A Computational Study on the Effects of the Organizational Structures on the Risk of Different Types of Banking Groups

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Chapter 1

Introduction

Banks are effective institutions for reorganizing the economy and ensuring long-term macroeconomic stability, as well as a competent platform for monetary control. In recent years, the global banking sector has undergone numerous changes. The Basel Committee has attempted to develop capital and banking regulations at various phases following the financial crisis in order to strengthen regulatory supervision and risk management in the banking sector.

The global financial crisis impressively demonstrated the weaknesses of the western financial system. The crisis affected all major banking systems, although the effects varied due to different economic starting conditions and structural weaknesses. According to estimates, about 3 trillion euros were wiped out in terms of market capitalization of banks in the United States and other western economies in Europe, 82% of that were lost in stock market value of banks from May 2007 until March 2009 (Altunbas, Manganelli, and Marques-Ibanez 2011). About $1 trillion has been lost by top U.S. and European banks on risky assets and from bad loans since the start of 2007. The financial crisis showed that the stability of systemically important banks and the banking sector in general can affect the economy and create substantial social costs. It was impossible to avoid the worst effects of the financial crisis without massive assistance from central banks and governments.

The financial crisis in 2008 also put the German banking system under pressure. The German banking system with its special three-pillar structure of private commercial banks, public sector banks, and cooperative banks was bombarded by one of the biggest financial crises in history. Prior to the financial crisis, Germany's flourishing economy had an impact on the unemployment rate, which fell from 12% in 2004 to 7% in 2007, but then climbed to 8.1% in 2009[1].

Some German banks were heavily affected, whereas the local saving banks and cooperative banks did well. Indeed, after a brief period of loss in 2008, the savings banks' profits were as high in 2009 as they were in 2007, while their private sector counterparts were still losing money (Hassan 2014). During this period, big banks reduced their medium and long-term lending to companies but savings and cooperative banks increased them. Consequently, the whole banking system encountered fewer losses and performed better among other important economies (Flögel and Gärtner 2018).

Therefore, it leads to the question: What gave the saving and cooperative banks such a rather strong position? Inside the German banking system with its universal banks, one can not only distinguish commercial, savings and cooperative banks, but also identify whether banking structures are rather centralized or decentralized (Stefan Gärtner and Franz Flögel 2014).

The thought arose that the structure of the bank could be very important to lubricate the loan market and banking relationships. Also, due to banks' special role in business and society, the banking sector is very sensitive to trust. If the bank customers lose confidence in the safety of their deposits, the banks can no longer fulfill their functions. The main idea of this dissertation is to compare banking structures and consider which aspects of banking structures, like decision-making, information transmission and banking relationship structure, could be helpful in stabilizing the banking system.

With regard to assessing the financial stability of banks, the purpose of this dissertation is to present different theoretical models for bank to compare centralised and decentralised banking structures. Although both types of banks serve the same function as financial intermediaries, proponents of decentralizing the banking structure argue that decentralized banks were not as affected by the recent global financial crisis as centralized banks and are therefore assumed to be more stable due to the inherent differences within the banking

[1]URL: https://www.statista.com/statistics/227005/unemployment-rate-in-germany/

structure.

The outline of this dissertation is as follows: Chapter 2 provides an overview of the most important characteristics of German banking system, wherein the focus particularly lies on the crucial differences that might affect financial stability. Chapter 3 presents a literature review and definitions of the relevant studies in the field of decision-making, information and banking relationship in combination with financial stability.

Chapter 4 provides a discussion on the study of the decision-making structure of the banks. In this chapter, a theoretical model is developed to compare centralized and decentralized banking structures within the context of lending policy. The problem for both banks is choosing an expansive credit policy or a restrictive credit policy without having complete knowledge of the state of the overall and local economies, i.e. signals. Observing and appraising hard local signals which are based on verifiable information about local economies is the benefit of the centralized banking system, whereas considering unverifiable information about local economies' so-called soft signals is an important asset of the decentralized banking system. To compare two banking systems, the risk-return trade-off method on Systemic Expected Shortfall (SES) and Expected Return (ER) are used.

Chapter 5 describes and compares the resilience of the different banking systems within the context of deposit business. A theoretical bank run model based on Chari-Jagannathan (1988) is developed, to compare centralized and decentralized banking structures during bank shocks when managers communicate strategically with their depositors to protect themselves from inefficient bank runs. There are conditions under which decentralized banking structures increase overall welfare. The research shows that bank resilience would be higher for small banks in event of banks being hit by an aggregate liquidity shock due to higher trustworthiness in relationship banking. Finally, chapter 6 summarizes the main conclusions.

Chapter 2

The German Banking System

The functionality of the economy needs a comprehensive banking system. Historical developments shows that the German banking system is stable and robust. Traditionally, the German banking system is the universal banking system, according to which banks handle all kinds of financial transactions. The structure with the three pillars are credit banks (which include the well-known large banks as well as foreign banks and small private bankers), savings banks, and cooperative banks. The savings banks are the most important sector according to the Deutsche Bundesbank with around 30% of the credit business volume of the entire banking industry in Germany (Bundesbank 2020b).

To ensure the functionality of the banking system and to guarantee the vital trust, supervision of banking is necessary. Therefore, there is the independent Bundesbank as a central bank, which is a bank of the state and a bank for the banks.

The supply of liquidity to an economy is crucially important in the real world. Its development has a strong impact on the supply and demand of goods. The money supply takes place through the issuing from central bank and the credit and money creation of the commercial banks. Therefore, banks are the first addressees of the monetary policy of the Deutsche Bundesbank.

Banks also need a certain position of power if they want to meet their corporate objectives and goals from a macroeconomic perspective. This position of power must be based on a responsible compromise between the interests of owners, customers and society. The position of the commercial and central banks requires special legal bases. The banking legislation is based on the German Federal Bank Act (BBankG), the Banking Act (KWG) and several special laws (e.g. for public credit institutions, mortgage banks, etc.)(Plumpe, Nützenadel, and Schenk 2020).

The close connection between banks and companies increased at the time of industrialization. In Germany, companies finance themselves to a large extent through bank loans. In contrast, American companies for example take in more debt securities that they sell on the stock market. Sufficient capital was available in Germany, but it had to be mobilized first. In the early industrialization, this task was taken over by the private bankers. In the long term, however, the private banks were unable to meet the rising capital requirements; other sources of capital and a better distribution of risk had to be achieved. Therefore, the branch banks emerged which was the rise of the savings banks and the cooperative banks (Naßmacher et al. 2013).

A short time later, the mortgage banks took over the financing in the construction of commercial and residential buildings properties. In the 19th century, due to the upswing economy and improved political framework conditions, big banks which are still of great importance in the German credit system today, were founded. Among them the Bayerische Vereinsbank (1869), the Commerzbank and the Deutsche Bank (1870) and in 1872 the Dresdner Bank were founded. In 1876 the Reichsbank was founded as the central bank for the German Empire (Hackethal 2003).

After almost 200 Joint-stock banks had emerged within a few years, concentration processes began in the period that followed, in which private banks and provincial banks were pushed back or taken over by larger banks (Riesser 1911). During this period from 1895 to 1923, the German universal banking system emerged, in which savings banks and cooperatives gained a growing share of the market.

The banking system in Germany differs between the central bank and business banks. Business banks are divided into universal banks and specialized banks. The latter are real credit institutions and banks with special functions. The different components of German banking system can be seen in the following figure. The so-called three-pillar System consists of commercial banks, savings banks and cooperative banks. The German banking system is very competitive due to its highly diversified structure. There are a variety of financial indicators that reflect how competitive German banks are. Business concentration is one financial metric that demonstrates a bank's competitiveness.

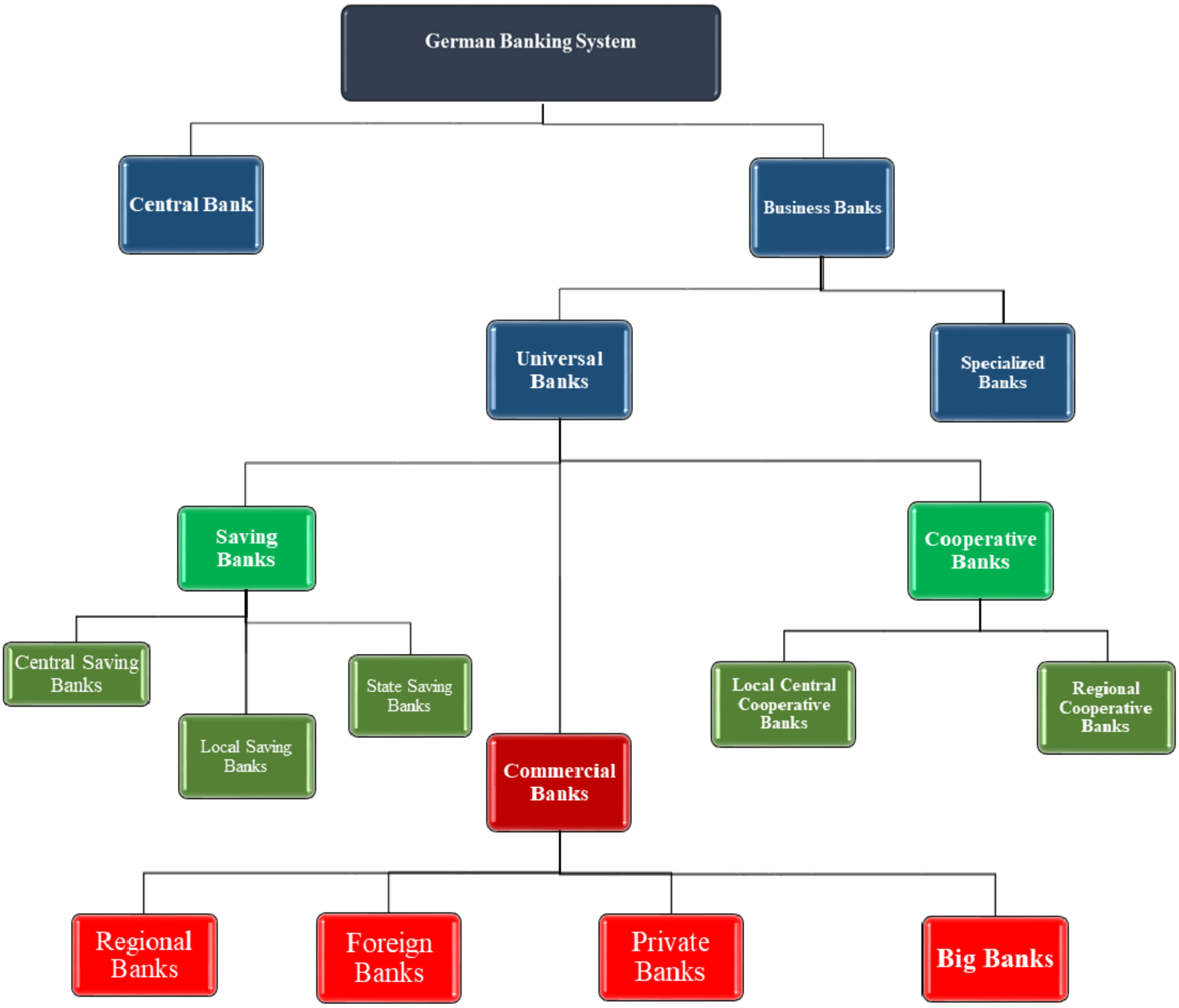


Figure 2.1: The German banking system diagram

The Herfindahl-Hirschman-Index (HHI) is one method of calculating business concentration. The HHI is a measure of banking business concentration based on total assets of banks. HHI number is scaled from 0 to 10,000. A higher HHI index value indicates greater business concentration. Germany has earned the lowest index among European countries during the last five years. By the end of 2021, the index was 289[1]. As a result,

[1]European Central Bank 2022, URL: https://sdw.ecb.europa.eu

the German banking sector can be inferred to be less concentrated and highly competitive.

2.1 The Universal Banking Sector

The German banking system is traditionally shaped by the universal bank type. Universal banks can conduct payment transactions, deposit and lending business as well as securities business with anyone. This does not preclude most types of bank specialization due to historical, regional or strategic reasons. In the Bundesbank statistics, the private credit banks, the savings banks and the cooperative banks are listed as universal banks. The term "credit banks" means universal banks that are organized under private law. Specially these are tend to be large banks, regional banks and other credit banks, foreign banks and private bankers.

2.1.1 Commercial Banks

The Deutsche Bundesbank traditionally refers to Deutsche Bank AG, Deutsche Zentral-Genossenschaftsbank (DZ bank) and Commerzbank AG as major banks. Besides those, UniCredit Bank AG (formerly Bayerische Hypo-Bayerische Hypo- undVereinsbank AG), Deutsche Postbank AG (from December 2004 up to April 2018) and DB Privat- und Firmenkundenbank AG (from May 2018) are big banks which correspond to the three major banks in terms of type and size. Characteristic for large banks are their universal orientation, large business volumes and a relatively dense nationwide branch network. Their reputation as issuers and their legal form as a stock corporation make it easier for the major banks to adjust their equity capital to their capital requirements. With regard to their fields of business, they are hardly subject to any restrictions. The securities business - securities commission, custody and issuing business - is one of the main pillars of their business activity. In international business, the major banks, together with the top institutions of the savings banks, cooperative banks, the regional banks, occupy the dominant market position. According to the Bundesbank, the share of the major banks in the total volume of business in the German banking industry was about 24% by the end of 2020. (Bundesbank 2020b).

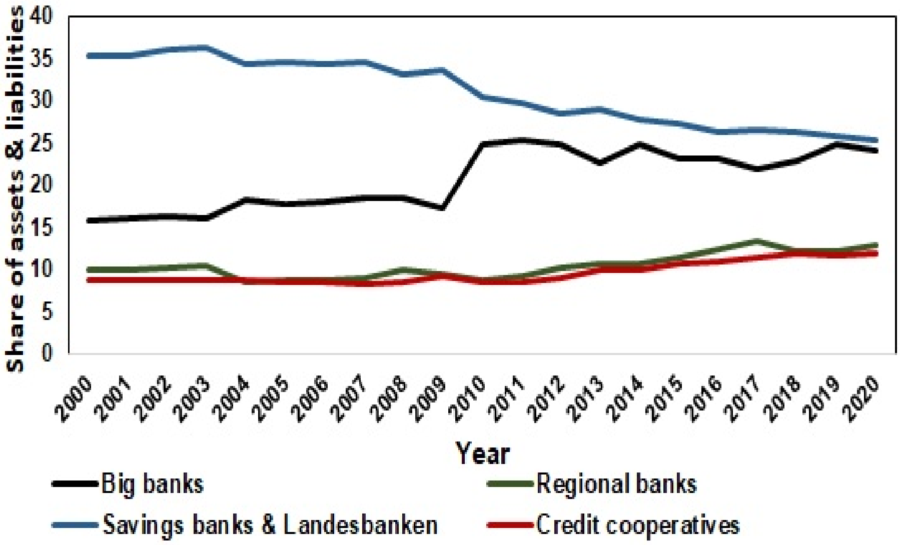


Figure 2.2: Share of principal assets and liabilities according to the balance sheets of four different types of German banks
Source: Deutsche Bundesbank

Another group within commercial banks is the group of regional banks and other credit banks. The designation regional bank, which suggests a geographically limited business area, is no longer applicable for many of the large regional banks (Bayerische Hypo- und Vereinsbank AG, BHF-Bank AG and BfG-Bank AG) because they operate nationwide (Gilquin 2014), (Naßmacher et al. 2013). Approximately 151 regional banks and other credit banks have a share of roughly 14% in the business volume of the banking industry (Bundesbank 2020b). The third group in commercial banks is the group of foreign banks which are branches of non-German banks. They comprise of both legally dependent branches that are managed according to the law of the foreign parent company, as well as majority-owned credit institutions of foreign banks that are subject to German law. The business volume of the foreign banks is around 5% of the total volume of the banking industry.The fourth type of commercial bank is the private banks. There were 276 private banks in Germany in 2019. Some of them, such as Joh. Berenberg, Gossler Co. (established in Hamburg in 1590), B. Metzler Seel. Sohn Co. KGaA (formed in Frankfurt in 1674) and Delbrück Co. (founded in Cologne in 1712), are among Germany's oldest banks (Hackethal 2003).

2.1.2 Saving Banks

The savings banks group is the largest banking sector in Germany. The savings bank organization in Germany is designed as a three-tier network consisting of the state saving banks, the regional Landesbanken and Deka Bank.

The first German public savings bank was established in Göttingen in 1801. The Prussian savings bank regulation on 1838 mandated all 234 Prussian savings banks the jurisdiction of the respective local governments. There were a total of 2,700 public institutions at the turn of the twentieth century (Hackethal 2003).

At the end of 2020 there were 386 savings banks with around 9000 bank branches. With a share of approximately 25% of the business volume of the entire German banking industry, the savings banks represent the preeminent banking group in Germany (Bundesbank 2020b). The original task of the savings banks was to provide investment opportunities and loans to small and medium-sized businesses. Compared with large banks, their profit sources are more concentrated on net interest income, with a focus on traditional lending to households and Small and Medium Enterprises (SMEs). With around 36% of the balance sheet total, the saving banks are the most important way of raising funds; they hold a total of 50% of the total savings deposits in Germany (Bundesbank 2020b). The long-term customer deposits are the basis for the granting of long-term loans, which are the focus of the savings banks' lending business.

Housing finance - especially in the form of mortgage loans - and lending to municipalities and associations of municipalities (Kommunalkredit in the true sense of the word) or to other public budgets are also important tasks of these banks. Special features of the savings bank sector are Gewährträgerhaftung (guarantor's liability) and Anstaltslast (maintenance obligation). Anstaltslast means that the institution must keep its savings bank operational. The guarantor's liability means that municipalities have unlimited liability for the obligations of savings banks to third parties (Naßmacher et al. 2013).

On a supraregional level of local saving banks, there is the 'DekaBank', which is active in all over Germany. On the level of federal states, there are the so-called 'Landesbanken'. This is the second level of the savings bank organization which are legally independent institutions under public law sponsored by the respective federal state, whilst also being members of the savings Banks and Giro Associatio. The state, other land banks, and regional savings groups own the majority of land banks. The primary purpose of these regional organizations is to give administrative support to their members, which are regional savings banks. Also the Landesbanken concentrate on businesses with large corporate customers, institutional investors and local authorities, while the regional savings banks mainly conduct retail business and business with smaller companies (Hackethal 2003).

All of the financial institutions mentioned above are represented in the association structure, which is led by the German Savings Banks and Giroverband (DSGV), which represents the savings bank group. It should be noted that the savings bank group is not a hierarchical organization with a top-down central planner.

2.1.3 Cooperative Banks

The cooperative banks with 812 banks and 8566 bank branches at the end of 2020 (Bundesverband der Deutschen Volksbanken und Raiffeisenbanken 2021), has the densest network in Germany alongside the savings banks and Deutsche Postbank AG, but at around 12% it has a significantly lower share of the business volume in the banking industry than the savings banks and Landesbanken (Bundesbank 2020b). The cooperative sector was originally structured in three levels, with the primary cooperatives on the first level, the regional central banks on the second and the Deutsche Zentral-Genossenschaftsbank (DZ Bank) as the supraregional top institution on the third level. They are united in the Federal Association of German Volksbanks and Raiffeisenbanks (Bundesverband der Deutschen Volksbanken und Raiffeisenbanken (BVR). The BVR, headquartered in Berlin, is the main organization of the German credit cooperatives and cooperative banks. The companies in the Cooperative Financial Network are also affiliated with it. In line with the cooperative tradition, the decision-making bodies (management board) and supervisory bodies (administrative council, association council, and general council) are formed democratically. The BVR is basically an economic and political influence association who is also responsible for the central security system of the cooperative banks (Pertl 2019). The members of the BVR are the 812 German cooperative banks (Volks- und Raiffeisenbanken, Sparda-Banken, PSD-Banken, Kirchenbanken). The cooperative central DZ bank covers the cooperative financial network (Bausparkasse Schwäbisch Hall AG, R+V-Versicherung, DG Hyp Deutsche Genossenschafts- Hypothekenbank AG, VR Leasing AG, and others), and the cooperative auditing associations (Baden-Württembergischer Genossenschaftsverband e.V., Genossenschaftsverband Bayern e.V., and others) (Bundesbank 2020b).

The cooperative central bank complements the range of services offered by their affiliated credit cooperatives, (especially in the areas of securities and international business) enable the cooperative banks to grant large loans through meta-credits, handle payment transactions between the credit cooperatives and serve as a source of refinancing (Naßmacher et al. 2013). The DZ Bank is a public corporation whose share capital is held by the regional central banks and their related companies. It works on the national and international financial markets as the cooperative banking organization, with a focus on the securities business. In the lending sector, DZ Bank grants loans both directly to large corporate customers, primarily from the cooperative sector, and indirectly through regional central banks and credit unions (Guinnane et al. 2013).

2.2 Banks with a Specialized Range of Services

Real estate credit institutions (Immobilienkreditinstitute) are credit institutions under private or public law that specialize in granting medium- to long-term loans. Mortgage banks refinance themselves by issuing mortgage bonds, municipal bonds and global loans from capital collection agencies. Most mortgage lenders have economic interests in the major banking groups (Hardegen 2005).

The building societies (Bausparkassen), which are run as private companies in the legal form of joint-stock companies or as public-law Bausparkassen belonging to their regional savings bank organization. They are the only banks which are allowed to conduct the so-called special purpose Bauspar business. With the Bauspar, the customers form a closed money circuit, which allows them to obtain liquidity for the loan from the deposits of the savers, decouple the interest on the Bauspar assets and loans from the market interest rate and to fix it for the entire term of the contract. In addition to the prime real estate loans of the mortgage banks, the Bausparkassen provide subordinated secured loans. In addition to the savings deposits of the Bauspar customers, financing is secured by loans from banks and capital institutions and by issuing bearer bonds.

The 19 German special-purpose banks all have one thing in common: they give loans to individuals, businesses, and projects that the German government deems appropriate for development. For example, the private Industriekreditbank promotes SMEs that might otherwise be unable to access finance markets. The AKA Ausfuhrkreditgesellschaft, which is backed by other German banks, supports German companies by providing export financing and direct loans to their international customers (Hackethal 2003).

According to Bank office report (Bundesbank 2020a), the number of specialized banks were 111 institutions at the end of 2020. These 111 institutions were 10 private building and loan associations, 8 public building and loan associations, 10 mortgage banks, 19 special purpose banks, 47 housing enterprises with savings facilities, 16 guarantee banks and 1 central securities depositories.

Chapter 3

Organizational Structure Of Banks

Banks have their own organizational structures that describe the relationships among personnel, the jobs they execute, and the roles and duties they provide. A well-organized bank accomplishes effective coordination, establishes a structure for formal communication channels, and connects the operations of individual activities. There has always been a link between a bank's organizational structure and its managers' decision-making strategy. A bank's structure can have a significant impact on its decision-making structure and plays an important role in improving the bank's efficiency (Fahey 1981). A portfolio of different types of banks with varied characteristics can alter the quality of a country's banking system, depending on the cultural structure of a bank, the cultural structure of the regions in which the banks operate, and the type of decision-making structure of the banks.

This chapter gives an overview about the characteristics of two types of banks, centralized and decentralized banks. The review of publications is first demonstrated, then the elements of these two structures are discussed, and lastly the two decision-making structures are compared.

The results of a small research study comparing these two types of banks will be discussed in order to determine which type of bank performs better in terms of risk and return performance measures.

3.1 Related Literature

3.1.1 Banking Structures

Different types of financial sectors exist in different countries. A country with only one bank would be an extreme example of a centralized banking system. A country having several distinct banks located around the country is an example of a decentralized system. As a result, looking at the number of bank headquarters on a map is a relatively simple way to see if a country is centralized or decentralized.
The distribution of bank headquarters in European countries and the United Kingdom is depicted in Figure 3.1. Every location is a representation of one of the headquarters.

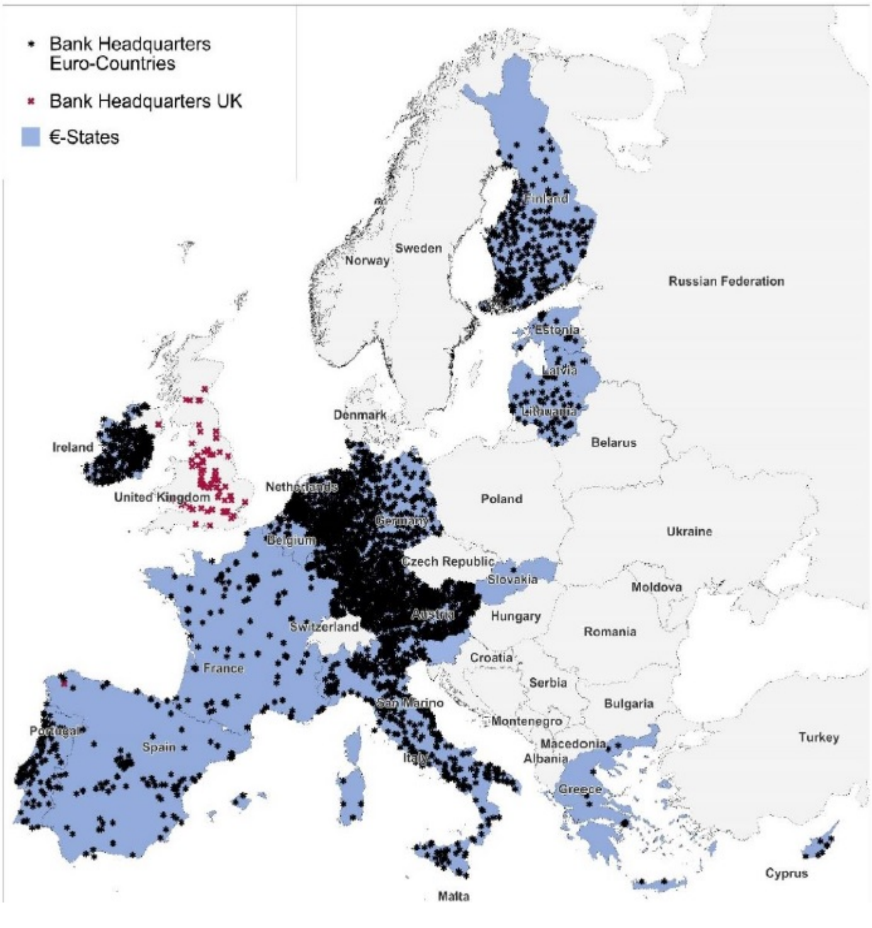


Figure 3.1: Bank headquarters locations in the Euro countries in 2014 and the UK in 2017
Source: Gärtner, Flögel (2018)

Based on the accumulation of spots, one can easily determine that Germany, along with Austria, Ireland, Italy, and the Netherlands, has a decentralized financial system.

France, Spain, and the United Kingdom are examples of centralized countries (Flögel and Gärtner 2018). Not only does the number of different banks indicate whether a country's financial system is centralized or decentralized, but the distribution of those banks also plays a part in determining whether it is centralized or decentralized.

If multiple banks exist, no one declares it to be a decentralized financial system; rather, it is more likely that they are all located in the same location. Gärtner and Flögel (2018) explained that the percentage of headquarters located in the top three financial centers in the particular countries when compared to all headquarters could be another way of measuring the centralization of the banking system. If the percentage is 100%, it is an indicator that the banking system is fully centralized, whereas when it is weighted towards to zero the banking systems are well spread throughout the country and is therefore more decentralized. The analysis confirms the impression that for example Germany has a decentralized banking system with the ratio of 10.91%, while countries like Luxembourg, Cyprus, Belgium, and Slovakia have the highest percentage rates ranging from 85.99% to 99.99%, which shows they have centralized banking system.

The impact of the financial system on enterprise funding in various regions, which may result in uneven development in these areas, is a reflection of the banks' unequal distribution structure. Small firms and startups, on the other hand, benefit from the lack of a centralized financial system because obtaining loans through a centralized banking system is more difficult (Klagge and Martin 2005). Competition is another result of a decentralized financial system. Increased competition may result in greater efficiency at the expense of financial stability. (Allen and Gale 2004).

The bank can be classified as either centralized or decentralized. These two systems can be distinguished by two properties. The first is based on geographycal point of view. (Flögel and Gärtner 2018). It makes a difference whether a bank is regional or supraregional. Regionally operating banks gather money from local savers and invest it in the same area. It also suggests that local or regional managers are free to make their own choices. While supraregional indicates that banks can spend their money wherever they desire, it also implies that central planner decisions control the investment structure. This raises the possibility of financial contagion and a bank run, in which a shock in one financial market spreads to others (Allen and Gale 2000).

The distance between a bank staff and a consumer is another crucial factor to consider. Decisions taken at a local branch and those made at headquarters can be distinguished. If bank managers are easily available or located near businesses, banks tend to be decentralized.

Despite the fact that large central banks have a huge branch network, distance is not the sole concern. Furthermore, when describing a bank's structure, functional distance is critical. As a bank's complexity develops, so does its functional distance. Various management levels, the number of different bank operating units, and the number of different functions within a bank organization can all be used to characterize complexity (Berger and Udell 1995a).

Bolton et al. 2016 introduced a bank structure based on a long-term relationship and simply a market transaction. They explain the differences between relationship and transactional lending during a crisis. Transactional lenders' banks are interested in the borrower's banking transactions in order to support them financially with the various instruments, financial goods, and services that a bank provides. The location and distance would have no impact on the result. Hierarchical or transactional lenders can be linked to big or centralized banks.

Relationship lenders' banks evaluate a borrower's profitability based on multiple interactions and possibly additional products and services (Boot 2000). Relationship lending has a deeper connection to decentralized institutions, where a banking relationship can build over time. Sette and Gobbi 2015 showed that the lending policy offered by relationship lenders is most likely due to the informational advantage that relationship lenders have. They conclude that the effect of relationship lending is stronger in more concentrated local credit markets, where the value of relationship lenders' rents is higher because borrowers have fewer opportunities to switch to other lenders.

3.1.2 Centralized vs. Decentralized Banks

In the following, the benefits and drawbacks of centralized and decentralized banks are explored so that the effects of the organizational structure can be assessed. Of course, the practicality and potential profitability of a project are the only factors in a credit decision, not a location near a financial center. However, it would be important to place a bank near a financial center in order to gain access to the specific knowledge of other markets or to benefit from new technologies or product innovations. In other words, financial centers experience positive economies of scale and scope as a result of numerous benefits accumulating in one location and resulting in synergistic effects (Flögel and Gärtner 2018). Centralized banks, on the other hand, tend to have better hierarchies, and managers do not give line units the authority to make final decisions. As a result, a bank may have an inefficient amount of bureaucracy. Furthermore, when a branch manager's manager ignores their data and decides to invest in another project, their incentives to gather sufficient and valuable information on an investment or customer may be weakened (Stein 2002). Another risk is that information may be lost due to noisy communication between different levels of the hierarchy (Dessein 2002). Furthermore, if a financial center contains multiple banks and other financial institutions, firms located nearby may be preferred by those banks (Klagge and Martin 2005). This is reasonable because information about these companies is likely to be more easily accessible. As a result, all firms located outside of the financial center face a competitive disadvantage.

Bank managers, on the other hand, play a crucial role in decentralized banks. They gather information, analyze enterprises, and then make decisions based on their implementation and evaluations. As a result, bank managers in decentralized banks are experts in their own economies. Customers in different locations may have distinct demands, and decentralized banks can meet those needs by offering a diverse range of services and products based on local expertise and understanding. In a banking relationship, the consumer is more inclined to disclose more information, and the branch officer would be more motivated to obtain information. When it comes to long-term contracts, this permits them to be more flexible. Bank managers in decentralized banks have a good understanding of local politics, culture, and businesses (Stefan Gärtner and Franz Flögel 2014).

The decentralized system has some drawbacks as well. When banks operate in the regional savings-investment cycle, they rely heavily on the region's economy if they invest money in the same region. As a result, if decentralized banks are located in weak areas, they may face high risks and low profit opportunities. In terms of risk diversification, this can be a major issue. Decentralized banks may be less efficient in general due to the lack of capital movement across different locations caused by the regional principle. Decentralized banks have a lower cost of screening potential borrowers, but due to a lack of coordination, their decision-making may result in unproductive outcomes (Holmberg, Sjögren, and Hellström 2012).

Finally, there is the risk of becoming enslaved to the bank, and with all of the information a bank has gathered, it has a monopoly on information to some extent. This could lead to higher loan rates. As a result, customers may be reluctant to borrow from the same bank again (Canales and Nanda 2012).

3.1.3 Hard Information and Soft Information

Advances in information technology have changed the small business lending area, and "hard" measurable and verifiable information, numbers and data about the companies have become available. Information can be classified as hard if it can be measured quantitatively. It is often publicly available for example through annual reports. Moreover, hard information tends to be standardized and constant over time, making it easier to deal with.

Small business lending rely heavily on "soft" information that gathered through banking relationships. Soft information is more qualitative than hard information. It is about concepts, ideas, and points of view. As a result, communication is not possible in numbers, but rather in texts or, occasionally, verbally. The issues arise because only the official who collects all of the information has complete knowledge, which is primarily based on a personal conversation with the customer.

Aghion and Tirole 1997 state that, in contrast to hard information, it is difficult for another official who must interpret soft information as a recommendation to verify the information gathered. Credit decisions are not made only on the basis of the past because there is always a subjective assessment of future prospects. For this impression, soft information is crucial. Soft information that officials can collect through a solid connection is vital, especially for small and information-impermeable enterprises that do not offer much publicly available information (Stiroh 2004).

Soft information can be associated with relationship lending because it is easier to collect the necessary details over time. Moreover, it is easier for decentralized banks to consider soft information in the final lending decision for two reasons. First, low geographic distance from the customer facilitates access to soft information. Second, the low functional distance in the internal organization makes it easier to deal with this type of information. To offer further thoughts, relationship lenders and decentralized banks are particularly important for SMEs because of the value of soft information that influences their credit rating (Agarwal and Hauswald 2010).

In summary, centralized banks are effective when distance from the customer is not important. As a result, these banks are associated with pure transaction lenders and their decision-making structure is based mainly on hard information. In contrast, decentralized banks are close to their customers and can easily gather soft information. Over time, a good relationship with customers can develop. Since local branch managers are experts in their respective fields, decentralized banks give clients better services.

3.2 The Banking Structures in Germany

To explain the centralized and decentralized banking structures in Germany and their impact on the German banking system as a whole, it is important to take a closer look at the structure of the German banking system. As mentioned in the first chapter, German banks are classified as three-pillar systems. The German banking system is a bank with some specialized banks. Specialized institutions engage in only selected business activities, mainly due to their interorganizational structure in terms of the chosen regulation or centralization of management. Big banks such as commercial, savings bank and cooperative banks engage in banking activities at all business levels. The first group, the so-called major banks were Deutsche Bank, Dresdener Bank, Commerzbank

AG and Hypo-Vereinsbank. Since the merger of Commerzbank AG and Dresdner Bank in 2009, the four major banks have been renamed Deutsche Bank, Commerzbank AG, Hypo-Vereinsbank and Deutsche Postbank AG.

The group of regional banks concentrate on particular regions and furthermore, a minor group called the private banking groups. The private banking groups are specialized in particular activities such as securities trading.

The savings bank sector contains two groups: the primary savings banks (Sparkassen) and the Land Banks or Landesbanks (also known as "state savings banks" or "central giro institutions"). Most local savings banks are only allowed to operate in their region. This includes lending and doing business in their area, meaning they are part of a two-tiered system of savings banks.

Landesbanken, as part of the second group, act as clearing houses for local savings banks in their regional area. Both groups have public functions and belong to their local governments (Bauer and Domanski 1999).

The credit cooperative sector is similar to the savings bank sector and they also have a two-tiered system. It must also be noted that regional institutions of credit cooperatives have the task to offering clearing services to credit cooperatives. They are also involved in other activities such as securities trading and investment banking. The members of credit cooperatives, such as local individuals and firms, own the local credit cooperatives. In general, cooperative institutions are owned by their local credit cooperatives.

Savings banks and cooperatives are both part of the public banking sector and therefore have a public mission. Moreover, public banks are owned through public shares and guaranteed by the federal government (Koetter et al. 2004).

3.2.1 Comparing Centralized and Decentralized Banks in Germany

As it was mentioned in the previous section, the big banks in Germany are assumed to be centralized banks, whereas saving banks are decentralized banks that work under the public law and where decisions are made peripherally. To compare these two structures the following sub-chapters focus on the business structure of these banks based on two different approaches.

The position that affects the assets quality in banks are mostly adjusted by loans. Stefan Gärtner and Franz Flögel 2014 pointed out that centralized banks nearly dropped their loan lending during the crisis, whereas decentralized banks experienced the opposite. Figure 3.2 shows that in the course of the financial crisis decentralized banks consistently increased lending.

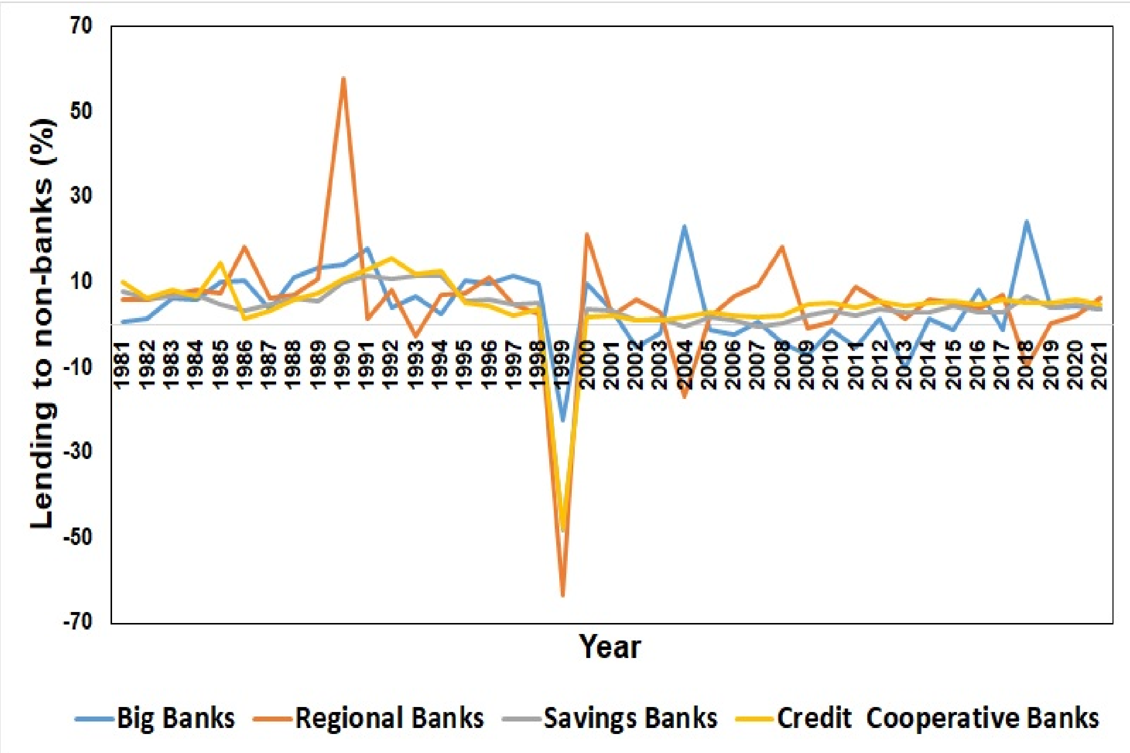


Figure 3.2: Lending to non banks for the German banks categories
Source: Deutsche Bundesbank

The percentage changes in lending to non-bank from saving banks and small banks is slightly decreased by 2008 but then it start to increase in. For the large banks those decrements were tremendous.

Figure 3.3 shows how the big banks' Return on Equity ratio (ROE) dropped dramatically from 20% to -22%. As a result, during the financial crisis, decentralized banks' loan lending had a stabilizing influence on the economy.

Particularly because of their regional orientation, proximity to clients, and extended customer ties, all of these factors contributed to excellent outcomes, which were amplified during the financial crisis (Schackmann-Fallis and Weiß 2017).

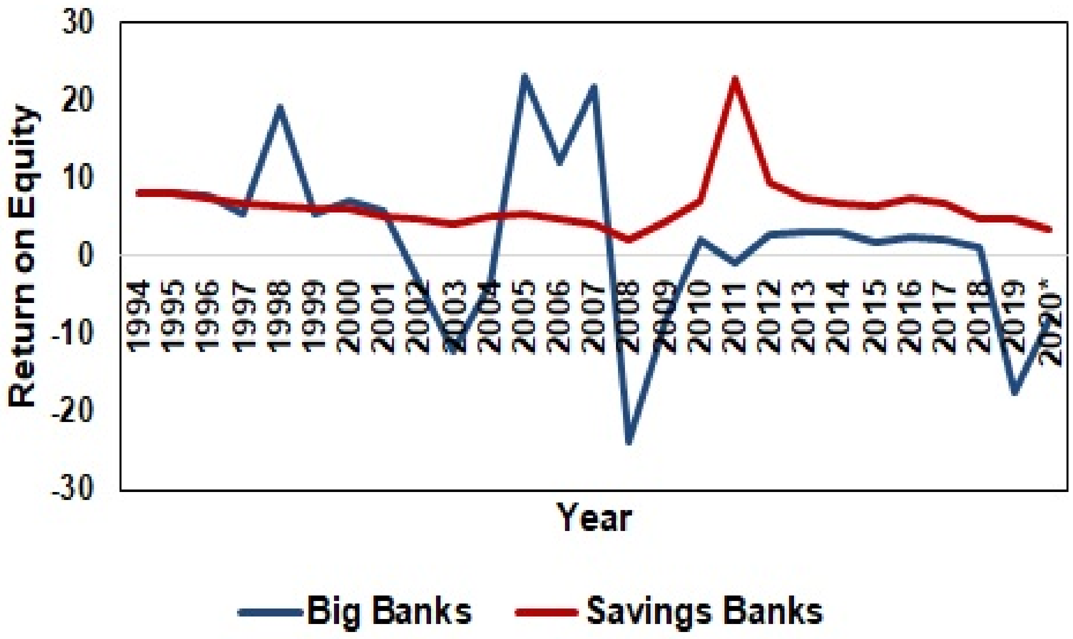


Figure 3.3: Return on equity for the big banks and saving banks
Source: Deutsche Bundesbank

In Germany, the number of banks has also fallen in recent years, from 1,711 in 2016 to 1,532 in January 2020 (Bundesbank 2020b). Multiple domestic bank mergers occurred in the EU prior to the Global Crisis, when the majority of countries experienced an increase in banking concentration between 1996 to 2007 (Masciandaro and Quintyn 2009).
The concentration ratio and Z-score from 1996 to 2016 are depicted in figure 3.4. It indicates that the German financial system's stability suffered during the crisis, but rebounded within two years. During the pre-crisis period, Germany's concentration ratio increased from 76.19 percent to 85.36 percent, whereas concentration ratios dropped from 2010 to 2016. Also, in comparison to the EU countries the German banking system is always more stable than Euro area (Economist 2012).

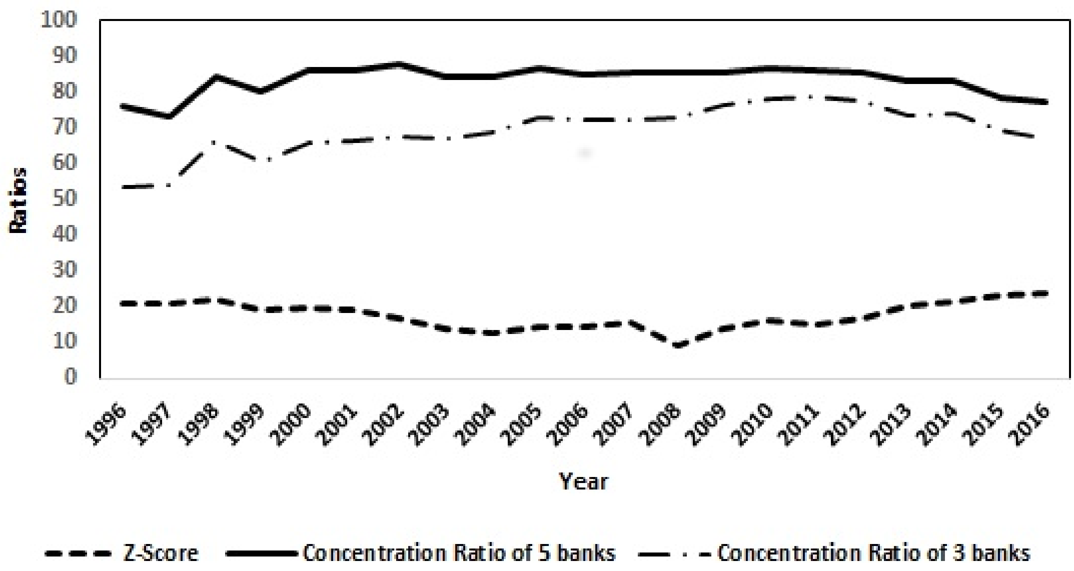


Figure 3.4: Z-score and concentration ratios of German banks during 1996-2016

Source: Federal Reserve Economic Data (FRED)

3.2.2 Brief Empirical Analysis of Representative Banks

In this section, the analysis focuses on German banks in terms of their profitability and stability. Due to the lack of data in our data source, it was decided to select and compare representative banks from each banking group. Therefore, the bank's annual reports as a source for collecting the required data were used. To analyze banks empirically, different types of measures can be used. Two common ratios Return On Assets (ROA) and Return On Equity (ROE) are used from 2006 to 2019 to compare profitability of two structures. The balance sheets of banks are used to calculate annual net income (Jahresüberschuss), total assets (Summe der Aktiva), and total equity (Eigenkapital). I used the same approach as cited in the thesis Schaal 2019. Due to a lack of data for banks, sample forms of decentralized banks are used. As a result, for the decentralized banks, the data contains two samples from "savings banks," "Volksbanken Raiffeisenbanken," and two general overviews of these banks in the forms of "Sparkassen aggregated" and "Volksbanken aggregated." The time period 2006-2019 was chosen to monitor profitability ratios during and after the crisis.

For the centralized banks the data is constructed from 6 banks. 'Deutsche Bank', ‘Commerzbank’, ‘Postbank’ and ‘Deutsche Kreditbank’ (DKB) are major or big German banks. DekaBank and DZ bank are centralized banks too. DekaBank is part of the second pillar of the German banking system. The Savings Banks Group’s core asset manager is DekaBank. It also has international presence in different countries, including branches, subsidiaries, representative offices, and is centrally organized. Therefore it is assumed as centralized bank. The same reasoning applies to DZ Bank, which is part of the third pillar and is linked to the Volksbanken and Raiffeisenbanken, but has a centralized organizational structure.

One reason why these banks are suitable to illustrate centralized banking structures, is the fact that they are part of the 30 largest banks in Germany and are important for the German economy (Hackethal 2003). ´Savings banks’ , ’Volksbanken Raiffeisenbanken’ and ’Sparda banks’ were used as examples of decentralized banks in the analysis. To compare decentralized banks with centralized ones, the aggregated and income statement of all these banks have been taken. The annual reports of the cooperative banks have been taken from the Bundesverband der Deutschen Volksbanken und Raiffeisenbanken annual report [1]. For the savings bank, the aggregated annual reports have been taken from the Finanzgruppe Deutscher Sparkassen- und Giroverband annual report[2]. I also used ’Bundesanzeiger’[3] which is the central platform for official announcements and notices as well as for legally relevant company news for gathering the data of the whole Sparda banks group and missing data. Therefore, five savings banks, five cooperative banks, and Sparda banks were aggregated and analyzed. Five different local banks were chosen in order to provide a diverse sample of banks. The savings banks ’Kreissparkasse Böblingen,’ ’Sparkasse Herford,’ ’Sparkasse Koblenz’, ’Sparkasse Krefeld,’ and ’Stadtsparkasse Düsseldorf’ were used as the ’Sparkassen sample’. The ’Volksbanken sample’ is comprised of ’Berliner Volksbank’, ’Dortmunder Volksbank,’ ’Volksbank BraWo,’ ’Volksbank Stormarn,’ and ’VR Bank München Land.’ In addition, in Germany, the ’Sparda’ banks are eleven cooperative banks that are affiliated with the ’Verband der Sparda-Banken e. V.’ The Sparda bank group operates on the regional principle (Regionalprinzip), which means

[1]URL: https://www.bvr.de/Publikationen/Jahresbericht
[2]URL: https://www.dsgv.de/sparkassen-finanzgruppe/publikationen
[3]URL: https://www.bundesanzeiger.de/pub/de

that each individual bank is responsible for a specific business area. As a result, it is a decentralized bank with eleven legally independent banks.

Profitability of Centralized and Decentralized Banks in Germany

In this sub-section I am going to analyse the profitability of the selected German banks. It is interesting to see which organizational structure can outperform its counterpart in terms of ROA and ROE. To compare theses two organizational structure, the information from their balance sheets were collected.
Table 3.1 provides the banks' average ROA and ROE rankings from the year 2006 to 2019. Centralized banks are labeled (C), while decentralized banks are labeled (DC). Centralized banks tend to have a lower equity ratio compared to decentralized banks. Centralized banks perform better in terms of ROE than ROA. It should be mentioned that centralized banks' total assets are substantially higher than those of decentralized banks due to their size. Their ROAs and ROEs, on the other hand, are considerably better than those of decentralized banks.

Average Return on Asset 2006-2019

Bank	ROA %
DKB (C)	0.36
Volksbanken aggregated (DC)	0.32
DekaBank (C)	0.27
DZ Bank (C)	0.25
Volksbanken sample (DC)	0.21
Sparda Bank (DC)	0.2
Sparkassen sample (DC)	0.15
Postbank (C)	0.14
Commerzbank (C)	0.08
Sparkassen aggregated (DC)	0.07
Deutsche Bank (C)	0.03

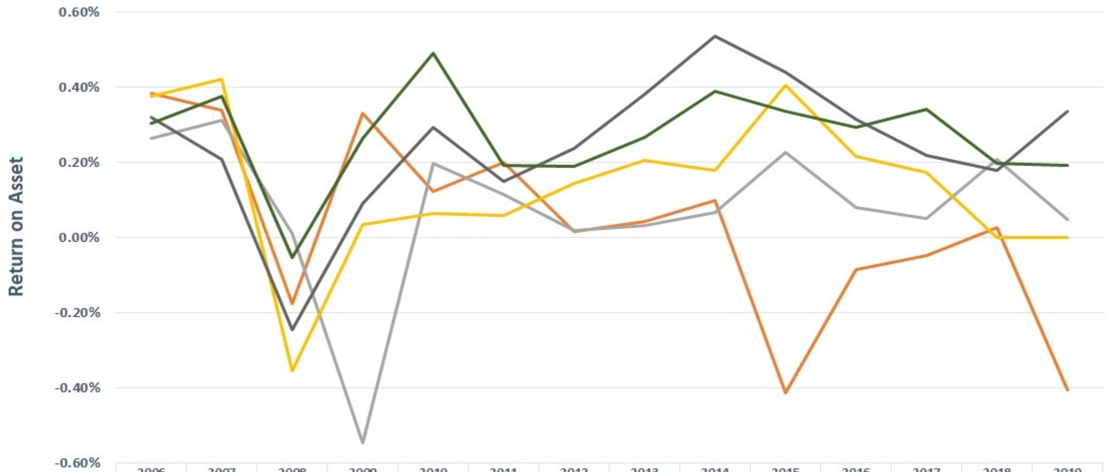
Average Return on Equity 2006-2019

Bank	ROE %
DKB (C)	8.62
DekaBank (C)	7.41
DZ Bank (C)	6.51
Volksbanken aggregated (DC)	6.02
Sparda Bank (DC)	5.01
Volksbanken sample (DC)	3.19
Postbank (C)	3.55
Sparkassen sample (DC)	2.62
Deutsche Bank (C)	2.25
Commerzbank (C)	1.85
Sparkassen aggregated (DC)	1.19

Table 3.1: Bank ranking based on average profitability ratios in percentage

I used the two sample t-test to compare the average ROA of centralized and decentralized banks from 2006 to 2019. With a degree of freedom of 20, a t-value of -0.55, and a p-value of 0.29, the difference was not significant. Therefore, no general conclusion can be drawn from the average values to deduce which form of organization is generally more profitable.

Figures 3.5 and 3.6 depict the ROA of centralized and decentralized banks, respectively. Considering the 2008 global financial crisis, this time period is of particular interest for assessing bank profitability.

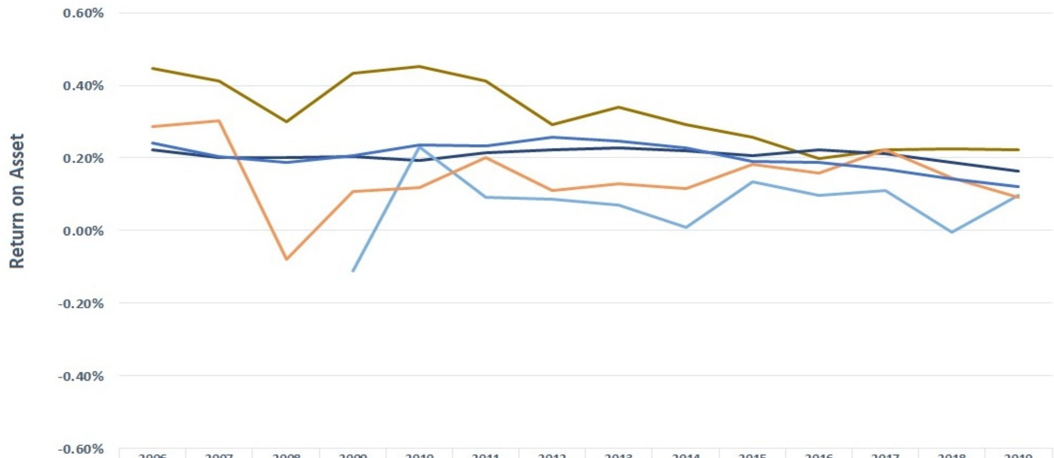


	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Deutsche Bank	0.38%	0.34%	-0.18%	0.33%	0.12%	0.20%	0.02%	0.04%	0.10%	-0.42%	-0.09%	-0.05%	0.03%	-0.41%
Commerzbank	0.26%	0.31%	0.01%	-0.55%	0.20%	0.11%	0.02%	0.03%	0.07%	0.23%	0.08%	0.05%	0.21%	0.05%
Postbank	0.38%	0.42%	-0.35%	0.03%	0.06%	0.06%	0.14%	0.20%	0.18%	0.41%	0.22%	0.17%	0.00%	0.00%
DZ Bank	0.32%	0.21%	-0.25%	0.09%	0.29%	0.15%	0.24%	0.38%	0.54%	0.44%	0.32%	0.22%	0.18%	0.33%
DekaBank	0.30%	0.38%	-0.05%	0.26%	0.49%	0.19%	0.19%	0.26%	0.39%	0.34%	0.29%	0.34%	0.20%	0.19%

Figure 3.5: Return on Assets of centralized banks from 2006-2019

The performance of centralized banks differs significantly from that of decentralized banks during this period. Every single centralized bank in this analysis has a year with negative results in either 2008 or 2009.

However, the costs of Commerzbank's 2009 merger with the failing Dresdner Bank must be considered. Allianz finally gave up in August 2008, selling Dresdner Bank to Commerzbank for €9.8 billion, less than half the price it had paid. Senior executives at Commerzbank were no doubt laughing all the way to the bank after refusing the original deal only to pick up Dresdner in the bargain basement seven years later (Thomas and Weber 2016). The merger of Commerzbank and Dresdner Bank in 2009 resulted in a significant increase in Commerzbank's total assets which affects the denominator of the ROA ratio. Nevertheless, the trend is clear among central banks that these banks are likely to suffer losses in the crisis period.



	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Volksbanken aggregated	0.45%	0.41%	0.30%	0.43%	0.45%	0.41%	0.29%	0.34%	0.29%	0.26%	0.20%	0.22%	0.22%	0.22%
Volksbanken sample	0.22%	0.20%	0.20%	0.20%	0.19%	0.22%	0.22%	0.23%	0.22%	0.21%	0.22%	0.21%	0.19%	0.16%
Sparkassen aggregated				-0.11%	0.23%	0.09%	0.09%	0.07%	0.01%	0.13%	0.10%	0.11%	0.00%	0.10%
Sparkassen sample	0.29%	0.30%	-0.08%	0.11%	0.12%	0.20%	0.11%	0.13%	0.12%	0.18%	0.16%	0.22%	0.15%	0.09%
Sparda bank aggregated	0.24%	0.20%	0.19%	0.21%	0.24%	0.23%	0.26%	0.25%	0.23%	0.19%	0.19%	0.17%	0.14%	0.12%

Figure 3.6: Return on Assets of decentralized banks from 2006-2019

In the decentralized banks group, Sparda Banks is also unique in that it is the only decentralized banking group with complete data. The bank's overall ROA reflects a strong and consistent performance. Also Volksbanks perform well in these years, both aggregated and as individual banks. In 2008, only the "savings bank sample" shows a loss. During the event of a crisis, savings banks are exposed to losses, which should be interpreted with caution. As previously stated, the sample consists of five banks, one of which, Sparkasse Düsseldorf, is a rather large savings bank when compared to the other banks in the sample. This bank experienced severe losses during the crisis, and as a result, the "savings bank sample" faced a significant loss.

Figure 3.7 shows the return on equity of centralized and decentralized banks. The table below the graph shows the ratio in percent.

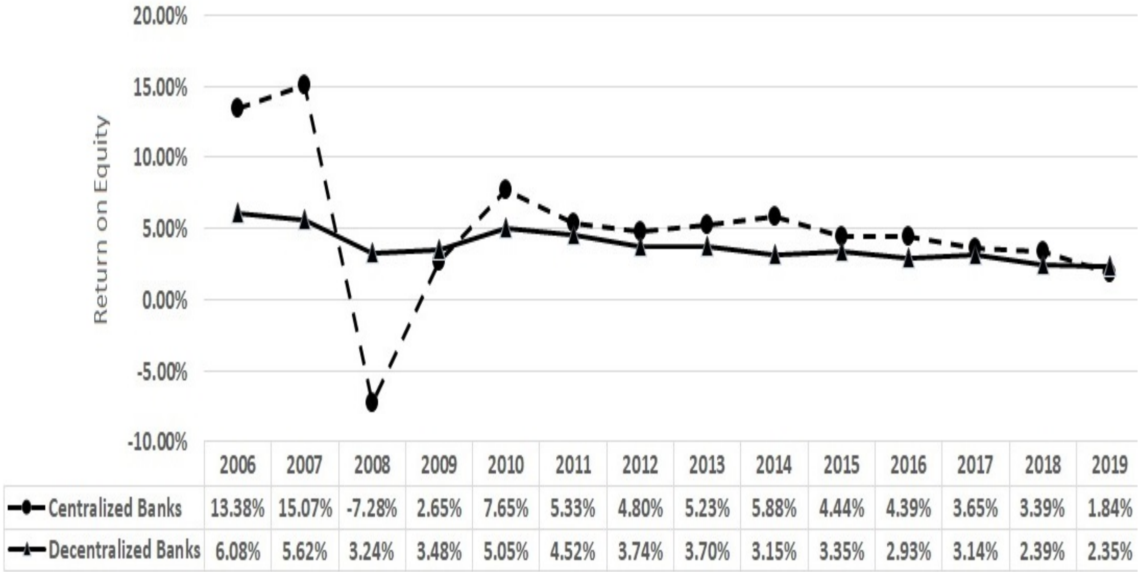


Figure 3.7: Return on Equity of centralized banks and decentralized banks

For the post-crisis period, the t-test was used once again on the data in figure 3.7. The ROE of centralized banks, which has a mean of 4.5 percent and a standard deviation of 0.016, is seen to be better to the ROE of decentralized banks, which has a mean of 3.4 percent and a standard deviation of 0.01. With a degree of freedom of 15, a t-value of 1.92, and a p-value of 0.04, the difference was significant. As a result, it can be stated that centralized banks are more profitable than decentralized banks. Decentralized banks, on the other hand, appear to be successful and steady based on their profitability measures. Overall, the German banking sector did well throughout this time period, as reflected by positive ratios.

Stability of Centralized and Decentralized Banks in Germany

The Z-score, which is defined as the standard deviation of the ROA, is used to compare bank stability. In contrast to profitability ratios, average Z-scores yield a clear result at first glance. Z-score, is used by different authors ((Beck, De Jonghe, and Schepens 2013),(Beck and Laeven 2006),(Boyd, Graham, et al. 1986),(Maechler, Mitra, and Worrell 2005),(Garcıa-Marco and Robles-Fernandez 2008)) defined and calculated as;

$$Z - score_{it} = \frac{ROA_{it} + EQ_{it}}{\sigma_{ROAip}} \tag{3.1}$$

The numerator is made up of bank i's ROA in year t and EQ is the ratio of total equity over total assets of bank i in year t. The numerator represents the financial performance of a bank. As a result, it is used as a performance measure and a measure of a bank's financial stability. The standard deviation of ROA over the observed period is denominator.

The Z-score represents the amount of standard deviations that returns must deviate from the mean to wipe out bank equity. Higher Z-score values indicate a lower likelihood of insolvency and stronger bank stability. A low standard deviation indicates dependable profits, whereas a high standard deviation predicts unpredictable future returns. Köhler 2015 explained that the decentralized banks are more stable than centralized ones.

Decentralized banks have a substantially smaller standard deviation than centralized banks. Consequently, the Z-score ratio's denominator is smaller than for centralized banks. As a result, they would have a higher Z-score.

Decentralized banks also have a greater equity ratio, which helps to raise the Z-score. A high equity ratio allows banks to offset future losses, making it a crucial aspect in a bank's stability.

Figure 3.8 depicts the log value of the Z-score of equally weighted z-score of centralized and decentralized banking groups. Because of the significant difference in the banks' Z-scores, and to put it into proper perspective, the log value of the Z-scores is used.

The gray solid line, as seen, represents the z-score of decentralized banks. The line is relatively straight and nonfluctuating. The z score of centralized banks is represented by the dashed black line.

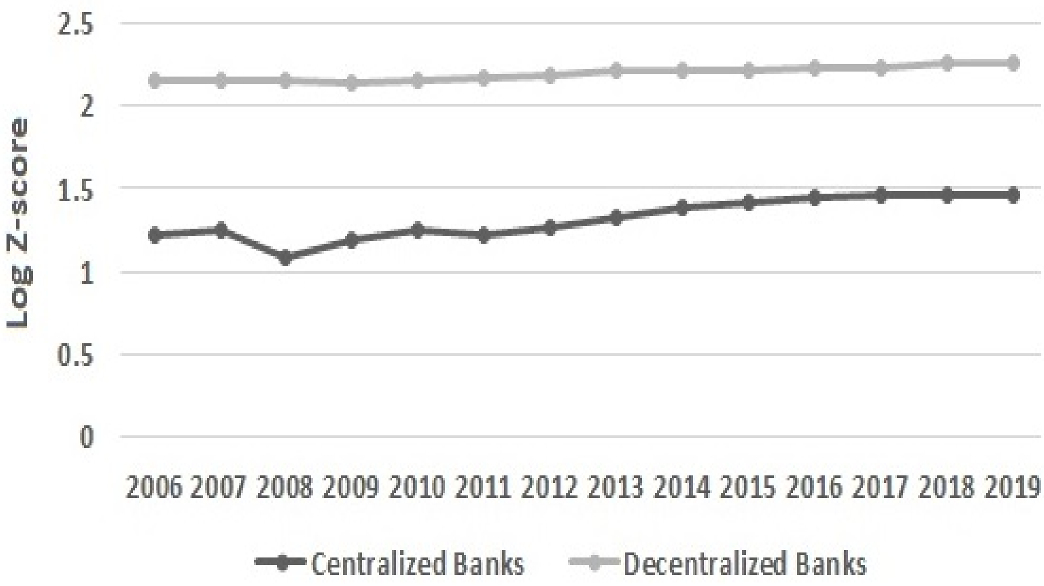


Figure 3.8: Z-score of centralized banks vs decentralized banks from 2006-2019

Decentralized banks' Z-score, with a log mean of 2.19 and a standard deviation of 0.04 was found to be higher than centralized banks' Z-score, with a log mean of 1.31 and a standard deviation of 0.12. With a degree of freedom of 16, a t-value of 25.78, and a p-value of less than 0.001, this difference was significant. As a result of our findings, decentralized banks appear to be more stable than centralized banks.

3.3 Discussion and Conclusion

Based on our small-scale findings, centralized banks are predicted to earn more profits than decentralized banks. However, with centralized banks, bigger earnings are accompanied with much higher risks. The effect of efficient customer targeting compensates the lack of regional diversification, which explains why decentralized banks have lower risk. The last significant finding demonstrates that decentralized banks' profits decline less than centralized banks' profits during times of crisis. This could be taken as a sign of stability. The benefit of decentralized banking structures such as saving banks or cooperative banks is noticeable. However, some disadvantages arise as a result of their organizations' decentralized structure. These banks have strong ties to their local communities because of the regional principle. This implies that these banks are heavily reliant on the local economy. This applies to both businesses looking for loans for investments and individuals looking to save money at a local bank.

Furthermore, the profitability ratios as well as the Z-score depend only on hard information. The importance of soft information for evaluating potential customers cannot be forgotten. Such information would also be useful for predicting the stability of a bank. It is the qualitative information about a bank's plans that would give further insight into stability as well as the Z-score. Monitoring and evaluating based on banking relationships becomes more important when your business is based on the local economy. Soft information about possible mergers of branches, mergers with other banks, staff reductions, or a general restructuring of the organization could be relevant for the future of the bank. All these aspects are important for employees, shareholders, as well as potential loan customers. Stability, therefore, also depends on aspects that are associated with soft information but are not included in the analysis.

In general, bank competition, further technological innovations, and the trend toward consolidation and concentration lead to changes in the entire banking business. These aspects could also have an impact on the German banking system. With the increment of consolidations, competition between the three pillars could increase. As the stability of each individual bank is essential, this topic remains relevant for the future, and even more so, considering that the number of stable decentralized banks is decreasing. Further analysis is needed to fully understand all the aspects leading to a stable banking system. Two models will be introduced in the following two chapters. To begin, the two banking systems will be compared using a decision-making model for lending relationships that uses both hard and soft information. The dissertation will then conclude with the introduction of a theoretical model of deposit relationships based on Chari and Jagannathan's 1998 bank run model.

Chapter 4

Centralized vs Decentralized Banking Systems

4.1 Introduction

The German banking system with its special structure and high share of public banks is ideally suited for a systematical analysis of the structure of financial systems and their characteristics. The financial crisis exerted the German banking system to immense pressure. This system with its special three-pillar structure of private commercial banks, public sector banks, and cooperative banks was bombarded by one of the biggest crises in history. During the ten years prior to the global financial crisis the trend of unifying and assigning the entire financial system to a single authority spread out to the whole Europe. Different papers have shown how the number of banks decreased in the past, e.g. in the USA (Berger and Udell 1995b) or in Germany (Fiorentino and Herrmann 2009). Also in recent history, the number of banks in Germany decreased from 1,711 in 2016 to 1,532 in January 2020 (Bundesbank 2020b). Before the Global Crisis, multiple domestic bank mergers happened in the EU and, then the majority of the countries experienced an increase in banking concentration over the years 1996-2007 (Masciandaro and Quintyn 2009). Some German banks were heavily affected, whereas the local saving banks and cooperative banks did well. Indeed, after a brief period of loss in 2008, the savings banks' profits were as high in 2009 as they were in 2007, while their private sector counterparts were still losing money (Hassan 2014). Private banks reduced their medium and long-term lending to companies but savings and cooperative banks increased them. Consequently, the whole banking system encountered with fewer losses and had better performance in comparison to other leading economies.

Scientists came up against the following question: What was the secret to the success of the savings and cooperative banks? Inside the German banking system with its universal banks, one can not only distinguish commercial, savings and cooperative banks, but also identify whether banking structures are rather centralized or decentralized (Stefan Gärtner and Franz Flögel 2014). A very simple approach to investigate if one country is rather centralized or decentralized is by looking at the number of bank headquarters on a map (Flögel and Gärtner 2018).

Many pieces of literature on bank lending to small companies explained how the organizational structure of banks can hinder small companies' access to credit (Rajan 1992) (Petersen and Rajan 1994) (Black and Strahan 2002) (Berger and Udell 1995a). They focused on the ability of smaller banks or decentralized banks to maintain bank lending relationships with small businesses. Siggelkow and Levinthal mentioned that a decentralized structure is an organizational structure when decisions are transferred to sub-units or subordinate organizational units. Those sub-units or subordinate organizational units are relatively autonomous and, as far as is possible, make their own decisions. Not only their decentralized structure but especially their decentralized lending structure gives them an important advantage when lending to small and medium enterprises (Canales and Nanda 2012).

The branch manager in a decentralized bank has far greater autonomy over decision-making and lending decisions than managers of centralized banks (Gärtner and Flögel 2015). When loan terms are set, branch managers often make use of so-called "soft information". Soft information is not easy comprehensible and very personal, which is why they can hardly be transmitted (Liberti and Petersen 2018). The use of soft information during the lending decisions gives decentralized banks an advantage in small-business lending compared to centralized banks (Canales and Nanda 2012) (Stein 2002).

Wegner and Burghof 2018 brought the preliminary idea based on Burghof and Müller 2013 that compare these two banks, but they did not focus on the characteristics of received signals for the managers and they did not include local economies and specifically soft information in their structures. The model is fundamentally built on these two models. First, I compare the banks using hard signals in the model. The decision set refers to two credit policies. The managers should decide whether to pursue an expansive credit policy[1] or a restrictive credit policy[2] based on their signals. Soft information will be added in the second phase. In the third section, assuming the financial institution has three branches, the smallest odd number on which I can implement the number of dominant signals has been chosen. Numerical analysis is used to compare two decision-making structures in the banking system. The fourth section concludes our findings.

[1]An expansive credit policy is defined as a strategy that bank offer high volume of loans and takes more risk

[2]A restrictive credit policy is a strategy in which a bank offers a limited number of loans in order to bear less risk, while also limiting loan offers to highly rated customers

4.2 The Model of Credit Decision Structure

4.2.1 The Basic Structure of the Model

In the basic model of banking structure, the central planner collects information from the local economies and, on the basis of this information, decides on lending policy. This setup may be interpreted as a model of a decentralized banking system in which decisions are delegated to the local branch manager, including soft information, or as a model of a centralized banking system in which decisions are made by the central planner without soft information.

To simplify the model, I assume that local managers in both banks are identical, so the local managers in both centralized bank and decentralized bank receive the same information about local economies. In decentralized banks local manager can decide about lending policy, whereas in centralized bank the central planner decides about it and the local manager only sends his verified information to the central planner. According to the Stein 2002, lack of incentive because of hierarchical structure of centralized caused local managers to exert little or no effort to gather soft information about the local economy and that is because the decision structure of the centralized bank is centrally planned. Please note that in reality branch managers have some authority to give loans in all banks but for the simplification of the model I assume based on Stein 2002, the above fact is useless to the model because in this theory they cannot make decisions. In decentralized bank soft information becomes important and helpful since local manager in this system can decide independently.

The Model

Consider a two-dates economy, $t = 0, 1$ with two types of banks and N regions. Each bank has N branches, operating in N regions, and they provide loans.

The banks' decision challenge is whether to be generous by employing expansive credit policies and providing a large volume of credit (H) or be strict by using limited credit rules and providing less credit (L), with maybe an incomplete information of the state of local and general economies.

Banks must rely on information from the economic environment, or signals, because they do not know all of the information about economies. As previously stated, centralized and decentralized banking structures are compared in the model. The decision mechanism in a centralized banking system could refer to the highest level of institution, which is known as the central planner (she), whereas in a decentralized banking system, the decision mechanism could refer to the lower layers or local branches of the bank, which are known as local bank managers (he).

The model's time frame is depicted in figure 4.1. Local managers in decentralized and centralized banking systems receive signals from their local economy at $t = 0$ and make lending policy decisions. The payoffs of the decisions would be calculated at $t = 1$.

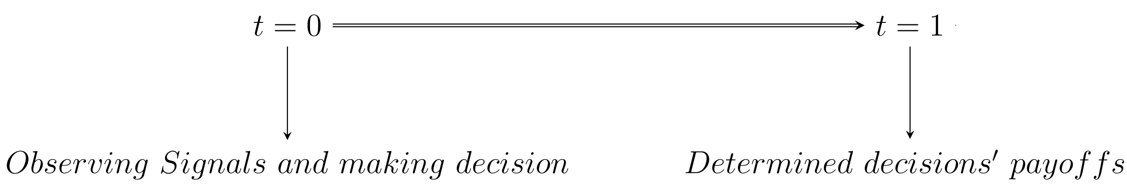


Figure 4.1: Time frame of the static model

The success and failure of the credit policy depend on both the state of local economy and general economy.

According to the table 4.1 each local branch encounters 4 possible states S_1 through S_4 with 4 different outcomes r_1 through r_4.

States	g	b
H	S_1	S_4
L	S_2	S_3

Returns	g	b
H	$r_1 = r$	$r_4 = -2r$
L	$r_2 = 0$	$r_3 = -r$

Table 4.1: Matrix of the states , matrix of returns with positive number r

The bank should make the highest profit if it is in a good local economic situation and has the expansive lending policy state (S_1), so consequently the bank then achieves a profit of $r_1 = r$. If the bank manager was careful enough in a bad economic state (S_3), the bank managers can presumably avoid losses or achieve minimum losses, i.e., $r_3 = -r$. It is quite unfavorable, however, if the bank managers pursues an expansive lending policy and then enters a bad economic state (S_4) which makes losses i.e., $r_4 = -2r$. To make the system realistic it is also assumed that in state (S_2) the bank has low risky position so the return r_2 would be zero.

4.2.2 Decision Making Structure for the Decentralized Banks

According to our assumptions, there are two banking structures in our model. For the sake of simplicity, at the beginning, I will focus on hard information or hard signals. Therefore, from now on, any signal is assumed to be a hard signal. Our model's assumptions are as follows:

Assumptions of the model

- The return of the project is based on the matrix payoff.
- The bank is risk neutral and has no time preference.
- The central planner has no extra information except that from the branch managers.
- The only channel of assessment is the loan item, and other items are equal in the balance sheets, so there are no other influences from other factors in the bank balance sheets on the returns.
- The weight of all local economies is equal.

The state of the entire economy G or B expresses as $\Theta = \{G, B\}$ and the state of local economy expresses as $\theta_i = \{g, b\}$ $i = 1, 2, \cdots, N$. The $p(\Theta)$ [3] assumes as the probability of good and bad state of the entire economy.

$$p(G) = \pi \ , \ p(B) = 1 - \pi$$

It is assumed that the state entire economy and the state of local economy have a correlation between each other, and therefore, the conditional probability of the state of

[3] For the sake of simplicity I use, $p(\Theta = G) = p(G)$ and $p(g)$ equivalent to $p(\theta_i = g)$

local economy θ_i, given the state of the entire economy Θ, is denoted by:

$$\begin{aligned} p(g \mid G) &= p(b \mid B) = \rho, \\ p(b \mid G) &= p(g \mid B) = 1 - \rho \end{aligned}$$

where $\rho > \frac{1}{2}$. Therefore, when $\rho \to 1$ the correlation between the local economy increases too.

Based on our assumption the local manager receives a signal from his local economy, therefore I assume that the local signal probability can be expressed as the conditional probability of the local signal given the state of local economy.

$$\begin{aligned} p(s^g \mid g) &= p\left(s^b \mid b\right) = \gamma, \\ p(s^g \mid b) &= p\left(s^b \mid g\right) = 1 - \gamma. \end{aligned}$$

where $\gamma > \frac{1}{2}$.
The representative structure of one regional branch as an event tree diagram is depicted in figure 4.2.
On the left side, the graph shows the structure of one big bank with N branches. In the tree structure, parent node is representative of the entire economy. The probability of being in the good state G is π which is an accessible general information of the entire economy and in the bad state B is $1 - \pi$.
In the next sibling nodes g and b are the nodes of i^{th} region with probability of being in a good local state ρ and in a bad local state $1 - \rho$. The logical explanation for having the symmetric structure of this tree is when you are at the parent node G the occurrence of g is probable so $\rho >\ 1/2$.
Each branch receives signal $s^{\theta_i} = \left\{s^g, s^b\right\}$ with the probability γ referring to his information set. Similarly when you are at the parent node g the occurrence of s^g is probable, thus $\gamma > 1/2$.

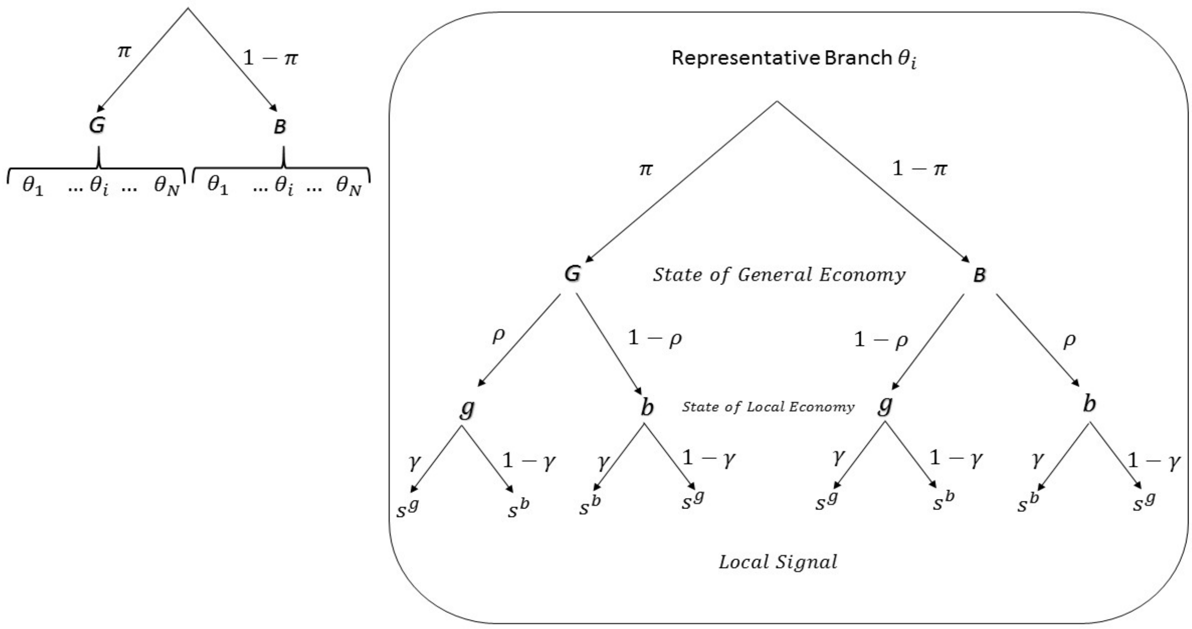


Figure 4.2: The event tree for the representative bank

The last part of event tree contains symmetric information of binary signals $\left\{s^g, s^b\right\}$ and according to the assumptions of the model, γ is a symmetric parameter for the probability of signals. The signal is a Symmetric Binary Signal (SBS) and in this case, they call γ as the precision of the signal (MacKay and Mac Kay 2003). But, using the definition of conditional probability, I define a belief of the signal as $prob\,(g \mid s^g)$ and $prob\left(b \mid s^b\right)$. For simplicity, the belief of the signal is called as the precision of the signal.

Definition 1. The precision of the signal is the measure which shows to what extent the signal entails the local economy *(Nimark 2013)*

The precision of the signal is used in order to formulate a local manager decision-making structure which helps him to realize how much the local state of economy can be described by the signal. When he receives the good signal s^g or the bad signal s^b the precision of the signal can be defined as conditional probability as follows:

$$prob\,(g \mid s^g) = \frac{\gamma\; p(g)}{\gamma\; p(g) + (1-\gamma)\; p(b)}$$

$$prob\left(b \mid s^b\right) = \frac{\gamma\; p(b)}{\gamma\; p(b) + (1-\gamma)\; p(g)}$$

The following expression defines the expected return of the local branch based on the probabilities of the different scenarios of local economy in the tree diagram.

Definition 2. Expected return for the representative bank is given by:

$$ER = r_1 prob(g \mid s^g).p(s^g) + r_2 prob(g \mid s^b).p(s^b)) + r_3 prob(b \mid s^b).p(s^b) + r_4 prob(b \mid s^g).p(s^g) \tag{4.1}$$

Risk measures are another essential performance indicators used by banks to avoid large losses. Three key risk measures have been identified in the literature. The most realistic risk measure is the standard deviation. The standard deviation is a measure of how dispersed two sets of data are (Bland and Altman 1996). However, the most often used risk metric, known as Value at Risk (VaR), is defined as a value that represents the maximum risk of loss at a given statistical confidence level or likelihood (Jorion 2000). VaR was being questioned by regulators as a basis for regulatory capital needs. Under Basel II, the establishment of minimum capital based on the stressed VaR metric was a significant example of new perspectives in banking supervision.
The third important downside risk, so-called "Expected Shortfall," is the average of exceeded losses which are greater than a threshold loss (VaR) or loss at a statistical confidence level. Because our approach is based on mathematical expressions, it is defined as the negative part of the expected return in this study. However, in the numerical simulation, VaR and expected shortfall are calculated using historical and variance-covariance methods. The following definitions are assumed for the VaR and expected shortfall: The first uses the Variance-Covariance method. The population is assumed to have a normal distribution.

Definition 3. The Value at Risk for the representative bank is given by:

$$VaR_p = -[\mu + L(p)\sigma] \tag{4.2}$$

The expected value of the outcomes is μ, and the standard deviation is σ. In the formula, the confidence level defines $L(p)$, which is the p-quantile of the standard deviation. For example, if the level of confidence is 99%, p equals 0.01 and $L(0.01) = -2.33$. The second method is the numerical method, which is known in literature as the historical method. If the level of confidence is 99 percent, the VaR denotes the 1% worst outcome. Conditional Value at Risk (CVaR) is the second definition of the expected shortfall, which can be driven from VaR. CVaR is calculated as the expected value of losses that are worse than VaR (Chen 2008). Using the numerical method, the expected shortfall at the 1% level is then the average losses, which are the worst 1% of the outcomes.

Definition 4. The expected shortfall for the representative bank is given by:

$$ES = r_3 prob(b \mid s^b).p(s^b) + r_4 prob(b \mid s^g).p(s^g) \tag{4.3}$$

Definition 5. The expected shortfall or Conditional Value at Risk (CVaR) using numerical method is given by:

$$ES_p = E(ER_i | ER_i < -VaR_p) \tag{4.4}$$

ER_i are the returns outcomes from the numerical decision making approach and VaR_p is the value at risk of the outcomes.

The following definition gives the expected return of choosing an expansive or restrictive credit policy, given that the branch manager receives a good or bad signal.

Definition 6. The expected payoffs from choosing high policy or low policy of the bank when the branch manager observes the good signal s^g is

$$\begin{aligned} \mathbb{E}[H \mid s^g] &= r_1\, prob(g \mid s^g) + r_4\, prob(b \mid s^g) \\ \mathbb{E}[L \mid s^g] &= r_2\, prob(g \mid s^g) + r_3\, prob(b \mid s^g) \end{aligned}$$

and when the branch manager observes the bad signal s^b is

$$\begin{aligned} \mathbb{E}[H \mid s^b] &= r_1\, prob(g \mid s^b) + r_4\, prob(b \mid s^b) \\ \mathbb{E}[L \mid s^b] &= r_2\, prob(g \mid s^b) + r_3\, prob(b \mid s^b) \end{aligned}$$

The relationship between the bank manager's decision and the signal is feasible if there is an incentive and participation mechanism, given that the best answers were extracted for the decision-making mechanism. As a result, the following remark must be valid:

Remark 1. Description of side constraints that make information decision relevant are given as:

$$\begin{aligned} \mathbb{E}[H \mid s^g] &> \mathbb{E}[L \mid s^g] \;\; \textit{when observed signal is } s^g \\ \mathbb{E}[L \mid s^b] &> \mathbb{E}[H \mid s^b] \;\; \textit{when observed signal is } s^b \end{aligned}$$

The local banks would like to provide a high volume of loans when the state of the local economy is good, and a low volume of loans when the state is bad.
Then what would be the critical values for $prob(g \mid s^g)$ and $prob(b \mid s^b)$? According to the remark 1 if $\mathbb{E}[H \mid s^g] > \mathbb{E}[L \mid s^g]$ then the manager chooses the high policy and if $\mathbb{E}[L \mid s^b] > \mathbb{E}[H \mid s^b]$ then the manager chooses the low policy. The following lemma describe a decision-making structure of the bank which depends on the precision of the signals:

Lemma 4.2.1. Decision mechanism of the local manager

1. When the local manager receives the good signal s^g, if the following conditions satisfied:

$$prob(g \mid s^g) > \frac{r_3 - r_4}{(r_1 - r_2) + (r_3 - r_4)} \;\; \Leftrightarrow \;\; prob(b \mid s^g) < \frac{r_1 - r_2}{(r_1 - r_2) + (r_3 - r_4)}$$

   then the optimal strategy is to choose expansive credit policy and provide loans, otherwise, the optimal strategy is providing low volume of loans.

2. When the local bank receives the signal s^b, if the following conditions satisfied:

$$prob(b \mid s^b) > \frac{r_1 - r_2}{(r_1 - r_2) + (r_3 - r_4)} \;\; \Leftrightarrow \;\; prob(g \mid s^b) < \frac{r_3 - r_4}{(r_1 - r_2) + (r_3 - r_4)}$$

   then the optimal strategy is providing the low volume of loans, otherwise, the optimal strategy is to choose an expansive credit policy and to provide loans.

Proof. Part 1

$$
\begin{aligned}
\mathbb{E}[H \mid s^g] &> E[L \mid s^g] \\
\Leftrightarrow r_1\, prob(g \mid s^g) + r_4\, prob(b \mid s^g) &> r_2\, prob(g \mid s^g) + r_3\, prob(b \mid s^g) \\
\Leftrightarrow r_1\, prob(g \mid s^g) + r_4\,(1 - prob(g \mid s^g)) &> r_2\, prob(g \mid s^g) + r_3\,(1 - prob(g \mid s^g)) \\
\Leftrightarrow r_1\, prob(g \mid s^g) - r_4\, prob(g \mid s^g) + r_4 &> r_2\, prob(g \mid s^g) - r_3\, prob(g \mid s^g) + r_3 \\
\Leftrightarrow ((r_1 - r_2) + (r_3 - r_4))\, prob(g \mid s^g) &> r_3 - r_4 \\
\Leftrightarrow prob(g \mid s^g) &> \frac{r_3 - r_4}{(r_1 - r_2) + (r_3 - r_4)} \\
&\Downarrow \\
prob(g \mid s^g) > \frac{r_3 - r_4}{(r_1 - r_2) + (r_3 - r_4)} &\equiv prob(b \mid s^g) < \frac{r_1 - r_2}{(r_1 - r_2) + (r_3 - r_4)}
\end{aligned}
$$

Similarly the second part can be proven. □

Corollary 4.2.1.1. The ratios $\frac{r_3 - r_4}{(r_1 - r_2) + (r_3 - r_4)}$ and $\frac{r_1 - r_2}{(r_1 - r_2) + (r_3 - r_4)}$ are the efficient threshold or critical values for the decision mechanism of the the local manager. There exist $\hat{\gamma}_g$ and $\hat{\gamma}_b$ so that $prob(g \mid s^g(\hat{\gamma}_g)) = \frac{r_3 - r_4}{(r_1 - r_2) + (r_3 - r_4)}$ and $prob(b \mid s^b(\hat{\gamma}_b)) = \frac{r_1 - r_2}{(r_1 - r_2) + (r_3 - r_4)}$.

Under decentralized structures, as long as information or signals are based on hard or verifiable information, the pure diversification effect also favors centralized banking in the sense that using aggregated information is more efficient. The signal is assumed to be a hard signal in this section. Therefore, in a representative bank with a centralized or decentralized structure, the probability $p(s^{\theta_i})$ is the same.

4.2.3 Decision Making Structure for the Centralized Banks

In the centralized decision-making structure, all of the branches choose the lending policy which is determined by higher supervision: the central planner. In this system the lending decision is perceived by the central planner more precisely. Therefore, she decides for each branch if they should pursue their own signal, or she persuades them to change their lending policy based on an analysis of the aggregated signals from the local economies. Building up the central planner decision-making structure, it has to be showed that the requirements of her decision-making structure exist. In fact the central planner estimates the state of the entire economy based on the cumulative information of states of local economies.

The updated probability of the state of the entire economy can be expressed as a macro-signal $\mu^{\theta} = \left\{\mu^{G}, \mu^{B}\right\}$. Regarding the new information of the entire economy, the central planner is going to update the local managers signals. As mentioned before, she will decide to change the local bank manager decision or let him to follow his lending policy. The preceding discussion shows that the decision made by the central planner is more precise than the decisions made by each of the local managers in the decentralized system. Besides, some pieces of information exist which are not captured by μ. If the aggregated information could help the central planner to improve the decision structure and therefore improve the outcome result, then the central planner asks the local manager to pursue her decision. In other words, the number of signals, the correlation of the branches, state of the entire economy and the precision of signals help the central planner to get more information about the entire economy.

To explain the central planner comprehensions, we use the partial conditional probability or -Jeffrey conditionalization introduced by Sir Harold Jeffrey (Jeffreys 1998) to build a mathematical structure of her decision-making.

The Jeffrey conditionalization is about the probability of the entire economy Θ given that each of the conditional event, local economies θ_i, has occurred to a degree $prob^{c}(\theta_i \mid s^{\theta_i})$[4] or degree of belief and it changes from 0% to 100%. By using local information and updating from old to new probabilities the precision of the macro signal from the state of general economy defined as follows:

Definition 7. The precision of the Macro-signal

The precision of the macro signal μ is defined as the partial conditional probability of the entire economy, Θ, assuming that each of the local economies θ_i occurred with a degree of $prob^{c}(\theta_i \mid s^{\theta_i})$;

$$p(\mu^{\Theta}) \equiv p(\Theta \mid \theta_1 \equiv prob^{c}(\theta_1 \mid s^{\theta_1}), ..., \theta_N \equiv prob^{c}(\theta_N \mid s^{\theta_N})) \tag{4.5}$$

[4]In view of foregoing, I use upper index 'c' to show that the belief of the central planner is different than the local manager and the parameter is updated by the central planner estimation

where $\Theta = \{G, B\}$.

Jeffrey conditionalization is a special case of partial conditional probability in which the condition events must form a partition (Jeffreys 1998)(Draheim 2017). Draheim explains about probability specification or frequency specification of conditional probability. He defined so-called Frequentist Partial conditionalization or F.P. conditionalization from the resulting partial conditionalization, which generalizes the notion of classical conditional probability. According to the assumptions local economies are mutually independent and therefore the local economies can be assumed as partitions of the entire economy.
Assuming a local economy with good signal in the entire economy, the Jeffrey Conditionalization over a single condition $p(\mu^G) \equiv p(G \mid g \equiv prob^c(g \mid s^g))$ for a single frequency specification $g \equiv prob^c(g \mid s^g)$ such that $0 < p(g) < 1$ is as follows:

$$p(G \mid g \equiv prob^c(g \mid s^g)) = prob^c(g \mid s^g)p(G \mid g) + (1 - prob^c(g \mid s^g))p(G \mid b) \tag{4.6}$$

In other words, the above method can be used to calculate the precision of the macro signal, which represents the entire economy.
The following lemma is an extension of the later formula for the more than one partitions events that derived from Draheim[5](Draheim 2017). The central planner estimates the entire economy based on related weighted belief of each signal since the number of signals also affects her approximation[6]. Therefore, the macro signal is estimated using a mathematical induction approach by the central planner.

Lemma 4.2.2. The macro signal estimation using Jeffrey Conditionalization
Given an F.P. conditionalization

$$p(\Theta \mid \theta_1 \equiv prob^c(\theta_1 \mid s^{\theta_1}), ..., \theta_N \equiv prob^c(\theta_N \mid s^{\theta_N}))_J$$

such that the events $\theta_1, ..., \theta_N$ form a partition, and, furthermore, the frequencies (precisions

[5]Generalized Jeffrey Conditionalization: A Frequentist Semantics of Partial Conditionalization. Page 36, Theorem 3.3

[6]Please note that the summation of the precision of signals for each bank is one, but for more than one branch, the weighted value should be considered, and for convenience, we use the same symbol for $prob^c$ as previously.

of the signals) $prob^c(\theta_1 \mid s^{\theta_1}), ..., prob^c(\theta_N \mid s^{\theta_N})$ sum up to one, then:

$$p(\mu^{\Theta}) = p(\Theta \mid \theta_1, ..., \theta_N)_J = \sum_{i=1}^{N} prob^c(\theta_i \mid s^{\theta_i}).p(\Theta \mid \theta_i) \tag{4.7}$$

Local economies in our model assumptions are mutually independent and the sum of the related weighted precision of each local signals is equal to one. Therefore, lemma 4.2.2 can be used as an updating process for the central planner.

Corollary 4.2.2.1. The following model can be used for the approximation of the statement of the overall economy.
The good economy based on the good economy signals can be approximated by:

$$p(\mu^{G}) = p(G \mid \theta_1, ..., \theta_N)_J = \sum_{i=1}^{N} prob^c(\theta_i \mid s^{g_i}).p(G \mid \theta_i) \tag{4.8}$$

or the bad economy based on the bad economy signals can be approximated by:

$$p(\mu^{B}) = p(B \mid \theta_1, ..., \theta_N)_J = \sum_{i=1}^{N} prob^c(\theta_i \mid s^{b_i}).p(B \mid \theta_i) \tag{4.9}$$

Using the Jeffrey conditionalization approach the central planner does the following steps to estimate the state of the entire economy based on the received signals. Decision-making process of the central manager in the centralized bank can be expressed as 5 following steps.

Step 1 When the central planner receive signals she estimates the macro signals using the Jeffrey Conditionalization (Draheim 2017) approach from Lemma 4.2.2.

Step 2 The central planner compares the signals from (4.8) and (4.9).

Step 3 She estimates the probability of the entire economy $p^C(\Theta)$ by comparing macro signals.

Step 4 She transmits her new information $p^C(\Theta)$ to local managers to update the precision of their signal according new information.

Step 5 The central planner compares the expected returns of expansionary and restrictive credit policies and decides whether to make the decision autonomously and change the branch manager strategy or to delegate the decision.

In the first 4 steps, the process can be implemented as an update process, which is used based on decision-making lemmas. But in step 5, after updating, the central planner compares the results because the information is hard and this information is accessible. This approach would not be so efficient for the bank with one branch, and the decision could differ only based on the lemmas for the decision-making structure of the representative branch. But if there were more branches, the game would change, and the impact of the number of local economies could change the whole scenario.

Now, taking into account the general and local signals, the decision-making structure of the central planner in the centralized banks can be modelled. To do so, the precision of the signal for the local economy $prob^c\left(\theta_i \mid s^{\theta_i}\right)$ is defined as follows:

Definition 8. The precision of the estimated signal in centralized system based on definition 4.2.2

The precision of the signal when the central planner receives signals s^{θ_i} $i = 1, 2, ..., N$ from the branch managers can be defined as:

$$prob^c\left(g \mid s^g\right) = \frac{\gamma\ p^c(g)}{\gamma\ p^c(g) + (1-\gamma)\ p^c(b)}$$

$$prob^c\left(b \mid s^b\right) = \frac{\gamma\ p^c(b)}{\gamma\ p^c(b) + (1-\gamma)\ p^c(g)}$$

The following lemma expresses the central planner critical value for choosing high or low volume of loan policy.

Lemma 4.2.3. Decision mechanism of the central planner

1. When the central planner receives the good signal s^g from local manager, with the given precision $prob^c(g \mid s^g)$ or $prob^c(b \mid s^g)$ with the following condition:

$$prob^c(g \mid s^g) > \frac{r_3 - r_4}{(r_1 - r_2) + (r_3 - r_4)} \Leftrightarrow prob^c(b \mid s^g) < \frac{r_1 - r_2}{(r_1 - r_2) + (r_3 - r_4)}$$

then, the optimal strategy for the local manager is providing a high volume of loans, otherwise, the central planner pursues the local manager to use restrictive credit policy and provide a low volume of loans.

2. When the central planner receives the bad signal s^b from local manager, with the given precision $prob(g \mid s^b)$ or $prob^c(b \mid s^b)$ with the following condition:

$$prob^c(b \mid s^b) > \frac{r_1 - r_2}{(r_1 - r_2) + (r_3 - r_4)} \quad \Leftrightarrow \quad prob^c(g \mid s^b) < \frac{r_1 - r_2}{(r_1 - r_2) + (r_3 - r_4)}$$

then, the optimal strategy is providing a low volume of loans, otherwise, the central planner pursues the local manager to use expansive credit policy and provide a high volume of loans.

Four possible scenarios can happen, the first scenario is when the local manager receives the good signal and the central planner updating strategy mimics the same strategy. The second scenario happens when the local manager receives the good signal but the updated information by the central planner differs from the local manager. The third and fourth scenarios are the same as the first and second scenarios but with the bad signal.

Corollary 4.2.3.1.

- When the updated $\hat{\pi}$ strengthens the precision of the signal and decision policy does not change then $ER^C = ER^{DC}$ and therefore, $ES^C = ES^{DC}$.
- When the updated $\hat{\pi}$ weakens the precision of the signal and decision policy does not change then $ER^C = ER^{DC}$ and therefore, $ES^C = ES^{DC}$.
- When the updated $\hat{\pi}$ weakens the precision of the signal and decision policy changes then $ER^C > ER^{DC}$ and therefore, $ES^C < ES^{DC}$.

Proof. The first two statements entail that the decision would not change since the precision level would not amend that decision. But in the third statement, the updated $\hat{\pi}$ weakens the precision of the signal, then,

$$prob^c(b \mid s^b) < \frac{r_1 - r_2}{(r_1 - r_2) + (r_3 - r_4)}.$$

In this case the low policy does not exist anymore, therefore, the first part of lemma 4.2.3 fulfilled, so $ER^C > ER^{DC}$. As a result,

$$prob^c(b \mid s^g) < \frac{r_1 - r_2}{(r_1 - r_2) + (r_3 - r_4)} \equiv r_3 * prob^c(b \mid s^g) > r_4 * prob^c(b \mid s^g)$$

Thus, inserting the later formula in the expected shortfall formula 4 then we have $ES^C < ES^{DC}$. □

In a financial institution with a decentralized structure, the decision is based on the analysis of the micro signal, whereas in a financial institution with a centralized structure the central planner has access to both micro and macro signals. As it was mentioned before, these signals are transmittable since they are hard information and soft information is not implemented in the model.

4.2.4 The Fifth Step: Central Planner vs Branch Manager

The fifth step of the central planner's decision-making process in the centralized bank refers to comparing the expected return of two modes. The first mode is when the branch manager receives a bad signal and wants to choose a restrictive credit policy, but the central planner recommends an expansive credit policy. The second mode is the opposite statement.

Obviously when the assumptions of the Lemma 4.2.1 are fulfilled the branch manager chooses expansion or restrictive credit policy. But it does not end there. In fact, if the central planner in the centralized bank receives several different signals, she should reconsider the precision of local signals. In other words, mathematically it is possible that the precision of both signals have the value more than critical values in lemmas. In the following graph, the output curves of high and low signals have been shown.

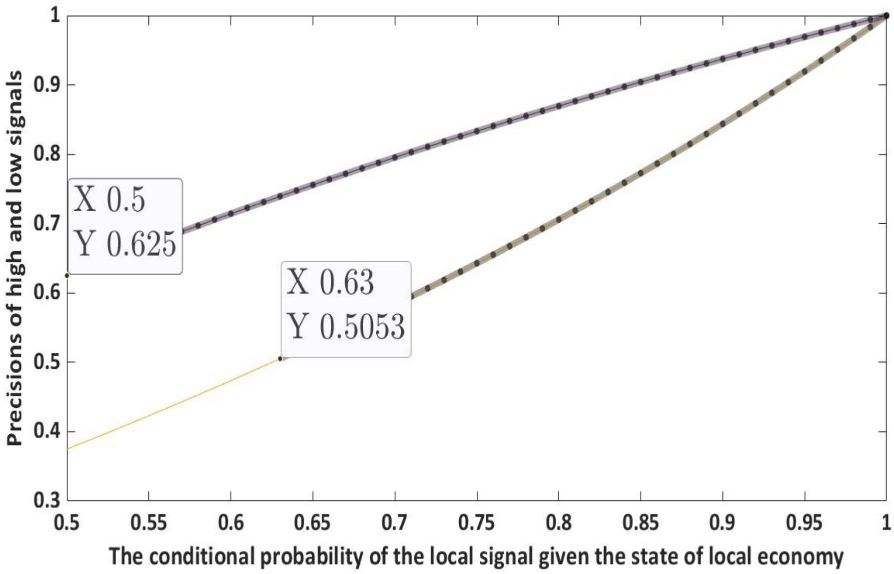


Figure 4.3: Precision's of high and low signals

As it shows in this example, the low signal which is also a lower curve has lower precision than high signal. But the assumptions when $\gamma > 0.63$ are valid since the precision (or Y in the graph) is higher than 0.5.

This may raise the question that when the precision of the signal is higher than the other signals then how the decision will be chosen? The answer to this question is when there is one branch then the decision should be made based on the signal with higher precision. However, the decision would change if the number of local economies and local signals increased. In this scenario not only the higher precision value is significant, but also the number of the signals would affect the decision.

For example the precision of good signal in local economy is higher than others, but there are many other local economies that receive bad signals. Yet, in general, the effect of them on the whole economy is higher that the remaining local economies.

The central planner in this step, compares expected returns of the two banking structures and decides to change the strategies or not.

The following lemma explains that under which conditions the central planner would change the lending policy and pursues the local manager follows her command.

Lemma 4.2.4. Hybrid decision making for the central planner

For a bank with only one branch, the rational central planner makes the decisions independently and

- she chooses expansive credit policy when the following condition fulfilled

$$p(b) < \gamma < 1 \tag{4.10}$$

- she chooses restrictive credit policy when the following condition fulfilled.

$$\gamma < p(b) \; and \; \gamma < \frac{2p(b)}{1+p(b)} \tag{4.11}$$

Proof. The central planner uses three outcomes: expected return of expansive credit policy, expected return of restrictive credit policy and expected return of delegated strategy or local manager's decision. Following formulas are the three expected returns, respectively:

$$\begin{aligned} ER^{C_H} &= \gamma p(g) - 2(1-\gamma)p(b) \\ ER^{C_L} &= -(1-\gamma)p(b) \\ ER^{DC} &= \gamma p(g) - 2(1-\gamma)p(b) - (1-\gamma)p(b) \end{aligned}$$

For the first part the central planner should compare expected return of both scenarios. The expected return of expansion policy is higher when $ER^{C_H} > ER^{C_L}$.

$$\begin{aligned} ER^{C_H} &> ER^{C_L} \\ \gamma p(g) - 2(1-\gamma)p(b) &> -(1-\gamma)p(b) \\ p(b) &< \gamma \end{aligned}$$

The expected return of the central planner for using expansive credit policy must be higher than delegation policy. It would happen when $ER^{C_H} > ER^{DC}$

$$ER^{C_H} > ER^{DC} \Leftrightarrow \gamma < 1 \tag{4.12}$$

So if the conditions $p(b) < \gamma$ and $\gamma < 1$ exist then she chooses an expansive credit policy. For the second part the conditions $ER^{C_L} > ER^{DC}$ and $ER^{C_L} > ER^{C_H}$ must be satisfied then like above we have:

$$ER^{C_H} > ER^{DC} \Leftrightarrow \gamma < \frac{2p(b)}{1 + p(b)} \tag{4.13}$$

also

$$ER^{C_L} > ER^{C_H} \Leftrightarrow \gamma < p(b) \tag{4.14}$$

so if γ is less than critical values (4.11) and (4.12) then the central planner chooses restrictive credit policy. □

As it was explained before, Lemma 4.2.4 is only focused on a representative bank in both banking structures. To show the effect of the number of signals on the central planner decision, in the later lemma number of branches has to be implemented.
Intuitively when the effect of the number of signals is important, at least three number of branches should be used. The assumption of the minimum three branches, leads to the product of three distributions. In this case the extended version of Lemma 4.2.4 can not easily solved, since for comparing the expected return of centralized and decentralized banks, solving an inequality or find roots for the cubic polynomials in three variables is needed. Although in the cases where the function is polynomial with one variable or quadratic polynomial, finding roots is possible but in this case the problem is open. Therefore, to solve the problem a numerical approach should be used.

4.3 Financial Institution with Three Branches

In this section the organizational decision problem with three branches is used. The odd number of branches is basically due to symmetrical one branch model. If I assume two branches, then the central planner has no extra information. Therefore, the smallest odd number that can be implemented in the model is used. In the figure 4.4, the schema of bank with three branches has been shown. θ_i with $i = 1, 2, 3$ represent the three local economies or branches.

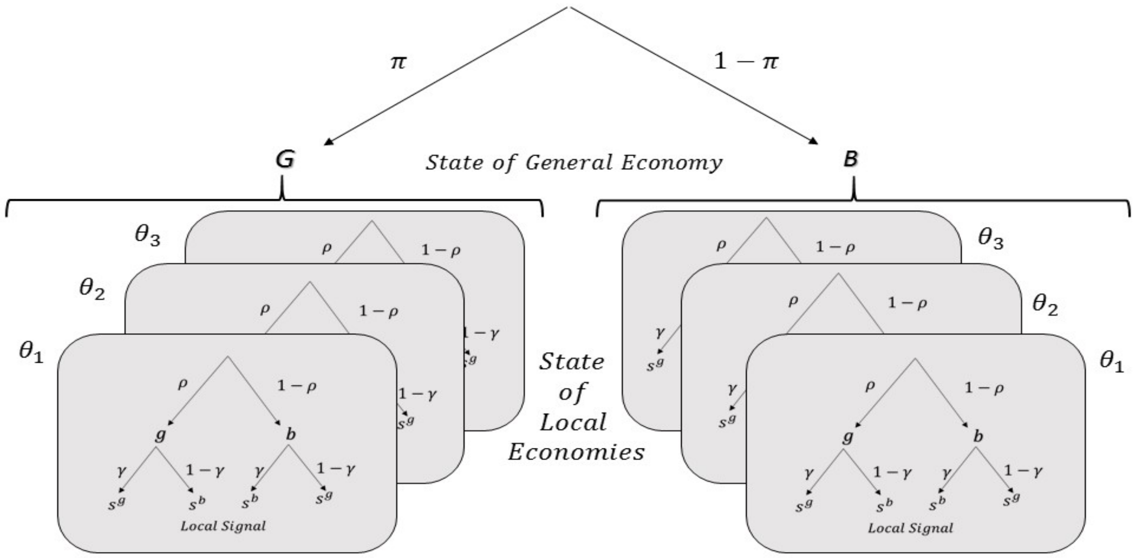


Figure 4.4: The schema of banks with three branches

4.3.1 Analytical Solution

In this section, two types of organizational structures will be considered: one in which knowledge about the environment is centralized and lending decisions are based on local and aggregated signals, and one in which knowledge about the environment is decentralized and lending decisions are based solely on local signals.

To compare these two decision-making structures, the formula from the definition of expected return of banks according to definition 4.2.2 is used. Considering heterogeneity in our model it is assumed that the financial institution has three branches.

From an ex-ante perspective, it is important to evaluate how each of the two types of decision-making structure perform under every possible scenario. There are four main permutations of states of branches $\{ggg, ggb, bbg, bbb\}$. As it was mentioned before θ_i is a local economy statement for being good or bad. Since the probabilities in the event tree are correlated to their above nodes, the scenarios like ggg and bbb have the same result for both banks. Put differently, when there are three branches with the same signals then the central planner will use delegation strategy, so both centralized and decentralized banks will have the same action.
The following example table for our three branch decision-making simulation is used.

S_i	Signals $\rightarrow$ Scenarios sets $\Downarrow$	HHH	LHH	LLH	LLL
ggg	p^3	3r γ^3	-2r $\gamma^2(1-\gamma)$	r $\gamma(1-\gamma)^2$	0 $(1-\gamma)^3$
ggb	$p^2(1-p)$	0 $\gamma^2(1-\gamma)$	-r $\gamma(1-\gamma)^2$	-2r $(1-\gamma)^3$	-r $\gamma(1-\gamma)^2$
gbg	$p^2(1-p)$	0 $\gamma^2(1-\gamma)$	-r $\gamma(1-\gamma)^2$	0 $\gamma^2(1-\gamma)$	r $\gamma(1-\gamma)^2$
bgg	$p^2(1-p)$	0 $\gamma^2(1-\gamma)$	r γ^3	0 $\gamma^2(1-\gamma)$	r $\gamma(1-\gamma)^2$
gbb	$p(1-p)^2$	-3r $\gamma(1-\gamma)^2$	-4r $(1-\gamma)^3$	-3r $\gamma(1-\gamma)^2$	-2r $\gamma^2(1-\gamma)$
bgb	$p(1-p)^2$	-3r $\gamma(1-\gamma)^2$	-2r $\gamma^2(1-\gamma)$	-3r $\gamma(1-\gamma)^2$	-2r $\gamma^2(1-\gamma)$
bbg	$p(1-p)^2$	-3r $\gamma(1-\gamma)^2$	-2r $\gamma^2(1-\gamma)$	-r γ^3	-2r $\gamma^2(1-\gamma)$
bbb	$(1-p)^3$	-6r $(1-\gamma)^3$	-5r $\gamma(1-\gamma)^2$	-4r $\gamma^2(1-\gamma)$	-3r γ^3

Table 4.2: Possible scenarios for the centralized banking structure

In the table 4.2, the second column entails the probabilities of each branch to be in a good or a bad local economy. p is in fact the probability of good local state which can be written as $p(g) = \pi\rho + (1-\rho)(1-\pi)$. In the remaining columns the bank lending strategy based on their local signals is depicted. So when the signal is good then it is shown by H, when it is bad then it is shown by L. Therefore, There are four main permutations of signals for the three-branch-bank, $\{HHH, HHL, LLH, LLL\}$. As a result, the various alternative permutations of the γ are shown in the other columns. Also, the numbers beside the signals entail the outcomes.
For comparison of these two structures the differences of their expected return and expected shortfall is used.
The assumptions of this framework are as follows:

1. Expected return of centralized system is greater than decentralized system when $\Delta(ER) = ER^C - ER^{DC} > 0$.

2. Expected shortfall of centralized system is greater than decentralized system when $\Delta(ES) = ES^C - ES^{DC} < 0$.

3. In all numeric simulations it is assumed that the parameters are mean values. Therefore the mean value of each parameter is determined as follows:

   - $High\ Correlation = \frac{7}{8},\ Low\ Correlation = \frac{5}{8}$.
   - $High\ Signal = \frac{7}{8},\ Low\ Signal = \frac{5}{8}$.
   - $Good\ Economy = \frac{6}{8},\ Bad\ Economy = \frac{2}{8}$.

Assuming that each parameter has random distribution, it is assumed that the mean value of each parameter distribution entails the expected value of the same parameter. To show the behaviors of parameters, I assume that each parameter would have one high value and one low value. Furthermore, to have more realistic environment, I divide the domain interval of each parameter to two intervals. The mean value of each interval represents the high or low value of the parameter. For example since the correlation parameter is between 0.5 and 1 or $0.5 < \rho < 1$, therefore, low and high correlation sub-intervals are as $[0.5, 0.75]$ and $[0.75, 1]$. In this case, the high correlation would be the mean value of the upper interval which is $\rho(High) = \frac{7}{8}$ and the low correlation level would be the mean value of the lower interval $\rho(Low) = \frac{5}{8}$.
The following algorithm 4.5 in Pseudo-code is used for the centralized bank decision-making simulation in MATLAB R2019b. The Pseudo-code describes the decision-making structure of centralized bank.

```
1.  Parameters are, π, ρ, ϒ,
2.  For i from 1 to 100
3.      Assign (i−1)/100 to π
4.          For j from 1 to 50
5.              Assign (i−1)/100 + 0.5 to ρ
6.                  For k from 1 to 50
7.                      Assign (k−1)/100 + 0.5 to γ
8.                          Assign p(g|s^g) to h and p(b|s^b) to l
9.                          Assign p(G|g ≡ h, g ≡ h, b ≡ l)_J to t_g
10.                         Assign p(B|b ≡ l, b ≡ l, g ≡ h)_J to t_b
11.                         Re-do step 8 with new t_g, t_b
12.                         If condition h is greater than 0.5 hold Then
13.                         If condition l is greater than 0.5 hold Then
14.                         Assign p = ER(HHH) − ER(HHL)
15.                         Assign q = ER(LLL) − ER(LLH)
16.                                         If p is positive then p = ER(HHH)
17.                          else
18.                                           else
19.                                               if l is less than 0.5 Then p = ER(HHH)
20.                                               else p = ER(HHL)
21.                                                end if
22.                                           End if
23.                                         If q is positive Then q = ER(LLL)
24.                          else
25.                                           else
26.                                                if h is less than 0.5 Then p = ER(LLL)
27.                                                else p = ER(LLH)
28.                                                 end if
29.                                            End if
30.                          End if
31.                   End For
32.         End For
33. End For
```

Figure 4.5: Decision-making code in MATLAB

First of all, the proper use of the algorithm requires the setting of several parameters whose exact values are more or less problem dependent, parameters like π, ρ, γ. Therefore, line 1 of Algorithm 4.5 lists of important parameters to be addressed. From line 2 to line 8, the 'For Loop' function is stated for each parameter. Line 8 computes the precision of the signals based on the parameter values. In lines 9 and 10, the precision values are entered into the estimation formula (4.7). The new estimates are then used again in line 8 to estimate the new state of the economy. In lines 14 to 29, the expected returns of banks in four scenarios $\{ggg, ggb, bbg, bbb\}$ are compared to find the maximum solution. In the case of decentralized, we only used the definition of the expected return in the same code.

4.3.2 Model with Hard Signal

In this section, both banks only use hard signals. Therefore the decentralized bank can not use soft information. Since the information is hard, all information can be seen by the central planner. The outcome distribution in the figure 4.6 shows the return distributions of two banks by using only hard information. I examine the whole permutation of possible outcomes for both centralized and decentralized banking systems[7]. For the normality test Kolmogorov-Smirnov test (KS-test) is used. The KS-test result value for both distributions were 1 in MATLAB, which indicates that the Kolmogorov-Smirnov test rejects the null hypothesis at the 5% significance level. As a result, the distributions of the two banks are not normal.

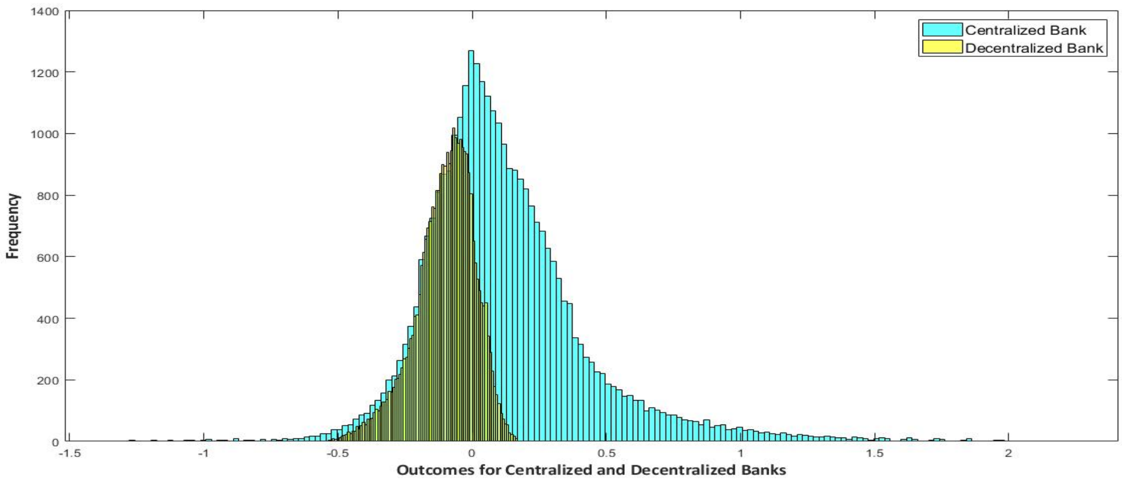


Figure 4.6: Distributions of the returns for centralized and decentralized banks with hard signals

The descriptive statistics for six scenarios are presented in the table below to provide

[7]HHH and LLL scenarios were excluded.

an overview of the returns distribution. The letters C and DC stand for centralized and decentralized banks, respectively. The last two rows represent general cases in which HHL and HLL were aggregated. The mean and standard deviation for two banks are the same in the scenario of HLL or the scenario with two bad signals, as shown in the table. It suggests that in HLL scenario the central planner prefers to delegate decision-making authority to local managers.

Scenarios	Number	Mean	SD	Min	Max	Skew	Kurtosis
HHL C-Bank	31250	0.13	0.31	-0.72	2.52	1.65	5.28
HHL DC-Bank	31250	-0.04	0.13	-0.61	0.27	-0.64	0.25
HLL C-Bank	31250	-0.17	0.1	-0.57	0.1	-0.74	1.14
HLL DC-Bank	31250	-0.17	0.1	-0.57	0.1	-0.74	1.14
C-Bank	31250	-0.02	0.19	-0.61	1.26	1.08	3.00
DC-Bank	31250	-0.1	0.11	-0.55	0.17	-0.65	0.52

Table 4.3: Descriptive statistics of the returns of scenarios with hard signal

For comparing distributions in general case, again two-sample Kolmogorov-Smirnov test in R is used. From the output, the test statistic is 0.24 and the corresponding p-value is less than 0.001. The null hypothesis is rejected because the p-value is less than 0.05. As a result, the total return of the centralized bank is greater than that of the decentralized bank. Furthermore, the centralized bank has a higher Standard Deviation (SD), indicating that the decentralized bank is more stable.

It is crucial to observe how these banks behave when the value of the correlation changes. To show that, we fix the correlation and calculate the expected return and expected shortfall as a function of the correlation.

In figures 4.7 the expected return and expected shortfall for each bank at a 99% confidence level in two possible scenarios are depicted. The solid black line refers to a centralized bank and the dashed black line refers to a decentralized bank.

The figure shows that when the signals in the banking systems are only based on hard information, the expected return of the centralized banking system is higher than decentralized banks.

In all levels of correlation, centralized bank performs better than the decentralized bank. However, the expected shortfalls of the centralized with the assumption of the same capital is higher than of the decentralized bank.

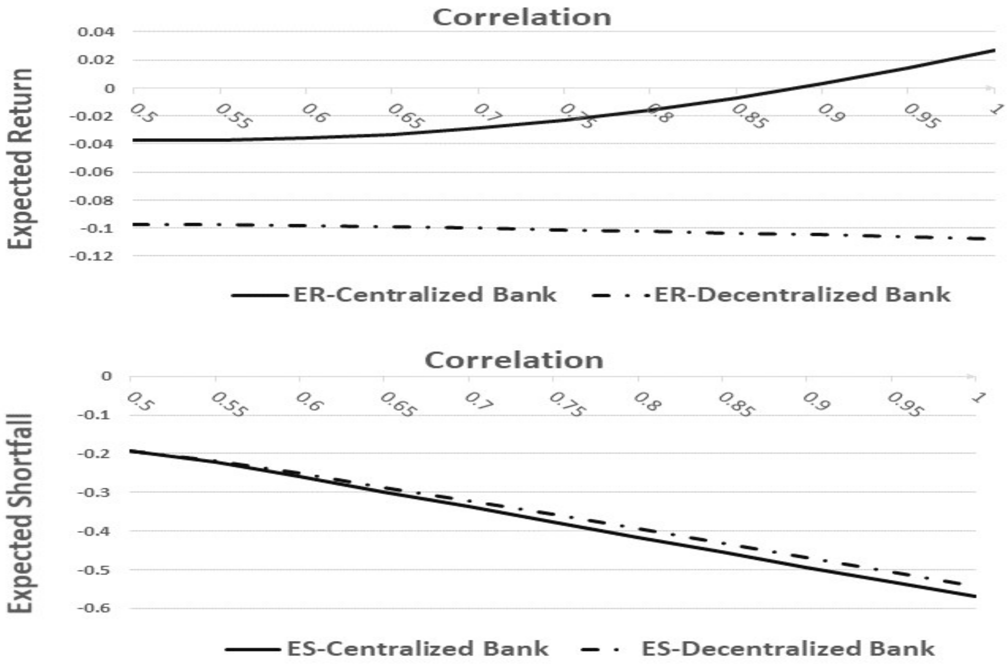


Figure 4.7: The expected returns and expected shortfall with hard Signals

At the low level of correlation, the central planner tries to mimic decentralized structure or -in other words- she gives delegation to local banks. One of the key reasons is that she finds the local bank's signal more dependable when she uses hard-verifiable information, and her updating approach due to high uncertainty is not feasible. Thereby, she opts for the local strategy.

When the correlation level is high, the proper decisions produce significantly better results. One can see that centralized bank's expected return curve grew dramatically. On the contrary, the wrong decision due to the high correlation bears big loses.[8]

In table 4.4 the results for the expected returns and expected shortfalls (ES) of critical scenarios (HHL and HLL) as well as general scenario for centralized and decentralized banks, have been shown. NM stands for numerical method and VCM stands for variance-covariance method. The t-tests or pairwise comparison tests were used to compare the mean values of the returns in different scenarios. The differences were significant with

[8]Note that since the absolute value of negative outcomes are much higher than positive ones, in some scenarios the results of expected returns is negative due to our outcome matrix, but this does not affect an overall argument.

t-value of 1.96 and p-value is less than 0.001. Therefore, the null hypothesis is rejected because the p-value is less than 0.05. Thus, the results are comparable.

Scenarios	Expected Return	VaR(NM)	ES(NM)	VaR(VCM)	ES(VCM)
HHL C-Bank	0.13	0.43	0.5	0.6	0.64
HHL DC-Bank	-0.04	0.41	0.46	0.35	0.42
HLL C-Bank	-0.17	0.45	0.49	0.4	0.44
HLL DC-Bank	-0.17	0.45	0.49	0.4	0.44
C-Bank	-0.02	0.48	0.5	0.47	0.5
DC-Bank	-0.1	0.47	0.48	0.36	0.41

Table 4.4: Expected Returns, Value at Risk (VaR) and Expected Shortfalls (ES) results at the 99% confidence level for centralized and decentralized banks with hard signals

The HHL and HLL are two important scenarios that decision-making may change by using a Bayesian update according to the central planner approach. In all scenarios the expected returns of the centralized bank are higher than decentralized bank. Also, the expected shortfalls for centralized bank is worse than the decentralized bank. In the HLL scenario, the outcomes are the same for both banks. As previously stated, the central planner delegated her choice to the local manager in this situation. Consequently, when the number of bad local signals is high enough, the decentralized banking system is preferred. This study supports the idea that decentralized decision making structures function better in a bad economy than centralized ones.

Another key finding is that the centralized bank's value at risk is slightly more than the decentralized bank's, but the centralized bank's expected shortfalls are significantly higher than the decentralized bank's. This supports the notion that value at risk is not always a reliable measure of downside risk.

In the HHL scenario where the number of good signals is high enough, the expected return of the centralized bank is much higher than the decentralized bank. One explanation is that, with a centralized decision-making framework, the central planner can better estimate the entire economy because the information is transmittable and verifiable. This does not, however, shield these banks from unavoidable losses when the correlation level is high. Furthermore, in comparison to decentralized banks, this higher profit comes with a significantly higher risk. Hence, even if decentralized banks appear to be unable to efficiently diversify across regions, their portfolios are less risky.

To show the combination effect of correlation factor ρ and the state of general economy that yield return values, contour plots help a lot. The contour lines and bands make it simple to identify combinations effects. In the following contour plots, the effect of correlation and the state of general economy when the precision of the signal is weak and equal to 0.625 and as well as strong and equal to 0.875 have been shown.

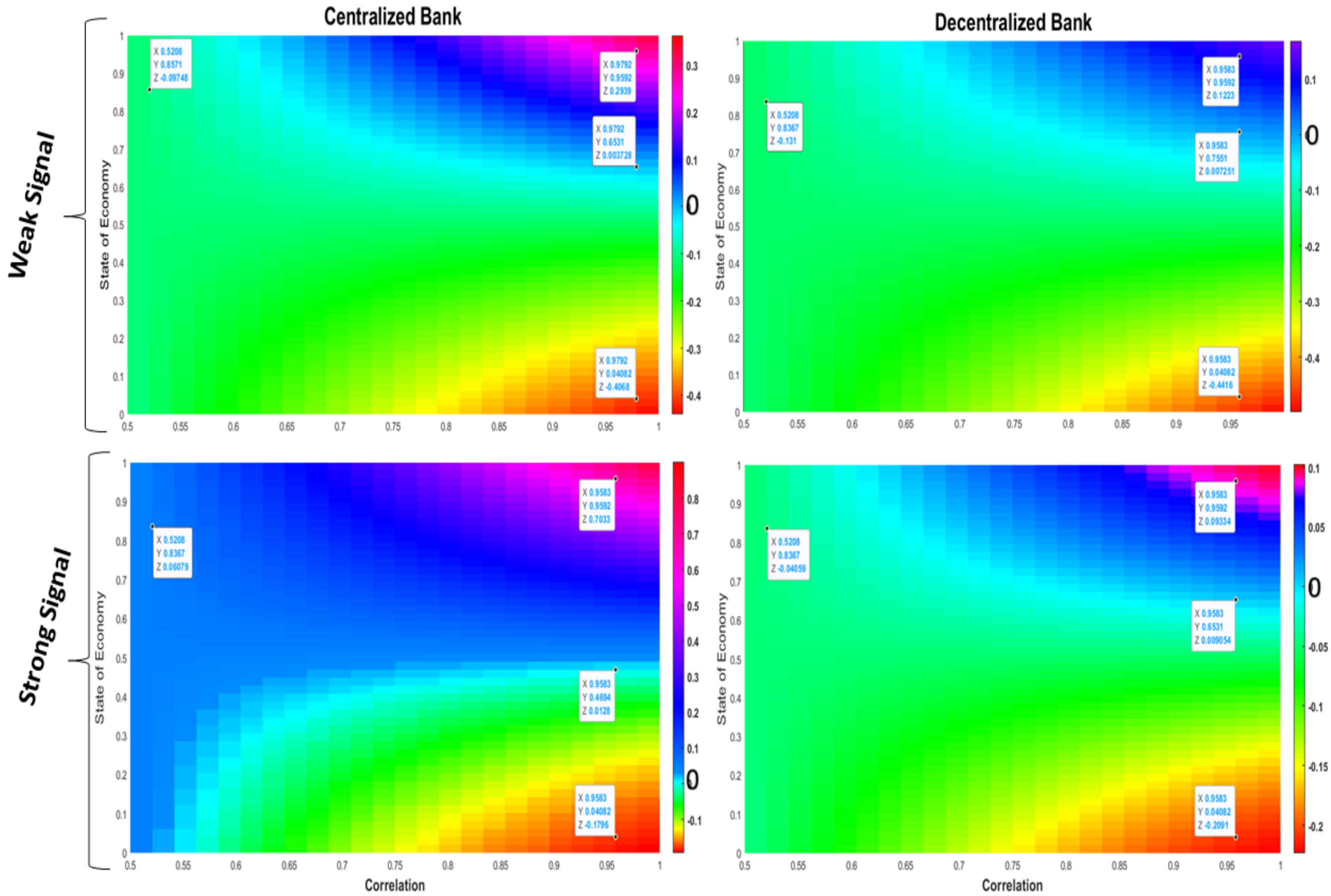


Figure 4.8: Contour plots of weak and strong signals for centralized and decentralized banks

The returns' ranges are represented by colored bands. The red and yellow bands in each plot represent the losses. Zero returns would be the border between the light blue and dark blue bands. The purple ring brought the favorable results.

As it can be seen when the signal is weak or the signal precision is low, the overall schematic of both centralized and decentralized bank is almost the same. This is consistent with the notion that the central planner imitates the decentralized strategy. As a result, their returns look almost the same. When the overall economy is booming enough, the centralized bank's returns increase. This is due to market synchronization as well as the central planner's improved estimation. In this circumstance, the central planner employs the HHH scenario or persuades all branches to employ an expansive credit policy. On the other hand, when the signal is strong, the centralized bank's economic estimation improves. In a bad economy, however, the loss coloured bands get larger. When the correlation level is high, the losses become even worse. This is due to the central planner's incorrect interpretation.

In both signal scenarios, the decentralized bank performs almost similarly. When signal precision is high, the local decision cost dominates the diversification impact due to the high level of correlation with the entire economy. As a result, the desirable returns are lowered.

4.3.3 Model with Soft Signal

According to the model, the centralized banking system dominates the decentralized banking system due to the lack of soft information. In reality, as stated in the introduction, there is an important factor or reason why decentralized banking systems are more stable. Because of their authority, local branch managers can use soft information or soft signals to change the outcome of the game. This local dominance, however, may be harmful if they use it to gain a monopoly role in local economies (Canales and Nanda 2012).

Analytical Solution

Adding a soft signal to our analysis, the decentralized bank now has better estimation of local economy. In addition, as before, the decision structure of centralized banking system is based on a hard local signal, as well as a hard macro signal. To compare these two decision-making structures the formula from the definition of expected return in 4.2.2 is used. Like the previous section, for comparison of these two structures their expected returns and expected shortfalls are used. In order to implement the soft signal in our model, a weighted coefficient for the soft signal is used. Therefore, the value of γ in this section would be the weighted average of the hard and soft signal by adding weighing parameter w_s where $0 < w_s < 1$.

The assumptions of the frame work are as follows:

1. Expected return of centralized system is greater than decentralized system when $\Delta(ER) = ER^C - ER^{DC} > 0$.

2. Expected shortfall of centralized system is greater than decentralized system when $\Delta(ES) = ES^C - ES^{DC} < 0$.

3. The weights of the signals are equal.

4. The following figures have the following assumptions:

   In all numeric simulations it is assumed that the parameters are mean values.

   - $High\ Correlation = \frac{7}{8}, Low\ correlation = \frac{5}{8}$.
   - $High\ signal = \frac{7}{8}, Low\ signal = \frac{5}{8}$.

     Signals in decentralized bank are $\hat{\gamma} = (1 - w_s) * \gamma + w_s$ where $0 < w_s < 1$ is the weight of soft signal.
   - $Good\ economy = \frac{6}{8}, Bad\ economy = \frac{2}{8}$.

The following histogram depicts the return distributions of two banks. The whole permutation of possible outcome for both centralized and decentralized banking systems were examined. The Kolmogorov-Smirnov test in Matlab with the kstest command is used. The test result indicates that at the 5% significance level, the Kolmogorov-Smirnov test rejects the null hypothesis. Therefore, comparing the expected returns of the two banks is possible.

Figure 4.9 shows the distribution of the returns of the two banks. Comparing 4.9 and 4.6 the returns of decentralized bank shifted to the right side and the gap in fat tails become larger.

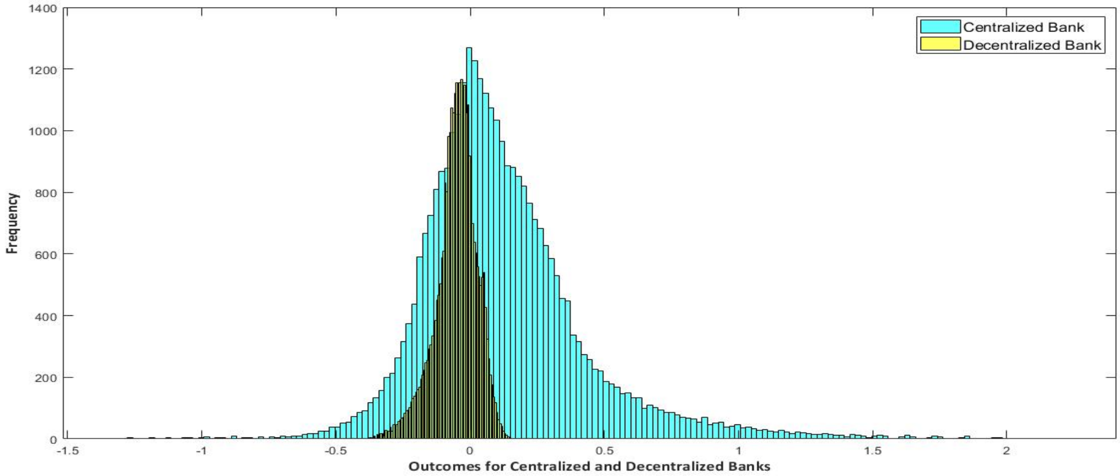


Figure 4.9: Distributions of the returns for centralized and decentralized banks with hard and soft signals

Again to observe how these banks behave when the value of the correlation changes, fixing the correlation, the expected return and expected shortfall as a function of the correlation were calculated.

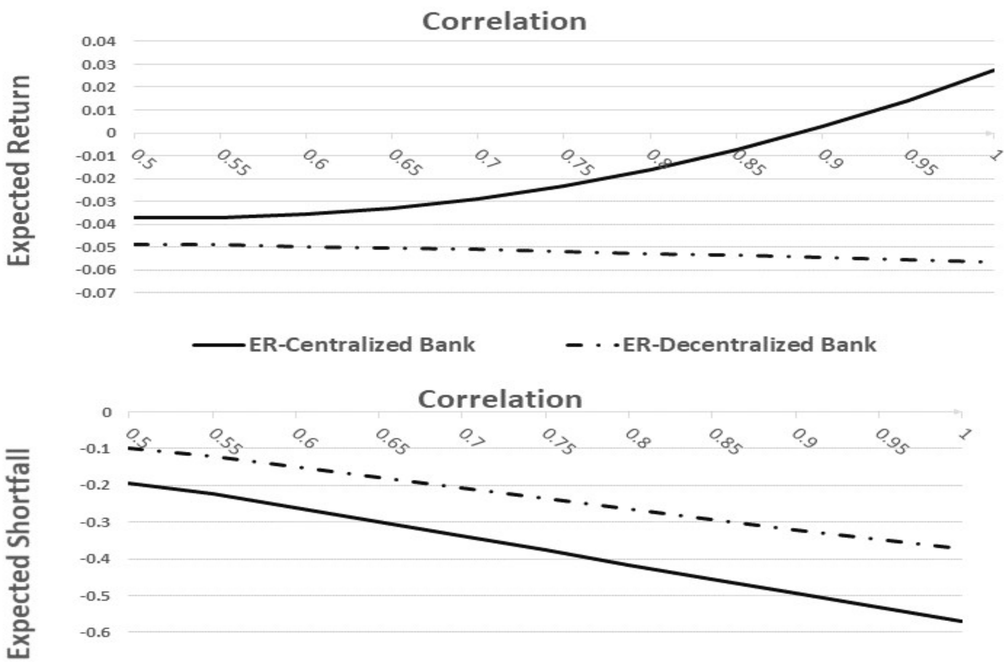


Figure 4.10: The expected returns and expected shortfalls with hard and soft signals dependent of correlation

Figure 4.10 depicts the expected return and expected shortfall for each bank at a 99%

confidence level in two possible scenarios. Clearly, the results for the centralized bank would not change, since the only signals that the central planner can use are hard signals. In fact the decentralized bank perform better than before. The only crucial aspect is that when the correlation level is high the losses for decentralized bank increases. This is reasonable since the decentralized banks has no screening ability, so when the correlation level is high the wrong decisions may occur, which in turn increases the potential of a risky decision.

Scenarios	Expected Return	VaR(NM)	ES(NM)	VaR(VCM)	ES(VCM)
HHL C-Bank	0.13	0.43	0.5	0.6	0.64
HHL DC-Bank	0.004	0.29	0.33	0.25	0.37
HLL C-Bank	-0.17	0.45	0.49	0.4	0.44
HLL DC-Bank	-0.16	0.45	0.49	0.37	0.44
C-Bank	-0.02	0.48	0.5	0.47	0.5
DC-Bank	-0.08	0.4	0.46	0.3	0.4

Table 4.5: Expected Returns, VaR and Expected Shortfalls (ES) results at the 99% confidence level for centralized and decentralized banks with hard and soft signals

In Table 4.5 the results for the expected returns and two risk measures for critical scenarios (HHL and HLL) as well as general scenario for centralized and decentralized banks, have been shown. NM stands for numerical method and VCM stands for variance-covariance method. Also, the absolute values of VaR and expected shortfall are used. For each scenario the differences were significant with t-value of 1.96 and p-value is less than 0.001. Therefore, the null hypothesis is rejected because the p-value is less than 0.05. Thus, the results are comparable. In all scenarios expected shortfall in centralized banks is equal or worst than in the decentralized banks.

As it was mentioned, in the model with hard signal, in the HLL scenario the central planner gives delegation and mimic the decentralized structure which means that for some degree of belief the decentralized structure dominates centralized banking structures.

However, decentralized banks outperformed centralized banks in the HLL scenario with a soft signal. This is due to the weighted soft signal's linear influence, which is included in the model.

In other words, even if the centralized bank mimics the decentralized structure, the decentralized bank performs better than the centralized bank in this scenario due to the lack of soft information.

In order to show the decision-making results of the bank mangers in centralized and decentralized banks the combination of different scenarios summarized in the Figure 4.11. Figure 4.11 visualizes the specific view of the contour plots from figure 4.8. The three different scenarios are depicted in this figure.

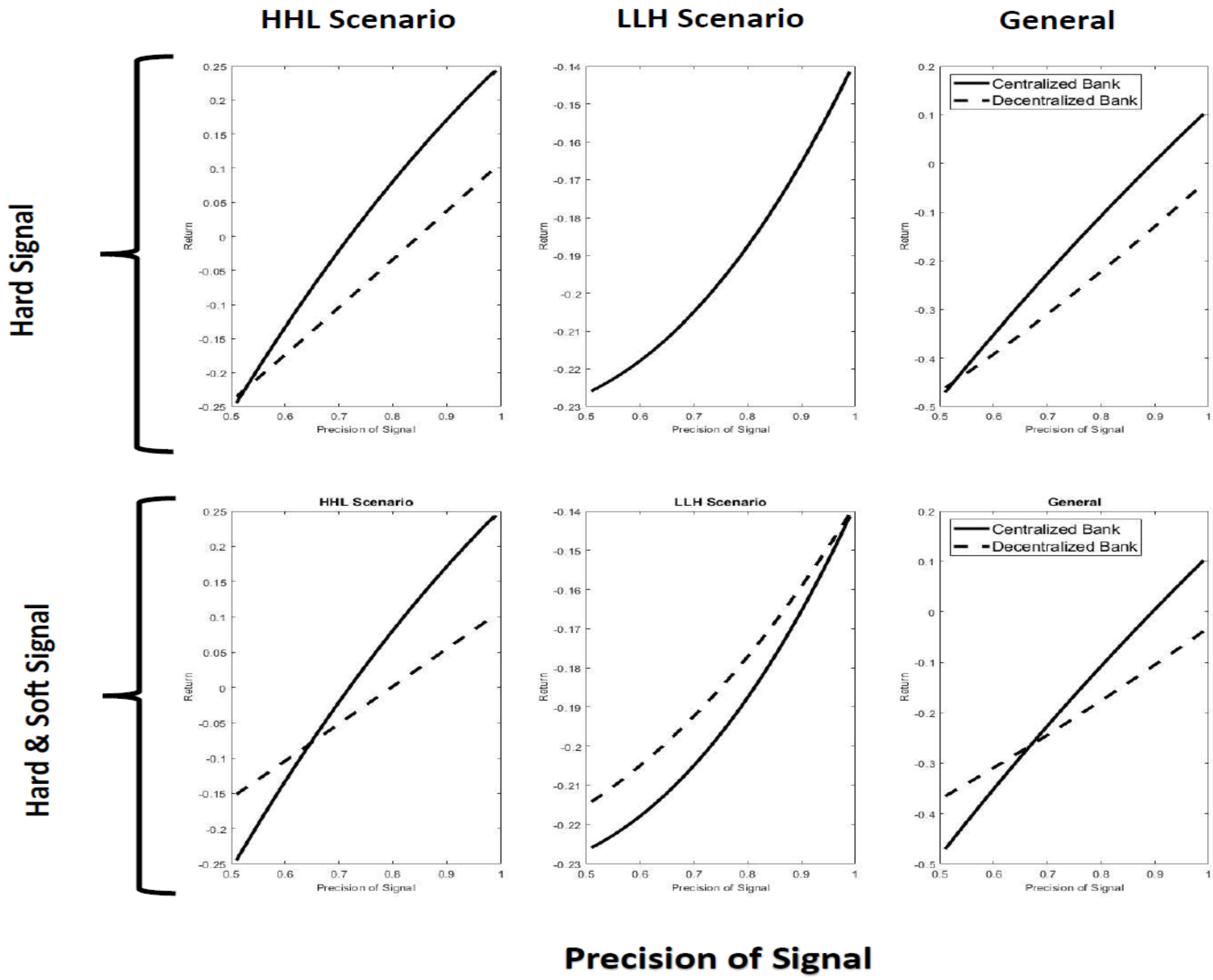


Figure 4.11: Different scenarios of expected returns for both banks

The centralized return is represented by the straight black line, while the decentralized return is represented by the dashed black line. The first three upper graphs show that in all scenarios centralized banking structure outperformed the decentralized one. Return changes are far smaller in a decentralized banking system ($\Delta = 0.4$) than in a centralized banking system ($\Delta = 0.6$). The decentralized bank's adjustments become even smaller ($\Delta = 0.3$) by incorporating soft signals. As a result, the decentralized organization has a higher degree of stability.

Decentralized banks operate substantially better than before when soft signals are added. The lower graphs show that the decentralized banking structure outperformed the centralized one at low precision levels. When the HLL scenario occurs, the central planner mimics the decentralized structure, which is consistent with the assumption that a decentralized bank operates more efficiently.

To summarize, an increase in the number of low signals from a bad local economy indicates that the economy is not doing well. As a result, the central planner attempts to delegate authority to her branch managers or to mimic a decentralized structure. Because this decision-making structure includes both hard and soft information, it can be concluded that the decentralized structure performs better overall during the crisis. In a good or calm economy, however, the centralized banking structure provides a higher return.

4.4 Discussion and Conclusion

A model was constructed to compare two different banking systems based on their decision-making structures. To investigate the effect of different system parameters on the return and risk measure, an analytical solution of decision-making structures in centralized and decentralized banks was performed.

The general conclusion is that the centralized banking system has a higher expected return than the decentralized banking system. It is vital to note that higher returns are associated with higher risks at centralized banks. The findings suggest, decentralized banks' expected returns change less than centralized banks' which can be presumed as a sign of stability.

In general, the decentralized bank's risk performance measures, VaR and expected shortfall, show lower values than the centralized bank. This supports the notion that decentralized banking structures are more stable and less risky than centralized banking structures.

Also, it was explained that as market synchronization increases (high correlation level), the expected shortfall of the decentralized bank is less than that of the centralized bank, whereas the centralized bank's average return is higher.

Moreover, when there are a lot of bad signals in a bad economy, the centralized decision-making structure should switch to a decentralized decision-making structure to protect the banking system from further losses. The purpose of this chapter was to present some important findings based on mathematical simulation to demonstrate the importance of small banks and how these small banks, which are mostly in the form of decentralized structures, can be extremely helpful during times of crisis and poor economic performance. The strict regulation would be detrimental to decentralized banks and would prevent them from breathing properly, causing them to commit "financial suicide" in the future. The complexity of EU banking regulations burdens small banks and is incompatible with their business model. Regulation is currently the single greatest driver of mergers, because of the high fixed costs it imposes on small banks.

Chapter 5

A Flood Catcher in Bank Shocks

5.1 Introduction

Changes and deregulations of the banking system were implemented by different countries in the 1980s. These changes and deregulation actually led somewhat to a shift from a decentralized to centralized system or liberalization in the banking structure. It gave the opportunity to non-local investors to invest more capital in local bank and because the local economy flourished in different countries depending on the local economy. The profits of these types of banks were higher in some local economies due to economic prosperity. Bank executives sought to bring changes and regularization to their agenda in order to attract new capital to inject into their industries. This was not possible except by easing restrictions on the ownership of equity firms. The changes started in April 1982. It had a profound effect on the savings and lending industry. Fundamental changes in the early 1980s were designed to help the savings and lending industry, but in reality led to the cost that led to the crisis.

Although these changes increased the profitability of the banks, on the contrary increased operating costs and thus increased risk. Deregulation of the banking system creates a situation in which banks, especially small banks, can not provide as appropriate services to their customers as in the past.

Viewed from this perspective, different conclusions can be reached, including the fact that with changes and deregulation, effective factors have sometimes caused changes in the structure of the banking system, which consequently causes some of the advantages of a decision-making structure to be overlooked. Despite, the structural risk that arises with such changes should be highlighted too.

These effects are maybe small in a general structure from the point of view of the legislator, but in the regional or neighborhood structure, these factors play a significant role in supporting the banking system of small enterprises and consequently the local economy. Germany, as previously stated, has the lowest Herfindahl-Hirschman-Index (HHI) among European countries. Spain and Italy are also two important European countries with low HHI indices. Hence, these countries' banking structures are more similar to Germany's.

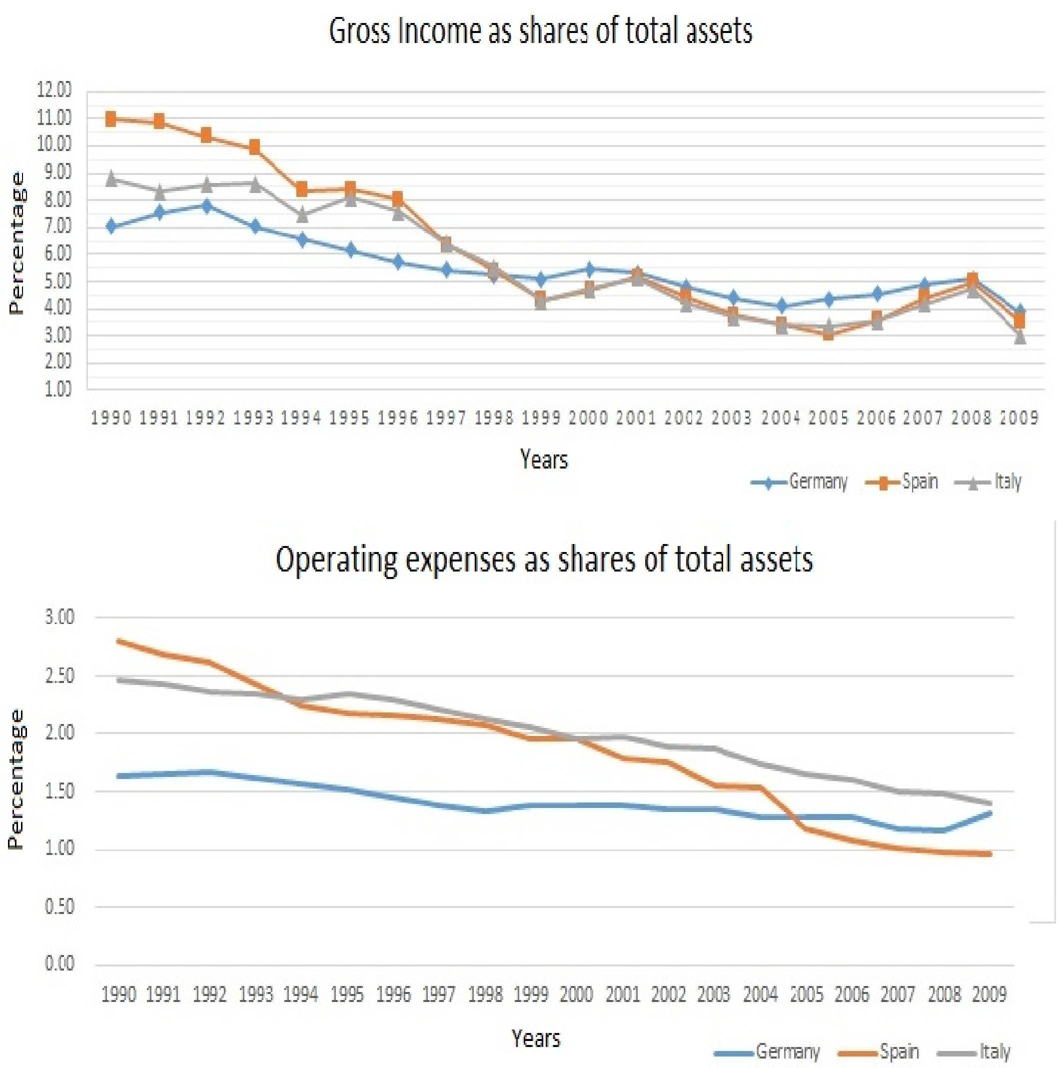


Figure 5.1: Net income and operating expenses as shares of total assets
Source: Organization for Economic Cooperation and Development (OECD)

In figure 5.1 the gross incomes and operating expenses of Germany, Italy and Spain have been shown. The gross income for Italian and Spanish banks are relatively high, but so are their operating costs in comparison to German banks.

The time series in all countries shows a downward trend, but in Italy and Spain, the decrease in costs more than compensates for the decrease in gross revenues. The negative trend in gross income in Italy is due to the shrinking interest income, a trend that can also be observed in many other European countries. However, this effect was offset by a significant increase in non-interest income (Carletti, Hakenes, and Schnabel 2005). A careful analysis would need to take into account the differences in risk appetite; Differences in returns alone could be misleading. Profit is not a reliable indicator since higher profitability may have been obtained at the expense of lesser availability of banking services and loans, as well as lower competition in the banking sector (Carletti, Hakenes, and Schnabel 2005).

Not only did deregulation in European countries increase operational risk, but it also had a negative impact in the United States. The 1980s savings and loan crisis in the United States was widely blamed on the moral hazard created by a combination of generous deposit insurance, financial liberalization, and regulatory failure (Kane et al. 1989).

Demirgüç-Kunt and Detragiache 2002 indicates that explicit deposit insurance is damaging to bank stability, especially where bank interest rates have been deregulated and the institutional environment is weak. Therefore, if institutions are good, moral hazard chances are restricted, and more effective prudential regulation and supervision can better offset the negative incentives provided by deposit insurance.

Liberalization and unrestricted competition have mainly resulted in instability as a result of regulatory and supervisory failings. Competition has significant benefits for an efficient and inclusive financial system, and regulatory and supervisory policies should focus on creating an incentive-compatible environment for banking rather than trying to fine-tune market structure or the degree of competition (Beck 2008).

As previously stated, mergers and consolidation have become more common, and small banks have vanished over time. The value of the banking relationships was fading day by day. Countries like Germany, on the other hand, were less affected by financial shocks since their banks worked regionally. One factor is that Germany's banking system is more decentralized and reliant on small banks. As a result, the German financial system is based on banking relationships. The close banking relationship between depositors and banks is very crucial to the degree of mutual trust. Cultural intimacy and mutual trust are really important.

In centralized banks, the relationship built in the form of a complex bureaucracy that makes the manager have no mutual obligation to the customer's trust. The manager does not have the necessary motivation to gain this trust or any personal characteristics of his client (Stein 2002). In a decentralized structure, this motivation leads to a longer customer relationship with the agent or bank and thus benefits the relationship between both parties.

Burghof, Jamshidi (2018) by using lending decision-making model, showed that hard information in the centralized banking structure based on verifiable information is the benefit of the centralized banking system, whereas considering unverifiable information, so-called soft information, is an important asset of the decentralized banking system.

This statement, however, would be one side of the coin in a crisis; the other side of the coin would be how much depositors trust the banks during the crisis. This trust would not be built over the course of a short-term banking relationship, and this soft information would be gathered over time. As a result, the bank's structure would be important because the deeper the relationship between bank managers and depositors, the greater their trust. More importantly, the bank manager's motivation is critical. A lack of communication motivation would be harmful for such relationship.

For example, in big banks, managers have less incentive to communicate with their clients. One reason would be the high salaries for the board members of the big banks. Therefore, small clients would not be that much important for their banks. They are less client-oriented and invest less time in their communication.

Table 5.1, shows the board members' salaries for different banks. The salary of small banks is much lower than big ones. Furthermore, another reason for not caring for depositors would be a punishment for the wrong decision. Due to the limited punishment and fair behavior of Justice Law, the bank managers bear much less punishment in comparison to the small ones when they make the wrong decision. Therefore, in the big banks managers are less interested in the bank's statement in comparison to the small banks.

Small Banks -50,000	Medium Banks 50,000-100,000	Big Banks +100,000
Teambank AG, Nurnberg 302,335	Frankfurter Sparkasse 616,500	Commerzbank 1,228,000
Sparkasse Ulm 366000	DKB 683,334	DZ Bank 1,312,500
IBB Berlin 486,600	DZ Hyp 706,667	Deutsche Bank 5,155,567

Table 5.1: Average total salary of the board members according to the balance sheet sum of the banks in Mio.€
Source: Annual reports 2019 or 2020 of banks

During the financial crisis 2008-2009, many bankers in Europe served jail time, mostly from Iceland, where 3 big banks in Iceland bankrupted (Laura Noonan, September 20, 2018). Only one banker in the United States - Kareem Serageldin, a banker at Credit Suisse - served jail time (Eisinger, April 30, 2014). No one convicted in United Kingdom. No one was convicted in United Kingdom. Another side of the argument is that the big banks managers could lie about their statements, e.g. Wirecard or Greensill banks.

In this chapter, the following questions have to be answered:

- How do bank managers dealt with revolting behavior of their depositors based on their banking structures?
- How do bank managers react during bank shocks to protect their banks from non-efficient bank runs?
- How do bank manager and depositors relationships mitigate the risk of bank run and reduce fragility?
- Should legislators impose stricter regulations for banks?

Hence, the general following statement has to be answered and explained;
Bank resilience would be higher for the small banks due to higher trustworthiness in relationship banking in case the banks are hit by an aggregate liquidity shock that affects the realized fraction of impatient depositors that the bank faces and which as a result might create a budget imbalance. In order to answer the questions, a theoretical bank run model based on Chari-Jagannathan (1988) is developed to compare centralized and decentralized banking structures during bank shocks when managers communicate strategically with their depositors in order to protect themselves from inefficient bank runs.

Related Literature

Some literature explain how organizational structure can affect small business access to credit (Rajan 1992) (Petersen and Rajan 1994) (Berger and Udell 1995a) (Black and Strahan 2002). They focused on the ability of smaller or decentralized banks to maintain credit relationships with small businesses. During 2007-2009, German banks were heavily affected by the crisis, where as the local saving banks and cooperative banks performed better (Hassan 2014).
On one hand, Maurer (2019) explains that business culture in the banking sector differs from bank to bank and from bank group to bank group, a fact that regulators need to take into account. Honesty is an important cultural and ethical dimension (Maurer et al. 2019). On the other hand, Cohn et al. (2014) report that finance professionals are more likely to behave dishonestly in their professional identity than in their private identity. Moreover, some studies show that finance professionals care more about social comparison and competition than other subject pools. The banking industry's business culture favours dishonest behavior of employees (Cohn, Fehr, and Maréchal 2014).
Also Sedunov (2020) states that countries with more small banks have fewer customer complaints, while the level of banking competition remains constant (Sedunov 2020). The branch manager in a small bank has far greater autonomy over decision-making and lending decisions than managers of centralized or big banks (Gärtner and Flögel 2015). Branch managers often make use of so-called "soft information", which are information that are hard to quantify and often based on forecasts and statements of the management's

future plans. Soft information are also not easy comprehensible and closely linked to a person, that is a reason why they can hardly be transmitted (Liberti and Petersen 2018). The use of soft information gives small banks an advantage in small-business relationship compared to big banks (Canales and Nanda 2012) (Stein 2002).

In fact, soft information can be expressed as the business culture in the banking industry that is important in the relationship banking. Therefore, in the local business culture small firms are less likely to borrow from banks subsequent to mergers (that tend to make them more centralized) in comparison to firms borrowing from banks that have not merged (Sapienza 2002).

I intend to examine and compare the behavior and decision-making structure of bank managers in the small or big banks. For this, I need to provide a model which shows the influence of the decisions of bank managers on the profit and losses of the bank based on their business culture or, as it was mentioned earlier soft information. Burghof, Jamshidi (2018) explained that during crisis periods, when the bad economy has an impact on small businesses, decentralized bank managers use soft information in their bank lending structure to select trustworthy clients (Burghof and Jamshidi Safari 2018).

Diamond and Dybvig (1983) model a bank as a mechanism that allows investors to finance illiquid but profitable projects and protect them from unanticipated shocks that lead to expected consumption (Diamond and Dybvig 1983). Calomiris and Kahn (1991) argue that the bank run is a market disciplining mechanism because when depositors realize that the bank is in trouble, they withdraw it and can trigger a bank run. Therefore, deposit insurance promotes moral hazard because depositors can invest in banks that take more risks (Calomiris and Kahn 1991). Chari and Jagannathan (1988) consider a similar model by Diamond and Dybvig, but introduce a random return on investment, which some patient agents may observe. When the agents' signal receives and indicates poor performance, it causes them to withdraw in the first stage (Chari and Jagannathan 1988). Moreover, Grasselli and Ismail 2013 used the Diamond-Dybvig model into a multi-bank environment. Santos and Nakane 2021 studied contagious effects on the banks from the inter-bank market where the small banks would bear higher punishment. Cihák and Hesse 2007 show that cooperative banks had lower returns volatility due to their ability to exploit customer surpluses during weaker times and were more stable than commercial banks in 29 OECD (Organization for Economic Cooperation and Development) member states from 1994 to 2004. They also explain that the cooperative banks increase the stability of the banking sector.

The bank run model by Chari and Jagannathan 1988 offers more realistic model assumptions, whereby the weight of the depositors who want to consume early and the state of the bank assets are stochastic. The depositors can observe and react to the deposit queue in the bank. The queue can be particularly long because some depositors have received information that the bank's asset portfolio is in poor condition. However, this can be confused with a high proportion of early consumers. If depositors' interpretations are incorrect and the bank is in good standing, bank managers can shield the bank in the event of a bank shock by providing unverified information through communication or cheap talk. There are literature that explain how cheap talk would be important to improve coordination ((Ellingsen and Östling 2010), (Austen-Smith and Feddersen 2009),(Hagenbach and Koessler 2010), (Godfrey-Smith and Martınez 2013)). A modified model based on Chari and Jagannathan 1988 and the cheap talk game model is introduced in the next section.

5.2 The Model

5.2.1 Basic Outline of the Model

The model builds on Chari and Jagannathan (1988). The model is dynamic and has three dates: a planning date, date 1 and date 2, $t = 0, 1, 2$.

- $t = 0$
  * An investment decision for endowment of one unit of good is made
- $t = 1$
  * Depositors learn about their types
  * State of nature for prospective time 2 returns revealed and managers receive perfect and complete information.

    - A random fraction of type 2 agents receive perfect but incomplete information about prospective time 2 returns.
    - Bank managers can communicate about their bank statement
    - Depositors make decision to run or not.
    - Resources reinvested in period 1 if possible
- $t = 2$
    - Resources which are invested in period 1 generate a random return at time 2 or no one gets paid
    - Fixed punishment for the deceptive manager

The crucial difference of our model with Chari and Jagannathan is that bank managers allow to communicate with the depositors about the state of the bank. The important aspect of this communication according to the structure of bank refers to the credibility of the communication for the depositors. In the next sections, it is explained that under certain conditions the bank managers can prevent an inefficient bank run.
There are two types of depositors, and those who maximize expected utility of consumption are risk-neutral. Type 1 depositors only interested in consuming at date 1. Type 2 depositors derive utility from consumption in both periods 1 and 2. No individuals knows his or her type at the planning date. All depositors endow with one unit of good at the planning date. The only information that is public are the aggregate investment decisions. The return in period 1 is affected by an exogenous factor (imposed externally). The utility function of a depositor U is

$$U(c_1, c_2) = \begin{cases} u(c_1) & \text{type 1 depositors} \\ u(c_1 + c_2) & \text{type 2 depositors} \end{cases} \tag{5.1}$$

where c_1 and c_2 are non-negative consumption of the depositors at dates 1 and 2. The utility function is u with $u' > 0$ and $u'' < 0$.
An investment decision for endowment of one unit of good is made during first period that yields a sure return at time 1. Then each bank invests it in a long-term project, which will mature at date 2. A random fraction of individuals are of type one which can

take three values of $w \in \{0, w_1, w_2\}$ with probabilities r_0, r_1, r_2. Output random variable in period 2 takes a good outcome r_H with probability p_H, and a bad outcome r_L with probability p_L. Early liquidation has a yield of 1 unit, unless the total withdrawal in t_1 exceeds a certain maximum value K, then L is only a fraction of the amount called for payment. In order for the concept of investment as a logical process to be meaningful in our model, $r_H p_H + r_L p_L > L$ and $r_H > L > r_L$. For sake of simplicity it is assumed that $L = 1$ and $r_L = 0$.

Type 2 depositors who do not have any further information do not want to withdraw their deposits until t_2. However, it can be the case that a certain proportion $\alpha \in \{0, \bar{\alpha}\}$ of the type 2 depositors known to all depositors already receives a secure message θ in t_1 about the value of the technology yield in t_2 with probabilities q and $1 - q$ respectively. A depositor of type 2, who receives the message $\theta = r_L$, prefers to withdraw his deposit in t_1 and accept possible liquidation losses in return.

Θ is the set of all possible triplet values of $\theta_i \equiv (w, R, \alpha)$ that represents the states of the world. Nine environmental states θ_i (table 5.2), can be distinguished at time t_1, which occur with a certain probability. The environmental conditions differ according to how the depositors are distributed among the individual types, whether some depositors receive additional information and what content this message has. However, uninformed depositors cannot always recognize which of these environmental states they are in. In order to be able to distinguish environmental conditions, the additional conditions are required in this discrete formulation, therefore assume that

$$\begin{cases} w_1 = \bar{\alpha} \\ w_2 = w_1 + \bar{\alpha}(1 - w_1) \end{cases} \tag{5.2}$$

The aggregate deposit deduction K can be defined as $K = w_2$ which is correlated to proportion of withdrawals and if the deposit deduction exceeds K then insolvency of the bank may be possible.

5.2.2 Equilibrium without Communication

The decision problem in the planning period is trivial, as there is no case for consuming at $t = 0$. For date 2, type 1 also trivially liquidate all their investments. A random fraction of type 2 depositors receives informative signals. Due to the fact that $r_H > 1$, type 2 depositors only liquidate their investment if they obtain information about the low return on the project, i.e, $\theta = r_L$. So the risk arises from the expectations of uninformed type 2 depositors. In Chari and Jagannathan (1988) they assume that the reserved equilibrium level of investment is correlated with the signal received by informed depositors but the signal is incomplete. For the sake of simplicity, I interpret this signal as the consequences of a large number of withdrawal requests when uninformed type 2 depositors see a long queue in front of the bank counters either for a large number of type 1 depositors or for informed type 2 depositors who receive bad news. If bad news is sufficiently probable to the uninformed type 2 depositors, they also withdraw their deposits.

The reason is that type 2 uninformed depositors will find that the equilibrium level K which is total investment level at $t = 1$ is correlated with the signal received by informed depositors but their signal, however, is 'incomplete'.

The following table provides an overview of the different scenarios and reactions, which leads to different forms of efficient or inefficient bank runs:

State	Probability	Signal	W	Deposit Deduction at $t = 1$	Bank Interpretation
S_1	$r_0(1-q)$	$\theta = \emptyset$	0	0	Efficient
S_2	$r_0 p_H q$	$\theta = r_H$	0	0	Efficient
S_3	$r_0 p_L q$	$\theta = r_L$	0	w_1	Inefficient
S_4	$r_1(1-q)$	$\theta = \emptyset$	w_1	w_1	Efficient
S_5	$r_1 p_H q$	$\theta = r_H$	w_1	w_1	Efficient
S_6	$r_1 p_L q$	$\theta = r_L$	w_1	100%	Efficient BR
S_7	$r_2(1-q)$	$\theta = \emptyset$	w_2	100%	Inefficient BR
S_8	$r_2 p_H q$	$\theta = r_H$	w_2	w_2	Efficient
S_9	$r_2 p_L q$	$\theta = r_L$	w_2	100%	Efficient BR

Table 5.2: Minimal panic equilibrium based on Chari and Jagannathan 1988

In states, 6 and 7 an uninformed type 2 depositor who observes a queue in front of the bank or hears the rumors can interpret this as a bad signal. Since an uninformed type 2 depositor cannot distinguish the environmental conditions, a bank run may occur in both statements. Only an inefficient bank run occurs in state 7 since no negative information of, for example, insolvency of the bank was known. In this situation, beneficiaries of a bank or supporters of calm conditions, to avoid irrational shocks attempt to prevent uninformed depositors from irrational reacting by restricting free media reporting or punishing those who have provoked a bank run. This would be one side of the coin, on the other side such a regulation would lead to an inefficient bank in the states like S_6 or S_3.

Burghof 1998 explains that an equity standard ensures a very low bankruptcy probability in t_2 - i.e. the probability p_L of the bankruptcy result r_L is very low. First reason is, informed depositors are less likely to receive bad news. Second, for uninformed depositors of type 2, who cannot distinguish between S_6 and S_7 , the fear in their decision calculation loses weight that the state could be S_7. They therefore react more relaxedly to high deductions and do not withdraw their deposits. Hence, The probability of occurrence of the states S_3 , S_6 and S_9 decreases.

As it was mentioned, an uninformed type 2 depositor who observes a 'queue' of length w_1 in front of the bank can interpret this as a signal for the states S_6 or S_7. At this point, I expand their model in the following steps: on the one side his decision on whether to withdraw his deposit depends on whether the expected value remains higher than its liquidation value $L = 1$ which is the condition for the deposit to remain in the bank.

On the other side, in state 7 there would be mutual trust communication to prevent - or to inform - uninformed depositors. In the latter case, the business culture, the importance of informal negotiations in the formation of economic actors and bilateral communications of manager and depositors would be another step forward to expand the model in order to provide soft information to prevent bank run.

The critical value p_L might affect the stability of the system. For high values of p_L , depositors will want to withdraw and there is a bank run. For the low values, they do not run. The following lemma derived from Burghof 1998[1] to explain the condition under which depositors respond to aggregate investment in $t = 1$.

[1]See Burghof 1998, section 3.3.4.4 "Zur Funktion von Eigenkapitalnormen bei der Vermeidung eines Bankruns nach Chari/Jagannathan"

Lemma 5.2.1. Decision Mechanism of the Uninformed Type 2 Depositors

When uninformed type 2 depositors who observes informed depositors in front of a bank, if the following conditions are satisfied:

$$p_L \leq \frac{(r_H - 1)(1-q)r_2}{r_H(1-q)r_2 + r_1 q}$$

then the optimal strategy is not withdraw, otherwise, the optimal strategy would be a bank run or deposit deduction.

Proof. Using the conditional probability of each state S_6 and S_7 given that S_6 or S_7 occurred, we have,

$$p(S_6 \mid S_6 or S_7) + (p_H r_H)(S_7 \mid S_6 or S_7) \geq L$$

Using Bayesian rule:

$$p(S_6 \mid S_6 or S_7) = \frac{(1-q)r_2}{r_H(1-q)r_2 + r_1 q}$$
$$p(S_7 \mid S_6 or S_7) = \frac{q r_1}{r_H(1-q)r_2 + r_1 q}$$

Using the latter two equations in the first inequality and assume that $L = 1$ they then get;

$$p_L \leq \frac{(r_H - 1)(1-q)r_2}{r_H(1-q)r_2 + r_1 q}$$

□

According to the lemma 5.2.1, the critical probability leads to the conclusion that bank shocks would not arise if the likelihood of a bad return investment was small enough. This could lead to an improvement in system stability. As a result, it can be shown that for some low value of p_L, a non-efficient bank run would not occur.

Corollary 5.2.1.1. The equilibrium based on the Chari and Jagannathan model holds if the condition in lemma 3.1 is not met or if

$$p_L > \frac{(r_H - 1)(1 - q)r_2}{r_H(1 - q)r_2 + r_1 q}$$

5.2.3 Equilibrium with Communication

I now modify the model by assuming that in some states the signal θ is not revealed. Therefore, the depositor obtains a signal from bank managers. This signal can be assumed to be the private information regarding the return of long-term investment. In case of hard information or long queues in front of banks, the private signal was not strong enough to lower the incentive of the uninformed depositor to run on the bank. Thus, he decides to withdraw.

In case of adding communication or soft information which are some pieces of information of the bank value that cannot be certified and it requires trust, the type 2 depositors receive this information from bank managers for the state outcome at t_1, then they decide to withdraw or not.

As it was mentioned before, in some states there would be no information and uniformed depositors cannot distinguish states i.e. S_7 from S_6. In our extended model, managers will communicate or have cheap talk with depositors and give them an information signal, soft information, to prevent run and deposit withdrawal. This soft information can be interpreted in the different business banking models. The regional scope of business activities and the business culture of the individual bank are the important factors in banking relationships that can be interpreted as soft information too. This idea is due to the reason that, at the level of three pillars in the German banking industry based on their business models, dishonesty for their own benefits in regional cooperative banks is not in favor of employees (Maurer et al. 2019).

One reason is that dishonesty can affect banking relationships and it would be harmful for the individual banks in the business culture as well as mutual trust between banks and depositors.

There would be an important consequence of distrust in the regional case. If bank managers jeopardized the reputation of the small banks then it would be difficult to rebuild trust in their regions. Therefore, it is vital for small banks to have trusting relationships with their depositors.

Another reason would be a low salary due to the lower return in small banks. Since cultural punishment is high, then the managers try not to deceive their clients. On the contrary, in the big banks managers receive high salaries and bonuses. The punishment for dishonesty is not high enough to prevent them being deceitful (Cohn, Fehr, and Maréchal 2014). Hence, it incentivizes them to lie or to hide bad information in favor of their depositors.In the next part, a model of strategic communication of informed bank manager who can send unverifiable signals to a depositor, who chooses to trust it or not and takes an action, is introduced.

Honesty in the Sub-game Equilibrium

In this strategic communication, bank managers who lie about their private information may obtain a higher payoff at cost of depositors in several scenarios. Assuming that 'say nothing' and 'lie' are the same, in this model there are two strategies available to the manager who interacts with type 2 investors. The outcome of the other interactions remains the same as described in the previous sections.

Figure 5.2 shows the graph tree of the events that occurred between t_1 and t_2. In this sub-game let us assume that bank manager and depositors are the players of this game. Assume that bank managers receive salaries S and punishment or fines is p^*.

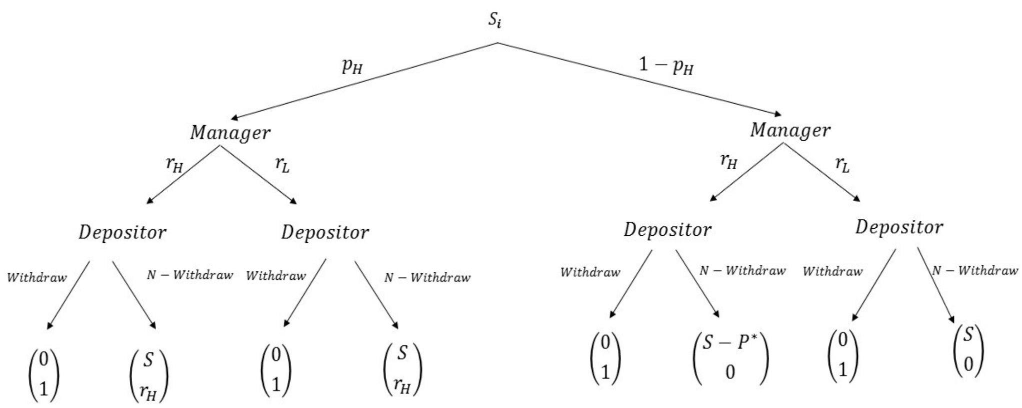


Figure 5.2: The event tree for the bank manager and depositor with their payoffs

Depositors may run in both states S_6 and S_7, as shown in table 5.2, however a bank run would not be optimal if particular criteria are met, as stated in Lemma 5.2.1. The punishment would be more effective in decentralized or small institutions due to smaller salaries than in large banks.

In our model, it is assumed that if there is an insolvency then the salary is zero; therefore in both cases of efficient and inefficient bank runs the salary would be zero. In state 7 only bank manager is informed about the payoff at $t = 2$. In this state the signal is noisy that depositors cannot realized the payoff at $t = 2$ according to θ. After the bank manager has been informed, they choose a mixed strategy of $\theta = \{r_H, r_L\}$. The outcome matrices for both managers and depositors based on withdrawal and non-withdrawal of depositors is shown as follows:

$\theta = \{r_H\}$	Manager	Depositor
Withdraw	0	1
Not Withdraw	S	r_H

$\theta = \{r_L\}$	Manager	Depositor
Withdraw	0	1
Not Withdraw	$S - p^*$	0

Table 5.3: Matrices of the returns based on depositors' action with different signals

In model there is the assumption that bank managers receive their salary at $t = 1$ so we simplify the model about the salary in date 2 where they receive their salary or not. When the bank managers say nothing about their signal, then the depositor's decisions would be the same as before and thus there is an inefficient bank run. In state 7 there are two possibilities when bank manager information about prospect return is high or when it is low. There is an argument that in the big or centralized banks managers could be deceitful and irresponsible due to the lack of monitoring from depositors, as well as the managers' high salary. However, low salary and close form of relationships in the small banks prevent bank managers being deceptive.

Limitation of punishment in the legal system leads us to assume that punishment p^* for both managers is fixed. This assumption is crucial to our model, but it is right. In real life you could get harsher punishment if you lie as the manager of a big bank, but the legal system has limitations. One is limited liabilities meaning you cannot get more than managers owns; secondly, you cannot put a director or board member of a big bank in jail for a longer time for the same wrong decision as made by the small bank. In other words, the penalty cannot grow with the size of the bank and size of the salary. In addition, cultural effect of punishment is different.

To take an example, in some countries, the death penalty is common and some countries like U.S.A. sentence people for more than normal life. A case in point is Bernard Lawrence Madoff, who has charged for securities fraud, investment advisor fraud, pleaded guilty and his penalty was 150 years in prison. However, in the German legal system, which is more humanitarian based and non-oppressive towards members of society, this kind of punishment is not acceptable.

In S_1, S_2, S_3, S_4, S_5 and S_8 because of available liquidity nobody runs, therefore the bank manager has no incentive to communicate with depositors. In states S_6 and S_9 since the withdrawal is based on bad signal and clearly the state of the nature is bad, there is an efficient bank run and therefore there is no need for communication either. However, in S_7 there is no signal and the depositors run only because of the news or queue. In this state since the bank manager knows whether $\theta = r_H$ or $\theta = r_L$ they have the incentive to communicate to prevent an inefficient bank run.

Remark 2. Description of different banks decisions

- Big Banks or centralized banks
  - Case 1: $\theta = r_L$

    The bank managers always want to lie to a prevent bank run and get their salary.

    Depositors will not withdraw.

    Bank manager payoff: $S - p^*$. Depositors payoffs: 0
  - Case 2: $\theta = r_H$

    The bank managers tell the truth to prevent bank run and get their salary.

    Depositors will not withdraw.

    Bank manager payoff: S. Depositors payoffs: r_H

  Bank managers in the big banks always say that everything is fine.

- Small Banks or decentralized banks

- Case 1: $\theta = r_L$

  The bank managers tell the truth since the punishment relative to their salary is so high.

  Depositors will withdraw.

  Bank manager payoff: 0 Depositors payoffs: 1

- Case 2: $\theta = r_H$

  The bank managers tell the truth to prevent bank run and get their salary.

  Depositors will not withdraw.

  Bank manager payoff: S. Depositors payoffs: r_H

In other words, bank managers in the small banks tell the truth.

Given the assumptions that in the real world the acceleration of the increment of the salaries in banks is higher than the punishment, it is assumed that the salary as a function of bank size is given by $S(z)$ with $dS > 0$ and $d^2S < 0$.
For visualizing our approach, let us assume that the punishment according to the legal system in Germany has lower bound and upper bound. Also assume that the punishment is a function of the size of the bank like $p^*(z)$ with $dp^* > 0$ and $d^2p^* < 0$.
The punishment function can also be a strictly decreasing convex function while based on our assumption the punishment effect for small banks due to the local cultural effect is so high.
Figure 5.3 depicts the salary and punishment functions dependent on the bank size. The intersection of these two functions happen when the salary amount and punishment are equal. This game has incomplete information and it is a signalling game or a cheap talk game (Farrell and Rabin 1996).

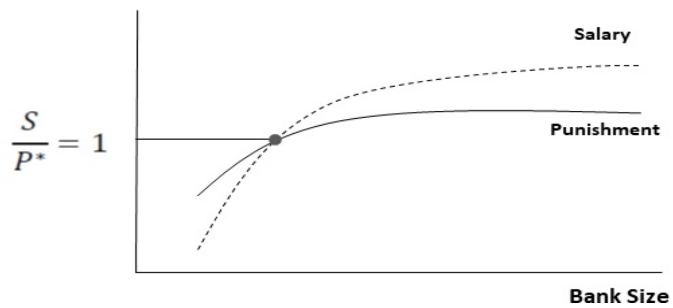


Figure 5.3: The salary and punishment as the function of bank size

Both types of managers can choose r_H or r_L here. However, depositors can watch the action and distinguish the message while not being able to distinguish the state of the manager. The question would be: what would be an equilibrium in this game?
Crawford and Sobel 1982 defined three criteria that must be met in order for a cheap talk to be informative. The following are the three requirements:

1. Managers have different priorities regarding the actions of depositors, which is consistent with our assumption that managers may lie based on the return at t_2. Furthermore, it is assumed that if the manager is in the r_L state, she has different preferences than the other states, and the different manager types have different preferences when it comes to depositor activities.

2. Depending on the type of manager, the depositor seeks different actions. This is consistent with the assumption that they would not trust the manager if they knew she lied.

3. The depositor's action preferences do not completely contradict those of the manager. This is consistent with the assumption that if they know the manager is trustworthy, they will not withdraw their deposits.

The following section will provide an overview of our cheap talk game.

Cheap Talk Game

A modified incomplete game[2] in the form of a signaling or cheap talk game based on Farrell and Gibbons 1989 will be introduced in this section. Let N={manager, depositor} be the set of players[3]. Because the state of nature is unknown, i.e., S_1, S_4, S_7, either r_H or r_L would be selected with equal probability, e.g., $p_H = p(r_H) = p(r_L) = 0.5$. Only the manager is informed about the payoff, but it is not verifiable. Assume that in states 1, 4 and 7 selecting $\theta \in \Theta = \{r_H, r_L\}$ means that final payoffs are realized according to θ. After being informed, the manager decides on a strategy depending on the message space

[2]Fudenberg and Tirole 1991

[3]In our model, managers are those who know the outcome at t_2, whether it is a high return (r_H) or low return (r_L).

$m = \{r_H, r_L\}$. The message or talk is cost-less, non-binding and non verifiable. This type of talk is referred to as "cheap talk," and the structure of our model is built on "cheap talk" games. If nature chooses r_H, the manager communicates with the strategy $m(r_H) = r_H$. She lies in with the strategy $m(r_H) = r_L$.This strategy is absurd and illogical. Similarly, if nature selects r_L, she communicates with the strategy $m(r_L) = r_L$ and represents the actual payoff scheme. She lies in this case with the strategy $m(r_L) = r_H$. The above four strategies are pure strategies for the bank manager.

"Pooling strategies" are strategies by which bank managers deliver the same message regardless of the state. "Separating strategies" are when the message and state are the same.

Taking these assumptions into account, the depositor opts for a mixed approach based on the action set A={Not-Withdraw (NW),Withdraw (W)}. The belief structure for the depositor is as follow. If $m = r_H$, which means the manager transmit message r_H, the depositor believed with probability $B(m(r_H) = r_H) \equiv B_{r_H}$ that the actual payoff scheme is based on r_H whereas he thinks with probability $B(m(r_H) = r_L) \equiv 1 - B_{r_H}$that the outcome state for r_L is the one determining payoffs. If $m = r_L$, the depositor believes with probability $B(m(r_H) = r_L) \equiv B_{r_L}$ the payoff is based on r_L and with probability $B(m(r_L) = r_L) \equiv 1 - B_{r_L}$ that the payoff for r_L state is relevant.

The structure of the cheap talk game as a tree diagram is depicted in figure 5.4.

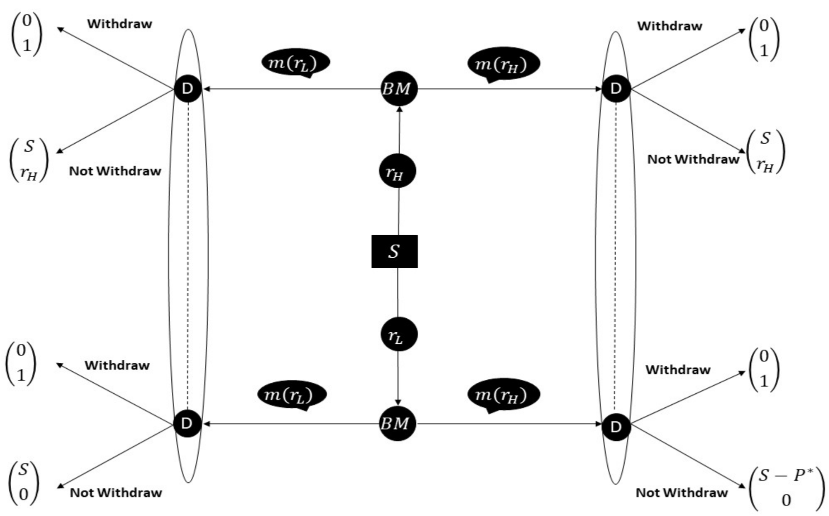


Figure 5.4: Cheap talk game for the bank manager (BM), depositor (D) and their payoffs

In our cheap talk game, since messages have no direct effect on the manager, managers'

pooling strategy is the best answer if the depositor ignores all messages. Since the manager is pooling, the best response for the depositor is to ignore all messages. If the depositor's optimal action in a pooling equilibrium is formally referred to as withdrawal, the depositor will get maximum benefit. Hence, if the manager plays any pooling strategy and if the depositor retains the previous belief that $p(r_i) = 0.5$ after all messages, it is a perfect pooling equilibrium performing the withdrawal action.
The expected payoff matrix from each type actions for pooling strategy is shown by the following table:

Managers vs Depositor	Depositor Not Withdraws	Depositor Withdraws
Manager tells r_H	$\frac{2S-p^*}{2}, \frac{r_H}{2}$	$0, 1$
Manager tells r_L	$\frac{S}{2}, \frac{r_H}{2}$	$0, 1$

Table 5.4: Expected payoffs for manager and depositors in pooling strategy

Lemma 5.2.2. Pooling Perfect Bayesian Equilibrium (PBE)
In a pooling perfect Bayesian equilibrium, the manager strategy is

$$m(r_H) = r_H, m(r_L) = r_H$$

The depositor's strategy is to ignore the messages. Thus, a pooling equilibrium exists if and only if $S > p^*$ and the depositors optimal action would be not withdrawal when $r_H > 2$ or withdrawal when $r_H < 2$.

Proof: In case of transmitting r_L, it makes no sense for the manager to downgrade the r_H state. Therefore the pooling strategy for the r_L case does not exist. However, if the bank manager consistently informs you that the state is r_H, the depositor's belief $(B_{r_H}, 1 - B_{r_H})$ at this information set is determined by Bayes' rule as: $B_{r_H} = \frac{0.5}{0.5+0.5} = 0.5$. Given this belief, the depositor does not trust the management, and as a result, he will choose the optimal response for himself based on the matrix output. The pooling equilibrium exists in this scenario if -and only if- the following conditions from table 5.4

are met.

$$\frac{2S-p^*}{2} > \frac{S}{2}, \frac{r_H}{2} > 1 \text{ or } \frac{r_H}{2} < 1 \Longleftrightarrow S > p^*, r_H > 2 \text{ or } r_H < 2. \quad \square$$

There are two crucial features to the pooling equilibrium. First, the depositors' return should be exceedingly large at t_2, or the bank should be too big to fail. As a result, even though this scenario $r_H > 2$ is improbable, he would not withdraw. Second, $S - p^*$ should be a positive number. Only when a bank manager works in a centralized banking organization, $S - p^*$ would be positive.

An interesting scenario would be the case separating equilibrium. That means the managers choose two $m(r_H) = r_H$ and $m(r_H) = r_L$ strategies or they choose $m(r_H) = r_L$ and $m(r_H) = r_L$. As previously stated, lying regardless of the state of nature is not rational. As a result, this can't truly be the equilibrium. The expected payoff matrix from each type actions for separating strategy is shown by the following table:

Managers vs Depositor	Depositor Trust	Depositor Not Trust
Manager tells lie	$\frac{2S-p^*}{2}, \frac{r_H}{2}$	$0, 1$
Manager tells truth	$\frac{S}{2}, \frac{r_H+1}{2}$	$0, 1$

Table 5.5: Expected payoffs for manager and depositors in separating strategy

The following lemma can be implemented as truth telling condition for the bank manager. In this cheap talk game, the manager's strategy is to tell the truth rather than lie.

Lemma 5.2.3. Truth telling condition in the separating equilibrium

In a separating perfect Bayesian equilibrium, the manager strategy is

$$[m(r_H) = r_H, m(r_L) = r_L]$$

and the depositor trusts the manager. Also, the depositor's strategy is

$$a(r_H) = NW, a(r_L) = W$$

Thus, a separating equilibrium exists if and only if $S < p^*$.

Proof: To have an equilibrium in table 5.2 when the manager tell the truth the following from table 5.5 conditions should be fulfilled.

$$\frac{S}{2} > \frac{2S - p^*}{2} \tag{5.3}$$

$$\frac{r_H + 1}{2} > \frac{r_H}{2} \tag{5.4}$$

$$\frac{S}{2} > 0 \tag{5.5}$$

$$\frac{r_H + 1}{2} > 1. \tag{5.6}$$

Conditions 5.5, 5.6 and 5.7 are clear. Condition 5.4 exists if and only if $S < p^*$. □

Since monitoring the bank is costly, there is no reason to expect depositors to monitor the bank. Therefore, the depositors should have incentives to deposit in the bank and that would not happened if the managers reveals decisive information. Hence, if the manager communicates falsely in all states except states 1, 4 and 7, the depositors will find out, since the α proportion of depositors or informed depositors knew it already. Therefore, they need only worry about states 1, 4 and 7. Given that the best responses for manager and depositors can be extracted from previous lemmas, then the communication of bank manager with depositors is feasible if -and only if- the incentive compatible and participation mechanism exist. In other words, the depositors trust the bank managers otherwise; they would not listen to their cheap talk.

Corollary 5.2.3.1. Sub-game equilibrium in the decentralized bank
In the decentralized banks, the communication between the bank manager and depositors is feasible and incentive compatible, and has sub-game equilibrium that decrease the probability of a non-efficient bank run.

Figure 5.3 shows that the punishment curve is always higher than salary curve for the managers in the small banks, and thus the separating equilibrium exists for the decentralized bank. The sub-game equilibrium is also equilibrium in dynamic games, it is also Nash equilibrium in our dynamic model (Selten 1965). Therefore, because the bank manager in small banks can persuade depositors with their unverifiable r_H signal in S_7, depositors will not withdraw. Therefore, the expected welfare in the equilibrium for the decentralized bank is higher than the expected welfare in the equilibrium for the Chari-Jagannathan model.

Corollary 5.2.3.2. Centralized vs Decentralized Banks

1. In the centralized bank or big bank if the bank manager knows the state r_L since $p^* < S$ then she lies or say nothing.

2. In the decentralized bank or small bank if the bank manager knows the state r_L since $p^* > S$ then she tells the truth.

Therefore, in the centralized bank, the depositors expected a telling lie statement of the bank managers so they would not trust them and they will not communicate. But in the decentralized bank or small bank, the depositors communicate since they believe the bank manager tells the truth. Consequently, in the worst-case scenario in state 7 they would not run when the bank manager communicates with them and tell the truth.

A Flood Catcher In Bank Shocks

The cheap talk model, described in the previous sub-section is an important approach to show how soft information can prevent a non-efficient bank run. In the Chari Jagannathan model one can deduce that when there is no information in the state, adding incentive constraints like higher return in S_8 lead the type 1 depositor become type 2 depositor. In addition, they mentioned that suspension of convertibility would improve expected utility. In this model instead of suspension of convertibility (which would be one problem for small banks that they have less ability to do such decisions,) a long-term relationship between bank managers and the depositors as a big advantage for the decentralized banks is implemented. Therefore following statement can be driven,

Remark 3. If the punishment for the bank manager is high enough, that conditions for truth telling mechanism hold, then the equilibrium with soft information yields higher ex-ante utility than the Chari-Jagannathan equilibrium.

In other words, depositors in decentralized banks are expected to contribute more than those in centralized or large banks. In decentralized banks, long-term banking relationships, which also capture soft information, act as a flood catcher to assist managers in decentralized banks in mitigating inefficient bank-runs.

5.3 Discussion and Conclusion

The chapter explained how banking culture and structures influenced bankers' honesty and dishonesty. I modified the model of Chari-Jagannathan (1988) to express that long-term banking relationships and mutual trust between bank managers and depositors are important benefits for decentralized banks.

Not only would the decentralized banking structure or small banks increase trustworthiness, but also the expected welfare for the depositors. As a result, the banking system would be more stable.

The limitation of punishment in the legal system incentivizes the managing system at some point to be cunning. The ratio $\frac{p^*}{S}$ and the difference between S and p^*, are critical values for the decision mechanism of the manager. Therefore, the higher the punishment or the lower the salary, the less likely the manager is to be persuaded to lie.

The expansion of huge corporations and banks equates to the abolition of small corporations and banks. It is up to legislators to give small or decentralized banks the yellow light and thereby eliminate them from competition. As a result of our findings, the system's resilience may be reduced.

Due to regional cultural effects, even social punishment will be obsolete in the future. I discussed how in small banks, trust and soft information between bank management and depositors protect inefficient bank runs. Hence, due to the higher probability of inefficient bank runs for big banks, imposing stricter regulations for big banks, like monitoring, and lowering their salaries, would be beneficial.

Chapter 6

Concluding Remarks

The German banking system, with its particular three-pillar structure and high share of public banks, is very well suited for the systematic analysis of the structure of financial systems and their characteristics. In the years before the financial crisis, the financial system was usually divided into two categories: bank-based and market-based systems. After the financial crisis, the situation changed and the system became more transparent, which also drew more attention to centralized and decentralized banking structures.

The degree of concentration on financial systems within individual banks was then investigated in order to clarify the German banking system's during the period from 2006 to 2020. Performance measures such as Return on Assets (ROA), Return on Equity (ROE), and Z-score were used to compare decentralized or small banks, such as savings and cooperative banking groups, and centralized or big banks, such as Deustchebank, Commerzbank, and other centralized bank groups. Furthermore, the structure of the banking system's decision-making system, as well as its impact and optimization across the entire banking system, have been analyzed. Decentralized banks were found to be more stable than centralized banks. Furthermore, despite the fact that centralized banks' profitability ratios are higher than decentralized banks', centralized banks' profitability ratios decreased during the financial crisis.

A computational analysis of decision-making structures in centralized and decentralized banks was performed to investigate its effects on different performance measures of the system, including expected return, value-at-risk, and expected shortfall. It was shown that when the market synchronization increases, the value-at-risk and expected shortfall of a decentralized bank are lower than a centralized bank, whereas the average profit of the centralized bank is higher. The delegated structure in the decentralized bank and the authority of the bank managers are important reasons for ameliorating the risk of decisions. The risky decision-making and staggering costs in the bad economy like the financial crisis of 2007-2008 showed that the structure of the bank should not only be governed by the centralized banks.

The performance of the decentralized bank is improved by incorporating soft signals into the model. Soft signals, in practice, would be the interpretation of local managers from local investments. Because of the bureaucracy and decision-making structure of a centralized bank, local managers are less motivated to employ and examine borrowers' investments and characteristics. In other words, in the decentralized banks once the primary needs, such as financial documents from companies or borrowers, are met (hard information), managers can use their perceptions about borrowers, which is so-called 'soft information'. In practice, there are forms that they use to give their feedback about borrowers. In the model, we used this information as a weighted soft signal. Although the overestimation of the local economy may have a negative impact, this soft signal has a quite positive impact on risk measures in general. The reason would be that the managers in decentralized banks can better prevent their banks from bad loans. Also, due to the less bureaucratic situation in small banks, the borrower can easily and quickly receive that loan.

Moreover, the behavior of decentralized and centralized banks in the deposit business was explored. The behavior of these two banks in the local economy was considerably different, and this issue is directly related to regional culture. Mutual trust and cultural closeness among employees, bank board members, and neighborhood residents are critical categories in banking relationships. The foundations of this trust were destroyed in the centralized system, mainly due to the management prospect and lack of attention to its clients. As a result, managers should not expect depositors to help them out in a crisis. Furthermore, the limitation of punishment in the legal system incentivizes the managing system in centralized banks at some point to be cunning. Consequently, based on the modified model the higher the punishment or the lower the salary, the less likely the manager is to be persuaded to lie.

According to the modified Chari-Jagannathan (1988) model, a decentralized banking system can significantly improve the financial system's credibility by mitigating unwanted shocks during bad economy. Hence, having decentralized banks in the banking structure may increase the depositors welfare.

Global competition, increased technology innovation, and mergers and concentration trends are all leading to a transformation in the banking industry. Competition between the three pillars of the German financial structure may become more severe as integration develops. Furthermore, big banks like Deutsche Bank and Commerzbank have discussed merging, suggesting that the centralized structure is insufficient. Because each bank's stability is crucial, this problem will continue to be relevant in the future, especially as the number of stable decentralized banks decreases.

The blockchain industry, on the other hand, has left all analysis in the dark. The fintech revolution and digital decentralization may be significant developments in the financial world, and banks should endeavor to adapt as quickly as feasible. Although I focused on small or decentralized banks in this dissertation, with thorough inspection and scrutiny, new decentralized financial institutions, as well as digital decentralized banks, might be implemented using artificial intelligence as a new way for analyzing soft information.

Of course, further research is required to completely comprehend all of the factors that contribute to a stable banking system. Although only one type of theoretical study was undertaken in this dissertation, similar researchers have examined the accuracy of this dissertation in practice and reached similar conclusions (Burghof, Gehrung, and Schmidt 2021) (Flögel and Gärtner 2018).

Investigating the relationship between policy and banking structures could be the "next step" in this research. One advantage would be to investigate how governments' monetary policies affect banking relationships, as well as which of these bank groups is least influenced by policy errors and mismanagement and is most likely to act independently.

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