ENDOGENIZING BANKING REGULATION AND SUPERVISION: A DYNAMIC EQUILIBRIUM APPROACH

A Master's Thesis

by
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Ankara
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To my family, with love and gratitude...

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by

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ABSTRACT

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This thesis presents a modified dynamic general equilibrium model by introducing a supervisory and regulatory agent (RS) that is responsible for setting the level of bank regulation and supervision quality (α) in order to ensure the banking sector's long term profitability. We solve the model to examine the effects of α on the optimizing agents, which are households, firms and banks. The level of bank regulation and supervision quality affects households, through the fraction of savings that are deposited in the banking system; firms, through the fraction of performing loans that they get from the banks; and banks, through the degree of law enforcement on the banks. Our model yields a unique equilibrium with the expected outcomes; that is to say, bank regulation and supervision quality affects the steady state levels of capital and output positively; and affects the steady state rates of deposit and loan interest negatively. We also examine the comparative statics of the steady state level of capital, the steady state rates of deposit and loan interest with respect to the rest of the model parameters.

Keywords: Banking Regulatory and Supervisory Agent, Financial Stability, Monetary Policy

ÖZET

BANKACILIK DENETLEME VE DÜZENLEMESİNİN İÇSELLEŞTİRİLMESİ: BİR DİNAMİK DENGE YAKLAŞIMI

Karakoyun,Oğuz Kaan
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Tez Danışmanı: Doç. Dr. Bilin Neyaptı

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Bu tez, bankacılık sektörünün uzun vadeli karlılığını sağlamak için banka düzenleme ve denetleme kalitesinin (α) düzeyini belirlemekle yükümlü olan denetleyici ve düzenleyici aracıyı (RS) sunarak tadil edilmiş bir dinamik genel denge modeli sunmaktadır. Alfanın, hane halkı, firma ve bankalar olan optimize ajanlar üzerindeki etkilerini incelemek için modeli çözdük. Banka düzenleme ve denetleme kalitesinin düzeyi, hane halkını, bankacılık sistemine yatırılan tasarrufların fraksiyonu vasıtasıyla; firmaları, bankalardan aldıkları kredilerin geri ödenmesi bakımından; ve bankaları da, bankalara uygulanan hukuki yaptırım derecesi yoluyla etkilemektedir. Modelimiz, beklenen sonuçları veren tek bir çözüm dengesi sağlamaktadır. Düzenleme ve denetleme kalitesi, durağan durum sermaye seviyesini ve çıktıyı pozitif bir şekilde etkilerken; mevduat ve kredi faiz oranlarının durağan durum seviyelerini negatif bir şekilde etkilemektedir. Ayrıca, durağan durum sermaye seviyesinin, durağan durum mevduat ve kredi faiz oranları seviyelerinin karşılaştırmalı statikleri, geriye kalan model parametrelerine göre incelenmektedir.

Anahtar kelimeler: Bankacılık Denetleme ve Düzenleme Kurumu, Finansal İstikrar, Para Politikası

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CHAPTER I

INTRODUCTION

In the economic history, banks emerged to facilitate transactions and protect the value of money against various risks. As the number of banks and their scale grew, regulation and supervision of banks emerged as a necessity. Hence, although banking regulation is older than banking supervision, banking regulation and banking supervision together might generally be thought as old as banking system itself [1]. White [2] claims that the establishment of banking regulation and supervision should be taken into consideration starting at 1864, when the National Banking Act was created in the US, following the civil war. This new system changed the existing regulation system and restructured the banking system. Owing to the National Banking Act, the Office of Comptroller of the Currency was established and given authority to charter national banks that were permitted to issue banknotes. At the same time, minimum capital and reserve requirements were imposed on the banks. According to White [2], those preclusions might be considered as first noticeable regulation and supervision in the financial history.

In progress of time, new regulatory and supervisory tools were created depending on the people's needs. For instance, the Federal Deposit Insurance Corporation was established in 1933 in order to provide deposit insurance to the depositors in the US. This corporation's main aims were to reduce moral hazard problems that occurred after the Great Recession and to increase the trust of the society to the American banking system [3]. In modern times, there are many different aspects that are the subject of regulation and supervision. Neyapti and Dincer [4] list ninety-eight criteria to evaluate a wide array of issues that are the subject of the bank regulation and supervision based on legal provisions of the banking laws. Those criteria are mainly categorized as capital requirements, lending, ownership structure, directors and managers, reporting/recording requirements, corrective action, supervision and deposit insurance. Under each criterion, there are some subcategories to take into account the detailed provisions stated in the banking laws. Consequently, it can be said that the aim of banking regulation and supervision is to protect depositors, which lend their assests to the banks; provide stability in financial markets by ensuring the efficiency of the credit system, and thus facilitate a well-functioning financial market. Additionally, banking regulation and supervision helps banks to minimize transaction and inter-mediation costs, which feeds positively into the real economy (see also Dincer and Neyapti [5]).

The importance of banking regulation and supervision was profoundly perceived after the Great Depression in 1929. Although this crisis was not regarded as a banking crisis, it deeply affected banks by reducing the confidence of depositors. When depositors became uncertain about the survival of their banks from this crisis, they started to convert their deposits into currency that indicated a bank crisis [1]. For instance, approximately fifty-percent of banks, which correspond to more than 5000 banks, in the US had to close [6]. At the time of the Great Depression, rather than having an independent regulatory and supervisory agent, the policies about banking regulation and supervision were operated by governments and central banks in most of the countries. However, the necessity of such an agent started to be argued after this crisis. As a result, several agencies started to be established. Consequently, these agencies have contributed to a reliable banking system. However, the complication of the regulatory mechanisms over time reduced the efficiency of the system.

Despite these developments in the post Great Depression era, many countries such as the US, Canada, Russia, China, Portugal, Spain, Iceland, Ireland, Turkey and Cyprus experienced financial crises in the 2000s. The reasons behind those financial crises were substantially different. When some countries were negatively affected by rapid changes of exchange rates, some of them were affected by an excessive risk taking banking system and some of them were affected by both of them. As a result, the Great Recession that erupted in 2007 [7] mainly emerged because of the inefficiencies in controlling the mortgage and insurance systems in the US. Before 2007, excessive credit expansion to high-risk consumers led to a great increase in housing prices, which was called the housing bubble. The housing bubble burst in the beginning of 2007 that led to a decrease in the prices of housing. In accordance with this burst, the wealth of the people who took the mortgage loans from the banks was affected negatively, hence, they could not pay their debts to the banks. While these situations occurred, agencies that were responsible for regulation and supervision did not manage this problem effectively. Hence, the banking crisis occurred and led to increase in unemployment and decrease in the GDP. Consequently, many people paid a heavy price for the poor management in the banking system.

The main motivation of this thesis is to examine the effectiveness of a regulatory and supervisory agent in averting banking crises. Bank regulation and supervision has been the subject of recent debate since the Great Recession of 2007. Currently, it might be seen that the effects of the global financial crisis have been lessened. However, a number of studies have pointed to the continued weaknesses in regulation and supervision in the banking systems around the world. While there are many descriptive studies on the merits or the status of the banking regulation and supervision, difficulty of an overall measurement of banking regulation and supervision leads to a limited number of empirical research thus far.

Theoretical modeling of the macroeconomic effects of the banking regulation and supervision is also limited. Kilinc and Neyapti [8] consider the quality of banking regulation and supervision not as a result of an optimizing agent's decision but define it as an exogenously given paramater in their model. De Walque et al. [9] define the regulatory and supervisory agent as one that determines the capital requirement ratio; however, this ratio is assumed as fixed in their model. Given this overview, this thesis aims to fill the gap in the literature by introducing an independent regulatory and supervisory agent (RS) that chooses the level of bank regulation and supervision

(α), which we consider to reflect the banking system quality that incorporates a wide array of issues covered in the studies above. We model formally households, firms, banks and the RS. The interrelations of these four agents can be seen in Figure 1 below. Dashed lines represent the effects of the regulatory and supervisory agent on the rest of the agents, whereas solid lines illustrate the interrelations amongst the households, firms and banks.

In this model, we assume that α affects "the fraction of savings that are deposited" by households, "the fraction of repayment on loans" by firms and "the degree of law enforcement" on the banks. From the perspective of the households, α affects the degree of the trust of the households in the banking system, hence, how much to be deposited from their savings. Hence, the households have a tendency to deposit if α is high, and have a tendency to put their savings under the pillow if α is low. In real life, there is a risk that firms are less likely to pay back their loans. This situation is called as a moral hazard problem. We consider that this fraction of repayment on loans is also affected through α, where an increase in α increases firms' tendency to pay their loans back. From the perspective of banks, an increase in α leads banks to choose the lending rate accordingly as they face a fee from the regulatory and supervisory agent in the case of non-performing loans. Hence, it is seen that α affects the whole system.

In our model, households maximize their lifetime utility, firms maximize their lifetime profit, and banks try to maximize their temporal profit. Different than households and firms, banks only regard one period profit maximization since there are different concerns of bank managers and bank owners. Even though bank owners, which are households, concern about the long term asset position, bank managers generally concern about short term profit maximization [10]. This is the principal-agent problem at the concept in the banking case [11]. Hence, in this model, bank managers' problem is modelled as maximizing one period profit maximization. The fourth agent, the RS, maximizes the lifetime profit in the banking system as the aim of the RS is to provide the long term survival of the banks. Those four agents constitute the general equilibrium model that we introduce in this thesis.

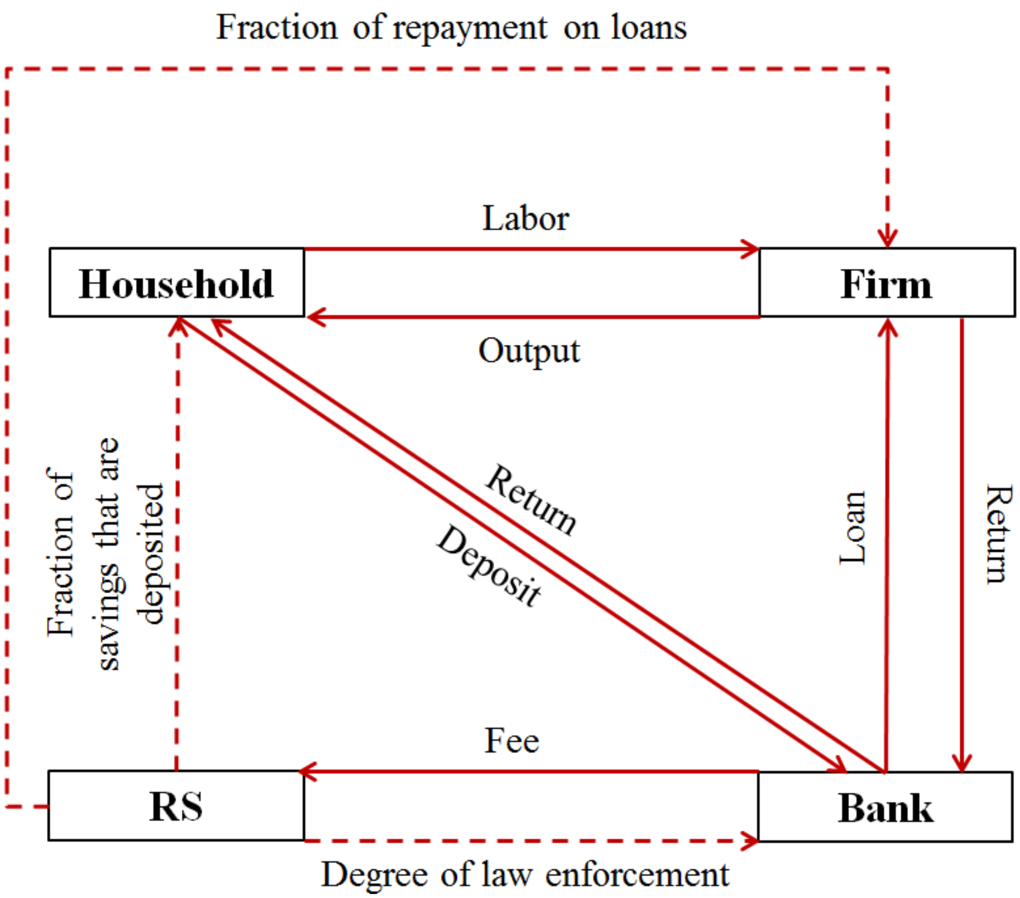

Figure 1: Illustration of the interrelations of agents

As the Nash equilibrium solution of our model, we show that the level of banking quality affects the steady state level of capital positively which results with a higher output level in the economy. It also affects the steady state interest rates on deposits and loans negatively. Hence, from steady state solutions of the model, it is observed that the existence of the steady state level of banking quality assures financial stability by decreasing the steady state interest rates on deposits and loans, and increasing the steady state level of capital. Additionally, we examine the comparative statics of the steady state levels of capital, interest rates on deposits and loans with respect to their parameters. To summarize those results, the relationship between the reaction of the households to the banking quality (d) and the steady state level of capital is positive and that between d and the steady state interest rates on deposits and loans is negative. Also, the discount factor (β) has similar effects on the steady state levels of those variables. Those results suggest that the level of banking quality improves the economic performance by decreasing the moral hazard problem.

The rest of this thesis is organized as follows: In Chapter 2, we review the literature of the regulatory and supervisory agent (RS) problem. In Chapter 3, we present the model in detail. In Chapter 4, we solve the model for the steady state and present a comparative static analyses of the model. Chapter 5 demonstrates the extensions of the model. The final chapter, Chapter 6, is the concluding remarks.

CHAPTER II

LITERATURE SURVEY

In this chapter, we review the existing literature on the importance of banking regulation and supervision. The related studies can be analysed in three subsections; (i) descriptive studies, (ii) empirical studies, and (iii) theoretical studies.

2.1 Descriptive Studies

The related descriptive studies generally question the context of bank regulation and supervision and its agencies, how they are important for the economy, which tools are used by these agents; and when tools of regulation and supervision are necessary to be used in the economy. Marston [12], Barth, Caprio and Levine [13], Hendrickson [1], Dincer and Neyapti [4, 5] are among the ones who investigate these questions.

The Basel Committee on Banking Supervision (BCBS) is the essential worldwide standard setter for the prudential regulation of banks and gives a discussion to collaboration on banking supervisory issues. Its aim is to reinforce the regulation, supervision and practices of banks worldwide with the motivation behind strengthening financial stability. In order to generate valid international standards, BCBS published a set of rules, which is commonly known as Basel I or Basel Accord, such as minimum capital requirements in 1988 for the first time [12]. Depending on new necessities, Basel I was extended by introducing some new set of rules, which are Basel II (published in 2004) and Basel III (publshed in 2013). Marston [12] defends the necessity of such an accord and explains the merits of the banking regulation and supervision in his study. It should be noted that according to these Basel Core Principles, different types of information sets were created such as questionnaire-based or legal-based data sets.

Barth et al. [13] evaluate the relationship between regulatory and supervisory exercises such as providing deposit insurance, regulating minimum capital-asset ratio or protecting rights of banks' shareholders and development, efficiency and stability of the banking sector. Using a questionnaire-based information set, they find that supervisory exercises are not correlated with banking development, stability and bank efficiency. On the other hand, they find that regulations resulted in remarkable banking development, efficiency and stability. They also assert that the relation between regulatory and supervisory practices and bank development and financial stability should be examined empirically since the effects of regulatory and supervisory policies can differ from country to country.

By contrast, Dincer and Neyapti [4] measure the quality of regulation and supervision by using the banking laws and create an expansive data set of bank regulation and supervision. They list ninety-eight criteria for regulation and supervision that cover legal provisions of the banking laws. Those criterion are divided mainly into 8 categories that cover bank capital, management and lending activities.Using the data constructed based on the banking laws of 23 countries, they find that the increase in the quality of regulation and supervision leads to an increase in the real GDP. On the other hand, by using a new set of the real banking laws data of 29 developed and less-developed countries, they improve their work in Dincer and Neyapti [5]. They find that in developed countries higher quality of the regulation and supervision is obtained compared to the less-developed countries. Hence, their study also indicates the importance of a regulatory and supervisory agent empirically.

Hendrickson [1] examines the theories of bank regulation, instability of banking system, and the lessons that can be deduced from the history of US banking and regulation. In contrast to favourable views and observations regarding bank regulation and supervision, he states that regulation causes destabilization of banks as it interferes the neutral market process. Hence, he argues that before banks are more regulated, they have a tendency to hold more capital and invest more in money markets. His assertion implies that every regulatory limitation that aims to prevent banking crisis causes a new crisis in the market. His claims are based on the historic pattern of banking crises in the US. Hence, the merits of bank regulation and supervision have been debated with no clear conclusion for the optimal level of bank regulation and supervision.

2.2 Empirical Studies

Several empirical studies specify the statistical relationship between the regulatory and supervisory agent or tools of regulation and supervision and various economic quantities by using real data. Below, we choose some of the studies that investigate the effects of the RS; namely, those are Barth et al. [14], Neyapti and Dincer [15], Angkinand [16], Demirguc-Kunt et al. [17], Chortareas et al. [18], Cihak et al. [19] and Delis and Staikouras [20].

Barth et al. [14] construct a new dataset of regulatory and supervisory policies based on questionnaires conducted in 180 countries from 1999 to 2011. They discuss the heterogeneity of these policies. Since the questionnaire is based on the individual experiences of the implications of the regulatory and supervisory policies, they provide indexes for the key banking policies and examine questions individually. They find that regulation and supervision of banks varies widely across countries in many different dimensions. They state that the variety of the regulatory policies leads to several research topics such as effects of the regulation policies on development, efficiency of banking systems and its impacts on the performance and long term profitability of banks.

Questionnaire-based quantification of bank regulation and supervision can be criticized on the grounds of subjectivity. However, Neyapti and Dincer [15] present an original set of regulation and supervision data, based on the banking laws of 53 countries. They examine the effects of regulation and supervision quality on bank deposits, investment rates and nonperforming loans. The aim of the banking laws is to reduce the transaction costs in the banking sector that are mainly occurred by the adverse selection and moral hazard problems. Implementing a level of banking quality of bank regulation and supervision, they test whether the regulation and supervision quality improves the performance of the banking sector by affecting both the trust of the households and borrower discipline. With an empirical analysis of 53 countries, they find that bank deposits and investment rates are increasing with regulation and supervision quality, whereas nonperforming loans are decreasing with regulation and supervision quality. Moreover, Angkinand [16] examines the effect of banking regulations (e.g. deposit insurance) on the reduction of the output costs of banking crisis. She finds that high deposit insurance coverage can decrease the output costs of the banking crisis.

Demirguc-Kunt et al. [17] examine whether the compliance with the Basel Core Principles for efficient regulation and supervision enhances bank soundness with the aim of showing the importance of development of supervision. By measuring the bank soundness with Moody's financial strength ratings, they find that reporting financial data to regulators and market participants regularly and accurately increases the banks' soundness. By taking financial strength ratings as a dependent variable, they construct a basic econometric model. In conclusion, they suggest that transparency in the information provision has an important effect on the increase in banking regulation and supervision.

Chortareas et al. [18] investigate the relationship between regulatory and supervisory policies and banking efficiency with a sample of banks of 22 European countries between the years of 2000 and 2008. They find that empowering the restrictions of supervisory agents can increase the efficiency of the operations in banks, but high level of limitations can decrease the efficiency levels of banks. They also state that the effect of limitations of regulatory and supervisory agents on bank efficiency is greater in the countries with high quality institutions than others.

Cihak et al. [19] analyze whether bank regulation and supervision have an effect on banks that can successfully escape from financial crisis. They separate countries as crisis countries, which suffer from 2008 crisis, and others and examine time periods of after and before 2008 crisis. They find that crisis countries have significantly weaker regulatory and supervisory frameworks compared to the others. On the other hand, Dincer and Neyapti [5] show that past crises lead bank regulation and supervision quality to increase.

Delis and Staikouras [20] examine the effects of regulation and supervision by considering their individual, stand alone and combinations on bank risk. Using the real data of enforcement outputs of the countries between the years of 1998 and 2008, they can also analyze the relationship between regulation and supervision and risks that banks may face with. They find that regulatory and supervisory examinations higher than a certain threshold can retain bank risk. They also find a negative correlation between disclosure requirements and bank risk, whereas they cannot find a relationship between capital requirements and bank risk. As a result, they state that effective supervision and transparent market are two key factors in reducing bank risk.

In contrast to aforementioned studies, Beck et al. [21, 22] and Barth et al. [23] argue that strict regulations may not be beneficial for the economy. Beck et al. [21] find that the possibility of financial crises is lower in concentrated banking system (banks that have higher share of assets) than non-concentrated ones. They also find that more competition lowers the probability of facing crisis. As regulatory activities restrict the competition among banks, they become susceptible to suffer from a financial crisis.

Likewise, Beck et al. [22] evaluate the relationship between regulatory and supervisory policies and corporate financing difficulties by using the real data of more than 2500 firms in 37 countries. They find that conventional approaches like empowering regulatory and supervisory agents to monitor banks do not improve bank lending. Hence, they state that firms in the countries that have powerful regulatory and supervisory agents have a tendency of facing difficulties to obtain bank loans.

Barth et al. [23] examine whether regulation and supervision increase the efficiency of the operations in the banks. Using data on 4050 banks from 72 countries for the years between 1999 and 2007, they find that more rigorous restrictions on banks activities cause inefficiency in banking operations. However, they claim that if a country has an independent regulatory and supervisory agent, empowering the effect of the agent can increase bank efficiency.

In addition to studies that are mentioned above, Klomp and Haan [24] investigate the effect of RS by dividing banks into two groups; high-risk banks and low-risk banks. By using the real data of 200 banks from the Organization for Economic Co-operation and Development (OECD) countries for the years between 2002 and 2008 and using quantile regressions, they examine the effect of regulation and supervision on the bank crisis. They find that regulation and supervision has a greater effect on high-risk banks in reducing the risk, whereas it has a lower effect on low-risk banks. Moreover, Fonseca and Gonzales [25] also claim that regulation and supervision policies can have different effects according to different variables of bank activities. For instance, restrictions on bank activities reduce the inducements to hold capital buffers by decreasing market transparency, yet they also improve the status of capital buffers by raising the market power.

2.3 Theoretical Studies

Theoretical studies generally focus on individual tools of regulation and supervision in their models. For instance, Angeloni and Faia [26] consider minimum capital ratio, whereas Gertler et al. [27] consider credit policy as a tool of regulation and supervision in their models (see also Meh and Moran [28] and Tchana [29]).

Beside those studies, there is a limited number of studies that consider the RS as an optimizing agent in an equilibrium framework; namely De Walque et al. [9] and Kilinc and Neyapti [8]. De Walque et al. [9] propose a dynamic stochastic equilibrium model to study the relations between the banking sector and the importance of regulatory and supervisory authorities in increasing financial stability. They use capital requirement ratio as a tool of regulation and supervision, which is selected optimally by a regulatory and supervisory agent. The capital requirement ratio is fixed over time.

Kilinc and Neyapti [8] propose a general equilibrium model to study the effects of the level of the banking quality. They assume that the regulatory and supervisory agent affects the decisions of households, firms and banks by determining the banking quality. They consider the regulation and supervision not to result from an optimizing agent but define it as exogenously given in their model. They find that the regulation and supervision quality has a positive effect on the growth rate, profits, investment, output, credits and wages, but a negative effect on the interest rates on deposits and loans.

To our best knowledge, these are the only papers that consider the level of bank regulation and supervision to result from the decision of an optimizing agent (RS). Our work is mostly inspired by Kilinc and Neyapti [8]. Different than Kilinc and Neyapti [8], we take the RS as an optimizing agent and solve for optimal level of banking quality explicitly. This means that the RS determines the value of banking quality in a general equilibrium context. We, then, analyze the effect of the banking quality on capital, interest rates on deposits and loans at the steady state.

Since we assume that the main aim of the RS is maintaining the sustainability of the banking system, modeling the banking problem gains more importance. This implies that modeling the RS problem depends on the banking problem. We consider the studies of Gerali et al. [30] and Agenor and Alper [31] as the basis of our banking problem. Gerali et al. [30] define two types of banking such as wholesale and retail bankings. Wholesale banking runs under perfect competition and in infinite time horizon. In this banking system, banks provide the cash flow between firms and households. Additionally, there is a penalty system in the work of Gerali et al. [30] according to the ratio of equity to loan that the banks are penalized if it can not fulfill this ratio. Furthermore, Agenor and Alper [31] construct their model by introducing the concept of non-performing loans. Instead of considering that all loans are paid back, Agenor and Alper [31] assume that some portion of the loans are paid back. With this assumption and without using any penalty mechanism, they construct their profit function. In our model, we construct the profit function of banks according to the cash flows and we assume that the RS penalizes the banks through nonperforming loans by inspiring the penalty system of the study of Gerali et al. [30] and the concept of nonperforming loans of the study of Agenor and Alper [31].

In the view of the above literature review, this thesis is an attempt to fill a gap in the literature by presenting a theoretical model that enables general equilibrium with a regulatory and supervisory agent. By choosing the level of α optimally, we enrich the general equilibrium set up with an important institutional feature. We assume that α affects the decisions of the households, firms and banks by reducing the moral hazard and adverse selection problems.

CHAPTER III

THE MODEL

3.1 The Environment

This section defines the structure of the model and the problems of each agent. There are four agents, which are households, firms, banks and a regulatory and supervisory agent. In this model, time is discrete and agents of each problem are identical. Hence, we focus on a representative agent in households', firms' and banks' problems. Furthermore, timing of decisions of agents is important. Figure 2 shows timing of loans and deposits for agents for one period of time. In this economy, households decide on the amount of their deposits (D_{t-1}) at the end of each period. These deposits are used for source of loans at the beginning of the next period. Firms take loans (L_t) at the beginning of each period in order to make investment and pay back some portion of these loans with some interest payments ($f(\alpha_t)L_t(1+R_t^l)$) at the end of that period. However, it is assumed that while some portion of loans are paid back, all deposits are paid to households by banks with some interest payments ($D_{t-1}(1+R_{t-1}^d)$). Those assumptions are inspired by Kilinc and Neyapti [8], Tchana [29], Covas and Driscoll [32] and Fernandez et al. [33]. These timing relations can be seen below in Figure 2. Additionally, timing assumptions will be explained in each problem in detail.

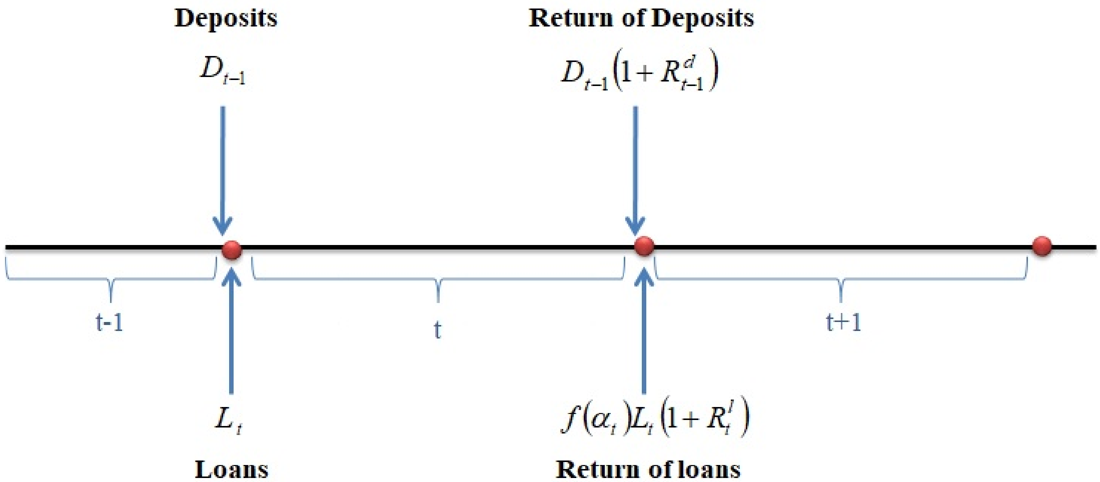

Figure 2: Timing of events for agents at the end of time t-1 and at the beginning of time t.

We solve the problems of households, firms, banks and the regulatory and supervisory agent simultaneously to obtain the Nash equilibrium. In the following, we present the problem of each agent, consisting of their objection functions and constraints as well as the general consistency condition for the economy. We also report the first order conditions for each problem. The rest of this chapter is organized as follows: In Section 2, we solve the household's problem and report the first order conditions. In Section 3, we solve the firm's problem and also report the first order conditions of this problem. In Section 4, we demonstrate the banks' problem within a perfect competition. In Section 5, the regulatory and supervisory agent's problem is solved and its first order condition is reported. The final section, Section 6, shows the general consistency condition. Table 1 and 2 below present the abbreviations for the variables and the parameters of the model.

3.2 Household's Problem

The households' problem can be described as follows. Households are identical and rational agents and maximize their lifetime utility level. Hence, we focus on a repre-

Table 1: Variables of the Model

Variables
C_t = consumption
S_t = savings
Y_t = output
W_t = wage
N_t = labor
W_tN_t = wage income
$d(\alpha_t)$ = the fraction of savings that are deposited
R_t^d = deposit interest rate
R_t^l = loan interest rate
Π_t^F = firm profit
Π_t^B = bank profit
K_t = physical capital
I_t = investment
$f(\alpha_t)$ = the fraction of repayment on loans
L_t = bank loans
D_t = bank deposits
H_t = required reserves
$\rho(\alpha_t)$ = the degree of law enforcement
z_t = technology
α_t = the banking regulation and supervision quality

Table 2: Parameters of the Model

Parameters
β : the discount factor
rr : the required reserve ratio
θ : the elasticity of output with respect to capital
$1-\theta$: the elasticity of output with respect to labor
δ : depreciation rate of capital
d : reaction of the households to the banking quality
f : reaction of the firms to the banking quality

sentative household. Utility depends on consumption (C) and leisure $(1-N)$, where N denotes the units of labor. Since we are measuring labor as the fraction of the day, $(1-N)$ is leisure. C_t is the quantity consumed and N_t denotes the fraction of work or employment at time t. The utility in period t is assumed to be continuous, concave and twice differentiable, with $U_{C,t} \equiv \frac{\partial U(C_t,1-N_t)}{\partial C_t} > 0$, $U_{CC,t} \equiv \frac{\partial^2 U(C_t,1-N_t)}{\partial C_t^2} \leq 0$, $U_{1-N,t} \equiv \frac{\partial U(C_t,1-N_t)}{\partial (1-N_t)} > 0$ and $U_{1-N1-N,t} \equiv \frac{\partial^2 U(C_t,1-N_t)}{\partial (1-N_t)^2} \leq 0$, where $U_{C,t}$ and $U_{1-N,t}$ represent the derivatives of the utility function with respect to C and $1-N$ at period t. Similarly, $U_{CC,t}$ and $U_{1-N1-N,t}$ represent the second derivatives of utility function with respect to C and $1-N$ at period t. In words, the marginal utility of consumption $U_{C,t}$ is assumed to be positive and non-increasing, while the marginal utility of leisure is also positive and non-increasing. The model is dynamic so that how much people care about tomorrow is important, the future is discounted by beta, where $0 < \beta < 1$.

The representative household maximizes its lifetime utility (Equation (1)) from consumption and leisure, subject to the budget constraint. Households are assumed to deposit their savings (S_t) in the banks at the end of each period to the extent that they have confidence in the banking system. Considering that a high α means a better functioning banking system that also, ensures depositor rights, $d(\alpha_t)$ is the rate at which savings are deposited at the interest rate of $(1+R_t^d)$, where $d'(\alpha_t) > 0$. The remaining part of savings, which is the $(1-d(\alpha_t))$ portion of it, is kept under the pillow, and does not bring any interest. Also, since households own firms, non-performing loans are considered in households' income. The households' budget also includes firm and bank profits since households own firms and banks. Lastly, for analytical purposes, we assume that the utility function is in the logarithmic form. Hence, household's problem can be written as:

$$\max_{\{C_t,1-N_t\}} E_0 \sum_{t=0}^{\infty} \beta^t U(C_t, 1-N_t) = E_0 \sum_{t=0}^{\infty} \beta^t (ln(C_t) + ln(1-N_t)) \tag{1}$$

subject to the constraints:

$$C_t + S_t \leq W_t N_t + D_{t-1}(1+R_{t-1}^d) + (1-d(\alpha_{t-1}))S_{t-1} + (1-f(\alpha_t))L_t + \Pi_t^F + \Pi_t^B \tag{2}$$

$$d(\alpha_t) S_t = D_t \tag{3}$$

The consumers' budget constraint is given in equation (2). Right hand side of the equation is the income of the households, consisting of six terms. First term is the nominal wage income. The second and the third terms are the gross returns from the savings as we explain above. The fourth one is the non-performing loans, which will be explained in the firm's problem. The fifth and the sixth terms are the firm's profit and banks' profit respectively. We use the Lagrange Method for the solution of the problem because of its ease. The first order conditions with respect to C_t and $1 - N_t$ yield the following expressions (see Appendix A):

$$U_C(C_t, 1 - N_t) = \beta U_C(C_{t+1}, 1 - N_{t+1})[d(\alpha_t)(1 + R_t^d) + (1 - d(\alpha_t))] \tag{4}$$

$$U_N(C_t, 1 - N_t) = W_t U_C(C_t, 1 - N_t) \tag{5}$$

3.3 Firm's Problem

We assume that firms are competitive and thus focus on a representative firm. The firm has an infinite horizon, with dynamics due to capital accumulation decision. It maximizes its lifetime profit, which is total value of production after payments to the factors of production. Output is given by; $Y_t = F(K_t, N_t)$. The price of the final good is normalized to 1 for simplicity and the firm's profit at time t is the following expression:

$$\Pi_t^F = F(K_t, N_t) - W_t N_t - f(\alpha_t)(1 + R_t^l)L_t \tag{6}$$

where $(W_t N_t)$ wages that are paid to workers and $(f(\alpha_t)(1 + R_t^l)L_t)$ is the $f(\alpha_t)$ fraction of loans (L_t) that is repaid with the interest $(1 + R_t^l)$ at the end of each period. We assume $f'(\alpha_t) > 0$ since supervision limits the moral hazard problem.

The production function is assumed to be of the Cobb-Douglas form:

$$Y_t = F(K_t, N_t) = e^{z_t} K_t^{\theta} N_t^{(1-\theta)} \tag{7}$$

Hence, the production function depends not only on capital (K) and labor (N) but also on technology (z), which we will assume constant as a benchmark case. K and N are endogenous variables but technology is an exogenous variable. K_t is quantity of capital at time t and N_t denotes the fraction of work or employment at time t. The period production function is assumed to be continuous and twice differentiable, with $F_{K,t} \equiv \frac{\partial F(K_t,N_t)}{\partial K_t} > 0$, $F_{KK,t} \equiv \frac{\partial^2 F(K_t,N_t)}{\partial K_t^2} \leq 0$, $F_{N,t} \equiv \frac{\partial F(K_t,N_t)}{\partial N_t} > 0$ and $F_{NN,t} \equiv \frac{\partial^2 F(K_t,N_t)}{\partial N_t^2} \leq 0$, where $F_{K,t}$ and $F_{N,t}$ represent the first derivatives of production function with respect to K and N at period t. Similarly, $F_{KK,t}$ and $F_{NN,t}$ represent the second derivatives of production function with respect to K and N at period t. In words, the marginal production of capital, $F_{K,t}$, is assumed to be positive and decreasing, while the marginal production of labor, $F_{N,t}$, is also positive and decreasing and both imply diminishing returns. Additionally, production function is assumed as satisfying constant returns to scale in capital and labor. The production function also satisfies the Inada conditions, which ensures the existence of an equilibrium:

$$\begin{aligned} &\lim_{K\to 0} F_K(K,N) = \infty, \lim_{K\to\infty} F_K(K,N) = 0 \\ &\lim_{N\to 0} F_N(K,N) = \infty, \lim_{N\to\infty} F_N(K,N) = 0 \end{aligned} \tag{8}$$

for all $K > 0$ and $N > 0$. Moreover, $F(0,N) = 0$ for all N and $F(K,0) = 0$ for all K.

The representative firm maximizes its lifetime profit by choosing optimally capital and labor (Equation (9)):

$$\max_{\{K_t,N_t\}} \sum_{t=0}^{\infty} \beta^t \Pi_t^F = E_0 \sum_{t=0}^{\infty} \beta^t \{F(K_t,N_t) - W_t N_t - f(\alpha_t)(1+R_t^l)L_t\} \tag{9}$$

subject to the constraints:

$$K_{t+1} = I_t + (1-\delta)K_t \tag{10}$$

$$I_t = L_t \tag{11}$$

$$F(K_t,N_t) = e^{z_t} K_t^{\theta} N_t^{(1-\theta)} \tag{12}$$

Capital accumulation constraint (10) is specified as follows; capital, which is used in this period, minus its depreciation plus the current investment, determines the capital in the next period. It is assumed in equation (11) that the loan in period t is converted to the investment in the same period. Equation (12) expresses the Cobb-Douglas production function. Again, Lagrange method is used and the first order conditions are found with respect to K_t and N_t. They yield the following expressions (see Appendix B):

$$f(\alpha_{t-1})(1+R_{t-1}^l) = \beta F_K(K_t,N_t) + \beta[f(\alpha_t)(1+R_t^l)(1-\delta)] \tag{13}$$

$$W_t = F_N(K_t,N_t) \tag{14}$$

3.4 Banks' Problem

Banks' problem is different than the firm's and household's problems in that it is a one period, static problem. While households and firms are concerned with the infinite period, banks' managers have short term concerns. As such, bank owners differ from bank managers as the former cares about the long term asset position, whereas the latter cares about the short term profit, as in a principal-agent framework (see also Laeven and Levine [10] and Agenor and Alper [31]). Hence, we model the bank managers' problem as maximizing one period of profit by choosing the lending interest rate and taking deposit interest rate as given.

The banks in our model act simply to channel the savings of households to the loans of firms. Those loans are invested in the given period and converted to capital of the next period. We assume that banks bridge the funding gap between the payment for the firm and the households (Fernandez et al. [33]). Moreover, we assume that there is zero profit condition for banks because of perfect competition among the banks [29]. Hence, the representative bank faces the following equation:

$$\Pi_t^B = f(\alpha_t)(1+R_t^l)L_t - (1+R_{t-1}^d)D_{t-1} - \rho(\alpha_t)(1-f(\alpha_t))(1+R_t^l)L_t = 0 \tag{15}$$

where

$$L_{t+1} + H_t = D_t \tag{16}$$

$$H_t = rrD_t \tag{17}$$

In equation (15), the fraction of $f(\alpha_t)$ of the loans that are given to the firms at the beginning of the period are taken at the end of the period with the interest of $(1+R_t^l)$ as revenue by banks. At the same time, deposits that are given to the households at the end of the period with the interest of $(1+R_{t-1}^d)$ are the expense for the banks. Finally, banks are punished by the regulatory and supervisory agent at rate $\rho(\alpha_t)$ for the non-performing loans. This penalty arises because of the wrong choices of firms that are given loans (last term in equation (15)). It means that banks pay some amount of non-performing loans to the regulatory and supervisory agent as a penalty. This amount returns to the regulatory and supervisory agent as a revenue that is used in order to cover its expenses. Equation (16) shows the balance sheet equilibrium for banks where L, H and D denote loans, required reserves and deposits, respectively. This shows the one-period nominal bank loans plus bank reserves equal to one-period nominal bank deposits. Equation (17) expresses the relation between required reserves (H_t) and deposits (D_t), where the required reserve ratio (rr) is exogenously given in the benchmark model that we solve.

Hence, banks' profit is the difference between its financial inflows and financial outflows. As it is mentioned above, we consider that there is sufficient competition in the banking sector such that banks gain zero profit [29]. Hence, rewriting the equation (15) after substituting equation (16) and (17) gives the following equation:

$$(1 + R_t^l) = \frac{(1 + R_{t-1}^d)}{(1 - rr)(f(\alpha_t) - \rho(\alpha_t)(1 - f(\alpha_t)))} \tag{18}$$

This expression shows the relation between loan interest rate and deposit interest rate given alpha at time t. The loan interest rate $(1 + R_t^l)$ cannot be greater than the right hand side (RHS) of this equation because of the zero profit condition of the competitive equilibrium. Also, the loan interest rate cannot be less than the right hand side of the equation because of the profit maximization. If that is less than the RHS, then profit will be negative, which means banks cannot survive (see Appendix C).

3.5 The Banking Regulatory and Supervisory Agent (RS) Problem

Since the regulatory and supervisory agent (RS) is considered to be an independent agent, it is interested in the whole banking system and its problem is dynamic. The RS determines the level of banking quality (α) to maximize the lifetime bank profit. As it is noted that α represents the summary measure of banking regulation and supervision and it is in the range of 0 and 1. Higher value of α means that the regulatory and supervisory agent acts strictly in the economy. As given in the banks' problem, banks' profit contains the fraction of repayment on loans times loans with interests minus repaid deposits with interests minus penalty. This relation is given in equation (15). The amount of the penalty is equal to the fraction of non-performing loans times total loans with interests times the degree of law enforcement, which forces banks to get all loans from firms. This penalty is positively related with the banking quality (α_t), which implies $\rho'(\alpha_t) > 0$.

Accordingly, rearranging the banks' problem in infinite time horizon subject to the constraints of (3), (15) and (16) and the following problem becomes the RS's problem:

$$\max_{\{\alpha_t\}} \sum_{t=0}^{\infty} \beta^t \{ f(\alpha_t)(1 + R_t^l)L_t - (1 + R_{t-1}^d)D_{t-1} - \rho(\alpha_t)(1 - f(\alpha_t))(1 + R_t^l)L_t \} \quad (19)$$

The first order condition of this problem with respect to alpha yields the following expression (see Appendix D):

$$\begin{aligned} \frac{\partial \Pi_t^B}{\partial \alpha_t} \quad = \quad & \Big\{ (f'(\alpha_t)d(\alpha_t) + f(\alpha_t)d'(\alpha_t))(1 + R_t^l)(1 - rr)S_t - \beta d'(\alpha_t)(1 + R_t^d)S_t \\ & - (\rho'(\alpha_t)d(\alpha_t) + \rho(\alpha_t)d'(\alpha_t) - \rho'(\alpha_t)f(\alpha_t)d(\alpha_t) - \rho(\alpha_t)f'(\alpha_t)d(\alpha_t) \\ & - \rho(\alpha_t)d'(\alpha_t)f(\alpha_t))(1 + R_t^l)(1 - rr)S_t \Big\} = 0 \end{aligned} \quad (20)$$

Assuming that $d(\alpha_t) = d\alpha_t$, $f(\alpha_t) = f\alpha_t$ where $0 < d \leq 1$, $0 < f \leq 1$ and $\rho(\alpha_t) = \alpha_t^2$ for the sake of simplicity, the following equation is obtained (see Appendix D):

$$\alpha_t(2f - 3\alpha_t + 4f\alpha_t^2) = \frac{\beta(1 + R_t^d)}{(1 - rr)(1 + R_t^l)} \quad (21)$$

3.6 Aggregate Consistency Condition

Any macroeconomic model must satisfy the conditions for aggregate consistency, which must hold when we add up the uses and sources of all the participants in the market (i.e. $Y = C + S$) [34]. In our model, as the households own firms and banks, the budget constraint of households given in equation (2) includes the profit function of firms and banks given in equation (6) and (15) respectively. Hence, we replace the profit function of the firms and banks into the budget constraint of households. The penalty that is imposed by the regulatory and supervisory agent to the banks are added in the aggregate profit since this penalty is the only income source of the regulatory and supervisory agent that it uses for its operations. Hence the following condition must be satisfied in each period of time:

$$Y_t = C_t + S_t = F(K_t, N_t) + (1 - d(\alpha_{t-1}))S_{t-1} + (1 - f(\alpha_t))L_t \tag{22}$$

where $F(K_t, N_t)$ represents the output produced by firms, $(1-d(\alpha_{t-1}))S_{t-1}$ represents savings that are not deposited (under the pillow) by households from previous period and $(1 - f(\alpha_t))L_t$ represents the total amount of non-performing loans.

CHAPTER IV

ANALYSIS OF THE MODEL

We assume that the agents have full information about the underlying parameters of the model and set non-cooperatively. The Nash solution of the above problems yields a unique equilibrium at the steady state. $\{K^*,\ R^{d^*},\ R^{l^*},\ \alpha^*\}$ are the steady state levels of capital, deposit interest rate, loan interest rate and the regulation and supervision quality respectively, given parameters $\{rr, d, f, \beta, \theta, \delta\}$. We also obtain the feasibility conditions for the existence of a unique equilibrium based on the values of the parameters.

Proposition 1. *Consider the profit function of the banks given in (15) and the maximization problem of the regulation and supervision agent given in (19) with assumptions of (3), (16) and (17), and suppose that* $f(\alpha) = f\alpha$, $d(\alpha) = d\alpha$ *and* $\rho(\alpha) = \alpha^2$. *Then, the steady state level of banking quality* (α^*) *is uniquely determined when* $0.76 \leq f \leq 1$ *and* $0.9 \leq \beta < 1$ *as the following:*

$$\alpha^* = \frac{3 - \beta + \sqrt{(\beta - 3)^2 + 8f(\beta - f)(4 - \beta)}}{2f(4 - \beta)} \tag{23}$$

Proof. See Appendix E. □

Proposition 1 shows that there exists a unique solution for the steady state level of banking quality (α^*) with respect to the ranges of the reaction of the firms to the banking quality (f) and the discount factor (β). In order to see the relations between f and α^* simply, we assume β as 0.99 [26]. According to our assumption, α^* should be in the range of 0 and 1. Given this assumption, when $\beta = 0.99$, f can have the values between 0.796 and 1 for a feasible solution. Figure 3 shows that α^* can have the values between 1 and 0.657 when f is in the range of 0.796 and 1.

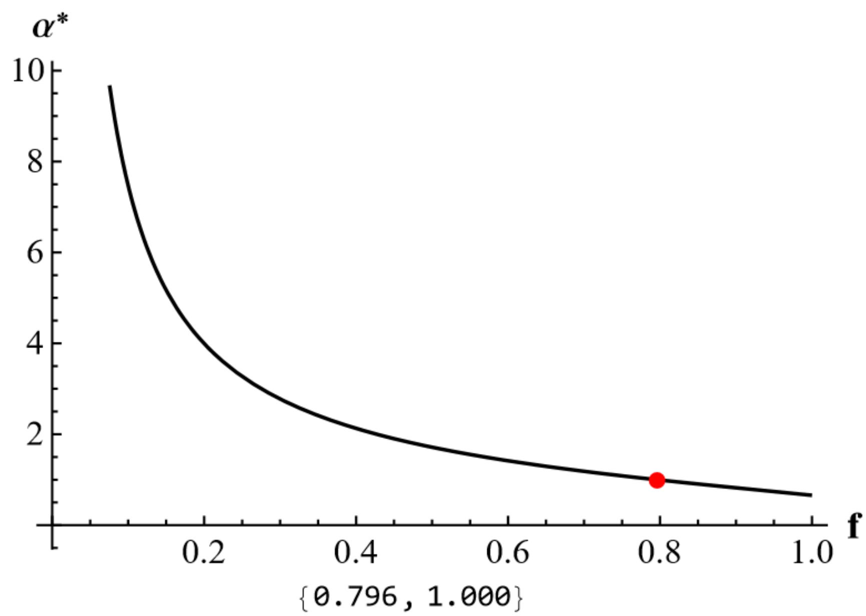

Figure 3: The change in α^* with respect to f.

Proposition 2. *Denote the steady state level of banking quality $\alpha^*(\beta, f)$ when the underlying parameters are f and β. Then,*

$$\frac{\partial \alpha^*(\beta, f)}{\partial f} < 0 \tag{24}$$

$$\frac{\partial \alpha^*(\beta, f)}{\partial \beta} > 0 \tag{25}$$

Proof. See Appendix F. □

Proposition 2 shows that there is a negative relation between the steady state level of banking quality (α^*) and the reaction of the firms to the banking quality (f), and positive relation between the steady state level of banking quality (α^*) and the discount factor (β). The increase in f leads a decrease in α^*. As f increases, the firms have a greater tendency to pay their loans back which reduces the need for strict RS. Additionally, there is a positive relation between α^* and β. As the discount factor β increases, the RS considers the future more highly. As the RS considers the future more, it increases the level of banking quality in order to ensure the security of the banking system.

Proposition 3. *Consider the maximization problems of households, firms, the regulatory and supervisory agent given in (1), (9) and (19) respectively and the profit function of the banks given in (15), and K^* is the steady state level of capital. Then, K^* is found explicitly as in the following:*

$$K^* = \left(\frac{f(1-\beta(1-\delta))\Big(1-\beta+\beta d\alpha^*\Big)}{\theta\epsilon^z N^{(1-\theta)}\beta^2 d(1-rr)\alpha^*(f-\alpha^*+f\alpha^{*2})} \right)^{\left(\frac{1}{\theta-1}\right)} \tag{26}$$

where α^* is given in equation (23).

Proof. See Appendix G. □

Proposition 3 shows the steady state level of capital (K^*). As it is seen that K^* depends only on the parameters of the model, which are the discount factor (β), the reaction of the households to the banking quality (d), the reaction of the firms to the banking quality (f), depreciation rate of capital (δ), the elasticity of output with respect to capital (θ) and the required reserve ratio (rr). Also, K^* depends on the technology (e^z) and labor (N). In order to analyse the behaviour of K^*, we take z and N constant as a benchmark case. We calibrate technology as $z = 0$ and the steady state level of labor as $N^* = 0.33$ that corresponds to 8 hours of daily working time [8] for the benchmark case.

Proposition 4. *Consider the maximization problem of firms given in (9) and the profit function of the banks given in (15) with assumptions given in the equation (3), (10), (11), (12), (16) and (17), and suppose that* $f(\alpha) = f\alpha$*,* $d(\alpha) = d\alpha$ *and* $\rho(\alpha) = \alpha^2$ *and* K^* *is the steady state level of capital. There is a positive relation between* K^* *and the steady state level of banking quality* (α^*)*. That is:*

$$\frac{\partial K^*}{\partial \alpha^*} > 0 \tag{27}$$

Proof. See Appendix H. □

The current model would suggests that the steady state level of capital in the standard growth models is lower than the level of capital when there exists a banking quality in the economy [8]. Here, Proposition 4 demonstrates that the higher the value of the steady state level of the banking quality (α^*) the greater is the steady state level of capital (K^*). Intuitively, this positive relation implies that when the regulatory and supervisory agent acts strictly, it ensures that the effectiveness of the financial intermediation is enormously productive because of increment in the trust of the households to the banking system and enabling borrower discipline. As a result of these, the economy has faced more deposits and more loans. Consequently, investment which is one of the main sources of capital overshoots since investment is connected to loans.

Proposition 5. *Consider the maximization problem of households given in (1) with assumptions (2) and (3), and suppose that* $d(\alpha) = d\alpha$*, and* R^{d^*} *is the steady state interest rate on deposits. Then, there is a negative relation between* R^{d^*} *and the steady state level of banking quality* (α^*)*. That is:*

$$\frac{\partial R^{d^*}}{\partial \alpha^*} < 0 \tag{28}$$

Proof. See Appendix I. □

Proposition 6. *Consider the maximization problem of households given in (1) and the profit function of the banks given in (15) with assumptions (2), (3), (16) and (17) and suppose that $f(\alpha) = f\alpha$, $d(\alpha) = d\alpha$, $\rho(\alpha) = \alpha^2$ and R^{l^*} is the steady state interest rate on loans. Then, there is a negative relation between R^{l^*} and the steady state level of banking quality (α^*). That is:*

$$\frac{\partial R^{l^*}}{\partial \alpha^*} < 0 \tag{29}$$

Proof. See Appendix I. □

Proposition 5 and 6 show that as the steady state level of banking quality increases (α^*), the steady state interest rate on deposits (R^{d^*}) and the steady state interest rate on loans (R^{l^*}) decreases. The increase in α^* means that the trust of households to the banking system increases and the firms' discipline, which is about paying their debts, can be ensured. Hence, the households make more deposits since they trust the banking system. This behaviour causes a decrease in the deposit interest rate. Furthermore, since the firms pay back their loans, there is no need to increase the loan interest rate. Hence, a mutual trust environment is established for all agents in this economy since the increase in α^* provides lower deposit and loan interests.

Proposition 7. *Denote the steady state level of capital $K^*(d, f, \beta, \theta, \delta, rr)$ where the underlying parameters given $\{d, f, \beta, \theta, \delta, rr\}$. Then,*

$$\frac{\partial K^*(d, f, \beta, \theta, \delta, rr)}{\partial d} > 0 \tag{30}$$

$$\frac{\partial K^*(d, f, \beta, \theta, \delta, rr)}{\partial f} < 0 \tag{31}$$

$$\frac{\partial K^*(d, f, \beta, \theta, \delta, rr)}{\partial \beta} > 0 \tag{32}$$

$$\frac{\partial K^*(d, f, \beta, \theta, \delta, rr)}{\partial \theta} > 0 \tag{33}$$

$$\frac{\partial K^*(d,f,\beta,\theta,\delta,rr)}{\partial \delta} < 0 \tag{34}$$

$$\frac{\partial K^*(d,f,\beta,\theta,\delta,rr)}{\partial rr} < 0 \tag{35}$$

Proof. See Appendix J. □

Proposition 7 shows the comparative statics of the steady state level of capital (K^*) which is a function of d, f, β, θ, δ and rr. There is a positive relation between the steady state level of capital and the reaction of the households to the banking quality (d), the discount factor (β), the elasticity of output with respect to capital (θ); and negative relation between the steady state level of capital and the reaction of the firms to the banking quality (f), depreciation rate of capital (δ) and the required reserve ratio (rr). The increase in K^* as d increases is expected since the increase in d represents that there is a tendency of households to have more deposits. As a result of this, banks might give more loans to the firms. Hence, the capital level can increase at the steady state.

As the discount factor (β) increases, agents value the future more. Hence, they make more deposits and the increase in deposits leads to increase in the capital level at the steady state. Additionally, the positive relation between the elasticity of output with respect to capital (θ) and K^* can be obviously seen from the Cobb-Douglas form of output function (Equation 12). Similarly, the negative relation between depreciation rate of capital (δ) and K^* can be easily seen from the capital accumulation rule (Equation 10).

The increase in f implies that the firms have a greater tendency to pay their loans back. This situation reveals two different mechanisms that affect capital in opposite directions. Firstly, if f increases, since the firms have a tendency to pay their loans back in the current period, the investment of firms will increase in the next period, which leads an increase in capital. Secondly, if f increases, the income of households at the current period decreases since non-performing loans of firms, which are one of the sources of the income of households, decrease. As the income of households decrease, their deposits also decrease. This situation leads to decrease in the source of loans of banks and the investments of firms. Hence, the capital level of the next periods will decrease. In our model, Proposition 7 demonstrate that the second mechanism, which explains the decrease in the capital of firms with respect to f, dominates the first mechanism at the steady state. Hence, there is a negative relation between the steady state level of capital (K^*) and the reaction of the firms to the banking quality (f).

Finally, the increase in rr means that the banks have less sources to give loans because they have to keep more reserves in their accounts. This implies that the firms cannot take loans as much as they desire, then this situation causes a negative impact on the steady state level of capital.

Proposition 8. *Denote the deposit interest rate at the steady state $R^{d^*}(d, f, \beta)$ where the underlying parameters given $\{d, f, \beta\}$. Then,*

$$\frac{\partial R^{d^*}(d, f, \beta)}{\partial d} < 0 \tag{36}$$

$$\frac{\partial R^{d^*}(d, f, \beta)}{\partial f} > 0 \tag{37}$$

$$\frac{\partial R^{d^*}(d, f, \beta)}{\partial \beta} < 0 \tag{38}$$

Proof. See Appendix K. □

Proposition 8 shows the comparative statics of the deposit interest rate at the steady state (R^{d^*}) which is a function of d, f and β. There is a negative relation between the steady state interest rate on deposits and the reaction of household to the banking quality (d) and the discount factor (β), and a positive relation between the steady state interest rate on deposits and the reaction of the firms to the banking quality (f). For the first relation, if the households have more incentive to make deposit, the banks have incentive to implement lower deposit interest rate due to profit maximization. Similarly, considering the future more (higher the discount factor β), leads an incentive to increase the deposits which will decrease the deposit interest rate with the same concern of the banks that is discussed above. Hence, the increase in d or β leads to decrease in R^{d^*}.

The effect on R^{d^*} of the reaction of the firms to the banking quality is positive. As the increase in f means the firms have tendency to pay their loans back, and as the non-performing loans are transferred to the households as an income, the increase in f decreases the income of the households. The decrease in the income of households leads them to make less deposits than they are able to make. Hence, the banks increase the deposit interest rate at the steady state so as to increase the deposits that will come from the households. Hence, it can be said that there is a positive relation between f and R^{d^*}.

Proposition 9. *Denote the loan interest rate at the steady state $R^{l^*}(d, f, \beta, rr)$ where the underlying parameters given $\{d, f, \beta, rr\}$. Then,*

$$\frac{\partial R^{l^*}(d, f, \beta, rr)}{\partial d} < 0 \tag{39}$$

$$\frac{\partial R^{l^*}(d, f, \beta, rr)}{\partial f} > 0 \tag{40}$$

$$\frac{\partial R^{l^*}(d, f, \beta, rr)}{\partial \beta} < 0 \tag{41}$$

$$\frac{\partial R^{l^*}(d, f, \beta, rr)}{\partial rr} > 0 \tag{42}$$

Proof. See Appendix L. □

Proposition 9 demonstrates the comparative statics of the the loan interest rate at the steady state (R^{l^*}) which is a function of d, f, β and rr. There is a negative relation between the steady state interest rate on loans and the reaction of the households to the banking quality (d) and the discount factor (β); and there is a positive relation between the steady state interest rate on loans and the required reserve ratio (rr), and the reaction of the firms to the banking quality (f).

The increase in the reaction of households to the banking quality leads to more deposits that can be given to the banks. The increase in deposits should be converted to loans by the banks in order to increase their profits. By decreasing R^{l^*}, banks can give more loans. The negative effect of the discount factor on R^{l^*} also can be explained considering the same idea behind the relation between the reaction of the households to the banking quality and R^{l^*}.

Additionally, there is a positive relation between the required reserve ratio and R^{l^*} since the increase in the required reserve ratio means the banks should keep their resources as reserves rather than giving firms as loans. In this situation, as the aim of the banks is to maximize their profits, they increase R^{l^*}. Finally, the banks may increase R^{l^*} in order to avoid to pay more penalty even if the firms have greater incentive to pay back their loans. Consequently, the relation between R^{l^*} and f is positive.

CHAPTER V

EXTENSION

In this chapter, we will solve our model by changing our timing assumptions. As it is mentioned in Figure 2 at the beginning of Chapter III, there is one period of lag between loans and deposits. Now, we assume that households make deposits at the beginning of the period, at the same time as the banks extend loans to the firms. It means that decisions of deposits and loans are taken at the same period. Also, from the perspective of banks, deposits that are given to the households at time t and performing loans that are taken from firms at time t determine the banks' profit of the next period. In short, we will do some tiny changes about timing assumptions and demonstrate new first order conditions of each agent and new steady state levels of banking quality, capital, deposit interest rate and loan interest rate. Furthermore, aggregate consistency condition is also satisfied for this new scenario. Results and calculations are shown in Appendix M.

In this new model, we found two different steady state values for α. For feasibility, which means that $0 \leq \alpha \leq 1$, for one of the solutions, f should be between 0 and 0.57 and for the other, f should be between 0.5 and 0.57. Otherwise, banking quality will be negative or greater than 1 (see Appendix M).

Finally, as it is mentioned in the RS problem section, we assume that the degree of law enforcement ($\rho(\alpha_t)$) is equal to α_t^2. This assumption implies that the penalty is implemented at a decreasing rate since the range of banking quality (α_t) is between 0 and 1. Nevertheless, we change this assumption in order to investigate the effects of increasing rate of penalty on the steady state solutions. Hence, we assume the degree of law enforcement as $\sqrt{\alpha_t}$ and we solve our current model by changing the degree of law enforcement. In this scenario, we found two different steady state values for α. Also, we checked the feasibility conditions of those results in order to get a valid solution. According to one of the solutions, we have no feasible solution for α since α is always negative when f and β are between 0 and 1. Otherwise, second solution can be valid if β is greater than 0.5 and f is less than 0.24. This scenario is not reported in this study.

CHAPTER VI

CONCLUSION

After the Great Recession (2007), bank regulation and supervision has been a subject of great interest. Hence, the effectiveness of the bank regulation and supervision is investigated in several studies in the literature. However, to the best of our knowledge, there is no study that considers an endogenous regulatory and supervisory agent which sets the level of the banking quality optimally in order to ensure the financial stability. With this motivation, in this thesis, the main aim is to present a theoretical model to study how an independent banking regulatory and supervisory agent (RS) should set the level of banking regulatory and supervision quality (α), and to observe its effects in a general equilibrium context.

In this thesis, we first construct an optimizing agent (RS) which sets the level of banking quality in order to ensure the survival of the banking system in the long term. It affects the decisions of households and firms such that how much deposit that households should make, and how much loans that firms should pay back. Hence, the existence of a regulatory and supervisory agent affects all agents that we consider in our model which are households, firms and banks. In order to ensure the survival of the banking system, we create a penalty mechanism which enables the RS to force banks to get their all loans back. It does this by penalizing the banks on the non-performing loans with a function of the banking quality. Hence, banks do not just have a cost of the non-performing loans, but also have a cost coming from this penalty. Therefore, with this mechanism, the RS forces the banks to make accurate decisions on their loans that are given to the firms in the upcoming periods. This penalty mechanism that the RS put into operation that we make is another contribution to the banking regulation and supervision literature.

In this thesis, after we model the problems of households, firms, banks and the RS, we find that there exists a unique steady state level of banking quality. Then, we analyze how this steady state level of banking quality affects the steady state levels of capital, interest rates of deposits and loans. We find that there is a positive relation between the steady state level of banking quality and the steady state level of capital, whereas there is a negative relation between the steady state level of banking quality and the steady state interest rates on deposits and loans. Hence, we conclude that the existence of the RS helps to ensure the financial stability by increasing the level of capital and decreasing the interest rates on deposits and loans at the steady state.

We also examine the comparative statics of the steady state levels of the banking quality, capital and deposit and loan interests. We find that there is a positive relation between the steady state level of capital and the reaction of the households to the banking quality, the discount factor, the elasticity of output with respect to capital; and a negative relation between the steady state level of capital and the reaction of the firms to the banking quality, the required reserve ratio and the depreciation rate of capital. Additionally, we find that there is a negative relation between the steady state interest rates on deposits and loans and both the reaction of households to the banking quality and the discount factor. Also, there is a positive relation between the steady state interest rates on deposits and loans and the reaction of the firms to the banking quality. Also, the required reserve ratio affects positively the loan interest rate at the steady state.

We realize that the results are all expected from the very set-up. Yet, this study is a significant step for future studies by providing a benchmark workable model.

As a future work, this study will be extended in multiple directions. First, we will examine the effects of production shocks on the endogenous variables. Second, we assume that banks are perfectly competitive with zero profit condition in our study, which may be relaxed. Thirdly, we assume that the fraction of savings that are deposited and the fraction of repayment on loans are linear functions that depend on the level of banking quality; this assumption can be relaxed by taking those functions as non-linear though we expect that the nature of the results will not change as a result of this modification. Lastly, we do not consider a monetary authority (i.e. Central Bank) decision on the required reserve ratio; introducing a rule-based decision making for the central bank may affect the solution of the model. Therefore, as an extension of our model, a monetary authority can be added into the model. Further, the strategic intersection between the RS and the Central Bank can be considered in the future works.

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APPENDICES

A Proof of the Household's Problem

$$\max_{\{C_t, 1-N_t\}} E_0 \sum_{t=0}^{\infty} \beta^t U(C_t, 1-N_t) = E_0 \sum_{t=0}^{\infty} \beta^t (ln(C_t) + ln(1-N_t)) \tag{43}$$

s.t.

$$C_t + S_t \leq W_t N_t + D_{t-1}(1 + R^d_{t-1}) + (1 - d(\alpha_{t-1}))S_{t-1} + (1 - f(\alpha_t))L_t + \Pi^F_t + \Pi^B_t \tag{44}$$

The Lagrangian for the household is as follows:

$$\xi = E_0 \sum_{t=0}^{\infty} \beta^t (ln(C_t) + ln(1-N_t)) + \lambda_t \Bigg[W_t N_t + d(\alpha_{t-1})(1 + R^d_{t-1})S_{t-1} + \\ (1 - d(\alpha_{t-1}))S_{t-1} + (1 - f(\alpha_t))L_t + \Pi^F_t + \Pi^B_t - C_t - S_t \Bigg] \tag{45}$$

The first order conditions are:

$$\frac{\partial \xi}{\partial S_t} = E_0 \Bigg\{ \beta^t \frac{1}{C_t} - \beta^{(t+1)} \frac{1}{C_{t+1}} [d(\alpha_t)(1 + R^d_t) + (1 - d(\alpha_t))] \Bigg\} = 0 \tag{46}$$

$$\frac{C_t}{C_{t+1}} = \beta[d(\alpha_t) R^d_t + 1] \tag{47}$$

$$\frac{\partial \xi}{\partial C_t} = E_0 \Bigg\{ \beta^t \frac{1}{C_t} - \lambda_t \Bigg\} = 0 \tag{48}$$

$$\frac{\partial \xi}{\partial N_t} = E_0 \Bigg\{ \beta^t \frac{(-1)}{1 - N_t} - \lambda_t W_t \Bigg\} = 0 \tag{49}$$

$$C_t = (1 - N_t)W_t \tag{50}$$

Implicit forms of the first order conditions are the following expressions:

$$U_C(C_t, 1 - N_t) = \beta U_C(C_{t+1}, 1 - N_{t+1})[d(\alpha_t)(1 + R_t^d) + (1 - d(\alpha_t))] \tag{51}$$

$$U_N(C_t, 1 - N_t) = W_t U_C(C_t, 1 - N_t) \tag{52}$$

B Proof of the Firm's Problem

$$\max_{\{K_t, N_t\}} E_0 \sum_{t=0}^{\infty} \beta^t \{F(K_t, N_t) - W_t N_t - f(\alpha_t)(1 + R_t^l)L_t\} \tag{53}$$

Using capital accumulation given in equation (10) and output given in equation (12), the problem can be rewritten as:

$$\max E_0 \sum_{t=0}^{\infty} \beta^t \{e^{z_t} K_t^{\theta} N_t^{(1-\theta)} - W_t N_t - f(\alpha_t)(1 + R_t^l)(K_{t+1} - (1 - \delta)K_t)\} \tag{54}$$

The first order condition with respect to K_t is:

$$\frac{\partial \Pi_t^F}{\partial K_t} = \beta^t(\theta e^{z_t} K_t^{(\theta-1)} N_t^{(1-\theta)}) - \beta^{t-1} f(\alpha_{t-1})(1 + R_{t-1}^l) + \beta^t(1 - \delta)f(\alpha_t)(1 + R_t^l) = 0 \tag{55}$$

$$\beta\theta e^{z_t} K_t^{(\theta-1)} N_t^{(1-\theta)} - f(\alpha_{t-1})(1 + R_{t-1}^l) + \beta(1 - \delta)f(\alpha_t)(1 + R_t^l) = 0 \tag{56}$$

$$K_t^{(\theta-1)} = \frac{f(\alpha_{t-1})(1 + R_{t-1}^l) - \beta(1 - \delta)f(\alpha_t)(1 + R_t^l)}{\beta\theta e^{z_t} N_t^{(1-\theta)}} \tag{57}$$

The first order condition with respect to N_t is:

$$\frac{\partial \Pi_t^F}{\partial N_t} = \beta^t F_N(K_t, N_t) - \beta^t W_t = 0 \tag{58}$$

$$W_t = (1 - \theta)e^{z_t} K_t^{\theta} N_t^{(1-\theta)} \tag{59}$$

Implicit forms of the first order conditions are the following expressions:

$$f(\alpha_{t-1})(1+R^l_{t-1}) = \beta F_K(K_t, N_t) + \beta[f(\alpha_t)(1+R^l_t)(1-\theta)] \tag{60}$$

$$W_t = F_N(K_t, N_t) \tag{61}$$

C Proof of the Banks' Problem

$$\Pi^B_t = f(\alpha_t)(1+R^l_t)L_t - (1+R^d_{t-1})D_{t-1} - \rho(\alpha_t)(1-f(\alpha_t))(1+R^l_t)L_t = 0 \tag{62}$$

subject to equations (3), (16) and (17).

Then the equation becomes the following:

$$f(\alpha_t)(1+R^l_t)L_t - (1+R^d_{t-1})D_{t-1} - \rho(\alpha_t)(1-f(\alpha_t))(1+R^l_t)L_t = 0 \tag{63}$$

$$f(\alpha_t)(1+R^l_t)L_t - (1+R^d_{t-1})\frac{L_t}{1-rr} - \rho(\alpha_t)(1-f(\alpha_t))(1+R^l_t)L_t = 0 \tag{64}$$

$$(f(\alpha_t)(1+R^l_t) - \frac{1+R^d_{t-1}}{1-rr} - \rho(\alpha_t)(1-f(\alpha_t))(1+R^l_t)) = 0 \tag{65}$$

$$(1+R^l_t)(f(\alpha_t) - \rho(\alpha_t)(1-f(\alpha_t))) = \frac{1+R^d_{t-1}}{1-rr} \tag{66}$$

$$1+R^l_t = \frac{1+R^d_{t-1}}{(1-rr)(f(\alpha_t) - \rho(\alpha_t)(1-f(\alpha_t)))} \tag{67}$$

D Proof of the Regulatory and Supervisory Agent's Problem

Since the regulatory and supervisory agent is considered to be an independent agent, it is interested in the whole bank system and its problem is dynamic. The RS determines α to maximize the lifetime bank profit:

$$\max_{\{\alpha_t\}} \sum_{t=0}^{\infty} \beta^t \{f(\alpha_t)(1+R_t^l)L_t - (1+R_{t-1}^d)D_{t-1} - \rho(\alpha_t)(1-f(\alpha_t))(1+R_t^l)L_t\} \quad (68)$$

subject to equations (3), (16) and (17) rearrange the problem as follows:

$$\begin{aligned} \max_{\{\alpha_t\}} \quad & \sum_{t=0}^{\infty} \beta^t \{f(\alpha_t)(1+R_t^l)(1-rr)d(\alpha_t)S_t - (1+R_{t-1}^d)d(\alpha_{t-1})S_{t-1} \\ & - \rho(\alpha_t)(1-f(\alpha_t))(1+R_t^l)(1-rr)d(\alpha_t)S_t\} \end{aligned} \quad (69)$$

The first order condition with respect to α is:

$$\begin{aligned} \frac{\partial \Pi_t^B}{\partial \alpha_t} \quad = \quad & \Big\{(f'(\alpha_t)d(\alpha_t) + f(\alpha_t)d'(\alpha_t))(1+R_t^l)(1-rr)S_t - \beta d'(\alpha_t)(1+R_t^d)S_t \\ & - (\rho'(\alpha_t)d(\alpha_t) + \rho(\alpha_t)d'(\alpha_t) - \rho'(\alpha_t)f(\alpha_t)d(\alpha_t) - \rho(\alpha_t)f'(\alpha_t)d(\alpha_t) \\ & - \rho(\alpha_t)d'(\alpha_t)f(\alpha_t))(1+R_t^l)(1-rr)S_t\Big\} = 0 \end{aligned} \quad (70)$$

Assuming that $d(\alpha_t) = d\alpha_t$, $f(\alpha_t) = f\alpha_t$ and $\rho(\alpha_t) = \alpha_t^2$, rearranging the equation (70) gives:

$$2fd\alpha_t(1-rr)(1+R_t^l) - \beta d(1+R_t^d) - (3d\alpha_t^2 - 4fd\alpha_t^3)(1-rr)(1+R_t^l) = 0 \quad (71)$$

$$(2fd\alpha_t - 3d\alpha_t^2 + 4fd\alpha_t^3)(1-rr)(1+R_t^l) = \beta d(1+R_t^d) \quad (72)$$

$$(2fd\alpha_t - 3d\alpha_t^2 + 4fd\alpha_t^3) = \frac{\beta d(1+R_t^d)}{(1-rr)(1+R_t^l)} \quad (73)$$

$$(2f\alpha_t - 3\alpha_t^2 + 4f\alpha_t^3) = \frac{\beta(1+R_t^d)}{(1-rr)(1+R_t^l)} \quad (74)$$

$$\alpha_t(2f - 3\alpha_t + 4f\alpha_t^2) = \frac{\beta(1+R_t^d)}{(1-rr)(1+R_t^l)} \quad (75)$$

E Proof of Proposition 1

The equations (21) and (18) can be rewritten at the steady state as the following:

$$\alpha(2f - 3\alpha + 4f\alpha^2) = \frac{\beta(1 + R^d)}{(1 - rr)(1 + R^l)} \tag{76}$$

$$(1 + R^l) = \frac{(1 + R^d)}{(1 - rr)(f(\alpha) - \rho(\alpha)(1 - f(\alpha)))} \tag{77}$$

Substituting equation (77) into equation (76), and assuming $f(\alpha) = f\alpha$ and $\rho(\alpha) = \alpha^2$ at steady state gives:

$$\alpha(2f - 3\alpha + 4f\alpha^2) = \frac{\beta(1 + R^d)}{(1 - rr)\left(\frac{(1+R^d)}{(1-rr)(f\alpha-\alpha^2(1-f\alpha))}\right)} \tag{78}$$

$$2f - 3\alpha + 4f\alpha^2 = \beta(f - \alpha + \alpha^2) \tag{79}$$

$$(4f - \beta f)\alpha^2 + (\beta - 3)\alpha + (2f - 2\beta) = 0 \tag{80}$$

Solving equation (80) gives the unique steady state solution in which α is in the range of 0 and 1 as in the following:

$$\alpha^* = \frac{3 - \beta + \sqrt{(\beta - 3)^2 + 8f(\beta - f)(4 - \beta)}}{2f(4 - \beta)} \tag{81}$$

F Proof of Proposition 2

$$\frac{\partial \alpha^*}{\partial f} = \frac{(\beta - 3)\sqrt{(\beta - 3)^2 + 8f(\beta - f)(4 - \beta)} + \beta(4f(\beta - 4) - \beta + 6) - 9}{2f^2(4 - \beta)\sqrt{(\beta - 3)^2 + 8f(\beta - f)(4 - \beta)}} < 0 \tag{82}$$

$$\frac{\partial \alpha^*}{\partial \beta} = \frac{64f - 3 - \sqrt{(\beta - 3)^2 + 8f(\beta - f)(4 - \beta)} - \beta(-4f^2 + 16f - 1) - 16f^2}{2f^2(4 - \beta)\sqrt{(\beta - 3)^2 + 8f(\beta - f)(4 - \beta)}} > 0 \tag{83}$$

The differentiations show the negative relation between the steady state level of banking quality and the reaction of the firms to the banking quality and the positive relation between the steady state level of banking quality and the discount factor.

G Proof of Proposition 3

Solving equation (4), which is the first order condition of the households problem, at the steady state gives the steady state level of interest rate of deposits as in the following:

$$R^{d^*} = \frac{1-\beta}{\beta d\alpha^*} \tag{84}$$

Substituting equation (84) into equation (77) and assuming $f(\alpha) = f\alpha$ and $\rho(\alpha) = \alpha^2$ at steady state gives:

$$(1 + R^{l^*}) = \frac{\left(1 + \left(\frac{1-\beta}{\beta d\alpha^*}\right)\right)}{(1-rr)(f\alpha^* - \alpha^{*2}(1 - f\alpha^*))} \tag{85}$$

Then, solving the equation (13) for the steady state and for $(1 + R^{l^*})$ gives:

$$(1 + R^{l^*}) = \frac{\beta\theta e^z K^{(\theta-1)} N^{(1-\theta)}}{f\alpha^*(1 - \beta(1-\delta))} \tag{86}$$

Then, equalizing equations (85) and (86) gives:

$$K^* = \left(\frac{f(1-\beta(1-\delta))\left(1 - \beta + \beta d\alpha^*\right)}{\theta\epsilon^z N^{(1-\theta)}\beta^2 d(1-rr)\alpha^*(f - \alpha^* + f\alpha^{*2})}\right)^{\left(\frac{1}{\theta-1}\right)} \tag{87}$$

where $\alpha^* = \frac{3-\beta+\sqrt{(\beta-3)^2+8f(\beta-f)(4-\beta)}}{2f(4-\beta)}$.

H Proof of Proposition 4

$$\frac{\partial K^*}{\partial \alpha^*} = A\left(\frac{\beta d {\alpha^*}^2(1-2f\alpha^*) - (1-\beta)(f - 2\alpha^* + 3f{\alpha^*}^2))}{\alpha^{*2}(f - \alpha^* + f\alpha^{*2})^2}\right)B > 0 \qquad (88)$$

where

$$A = \left(\frac{1}{\theta - 1}\right)\left(\frac{f(1-\beta(1-\delta))}{\theta e^z N^{(1-\theta)}\beta^2 d(1-rr)}\right) < 0$$

$$B = \left(\frac{f(1-\beta(1-\delta))\Big(1-\beta+\beta d\alpha^*\Big)}{\theta\epsilon^z N^{(1-\theta)}\beta^2 d(1-rr)\alpha^*(f-\alpha^*+f{\alpha^*}^2)}\right)^{\left(\frac{2-\theta}{\theta-1}\right)} > 0$$

$$\alpha^* = \frac{3-\beta+\sqrt{(\beta-3)^2+8f(\beta-f)(4-\beta)}}{2f(4-\beta)}$$

In order to find the relation between the steady state levels of capital and the banking quality, firstly, the middle expression is examined. Since $(1-2f\alpha^*)$ is always negative for all feasible ranges of f and α^* and $(f - 2\alpha^* + 3f\alpha^{*2})$ is always positive from the RS problem (equation 19), the numerator of the middle term is negative. The denominator of this term is obviously positive since it is a square of a function. Furthermore, A is negative since $(\frac{1}{\theta-1})$ is negative. Finally, B is always positive in our setup. Hence, the differentiation show the positive relation between the steady state level of banking quality and the steady state level of capital.

I Proof of Proposition 5 and 6

There is a negative relation between the steady state interest rates on deposits and loans seen in equation (84) and (85) and the steady state level of the banking quality which can be seen in the following:

$$\frac{\partial R^{d^*}}{\partial \alpha^*} = -\Big(\frac{1-\beta}{\beta d}\Big)\frac{1}{\alpha^{*2}} < 0 \qquad (89)$$

$$\frac{\partial R^{l^*}}{\partial \alpha^*} = \frac{1}{\beta d(1-rr)} \frac{\beta d\alpha^{*^2}(2\alpha^* - f - 3f\alpha^*) - (1-\beta)\alpha^*(2f - 3\alpha^* + 4f\alpha^{*^2})}{\alpha^{*^4}(f - \alpha^* + f\alpha^{*2})^2} < 0 \tag{90}$$

The relation between the steady state levels of banking quality and deposit interest rate is negative since all terms are positive except for minus sign at the beginning. Secondly, it is hard to see that the relation between the steady state levels of banking quality and loan interest rate. Here, the first expression ($\frac{1}{\beta d(1-rr)}$) is always positive. Also, the denominator of the second term is positive since it is a square of a function. However, the numerator of this term is negative since $(2\alpha^* - f - 3f\alpha^{*^2})$ is negative for all feasible ranges of f and α^* and $(2f - 3\alpha^* + 4f\alpha^{*^2})$ is positive from the RS problem (equation 19). Hence, the numerator of the second term is negative and the relation between the steady state levels of the banking quality and loan interest rate is negative at the steady state.

J Proof of Proposition 7

$$\frac{\partial K^*}{\partial f} = \frac{\partial K^*}{\partial \alpha^*}\frac{\partial \alpha^*}{\partial f} < 0 \tag{91}$$

Since we show in Appendix B.5. that $\frac{\partial K^*}{\partial \alpha^*} > 0$ and in Appendix B.2. that $\frac{\partial \alpha^*}{\partial f} < 0$, we can say that $\frac{\partial K^*}{\partial f} < 0$.

$$\frac{\partial K^*}{\partial \beta} = \frac{\partial K^*}{\partial \alpha^*}\frac{\partial \alpha^*}{\partial \beta} > 0 \tag{92}$$

Since we show in Appendix B.5. that $\frac{\partial K^*}{\partial \alpha^*} > 0$ and in Appendix B.2. that $\frac{\partial \alpha^*}{\partial \beta} > 0$, we can say that $\frac{\partial K^*}{\partial \beta} > 0$.

$$\frac{\partial K^*}{\partial d} = -A\left(\frac{1}{\theta - 1}\right)\left(\frac{1-\beta}{d^2}\right)B > 0 \tag{93}$$

where

$$A = \left(\frac{f(1-\beta(1-\delta))}{\theta\epsilon^z N^{(1-\theta)}\beta^2(1-rr)\alpha^*(f-\alpha^*+f{\alpha^*}^2)}\right) > 0$$

$$B = \left(\frac{f(1-\beta(1-\delta))\Big(1-\beta+\beta d\alpha^*\Big)}{\theta\epsilon^z N^{(1-\theta)}\beta^2 d(1-rr)\alpha^*(f-\alpha^*+f{\alpha^*}^2)}\right)^{(\frac{2-\theta}{\theta-1})} > 0$$

Then, equation (93) shows that there is a positive relation between K^* and d since A and B are positive and $(\frac{1}{\theta-1})$ is negative.

$$\frac{\partial K^*}{\partial rr} = A\left(\frac{1}{\theta - 1}\right)\left(\frac{1}{(1-rr)^2}\right)B < 0 \tag{94}$$

where

$$A = \left(\frac{f(1-\beta(1-\delta))\Big(1-\beta+\beta d\alpha^*\Big)}{\theta\epsilon^z N^{(1-\theta)}\beta^2 d\alpha^*(f-\alpha^*+f{\alpha^*}^2)}\right)$$

$$B = \left(\frac{f(1-\beta(1-\delta))\Big(1-\beta+\beta d\alpha^*\Big)}{\theta\epsilon^z N^{(1-\theta)}\beta^2 d(1-rr)\alpha^*(f-\alpha^*+f{\alpha^*}^2)}\right)^{(\frac{2-\theta}{\theta-1})}$$

Then, equation (94) shows that there is a negative relation between K^* and rr

since A and B are positive, but $(\frac{1}{\theta-1})$ is negative.

$$\frac{\partial K^*}{\partial \delta} = A\beta \left(\frac{1}{\theta-1}\right) B < 0 \tag{95}$$

where

$$A = \left(\frac{f\Big(1-\beta+\beta d\alpha^*\Big)}{\theta\epsilon^z N^{(1-\theta)}\beta^2 d\alpha^*(f-\alpha^*+f\alpha^{*2})}\right)$$

$$B = \left(\frac{f(1-\beta(1-\delta))\Big(1-\beta+\beta d\alpha^*\Big)}{\theta\epsilon^z N^{(1-\theta)}\beta^2 d(1-rr)\alpha^*(f-\alpha^*+f\alpha^{*2})}\right)^{(\frac{2-\theta}{\theta-1})}$$

Then, equation (95) shows that there is a negative relation between K^* and δ since A, β and B are positive, but $(\frac{1}{\theta-1})$ is negative.

K Proof of Proposition 8

$$\frac{\partial R^{d^*}}{\partial f} = \frac{\partial R^{d^*}}{\partial \alpha^*}\frac{\partial \alpha^*}{\partial f} > 0 \tag{96}$$

Since we show in Appendix B.5. that $\frac{\partial R^{d^*}}{\partial \alpha^*} < 0$ and in Appendix B.2. that $\frac{\partial \alpha^*}{\partial f} < 0$, we can say that $\frac{\partial R^{d^*}}{\partial f} > 0$.

$$\frac{\partial R^{d^*}}{\partial \beta} = \frac{\partial R^{d^*}}{\partial \alpha^*}\frac{\partial \alpha^*}{\partial \beta} < 0 \tag{97}$$

Since we show in Appendix B.5. that $\frac{\partial R^{d^*}}{\partial \alpha^*} < 0$ and in Appendix B.2. that $\frac{\partial \alpha^*}{\partial \beta} > 0$, we can say that $\frac{\partial R^{d^*}}{\partial \beta} < 0$.

$$\frac{\partial R^{d^*}}{\partial d} = -\Big(\frac{1-\beta}{\beta\alpha^*}\Big)\frac{1}{d^2} < 0 \tag{98}$$

Also, equation (98) shows that there is a negative relation between R^{d^*} and d.

L Proof of Proposition 9

$$\frac{\partial R^{l^*}}{\partial f} = \frac{\partial R^{l^*}}{\partial \alpha^*}\frac{\partial \alpha^*}{\partial f} > 0 \tag{99}$$

Since we show in Appendix B.5. that $\frac{\partial R^{l^*}}{\partial \alpha^*} < 0$ and in Appendix B.2. that $\frac{\partial \alpha^*}{\partial f} < 0$, we can say that $\frac{\partial R^{l^*}}{\partial f} > 0$.

$$\frac{\partial R^{l^*}}{\partial \beta} = \frac{\partial R^{l^*}}{\partial \alpha^*}\frac{\partial \alpha^*}{\partial \beta} < 0 \tag{100}$$

Since we show in Appendix B.5. that $\frac{\partial R^{l^*}}{\partial \alpha^*} < 0$ and in Appendix B.2. that

$\frac{\partial \alpha^*}{\partial \beta} > 0$, we can say that $\frac{\partial R^{l^*}}{\partial \beta} < 0$.

$$\frac{\partial R^{l^*}}{\partial d} = -\frac{1}{\beta\alpha^{*2}(1-rr)(f-\alpha^*+f\alpha^{*2})}\frac{1-\beta}{d^2} < 0 \tag{101}$$

Here, all terms are positive except for the minus sign at the beginning of the equation. Hence, equation (101) shows that there is a negative relation between R^{l^*} and d.

$$\frac{\partial R^{l^*}}{\partial rr} = \frac{1-\beta+\beta d\alpha^*}{\beta d\alpha^{*2}(f-\alpha^*+f\alpha^{*2})}\frac{1}{(1-rr)^2} > 0 \tag{102}$$

Additionally, equation (102) shows that there is a positive relation between R^{l^*} and rr.

M Extension of the Model

In this extension, we model households' deposits and firms' loans being made simultaneously. This means that decisions of deposits and loans are taken at the same period. Hence, there is no timing difference between deposits and loans. This alteration affects the results of each problem. Now, we will demonstrate those problems and their solutions.

M.1 Household's Problem

Household's problem becomes the following:

$$\max_{\{C_t, 1-N_t\}} E_0 \sum_{t=0}^{\infty} \beta^t U(C_t, 1-N_t) = E_0 \sum_{t=0}^{\infty} \beta^t (ln(C_t) + ln(1-N_t)) \tag{103}$$

subject to the constraint:

$$C_t + S_t \leq W_t N_t + D_{t-1}(1+R^d_{t-1}) + (1-d(\alpha_{t-1}))S_{t-1} + (1-f(\alpha_{t-1}))L_{t-1} + \Pi^F_t + \Pi^B_t \tag{104}$$

The Lagrangian for the household is the following:

$$\xi = E_0 \sum_{t=0}^{\infty} \beta^t (ln(C_t) + ln(1-N_t)) + \lambda_t \Big[W_t N_t + d(\alpha_{t-1})(1+R^d_{t-1})S_{t-1} +$$
$$(1-d(\alpha_{t-1}))S_{t-1} + (1-f(\alpha_{t-1}))L_{t-1} + \Pi^F_t + \Pi^B_t - C_t - S_t \Big] \tag{105}$$

Implicit forms of the first order conditions with respect to consumption and leisure are the following expressions:

$$U_C(C_t, 1-N_t) = \beta U_C(C_{t+1}, 1-N_{t+1})[d(\alpha_t)(1+R^d_t) + (1-d(\alpha_t))] \tag{106}$$

$$U_N(C_t, 1-N_t) = W_t U_C(C_t, 1-N_t) \tag{107}$$

M.2 Firm's Problem

Firm's problem becomes the following:

$$\max_{\{K_t, N_t\}} E_0 \sum_{t=0}^{\infty} \beta^t \{F(K_t, N_t) - W_t N_t - f(\alpha_{t-1})(1+R^l_{t-1})L_{t-1}\} \tag{108}$$

Using capital accumulation given in equation (10) and output given in equation

(12), the problem can be rewritten as:

$$\max E_0 \sum_{t=0}^{\infty} \beta^t \{ e^{z_t} K_t^{\theta} N_t^{(1-\theta)} - W_t N_t - f(\alpha_{t-1})(1 + R_{t-1}^l)(K_t - (1-\delta)K_{t-1}) \} \quad (109)$$

The first order condition with respect to K_t is:

$$\frac{\partial \Pi_t^F}{\partial K_t} = \beta^t (\theta e^{z_t} K_t^{(\theta-1)} N_t^{(1-\theta)}) - \beta^t f(\alpha_{t-1})(1 + R_{t-1}^l) + \beta^{t+1}(1-\delta) f(\alpha_t)(1 + R_t^l) = 0 \quad (110)$$

The first order condition with respect to N_t is:

$$\frac{\partial \Pi_t^F}{\partial N_t} = \beta^t F_N(K_t, N_t) - \beta^t W_t = 0 \quad (111)$$

Implicit forms of the first order conditions are the following expressions:

$$f(\alpha_{t-1})(1 + R_{t-1}^l) = F_K(K_t, N_t) + \beta[f(\alpha_t)(1 + R_t^l)(1 - \theta)] \quad (112)$$

$$W_t = F_N(K_t, N_t) \quad (113)$$

M.3 Banks' Problem

Banks' problem becomes the following:

$$\Pi_{t+1}^B = f(\alpha_t)(1 + R_t^l)L_t - (1 + R_t^d)D_t - \rho(\alpha_t)(1 - f(\alpha_t))(1 + R_t^l)L_t = 0 \quad (114)$$

subject to the equations (3), (17) and the budget balance:

$$Ł_t + H_t = D_t$$

Then the equation becomes the following:

$$1 + R_t^l = \frac{1 + R_t^d}{(1 - rr)(f(\alpha_t) - \rho(\alpha_t)(1 - f(\alpha_t)))} \quad (115)$$

M.4 Regulatory and Supervisory Agent's Problem

Since the regulatory and supervisory agent is considered to be an independent agent, it is interested in the whole banking system and its problem is dynamic. RS determines α to maximize the lifetime bank profit. The RS problem becomes the following:

$$\max_{\{\alpha_t\}} \sum_{t=0}^{\infty} \beta^t \{f(\alpha_t)(1+R_t^l)L_t - (1+R_t^d)D_t - \rho(\alpha_t)(1-f(\alpha_t))(1+R_t^l)L_t\} \tag{116}$$

subject to equations (3), (16) and (17) rearrange the problem as follows:

$$\begin{aligned} \max_{\{\alpha_t\}} \quad & \sum_{t=0}^{\infty} \beta^t \{f(\alpha_t)(1+R_t^l)(1-rr)d(\alpha_t)S_t - (1+R_t^d)d(\alpha_t)S_t \\ & - \rho(\alpha_t)(1-f(\alpha_t))(1+R_t^l)(1-rr)d(\alpha_t)S_t\} \end{aligned} \tag{117}$$

The first order condition with respect to α is:

$$\begin{aligned} \frac{\partial \Pi_t^B}{\partial \alpha_t} = & \Big\{(f'(\alpha_t)d(\alpha_t) + f(\alpha_t)d'(\alpha_t))(1+R_t^l)(1-rr)S_t - d'(\alpha_t)(1+R_t^d)S_t \\ & - (\rho'(\alpha_t)d(\alpha_t) + \rho(\alpha_t)d'(\alpha_t) - \rho'(\alpha_t)f(\alpha_t)d(\alpha_t) - \rho(\alpha_t)f'(\alpha_t)d(\alpha_t) \\ & - \rho(\alpha_t)d'(\alpha_t)f(\alpha_t))(1+R_t^l)(1-rr)S_t\Big\} = 0 \end{aligned} \tag{118}$$

Assuming that $d(\alpha_t) = d\alpha_t$, $f(\alpha_t) = f\alpha_t$ and $\rho(\alpha_t) = \alpha_t^2$, rearranging the equation (118) gives:

$$\alpha_t(2f - 3\alpha_t + 4f\alpha_t^2) = \frac{(1+R_t^d)}{(1-rr)(1+R_t^l)} \tag{119}$$

M.5 Aggregate Consistency Condition

Aggregate consistency condition is the following expression:

$$Y_t = C_t + S_t = F(K_t, N_t) + (1 - d(\alpha_{t-1}))S_{t-1} + (1 - f(\alpha_{t-1}))L_{t-1} \tag{120}$$

M.6 The Steady State Solutions

Using equations (106), (107), (112), (113), (115) and (119) and rearranging those equations at the steady state, we can find two different steady state levels of banking quality as the following expressions:

$$\alpha_1^* = \frac{1 - \sqrt{1 - 3f^2}}{3f} \tag{121}$$

where $0 < f \leq 0.57$

$$\alpha_2^* = \frac{1 + \sqrt{1 - 3f^2}}{3f} \tag{122}$$

where $0.5 \leq f \leq 0.57$

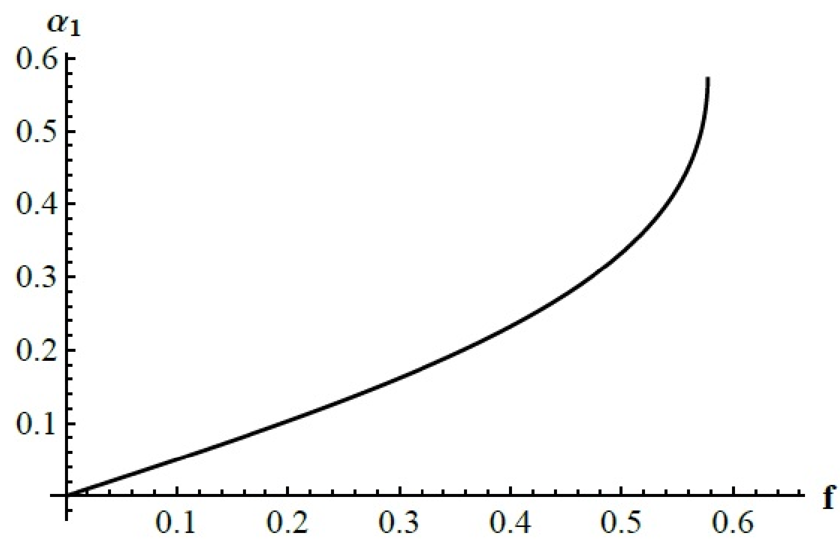

Figure 4: The change in α_1^* with respect to f.

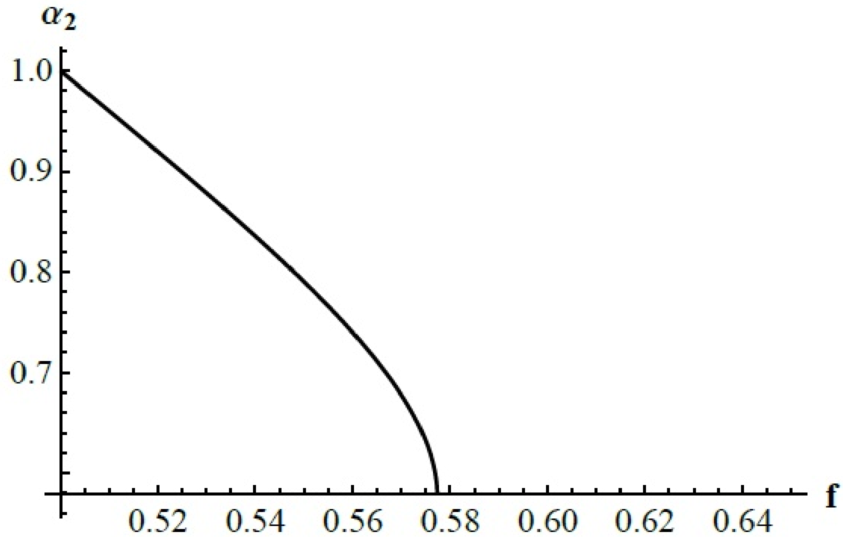

Figure 5: The change in α_2^* with respect to f.

Figure 4 and 5 show the relation between the steady state level of banking quality and f for each steady state solution. As it is seen, the regulatory and supervisory agent might choose two different long-term banking quality policies. According to its choice, f affects the banking quality negatively or positively at the steady state.

The steady state level of capital is the following expression:

$$K^* = \left(\frac{f(1-\beta(1-\delta))\Big(1-\beta+\beta d\alpha^*\Big)}{\theta\epsilon^z N^{(1-\theta)}\beta^2 d(1-rr)\alpha^*(f-\alpha^*+f\alpha^{*2})} \right)^{(\frac{1}{\theta-1})} \tag{123}$$

where α^* is given in equation (121) or (122).

The steady state level of deposit interest rate is the following expression:

$$R^{d^*} = \frac{1-\beta}{\beta d\alpha^*} \tag{124}$$

where α^* is given in equation (121) or (122).

The steady state level of loan interest rate is the following expression:

$$R^{l^*} = \frac{\left(1 + \left(\frac{1-\beta}{\beta d \alpha^*}\right)\right)}{(1-rr)(f\alpha^* - {\alpha^*}^2(1 - f\alpha^*))} - 1 \tag{125}$$

where α^* is given in equation (121) or (122).