Centralized and Decentralized Decision Making Structures in the Banking System: A Preliminary Model

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Abstract

This paper proposes to study the welfare consequences of centralized and decentralized lending decision structures in the banking system. Centralized systems tend to perform better when companies can make use of hard information, whereas decentralized structures are better in case of small firms that rely on relationship banking and soft information. Moreover, a preliminary model shows that a decentralized systems performs better when economic agents (firms) are uncertain of the state of the economy (good or bad).

Keywords: Financial intermediation, relationship lending; SMEs; hard-information; soft-information.

JEL Classification: G2.

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1 Introduction

The German banking system has always drawn considerable attention. Consisting of three pillars, which are private commercial banks, public sector banks, and cooperative banks, it is able to combine profit maximizing institutions - private banks - with others that aim instead at fostering local economic development - public and cooperative banks. The high number of banks - 1,919 according to 2010 figures, the largest among euro area countries - represents the fact that Germany is a bank-based economy (IMF (2011)).

The public sector banks in Germany, namely savings banks, Sparkassen, and their corresponding apex institutions, Landesbanken, operate under a regional principle. The focus of savings banks is on retail and small and medium-sized enterprises (SMEs) relationship banking, with the regional principle ensuring that savings banks operate only within their regions, facing competition from commercial and cooperative banks but not from other savings banks. The public banks also operate under a mutual guarantees scheme through which they provide co-insurance to each other.

The global financial crisis of 2007-2009 put the German Banking system and its corresponding structure to test. Whereas exposure to toxic assets in the U.S. led to large losses in private sector banks and in the Landesbanken, requiring government bailout operations funded by taxpayers’ money, the savings banks did remarkably well. Indeed, after a short period of losses in 2008, savings banks’ profits in 2009 were as high as in 2007, while their private sector counterparts were still losing money (Finance Watch (2014)).

Savings banks are of predominant importance to the German economy. Together with cooperative banks, they constitute a substantive source of funds to German small businesses which, by virtue of their size, do not have access to financial markets to obtain long-term financing. Mittelstand, or SMEs in Germany (up to 500 employees and up to €50m annual turnover), represent more than 99% of all German firms, accounting for almost 52% of total economic output. Roughly 95% of all the SMEs are family-owned, among which 85% are managed by their owner. SMEs in Germany focus on medium and long-term investments, with almost one third of it being financed by banks’ loans (BMWi (2012)).

The global financial crisis and its aftermath highlighted not only the resilience of savings banks, but also their response to it. Whereas private banks, at the expense

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1A comprehensive debate of the German banking system is found in, among others, Hackethal, Schmidt, and Tyrell (2006), Schmidt (2009) and Hüfner (2010).

2This included the establishment of the Sonderfonds Finanzmarktstabilisierung (SoFFin), a €480 billion rescue package to provide guarantees and recapitalization.
of medium and long-term lending, increased short-terms loans to companies and households in the period between 2007 and 2012, savings banks did the opposite (The Economist (2012)). Given that private banks also have local branches that could presumably extend loans to small businesses, the question is: what differentiates savings banks in their ability to finance SMEs in Germany?

We argue, based on theoretical and empirical evidence to be presented in the following sections of this proposal, that savings banks are better able to serve SMEs due to their capacity of engaging in relationship lending, which in turn is due to the decentralized decision making structure that is embedded in their organizational structure. Indeed, quoting a technical note on the German banking sector structure released by the International Monetary Fund (IMF (2011)):

“The relatively low cyclicity of NPLs (non-performing loans) may contribute to, and be supported by the “house bank” relationship between banks and many of their borrowers, which smooths credit conditions over the cycle.”

Against a background of extensive consolidation of the banking sector in Germany, which observed a decrease of 44% in the number of banks since 1990, and regulatory changes in the aftermath of the financial crisis, this has profound implications for both the efficiency and risk of bank lending in Germany.

First, the benefit of the decentralized structure of savings banks lies on the fact that it allows loan officers to act on soft information, i.e., information that is hard to quantify, but that nonetheless represents the viability and performance of small businesses. Turning small, local banks, into large institutions, with their accompanying hierarchical layers and central decision structure, would undermine the benefits of soft information, as it would be impractical for it to be transmitted credibly. This would destroy the incentives for loan officers to collect soft information, which in turn can increase the risk profile of loans extended and, in turn, of the banking system itself.

Second, one criticism regarding the structure of the German banking system is grounded on the fact that it exhibits a high degree of public ownership. Due to that, public sector banks are not subject to market discipline, the third pillar of the Basel II agreement envisaging the safeguarding of financial stability. If arguably true in the case of the Landesbanken, the mutual guarantee regime under which savings banks operate lead Sparkassen associations to exercise strong oversight over their members and, if anything, imposing market discipline would induce short-termism in the lending decision of savings banks, ultimately hurting SMEs in Germany.
2 A Brief Overview of Relationship Lending

"Smaller banks traditionally have been the source of capital for small businesses that do not generally have access to securities markets. In turn, small, new businesses, often employing new technology, account for much of the growth in employment in our economy. The new firms come into existence often to replace old firms that were not willing or able to take on the risks associated with high-growth strategies. This replacement of stagnating firms with dynamic new firms—what the economist Joseph Schumpeter called the "perennial gale of creative destruction"—is at the heart of our robust, growth-oriented economy." (Greenspan (1997))

The relationship between financial development and growth has been extensively studied in the economics and finance literature. In a seminal paper, Rajan and Zingales (1998) have shown that, by reducing the costs of external finance to firms, financial development facilitates economic growth. Arguably, small and medium-sized enterprises (SMEs) are more financially constrained than big and well established companies, which makes financial development even more of an issue for them. To the extent that SMEs do not have access to financial markets, they must then rely primarily on banks to finance their operations and development.

Not only by virtue of their size, SMEs differ substantially from large companies. One aspect of this differentiation regards the type of information available about them, a crucial aspect since, ultimately, availability of credit relies on information. In this regard, information about SMEs tend to be, following the classification in Petersen (2004), soft, i.e., less quantitative and hence not easy to be stored and to be transmitted in impersonal ways, as opposed to hard information, on the other end of the spectrum.

Another important aspect that differentiates SMEs from large companies is that, arguably, they are more sensitive to oscillations in cash-flows from their operations:

3Campbell and Loumioti (2013), on the other hand, present evidence against the prevailing views on the limited portability of soft information.
whereas large companies can not only rely on financial markets but also on internal funds, SMEs need a steady source of funds through the business cycle: intertemporal smoothing, as in Allen and Gale (1997), matters more for them.

In this context, it is important for SMEs to be able to engage in relationships with banks that will provide the necessary funds for their operations, as that facilitates the overcoming of asymmetric information problems due to the nature of soft-information that they can provide, and also the uncertainty regarding future cash-flows that they face. Indeed, as Boot (2000) puts it, relationship banking is most directly aimed at resolving problems of asymmetric information: through the course of a relationship, lenders can become better informed of the firms that they fund.

The question that follows is, what kind of banks are better suited to engage in relationships with firms, in particular with SMEs? Many attempts have been made in trying to answer this question, with some summarized in the sequence, starting with the theoretical literature.

### 2.1 Theoretical Literature

The theoretical literature related to relationship lending can be mainly divided in two parts. The first one explores the emergence of bank-firm relationships as a way to overcome problems due to asymmetric information, as in Sharpe (1990). However beneficial in diminishing the degree of asymmetric information between banks and firms, relationship lending might lead to a hold-up problem, since banks have bargaining power over the firm’s profit once projects have begun, as pointed out by Rajan (1992). Nevertheless, even without learning, bank-firm relationships can be welfare enhancing, as showed by Boot and Thakor (1994) using a model with a competitive credit market with risk neutrality. This part of the theoretical literature also explore other issues, e.g. the terms of the contract between the bank and the firm under relationship lending, as in Greenbaum, Kanatas, and Venezia (1989) (interest rate) and Inderst and Mueller (2007) (collateral).

The second branch of the theoretical literature, summarized in Bellucci, Borisov, and Zazzaro (2016), addresses directly the question of what type of banks are better suited to engage in relationship lending. Stein (2002) develops a model where banks differ in terms of their organizational structure, which can be decentralized or hierarchical: whereas loan officers have more authority in the former, in the later the authority to grant loans is allocated upper in the hierarchy. In this setup, it is shown that, to the extent that the information that firms are able to provide is

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4A subsequent correction of some of the results is presented in von Thadden (2004).
soft, decentralized banks perform better than hierarchical structures. The model developed traces back to that of Aghion and Tirole (1997), which develops a theory of formal and real authority within organizations. Degryse, Laeven, and Ongena (2009) proposes a model where the organizational structure of banks is determined by that of its rivals, which in turn impacts the bank’s choice for lending reach and loan pricing strategy, ultimately shaping competition.

Another aspect that affects the impact of the organizational structure of a bank on relationship lending is the institutional environment where the relationship between the firm and the bank takes place. For instance, Park and Shen (2008), building on Dewatripont and Maskin (1995), show that, if institutions are weak to the extent that the negotiation and enforcement of lending contracts are problematic, decentralization increases the value of loan officers local knowledge, but at the same time leads to soft-budget constraints whereby bad projects are continually refinanced. Indeed, as the authors point out, the response of Chinese banks to financial reforms in the mid-90s was a centralization of lending authority.

The theoretical literature seems to agree on the fact that banks under a decentralized decision structure are better suited to engage in relationship lending or, as stated by Berger and Udell (2002), that the agency problems arising due to the very nature of soft information are better tackled by structuring the bank as a small organization with few managerial layers. Indeed, small banks tend to be decentralized and, therefore, according to the previous argument, they would better serve an economy where local firms, i.e., SMEs, operate in regions impaired by credit rationing.

The intuition regarding the role played by small banks is confirmed theoretically and empirically in Hakenes, Hasan, Molyneux, and Xie (2014) and similarly in Slotty (2009), leading one to question the future of relationship lending in a world where the banking sector becomes more concentrated and competitive. This question is addressed initially in Petersen and Rajan (1995), who argue that concentration in the credit markets allows creditors to internalize the benefits of assisting firms, in particular young ones, hence fostering relationship lending.

On the other hand, Boot and Thakor (2000) provide a model showing that, as interbank competition increases, the volume of interbank loans increases, but there is a concomitant decline in the value added of each loan to the firms. Heider and Inderst (2012) additionally argue that fierce competition increases the incentives of loan officers to not only prospect for loans, but also to be overly optimistic about them, forcing banks to choose to rely only on hard information and therefore harming SMEs. In Hauswald and Marquez (2006) competition is also detrimental, leading to less investments in information acquisition and hence less efficient lending decisions.

To sum up, there is still much to be added to the debate regarding the role on
relationship lending played by the organizational structure of banks, and how that is impacted by changes in the banking sector that affect competition. Quoting Berlin (2008):

“One of the most fertile areas for future investigators concerns the optimal internal structure of financial intermediaries. Researchers have made much more progress in understanding the effects of bank size and market concentration on lending behavior and bank efficiency than they have in understanding the factors governing the internal organizational choices of banks.”

2.2 Empirical Literature

Turning to the empirical literature on relationship lending, it is much more vast than the theoretical one, as pointed out in Strahan (2008). A few papers belonging to it are discussed in the sequence. Using U.S. data, Petersen and Rajan (1994) estimate the effects of relationships on both the availability and the price of credit to small businesses. Subsequently, in Petersen and Rajan (1995), they study the effects of the structure of the credit market on relationship lending, showing that relationships are strengthened under more concentrated markets. Strahan and Weston (1998) offer similar conclusions, however pointing that an increase in bank lending to small business follows only when consolidation occurs among small banking companies.

Addressing the importance of size in the ability to engage in relationship banking, Berger, Klapper, and Udell (2001) find evidence that both large and foreign-owned banks face difficulties to engage in relationship lending with small firms. Berger, Miller, Petersen, Rajan, and Stein (2005), in addition, find that large banks lend at a greater distance and interact less personally with their borrowers. Analysing data from the loan-approval process, Cole, Goldberg, and White (2004) find that, whereas small banks tend to rely on information about the character of the borrower, large banks adopt criteria obtained from financial statements. These results are corroborated in Agarwal and Hauswald (2010), showing that borrower proximity facilitates the collection and use of private information.

The organizational structure of banks is not readily observable, and size is frequently used as a proxy for it. Nonetheless, some empirical studies explore other variables that might account for banks’ choice of organizational structure. Brickley, Linck, and Smith Jr. (2003) point to the complementarity between the strategy pursued by banks and their organizational structure by finding evidence that the local ownership of banks increases with the need of granting greater decision authority to banks’ local managers. Alessandrini, Presbitero, and Zazzaro (2009) use a properly
defined “functional” distance between a bank’s branches and the headquarters as the factor shaping the degree of hierarchy of a bank, and find that SMEs in regions where this distance is greater are more financially constrained, the same result found by Cotugno, Monferrà, and Sampagnaro (2013) using a different dataset but a similar methodology. In turn, Liberti and Mian (2009) find that greater hierarchical distance between the information collecting agent and the loan approving officer leads to a lower use of soft information.

The impact of bank’s size on their performance as relationship lenders indirectly touches upon the issue of how competition and consolidation of the banking industry affect the availability of credit to SMEs. Using industry-level data, Claessens and Laeven (2005) find that competition in the banking industry foster the growth of industries that are more financially dependent. Degryse and Ongena (2005), in an analysis of bank loans in Belgium, provide evidence of spatial discrimination of banks engaging in relationship lending: loan rates increase with the distance between the firm and competing banks, which is taken as a measure of competition. Using the same dataset, Degryse and Ongena (2007) additionally show that, to the extent that banks’ branches face a more competitive environment, relationship lending increases. Using data from Germany, a similar result is found in Elsas (2005). On the other hand, using data from Mexico, Canales and Nanda (2012) argue that the ability of a decentralized banking system to alleviate credit constraints through relationship lending is positively relate to the degree of competition faced by banks.

3 Research Questions and Methodology

Following the discussion presented in the introduction, savings banks play a predominant role in the German economy, by means of being a substantial provider of funds to the Mittelstand, or SMEs, which in turn are a fundamental driver of economic growth. As exposed in the review of the theoretical and empirical literatures, savings banks, due to their organizational structure, are better positioned than large, private banks, to engage in relationship lending and, therefore, to serve SMEs.

The trend in consolidation of the banking system, coupled with regulatory changes in the aftermath of the 2007-2009 global financial crisis, might pose a threat to the German banking system as we know it. In particular, savings banks might face the risk of having their organizational structure changed, if forced into market discipline resulting from their ownership structure being opened to private investors, or else if forced into consolidation.

The consequences from changing the organizational structure of savings banks can be expressed in terms of a risk-return relation. If, on the one hand, increasing
the size of savings banks might lead to gains of scale due to lower operational costs, on the other it presumably leads to informational losses due to loan officers having less incentives to collect soft information that can alleviate adverse selection problems, creating the likelihood of overinvestment in bad projects and underinvestment in high quality ones, bringing more risk to the economy. Indeed, this is shown in a preliminary model presented in the appendix to this proposal. Based on this argument, the first hypothesis to be investigated is:

Hypothesis 1: Changing the organizational structure of savings banks from a decentralized to a centralized structure increases the risk profile of the German banking system, increasing the likelihood of a crisis in the real economy.

Additionally, the global financial crisis showed that savings banks incurred relatively high risks only to the extent that they were exposed to proprietary losses incurred by their apex institutions, the Landesbanken\(^5\). The mutual guarantees scheme that savings banks are part of can be blamed for that, and a regulatory design that aims at improving the financial stability of the system needs to take that into account. On the other hand, the system of mutual guarantees creates an implicit guarantee that decreases the cost of funding for savings banks, which can be passed on to qualified borrowers, increasing efficiency and promoting growth. This leads to our second hypothesis:

Hypothesis 2: Financial regulation impairing the implicit guarantees enjoyed by savings banks will lead to a loss of efficiency to the German economy.

The theoretical literature exploring the interplay of organizational design, relationship lending and market competition is scarce. Additionally, the relatively few models that exist do not appropriately fit into the three-pillared German banking system. Based on that, the objective is to first lay out the foundations of a theoretical model that can be used to describe the inner workings of savings banks, and the feedback that exists between them and the economic environment where they operate, consisting of the market structure and the organizational design of competitor banks.

After the development of a theoretical model, the next step is to perform a study that aims at describing numerically and empirically the behavior of savings

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\(^5\)Evidence is provided in Dwenger, Fossen, and Simmler (2015).
banks and the impact they have on the German economy, under different baseline scenarios. That would offer insights for questions related to the regulatory framework that would best fit the three-pillar structure of the German banking system.
References


Appendix

A Preliminary Model

Consider a one-good, two-date economy, $t = 0, 1$, populated by a financial institution and $N$ entrepreneurs. The financial institution is composed of $N$ branches, to be called banks, operating in different regions of the economy, and they provide the means through which the entrepreneurs finance their businesses. The success or failure of the investments to be made by the entrepreneurs depend on the state of the economy, which can be either good, $G$, or bad, $B$.

The decision problem faced by banks is whether to provide a high volume of loans, $H$, or a low volume of loans, $L$, without having perfect information of the state in which the economy operates. Figure 1 gives the payoff of each bank, according to the volume of loans chosen and the state of the economy.

\[
\begin{array}{c|cc}
 & G & B \\
\hline
H & S_1 & S_4 \\
L & S_2 & S_3 \\
\end{array}
\]

Figure 1: Payoff Matrix for Volume of Loans According to the State of the Economy.

Entrepreneurs have limited liability, and given that the success or failure of their enterprises is a direct function of the state of the economy, the rate of default on loans taken from banks is higher in the bad than in the good state. Therefore, whatever the level of loans provided, banks’ payoff in the good state is always higher than in the bad state, i.e.:

\[
S_1 > S_4, \quad (1) \\
S_2 > S_3. \quad (2)
\]

Assuming that the profit of banks with loans provided to entrepreneurs follows a constant returns to scale function, the payoff from a high level of loans will be higher than that of a low level, if the economy turns out to be in a good state. On the other hand, the opposite is true if the economy is in a bad state, when banks would have preferred to provide a low level of loans. Accordingly, it follows that:
The problem faced by banks is that they must choose a level of loans without having knowledge of the state in which the economy operates. Instead, banks must rely on information provenient from the economic environment, i.e., signals, according to which their loan decisions will be made.

The signals generated by the economy in which banks operate can be of two types, namely *macro-signals*, i.e., information of the overall economic environment, $\mu^\Theta \in \{\mu^G, \mu^B\}$, or *local-signals*, i.e., information related to the local economic environment where entrepreneurs perform their activities, $\lambda^\Theta \in \{\lambda^G, \lambda^B\}$. Both macro and local signals contain information regarding the state of the economy, $\Theta \in \{G, B\}$, with probabilities of good and bad states given by:

$$P(G) = \pi, \quad P(B) = 1 - \pi. \quad (5)$$

The state of the economy dictates the macro-signal and, based on that, the local-signal determining the prospects of the entrepreneurs’ business is generated. Based on that, it is assumed that the conditional probability of the macro-signal, $\mu^\Theta \in \{\mu^G, \mu^B\}$, given the state of fundamentals, $\Theta \in \{G, B\}$, is given by:

$$P\left(\mu^G \mid G\right) = P\left(\mu^B \mid B\right) = \mu, \quad (7)$$
$$P\left(\mu^B \mid G\right) = P\left(\mu^G \mid B\right) = 1 - \mu. \quad (8)$$

and the conditional probability of the local-signal, $\lambda^\Theta \in \{\lambda^G, \lambda^B\}$, given the macro-signal, $\mu^\Theta \in \{\mu^G, \mu^B\}$, is:

$$P\left(\lambda^G \mid \mu^G\right) = P\left(\lambda^B \mid \mu^B\right) = \lambda, \quad (9)$$
$$P\left(\lambda^B \mid \mu^G\right) = P\left(\lambda^G \mid \mu^B\right) = 1 - \lambda. \quad (10)$$

The story behind the assumed structural dependence of the signals is the following: the macro-signal is thought of as representing the trend of the economy, i.e., its
overall level of performance. The local-signal, in turn, purports to represent the local environment where entrepreneurs do their activities. Clearly, the local-environment should be related to the overall economic environment, which in turn must be related to the state of the economy. This is the reason why the probability law of the local-signal is conditional on the macro-signal, and the one for the macro-signal is conditional on the state of the economy.

The decision making structure of the financial institution can be of two different types. In the first one, to be called *centralized structure*, the volume of loans to be provided by banks to entrepreneurs is based on the macro-signal, and the lending decision of all the $N$ banks will be the same. In the second one, to be called *decentralized structure*, each of the $N$ banks part of the financial institution act based on their individual local-signals, which might lead to different lending decision across the banks.

Figure 2 depicts the economic environment according to the type of the financial institution at place. In the sequence, the goal is to analyse the consequences in terms of welfare and risk that are entailed by centralized and decentralized structures of financial institutions.

![Figure 2: Information Structure for Centralized and Decentralized Banking.](image)

**A.1 Financial Institution with a Centralized Structure**

In a financial institution with a centralized decision structure, all the $N$ banks must choose the same volume of loans to be provided to entrepreneurs. The lending decision is thought of as being made by a research department at the financial institution, based on an analysis of the macro-signal provenient from the economic environment.
Since the state of the economy cannot be directly observed by the financial institution, a decision regarding the volume of loans to be provided has to be based on the macro-signal received. In this way, the lending strategy of the financial institution will be a function of $\mu^\Theta \in \{\mu^G, \mu^B\}$, i.e., the macro-signal.

Based on the assumptions made regarding the entries of the payoff matrix in Figure 1, a financial institution would like its banks to provide a high volume of loans when the state of the economy is good, and a low volume of loans when the state is bad. In order to formulate its strategy, a financial institution must then realize how likely the good and the bad states are, conditional on the macro-signal received. In other words, the financial institution must determine the probability $P(\Theta | \mu)$, for $\Theta \in \{G, B\}$ and $\mu^\Theta \in \{\mu^G, \mu^B\}$. In this regard, from Bayes’ rule it follows that:

$$P(G | \mu^G) = \frac{\mu \pi}{\mu \pi + (1 - \mu)(1 - \pi)}, \quad (11)$$

$$P(G | \mu^B) = \frac{(1 - \mu) \pi}{(1 - \mu) \pi + \mu(1 - \pi)}, \quad (12)$$

and:

$$P(B | \mu^G) = \frac{(1 - \mu)(1 - \pi)}{\mu \pi + (1 - \mu)(1 - \pi)}, \quad (13)$$

$$P(B | \mu^B) = \frac{\mu(1 - \pi)}{(1 - \mu) \pi + \mu(1 - \pi)}. \quad (14)$$

The conditional probabilities $P(G | \mu^G)$ and $P(B | \mu^B)$ define the precision of the macro-signal. Based on these probabilities, the financial institution is able to calculate the expected payoff from imposing either a high, $H$, or a low, $L$, volume of loans to be provided by its banks to entrepreneurs. In this way, the expected payoff from choosing a high volume of loans, $H$, and a low volume of loans, $L$, conditional on the macro-signal received being $\mu^G$, are given by, respectively:

$$E[H | \mu^G] = S_1 P(G | \mu^G) + S_4 P(B | \mu^G), \quad (15)$$

$$E[L | \mu^G] = S_2 P(G | \mu^G) + S_3 P(B | \mu^G). \quad (16)$$

Analogously, if the macro-signal observed is $\mu^B$, the expected payoff from choosing either course of action is:
Based on the expected payoffs from choosing a high, $H$, and low, $L$, volume of loans, conditional on the macro-signal, $\mu^\Theta \in \{\mu^G, \mu^B\}$, the optimal strategy to be followed by a financial institution under a centralized decision making structure is given by Proposition 1:

**Proposition 1.** (Optimal strategy under a centralized structure) Under a centralized structure, the optimal strategy of the financial institution, conditional on the macro-signal received, is:

1. If the macro-signal is $\mu^G$, then:
   - If the precision of the macro-signal is sufficiently high, i.e.:
     \[
     P \left( G \mid \mu^G \right) > \frac{S_3 - S_4}{(S_1 - S_2) + (S_3 - S_4)},
     \]
     then the optimal strategy of the financial institution is to have its banks to provide a high volume of loans, $H$. Otherwise, the optimal strategy is to choose $L$.

2. If the macro-signal is $\mu^B$, then:
   - If the precision of the macro-signal is sufficiently high, i.e.:
     \[
     P \left( B \mid \mu^B \right) > \frac{S_1 - S_2}{(S_1 - S_2) + (S_3 - S_4)},
     \]
     then the optimal strategy of the financial institution is to have its banks to provide a low volume of loans, $L$. Otherwise, the optimal strategy is to choose $H$.

**Proof:** Follows directly from comparing the expressions for $E \left[ H \mid \mu^G \right]$ and $E \left[ L \mid \mu^G \right]$, in the case where the macro-signal is $\mu^G$, and the expressions for $E \left[ L \mid \mu^B \right]$ and $E \left[ H \mid \mu^B \right]$, in the case where the macro-signal is $\mu^B$. □
The decision of the financial institution in regards to the level of loans to be provided by its banks will, therefore, depend not only on the macro-signal observed, but also on the precision of the macro-signal. Intuitively, one would expect conditions (19) and (20) in Proposition 1 to be satisfied, otherwise the financial institution would be better-off choosing a high volume of loans when the macro-signal is bad, $\mu^G$, and a low volume of loans when the macro-signal is good, $\mu^B$. The next section provides a similar analysis of the optimal lending strategy of a financial institution, this time instead under a decentralized decision structure.

A.2 Financial Institution with a Decentralized Structure

Under a decentralized structure, a financial institution gives autonomy to its banks to decide whether to provide a high or low volume of loans to entrepreneurs. According to that, banks in different regions of the economy must rely on their local-signals in order to make a decision regarding the volume of loans. Since the problem faced by all the banks is the same, the analysis that follows is focused on an arbitrary bank $i$.

Similarly to the problem faced by the financial institution under a centralized structure, a bank $i$ under a decentralized structure cannot observe the state of the economy. Instead, bank $i$ observes a local-signal $\lambda_i \in \{\lambda_i^G, \lambda_i^B\}$, where the subscript $i$ denotes the fact that the signal relates only to information observed by bank $i$. Based on the local-signal, bank $i$ will choose the volume of loans to provide and, for that, it needs to determine the probabilities of the state being good and bad, conditional on the local-signal observed. Using Bayes’ rule, these probabilities are given by:

\[
P\left(G \mid \lambda_i^G \right) = \frac{\pi [\mu \lambda + (1 - \mu) (1 - \lambda)]}{\lambda [\mu \pi + (1 - \mu) (1 - \pi)] + (1 - \lambda) [(1 - \mu) \pi + \mu (1 - \pi)]}, \tag{21}
\]

\[
P\left(G \mid \lambda_i^B \right) = \frac{\pi [\lambda (1 - \mu) + (1 - \lambda) \mu]}{\lambda [(1 - \mu) \pi + \mu (1 - \pi)] + (1 - \lambda) [\mu \pi + (1 - \mu) (1 - \pi)]}, \tag{22}
\]

and:

\[
P\left(B \mid \lambda_i^G \right) = \frac{(1 - \pi) [\lambda (1 - \mu) + (1 - \lambda) \mu]}{\lambda [\mu \pi + (1 - \mu) (1 - \pi)] + (1 - \lambda) [(1 - \mu) \pi + \mu (1 - \pi)]}, \tag{23}
\]

\[
P\left(B \mid \lambda_i^B \right) = \frac{(1 - \pi) [\mu \lambda + (1 - \mu) (1 - \lambda)]}{\lambda [(1 - \mu) \pi + \mu (1 - \pi)] + (1 - \lambda) [\mu \pi + (1 - \mu) (1 - \pi)]}. \tag{24}
\]
In the same way as in the problem of the financial institution under a centralized structure, the probabilities \( P(G|\lambda_i^G) \) and \( P(B|\lambda_i^B) \) define the precision of the information observed by banks in a decentralized structure, but this time in regards to the local-signal. According to these probabilities, and conditional on the local-signal being \( \lambda_i^G \), the expected payoff of bank \( i \) from choosing a high, \( H \), or low, \( L \), volume of loans is given by, respectively:

\[
E[H|\lambda_i^G] = S_1P(G|\lambda_i^G) + S_4P(B|\lambda_i^G), \tag{25}
\]
\[
E[L|\lambda_i^G] = S_2P(G|\lambda_i^G) + S_3P(B|\lambda_i^G), \tag{26}
\]

and, for the case where the local-signal is \( \lambda_i^B \), the expected payoffs are:

\[
E[H|\lambda_i^B] = S_1P(G|\lambda_i^B) + S_4P(B|\lambda_i^B), \tag{27}
\]
\[
E[L|\lambda_i^B] = S_2P(G|\lambda_i^B) + S_3P(B|\lambda_i^B). \tag{28}
\]

A comparison of the expected payoffs entailed by a high, \( H \), and a low, \( L \), volume of loans, for each of the two possible cases representing the realization of the local-signal \( \lambda_i^\Theta \in \{\lambda_i^G, \lambda_i^B\} \), leads to the optimal strategy of bank \( i \) under a decentralized decision structure, given by Proposition 2:

**Proposition 2.** (Optimal strategy under a decentralized structure) Under a decentralized structure, the optimal strategy of an arbitrary bank \( i \), conditional on the local-signal received, is:

1. If the local-signal is \( \lambda_i^G \), then:
   - If the precision of the local-signal is sufficiently high, i.e.:
     \[
     P(G|\lambda_i^G) > \frac{S_3 - S_4}{(S_1 - S_2) + (S_3 - S_4)}, \tag{29}
     \]
     then the optimal strategy of bank \( i \) is to provide a high volume of loans, \( H \). Otherwise, the optimal strategy is to choose \( L \).

2. If the local-signal is \( \lambda_i^B \), then:
If the precision of the local-signal is sufficiently high, i.e.:

\[ P\left( B \bigg| \lambda_i^B \right) > \frac{S_1 - S_2}{(S_1 - S_2) + (S_3 - S_4)}, \]

then the optimal strategy of bank \( i \) is to provide a low volume of loans, \( L \). Otherwise, the optimal strategy is to choose \( H \).

Proof: Follows directly from comparing the expressions for \( E\left[ H \bigg| \lambda_i^G \right] \) and \( E\left[ L \bigg| \lambda_i^G \right] \), in the case where the local-signal is \( \lambda_i^G \), and the expressions for \( E\left[ L \bigg| \lambda_i^B \right] \) and \( E\left[ H \bigg| \lambda_i^B \right] \), in the case where the local-signal is \( \lambda_i^B \).

The optimal strategy of banks in a decentralized decision structure, in conjunction with the optimal strategy of a financial institution in a centralized structure derived in the previous section, allows an ex-ante comparison of both structures in terms of the total expected payoff that each one entails. Such an analysis is performed in the following section.

### A.3 Analysis

In a financial institution with a centralized structure, the decision regarding the volume of loans to be extended to entrepreneurs is based on the analysis of a macro-signal, and must be followed by all the \( N \) banks that are part of the financial institution. If the \( N \) banks are instead part of a financial institution that has a decentralized structure, the decision making power lies on the banks themselves, which in turn must rely on local-signals that are potentially different across the regions.

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, defined as a combination of the state of the economy and the information generated by the environment, i.e., either a macro or a local-signal. For the case of a financial institution with a centralized decision structure, the possible scenarios are displayed in Figure 3: in scenarios 1 and 3, the state of the economy coincides with the macro-signal observed, whereas in scenarios 2 and 4, the opposite is true.

Under the assumption that macro-signals are precise enough, i.e., both \( P\left( G \bigg| \mu^G \right) \) and \( P\left( B \bigg| \mu^B \right) \) satisfy the corresponding conditions in Proposition 1, the optimal strategy of a financial institution with a centralized structure pre-determines the lending behavior of the \( N \) banks in each of the possible scenarios of Figure 3.

In scenarios 1 and 2, the financial institution instructs all of its \( N \) banks to provide a high volume of loans to entrepreneurs, since the macro-signal observed is
Scenario 1

$G \cap \mu^G$

Scenario 2

$B \cap \mu^G$

Scenario 3

$B \cap \mu^B$

Scenario 4

$G \cap \mu^B$

Figure 3: Scenarios’ Set, Centralized Structure.

However, whereas in scenario 1 the economy is in a good state and the payoff to each bank is $S_1$, in scenario 2 the economy is in a bad state, and a high volume of loans leads to a payoff of $S_4$.

Analogously, in scenarios 3 and 4, the macro-signal is $\mu^B$, and according to the optimal strategy of the financial institution, all of its banks must provide a low level of loans to entrepreneurs. In scenario 3, a low level of loans indeed maximizes the payoff of banks, $S_3$, which is not the case in scenario 4, where the economy is in a good state but the macro-signal turns out to be incorrect, and a low level of loans leads to a payoff of $S_2$.

Summarizing, in scenarios 1 and 2, where the macro-signal is $\mu^G$, the total payoff to the financial institution is, respectively, $NS_1$ and $NS_4$, whereas in scenarios 3 and 4, where the macro-signal is $\mu^B$, the respective total payoffs are $NS_3$ and $NS_2$.

Given the total payoff of the financial institution with a centralized structure under each of the possible scenarios, what is left to complete the ex-ante analysis is to determine the likelihood of each scenario. Clearly, the likelihood of each scenario depends on the probability of the event that defines it, which in turn are, for scenarios 1 and 2, respectively, where the macro-signal is $\mu^G$:

$$P(G \cap \mu^G) = P(\mu^G | G) P(G) = \mu \pi,$$  \hspace{1cm} (31)

$$P(B \cap \mu^G) = P(\mu^G | B) P(B) = (1 - \mu) (1 - \pi),$$  \hspace{1cm} (32)

and, for scenarios 3 and 4, where the macro-signal is $\mu^B$:

$$P(B \cap \mu^B) = P(\mu^B | B) P(B) = \mu (1 - \pi),$$  \hspace{1cm} (33)

$$P(G \cap \mu^B) = P(\mu^B | G) P(G) = (1 - \mu) \pi.$$  \hspace{1cm} (34)

Let the expected welfare entailed by each decision structure be defined as:

$$E[W^i] := \sum_{j=1}^{n} w_j p_j, \quad i \in \{c, d\},$$  \hspace{1cm} (35)
where $W^i$ denotes the total welfare under a structure which is either centralized, $i = c$, or decentralized, $i = d$; the number of scenarios is given by $n$, and; the probability of each scenario, and the corresponding total payoff of banks in each of them, are $p_j$ and $w_j$, respectively. Therefore, a financial institution with a decentralized structure leads, ex-ante, to a level of expected welfare given by:

$$E[W^d] = NS_1P(G \cap \mu^G) + NS_4P(B \cap \mu^B) + NS_3P(B \cap \mu^G) + NS_2P(G \cap \mu^B)$$

$$= N \{\pi \mu S_1 + (1 - \mu) S_2 + (1 - \pi) \mu S_3 + (1 - \mu) S_4\}.$$  (36)

After obtaining the expected welfare implied by a financial institution with a centralized structure, the next step should be to compare it to the analogous expected welfare obtained by banks that belong to a financial institution with a decentralized structure.

Recall that the local-signals observed by banks in a financial institution with a decentralized structure are derived from the macro-signal, which in turn depends on the state of the economy. This implies that the set of possible scenarios under a decentralized structure is finer as compared to the analogous set under a centralized structure. Figure 4 depicts all the possible cases that banks under a decentralized structure might face.

Invoking Proposition 2 and assuming that the precision of the local-signal faced by any arbitrary bank $i$ satisfies the conditions there stated, the scenarios where a local-signal $\lambda^G_i$ is observed will lead to a high volume of loans, whereas those where a local-signal $\lambda^B_i$ takes place will lead to a low volume of loans. According to the state realized, therefore, the payoff of a bank $i$ in scenarios 1 and 7 will be $S_1$; in scenarios 2 and 8, $S_2$; in scenarios 3 and 5, $S_4$; finally, in scenarios 4 and 6, $S_3$.

Determining the probability of each possible scenario under the decentralized structure will allow then the calculation of the corresponding expected welfare, $E[W^d]$. For the scenarios where the local-signal observed is $\lambda^G_i$, i.e., scenarios 1, 3, 5 and 7, those probabilities are:
a decentralized structure is given by:

\[ P \left( G \cap \mu^G \cap \lambda_i^G \right) = P \left( \lambda_i^G \mid \mu^G \right) P \left( \mu^G \mid G \right) P(G) = \lambda \mu \pi, \quad (37) \]

\[ P \left( B \cap \mu^G \cap \lambda_i^G \right) = P \left( \lambda_i^G \mid \mu^G \right) P \left( \mu^G \mid B \right) P(B) = \lambda (1 - \mu) (1 - \pi), \quad (38) \]

\[ P \left( B \cap \mu^B \cap \lambda_i^G \right) = P \left( \lambda_i^G \mid \mu^B \right) P \left( \mu^B \mid B \right) P(B) = (1 - \lambda) \mu (1 - \pi), \quad (39) \]

\[ P \left( G \cap \mu^B \cap \lambda_i^G \right) = P \left( \lambda_i^G \mid \mu^B \right) P \left( \mu^B \mid G \right) P(G) = (1 - \lambda) (1 - \mu) \pi, \quad (40) \]

whereas for the scenarios where the local-signal is \( \lambda_i^B \), i.e., scenarios 2, 4, 6 and 8, the probabilities are:

\[ P \left( G \cap \mu^G \cap \lambda_i^B \right) = P \left( \lambda_i^B \mid \mu^G \right) P \left( \mu^G \mid G \right) P(G) = (1 - \lambda) \mu \pi, \quad (41) \]

\[ P \left( B \cap \mu^G \cap \lambda_i^B \right) = P \left( \lambda_i^B \mid \mu^G \right) P \left( \mu^G \mid B \right) P(B) = (1 - \lambda) (1 - \mu) (1 - \pi), \quad (42) \]

\[ P \left( B \cap \mu^B \cap \lambda_i^B \right) = P \left( \lambda_i^B \mid \mu^B \right) P \left( \mu^B \mid B \right) P(B) = \lambda \mu (1 - \pi), \quad (43) \]

\[ P \left( G \cap \mu^B \cap \lambda_i^B \right) = P \left( \lambda_i^B \mid \mu^B \right) P \left( \mu^B \mid G \right) P(G) = \lambda (1 - \mu) \pi. \quad (44) \]

Upon the payoff of banks under each possible scenario and their corresponding likelihood of occurrence, the expected welfare implied by a financial institution with a decentralized structure is given by:

\[
E \left[ W^d \right] = NS_1 P \left( G \cap \mu^G \cap \lambda_i^G \right) + NS_2 P \left( G \cap \mu^G \cap \lambda_i^B \right) + NS_3 P \left( B \cap \mu^G \cap \lambda_i^G \right) + NS_3 P \left( B \cap \mu^G \cap \lambda_i^B \right) + NS_4 P \left( B \cap \mu^B \cap \lambda_i^G \right) + NS_4 P \left( B \cap \mu^B \cap \lambda_i^B \right) + NS_5 P \left( \mu^G \mid \mu^B \cap \lambda_i^G \right) + NS_5 P \left( \mu^G \mid \mu^B \cap \lambda_i^B \right) + NS_6 P \left( \mu^B \mid \mu^G \cap \lambda_i^G \right) + NS_6 P \left( \mu^B \mid \mu^G \cap \lambda_i^B \right) - N (1 - \pi) \left\{ \left[ \mu (1 - \lambda) + (1 - \mu) \lambda \right] S_4 + \left[ \mu (1 - \lambda) + (1 - \mu) (1 - \lambda) \right] S_5 \right\} .
\]  

\[
(45)
\]

Having computed the expected welfare under both a centralized structure and a decentralized one, it is just a matter of comparing their expressions in order to evaluate the circumstances under which one performs better than the other, which is the result of Proposition 3:

**Proposition 3.** (Expected welfare under alternative decision structures) The expected welfare entailed by a financial institution under a centralized structure is higher than the equivalent one under a decentralized structure if and only if the probability of the economy generating the correct macro-signal is sufficiently high, i.e.:

\[
E \left[ W^c \right] > E \left[ W^d \right] \iff \mu > 1/2. \quad (46)
\]

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Proof: Follows directly from comparing the expressions for $E[W^c]$ and $E[W^d]$. □

The result of Proposition 3 is a very powerful one: it indicates that the centralized structure performs better than the decentralized one, in terms of expected welfare, if and only if the macro-signal generated by the economic environment is in accordance with the state of the economy.

Recall that, by assumption, the payoff to a specific volume of loans depends on the state of the economy. The fact that the macro-signal is a direct function of the state of the economy makes it less noisy than its local counterpart. Whereas banks under a decentralized structure observe the later signal, a centralized financial institution observes the former, which gives it an edge, but only conditional on the economy being able to generate the correct macro-signal, i.e., for $\mu > 1/2$.

Conversely, an economy that generates the correct macro-signal minimizes the chances of the financial institution being induced to choose the wrong course of action. This is because, from the definition of $\pi$, it follows that:

$$P(\mu^G|G) = P(\mu^B|B) = \mu > 1/2 \iff P(\mu^G|G) = P(\mu^G|B) = 1 - \mu < 1/2. \quad (47)$$

A misalignment between the state of the economy and the macro-signal is a particularly acute problem under a centralized structure, since in such a structure all the banks follow the same course of action, as determined by the financial institution. Therefore, whenever the financial institution receives the wrong signal, it induces all of its banks into a mistake. This is not the case under a decentralized structure, where banks act independently in terms of the volume of loans they choose to provide to entrepreneurs.