \lambda)\beta\pi^H + (1 - \lambda)\beta p_H(R_H - R_L) - N(\beta).$$

The first term captures the bank's profits from financing low-risk projects, while the second term captures the bank's losses from granting loans to high-risk entrepreneurs. The third term gives the surplus of the high-risk entrepreneurs from obtaining funding from the bank. And the fourth term gives the costs of screening. The solution is given by the first-order condition:

$$(1 - \lambda)\pi^H + (1 - \lambda)p_H(R_H - R_L) - N'(\beta) = 0.$$

In order to compare the bank's optimal level of screening intensity, β^* , with the socially optimal level of screening intensity, $\hat{\beta}$, we insert the explicit formula for the screening function into the above first-order condition,

$$N(\beta) = \frac{1 - \beta}{z\beta}.$$

So, the first order condition takes the form,

$$(1 - \lambda)\pi^H + (1 - \lambda)p_H(R_H - R_L) + \frac{1}{z\beta^2} = 0.$$

From here we can find the socially optimal level of screening intensity,

$$\hat{\beta} = \sqrt{\frac{1}{-z([1 - \lambda][\pi^H + p_H(R_H - R_L)])}}. \quad (4.5)$$

Comparing $\hat{\beta}$ and β^* , we see that the denominator of $\hat{\beta}$ is smaller than that of β^* , meaning that $\hat{\beta}$ is larger than β^* . In words, from the society's perspective, the bank over-invests in screening. The reason behind this result is that unlike the bank, the society cares also about the welfare of the bad entrepreneurs.

4.2.2 Model of Costly Deposits

In case of costly deposits, first note that the marginal cost of granting a loan equals the deposit interest rate:

$$MC = r = \frac{S}{f}.$$

This means that the total cost can be obtained in the following way:

$$TC = \int_0^S MC(x)dx = \int_0^S \frac{x}{f} dx = \frac{S^2}{2f}.$$

The society maximises the following social welfare function:

$$W(\beta, K) = \lambda K\pi^L + (1 - \lambda)K\beta\pi^H + (1 - \lambda)K\beta p_H(R_H - R_L) - \frac{S^2}{2f} - N(\beta, K).$$

As in the bank's problem, the total deposits that the bank can attract are equal to the total amount of loans it grants, and are given by

²⁴ To see that the denominator is positive, first note that $\pi^H = p_H R_L - 1$, meaning that $\pi^H + p_H(R_H - R_L) = p_H R_H - 1 < 0$, as $p_H R_H$ was assumed to be less than one in Section 2.1.

$$S = L = K[\lambda + (1 - \lambda)\beta].$$

The solution to the optimisation problem is given by the following first-order conditions:

$$\begin{aligned} \frac{\partial W(\beta, K)}{\partial \beta} &= (1 - \lambda)K\pi^H + (1 - \lambda)Kp_H(R_H - R_L) - \frac{K^2(1 - \lambda)[\lambda + (1 - \lambda)\beta]}{f} \\ &\quad - N_\beta(\beta, K) = 0, \end{aligned}$$

$$\begin{aligned} \frac{\partial W(\beta, K)}{\partial K} &= \lambda\pi^L + (1 - \lambda)\beta\pi^H + (1 - \lambda)\beta p_H(R_H - R_L) - \frac{K[\lambda + (1 - \lambda)\beta]^2}{f} \\ &\quad - N_K(\beta, K) = 0. \end{aligned}$$

In order to compare the socially optimal and privately optimal values of the bank's decision variables, we insert the same explicit formula (Formula 4.2) of the screening function into the above first-order conditions. We get:

$$\begin{aligned} \frac{\partial W(\beta, K)}{\partial \beta} &= (1 - \lambda)K\pi^H + (1 - \lambda)Kp_H(R_H - R_L) - \frac{K^2(1 - \lambda)[\lambda + (1 - \lambda)\beta]}{f} \\ &\quad + K \frac{1}{z\beta^2} = 0, \end{aligned}$$

$$\begin{aligned} \frac{\partial W(\beta, K)}{\partial K} &= \lambda\pi^L + (1 - \lambda)\beta\pi^H + (1 - \lambda)\beta p_H(R_H - R_L) - \frac{K[\lambda + (1 - \lambda)\beta]^2}{f} \\ &\quad - \frac{1 - \beta}{z\beta} = 0. \end{aligned}$$

Solving these as a system of equations, we obtain the explicit formulas for the socially optimal values of the screening intensity, $\hat{\beta}$, and for the socially optimal number of loan applications screened, \hat{K} :

$$\hat{\beta} = \frac{(1 - \lambda) + \sqrt{(1 - \lambda)^2 + \lambda(1 - \lambda)[1 + \lambda\{(\pi^L - \pi^H) - p_H(R_H - R_L)\}z]}}{(1 - \lambda)[1 + \lambda\{(\pi^L - \pi^H) - p_H(R_H - R_L)\}z]}, \quad (4.6)$$

$$\hat{K} = \frac{f \left[(1 - \lambda)\pi^H + (1 - \lambda)p_H(R_H - R_L) + \frac{1}{z(\hat{\beta})^2} \right]}{(1 - \lambda)[\lambda + (1 - \lambda)\hat{\beta}]}. \quad (4.7)$$

(To save space, in Formula 4.7 we used $\hat{\beta}$.)

As in the bank's problem, we conducted a numerical analysis. The results of the analysis are presented in the Appendices 5 and 6. There the socially optimal values of the bank's decision variables (dotted curves) are compared with the privately optimal values of the decision variables.

The results show that the bank screens too few loan applications too intensely. The society, which also cares for the welfare of the "bad" entrepreneurs, would prefer the

bank to make less investment in screening high-risk projects out. The reason behind the bank's failure – from the society's perspective – to screen more loan applications is in the imperfect competition: a monopoly always under-produces in comparison with the social optimum. Moreover, since the bank does not care about the welfare of the depositors, it faces a higher cost of funds than the society, meaning that it under-screens and subsequently funds too few loans.

Our findings can be summarised in the following conclusion.

From a social perspective, the bank screens too few loan applications. Moreover, it over-invests in screening of each loan application.

4.3 Discussion

Many results of this chapter are close to the results of Chapter 3, while some results are different. Both in the analysis of this chapter and in Chapter 3, a lower cost of funds gives the bank incentives to finance more loans in boom times. However, while in Chapter 3 a lower cost of funds encouraged the bank to fund loans without performing any ex ante screening, in this chapter the cost of funds does not affect the quality, with which the bank screens loan applicants, but only affects the number of loan applicants screened.

In Chapter 3, lower screening costs gave the bank incentives to perform more screening and to engage less in funding loans without screening. Similarly, in this chapter lower screening costs encourage the bank to screen more loan applications and to screen each loan application more thoroughly.

The main result of this chapter is that the cost of funds has a big effect on the number of loan applications that the bank screens, while the cost of funds has no effect on the quality of screening. For a policy maker, this means that encouraging the banks to screen – and to subsequently fund – more loans requires making the supply of funds less expensive. This policy would also appear rather safe, as the banks would not have an incentive to decrease the quality of screening. However, results of Chapter 3 suggest that a lower cost of funds in boom times might encourage the bank to run a higher credit risk. The combination of the results of Chapter 3 and Chapter 4 suggests that a lower cost of funds could encourage the banks to screen more loan applicants as long as the economic outlook is not too gloomy. But the policy makers should probably be cautious in boom times and ensure that the cost of funds is not too low, as the result of Chapter 3 suggests that the bank could engage in funding loans without performing any ex ante screening in boom times – especially if the cost of funds is low.

Making the supply of funds less expensive, however, would not encourage the banks to lend in recessions when the loan pool quality is low. This would require policy measures aimed at reducing the costs of screening, such as information sharing, tax breaks, etc. This policy also appears safe as it would encourage the banks both to lend more and to screen more carefully. Similar policy implications with regards to screening costs followed also from the analysis in Chapter 3.

A more difficult policy question is how to discourage the banks from decreasing the quality of screening too much in boom times. This might require making the supply of funds more expensive, which could encourage the banks to be more selective about which loans they finance. This is also confirmed by the results of Chapter 3.

The welfare analysis in this chapter suggested that the bank screens too few loan applications too carefully. The latter result of the welfare analysis – that the bank invests too much in the quality of screening – is driven by the imperfections of the welfare analysis: the social planner cares about the welfare of high-risk entrepreneurs, while the policy makers in the real world might not care that much. But the former result of the welfare analysis – that the bank screens too few loan applications – makes perfect economic sense, as a monopoly tends to under-produce. For a policy maker it means that encouraging a more intense competition could be welfare improving, as banks competing against each other could fund more loans. We will return to this important policy issue in the next chapter.

In Chapter 3 we discussed how the central bank could affect the banks' costs of funds. However, the government's policy can also have a significant impact on the banks' cost of funds. The government can lower the banks' costs of funds in recessions through a lending subsidy. The lending subsidy could take a form of a reduction in taxes. Once the economy is on track to recovery, this subsidy could be reduced, which would increase the banks' costs of funds. In order to discourage the banks from lending too much in boom times, the government could impose an additional tax, the proceedings from which could finance the lending subsidies in recessions.

A capital income tax can also affect the banks' costs of funds. Our analysis implies that an optimal capital income tax depends on the parameters which fluctuate over the business cycle. If the capital income tax is set at a low level in recessions, it would decrease the banks' costs of funds and stimulate investment and lending. But the capital income tax could be set high in boom times in order to prevent the economy from overheating.

The government can also pursue technological changes that would permanently reduce the deposit interest rate. For example, widening the use of the Internet banking can lower the banks' costs of funds. In a Hotelling setting, the employment of the Internet banking would mean that the depositors no longer need to commute to the bank, as they can make deposits while sitting comfortably at home. Even though in Hotelling's (1929) model the distance is supposed to be interpreted as a way to model the horizontal product differentiation, there is a literature (see e.g. Petersen and Rajan 2002, Degryse and Ongena 2005) that shows that the physical distance between the bank and its customers does play a role. In the real world, Internet banking reduces the banks' costs on customer service. The Internet banking can be made more popular by the policies of the government, aimed at widening people's access to the Internet, reducing institutional barriers, investing in high-speed cable network, improving the security of Internet payments, etc.

Chapter 3 and Chapter 4 complement each other. An ideal model would have allowed the bank to optimise over all the three decision variables: how many loan applicants to screen, how well to screen each loan applicant, and how many loans to grant without screening. However, it is technically impossible to solve such a model analytically. We have done the best next thing: we split this analysis into two different models.

The main weakness of Chapters 3 and 4 is focusing on a monopoly bank and thus abstracting from the effects of competition. However, this approach allows studying bank's screening incentives much deeper. It is a modelling trade-off. Should one have one bank with two decision variables in the model or two banks with only one decision variable? Having two decision variables and two banks would be impossible to solve analytically. That is why in this chapter, as well as in Chapter 3, we have chosen to focus

exclusively on screening incentives. Main contribution of this chapter in comparison with previous literature is realistically assuming that banks have to pay a positive deposit interest rate. In Chapters 5 and 6 we will study effects of bank competition on screening.

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APPENDIX 5

In Figure 11 we see that the socially optimal levels of the bank's decision variables follow the same pattern as the privately optimal levels of the decision variables. From the society's perspective, however, the bank clearly screens too few loan applications (see pictures on the left). The social planner would have preferred the bank to become active in the lending market at a lower threshold of the loan pool quality and to screen a lot more loan applications. Furthermore, as we see from the pictures on the right, the social planner would prefer the bank to decrease the quality of screening – or, in other words, to make more mistakes. The social planner's preferences, if implemented by the bank, would have resulted in a larger share of both low- and high-risk projects obtaining financing, lower bank's profits, and much higher surplus of the “bad” entrepreneurs.

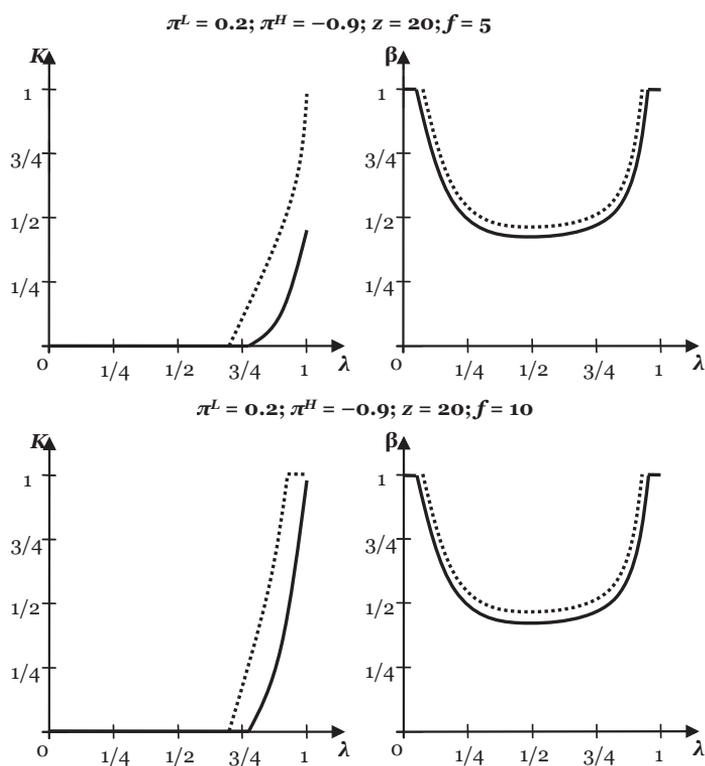


Figure 11 Bank's screening incentives (thick curves) and socially optimal screening (dotted curves) under high screening costs.

APPENDIX 6

In Figure 12, when comparing with Figure 11, we notice one interesting detail. At the peak of the business cycle – or, in other words, at highest quality of the loan pool – the social planner would prefer the bank to finance all loan applications, independently of the deposit costs, because the social planner cares about the welfare of the depositors as well. In both Figure 11 and Figure 12, the social planner allocates much greater surplus to depositors than the bank does.

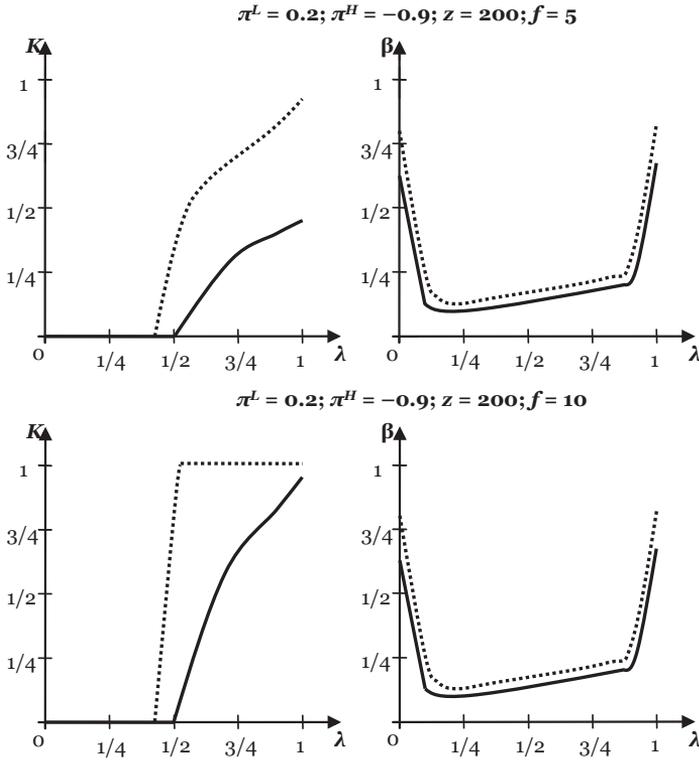


Figure 12 Bank's screening incentives (thick curves) and socially optimal screening (dotted curves) under low screening costs.

APPENDIX 7

In Figure 13 we see that an increase of the parameter z from 20 (on the left) to 200 (on the right) results in a dramatic decrease of per-project screening costs.

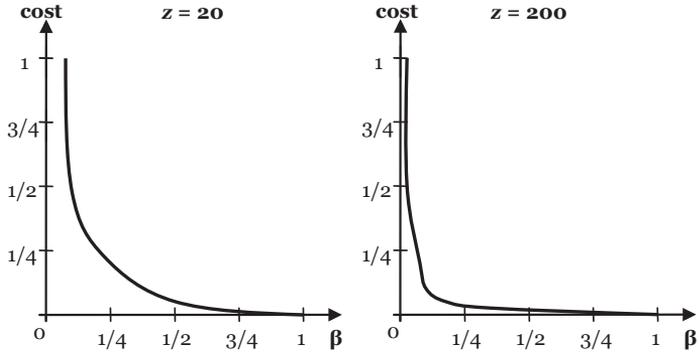


Figure 13 Bank's per-project screening costs.

APPENDIX 8

Formula 4.4 is derived in a straightforward manner from the first-order condition with respect to β . Formula 4.4 is then substituted in the first-order condition with respect to K to obtain the following equation:

$$\lambda\pi^L + (1 - \lambda)\beta\pi^H - \frac{(1 - \lambda)\pi^H + \frac{1}{z\beta^2}}{(1 - \lambda)} [\lambda + (1 - \lambda)\beta] - \frac{1 - \beta}{z\beta} = 0.$$

Using Wolfram Alpha, we solve the above equation and obtain two roots:

$$\beta_1 = \frac{(1 - \lambda) - \sqrt{(1 - \lambda)^2 + \lambda(1 - \lambda)[1 + \lambda(\pi^L - \pi^H)z]}}{(1 - \lambda)[1 + \lambda(\pi^L - \pi^H)z]},$$

$$\beta_2 = \frac{(1 - \lambda) + \sqrt{(1 - \lambda)^2 + \lambda(1 - \lambda)[1 + \lambda(\pi^L - \pi^H)z]}}{(1 - \lambda)[1 + \lambda(\pi^L - \pi^H)z]}.$$

The second root, β_2 , is our Formula 4.3. β_1 , on the other hand, is negative. Therefore the conclusion that we can make is that the only reasonable solution to the system of equations is our Formulas 4.3 and 4.4.

5 COMPETITION, SCREENING, AND LENDING VOLUMES OVER THE BUSINESS CYCLE

How does bank competition affect screening and lending volumes over the business cycle? Banks tend to supply a lot of credit during booms but are generally very stingy during recessions. Such bank behaviour could aggravate the business cycles. Moreover, it could lead to prolonged recessions and to asset bubbles in expansions. Bursting of an asset bubble, on the other hand, could lead to a new recession. However, such screening and lending behaviour might be in the banks' short-term interest, even though it is not in the interest of the consumers or the policy makers. That is why there is a need to understand why the banks behave the way they do.

Typically, the changes in the banks' behaviour over the course of a business cycle have been attributed to the effects of banking competition. Previous bank screening literature has focused on banks competing with each other over lending interest rates (see e.g. Broecker 1990, Riordan 1993), over screening standards (see e.g. Gehrig and Stenbacka 2013) or over both lending interest rates and screening standards (see e.g. Ruckes 2004, Hauswald and Marquez 2005). Unlike in the previous literature, in this chapter, the banks are competing for customers over screening and lending volumes. This is of foremost interest to policy makers, who would like the banks to lend more during recessions. Moreover, unlike in much of the previous bank screening literature, in our analysis the banks face costly funds.

Competition authorities often need to approve major mergers and acquisitions. The approval depends on whether a proposed merger would reduce the competition and hurt the consumers as a consequence. However, as already pointed out by Broecker (1990) and Riordan (1993), more intense competition in banking does not necessarily lead to a better market performance and can, as a matter of fact, hurt the consumers. This chapter contributes to the discussion in the literature by pointing out that more intense competition leads to greater volumes of lending, which, we argue, could improve the society's welfare.

In our model, we focus on two banks. Each of the banks decides how many loan applications to screen. Screening is costly, but it perfectly reveals whether a given loan application is of high or low quality. Unlike in Chapters 3 and 4 we explicitly model banking competition by assuming that there are two competing banks in the industry, while in the previous chapters we assumed that there was only one bank. The technical downside of modelling competition between the banks is that the two banks can optimise only over one decision variable: the number of loan applicants to screen. In Chapters 3 and 4 a monopoly bank had two decisions to make. In addition to deciding how many loan applicants to screen, in Chapter 3 the bank also decided how many loans to fund without screening, while in Chapter 4, the bank also decided how carefully to screen each loan applicant. But analysis in this chapter allows us to see the effects of competition in the number of projects screened – and given that a project that is screened and deemed creditworthy is funded, the analysis also allows us to study the effect of competition on lending volumes.

Our findings suggest that a more intense banking competition leads to more loan applications being screened, and subsequently leads to more lending. Even though each of the banks in a duopoly banking industry individually screens fewer loan applications than a monopoly bank, two duopoly banks together screen significantly more than a monopoly bank. Thus, we show that banking competition stimulates lending.

Further, we find that a lower cost of funds and a lower screening cost also stimulate more screening of loan applications and more lending. In deep recessions, independently of the costs of funds and of the screening costs, the banks either screen very few loan applications or are not at all active in the market. There are too many bad projects and too few good ones, making lending activity unattractive. Once the economy picks up, both screening costs and costs of funds start to play a role. If both costs are high, screening – and subsequently lending – remains at a very low level. If either the cost of funds or screening costs decline, the banks start to screen more loan applications, as the economic outlook improves. But the effect of the deposit rate is significantly stronger than that of the screening costs. A small decline in the costs of raising funds results in a big increase in a screening activity. If the cost of funds is sufficiently low, then in boom times both banks screen almost all loan applicants.

Our welfare analysis produces our most interesting result, which, to the best of our knowledge, has not been documented in the previous literature. From the social welfare perspective, whether the banks under- or over-screen depend on the costs of funds. If the costs are high, the banks under-screen relative to the social optimum, while if the costs are low, the banks over-screen. This result is interesting because the previous literature has either pointed out over-screening (see e.g. Hauswald and Marquez 2005) or under-screening (see e.g. Kanniainen and Stenbacka 1998). Moreover, this result has important policy implications, which are discussed in detail in Section 5.3.

Previous bank screening literature mostly focused on the effects of lending market competition on screening outcomes. Hauswald and Marquez (2005) argue that in equilibrium each loan applicant is screened by at most one bank. This result contrasts sharply with our model, where each loan application might be screened by both banks.

Petriconi (2012) argues that increased competition between lenders leads to increasingly pronounced credit cycles. Low interest rates and high collateral liquidation costs result in an inefficient credit expansion with declining average quality of new loans. This leads to a bust, which in turn is followed by excessive credit rationing.

Gehrig and Stenbacka (2011) focus on the analysis of perfect competition in banking. Studying a model of decentralised costly screening, Gehrig and Stenbacka establish conditions under which the banking industry produces excessive screening, duplication of screening or screening cycles.

The rest of the chapter is organised as follows. Next section presents the main results. Section 5.2 is dedicated to the welfare analysis. Section 5.3 concludes.

5.1 The Bank's Problem

This section is organised as follows. In 5.1.1 we present a benchmark monopoly case, while in 5.1.2 we present a corresponding duopoly case. In 5.1.3 and 5.1.4 we modify the screening costs function and explore how this affects the results.

5.1.1 Simple Monopoly Case

In a simple case of a monopoly bank, the profit function takes the following form:

$$\pi(K) = K\lambda\pi^L - rL - K^2z.$$

The first term captures the bank's revenue from financing low-risk projects. The second term gives the interest payments to the depositors and the last term captures the cost of screening. According to our assumptions, total amount of deposits that the bank raises is given by the following expression:

$$S = fr.$$

The total amount of loans that the bank grants, on the other hand, is given by

$$L = K\lambda.$$

Obviously, the total amount of deposits that the bank raises equals the total amount of loans that the bank grants:

$$S = L.$$

So, the second term in the bank's profit function takes the following form:

$$rL = \frac{(K\lambda)^2}{f}.$$

Differentiating the profit function with respect to the bank's decision variable, we obtain the following first-order condition:

$$\frac{\partial\pi(K)}{\partial K} = \lambda\pi^L - \frac{2K\lambda^2}{f} - 2Kz = 0.$$

From the above expression, we can easily obtain the formula for the optimal number – or, given our normalisations, probability or fraction – of loan applications that the bank chooses to screen, expressed through the exogenous parameters:

$$K^* = \frac{f\lambda\pi^L}{2(fz + \lambda^2)}. \quad (5.1)$$

In order to investigate how changes in the parameter values affect the bank's decision to screen loan applications, we proceed to the comparative statics analysis. First, let us take a look at how a change in the economic outlook affects the bank's screening decision:

$$\frac{dK}{d\lambda} = \frac{f\pi^L(fz - \lambda^2)}{2(fz + \lambda^2)^2}.$$

The above expression is positive when $fz > \lambda^2$, is negative when $fz < \lambda^2$ and equals zero when $fz = \lambda^2$. This means that whether an improvement in the economic outlook results in more or less screening depends on the combination of f and z , which are the parameters that reflect the costs of funds and the screening costs respectively. This is intuitive, as the former parameter affects the costs of making loans, while the latter affects the costs of screening itself.

Here, it should be noted that most of the previous literature, which assumed the deposit interest rate to be zero, implicitly assumed that the elasticity of supply of deposits, f , tends to infinity, which is just a special case of the analysis in this chapter. Let us take a limit of the above expression and see whether it is positive or negative. As the above limit is of ∞/∞ type, we apply l'Hôpital's rule twice to obtain the result.

$$\lim_{f \rightarrow \infty} \frac{f\pi^L(fz - \lambda^2)}{2(fz + \lambda^2)^2} = \frac{\pi^L}{2z} > 0.$$

The above result tells us that assuming away the deposit market could lead the researchers to believe that a better economic outlook necessarily results in more loan applications being screened. However, our results show that with a positive deposit interest rate, this result does not necessarily hold and an improvement in the economic outlook could result either in more or less loan applications being screened.

Now let us see what happens if the costs of funds are extremely high, i.e. that the parameter f tends to zero. In this special case, $dK/d\lambda$ is also zero, meaning that when the funds are extremely expensive, the economic outlook does not affect the number of loan applications that the bank screens. Moreover, we can also establish that the bank does not screen at all, as K^* also equals zero in this special case.

What if screening costs are extremely low or prohibitively high? If the parameter z tends to zero, $dK/d\lambda$ is clearly negative, while if the parameter z tends to infinity, $dK/d\lambda$ is zero and K^* is also zero. These results are intuitive. When the costs of screening are extremely low, the screening activities are most profitable in deepest recessions, as screening generates the highest return on the investment in screening, because screening is aimed at detecting high-risk loan applications which are abundant in recessions. When the costs of screening are prohibitively high, clearly the bank does not find it profitable to enter the loan market.

Next, let us take a look at the effect of the cost of funds on screening:

$$\frac{dK}{df} = \frac{\lambda^3\pi^L}{2(fz + \lambda^2)^2} > 0.$$

An increase in the parameter f makes the supply of deposits more elastic, reducing the bank's costs. It is natural that a lower cost of funds results in more screening. And last, the effect of a change in the screening costs on screening:

$$\frac{dK}{dz} = -\frac{f^2\lambda\pi^L}{2(fz + \lambda^2)^2} < 0.$$

A reduction in the parameter z makes screening less expensive. As screening becomes less and less expensive, the bank screens more and more loan applications.

The above analytical results could be summarised in the following proposition:

Proposition 5.1

A lower cost of funds and lower screening costs give the bank incentives to increase the number of loan applications screened. An improvement in the economic outlook,

on the other hand, might lead either to more or fewer loan applications being screened, depending on the parameter values.

A clear policy implication of Proposition 5.1 is that encouraging the bank to screen – and to subsequently lend – more loan applications requires measures aimed at reducing the costs of funds and the screening costs. Costs of funds can be reduced by the central bank’s monetary policy, for example, through quantitative easing or through setting a lower interest rate for discount loans. Screening costs could be reduced through improving the banks’ access to information about the potential borrowers, through tax breaks, etc. Policy implications are discussed in greater detail in Section 5.3.

For numerical illustrations of the points discussed in this subsection, see Figures 14 and 15 in the next subsection.

5.1.2 Duopoly Case

Next, we turn our attention to a duopolistic banking industry. Given that both banks randomly and independently choose which loan applications to screen, there are four groups of loan applications. First, loan applications that have been screened – and, given that screening is perfect – classified as low-risk by both banks. Second, loan applications that have been screened only by the bank *A*, but not by the bank *B*. Third, loan applications that have been screened only by the bank *B*, but not by the bank *A*. And fourth, loan applications that have not been screened by either bank. Banks fund only the projects that they have screened and classified as low-risk.

In this chapter we make an assumption that the banks have no possibility to fund loans without performing screening. This analysis was done in Chapter 3 with only one bank in the banking industry. Unfortunately, solving a problem of two banks that optimise over two decision variables is beyond our abilities.

So, the bank *A*’s profit function in this industry is given by²⁵

$$\pi_A(K_A, K_B) = K_A K_B \frac{\lambda}{2} \pi^L + K_A (1 - K_B) \lambda \pi^L - r L_A - K_A^2 z.$$

The first term captures the bank *A*’s profit from financing loan applications from the first group, in which it competes with the bank *B* and therefore gets to finance only half of that group. The second term is the bank *A*’s profit from financing loan applications from the second group, where the bank does not compete with the other bank. Third and fourth terms capture the deposit costs and the screening costs respectively.

The amount of loans that the banks grant is given by the following expressions:

$$L_A = K_A K_B \frac{\lambda}{2} + K_A (1 - K_B) \lambda,$$

$$L_B = K_A K_B \frac{\lambda}{2} + K_B (1 - K_A) \lambda.$$

In order to finance loans, the banks raise the funds in the deposit market:

²⁵ For bank *B*, refer to Appendix 10

$$L_A + L_B = fr.$$

The solution to the optimisation problem of the bank A is given by the following first-order condition:

$$\frac{\partial \pi_A(K_A, K_B)}{\partial K_A} = K_B \frac{\lambda}{2} \pi^L + (1 - K_B) \lambda \pi^L - \frac{2L_A \frac{\partial L_A}{\partial K_A} + \frac{\partial L_A}{\partial K_A} L_B + L_A \frac{\partial L_B}{\partial K_A}}{f} - 2K_A z = 0.^{26}$$

Given that there is no reason to assume that the banks are different in any way, we are looking for a symmetric equilibrium, in which $K_A = K_B$. After much algebra we get the following third-order polynomial (for details, see Appendix 9):

$$2\lambda^2 K^3 - 7\lambda^2 K^2 + (f\lambda\pi^L + 6\lambda^2 + 4fz)K - 2f\lambda\pi^L = 0.$$

The optimal number of loan applications that either bank screens is given by,

$$K^* = \frac{7}{6} - \frac{x_2}{3(2^{2/3})\lambda^2 x_1} + \frac{x_1}{6(2^{1/3})\lambda^2}.^{27} \quad (5.2)$$

Formula 5.2 is the unique solution to the third-order polynomial above. The other two roots are complex numbers that do not make economic sense.

The above expression was obtained with the help of Wolfram Alpha²⁸. The expression is extremely complex and can only be analysed numerically. Unlike in the previous subsection, the complexity of Formula 5.2 does not allow us to analyse any meaningful special cases.

We are interested how various exogenous parameters affect the banks' screening incentives. For example, we are interested in how the banks' screening incentives change when the costs of funds are high or low (reflected in the parameter f) or when the screening costs are high or low (reflected in the parameter z). Furthermore, we want to see how changes in these parameters affect the screening incentives depending on the quality of the loan pool (reflected in λ). As in Chapters 3 and 4, we fix π^L at 0.2. π^H does not affect the results, as screening is assumed to be perfect.

Analysing Figure 14, we see that independently of the banks' costs of funds, a monopoly bank screens more than an individual duopoly bank. However, as there are two banks in the duopolistic banking industry, it is obvious that the two banks in the duopoly

²⁶ $\frac{\partial L_A}{\partial K_A} = \lambda - \frac{K_B}{2} \lambda,$

$\frac{\partial L_B}{\partial K_A} = -\frac{K_B}{2} \lambda.$

²⁷

$x_1 = \left(x_3 + \sqrt{4(x_2)^3 + (x_3)^2} \right)^{1/3}$

$x_2 = -13\lambda^4 + 6f\lambda^3\pi^L + 24f\lambda^2 z,$

$x_3 = -70\lambda^6 + 90f\lambda^5\pi^L - 504f\lambda^4 z.$

²⁸ <http://www.wolframalpha.com/>

together screen clearly more than a monopoly bank. This is clearly an effect of competition.

Further, we see that screening incentives are about the same independently of the costs of funds in deep recessions (until $\lambda \approx 1/4$). This is not a very interesting result as it is explained by our choice of the screening costs: with quadratic screening costs, screening is very inexpensive in the beginning, but becomes more and more expensive as the bank screens more and more loan applications.

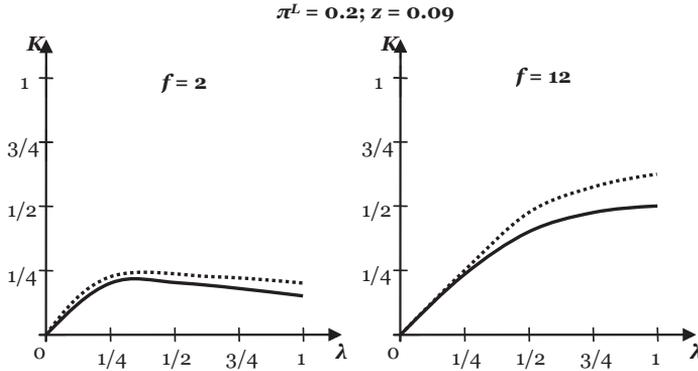


Figure 14 Monopoly (dashed line) and an individual duopoly bank's screening incentives under high screening costs.

However, as the quality of the loan pool improves beyond $\lambda \approx 1/4$, we see that the screening incentives very much depend on the banks' costs of funds. When the costs of funds are high ($f = 2$, picture on the left), screening incentives are low and do not change much with a further improvement in the economic outlook. In fact, they slightly decline, as the loan pool quality improves, which is an illustration of a comparative static result of the previous subsection, in which we found that an improvement in the economic outlook could result either in more or less screening. But when the costs of funds are low ($f = 12$, picture on the right), the banks screen significantly more and the screening incentives are upward-sloping: as the economic outlook improves, the banks screen more and more loan applications. The mechanism of an effect of the banks' costs of funds on the number of loan applications that the banks screen is intuitive. Screening costs are increasing in the number of loan applications screened, so the expected profit from screening is low when the costs of funds are high, while the expected profit from screening is high when the costs of funds are low.

As the screening costs decline from Figure 14 to Figure 15, banks' screening incentives change. The main difference is that the maximum number of loan applications screened in Figure 15 is significantly higher than in Figure 14. But otherwise, the similar patterns from Figure 14 can be observed also in Figure 15. As in Figure 14, the monopoly bank almost always screens more than a duopoly bank. Also screening incentives coincide in deep recessions, but under low costs of funds, they are upward-sloping as the economic outlook improves, while under high costs of funds, they are after a certain point downward-sloping as the loan pool quality improves.

However, on at least two counts Figure 15 appears unrealistic. First, it seems totally unrealistic that a monopoly bank would screen fewer loan applications in boom times

(picture on the right) while screening all loan applications in the interval from $\lambda \approx 1/2$ to $\lambda \approx 7/8$. Second, also the picture on the left seems unrealistic. The maximum number of loan applications that the banks screen is attained at $\lambda \approx 1/4$ and as the economic outlook improves, this number sharply declines. However, these results are in line with the comparative static result of the previous section, which predicted that an improvement in the economic outlook could result in fewer loan applications being screened. Also note the waste of screening effort by the duopoly in picture on the right, though this might be due to competition rather than shortcomings in the model. At $\lambda \approx 1$, both banks screen everyone, but fund only half.

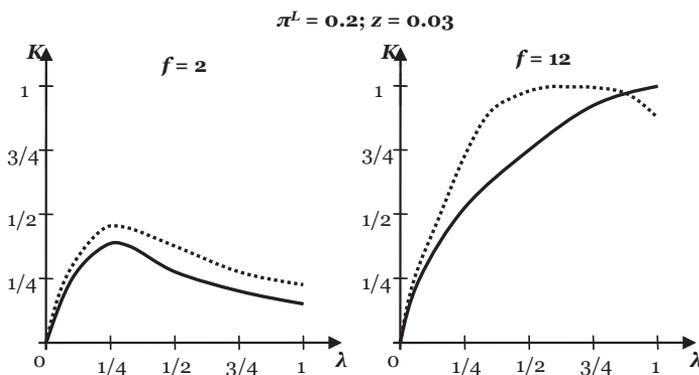


Figure 15 Monopoly (dashed line) and an individual duopoly bank's screening incentives under low screening costs.

Given the abovementioned shortcomings, we modify the form of the screening costs.

5.1.3 Monopoly Case Extension

In this section we modify the screening costs function and assume that the screening costs depend on the loan pool quality, λ . This modification mathematically compensates for extremely low screening costs in deep recessions. So, the profit function is given by

$$\pi(K) = K\lambda\pi^L - rL - K^2\frac{z}{\lambda}.$$

The only difference with Section 5.1.1 is in the last term, which is now divided by λ , mathematically compensating for extremely low screening costs in deep recessions when screening and lending volumes are low.

The economic motivation for this modification is a possibility of obfuscation. A bad project that appears to be a good project could be more expensive to screen than just a good project. Hence screening could be more expensive when the loan pool quality is bad than when it is good. Consider also the problem of plagiarism, the example of which we discussed in Section 3.1.3 in Chapter 3. To remind, the former German Defence Minister Carl-Theodor zu Guttenberg in 2007 was awarded a doctoral title in law. Moreover, his dissertation received the university's highest honour. In 2011, however, it was discovered that the dissertation included numerous copied passages without citation. The doctoral title was subsequently revoked by the university and the

minister had to resign from the government.²⁹ If it is possible to obtain a doctoral degree with honours by a Copy & Paste method, it is certainly possible to make a convincing loan application using the same method.

The solution to the optimisation problem is given by the following first-order condition:

$$\frac{\partial \pi(K)}{\partial K} = \lambda \pi^L - \frac{2K\lambda^2}{f} - 2K \frac{z}{\lambda} = 0.$$

So, the optimal number of loan applications that the bank screens is given by

$$K^* = \frac{f\lambda^2\pi^L}{2\lambda^3 + 2fz}. \quad (5.3)$$

As in Section 5.1.1, we perform a comparative statics analysis. First, the effect of the economic outlook on screening:

$$\frac{dK}{d\lambda} = \frac{f\lambda\pi^L(2fz - \lambda^3)}{2(fz + \lambda^3)^2}.$$

This expression is positive when $2fz > \lambda^3$, is negative when $2fz < \lambda^3$ and equals zero when $2fz = \lambda^3$. Just as in Section 5.1.1, whether a better economic outlook means more or less screening depends on a combination of the costs of funds and the screening costs. As in Section 5.1.1 we can take a limit of the above expression with f tending to infinity to show the limitations of assuming the deposit interest rate to be zero. Application of l'Hôpital's rule twice gives:

$$\lim_{f \rightarrow \infty} \frac{f\lambda\pi^L(2fz - \lambda^3)}{2(fz + \lambda^3)^2} = \frac{\lambda\pi^L}{z} > 0.$$

As in Section 5.1.1, assuming away the deposit market leads to a conclusion that an improvement in the economic outlook necessarily leads to more loan applications being screened. But taking into account the fact that the cost of funds is positive in the real world demonstrates that the relationship between the economic outlook and the number of loan applications being screened might go either way.

The effects of costs of funds and screening costs on the number of loan applications that the bank chooses to screen hold as in Section 5.1.1:

$$\frac{dK}{df} = \frac{\lambda^5\pi^L}{2(fz + \lambda^3)^2} > 0,$$

$$\frac{dK}{dz} = -\frac{f^2\lambda^2\pi^L}{2(fz + \lambda^3)^2} < 0.$$

As in Section 5.1.1, a lower cost of funds and a lower cost of screening encourage the bank to screen – and to subsequently lend – more. Overall, the analytical results of this section follow Proposition 5.1. For numerical illustrations see Figure 16.

²⁹ http://en.wikipedia.org/wiki/Causa_Guttenberg

5.1.4 Duopoly Case Extension

In case of a duopoly, the bank A 's profit function is given by the following expression:

$$\pi_A(K_A, K_B) = K_A K_B \frac{\lambda}{2} \pi^L + K_A (1 - K_B) \lambda \pi^L - r L_A - \frac{K_A^2 z}{\lambda}.$$

Again, the difference with Section 5.1.2 is in the last term, which gives the costs of screening. In comparison with Section 5.1.2 this term is divided by λ , the loan pool quality, in order to mathematically compensate for the low screening costs in recessions and in order to produce more realistic results.

The solution to the bank's profit maximisation problem is given by the following first-order condition:

$$\frac{\partial \pi_A(K_A, K_B)}{\partial K_A} = K_B \frac{\lambda}{2} \pi^L + (1 - K_B) \lambda \pi^L - \frac{2L_A \frac{\partial L_A}{\partial K_A} + \frac{\partial L_A}{\partial K_A} L_B + L_A \frac{\partial L_B}{\partial K_A}}{f} - 2K_A \frac{z}{\lambda} = 0^{30}.$$

Assuming symmetry, we obtain a third-order polynomial similar to the one in Section 5.1.2:

$$2\lambda^2 K^3 - 7\lambda^2 K^2 + \left(f \lambda \pi^L + 6\lambda^2 + \frac{4fz}{\lambda} \right) K - 2f \lambda \pi^L = 0.$$

The optimal number of loan applications that the bank screens is given by

$$K^* = \frac{7}{6} - \frac{x_2}{3(2^{2/3})\lambda^3 x_1} + \frac{x_1}{6(2^{1/3})\lambda^3}^{31}. \quad (5.4)$$

An illustration of the results of the numerical analysis is presented in Figure 16. As in Section 5.1.2, there is no possibility to present and discuss any meaningful special cases, as Formula 5.4 is far too complex.

³⁰

$$\frac{\partial L_A}{\partial K_A} = \lambda - \frac{K_B}{2} \lambda,$$

$$\frac{\partial L_B}{\partial K_A} = -\frac{K_B}{2} \lambda.$$

³¹

$$x_1 = \left(x_3 + \sqrt{4(x_2)^3 + (x_3)^2} \right)^{1/3}$$

$$x_2 = -13\lambda^6 + 6f\lambda^5\pi^L + 24f\lambda^3z,$$

$$x_3 = -70\lambda^9 + 90f\lambda^8\pi^L - 504f\lambda^6z.$$

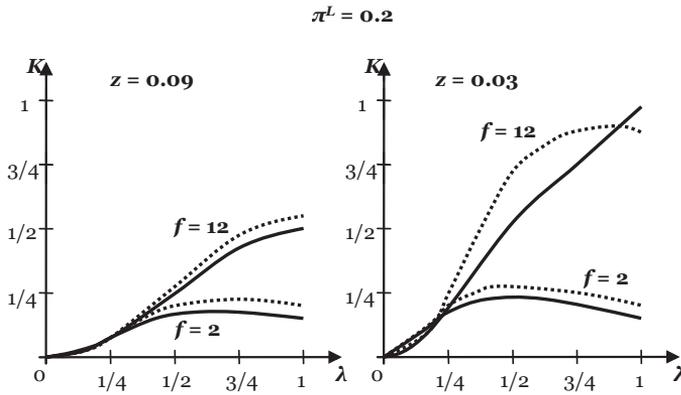


Figure 16 Monopoly (dashed line) and an individual duopoly bank's screening incentives: high screening costs (on the left) and low screening costs (on the right).

Figure 16 is clearly more realistic than the corresponding analysis in Figures 14 and 15. It seems a lot more plausible that the banks would not rush to screen loan applicants in recessions but instead behave very carefully and start active screening as the economic outlook is firmly positive. Otherwise, Figures 14 and 16 are almost the same. A monopoly bank also screens more than an individual duopoly bank. And screening incentives are the same independently of the costs of funds in deep recessions, but are upward-sloping when the costs of funds are low and are somewhat downward-sloping when the costs of funds are high. Mathematically, division by λ of the screening function compensates for the quadratic screening costs in the lower range of λ (in recessions).

The picture on the right in Figure 16 is clearly an improvement on Figure 15. The downward slope in the right-hand picture in Figure 15 is much less pronounced in this section and the maximum is attained at a lot higher value of λ .

We can summarise our findings in the following conclusion:

Each of the banks in a duopolistic banking industry screens fewer loan applications than a monopoly bank. However, two banks in a duopolistic banking industry together screen more than a monopoly bank. Both costs of funds and screening costs have a strong effect on the screening incentives.

So far, our analysis is in line with the previous contributions (see e.g. Broecker 1990, Riordan 1993): a more intense bank competition leads to more loans being funded. Previous contributions, however, argued that the lending volumes increase at the cost of higher credit losses. The next section is dedicated to our welfare analysis. There we are going to explore whether a more intense competition is welfare-improving or not.

5.2 The Welfare Analysis

In this section, we perform the welfare analysis that corresponds to the analysis of the bank's problem in the previous section. In 5.2.1 we compare a monopoly bank's screening incentives with the social optimum, while in 5.2.2 we conduct the welfare analysis of a duopoly. In 5.2.3 and 5.2.4 we consider the extended models.

5.2.1 Simple Monopoly Case

Let us start our welfare analysis by first noting that the marginal cost of granting a loan equals the deposit interest rate:

$$MC = r = \frac{S}{f}.$$

This means that the total cost of funds can be obtained in the following way:

$$TC = \int_0^S MC(x)dx = \int_0^S \frac{x}{f} dx = \frac{S^2}{2f}.$$

The society maximises the following social welfare function:

$$W(K) = K\lambda\pi^L - \frac{S^2}{2f} - K^2z.$$

This social welfare function takes into account the welfare both of the bank and of the depositors. The first term is the bank's revenues from financing loans. The second and third terms give the costs of funds and the costs of screening respectively. The solution is given by the following first-order condition:

$$\frac{\partial W(K)}{\partial K} = \lambda\pi^L - \frac{K\lambda^2}{f} - 2Kz = 0.$$

From the above first-order condition we can obtain the socially optimal number – or fraction – of loan applications that the bank should screen:

$$\widehat{K} = \frac{f\lambda\pi^L}{\lambda^2 + 2fz}. \quad (5.5)$$

Comparing the socially optimal fraction of loan applications that the bank should screen \widehat{K} and the banks' privately optimal fraction K^* (Formula 5.1), we see that the two expressions have the same numerator, but somewhat different denominators. The denominator of K^* is larger than or equal to the denominator of \widehat{K} , meaning that K^* is smaller than or equal to \widehat{K} . This leads us to the following conclusion: from the social welfare perspective, the bank screens too few loan applications.

Proposition 5.2

The monopoly bank screens too few loan applications in comparison with the social optimum.

The result in Proposition 5.2 is a standard monopoly under-production result. It is a market failure that arises as a result of imperfect competition. The bank, which cares only about maximising its own profit, chooses the number of loan applications to screen that simply generates the highest profit. Moreover, the bank cares neither about the welfare of the bad entrepreneurs nor about the welfare of the depositors. As it does not take into account the depositors' welfare, the bank faces a higher cost of funds than the society. This makes the bank screen and subsequently fund too few loans.

Combined with the conclusions of the previous subsection, in which it was argued that an increased competition between the banks leads to greater screening and lending volumes, we can see that an increased competition could be welfare improving. This could mean that even though a more intense competition could result in higher credit losses, as was argued by Broecker (1990) and by Riordan (1993), a more intense bank competition could still be welfare improving. The sections dedicated to the welfare analysis of a duopoly will shed more light on the issue.

5.2.2 Duopoly Case

In case of a duopoly, the social welfare function takes the following form:

$$\begin{aligned} W(K_A, K_B) &= K_A K_B \lambda \pi^L + (K_A(1 - K_B) + K_B(1 - K_A)) \lambda \pi^L - \int_0^{S_A + S_B} MC(x) dx - K_A^2 z - K_B^2 z \\ &= (K_A + K_B - K_A K_B) \lambda \pi^L - \frac{\lambda^2 (K_A + K_B - K_A K_B)^2}{2f} - K_A^2 z - K_B^2 z. \end{aligned}$$

The social welfare function takes into account the revenues generated by both bank A and by bank B from funding loan applications, as well as the costs of deposits and the costs of screening. The solution is given by the first-order condition with respect to K_A :

$$(1 - K_B) \lambda \pi^L - (1 - K_B) \frac{\lambda^2 (K_A + K_B - K_A K_B)}{f} - 2K_A z = 0.$$

After imposing symmetry, in which $K_A = K_B$, the above expression becomes:

$$(1 - K) \lambda \pi^L - (1 - K) \frac{\lambda^2 (2K - K^2)}{f} - 2Kz = 0.$$

After rearranging and doing some algebra, we obtain the following third-order polynomial:

$$K^3 \lambda^2 - K^2 3\lambda^2 + K(f\lambda\pi^L + 2\lambda^2 + 2zf) - f\lambda\pi^L = 0.$$

This allows us to solve for the socially optimal screening:

$$\hat{K} = 1 - \frac{\sqrt[3]{2x_1}}{3\lambda^2 x_3} + \frac{x_3}{3\lambda^2 \sqrt[3]{2}}. \quad (5.6)$$

As in the bank's problem, the above expression, obtained with the help of Wolfram Alpha, is extremely complex. Therefore we perform a numerical analysis, using the same parameter values as in the bank's problem. The results of the numerical analysis are presented in Figures 17 and 18.

³² $S_A + S_B = K_A K_B \lambda + (K_A(1 - K_B) + K_B(1 - K_A)) \lambda = K_A \lambda + K_B \lambda - K_A K_B \lambda$

³³ $x_1 = 3f\lambda^3\pi^L + 6f\lambda^2z - 3\lambda^4$,

$x_2 = \sqrt{2916f^2\lambda^8z^2 + 4x_1^3}$,

$x_3 = \sqrt[3]{x_2 - 54f\lambda^4z}$.

In Figure 17 we see a very curious phenomenon: whether the banks under- or over-screen depend on the banks' costs of funds. When the costs of funds are high, the duopoly bank under-screens, while when the costs of funds are low, the bank over-screens. Given that in the real world, the central banks have an influence over the banks' costs of funds through monetary policy it means that the central banks could affect the cost of funds, thereby affecting the banks' screening incentives.

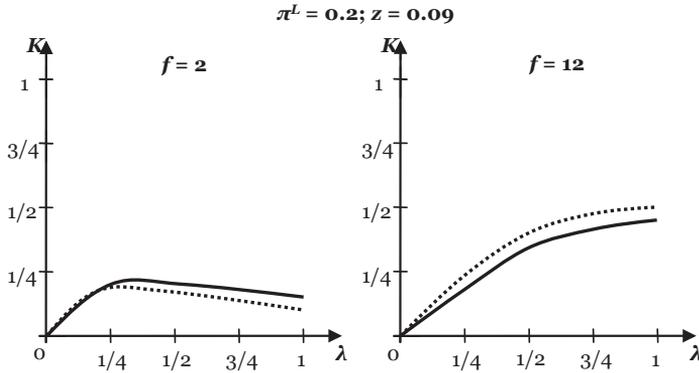


Figure 17 Bank's privately optimal (dashed line) and socially optimal screening incentives under high screening costs.

In Figure 18 we observe the same interesting phenomenon as in Figure 17: the banks' costs of funds have an influence on whether the banks over- or under-screen. We can also note that this difference is even more pronounced under low screening costs than under high screening costs.

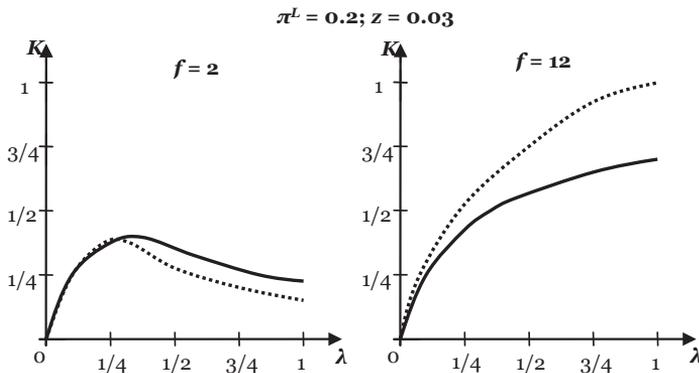


Figure 18 Bank's privately optimal (dashed line) and socially optimal screening incentives under low screening costs.

The explanation for this curious phenomenon is in waste of the screening effort by the banks on one hand, and in the asymmetric information problem, on the other hand. As the number of banks in the banking industry increases and the funds become less expensive, more screening is performed and therefore more screening effort is wasted, leading to too many loan applications being screened. But as the funds become more expensive, the banks become more cautious, as a potential loss increases. Since the

entrepreneurs cannot signal their types, the asymmetric information problem, coupled with a high cost of funds, leads to a market failure in which too few loan applications are screened and funded.

5.2.3 Monopoly Case Extension

Similarly to Section 5.2.1, the social welfare function takes the following form:

$$W(K) = K\lambda\pi^L - \frac{S^2}{2f} - \frac{K^2Z}{\lambda}.$$

The difference with Section 5.2.1 is in the last term, which accounts for the fact that the screening costs could be affected by the loan pool quality. The first-order condition is given by:

$$\frac{\partial W(K)}{\partial K} = \lambda\pi^L - \frac{K\lambda^2}{f} - \frac{2KZ}{\lambda} = 0.$$

And the socially optimal level of screening is given by

$$\hat{K} = \frac{f\lambda^2\pi^L}{\lambda^3 + 2fZ}. \quad (5.7)$$

As in Section 5.2.1, comparing the socially optimal \hat{K} and the privately optimal K^* (Formula 5.3), we see that the two expressions have the same numerator, but slightly different denominators. The denominator of K^* is larger than or equal to the denominator of \hat{K} , meaning that K^* is smaller than or equal to \hat{K} . This leads us to the same conclusion as in Section 5.2.1: from the social welfare perspective, the bank screens too few loan applications.

5.2.4 Duopoly Case Extension

In case of a duopolistic banking industry, the society maximises the following social welfare function:

$$W(K_A, K_B) = (K_A + K_B - K_A K_B)\lambda\pi^L - \frac{\lambda^2(K_A + K_B - K_A K_B)^2}{2f} - \frac{K_A^2 Z}{\lambda} - \frac{K_B^2 Z}{\lambda}.$$

The first-order condition with respect to K_A is given by

$$(1 - K_B)\lambda\pi^L - (1 - K_B)\frac{\lambda^2(K_A + K_B - K_A K_B)}{f} - 2\frac{K_A Z}{\lambda} = 0.$$

After imposing symmetry, in which $K_A = K_B$, the above expression becomes:

$$(1 - K)\lambda\pi^L - (1 - K)\frac{\lambda^2(2K - K^2)}{f} - 2\frac{KZ}{\lambda} = 0.$$

After rearranging and doing some algebra, we obtain the following third-order polynomial:

$$K^3\lambda^2 - K^23\lambda^2 + K\left(f\lambda\pi^L + 2\lambda^2 + 2\frac{zf}{\lambda}\right) - f\lambda\pi^L = 0.$$

The socially optimal number of loan applications that the bank screens is given by

$$\hat{K} = 1 - \frac{\sqrt[3]{2}x_1}{3\lambda^3x_3} + \frac{x_3}{3\lambda^3\sqrt[3]{2}}. \quad (5.8)$$

Similarly to Section 5.2.2, we perform a numerical analysis, the results of which are presented in Figures 19 and 20. In Figure 19, we see the same curious result as in Figure 17: whether the banks over- or under-screen depend on the costs of funds. When the costs of funds are high, the banks seem to screen too few loan applications in comparison with the social optimum. But when the costs of funds are low (see the picture on the right) the banks seem to screen too many loan applications in comparison with the social optimum.

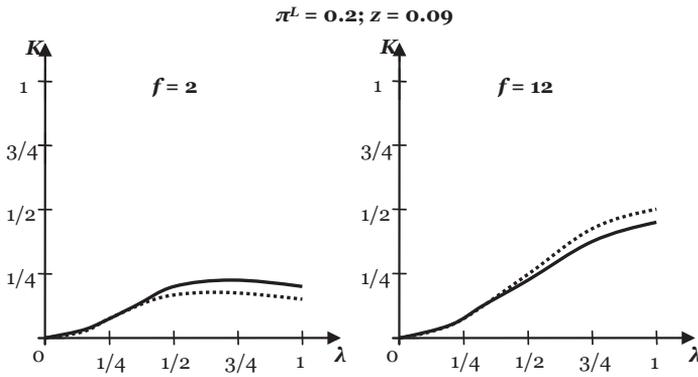


Figure 19 Bank's privately optimal (dashed line) and socially optimal screening incentives under high screening costs.

And also in Figure 20, the dependence of the social optimum on the banks' costs of funds is clearly seen. As in Section 5.1.4, under low screening costs, the interdependence between the costs of funds and the socially optimal screening incentives is even more pronounced.

$${}^{34} x_1 = 3f\lambda^5\pi^L + 6f\lambda^3z - 3\lambda^6,$$

$$x_2 = \sqrt{2916f^2\lambda^{12}z^2 + 4x_1^3},$$

$$x_3 = \sqrt[3]{x_2 - 54f\lambda^6z}.$$

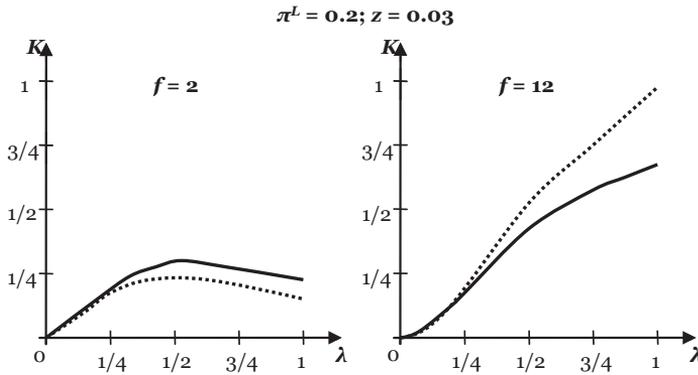


Figure 20 Bank's privately optimal (dashed line) and socially optimal screening incentives under low screening costs.

We can summarise our findings in the following conclusion.

Whether the banks under- or over-screen depend on their costs of funds. When the costs of funds are high, the banks under-screen, while when the costs of funds are low, the banks over-screen.

This conclusion has very interesting policy implications. Given that the central banks have the power of affecting the costs of funds of the banks, the central banks could affect the banks screening incentives and thus affect the amount of screening and lending that the banks do. More discussion of the policy implication can be found in the next section.

5.3 Discussion

In this chapter, we found that the introduction of competition encourages the banks to screen more loan applicants. Even though an individual bank in a duopolistic banking industry might screen fewer loan applications than a monopoly bank, two banks in a duopoly together appear to screen significantly more than a monopoly bank. For a policy maker it means that encouraging entry of the new banks into the banking industry and resisting consolidation of existing banks would lead to more screening and subsequently to more lending.

In the Arrow-Debreu world of complete financial markets, a more intense bank competition always leads to more efficient markets. However, banks do not compete solely on the deposit and lending interest rates. Banks also choose the level of riskiness of their operations, as well as decide on screening, monitoring, etc. So in the real world, more intense banking competition might not always be desirable. The theoretical analysis of banking competition using Salop (1979) model shows that free competition leads to too many banks (Freixas and Rochet 2008).

Previous bank screening literature (see e.g. Broecker 1990, Riordan 1993) warned that a more intense banking competition leads to inefficiently low screening standards and subsequently to credit losses. In view of Broecker and Riordan, more lending does not compensate for bigger credit losses. In contrast to this result, our welfare analysis suggests that more intense banking competition could actually be welfare improving.

More generally, the banking literature has argued that a more intense competition encourages the banks to take more risk. Keeley (1990), Suarez (1994) and Matutes and Vives (1996) warn that a more intense bank competition, in an environment where deposits are not insured and the depositors cannot observe the banks' actions, gives the banks incentives to choose the maximum level of riskiness. Moreover, Suarez argues that the possibility of recapitalisation by the bank owners gives the banks greater incentives to engage in a risk-taking behaviour.

Freixas and Rochet (2008) argue that transparency, capital requirements and relationship banking prevent the banks from taking excessive risks in a competitive environment. Taking into account the results of the previous literature and the results of this chapter, we can conclude that competition can either lead to a more efficient banking industry or be very harmful and destabilising. Whether the outcome is good or bad depends on the regulatory environment.

Both in Chapter 3 and in Chapter 4 we found that a lower cost of funds gives the banks incentives to increase the lending volume. This result holds also in this chapter.

One of the policy measures that could decrease the banks' cost of funds is regulation of deposit interest rates. There is a historic example of such a regulation. In the United States Regulation Q limited the deposit interest rates that the banks could pay in the 1970s. The regulation was abolished in the 1980s, which led to a savings and loans industry's crisis in the late 1980s (Freixas and Rochet 2008), because free competition for the deposits led to a significant rise in the rates, while lending interest rates could not be adjusted fast enough.

However, there is new literature arguing that re-introduction of the deposit interest rate regulation could have a positive impact on the banking industry. Hellman, Murdock and Stiglitz (2000) argue that the deposit interest rate regulation could encourage the banks to take less risk and therefore could improve the stability of the banking system. Chiappori, Perez-Castillo, and Verdier (1995) argue that the regulation of deposit interest rates leads to lower lending interest rates.

Our main result comes from our welfare analysis. We find that the banks over-screen when the cost of raising funds is low, while the banks under-screen when the cost is high. This result has many interesting policy implications.

First, our finding that the banks over-screen if the costs of funds are low is driven by a waste of screening effort, which results from a more intense banking competition. The more banks there are in the banking industry, the more screening effort is wasted on performing costly screening. To counter this inefficiency, the policy should be aimed at increasing transparency. If banks share information about the potential borrowers, less screening effort is going to be wasted.

Second, the finding that the banks under-screen if the costs of funds are high results from the asymmetric information problem, in which the low-risk entrepreneurs are unable to signal their type to the bank. The efficient way for a low-risk entrepreneur to signal his type is to introduce a cost of making a loan application. This cost can serve as a screening device, as a high enough loan application cost would deter the high-risk entrepreneurs from making a loan application.

Third, given that the central banks have the power of affecting the cost of raising funds through setting of the main interest rate and through other monetary policy tools, such as quantitative easing, it means that the central banks could potentially affect the bank

screening incentives, which would affect both the volume of lending and the allocation of credit, resulting in greater social welfare.

In comparison with Chapters 3 and 4, this chapter has studied the effects of banking competition on screening, while taking into account the fact that the banks must pay a positive deposit interest rate. However, the cost of studying bank competition was that we had to drop one of the key decisions that the banks make in their screening. The banks in this chapter competed only over screening volumes, but did not compete over screening quality. In Chapter 6, we will introduce a model in which two banks compete over screening quality, but not over how many loan applications to screen.

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APPENDIX 9

We have the following expression:

$$\frac{\partial \pi_A(K_A, K_B)}{\partial K_A} = K_B \frac{\lambda}{2} \pi^L + (1 - K_B) \lambda \pi^L - \frac{2L_A \frac{\partial L_A}{\partial K_A} + \frac{\partial L_A}{\partial K_A} L_B + L_A \frac{\partial L_B}{\partial K_A}}{f} - 2K_A z = 0,$$

where

$$L_A = K_A K_B \frac{\lambda}{2} + K_A (1 - K_B) \lambda,$$

$$L_B = K_A K_B \frac{\lambda}{2} + K_B (1 - K_A) \lambda,$$

$$\frac{\partial L_A}{\partial K_A} = \lambda - \frac{K_B}{2} \lambda,$$

$$\frac{\partial L_B}{\partial K_A} = -\frac{K_B}{2} \lambda.$$

Once assuming the symmetry, in which $K_A = K_B$, L_A , L_B , $\frac{\partial L_A}{\partial K_A}$ and $\frac{\partial L_B}{\partial K_A}$ take the following form:

$$L_A = L_B = K^2 \frac{\lambda}{2} + K(1 - K) \lambda,$$

$$\frac{\partial L_A}{\partial K_A} = \lambda - \frac{K}{2} \lambda,$$

$$\frac{\partial L_B}{\partial K_A} = -\frac{K}{2} \lambda.$$

After substituting the above expressions and some rearranging, the first-order condition becomes:

$$K \frac{\lambda}{2} \pi^L + (1 - K) \lambda \pi^L - \frac{\left(K^2 \frac{\lambda}{2} + K(1 - K) \lambda \right) \left[3 \left(\lambda - \frac{K}{2} \lambda \right) - \frac{K}{2} \lambda \right]}{f} - 2Kz = 0.$$

This leads us to the third-order polynomial:

$$2\lambda^2 K^3 - 7\lambda^2 K^2 + (f\lambda\pi^L + 6\lambda^2 + 4fz)K - 2f\lambda\pi^L = 0.$$

APPENDIX 10

The bank B 's profit is given by

$$\pi_B(K_A, K_B) = K_A K_B \frac{\lambda}{2} \pi^L + K_B (1 - K_A) \lambda \pi^L - r L_B - K_B^2 z.$$

The amount of loans that the banks grant is given by the following expressions:

$$L_A = K_A K_B \frac{\lambda}{2} + K_A (1 - K_B) \lambda,$$

$$L_B = K_A K_B \frac{\lambda}{2} + K_B (1 - K_A) \lambda.$$

The banks raise the funds in the deposit market:

$$L_A + L_B = fr.$$

The solution to the optimisation problem is given by the following first-order condition:

$$\frac{\partial \pi_B(K_A, K_B)}{\partial K_B} = K_A \frac{\lambda}{2} \pi^L + (1 - K_A) \lambda \pi^L - \frac{2L_B \frac{\partial L_B}{\partial K_B} + \frac{\partial L_B}{\partial K_B} L_A + L_B \frac{\partial L_A}{\partial K_B}}{f} - 2K_B z = 0,$$

where

$$\frac{\partial L_B}{\partial K_B} = \lambda - \frac{K_A}{2} \lambda,$$

$$\frac{\partial L_A}{\partial K_B} = -\frac{K_A}{2} \lambda.$$

6 COSTS OF FUNDS AND BANK COMPETITION OVER SCREENING STANDARDS

How does competition affect screening standards? This question has been addressed in the literature. This chapter contributes to the literature by accounting for the fact that in the real world the banks have to pay a positive deposit interest rate. Previous bank screening literature focused only on the lending market, assuming away the other side of banking.

In Chapters 3 and 4 we argued that lower costs of funds could encourage the bank to run a higher credit risk. However, in both Chapter 3 and in Chapter 4, we focused only on one bank in the banking industry, ignoring the effects of banking competition on screening standards. In this chapter, we focus on bank competition.

As in Chapter 5, in this chapter we also focus on two banks in the banking industry. But if in Chapter 5 the banks decided how many loan applications to screen and therefore competed against each other in lending and screening volumes, in this chapter the banks decide how well to screen each loan application. Screening is assumed to be costly and imperfect. The screening technology is designed so that it detects high-risk loan applications. However, there is a misclassification error, defined as a probability that a high-risk loan application is mistakenly classified as a low-risk one. The banks can adjust the misclassification error – or in other words, the precision or quality of screening – by investing in the screening technology. The more precise the screening is, the more expensive it is. We find that the banks' decision to invest in screening is strongly influenced by the cost of funds.

This chapter is most related to Chapter 4. In Chapter 4 there is one bank that decides both on the quality of screening and on how many loan applications to screen. In this chapter, there are two banks deciding on the quality of screening. In Chapter 5, there were also two banks, but they determined how many loan applications to screen. The banks did not decide on the quality of screening.

We find that the higher the cost of funds is, the more cautious the banks become in their screening decisions. When the cost of funds is high, the banks exert a significant effort in screening out high-risk loan applications. But when the cost of funds is low, the banks become less willing to invest resources in screening. Thus, the lower the cost of funds is, the more willing the banks become to fund high-risk loan applications. This link between the riskiness of the bank loan portfolio and the cost of funds has not been discovered by the previous literature. However, there is evidence in the finance literature that a lower cost of funds encourages the bank risk-taking (see e.g. Dell'Ariccia et al. 2011). Acharya and Naqvi (2012), in a model of bank moral hazard, show that a low cost of funds could lead to excessive lending, which could result in asset bubbles.

The economic outlook also affects the screening standards. We find that in boom times, independently of the cost of funds, the banks are unwilling to invest much in screening out high-risk loan applications. This finding is consistent with the results of Chapter 3 and of Chapter 4.

Another interesting finding suggests that a more intense bank competition undermines the banks' investment in screening. A monopoly bank invests more in screening out bad loan applications than a duopoly bank. This result is consistent with the previous

literature (see e.g. Broecker 1990, Riordan 1993, Kannianen and Stenbacka 1998, Gehrig 1998). Broecker and Riordan argue that a more intense banking competition could lead to a worse banking performance, as the competing banks have an incentive to decrease their screening standards. In Chapter 5 we found that a more intense banking competition leads to more loans being funded. Moreover our welfare analysis showed that this could be welfare-improving, as our results suggest that a monopoly bank over-invests in screening in comparison with the social optimum. So the introduction of competition could be potentially welfare-improving.

When it comes to a duopoly bank, the story is more complex. Whether the banks in a duopoly banking industry over- or under-screen in comparison with the social optimum depends on the economic outlook, on the costs of funds, and on the screening costs. Banks tend to over-screen in recessions, when the costs of funds are high or when the screening costs are low, while the banks tend to under-screen in boom times, when the costs of funds are low or when the screening costs are high. These welfare results contrast with Hauswald and Marquez (2005) who find that the banks competing for borrowers in a Salop-type setting invest too much in screening of each loan applicant. Gehrig and Stenbacka (2013) also report over-investment in screening intensity relative to the social optimum.

This chapter is most related to Kannianen and Stenbacka (1998), to Ruckes (2004), and to Gehrig and Stenbacka (2013). All these papers focus on two banks competing over screening standards. Just like this chapter, these papers also implicitly assume that the banks do not choose the number of loan applications to screen, thus none of these papers, nor this chapter, analyse the market entry decisions. However, unlike these papers, this chapter explores the link between the cost of funds and bank screening standards.

Ruckes (2004) argues that the screening intensity displays an inverse U-shaped function of the economic outlook. However in the Ruckes model the screening costs are sunk and do not affect the lending decisions. In contrast, in our model the banks choose screening intensities that maximise their profits.

The rest of the chapter is organised as follows. Next section presents the main results. Section 6.2 is dedicated to the welfare analysis. Section 6.3 concludes.

6.1 The Bank's Problem

This section is organised as follows. In 6.1.1 we present a benchmark monopoly case. In 6.1.2 we present our main duopoly model.

6.1.1 Monopoly Case

Let us start our analysis with a simple case of a monopoly bank, whose problem is to choose a screening intensity that maximises its profit:

$$\pi(\beta) = \lambda\pi^L + (1 - \lambda)\beta\pi^H - rL - z(1 - \beta)^2.$$

In the profit function above, the first term gives the bank's revenue from funded low-risk loan applications, while the second term gives losses from funded high-risk loans, which had been mistakenly classified as low-risk. The third term in the profit function

is the bank's cost of funds, which is a product of the deposit interest rate and the amount of loans that the bank funds. The latter is given by

$$L = \lambda + (1 - \lambda)\beta.$$

The deposit interest rate can be found from our formula that gives the supply of deposits:

$$S = fr.$$

And given that it is not efficient to raise more deposits than the bank grants in loans,

$$S = L.$$

The last term in the bank's profit function is the cost of screening. The solution to the bank's optimisation problem is given by the following first-order condition:

$$\pi'(\beta) = (1 - \lambda)\pi^H - \frac{2(1 - \lambda)[\lambda + (1 - \lambda)\beta]}{f} + 2z(1 - \beta) = 0.$$

From the first-order condition above, we can find an explicit formula for the bank's optimal screening intensity, expressed through the exogenous parameters:

$$\beta^* = \frac{f[(1 - \lambda)\pi^H + 2z] - 2\lambda(1 - \lambda)}{2(fz + (1 - \lambda)^2)}. \quad (6.1)$$

In order to investigate how a change in the economic outlook, λ , a change in the costs of funds, f , and a change in the screening costs, z , affect the optimal screening intensity, let us now proceed to the comparative static analysis. First, the effect of the economic outlook on screening:

$$\frac{d\beta}{d\lambda} = \frac{[fz - (1 - \lambda)^2](2 - f\pi^H)}{2(fz + (1 - \lambda)^2)^2}.$$

This expression is positive if $fz > (1 - \lambda)^2$, is negative if $fz < (1 - \lambda)^2$, and is equal to zero if $fz = (1 - \lambda)^2$. This means that whether the bank intensifies its screening or reduces its screening effort as the economic outlook improves depends on the costs of funds and on the costs of screening. The next comparative static results sheds more light on the issue.

But before proceeding to those, let us make one remark. Given that the previous literature that assumes the deposit interest rate to be zero implicitly assumes that the elasticity of supply of deposits, f , tends to infinity, let us take a limit of the above expression. Given that it is of $-\infty/\infty$ type, we can apply l'Hôpital's rule (twice):

$$\lim_{f \rightarrow \infty} \frac{[fz - (1 - \lambda)^2](2 - f\pi^H)}{2(fz + (1 - \lambda)^2)^2} = \frac{-\pi^H}{2z} > 0.$$

As we can see, if reducing attention only to a deposit interest rate of zero, one gets a clear but misleading result that an improvement in the economic outlook necessarily leads to a lower screening effort by the bank. But our result shows that this effect can go

either way. This way the new result of this chapter enriches our understanding of the bank screening incentives.

Now, let us take a look at the effect of the cost of funds on the screening intensity:

$$\frac{d\beta}{df} = \frac{(1-\lambda)(\pi^H(1-\lambda)^2 + 2z)}{2(fz + (1-\lambda)^2)^2} > 0.$$

If f increases, it means that the funds become less expensive. If β increases, it means that the misclassification error of the bank screening increases, making the screening less effective. This expression shows us that the bank reduces its per-project screening if funds become less expensive. This is an interesting result. The intuition for this is that with less expensive funds, the bank can afford to run a higher credit risk, as funded bad loans inflict less damage on the bank's balance sheet.

And last, let us take a look at the effect of the cost of screening on the screening intensity:

$$\frac{d\beta}{dz} = \frac{f(1-\lambda)(2-f\pi^H)}{2(fz + (1-\lambda)^2)^2} > 0.$$

If z increases, it means that the screening costs increase. This comparative static result tells us that whenever the screening costs increase, the bank is willing to accept a higher misclassification error, β , meaning that the bank is willing to take more risk and reduce its investment in screening.

Let us summarise our analytical results in the following proposition:

Proposition 6.1

A lower cost of funds and higher screening costs give the bank incentives to reduce its screening effort. An improvement in the economic outlook, on the other hand, might lead either to more or less intense screening, depending on the parameter values.

Proposition 6.1 shows that a monopoly bank's screening incentives are reduced with lower costs of funds and with higher screening costs. When it comes to the effect of the screening costs, the result here is largely consistent with the results of the previous chapters. However, the effect of costs of funds is more complex.

In Chapter 3 we found that lower costs of funds encouraged the bank to fund more loans without screening. Result of the monopoly analysis of this chapter is similar to that finding in a sense that in this chapter less expensive funds also encourage the monopoly bank to run a higher credit risk.

But in Chapter 4 screening standards were not affected by the changes in the costs of funds at all. There the number of loan applications screened was strongly affected. However, the models in the two chapters are different. The main focus of the analysis of this chapter is in the next section, in the study of a duopoly banking industry.

For a numerical illustration of the results of this section, see Figure 21 in the next section.

6.1.2 Duopoly Case

In case of a duopoly, there are five groups of loan applications. In the first group there are low-risk loan applications that have been correctly classified as low-risk by both banks. Second group consists of high-risk loan applications that have been correctly classified as high-risk by bank A , but mistakenly classified as low-risk by bank B . In the third group there are high-risk loan applications that have been correctly classified as high-risk by bank B , but mistakenly classified as low-risk by bank A . The fourth group consists of high-risk loan applications that have been mistakenly classified as low-risk by both banks. And the fifth group consists of loan applications that have been correctly classified as high-risk by both banks. This structure is taken into account in the profit function of the bank A :³⁵

$$\pi_A(\beta_A, \beta_B) = \frac{\lambda}{2}\pi^L + (1 - \lambda)\beta_A\left(1 - \frac{\beta_B}{2}\right)\pi^H - rL_A - z(1 - \beta_A)^2.$$

The first term in the bank A 's profit function gives the revenue from funding loan applications from the first group (low-risk loans). Bank A gets to fund only half of this group, while bank B funds the other half. The second term gives the losses from funding mistakenly classified high-risk loan applications from the third group and the fourth group. Bank A gets to fund the whole of the third group and the half of the fourth group. The third term is the cost of funds, which is a product of the deposit interest rate and the amount of loans granted. The latter is given by

$$L_A = \frac{\lambda}{2} + (1 - \lambda)\beta_A\left(1 - \frac{\beta_B}{2}\right).$$

The banks raise the funds in the deposit market:

$$L_A + L_B = fr,$$

where L_B is the amount of loans granted by the bank B :

$$L_B = \frac{\lambda}{2} + (1 - \lambda)\beta_B\left(1 - \frac{\beta_A}{2}\right).$$

The deposit interest rate, r , is given by

$$r = \frac{L_A + L_B}{f}.$$

The intuition for the above formula is that the deposit interest rate depends on the amount of loans funded by both banks. In other words, the banks compete for the deposits.

The last term in the bank's profit function gives us the cost of screening. The solution to the bank's optimisation problem is given by the following first-order condition:

$$\frac{\partial \pi_A(\beta_A, \beta_B)}{\partial \beta_A} = (1 - \lambda)\left(1 - \frac{\beta_B}{2}\right)\pi^H - \frac{2L_A \frac{\partial L_A}{\partial \beta_A} + \frac{\partial L_A}{\partial \beta_A} L_B + L_A \frac{\partial L_B}{\partial \beta_A}}{f} + 2z(1 - \beta_A) = 0,$$

³⁵ The analysis for bank B is given in Appendix 12

where

$$\frac{\partial L_A}{\partial \beta_A} = (1 - \lambda) \left(1 - \frac{\beta_B}{2} \right),$$

$$\frac{\partial L_B}{\partial \beta_A} = -\frac{1 - \lambda}{2} \beta_B.$$

Given that there is no reason to assume that the banks A and B are different in any way, we are looking for a symmetric equilibrium, in which $\beta_A = \beta_B$. This gives us the following expression (for details, refer to Appendix 11):

$$(1 - \lambda) \left(1 - \frac{\beta}{2} \right) \pi^H - \frac{(\lambda + (1 - \lambda)\beta(2 - \beta))(1 - \lambda)(3 - 2\beta)}{2f} + 2z(1 - \beta) = 0.$$

Note that the lending interest rate does not affect the results, because the screening decisions are not affected by revenues from making good loans. This holds as long as the probability of success of high-risk loan applications is low enough. Solving the above expression, we obtain the optimal screening intensity, expressed through the exogenous parameters:

$$\beta^* = \frac{7}{6} - \frac{x_5}{3x_1 2^{2/3} x_6} + \frac{x_6}{6x_1 2^{1/3}} \quad (6.2)$$

Formula 6.2 is the unique solution to the third-order polynomial above. The other two roots of the polynomial are complex numbers.

The above expression was obtained with the help of Wolfram Alpha³⁷. The expression is extremely complex to be analysed analytically, using the comparative static analysis. That is why we will analyse this expression numerically. As in the previous chapters, we will assume that $\pi^H = -0.9$. The illustrations of our numerical analysis are presented in Figures 21 and 22. There we have drawn the monopoly bank's (illustration of the results of the previous section) optimal screening intensity with dashed curves, while we have drawn the optimal screening intensity of a duopoly bank with thick curves.

³⁶ $x_1 = \lambda^2 - 2\lambda + 1$,

$x_2 = 6 - f\lambda\pi^H + f\pi^H + 4fz + 8\lambda^2 - 14\lambda$,

$x_3 = -90f\lambda^5\pi^H + 450f\lambda^4\pi^H - 900f\lambda^3\pi^H + 900f\lambda^2\pi^H - 72f\lambda^4z + 288f\lambda^3z - 432f\lambda^2z$,

$x_4 = -450f\lambda\pi^H + 90f\pi^H + 288f\lambda z - 72fz + 2\lambda^6 + 60\lambda^5 - 330\lambda^4 + 680\lambda^3 - 690\lambda^2 + 348\lambda - 70$,

$x_5 = 6x_1x_2 - 49x_1^2$,

$x_6 = \left(x_3 + \sqrt{4x_3^2 + (x_3 + x_4)^2 + x_4} \right)^{1/3}$.

³⁷ <http://www.wolframalpha.com/>

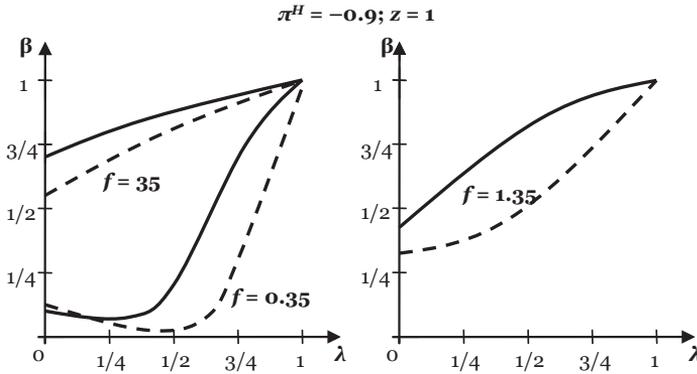


Figure 21 Duopoly (thick curves) and monopoly (dashed curves) banks screening incentives.

The first conclusion that we can make analysing Figure 21 is that an increase in the elasticity of supply of deposits, f – or, in other words, less expensive deposits – reduce both monopoly and duopoly banks' screening intensity. As funds become less and less expensive, the banks accept higher and higher risk. The banks are extremely cautious in bad times when the majority of loan applications are high-risk ($\lambda < 1/2$) and when funds are very expensive. When either funds are cheap or the economic outlook is good, the banks are willing to accept a higher misclassification error.

Next, note that almost always a monopoly bank screens significantly more intensely than an individual duopoly bank. This is clearly an effect of competition. This finding is consistent with the results in the previous bank screening literature (see e.g. Gehrig 1998, Kanniainen and Stenbacka 1998).

And last, let us take notice of the shape of the banks' screening intensities curves at $f = 0.35$. They look somewhat like inverse U-shapes predicted by Ruckes (2004). Both monopoly and duopoly banks intensify screening as the economic outlook improves until a certain point, after which, with further improvement of the economic outlook, the screening intensity drops sharply. However, Ruckes (2004) prediction holds in this model only for very expensive deposits or for a very low screening costs (see Figure 22).

Now let us turn our attention to Figure 22. There we fixed the cost of funds at $f = 1.35$ and explored how the screening costs affect screening incentives. Note that the screening costs increase with an increase in parameter z .

As we can see in Figure 22, an increase in the screening costs has a similar effect on the banks' screening incentives as a decrease in the costs of funds (consistent with Proposition 6.1 of the previous section). Both when the costs of funds decrease and the costs of screening increase, the banks have incentives to accept a higher misclassification error in their screening decisions, making screening less effective in detecting high-risk loan applications and resulting in higher riskiness of the banks' loan portfolios.

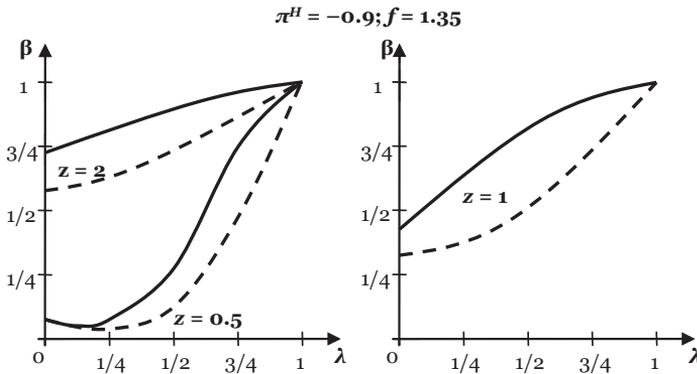


Figure 22 Duopoly (thick curves) and monopoly (dashed curves) banks screening incentives.

We can summarise our findings in the following conclusion:

A duopoly bank screens less intensely than a monopoly bank. Lower costs of funds and higher costs of screening encourage the banks to screen each loan application less intensely.

The policy implications that we can draw from the above conclusion are as follows. If the policy makers would want to encourage the banks to screen loan applications more thoroughly, the policy should be aimed at reducing bank competition (for example, through approving mergers and acquisitions), increasing the costs of funds (with the help of the tools of the monetary policy) and reducing the costs of screening (for example, through tax breaks and improving the banks' access to information about the potential borrowers). Further policy implications are discussed in Section 6.3.

We can also provide an alternative explanation to the empirical phenomenon that was documented by Petersen and Rajan (1995) who, focusing on bank moral hazard, found that in the United States credit is cheaper and more easily available in less competitive lending markets. Results of this chapter suggest that the competition between the banks makes the banks less informed about their potential borrowers. A better informed bank, in a less competitive environment, could be better equipped to assess the borrower's creditworthiness and thus be able to extend a loan.

6.2 The Welfare Analysis

In this section, we perform the welfare analysis that corresponds to the analysis of the bank's problem in the previous section. In 6.2.1 we compare a monopoly bank's screening incentives with the social optimum, while in 6.2.2 we conduct the welfare analysis of a duopoly.

6.2.1 Monopoly Case

Let us start our welfare analysis by first noting that the marginal cost of granting a loan equals the deposit interest rate:

$$MC = r = \frac{S}{f}.$$

This means that the total cost of funds can be obtained in the following way:

$$TC = \int_0^S MC(x)dx = \int_0^S \frac{x}{f} dx = \frac{S^2}{2f}.$$

The society maximises the following social welfare function:

$$W(\beta) = \lambda\pi^L + (1 - \lambda)\beta\pi^H + (1 - \lambda)\beta p_H(R_H - R_L) - \frac{S^2}{2f} - z(1 - \beta)^2.$$

The first two terms are like in the bank's profit function. They give the revenues from funded good and bad loans respectively. The third term accounts for the surplus of bad entrepreneurs who were mistakenly granted funding by the bank and whose projects succeeded. The last two terms give the costs of funds and costs of screening. The solution is given by the following first-order condition:

$$W'(\beta) = (1 - \lambda)\pi^H + (1 - \lambda)p_H(R_H - R_L) - \frac{(1 - \lambda)[\lambda + (1 - \lambda)\beta]}{f} + 2z(1 - \beta) = 0.$$

Solving the above first-order condition, we obtain the socially optimal screening intensity, expressed through the exogenous parameters:

$$\hat{\beta} = \frac{f[(1 - \lambda)\pi^H + 2z + (1 - \lambda)p_H(R_H - R_L)] - \lambda(1 - \lambda)}{2fz + (1 - \lambda)^2}. \quad (6.3)$$

Comparing the socially optimal misclassification error $\hat{\beta}$ and the privately optimal β^* (Formula 6.1), we see that under rather general conditions³⁸ $\hat{\beta} > \beta^*$, meaning that from the social welfare perspective the bank over-screens:

$$\hat{\beta} - \beta^* = f(1 - \lambda) \frac{2p_H(R_H - R_L)zf + (1 - \lambda)^2[\pi^H + 2p_H(R_H - R_L)] + 2(1 - \lambda)z}{[2fz + (1 - \lambda)^2][2fz + 2(1 - \lambda)^2]}.$$

We can also see that as λ approaches one, or in other words, as the economy approaches the peak of the business cycle, the differences between the socially optimal and the privately optimal screening incentives disappear.

We have also done a numerical analysis to illustrate the above analytical points. The results of the numerical analysis are presented in Figure 23. There, the socially optimal screening intensities are drawn with thick lines, while privately optimal screening intensities are drawn with thin lines.

In Figure 23, we see that the bank screens too intensely in comparison with the social optimum. The more expensive the deposits are, the more the difference between the social and private screening incentives is.

We can summarise our findings in the following conclusion:

³⁸ This holds especially for not too small f

As long as the cost of funds is not too low, the monopoly bank screens each loan application too intensely, in comparison with the social optimum.

The above conclusion is in line with our findings in Chapter 4. As in Chapter 4, the difference between the socially and privately optimal screening incentives is explained by the fact that the society, unlike the bank, cares also about the welfare of the bad entrepreneurs.

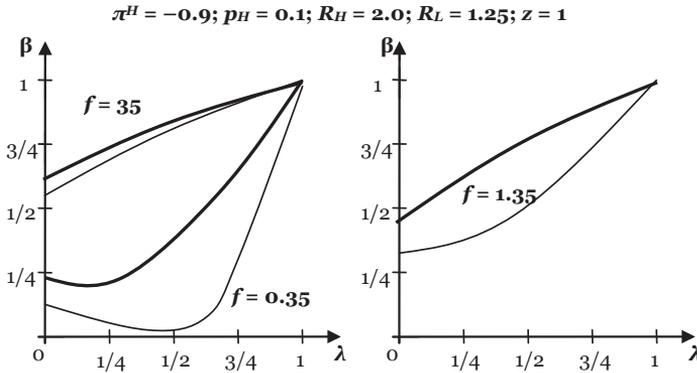


Figure 23 Bank's privately optimal (thin curves) and socially optimal (thick curves) screening incentives.

6.2.2 Duopoly Case

In case of a banking duopoly, the society would prefer to close down one of the banks in order not to waste resources on screening the same pool of loan applicants twice and in order not to make more screening mistakes. Riodran (1993) warned that an increase in the number of banks could lead to more high-risk loans being funded.

The screening technology is such that the banks correctly identify all low-risk loan applications. However, each of the banks makes own screening mistakes, meaning that a monopoly banking industry funds fewer high-risk loan applications than a duopoly banking industry. Moreover, a monopoly banking industry achieves this lower mistake in funding bad loans at a lower cost. That is why, in order to compare the socially optimal and the privately optimal screening intensities, we need to compare monopoly socially optimal screening with duopoly privately optimal screening. An illustration of this comparison is given in Figure 24. There, the socially optimal screening intensities are drawn with thick lines, while privately optimal screening intensities are drawn with thin lines.

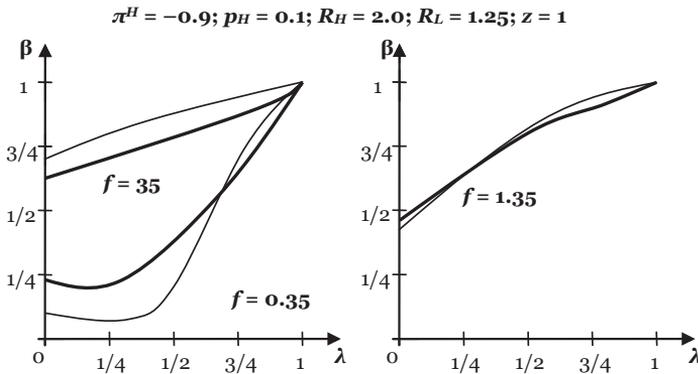


Figure 24 Bank's privately optimal (thin curves) and socially optimal (thick curves) screening incentives.

In Figure 24, we see that in deep recessions, the banks screen loan applications too carefully, while they do not screen carefully enough in boom times. This conclusion seems to be independent of the banks' cost of funds. However, screening costs seem to have a more profound effect on the social optimality of bank screening, as can be clearly seen in Figure 25. When the screening costs are high ($z = 2$), the banks seem to under-screen, while when the screening costs are low ($z = 0.5$), the banks mostly seem to over-screen, with under-screening only occurring closer to the peak of the business cycle.

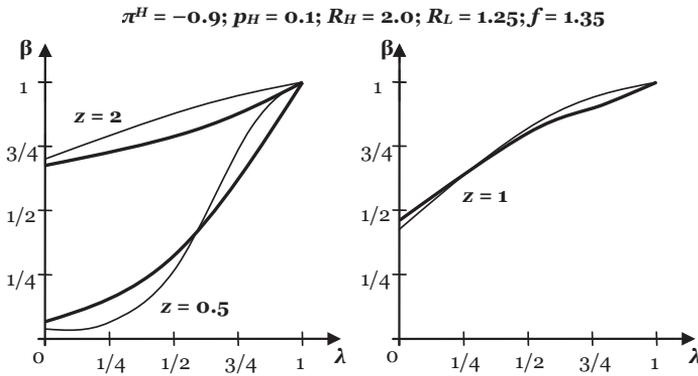


Figure 25 Bank's privately optimal (thin curves) and socially optimal (thick curves) screening incentives.

We can conclude that whether the banks over- or under-screen in comparison with the social optimum depends on the economic outlook (banks tend to over-screen in recessions and under-screen in boom times), on the costs of funds (banks tend to over-screen when the costs of funds are higher), and on the screening costs (banks tend to over-screen with lower screening costs and under-screen with higher screening costs).

6.3 Discussion

In this chapter, we found that the introduction of competition undermines the incentives of the banks to screen loan applicants thoroughly: a monopoly bank screens each loan application better than either of the banks in a duopolistic banking industry. This result enriches our understanding of the effects of banking competition on screening. In Chapter 5 we found that two banks in a duopolistic banking industry screen more loan applicants than a monopoly bank. Combining the results of Chapter 5 and of this chapter, we can say that the introduction of competition leads to more loan applications being screened, but also leads to lower quality of screening of each loan application. This result is in line with the previous screening literature, most notably with Broecker (1990) and Riordan (1993). Broecker and Riordan warned that increased competition could lead to more loans being funded and to more credit losses, as a result of poorer screening standards. In Chapter 5, however, we showed that increased banking competition could be welfare improving.

In line with the results in Chapter 3, we found that a lower cost of funds encourages the bank to run a higher credit risk. In Chapter 3, a lower cost of funds gave the bank incentives to fund more loans without screening in boom times. In this chapter, a lower cost of funds encourages the banks to screen each loan application less intensely. These results suggest that the banking regulator, in order to ensure that the banks do not run a too high credit risk in boom times, should increase the banks' cost of funds. The central bank's monetary policy has a significant and direct impact on the banks' cost of funds.

The results of this chapter contrast with the results in Chapter 4. In Chapter 4 we found that the cost of funds has no effect on the bank screening intensity, but the model in Chapter 4 allowed the bank to optimise over two decision variables, and screening intensity was only one of the variables. In this chapter, the banks have only one decision to make: how intensely to screen each loan application. But in line with Chapter 4, in this chapter we also found that in expansions the banks' incentives to screen loan applicants thoroughly diminish and the banks screen less and less intensely as the economic outlook improves.

Moreover, in line with the results of all the previous chapters, we found that a lower screening cost also encourages the banks to perform a more thorough screening of loan applications. In order to reduce the banks' screening costs, the policy should be aimed at reducing the asymmetric information problem in banking through greater transparency.

One possible measure is creating a register of loan applicants. Any information that the banks could get from such a register is potentially very useful. It could be simple information about who has made a loan application to which bank.

Such a register can alternatively contain information on the good borrowers, i.e. the borrowers who have repaid their loans successfully. This would be a register containing a so called "white" or "positive" information. An alternative is a register with the information on the bad borrowers, i.e. the borrowers who have defaulted on their loans. Such registers exist in the real world. An example of such a register is German Schufa³⁹.

³⁹ www.schufa.de

Jappelli and Pagano (2000) argue that the existence of credit registers leads to lower credit risks, lower lending interest rates, and more extensive loan markets.

A related policy measure could be a requirement for the banks to reveal credit history of all potential borrowers. Also other information about the potential borrowers can be very valuable to the banks. History of tax payments could also reveal important information about the borrowers.

However, information sharing between the banks could be potentially an issue for the competition policy because such an information-sharing scheme could facilitate tacit collusion. However, without information sharing, encouraging entry of new banks and intensifying competition could have bad consequences, as it would lead to more waste of screening effort.

Another possible measure is creation of a screening agency, an additional financial intermediary whose sole task is screening loan applications. Once the loan applications are screened and are deemed to be good, the banks could compete for the borrowers. The efficient way of paying for the services of such an agency is to make any payment conditional on the performance of the whole loan portfolio that a bank holds, i.e. conditional on the repayment rate.

Reducing the incentives of the high-risk entrepreneurs from seeking bank loans could also be done through a tax on the profits of the entrepreneurs. If interest payments are tax deductible, the tax, in our models, would affect only the bad entrepreneurs. In our models it would be optimal to set the tax rate at 100%. Even though in the real world, 100% tax rate might seem unrealistic, consider the bill that the US House of Representatives passed by 328 votes in March 2009. It imposed a retroactive (to December 31, 2008) tax of 90% on “bonuses granted to employees who earn more than \$250,000 at companies that have received at least \$5 billion from the government’s financial rescue program”⁴⁰.

⁴⁰ <http://online.wsj.com/news/articles/SB123745823318182841>

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APPENDIX 11

We have the following first-order condition:

$$(1 - \lambda) \left(1 - \frac{\beta_B}{2}\right) \pi^H - \frac{2L_A \frac{\partial L_A}{\partial \beta_A} + \frac{\partial L_A}{\partial \beta_A} L_B + L_A \frac{\partial L_B}{\partial \beta_A}}{f} + 2z(1 - \beta_A) = 0,$$

where

$$L_A = \frac{\lambda}{2} + (1 - \lambda)\beta_A \left(1 - \frac{\beta_B}{2}\right),$$

$$L_B = \frac{\lambda}{2} + (1 - \lambda)\beta_B \left(1 - \frac{\beta_A}{2}\right),$$

$$\frac{\partial L_A}{\partial \beta_A} = (1 - \lambda) \left(1 - \frac{\beta_B}{2}\right),$$

$$\frac{\partial L_B}{\partial \beta_A} = -\frac{1 - \lambda}{2} \beta_B.$$

Once we assume symmetry, in which $\beta_A = \beta_B$, the first-order condition becomes:

$$(1 - \lambda) \left(1 - \frac{\beta}{2}\right) \pi^H - \frac{2L_A \frac{\partial L_A}{\partial \beta_A} + \frac{\partial L_A}{\partial \beta_A} L_B + L_A \frac{\partial L_B}{\partial \beta_A}}{f} + 2z(1 - \beta) = 0,$$

where

$$L_A = L_B = \frac{\lambda}{2} + (1 - \lambda)\beta \left(1 - \frac{\beta}{2}\right),$$

$$\frac{\partial L_A}{\partial \beta_A} = (1 - \lambda) \left(1 - \frac{\beta}{2}\right),$$

$$\frac{\partial L_B}{\partial \beta_A} = -\frac{1 - \lambda}{2} \beta.$$

After some algebra, we obtain the following expression:

$$(1 - \lambda) \left(1 - \frac{\beta}{2}\right) \pi^H - \frac{\left[\frac{\lambda}{2} + (1 - \lambda)\beta \left(1 - \frac{\beta}{2}\right)\right] \left[3(1 - \lambda) \left(1 - \frac{\beta}{2}\right) - \frac{1 - \lambda}{2} \beta\right]}{f} + 2z(1 - \beta) = 0.$$

This leads us to the desired result:

$$(1 - \lambda) \left(1 - \frac{\beta}{2}\right) \pi^H - \frac{(\lambda + (1 - \lambda)\beta(2 - \beta))(1 - \lambda)(3 - 2\beta)}{2f} + 2z(1 - \beta) = 0.$$

APPENDIX 12

The profit function of the bank B :

$$\pi_B(\beta_A, \beta_B) = \frac{\lambda}{2}\pi^L + (1 - \lambda)\beta_B \left(1 - \frac{\beta_A}{2}\right)\pi^H - rL_B - z(1 - \beta_B)^2.$$

The third term is the cost of funds, which is a product of deposit interest rate and the amount of loans granted. The latter is given by

$$L_B = \frac{\lambda}{2} + (1 - \lambda)\beta_B \left(1 - \frac{\beta_A}{2}\right).$$

The banks raise the funds in the deposit market:

$$L_A + L_B = fr,$$

where L_A is the amount of loans granted by the bank A :

$$L_A = \frac{\lambda}{2} + (1 - \lambda)\beta_A \left(1 - \frac{\beta_B}{2}\right).$$

The deposit interest rate, r , is given by

$$r = \frac{L_A + L_B}{f}.$$

The solution to the bank's optimisation problem is given by the following first-order condition:

$$\frac{\partial \pi_B(\beta_A, \beta_B)}{\partial \beta_B} = (1 - \lambda) \left(1 - \frac{\beta_A}{2}\right) \pi^H - \frac{2L_B \frac{\partial L_B}{\partial \beta_B} + \frac{\partial L_B}{\partial \beta_B} L_A + L_B \frac{\partial L_A}{\partial \beta_B}}{f} + 2z(1 - \beta_B) = 0,$$

where

$$\frac{\partial L_B}{\partial \beta_B} = (1 - \lambda) \left(1 - \frac{\beta_A}{2}\right),$$

$$\frac{\partial L_A}{\partial \beta_B} = -\frac{1 - \lambda}{2} \beta_A.$$

7 CONCLUDING COMMENTS

One of the key policy-relevant questions of this thesis is: Do banks screen too little in boom times? We have found that the banks do indeed have incentives to reduce their screening effort in boom times and to even fund loans without performing any screening at all. This can lead to higher credit risk in boom times.

However, whether the banks screen too little or too much depends on the social optimum. We have not found conclusive evidence that the banks screen too little in boom times in comparison with the social optimum.

Encouraging the banks to adjust their screening standards in line with the social optimum might be in the interest of the government, which cares about the welfare of all citizens, but might be not in the interest of the central bank, which decides on the monetary policy. The welfare analysis generally does not take into account the objectives of the monetary policy.

These concluding remarks provide a summary of the main results of all the four chapters included in the thesis. They also discuss overall policy implications, taking into account all the results of the thesis.

Any research work should provide some answers to the topical issues in the area in which the research is conducted. However, it should also raise new questions. In the last part of our concluding remarks, we discuss some suggestions for future research.

7.1 To Screen or Not to Screen?

In Chapter 3, we study conditions under which the bank could find it optimal to finance loans without performing any ex ante screening at all. We focus on one bank, which makes two types of decisions. First, the bank decides how many loan applications to screen. Second, the bank decides how many loans to fund without screening.

We found that the bank has low screening incentives both when the economic outlook is very bright and when it is very gloomy. But in boom times, the bank is willing to fund loans without performing any screening at all.

Lower costs of funds give the bank incentives to screen more loan applications – as long as it is not optimal to fund loans without screening. When funding loans without screening becomes optimal, which typically happens in boom times, a lower cost of funds encourages the bank to fund more loans without screening. Thus follows our main finding: A lower cost of funds encourages the bank to run a higher credit risk in boom times, as the bank grants more loans without screening.

Lower screening costs encourage the bank to screen more loan applications and to fund fewer loans without screening.

The welfare analysis suggests that the bank under-screens on all stages of the business cycle aside from the boom times. In boom times, the bank over-screens. Moreover, in boom times the bank funds too few loans without screening.

7.2 Costs of Funds and Incentives of Banks to Screen Loan Applicants over the Business Cycle

In Chapter 4, we analyse the bank's screening incentives over the business cycle. We study one bank, which decides how many loan applications to screen and how well to screen each loan application.

We found that a lower cost of funds gives the bank incentives to finance more loans. Surprisingly, the costs of funds do not seem to affect either the quality of screening or the bank's decision to enter the loan market.

Lower screening costs encourage the bank to screen more loan applications and to screen each loan application more thoroughly. Moreover, lower screening costs make the bank more willing to enter the loan market in a sense that with lower screening costs the bank would enter the market at a worse quality of the loan pool.

The welfare analysis shows that the bank over-invests in quality of screening. Moreover, the society would prefer the bank to screen more loan applications. In other words, the bank screens too few loan applications too carefully.

7.3 Competition, Screening, and Lending Volumes over the Business Cycle

In Chapter 5, we study the effect of bank competition on the number of loan applications that the banks screen. We focus on two banks. Each of the banks makes a decision how many loan applications to screen.

We found that the introduction of competition encourages the banks to screen more loan applicants. Even though an individual bank in a duopolistic banking industry might screen fewer loan applications than a monopoly bank, two banks in a duopoly together appear to screen significantly more than a monopoly bank.

We have also found that a lower cost of funds and lower screening costs give the banks incentives to increase lending volume in a sense that the banks screen – and subsequently fund – more loan applications if either (or both) screening costs or screening costs decrease.

Our most interesting result in Chapter 5 comes from the welfare analysis. We find that the banks over-screen when the cost of raising funds is low, while the banks under-screen when this cost is high.

7.4 Cost of Funds and Bank Competition over Screening Standards

In Chapter 6, we study the effect of bank competition on the quality of bank screening. We focus on two banks. The banks decide on the quality of screening of loan applications.

We found that the introduction of competition undermines the incentives of the banks to screen loan applicants thoroughly: A monopoly bank screens each loan application more intensely than either of the banks in a duopolistic banking industry. This result enriches our understanding of effects of competition on bank screening.

We have also found that a lower cost of funds encourages the bank to run a higher credit risk in a sense that a lower cost of funds gives the banks incentives to screen each loan application less intensely. Moreover, in expansions, the banks' incentives to screen loan applicants thoroughly diminish and the banks screen less and less intensely as the economic outlook improves.

In line with the results in all the previous chapters, we found that lower screening costs encourage the bank to screen each loan application more intensely.

The welfare analysis shows that the banks tend to over-screen in recessions but that they tend to under-screen in boom times.

7.5 Policy Implications

The results of this thesis have implications for banking regulation, competition policy and monetary policy. The policy issues that we have addressed include three main questions. First, how do costs of funds affect the screening incentives of banks? Second, how do screening costs affect the screening incentives of banks? And third, how does bank competition affect the banks' incentives to screen loan applicants?

Before we proceed to answering the above questions, we need to point out that in the real world different policy makers have different objectives. For example, the central bank's objective is to ensure the stability of the financial system and to keep the inflation rate at a certain level. The European Central Bank, for instance, aims to keep the inflation rate across the euro area at about 2%. It is not the objective of a central bank to care about the welfare of the high-risk entrepreneurs. This task belongs to the government.

The policy makers could also have conflicting interests. For example, it could be in the politicians' – or even in the government's – short-term interest to have a less restrictive monetary policy. The politicians might want the central bank to stimulate the economy, for example, before the elections. This is one of the reasons why central banks are independent in many countries.

Moreover, different policy makers could affect the parameters which are studied in this thesis. As an example, let us take the costs of funds. These costs are directly affected by the central bank. The central bank, through the monetary policy tools, such as quantitative easing, setting of an interest rate for discount loans, or reserve requirements, can significantly affect the costs of funds that the banks face. However, the central bank is not the only authority that has the power over the cost of funds. The government's policy has also an effect on the banks' costs of funds. For example, the government could announce a lending subsidy during a recession, which would reduce the banks' costs of funds.

Now, taking into account the above considerations, we can proceed to answering the three policy-relevant questions.

When answering the first question, how costs of funds affect the screening incentives of banks, one needs to account for two points. On one hand, a lower cost of funds could give the banks incentives to screen – and to subsequently fund – more loan applications. On the other hand, a lower cost of funds could encourage the banks to run a higher credit risk in boom times.

Overall results of all the four chapters of this thesis suggest that encouraging the banks to fund more loans in recessions – which is typically high on the agenda of policy makers – requires cuts in the banks' costs of funds. Discouraging the banks from running a high credit risk in boom times, on the other hand, requires increasing the banks' costs of funds.

The banks' costs of funds are directly and strongly influenced by the tools of monetary policy. The costs of funds are also both directly and indirectly affected by the policies of the government.

The central bank cares about the stability of the banking system and therefore it is in the central bank's interest to discourage the banks from running a high credit risk. Given that banks have an incentive to lower screening standards in boom times, the appropriate response of the central bank is a more restrictive monetary policy in boom times. This can be achieved, for example, by stopping or reducing the stimulus programmes or by setting of a higher interest rate for discount loans. Moreover, the central bank cares about the inflation. Too low costs of funds in boom times could lead to too much lending and therefore to overheating of the economy and to high inflation. Thus, a more restrictive monetary policy by the central bank in boom times could achieve both greater stability of the banking system and meeting of the inflation target.

When it comes to the appropriate response by the central bank in recessions, it is also in the central bank's interest to stimulate lending via lowering of the banks' costs of funds. Too little lending in recessions could lead to a very slow recovery and to too low inflation or even to deflation. In order to meet the inflation target, the central bank should stimulate the lending by commercial banks. The costs of funds can be lowered, for example, through quantitative easing or through setting of a lower interest rate for discount loans.

The government can lower the banks' costs of funds in recessions through a lending subsidy. The lending subsidy could be in the form of tax deductions. Once the economy is on track to recovery, this subsidy could be reduced, which would increase the banks' costs of funds. In order to discourage the banks from lending too much in boom times, the government could impose additional taxes, the proceedings from which could finance the lending subsidies in recessions.

A capital income tax can also affect the banks' costs of funds. Our analysis implies that the optimal capital income tax depends on the parameters that fluctuate over the business cycle. It could be low in recessions. This would decrease the banks' costs of funds and stimulate investment and lending. But the capital income tax could be set high in boom times in order to prevent the economy from overheating.

The government can also pursue technological changes that would permanently reduce the deposit interest rate. For example, widening the use of the Internet banking can lower the banks' costs of funds. In a Hotelling setting, the application of Internet banking would mean that the depositors no longer need to commute to the bank, as they can make deposits while sitting comfortably at home. Banking literature found that the physical distance between the bank and its clients has been increasing in the recent decades. In the real world, Internet banking reduces the banks' costs on customer service. The Internet banking can be made more popular by the policies of the government, aimed at widening people's access to the Internet, reducing institutional barriers, investing in high-speed cable network, improving the security of Internet payments, etc.

When it comes to the second question, how screening costs affect the screening incentives of banks, the results of all the four chapters point out that lower screening costs encourage the banks both to screen more loan applicants and to screen each loan applicant more thoroughly. If it is in the policy makers' interest to give the banks incentives to increase lending volumes or to improve the quality of the banks' screening, the policy makers should help the banks in decreasing their screening costs.

There are many different policies that could result in a reduction in screening costs. First let us discuss policies that could make screening activities of the banks more efficient.

One measure is creating a register of loan applicants. Any information that the banks could get from such a register is potentially very useful. It could be simple information about who has made an application for a loan to which bank. Such a register can alternatively contain information on the bad borrowers, i.e. borrowers who have defaulted on their loans. Such registers exist in the real world. One example of such a register is German Schufa⁴¹.

A related policy measure could be a requirement for the banks to reveal credit history of all potential borrowers. Also other information about the potential borrowers can be very valuable to the banks. History of tax payments could also reveal important information about the borrowers.

However, information sharing between the banks could be potentially an issue for the competition policy because such an information-sharing scheme facilitates tacit collusion. However, without information sharing, encouraging entry of new banks and intensifying competition could have bad consequences, as it would lead to more waste of screening effort.

Another possible measure is creation of a screening agency, an additional financial intermediary whose sole task is screening loan applications. Once the loan applications are screened and are deemed to be good, the banks could compete for the borrowers. The efficient way of paying for the services of such an agency is to make any payment conditional on the performance of the whole loan portfolio that a bank holds, i.e. conditional on the repayment rate.

The third possible measure is introduction of a loan application cost. Even a small loan application cost could prevent high-risk entrepreneurs from seeking out bank loans, in hopes of banks' low enough screening standards. Therefore a loan application cost can itself act as a screening device that would separate low-risk entrepreneurs from the high-risk ones.

There can also be a separate charge for bank screening. The charge could be in the form of time, which might be somewhat inefficient, as it would lead to time waste, or in the form of money.

The answer to the third question, how bank competition affects the banks' incentives to screen loan applicants, is complex. The results of this thesis suggest that a more intense competition could lead to more loan applications being screened (and subsequently lead to more loans being funded), but it can also lead to a lower quality of screening of each loan application.

⁴¹ www.schufa.de

One of the key problems in the models of Chapters 5 and 6, where bank competition is modelled, is that there is no price competition, i.e. the banks collude on the lending interest rates at a level of a monopoly bank. Lending market competition would have led to lower lending interest rates and subsequently to lower rents and to lower returns from screening activities. The previous literature concluded that price competition in the lending market leads to worsening of the screening standards.

So when it comes to approval of mergers and acquisitions, the competition authorities should be extra careful in assessing both potential benefits and potential drawbacks of reduced competition.

7.6 Suggestions for Future Research

Throughout the thesis, we interpreted an exogenous change in the loan pool quality as a change in the macroeconomic conditions. Future research should do this better. One could think of dynamic screening models in which the changes in the loan pool quality are endogenous.

In Chapters 5 and 6, we modelled bank competition in screening only, ignoring competition in lending interest rates. Future research could come up with models where banks would compete in interest rates in both lending and deposit markets.

Also in Chapters 5 and 6, banks perform screening of loan applications independently. The results of screening of one bank are statistically independent of the results of the other bank. However, in reality the results could be correlated. Future researchers could account for a correlation in screening results.

Last, but not least, this thesis has been totally theoretic. Future research should test empirically the predictions of the models of this thesis.

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RINAT MUKMINOV

DEPOSIT MARKETS, LENDING MARKETS AND BANK SCREENING INCENTIVES

In the period from 2007 to 2009 the world experienced the deepest financial crisis since the Great Depression. The world economy was in the most severe recession since the Second World War. The financial crisis was followed by a debt crisis in the euro area, which is still far from being resolved. The world economy is yet to recover from the crisis.

The financial crises are recurring phenomena. The financial crisis of 2007-2009 is in many ways similar to the previous crises. It has been argued that banks' poor screening incentives at the peak of the business cycle are one of the main causes of the recurring crises. Bank screening literature argues that in boom times, when the majority of loan applications are good, the price competition between the banks intensifies, leading to lower returns from screening loan applicants. As a consequence, screening standards decline and many bad loans end up on the bank balance sheets. Defaults of the bad loans lead to a deterioration of the banks' loan portfolios, which causes credit crunches and bank crises.

There is also an emerging finance literature arguing that a lower cost of funds, such as a lower cost of deposits, cheaper credit in the interbank market, a lower discount rate, encourages the banks to take excessive risks. Excessive risk-taking by the banks can also lead to a bank crisis.

These two approaches explain excessive bank risk-taking from two different points of view: the former one from the point of view of bank revenues, while the latter approach explains excessive risk-taking from the point of view of bank costs.

The aim of this dissertation is to build a bridge between these two approaches. This dissertation contributes to the screening literature by explicitly introducing the cost of funds into a bank screening model. This is novel, as most previous bank screening literature has assumed the deposit market to be fully competitive with zero interest rate, thus ignoring the impact of the deposit interest rate on bank screening incentives. This dissertation also extends the literature, which explores the effects of costs of funds on the bank risk-taking, by explicitly modelling the banks' investment in screening of potential loan applicants.



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HELSINKI
ARKADIANKATU 22, P.O. BOX 479
00101 HELSINKI, FINLAND
TEL +358 (0)9 431 331. FAX +358 (0)9 431 33 333

VAASA
KIRJASTONKATU 16, P.O. BOX 287
65101 VAASA, FINLAND
TEL +358 (0)6 3533 700. FAX +358 (0)6 3533 703

PUBL@HANKEN.FI
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