STAGGERED LOAN CONTRACT IN A NEW KEYNESIAN FRAMEWORK

A THESIS SUBMITTED TO
THE GRADUATE SCHOOL OF SOCIAL SCIENCES
OF
MIDDLE EAST TECHNICAL UNIVERSITY

BY

HARUN ALP

IN PARTIAL FULFILLMENT OF THE REQUIREMENTS
FOR
THE DEGREE OF MASTER OF SCIENCE
IN
THE DEPARTMENT OF
ECONOMICS

AUGUST 2009

Approval of the Graduate School of Social Sciences

Prof. Dr. Sencer Ayata
Director

I certify that this thesis satisfies all the requirements as a thesis for the degree of Master of Science.

Prof. Dr. Erol Taymaz
Head of Department

This is to certify that we have read this thesis and that in our opinion it is fully adequate, in scope and quality, as a thesis for the degree of Master of Science.

Assoc. Prof. Dr. Nadir Öcal
Co-Supervisor

Assist. Prof. Dr. Ebru Voyvoda Temizsoy
Supervisor

Examining Committee Members

Assoc. Prof. Dr. Nadir Öcal (METU, ECON)

Assist. Prof. Dr. Ebru Voyvoda Temizsoy (METU, ECON)

Assist. Prof. Dr. Dürdane Şirin Saracoğlu (METU, ECON)

Assist. Prof. Dr. Refet S. Gürkaynak (BILKENT U., ECON)

Dr. Ali Hakan Kara (CBRT, RESEARCH DEPT.)

I hereby declare that all information in this document has been obtained and presented in accordance with academic rules and ethical conduct. I also declare that, as required by these rules and conduct, I have fully cited and referenced all material and results that are not original to this work.

Name, Last Name : Harun ALP

Signature :

ABSTRACT

STAGGERED LOAN CONTRACT IN A NEW KEYNESIAN FRAMEWORK

Alp, Harun

M. S., Department of Economics

Supervisor : Assist. Prof. Dr. Ebru Voyvoda Temizsoy

Co-Supervisor : Assoc. Prof. Dr. Nadir Öcal

August 2009, 48 pages

This thesis aims to understand the role of interest rate setting behavior of the banks for the transmission of technology, monetary policy and loan rate shocks into the real economy. To this end, we introduce a monopolistically competitive banking sector into a New Keynesian model. Here, each bank can change its loan rate only infrequently in the fashion of Calvo type staggered contract. This setting implies that the adjustment of the aggregate loan rate is sticky, which is consistent with the empirical evidence. The results show that having sticky adjustment in the loan market changes the dynamics of the model significantly. Following each shock, the sluggish adjustment of the loan rate affects the amount of loan used by the borrowers considerably. This is the main reason behind the differentials across the impulse responses of the model with sticky loan rate and flexible loan rate.

Keywords: Banking Sector, Sticky Loan Rates, Collateral Constraint.

ÖZ

KATI BORÇ KONTRATLARININ YENİ KEYNESYENCİ YAKLAŞIM
ÇERÇEVESİNDE MODELLENMESİ

Alp, Harun

Yüksek Lisans, İktisat Bölümü

Tez Yöneticisi : Yrd. Doç. Dr. Ebru Voyvoda Temizsoy

Ortak Tez Yöneticisi : Doç. Dr. Nadir Öcal

Ağustos 2009, 48 sayfa

Bu tezde, bankaların faiz belirleme davranışının teknoloji, para politikası ve kredi faizi şoklarının ekononomiye aktarımı üzerindeki etkisi çalışılmıştır. Bu doğrultuda, Yeni Keynesyenci bir modele monopolcü rekabetçi bankacılık sektörü dahil edilmiştir. Bu yapıda, her banka kredi faizini Calvo tipi katı kontrat mekanizması çerçevesinde değiştirmektedir. Yapılan bu varsayım kredi faizlerinin ampirik çalışmalarla tutarlı bir şekilde katı olmasını sağlamaktadır. Sonuçlar katı kredi faizinin, modelin dinamiklerini önemli bir biçimde değiştirdiğini göstermektedir. Yavaş intibak eden kredi faizlerinin varlığı, söz konusu şokları takiben kullanılan kredi miktarını etkilemektedir. Bu durum, esnek ve katı kredi faizi modellerinin ima ettiği etki tepki fonksiyonlarının arasındaki farkın temel kaynağıdır.

Anahtar Kelimeler: Bankacılık Sektörü, Katı Kredi Faiz Oranları, Teminat Kısıtı.

To My Precious Wife

ACKNOWLEDGEMENTS

I would like to express my deepest gratitude to my thesis supervisors Assist. Prof. Dr. Ebru Voyvoda Temizsoy and Assoc. Prof. Dr. Nadir Öcal for their guidance and effort throughout this study. I would also like to thank to the examining committee members Dr. Dürdane Şirin Saracoğlu, Assist. Prof. Dr. Refet S. Gürkaynak and Dr. Ali Hakan Kara for their valuble comments and critiques.

I owe special thanks to The Scientific and Technological Reseach Council of Turkey for the financial support they provided throughout my graduate studies.

I am also grateful to Tommaso Monacelli for his helpful comments and suggestions.

Furthermore, I would also like to thank my family for the support they provided me throughout my entire life.

Finally, I would also like to express genuine appreciation to my beloved wife, Sevim Kösem Alp for all her help, tolerance and motivation. Without her love and invaluable company, this thesis could not be completed.

TABLE OF CONTENTS

CHAPTER 1

INTRODUCTION

In the last several decades, many sources of frictions have been introduced into the theoretical models in order to explain economic fluctuations in the business cycle. Staggered price settings, sticky wage contracts and adjustment cost of investment are some of the mechanisms which have been analyzed thoroughly in the literature and become main ingredients of the workhorse general equilibrium models that are employed in policy institutions or academia. In addition to these, financial frictions are also considered as an important factor that shapes the business cycle.[1] However, the models with frictions in financial markets are still in theoretical infancy and most of the general equilibrium models employed to study the dynamics of the main macroeconomic variables do not include any interaction between financial variables and the rest of the economy. Moreover, frictionless financial market assumption implies that the interest rate set by the central bank exactly coincides with all the other interest rates in the economy due to the arbitrage opportunities. That is to say, once the policy rate is determined, all the economic agents become subject to the same interest rate irrespective of whether they are borrowers or are savers. However, we know that in actual economies, there are different interest rates relevant for the borrowing and saving decisions and they do not move perfectly together.

Regarding the introduction of financial frictions into the dynamic stochastic general equilibrium (DSGE) models, Carlstrom and Fuerst (1997) and Bernanke et al. (1999) are the most prominent studies which introduce credit and collateral requirements and study how macroeconomic shocks are transmitted or amplified in the presence of these financial elements. Despite the important role assigned to financial frictions, these studies mainly assume that financial transactions occur through the market and

[1] See Christiano et al (2007) and Heideken (2008) for U.S. and euro area, Guajardo (2004) for the evidence from developing countries.

they do not devote any specific role to the financial intermediaries, namely to the banking sector. For instance, Bernanke et al. (1999) mentions the existence of capital mutual funds, having the role of collecting resources from lenders and distributing them to borrowers; these intermediaries, however, just perform a risk-pooling activity by collecting savings from all households and lending them to all entrepreneurs. However, for example in Turkey, many of the transactions and activities in both money and capital markets are carried out by banks and the banking sector constitutes the major part of the Turkish financial system.

More recent contributions to the literature have tried to provide more realistic and complete models of the banking sector, where intermediaries have an active role in determining the price or the supply of financial assets. An example is Christiano et al. (2007), which extends the model in Bernanke et al. (1999) by introducing a perfectly competitive banking sector offering a variety of saving and liquidity services and lending opportunities to households and firms. However, this model, still, lacks of realism in the sense that banks are assumed to operate under a perfectly competitive environment; that is to say, no role is devoted to the banking sector as an interest rate setter.

In this thesis, we introduce a monopolistically competitive banking sector in a New Keynesian model in order to understand the role of interest rate setting behavior of banks in the dynamics of the economy and analyze how different shocks are transmitted to the real economy. With this type of banking sector, we allow for another friction which is staggered loan contract mechanism. In order to introduce staggered loan contract mechanism into the model, banks are assumed to extend loans to consumers in an environment of monopolistic competition by setting the loan rate in the fashion of Calvo-type staggered contract. In this setup, only a random fraction of banks adjusts their loan rate to a change in the policy rate that determines the marginal costs, while the remaining fraction leaves their loan rate unchanged, which means that the adjustment of the aggregate loan rate to a monetary policy change is sticky. This type of setting allows us to consider the dynamics of the economy in a more sensible financial sector environment: while the presence of monopolistic competition among the banks creates an endogenous spread between the loan rate and policy rate, the introduction of sticky adjustment of loan rate enables us to obtain a time-varying and slowly adjusting mark-up for the loan rate over the policy rate. With the recognition of the spread between different interest rates, it is no longer the case that the monetary policy, deciding on single interest rate, has a direct influence on the economy.

Within this framework, this thesis analyzes the implications of the existence of staggered loan contract mechanism by looking at the impulse-responses of the model under technology, monetary policy and loan rate shocks. The results show that the introduction of sticky loan rates alters the transmission of the shocks significantly. Following each shock, the sluggish behavior of the loan rate affects the amount of loan used by the borrowers significantly, which is the main reason that creates the differentials across the impulse responses of the model with sticky loan rate and flexible loan rate. For instance, under the technology shock to non-durable sector, the presence of staggered loan contract mechanism induces smaller reduction in the loan rate, which results in smaller amount of loan used by the borrowers compared to the flexible loan rate case. Following a contractionary monetary policy shock, stickiness in the loan rate *moderates* the effects of the collateral constraints on variables. On the other hand, the introduction of staggered loan contract mechanism leads to very persistent movements in all variables following loan rate shock and produces an internal propagation mechanism that renders the effects of the shock amplified and long-lasting.

The remainder of the thesis is organized as follows: the following chapter provides some discussion on the related literature. Chapter 3 introduces the theoretical model. Chapter 4 presents the calibration of the model and simulation outcomes. The last chapter concludes.

CHAPTER 2

RELATED LITERATURE

This chapter presents a review of the literature that is relevant for this thesis in two parts. The first section provides a brief summary of the literature on DSGE modeling which is the modeling approach employed in this thesis. Then, section 2 briefly describes the empirical literature on the estimation of the degree of interest rate pass-through in the loan rate. This line of literature basically motivates the usage of staggered loan contract mechanism, the main ingredient of the theoretical model that is explained in Chapter 3 in detail.

2.1 A Brief Summary of the Literature on DSGE Modeling

This section aims to provide an overview of the literature that has led to the development of DSGE models[2]. This type of approach to macroeconomic modeling, a variant of which is employed in this thesis, provides the main reference framework for the analysis of economic fluctuations in modern macroeconomic theory and has started to be used by many policy-making institutions as a modeling framework.

During the 1970s, the existing traditional quantitative macroeconomic models have lost their popularity on both empirical and theoretical grounds. The traditional macro models, typically derived from the so-called Cowles Commission Approach[3], are typically featured by a rich set of ad-hoc equations depicting the behavior of key macroeconomic variables and generally estimated by simultaneous equations techniques. Even though these macroeconometric models were used extensively in policy institutions for policy making and forecasting purposes, many economists

---

[2] This section dwells heavily on Kremer et al. (2006), Avouyi et al. (2007) and Gali (2008).

[3] See Fair (1992) for the details of Cowles Commission Approach.

raised severe criticisms to these frameworks because of their poor performance in 1970s. For example, some of the traditional models, like the Wharton Econometric model and the Brookings Model, failed to predict the stagflation, i.e. the combination of high unemployment and high inflation occurred during the 1970s. This failure was mainly attributed to the inability of the traditional models to handle the short run trade-off between inflation and unemployment, given by the Phillips curve, properly. On the theoretical front, Lucas (1976) criticized the absence of an optimization-based approach in the development of the structural equations in the traditional models and forcefully argued that these models are not likely to be useful for policy purposes. Basically, the so-called Lucas Critique proposed that reduced-form econometric models could not provide useful information about the actual consequences of alternative policies because the structure of the economy will change when policy changes, thereby rendering the estimated parameters in reduced-form econometric models nonconstant. This means that a macroeconometric model that is estimated by using historical data cannot be a guide for accessing the effects of current policy actions. Similarly, Sims (1980) proposed that the absence of convincing identifying assumptions to sort out the vast simultaneity among macroeconomic variables meant that one could have little confidence that the parameter estimates would be stable across different regimes. These powerful critiques made clear why macroeconometric models fit largely on the relationships implied by the historical data did not survive after the structural changes of 1970s.

2.1.1 The Emergence of the Real Business Cycle Theory

In response to these critiques, Lucas (1977) and Kydland and Prescott (1982) and others initiated a new research program, often termed as the real business cycle (RBC) approach, where the models used for policy analysis are immune to the Lucas critique because of their micro foundations. The main view of their approach was that a model of a frictionless and perfectly competitive market economy, populated by explicitly utility-maximizing rational agents that are subject to budget constraints and technological restrictions, could replicate a number of stylized business cycle facts when the economy is hit by exogenous productivity shocks. Although this so-called RBC approach to macroeconomic modeling was criticized on several aspects, it is widely acknowledged that the RBC theory has made important contributions to the macroeconomic theory and established the use of DSGE models as a central tool for macroeconomic analysis. Most of today's DSGE models adopt the general structure of a RBC model, i.e. they feature an impulse--response structure built around optimizing agents in a general equilibrium setting. That is why main contribution of the RBC literature to the DSGE modeling was considered to be methodological, namely to propose a coherent way to depict and solve a rational expectation dynamic stochastic general equilibrium model.

Despite its essential contributions and initial empirical success, RBC theory was also seriously evaluated on several fronts. From a theoretical perspective, the RBC approach was criticized for its use of perfect competition and frictionless markets assumptions. Under these critical assumptions, the RBC literature proposed that cyclical fluctuations did not necessarily signal an inefficient allocation of resources. That view implied that stabilization policies may not be necessary or desirable, and they could even be counterproductive. This was actually in contrast with the conventional interpretation, tracing back to Keynes (1936), of recessions as periods with an inefficiently low utilization of resources, which could be brought to an end by means of economic policies aimed at expanding aggregate demand.

Another criticism to this approach concerns empirical properties of the RBC models. Although, the models belonging to this literature succeeded in reproducing the properties of the cyclical components of some macroeconomic variables, they are unable to reproduce realistic fluctuations in hours worked and real wages. Moreover, RBC theory basically attempted to explain economic fluctuations with no reference to monetary factors, even abstracting from the existence of a monetary sector. That is to say, RBC theory suggested an economic environment where monetary policy does not have any effect on real variables.

All these controversial points explain why the RBC approach had a very limited impact on central banks and other policy institutions. Many central banks continued to rely on large-scale macroeconometric models to produce forecasts of the economy that assumed no structural change, but they did so knowing that these models could not be used with any degree of confidence to generate forecasts of the results of policy changes.

2.1.2 The New Keynesian Theory

A vast literature has therefore been devoted to the improvement of RBC models on the theoretical as well as the empirical front. Consequently, modeling assumptions regarding the real side of the economy have become more diversified. At the same time, the New Keynesian paradigm also arose as an attempt to provide microfoundations for key Keynesian concepts such as the inefficiency of aggregate fluctuations, nominal price stickiness, and the non-neutrality of money (Mankiw and Romer (1991)). The early models of New Keynesian literature emerged in the late 1970s and 1980s were often static or used reduced form equilibrium conditions that were not derived from explicit dynamic optimization problems facing firms and households. In contrast to the RBC approach, however, the researchers following the New Keynesian ideas considered market imperfections as the key element to understanding the real world. As the methodological framework introduced by the RBC literature became more influential in macroeconomic theory, the New Keynesian school started to share with the RBC approach the belief that macroeconomics needed more rigorous microfoundations. The emphasis of much of the work in New Keynesian literature was, then, on providing microfoundations of New Keynesian ideas, namely nominal rigidities such as stickiness of prices, real rigidities like labor market imperfections and financial market imperfections. In the following subsections, the key elements of the New Keynesian models and related studies are presented.

2.1.2.1 Nominal rigidities

In the 1990s, several papers demonstrated how to incorporate nominal rigidities into dynamic general equilibrium frameworks (Calvo (1983), Hairault and Portier (1993), Yun (1996), King and Wolman (1996)). As with the new Keynesian literature, the initial emphasis was given to the nominal price rigidities. These models, which share the same basic foundations, are essentially monopolistic competition versions of the neoclassical growth model, modified to allow for variable labor supply. In this setting, monopolistically competitive firms are subject to some constraints on the frequency with which they can adjust the prices of the goods and services they sell. Alternatively, firms may face some costs of adjusting those prices. As a consequence of the presence of nominal rigidities, changes in short term nominal interest rates are not matched by one-for-one changes in expected inflation, thus leading to variations in real interest rates. This brings about changes in consumption and investment and, as a result, on output and employment, since firms find it optimal to adjust the quantity of goods supplied to the new level of demand affected by the real interest rate.

As part of these developments, a vast body of research emerged on what is now known as the New Keynesian Phillips curve. Using a modified version of the model devised by King and Wolman (1996), Galí and Gertler (1999) showed that the inflation dynamics equation is a forward looking version of the Phillips curve that links inflation to its past value, its future value and real marginal cost.

2.1.2.2 Real rigidities

Another line of the New Keynesian literature revisited the theoretical findings of Ball and Romer (1990), which called for a combination of nominal and real rigidities. One line of research, summarized by Woodford (2003), was done in order to explain the slope of the Phillips curve without assuming strong nominal rigidities. Woodford stresses the notion of strategic complementarities, where pricing decisions by companies depend positively on their competitors' choices. When faced with a shock that encourages it to revise prices upwards, a firm will be tempted to make a partial increase if it is afraid that its competitors will not put up their prices. At equilibrium, all monopolistically competitive producers end up making small price changes, which tends to make inflation insensitive to changes in real marginal cost.

On the other hand, a series of work took the route of explaining the persistence of real marginal cost (Dotsey and King (2001), Christiano et al (2005)). Here, the most commonly encountered mechanisms involve assuming that capital utilization is variable and that nominal wages are sticky. When it varies over time, the utilization rate absorbs part of the shocks that increase demand for capital. This leads to modest changes in the price of capital and hence in real marginal cost.

2.1.2.3 Financial Market Imperfections

Several studies incorporate financial market imperfections within the New Keynesian framework, with the aim of better understanding the role of financial factors in business cycle. A reference framework combining nominal rigidities and financial frictions has been developed by Bernanke et al. (1999). In this paper, entrepreneurs, who borrow funds to undertake investment projects, face an external finance premium that rises when their leverage increases. A tightening in monetary policy, for example, reduces the return on capital resulting in a decline in the net worth of firms. Declines in net worth increase firm leverage, leading to further raising in external financing costs and reducing the demand for capital. The drop in demand for capital reinforces the decline in its value. This mechanism is often called an “accelerator” effect, because the lower price of capital has a feedback effect, further lowering the net worth of firms. Using this setting calibrated to postwar US data, Bernanke et al. (1999) show that the financial accelerator mechanism amplifies the impact of shocks and provides a quantitatively important mechanism that propagates shocks at business cycle frequencies.

Other recent papers have also explored the implications of the coexistence of nominal rigidities with different type of credit frictions. For example Monacelli

(2006) and Campbell and Hercowitz (2005) introduced collateral-based borrowing constraint as a source of credit market imperfection, that is the private borrowing is subject to a limit which is tied to the value of the durable good stock. With the introduction of collateral constraint, rising asset prices allow the financially constrained agents to expand their borrowing and increase consumption and investment, thus stimulating real activity. Decrease in asset prices, on the other hand, leads to collateral devaluations, which induce agents to additionally cut on their expenditures. Note that this type of credit frictions constitutes the main starting point of the modeling approach that is utilized in this thesis.

Monacelli (2006) studied the relevance of the presence of collateral constraint for optimal monetary policy and showed that optimal policy in this context requires a partial use of inflation volatility with a redistributive motive. Moreover, the introduction of collateral constraint makes the evolution of asset prices relevant for monetary policy. Campbell and Hercowitz (2005) also used a very similar modeling approach for introducing financial frictions. The paper examined the contribution of the financial reforms of the early 1980s which relaxed collateral constraints on household borrowing in U.S. to the macroeconomic stabilization that occurred shortly thereafter. The model predicted that the relaxation of collateral constraints can explain a large fraction of the actual volatility decline in hours worked, output, household debt, and household durable goods purchases.

Despite the important role assigned to credit frictions, the models mentioned above do not pay attention to the banking sector as a financial intermediary. More recent contributions to the literature have tried to provide more realistic and complete models of the banking sector, where intermediaries have an active role in determining the price or the supply of financial assets. An example is Christiano et al. (2007) which augmented a medium-scale DSGE model with nominal rigidities to include financial market which offers a variety of saving and liquidity services and lending opportunities to the households and firms. Different from the early studies, they introduced two types of financial intermediaries into the model. The first one operates as a perfectly competitive bank; it intermediates loans between households and firms, and produces transactions services using capital, labor and reserves. The second one, on the other hand, replicates the financial accelerator mechanism proposed by Bernanke et al. (1999). The results of the Bayesian estimation for euro area showed that financial frictions may play an important role in the propagation of shocks and that financial factors can be useful to explain past episodes of business cycle fluctuations.

Recently, Gerali et al. (2009) extended the existing models in the literature by introducing a monopolistically competitive banking sector similar to our framework. They extend the model in Iacoviello (2005) by introducing a banking sector with imperfect competition and endogenous accumulation of bank capital. Having estimated the model for euro area, they found that that shocks originating in the banking sector explain the largest fraction of the fall of output in 2008 in the euro area, while macroeconomic shocks played a smaller role. They also find that an unexpected reduction in bank capital can have a substantial impact on the real economy and particularly on investment. Our framework differs from this model in three respects. Firstly, rather than the implications of the existence of stickiness in loan rates, they focused on those of monopolistic competition and accumulation of banking capital. Secondly, while we assume staggered loan contract mechanism à la Calvo in loan setting problem of private banks, they presume that the private banks face an adjustment cost of changing the loan rate. Finally, instead of a constant supply of durable goods as is the case in Gerali et al. (2009), we allow for production in the durable good sector which is used as collateral for borrowing.

To sum up, the quantitative general equilibrium models that were developed in response to the Lucas critique have become sophisticated over time. With the methodological contribution of the RBC theory and introduction of various types of imperfections and rigidities in the markets for goods, for factors of production into the DSGE models, today, the DSGE modeling strategy dominates most of branches of macroeconomics. Particularly important contributions are made in monetary economics by Rotemberg and Woodford (1997), in international macroeconomics by Obstfeld and Rogoff (1995), and in fiscal policy analysis by Chari, Christiano and

Kehoe (1994). The latest-generation models are medium-sized models that incorporate virtually all the theoretical advances and many New Keynesian ideas such as nominal rigidities in price and wage setting, real rigidities, imperfect competition, financial frictions and other types of imperfections. The two most often cited ones are those developed by Smets and Wouters (2003) and Christiano et al (2005). These models incorporate many theoretical mechanisms and several shocks and are generally well enough suited to the data. For this reason, central banks and other policy institutions have become increasingly interested in developing full-fledged DSGE models for policy analysis and forecasting.

2.2 The Empirical Literature

The literature includes a huge number of empirical studies on the estimation of the degree of interest rate pass-through in the loan rates. Despite the diversity of approaches and data sets, the majority of the studies conclude that change in the policy rate is only partially passed through to loan rates in the short run, although the estimates of the degree of pass-through differ among studies. In one of the early studies, Goldfeld (1966) tests the adjustment speeds of commercial loan rates compared to open market rates and demonstrates that the loan rates adjust relatively slowly. Berger and Udell (1992) investigates over one million individual loans in the U.S. from 1977 to 1988 and concludes that the adjustment process of loan rates is sticky. From the recent literature, by using harmonized ECB bank interest rate statistics, Sørensen and Werner (2006) investigates the pass-through between market interest rates and bank interest rates in the Euro area and shows that shifts in money-market rates, including the policy rate, are not completely passed through to retail lending rates. Furthermore, Gropp et al. (2007) argues that interest rate pass-through in the euro area is incomplete even after controlling for differences in bank soundness, credit risk, and the slope of the yield curve.[4]

[4] Mojon (2000), Donnay and Degryse (2001), Sander and Kleimeier (2002), Espinosa-Vega and Rebucci (2003), Hofmann (2004), Gambacorta (2004), Bondt et al (2005), are some of the other studies confirming the same fact for different countries.

While all these studies confirm the presence of sticky loan rates as a well-established fact, the literature may provide different explanations for its roots. According to some researchers, this type of financial market imperfections can be explained by the existence of long-term relationships between banks and customers. For instance, Fried and Howitt (1980) and Berger and Udell (1992) argue that the benefit from banker customer relationships that are predominately continuous arises from banks offering an implicit interest rate insurance to risk averse customers by keeping loan rates less variable than market rates. This means that loan rates are sticky with the consequence that the pass through from changes in money market rates to loan rates is incomplete. On the other hand, Gropp et al. (2007) argues that the level of competitiveness of the financial market is the key factor in understanding the incomplete pass-through in loan rates. Bondt et al. (2005) also provides an explanation that the loan rates are not completely responsive to policy or money market rates because loan rates are also tied to long-term market interest rates. Note that, the theoretical model for banking sector developed in Chapter 3 embodies some insight from these explanations. With the usage of Calvo-type staggered contract in the loan rate setting problem, it is shown that, the optimal loan rate set at time t is a weighted average of current and future policy rates, which is consistent with the explanation provided by Bondt et al. (2005).

CHAPTER 3

THE MODEL

This chapter presents the model that is used to analyze the implications of the existence of staggered loan contract mechanism. The model builds on Monacelli (2006) and Campbell and Hercowitz (2005). The economy consists of two types of households, impatient (borrowers) and patient (savers) households; two production sectors - durable and non-durable goods sector - each populated by a large number of monopolistic competitive intermediate good producers and by perfectly competitive final good producers; private banks which operate under a monopolistically competitive environment and a central bank.

3.1 The Households

Both types of households derive utility from consumption of non-durable final goods and from the stock of durable goods. The borrowers differ from the savers in that they exhibit a lower patience rate, which implies higher propensity to consume for them.[5] Note that, such an assumption allows for inter-temporal equilibrium trading of debt between savers and borrowers. In other words, this type of heterogeneity generates credit flow between two types of agents as an equilibrium phenomenon; patient households hold a positive amount of deposit with no borrowing, whereas impatient households borrow a positive amount of loans.[6] Complementary to this

[5] Here, in order to differentiate the patience rate of two types of households, the discount rate for the borrowers is set lower than discount rate of savers. For the examples of the models with heterogeneous agents, see Kiyotaki and Moore (1997), Krusell and Smith (1998) Iacoviello (2005), Campbell and Hercowitz (2005).

[6] That is why the impatient household is called borrower and patience household is called saver.

assumption, the borrowers face a collateral constraint, with the borrowing limit tied to the value of the stock of durable goods.[7]

3.1.1 The Borrowers

A typical borrower consumes an index of durable and non-durable final goods, defined:

$$S_t \equiv \left[(1-\alpha)^{\frac{1}{\eta}} (C_t)^{\frac{\eta-1}{\eta}} + \alpha^{\frac{1}{\eta}} (D_t)^{\frac{\eta-1}{\eta}} \right]^{\frac{\eta}{\eta-1}} \tag{1}$$

where C_t denotes the consumption of final non-durable goods, D_t denotes the consumption of the stock of the final durable goods, α is the share of the durable goods in the consumption index and η is the elasticity of substitution between non-durable and durable goods.[8]

The problem of the borrower is set to maximize the following lifetime utility:

$$U \equiv E_t \left\{ \sum_{k=0}^{\infty} \beta^k \left(\log(S_{t+k}) - \frac{\varsigma}{1+\vartheta} N_{t+k}^{1+\vartheta} \right) \right\} \tag{2}$$

where β stands for the discount rate of the borrower, ϑ is the inverse elasticity of labor supply and ς is a scale parameter, determining the steady state value of labor supply.

[7] In fact, if borrowers were free to borrow at the market interest rate, they would exhibit a tendency to accumulate debt indefinitely, rendering the steady state of the model indeterminate. For further discussion, see Becker (1980).

[8] The case $\eta \to 0$ implies that non-durable and durable consumption are perfect complements, whereas the case $\eta \to \infty$ implies that two consumption components are perfect substitutes.

The utility maximization problem of the borrower is subject to the following budget constraint:

$$P_t^c C_t + P_t^d \left(D_t - (1-\delta)D_{t-1}\right) + R_{t-1}^l L_{t-1} = L_t + W_t N_t + T_t \tag{3}$$

In equation (3), P_t^c and P_t^d are the price of non-durables and durables respectively, L_t is the period t nominal debt, R_t^l is the nominal borrowing rate on loan contract. Moreover, W_t is the nominal wage, N_t is the amount of total labor supply and T_t is net of government transfers in period t. Lastly, δ represents the depreciation rate for the durable goods. Here, for simplicity, labor is assumed to be perfectly mobile across sectors.[9]

In real terms, the budget constraint of the borrowers can be represented as (in terms of non-durables):

$$C_t + q_t \left(D_t - (1-\delta)D_{t-1}\right) + \frac{R_{t-1}^l l_{t-1}}{\pi_t^c} = l_t + w_t N_t + t_t \tag{4}$$

where $q_t = \dfrac{P_t^d}{P_t^c}$ is the relative price of durable goods with respect to non-durable goods, l_t is the real debt of borrower in terms of non-durable goods, π_t^c denotes the gross inflation of non-durable at time t, and w_t denotes the real wage in terms of non-durable goods.

In this model, the borrower is also assumed to face a borrowing constraint, tied to the value of durable good stock:

---

[9] This implies a uniform nominal wage rate across the sectors.

$$L_t \leq (1-\psi) D_t P_t^d \tag{5}$$

where ψ is the fraction of the value of durable goods that cannot be used as a collateral. From a microeconomic point of view, ψ can be interpreted as the proportional cost of collateral repossession for banks given default (Gerali et al., 2009). In general, $1-\psi$ can be considered as loan-to-value ratio, a measure of the tightness of the credit market.[10]

In Monacelli (2009), it is shown that the collateral constraint is satisfied with equality around the steady state under heterogeneous discount rate assumption. Since we focus on small fluctuations around the steady state of the model; we assume that, in the neighborhood of the steady state, the constraint is always satisfied with equality.[11]

In real terms, the collateral constraint can be written as;

$$l_t = (1-\psi) D_t q_t \tag{6}$$

Then, the complete problem of the borrower is defined as to choose $\{N_t, l_t, D_t, C_t\}$ to maximize the lifetime utility function, (2), subject to the budget constraint, (4), and the collateral constraint, (6). The first order conditions of the problem are:

$$-\frac{U_t^n}{U_t^c} = w_t \tag{7}$$

[10] The existence of the collateral constraint can be justified by the limited enforcement problem. See Kiyotaki and Moore (1997) and Rampini and Viswanathan (2008) for the microfoundation of the collateral constraint. For other forms of collateral constraints, see and Kocherlakota (2000), Campbell and Hercowitz (2005), Iacoviello (2005), Calza et al. (2006) and Monacelli (2009).

[11] Therefore the standard local approximation techniques are applicable in order to analyze the equilibrium dynamics of the model.

$$U_t^c q_t = U_t^d + \beta(1-\delta)E_t\left\{U_{t+1}^c q_{t+1}\right\} + \lambda_t(1-\psi)q_t \tag{8}$$

$$U_t^c = \lambda_t + \beta E_t U_{t+1}^c \frac{R_t^l}{\pi_{t+1}^c} \tag{9}$$

where U_t^n, U_t^c and U_t^d represents marginal disutility of labor, marginal utility of non-durable consumption and marginal utility of durable consumption, respectively. λ_t stands for the multiplier for the collateral constraint.

Here, equation (7) shows the standard efficiency condition linking the marginal rate of substitution between consumption and labor supply to the real wage (in terms of non-durable good). Equation (8) is an intertemporal condition driving the choice between non-durable and durable goods, requiring the borrowers to equate the marginal utility of current non-durable consumption (left-hand side) to the marginal gain of durable consumption (right-hand side). The left-hand side of the equation (8) proposes three different types of gain from consuming durable goods: (i) the direct utility gain from consuming an additional unit of durable goods, U_t^d; (ii) the expected discounted utility from the possibility of increasing the future consumption by selling the remaining durable goods after depreciation, $\beta_b(1-\delta)E_t\left\{U_{t+1}^c q_{t+1}\right\}$; (iii) the marginal value from relaxing the collateral constraint, $\lambda_t(1-\psi)q_t$. The last term implies that, durable good plays a dual role for the borrowers; as collateral for loans and as an intrinsically valued good. Note that when collateral constraint is not binding, that is to say λ_t is zero, this last term disappears. On the other hand, when the borrowing constraint binds more tightly, that is to say λ_t gets higher values, the marginal value of relaxing the constraint becomes larger. The last condition, equation (9), is the *modified* version of Euler equation which reduces to a standard one when λ_t is zero.[12]

[12] There is also one additional problem of the borrower, namely; choosing the loan types among varieties. This problem will be introduced later in private banking sector part.

3.1.2 The Savers

This second category of households differs from borrowers in three ways: (i) the savers have higher patience rate, (ii) they are the owner of the monopolistic firms and banks and, (iii) for simplicity, they do not supply labor.

Under such assumptions, the problem of the savers can be described as maximizing a discounted lifetime utility given by:

$$E_t \left\{ \sum_{k=0}^{\infty} \gamma^k \log(\tilde{S}_t) \right\} \tag{10}$$

where γ is the discount rate of the savers ($\gamma > \beta$).[13] The budget constraint of the savers can be written as (in nominal terms);

$$P_t^c \tilde{C}_t + P_t^d \left(\tilde{D}_t - (1-\delta)\tilde{D}_{t-1} \right) + R_{t-1}^d \tilde{L}_{t-1} = \tilde{L}_t + \tilde{T}_t + \sum_j \tilde{\Gamma}_{j,t} \tag{11}$$

where $\tilde{C}_t$ is the non-durable consumption of savers, $\tilde{D}_t$ is the stock of the durable goods held by the savers, $\tilde{L}_t$ is the amount of deposits to the private banks, R_{t-1}^d is the deposit rate, $\tilde{T}_t$ is the net transfer from the government and lastly $\sum_j \tilde{\Gamma}_{j,t}$ is the nominal profit obtained from the monopolistic firms and banks.

Budget constraint in real terms become:

[13] The variables with $\sim$ refer to the variables of the savers.

$$\tilde{C}_t + q_t\left(\tilde{D}_t - (1-\delta)\tilde{D}_{t-1}\right) + \frac{R^d_{t-1}\tilde{l}_{t-1}}{\pi^c_t} = \tilde{l}_t + \tilde{t}_t + \sum_j \vartheta_{j,t} \qquad (12)$$

The problem of the representative saver is, then, to choose $\{\tilde{C}_t, \tilde{D}_t, \tilde{l}_t\}$ in order to maximize (10) subject to (12). The first order condition of this problem yields:

$$\tilde{U}^c_t = \gamma E_t\left\{\tilde{U}^c_{t+1}\frac{R^d_t}{\pi^c_{t+1}}\right\} \qquad (13)$$

$$\tilde{U}^c_t q_t = \tilde{U}^d_t + \gamma(1-\delta)E_t\left\{\tilde{U}^c_{t+1}q_{t+1}\right\} \qquad (14)$$

Equation (13) represents a standard Euler equation for the savers that relates current and future marginal utilities from non-durable consumption. Equation (14) shows the efficiency condition which equates the marginal utility of current non-durable consumption to the marginal benefit of durable goods. Equation (14) corresponds to the Equation (8) with no borrowing constraint.

3.2 Final Good Sectors

At time t, a final consumption good of sector $j \ (= c, d)$, Y^j_t, is produced by a representative perfectly competitive firm.[14] The final good firm does so by combining a continuum of differentiated intermediate goods produced by a continuum of monopolistically competitive intermediate firms for sector j, indexed by $i \in [0,1]$, using the technology defined as a Dixit-Stiglitz aggregator as in Dixit and Stiglitz (1977):

[14] Notice that Y^d_t refers to the increase in the durable goods stock after depreciation. In other words, it is the gross investment to the durable good sector. Therefore it should be considered as a flow variable.

$$Y_t^j = \left(\int_0^1 Y_t^j(i)^{\frac{\varepsilon_j - 1}{\varepsilon_j}} di \right)^{\frac{\varepsilon_j}{\varepsilon_j - 1}} \qquad j \equiv c, d \tag{15}$$

where $Y_t^j(i)$ defines the quantity demanded of a particular differentiated intermediate good i by final good producer j, and $\varepsilon_j > 1$ is the elasticity of substitution across intermediate varieties in sector j. Let P_t^j and $P_t^j(i)$ denote the time t price of the consumption good j and the price of the intermediate good i for sector j, respectively. Then, the profit maximization problem of the final good sector j is:

$$\max_{Y_t^j(i)} \left\{ P_t^j Y_t^j - \int_0^1 P_t^j(i) Y_t^j(i) di \right\} \tag{16}$$

subject to equation (15). The first order condition of the profit maximization problem yields the demand function for a typical intermediate good i in sector j, given by:

$$Y_t^j(i) = Y_t^j \left(\frac{P_t^j(i)}{P_t^j} \right)^{-\varepsilon_j} \tag{17}$$

According to equation (17), the demand for intermediate good i is a decreasing function of the relative price of that good and an increasing function of aggregate output of that sector, Y_t^j. Imposing the zero profit condition to the problem and substituting equation (17), the following relationship between the price of final good and the price of the intermediate good is obtained:

$$P_t^j \equiv \left(\int_0^1 P_t^j(i)^{1-\varepsilon_j} di \right)^{\frac{1}{1-\varepsilon_j}} \tag{18}$$

3.3 Intermediate Good Firms

Intermediate good i for sector j is assumed to be produced by a monopolist who uses the following linear production technology:

$$Y_t^j(i) = A_t^j N_t^j(i) \tag{19}$$

where A_t^j is the exogenous technology process following an autoregressive scheme[15] and common to all intermediate good firms in sector j, $N_t^j(i)$ denotes the time t labor supplied by the borrowers and used by intermediate good firm i in sector j.

Intermediate firms rent labor in a perfectly competitive factor market thus they take the wages as given. Profits are assumed to be distributed to the savers at the end of each period. Each firm i has monopolistic power in the production of its own variety and therefore has the power to set its price. Here we assume that, following Rotemberg (1982), each firm faces a quadratic cost of nominal price adjustment, measured in terms of the final good. The adjustment cost is given by:

$$\frac{\varsigma_j}{2} \left(\frac{P_t^j(i)}{\overline{\pi}^j P_{t-1}^j(i)} - 1 \right)^2 P_t^j Y_t^j \tag{20}$$

[15] It is given by

$$\exp(A_t^j) = \exp(A_t^j)^{\rho_{A^j}} \nu_t$$

with $\nu_t \approx i.i.d.$ and $0 < \rho_{A^j} < 1.$.

where $\varsigma_j \geq 0$ governs the size of the price adjustment cost in sector j and $\overline{\pi}^j \geq 1$ is the gross steady state inflation rate in sector j.[16] The higher the adjustment cost parameter, the more sluggish is the adjustment of nominal prices. In the special case where $\varsigma_j = 0$, the model collapses to a flexible price specification. Note that, the quadratic cost of price adjustment scheme makes the profit maximization problem of a intermediate good firm dynamic; instead of maximizing its profit period by period, it seek to maximize its total (discounted) life-time profit.

Given the equations (17), (18) and (19) and wage in the labor market, an intermediate firm chooses a sequence for $P_t^j(i)$ to maximize the expected sum of future discounted nominal profits:

$$E_t \sum_{k=0}^{\infty} \Theta_{t+k} \left[P_{t+k}^j(i) Y_{t+k}^j(i) - W_{t+k} N_{t+k}^j - \frac{\varsigma_j}{2} \left(\frac{P_{t+k}^j(i)}{P_{t-1+k}^j(i)} - 1 \right)^2 P_{t+k}^j Y_{t+k}^j \right] \tag{21}$$

where $\Theta_{t+k} = \gamma^k \frac{\tilde{\Xi}_{t+1+k}}{\tilde{\Xi}_{t+k}}$ is the stochastic discount factor of the savers[17] and $\tilde{\Xi}_t$ denotes the saver's marginal utility of nominal income.[18] Note that labor is flexible both across firms and across sectors, therefore the wage rate is common across firms and across sectors.

In a symmetric equilibrium, all intermediate good-producing firms in sector j make identical decisions. That is to say, the optimal price $P_t^j(i)^*$ is same for all firms in

[16] We assume that gross steady state inflation is equal to 1, therefore in the following analysis, the term $\overline{\pi}^j$ drops out from the equations.

[17] It is because of the assumption that all firms and private banks are owned by the savers.

[18] Marginal utility of nominal income corresponds to the lagrange multiplier of the nominal budget constraint in profit maximization problem of the savers.

sector j, $P_t^j(i)^* = P_t^j$, and all firms in sector employ the same amount of labor in each sector j. The first order condition of the profit maximization problem is:

$$(1-\varepsilon_j)+\varepsilon_j \frac{W_t}{P_t^j A_t^j} = \varsigma_j(\pi_t^j - 1)\pi_t^j - \varsigma_j E_t\left[\frac{\Theta_{t+1}}{\Theta_t}\frac{P_{t+1}^j}{P_t^j}\frac{Y_{t+1}^j}{Y_t^j}(\pi_{t+1}^j - 1)\pi_{t+1}^j\right] \qquad (22)$$

$$\frac{\Theta_{t+1}}{\Theta_t}\frac{P_{t+1}^j}{P_t^j} \equiv \gamma \frac{\tilde{U}_{t+1}^c}{\tilde{U}_t^c} \quad if \quad j = c \qquad (23)$$

$$\frac{\Theta_{t+1}}{\Theta_t}\frac{P_{t+1}^j}{P_t^j} \equiv \gamma \frac{\tilde{U}_{t+1}^c}{\tilde{U}_t^c}\frac{q_{t+1}}{q_t} \quad if \quad j = d \qquad (24)$$

By rearranging the terms in equation (22), one can obtain the standard pricing equation of the intermediate firms, so called New Keynesian Phillips curve (in non-linear form). In flexible price case, where $\varsigma_j = 0$, the pricing equation implies;

$$P_t^j = \frac{\varepsilon_j}{\varepsilon_j - 1}\frac{W_t}{A_t^j} \qquad (25)$$

Equation (25) proposes that, in flexible price case, pricing decision of a monopolistic firm is to put a constant mark-up, $\frac{\varepsilon_j}{\varepsilon_j - 1}$, over its marginal cost, $\frac{W_t}{A_t^j}$.

3.4 Private Banking Sector

The private banking sector consists of a continuum of monopolistically competitive small banks populated over [0,1] interval that handles the job of financing the borrower. In order to justify the existence of the monopoly power of each bank, we assume that; to obtain a total amount of loan L_t, the borrowers need to take a continuum of loans, $L_t(i)$, from all existing small banks, $\forall i \in [0,1]$ such that the following condition is satisfied;

$$L_t = \left(\int_0^1 L_t(i)^{\frac{\sigma-1}{\sigma}} di \right)^{\frac{\sigma}{\sigma-1}} \tag{26}$$

where $\sigma \geq 1$ is the elasticity of substitution between differentiated loan varieties in banking sector. Actually this type of modeling for banking sector is very similar to the one that we follow for the monopolistically competitive production sector. Although this assumption might seem unrealistic at an *individual level*, the resulting interest rate setting equation can be considered as a suitable representation of the *aggregate* behavior of the loan market.

Let $R_t^l(i)$ denotes the gross loan rate that is charged by bank i and R_t^l denotes the aggregate loan rate. Given equation (26), the borrowers choose their portfolio of loans so as to minimize the total cost of borrowing;

$$\min \int_0^1 R_t^l(i) L_t(i) di \tag{27}$$

This problem yields a downward-sloping demand curve faced by each bank;

$$L_t(i) = L_t \left(\frac{R_t^l(i)}{R_t^l} \right)^{-\sigma} \tag{28}$$

where the aggregate loan rate, R_t^l, corresponds to;

$$R_t^l = \left(\int_0^1 R_t^l(i)^{1-\sigma} di \right)^{\frac{1}{1-\sigma}} \tag{29}$$

3.4.1 The Problem of the Bank "*i*"

Each bank i accepts deposit from the savers and extends a differentiated loan to the borrowers by using a simple linear production function; one unit of deposit is converted into one unit of loan. In this model, saver's deposit constitutes the only source of funds for banks. Here we assume that the private banks are not required to hold excess reserves, therefore they grant all their funds as loans to the borrowers. Loan rate stickiness is introduced to the problem of the individual bank i by assuming that banks face nominal frictions in setting their loan rates similar to Calvo (1983) and Yun (1996). In this setup, only a random fraction of banks adjust their loan rate to a change in the deposit rate that determines the marginal costs of the banks while the remaining fraction leaves their loan rate unchanged, which implies that the adjustment of the aggregate loan rate is sticky. Thus, when private banks have the chance to reset their rates, they must take into account that the rates may be fixed for many periods.

Under the downward-sloping loan demand curve given by equation (28), the problem of the bank i is to maximize discounted future profits[19];

[19] Note that in profit maximization problem, the individual bank takes the aggregate loan rate, R_t^l and total loan demand, L_t, as given. This means that banking sector abstracts from any strategic interactions between banks since in this model, each bank cannot affect the loan market as a whole and takes the market-wide developments as given. For oligopolistic banking sector structure in a DSGE environment, see Cetorelli and Peretto (2000).

$$\max_{R_t^l(i)} E_t \sum_{s=0}^{\infty} \theta^s \Theta_{t+s} \left[\underbrace{R_t^l(i) L_{t+s}(i)}_{Total\ Revenue} - \underbrace{R_{t+s}^d L_{t+s}(i)}_{Total\ Cost} \right] \tag{30}$$

where θ is the probability of not resetting the loan rate, which is independent of the time elapsed since the last adjustment. In other words, θ shows the fraction of the banks at each period t that cannot change their loan rates. Therefore, the average duration of the loan rates is given by $(1-\theta)^{-1}$. As profits are redistributed to the savers at the end of the each period, Θ_t is used also in this problem as a stochastic discount factor. For simplicity, the deposit rate is assumed to be equal to the monetary policy rate due to the arbitrage conditions (Freixas and Rochet, 2006; Huelsewig et al, 2006).

The maximization of the intertemporal profit function, subject to the borrower's loan demand function, yields the following first order condition:

$$\sum_{s=0}^{\infty} \theta^s \Theta_{t+s} L_{t+s} (R_{t+s}^l)^{\sigma} \left[R_t^{l*}(i)^{-\sigma} - \frac{\sigma}{\sigma-1} R_t^{l*}(i)^{-\sigma-1} R_{t+s}^d \right] = 0 \tag{31}$$

where $R_t^{l*}(i)$ is the new loan rate set optimally. Equation (31) represents the optimal loan rate setting decision of the of the private bank i that can change its loan rate at time t. When $\theta = 0$, that is the flexible loan rate setting, equation (31) reads:

$$R_t^{l*}(i) = \frac{\sigma}{\sigma-1} R_t^d \tag{32}$$

Equation (32) implies that in the flexible case, the monopolistic private banks simply put a constant markup over the deposit rate while deciding on their loan rates.

The log-linearized version of the optimality condition given by equation (31) implies:

$$\hat{R}_t^{l*} = (1-\gamma\theta)\hat{R}_t + (1-\gamma\theta)\sum_{s=1}^{\infty}(\gamma\theta)^s \hat{R}_{t+s} \qquad (33)$$

The optimality condition implies that the newly set loan rate, $\hat{R}_t^{l*}$, depends on both current policy rate and the expected future policy rates. While the weight of the current policy rate is given by $(1-\gamma\theta)$, the weights on future policy rates sum up to $\gamma\theta$. Given that the long-term market rates can be represented as a function of the forward policy rates, as proposed by the standard asset pricing theory, the optimality condition suggests that changes in long-term market rates are taken into account in the loan rate setting decision, meaning that changes in the current policy rate may not fully reflected in the loan rate. Therefore this setting can be considered as a consistent framework with the explanation made by Bondt et al. (2005) regarding the sources of stickiness in loan rate adjustment.

Note that, under Calvo pricing scheme, the aggregate loan rate at time t given by equation (29) can be re-written as[20]:

$$R_t^l = \left[(1-\theta)R_t^{l*}(i)^{1-\sigma} + \theta\left(R_{t-1}^l\right)^{1-\sigma}\right]^{\frac{1}{1-\sigma}} \qquad (34)$$

After log-linearizing the equations (31) and (34), one can show that the aggregate loan rate follows a process which is similar to a New Keynesian Phillips curve:

[20] Note that since all private banks are assumed to be homogenous, all the private banks that have the oppurtunity to change their rates choose the same loan rate, $R_t^{l*}(i)$.

$$\hat{R}_t^l = \frac{(1-\theta)(1-\gamma\theta)}{1+\gamma\theta^2}\hat{R}_t^d + \frac{\theta}{1+\gamma\theta^2}\hat{R}_{t-1}^l + \frac{\gamma\theta}{1+\gamma\theta^2}\hat{R}_{t+1}^l \quad (35)$$

where the hatted variables represent the percentage deviations of the variables from their steady states. Equation (35) describes the aggregate interest rate setting behavior of the banking sector. In this setting, when all banks are allowed to set their rates optimally at each period, that is to say when $\theta = 0$, equation (35) implies *full pass-through* from the deposit rate (or monetary policy rate) to the loan rates, $\hat{R}_t^l = \hat{R}_t^d$. However, when $\theta > 0$, indicating that some fraction of the banks cannot change their loan rates at period t; the pricing equation of the banking sector implies that the aggregate loan rates adjust gradually as a response to a change in the deposit rate. That is to say, with positive calibration of θ, one can get incomplete pass-through of aggregate loan rate in the short run. Moreover, as θ takes higher values, the adjustment process of the loan rates becomes slower. The lag value of the loan rate at the right-hand side of the equation, $\hat{R}_{t-1}^l$, shows one of the important implications of the modeling feature in this model. The adjustment of the loan rates to a change in the deposit rate occurs with a lag as the banks do *not* revise their loan rates at each period. The same nature of the banking sector also proposes that while deciding on their loan rates, the banks also take into account the expectations on future financing conditions , which depend on the level of the deposit rate. By solving the equation (35) forward, it can be easily shown that while setting the loan rate, banking sector takes into account the expected future level of the deposit rates.

3.5 Central Bank

In this model, the central bank is assumed to respond systematically to the current inflation and sets its policy rate in every period by following simple Taylor rule:

$$R_t = R\left((\pi_t^c)^{1-\alpha}(\pi_t^d)^{\alpha}\right)^{\phi_\pi}\xi_t \tag{36}$$

where R_t is the gross nominal policy rate, R is the steady state level of nominal policy rate and ξ_t is the exogenous monetary policy shock which is assumed to evolve according to:

$$\exp(\xi_t) = \exp(\xi_{t-1})^{\rho}\mu_t \tag{37}$$

with $\mu_t \approx i.i.d.$ and $0 < \rho < 1$.

3.6 Market Clearing Conditions

To close the model, equilibrium in good market j requires that the production of the final good j be equal to the sum of total consumption and the cost associated with the adjustment of prices:

$$Y_t^c = C_t + \widetilde{C}_t + \frac{\varsigma_c}{2}\left(\pi_t^c - 1\right)^2 Y_t^c \tag{38}$$

$$Y_t^d = D_t - (1-\delta)D_{t-1} + \widetilde{D}_t - (1-\delta)\widetilde{D}_{t-1} + \frac{\varsigma_d}{2}\left(\pi_t^d - 1\right)^2 Y_t^d \tag{39}$$

Lastly, equilibrium in the labor market requires that labor supply should be equal to the total amount of labor demanded by the intermediate good firms:

$$N_t = \sum_j \sum_i N_t^j(i) \tag{40}$$

3.6 Equilibrium and Model Solution

Under plausible parameter calibration, which is introduced in the next chapter, the model has unique stationary equilibrium in which the representative borrower hits the collateral constraint and gets a positive amount of loan. Given the exogenous processes for A_t^j and ξ_t, the competitive allocation is given by the sequence for $\{C_t, \tilde{C}_t, D_t, \tilde{D}_t, N_t, L_t, \tilde{L}_t, q_t, \pi_t^c, \pi_t^d, w_t, R_t, R_t^l, \lambda_t\}$ satisfying the equations (4), (6), (9), (13), (14), (23)-(25), (35), (36), (38)-(40). As the first order conditions of the model are typically nonlinear, it is generally difficult to solve these types of models analytically. Therefore, following the standard practice in the literature, the model presented in this thesis is solved and analyzed by obtaining the first-order Taylor approximation of the non-linear equations around a stable steady state, which makes the analysis locally valid. The approximated model is, then, solved by using numerical computer algorithms.[21]

[21] To carry out the numerical procedure, the software called Dynare is used in this thesis. Dynare is a collection of Matlab and GNU Octave routines (freely available http://www.cepremap.cnrs.fr/dynare/) which basically solve, simulate and estimate the models with forward looking variables.

CHAPTER 4

THE QUANTITATIVE RESULTS

To assess the quantitative implications of introducing staggered loan contract mechanism, the model is solved and simulated under different shocks and the quantitative importance of the sluggish adjustment of the loan rates is examined by looking at the impulse-responses of the model. To this end, this chapter mainly focuses on an expansionary technology innovation to the non-durable sector, a contractionary monetary policy shock and a shock to the loan rates setting given by the equation (36). Before proceeding to the simulation results, the calibration that is employed in the quantitative analysis is introduced in the next section.

4.1 Calibration

In order to explore the quantitative implications of the model robustly, the model is calibrated on a quarterly basis. The calibration basically uses the standard values which are commonly employed in the literature[22]. Most of the parameter values are borrowed from Monacelli (2006), Iacoviello (2005) and Campbell and Hercowitz (2005). In this regard, the savers' subjective discount factor is taken as $\gamma = 0.99$, which produces an annual real interest rate on deposit of 4 percent. Following Iacovelli (2005), the discount rate for borrower is chosen as $\beta = 0.95$.[23] The inverse elasticity of labor supply, ϑ, is set equal to 1. The scale parameter for the disutility

---

[22] Note that, in this thesis, we do not focus on the implications of staggered loan contract mechanism for a specific country; therefore the model is not calibrated to any particular economy. In other words, the model that is calibrated in this thesis can be considered as representing a hypothetical economy.

[23] There are some other studies, such as Krusell and Smith (1998) and Campbell and Hercowitz (2005), which use higher discount rate for the borrowers. Since in this model the lending rate is higher than the deposit rate, we choose a lower discount rate for the borrowers to ensure that the collateral constraint is always binding around steady state.

from working for the borrowers, ς, is calibrated such that the steady state level of hours worked is equal to 1/3. The depreciation rate for the durable goods is assumed to be set at $\delta = 0.025$. Following Monacelli (2006), the parameter that affects tightness of the credit market, ψ, is set to be 0.25. The share of durable consumption in the aggregate spending index, α, is calibrated in such a way that, the steady state share of durable consumption spending in total consumption spending, becomes 0.2. The elasticity of substitution between varieties in both durable sector and non-durable sector ε_j is set equal to 8, which yields a steady state mark-up of about 15%. We set the elasticity of substitution between durable and non-durable consumption equal to $\eta = 1$, implying a Cobb-Douglas specification of the consumption aggregator. The parameter which determines the cost of changing price for non-durable sector is set in a way that, given the value of ε_c, the implied slope of the log-linearized Phillips curve takes the same value with the one in Gali and Gertler (1999). Regarding the durable goods, Bils and Klenow (2004) document that prices of durable goods are generally more flexible than those of non-durable goods. Therefore, following Iacoviello (2005) and Monacelli (2009), we assume that durable good prices are flexible. Note that the results, however, do not hinge on this assumption. Regarding the monetary policy, the policy parameters in Taylor rule are set as $\phi_\pi = 2$ to satisfy determinacy. For the banking sector parameter, no estimates for the stickiness of the loan rate, θ, is available in the literature. Therefore, in order to show how the existence of monopolistic banking sector with staggered loan setting affects the transmission of various shocks in the economy, we simply assume two cases for the stickiness parameter in the banking sector. In the first case, θ is set to zero, implying a standard model with no stickiness in the loan setting. In the second case, $\theta = 0.5$, implying that the average duration of the loan rate is two quarters. Table 1 summarizes the parameter values that is used in the baseline calibration.

4.2 Technology Shock to Non-durable Sector

We assume an unexpected 1% positive technology shock to non-durable sector. Figure 1 shows the simulation outcomes under two different calibration of private bank stickiness parameter. Following the technology shock, the firms in the non-durable sector become more productive so they tend to increase their production. On the other hand, since the marginal cost of producing non-durable good decreases due to the increase in the productivity, we also observe a decrease in the non-durable prices. The extra profit earned under monopolistic competition which is distributed to the savers allows the savers to expand their non-durable consumption. Moreover, the increase in the real wages and the amount of loan obtained from the banking sector enable the borrowers to enjoy more consumption and leisure. Under this situation, due to the wealth effect, demand for durable good also increases. Therefore we observe an increase in both output and prices of durable good. As a response to decrease in the prices of non-durables, nominal policy rate and loan rate decreases but the real rates ($R_t^l - \pi_{t+1}^c$) remain higher so as to restore the equilibrium.

However, once the sticky loan rate mechanism is introduced, the transmission of the shock is affected significantly. Under flexible loan rates, as the policy rate starts to decrease, loan rate decreases even more in absolute value due to the constant mark-up, which creates a strong incentive to expand the loan demand. Therefore we observe an increase in the level of loan used by the borrowers. This is another source of fund for the borrowers to expand the consumption of both type of goods. However, under sticky loan rates, even if we observe a decrease in the policy rate, the loan rate which is relevant rate for the decision of the borrowers does not decrease much. This implies a higher cost of obtaining loans. Thus the level of loan extended to the borrowers is smaller compared to the flexible case. Due to the smaller amount of loan, the increase in the borrowers' consumption of both durables and non-durables becomes smaller. However, the remaining funds which is not used by the borrowers as loan create an increase in the consumption of savers on durables and non-durables due to the general equilibrium effect.[24]

Note that the introduction of sticky loan rates affects also the whole path of the policy rate. Given the specification of the Taylor rule, the Central Bank needs to decrease its policy rate more compared to flexible case, since the transmission from the policy rate to the loan rate is not complete in the short run under sticky loan rate assumption. That is to say, the central bank should response more aggressively to the technology shock in order to set the inflation on target.

4.3 Monetary Policy Shock

In this section, the transmission of a contractionary monetary policy shock is discussed by looking at the impulse responses under sticky and flexible loan rates. Here we assume an unexpected 1% positive policy rate shock. Figure 2 shows the impulse-responses of selected variables under both cases. Under both cases, the transmission of the shock shows similar qualitative properties. Basically, an unexpected increase in policy rates (deposit rates) leads to an increase in the loan rates with a complete pass-through under flexible rates and with a imperfect pass-through under stick loan rates. In both cases, this increase induces the borrowers to postpone their current consumption of both type of goods. The decrease in the current consumption of the borrowers is further intensified by the presence of the financial accelerator effect induced by the collateral constraint. On impact, the rise in the interest rates reduces real value of durable stock due to the decrease in the relative price of durable goods and this causes banks to cut the amount of loans they are willing to supply to the borrowers. Moreover, the increase in loan rates directly increases the cost of borrowing. Overall, all of these channels lead to a decrease in the amount of loan used by the borrowers, which exacerbates the decrease in the consumption. Regarding the savers, they also tend to postpone their consumption and

[24] Note that in this model, the only instrument that enables the savers to postpone their consumption is to deposit their savings on private banks.

increase their savings due to the rise in the interest rate. However in equilibrium, due to these channels, the amount of loan used by the borrowers through the banking sector decreases. Therefore the remaining funds which are not extended as loans to the borrowers have to be used by the saver in consumption. The overall effect is, then, an increase in the savers' consumption of both durables and non-durables.

When the sticky loan rate is introduced into the model, what we observe, compared to the flexible case, on impact is that the new mechanism basically moderates the reaction of the variables to the monetary policy shock. As seen from the impulse responses, the Calvo pricing scheme used in the loan rate decision problem of the banks prevents them to fully reflect the exogenous increase in the policy rate to the loan rate. The smaller increase in the loan rate results in a smaller reduction in the loan demand. This means that while the borrowers now have higher amount of funds to finance their current consumption, the savers decrease their current consumption and have deposit on banking sector by a greater amount. Note that the modification of the model creates a significant incentive to purchase durable goods for the borrowers and changes the response of durable good consumption qualitatively since smaller increase in the loan rates is enough to create higher user value of durable goods by relaxing the collateral constraint. Therefore under sticky adjustment of loan rate mechanism, the whole dynamics of the model is modified in a way that the responses of the all variables to the monetary policy shock which is accelerated by the presence of collateral constraint are suppressed and we obtain smaller reductions the consumption of the borrowers.

4.4 Loan Rate Shock

We finally focus on the effects of an unexpected 1% positive shock to the loan rate setting behavior of the private banking sector implied by the equation (35). The responses of the selected variables to the shock are reported in Figure 3. This shock can be interpreted as a change in the bank's lending attitude towards the borrowers, which manifests itself as an exogenous change in the lending spread, or as a change in the competitiveness of the banking sector driven by the parameter σ.[25] Note that, this shock represents an exogenous change in the interest rate which is not driven by the monetary authority but takes its source solely from the private banking sector. That is to say, from a policy analysis point of view, the framework introduced in this thesis enables us to consider a pure monetary policy shock and a loan rate shock separately, which have different origins but both yields an exogenous increase in the interest rates.

The responses reveal that the introduction of sticky rates alters the transmission of the shocks in a very significant way; under stick loan rates, we observe very persistence behavior of the real and nominal variables as response to the loan rate shock. As mentioned before, the shock basically produces an exogenous increase in the spread between policy rate and loan rate, resulting in an increase in the loan rates. As a reaction to this, the borrowers immediately cut their amount of loans which is used to finance their consumption of durables and non-durables. Overall, the shock leads to a reduction in the consumption of borrowers on both type of goods, as well as in the non-durable consumption. Due to the shortening in demand, we also observe a decrease in the price of both goods. As a response to this, the monetary authority decreases its policy rate, which helps the loan rate to come back to its steady state value and restore the equilibrium. On the other hand the amount of deposit demanded by the private banking sector also decreases, consistent with the decrease in the amount of loan. Coupled with the increase the profits of the banking sector due to the increase in the interest rate spread, this leaves the savers with extra funds, yielding an increase in the savers' consumption of both goods.

Notice that as the sticky adjustment of the loan rates is taken into account, the shock process leads to very persistent movements in all variables; although the direction of the responses are the same under two alternative calibrations of the banking sector, under sticky loan rates their magnitudes becomes greater and it takes much more time to return to their steady states. Following the introduction of sticky loan rates

[25] This is very similar to the cost-push shock interpretation analogous to the framework in Smets and Wouters (2003).

mechanism, a given level of shock has a greater and more persistent effect on the loan rate due to its internal sticky adjustment process. Thus the path of the loan rate under sticky rates mechanism becomes higher, which affects the dynamics of all other variable significantly. Higher and persistent loan rates result in greater and persistent decreases in the amount of loan and the consumption of borrowers. One can also see the greater decreases in the production of non-durable goods and its prices. In this environment, the Central Bank needs to respond more aggressively to this shock and reduce its policy rate in a very persistent manner. Overall, even though both model economies are hit by the same shock, the one with sticky rates produces an internal propagation mechanism which renders the effects of the loan rate shock amplified and long lasting.

CHAPTER 5

CONCLUSION

The standard models of monetary transmission employed in both academic literature and central banks generally assume no role for financial intermediation and a single interest rate set by the central bank to exist in the economy. However, in actual economies, we observe different interest rates relevant for different decisions. Moreover, these benchmark models lack the realism that financial intermediaries determine the rates charged on loans as profit maximizing agents. In this thesis, we introduce monopolistically competitive banking sector into a New Keynesian model in order to recognize the spread between different interest rates, namely the loan rate and the policy rate. This framework also enables the introduction of sluggish adjustment of the loan rates which is also consistent with the empirical evidence.

In the thesis, the implications of the existence of a loan rate setting-banking sector are analyzed by looking at the impulse-responses of the model under technology, monetary policy and the loan rate shocks. The simulation results show that the impulse responses of the variables under sticky loan rate differ significantly from those implied by the model with a flexible loan rate. In all cases, the sluggish behavior of the loan rate affects the amount of loan used by the borrowers significantly, which is the main reason that creates the differentials across the impulse responses of two models. Following the technology shock, the presence of staggered loan contract mechanism induces smaller reduction in the loan rate, which results in smaller amount of loan used by the borrowers compared to the flexible loan rate case. Moreover, stickiness in the loan rate implies a more aggressive decrease in the policy rate due to the decrease in the efficiency of the interest rate channel of monetary policy transmission with the introduction of staggered loan contract mechanism. Under a contractionary monetary policy shock, stickiness in the loan rate moderates the effects of the collateral constraints on variables and we observe smaller reductions the consumption of the borrowers. On the other hand, the introduction of staggered loan contract mechanism leads to very persistent movements in all variables following loan rate shock and produces an internal propagation mechanism that renders the effects of the shock amplified and long-lasting.

REFERENCES

Avouyi, S., Matheron, J., Feve, P. (2007) DSGE Models and Their Importance to Central Banks, *Quarterly Selection of Article, Banque de France,* No. 9.

Ball, L., Romer, D. (1990) Real rigidities and the non-neutrality of money, *Review of Economic Studies*, 57, 183-203.

Becker R. (1980) On the Long-Run Steady State in a Simple Dynamic Model of Equilibrium with Heterogeneous Agents, *Quarterly Journal of Economics*, Vol. 95, No 2, 375-382.

Berger, A. N., Udell, G. F. (1992) Some Evidence on the Empirical Significance of Credit Rationing, *Journal of Political Economy*, University of Chicago Press, vol. 100(5), 1047-77.

Bernanke, B. S., Gertler, M., Gilchrist, S. (1999) The Financial Accelerator in a Quantitative Business Cycle Framework, *Handbook of Macroeconomics, in: J. B. Taylor and M. Woodford (ed.)*, Edition 1, volume 1, chapter 21, 1341-1393.

Bils, M., Klenow, P. J. 2004 Some Evidence on the Importance of Sticky Prices, *Journal of Political Economy*, University of Chicago Press, vol. 112(5), 947-985.

Bondt, G., Mojon, B., Valla, N. (2005) Term Structure and the Sluggishness of Retail Bank Interest Rates in Euro Area Countries, *Working Paper Series 518, European Central Bank.*

Calza, A., Monacelli, T., Stracca, L. (2007) Mortgage Markets, Collateral Constraints, and Monetary Policy: Do Institutional Factors Matter?, *CEPR Discussion Papers*, 6231.

Calvo, G. (1983) Staggered Prices in a Utility Maximizing Framework, *Journal of Monetary Economics*, 12, 383-398.

Campbell, J. R., Hercowitz, Z. (2005) The Role of Collateralized Household Debt in Macroeconomic Stabilization, *NBER Working Papers,* 11330.

Carlstrom, C. T., Fuerst, T. S. (1997) Agency Costs, Net Worth, and Business Fluctuations: A Computable General Equilibrium Analysis. *The American Economic Review*, vol 87, 893-910

Cetorelli, N., Peretto, P. F. (2000) Oligopoly Banking and Capital Accumulation, *Working Paper Series, Federal Reserve Bank of Chicago*, 12.

Chari, V., Christiano, L., Kehoe, P. (1994) Optimal Fiscal policy in a Business Cycle Model, *Journal of Political Economy,* 102, 617–652.

Christiano, L. J., Eichenbaum, M., Evans, C. L. (2005) Nominal Rigidities and the Dynamic Effects of a Shock to Monetary Policy, *Journal of Political Economy,* 113, 1-45.

Christiano, L.,Motto, R. and Rostagno, M. (2007) Financial Factors in Business Cycle, mimeo.

Cowling, M. (2007) The Role of Loan Guarantee Schemes in Alleviating Credit Rationing in the UK, *MPRA Paper,* 1613, University Library of Munich, Germany.

Dixit, A. K., Stiglitz, J.E. 1977 Monopolistic Competition and Optimum Product Diversity, *American Economic Review*, vol. 67(3), 297-308.

Donnay, M., Degryse, H. (2001). Bank Lending Rate Pass-Through and Differences in the Transmission of a Single EMU Monetary Policy, *Center for Economic Studies, Discussion Papers*, 0117, Katholieke Universiteit Leuven.

Dotsey, M., King, R. G. (2001) Pricing, Production and Persistence, *NBER Working Paper,* 8407.

Espinosa-Vega, M. A., Rebucci, A. 2003 Retail Bank Interest Rate Pass-Through: Is Chile Atypical?, *Working Papers Central Bank of Chile,* 221, Central Bank of Chile.

Fair, R.C. (1992) The Cowles Commission Approach, Real Business Cycle Theories, and New Keynesian Economics, *Cowles Foundation Discussion Papers*, 1004, Cowles Foundation, Yale University.

Freixas, X., Rochet, J.C. (2008) *Microeconomics of Banking*, The MIT Press, edition 2, volume 1, number 0262062704.

Fried, Joel and Howitt, Peter, (1980) Credit Rationing and Implicit Contract Theory, *Journal of Money, Credit and Banking*, Blackwell Publishing, vol. 12(3), 471-87.

Gropp, R., Sørensen, C., Lichtenberger, J. D. (2007) The Dynamics of Bank Spreads and Financial Structure,*Working Paper Series, European Central Bank*, 714.

Hairault, J. O., Portier, F. (1993) Money, New-Keynesian Macroeconomics and the Business Cycle, *European Economic Review*, 37, 1533-1569.

Heideken, V. (2008) How Important are Financial Frictions in the U.S. and the Euro Area?, *Working Paper Series 223*, *Sveriges Riksbank (Central Bank of Sweden).*

Hofmann, B. (2004) Bank Lending and Property Prices: Some International Evidence, *Money Macro and Finance (MMF) Research Group Conference*, 2003 46, Money Macro and Finance Research Group.

Hülsewig, O., Mayer, E., Wollmershaeuser, T. (2006) Bank Behavior and the Cost Channel of Monetary Transmission, *CESifo Working Paper Series*, No. 1813.

Iacoviello, M. (2005) House Prices, Borrowing Constraints, and Monetary Policy in the Business Cycle, *American Economic Review*, vol. 95(3), 739-764.

Gali, J. (2008) *Monetary Policy, Inflation, and the Business Cycle*, Princeton University Press.

Gali, J., Gertler, M. (1999) Inflation Dynamics: a Structural Econometric Analysis", *Journal of Monetary Economics*, 44, 195-222.

Gambacorta, L. (2004) How Do Banks Set Interest Rates?, *NBER Working Papers*, 10295.

Gerali, A., Neri, S., Sessa, L., Signoretti, F. (2009) Credit and Bank in a DSGE Model of the Euro Area, *Banca d'Italia, Research Department*.

Goldfeld, S. M. (1966), Commercial Bank Behaviour and Economic Activity. Amsterdam. North Holland.

Guajardo, J. (2004) Financial Frictions and Business Cycles in Developing Countries, *Econometric Society 2004 Latin American Meetings*, 307, Econometric Society.

Keynes, J.,M. (1936) *The General Theory of Employment, Interest and Money*, Macmillan Cambridge University Press.

Kiyotaki, N., Moore, J. (1997) Credit Cycles, *Journal of Political Economy*, University of Chicago Press, vol 105(2), 211-48.

Kocherlakota, N. R. (2000) Creating Business Cycles through Credit Constraints, *Quarterly Review, Federal Reserve Bank of Minneapolis*, 2-10.

King, R. G., Wolman, A. L. (1996) Inflation Targeting in a St. Louis Model of the 21st Century", *Federal Reserve Bank of Saint-Louis Quarterly Review*, 78, 83-107.

Kremer, J., Lombardo, G., Thadden, L., Werner, T. (2006) Dynamic Stochastic General Equilibrium Models as a Tool for Policy Analysis, *CESifo Economic Studies, Oxford University Press*, vol. 52(4), 640-665.

Krusell, P., Smith, A. A. (1998) Income and Wealth Heterogeneity in the Macroeconomy, *Journal of Political Economy,* University of Chicago Press, vol 106(5), 867-896.

Mankiw, N. G., Romer, D. (1991) *New Keynesian Economics*, MIT Press; Cambridge, MA.

Mojon, B. (2000) Financial Structure and the Interest Rate Channel of ECB Monetary Policy, *Working Paper Series, European Central Bank,* 40.

Monacelli, T. (2006) New Keynesian Models, Durable Goods and Collateral Constraints, *CEPR Discussion Papers,* 5916.

Monacelli, T. (2009) New Keynesian Models, Durable goods, and Collateral Constraints, *Journal of Monetary Economics*, vol. 56(2), 242-254

Obstfeld, M., Rogoff, K. (1995), Exchange Rate Dynamics Redux, *Journal of Political Economy*, 103(3), 624–660.

Rampini, A.A., Viswanathan, S. (2008) Collateral, Financial Intermediation, and the Distribution of Debt Capacity, mimeo.

Rotemberg, J. J. (1982) A Monetary Equilibrium Model with Transactions Costs, *NBER Working Papers,* 0978.

Rotemberg, J., Woodford, M. (1997) An Optimization-Based Econometric Framework for the Evaluation of Monetary Policy, *NBER Macroeconomics Annual*, 297–346.

Sander, H., Kleimeier, S. (2006) Interest Rate Pass-Through in the Common Monetary Area of The Sacu Countries, *South African Journal of Economics*, vol. 74(2), 215-229.

Smets, F., Wouters, R. (2003) An Estimated Dynamic Stochastic General Equilibrium Model of the Euro Area, *Journal of the European Economic Association*, MIT Press, vol. 1(5), 1123-1175.

Sorensen, C., Werner, T. (2006) Bank Interest Rate Pass-through in the Euro Area: a Cross Country Comparison, *Working Paper Series, European Central Bank,* 580.

Yun, T. (1996) Nominal Price Rigidity, Money Supply Endogeneity and Business Cycles, *Journal of Monetary Economics*, 37, 175-391.

Woodford, M. (2003) *Interest and Prices: Foundations of a Theory of Monetary Policy*, Princeton University Press.

APPENDIX

Tables and Graphs

Table 1: Baseline Calibration

Parameter	***Definition***	***Value***
γ	Savers' subjective discount factor	0.99
β	Borrowers' subjective discount factor	0.95
δ	Depreciation rate	0.025
α	Share of durable consumption in the aggregate spending index	0.265
σ	Elasticity of substitution between loans	30
υ	Inverse elasticity of labour supply	1
ψ	Tightness of the credit market	0.25
ε_j	Elasticity of substitution between varieties	8
η	Elasticity of substitution between durable and non-durable	1
ς	Disutility from working for borrowers	6
ς_c	Adjustment cost for non-durable	75
ς_d	Adjustment cost for durable	0
φ_π	Coefficient of inflation in Taylor rule	2

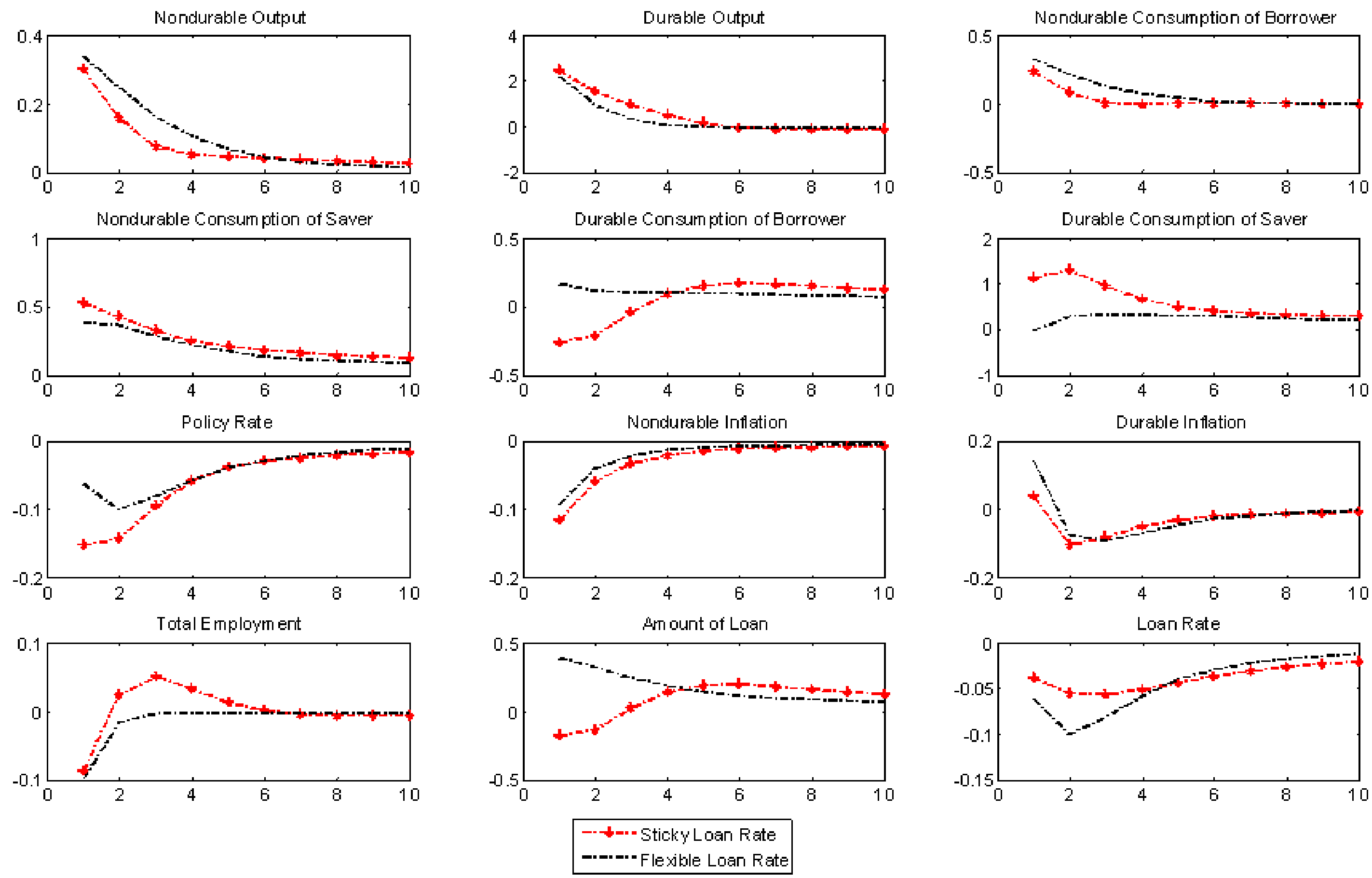

Figure 1: Impulse responses following a positive technology shock to non-durables (percentage deviations from steady state).

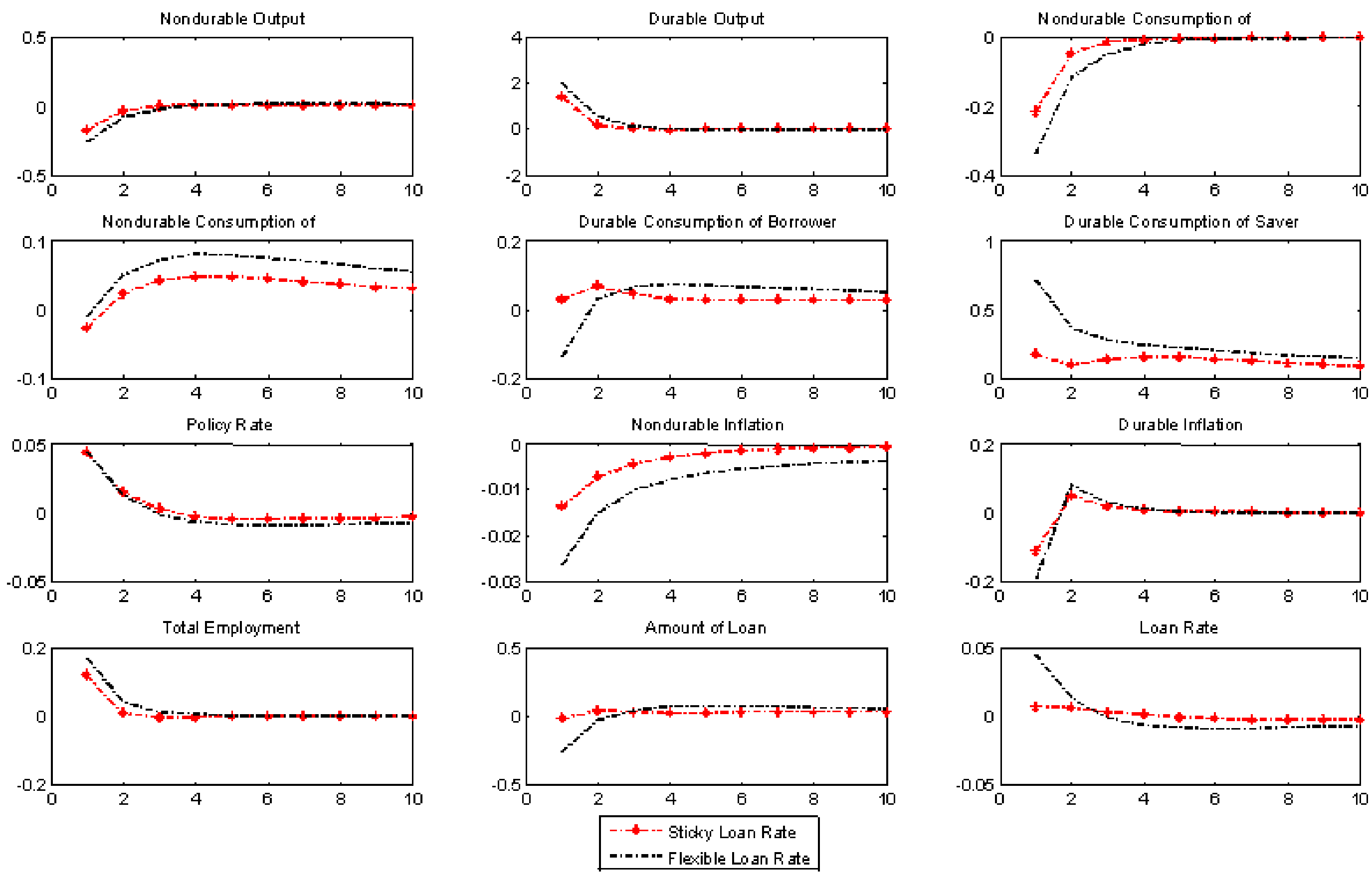

Figure 2: Impulse responses following a contradictory monetary policy shock (percentage deviations from steady state).

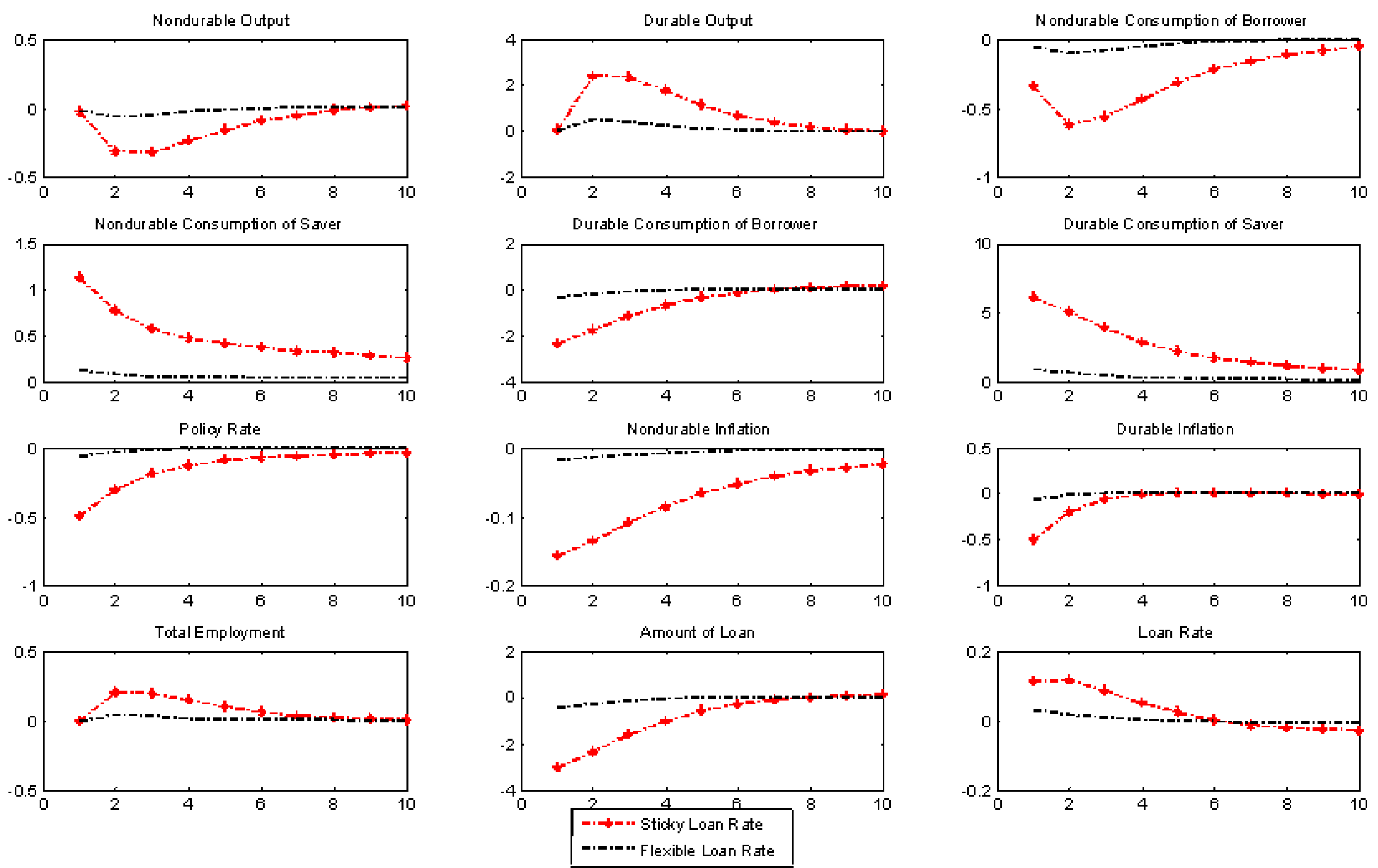

Figure 3: Impulse responses following a positive loan rate shock (percentage deviations from steady state).