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Doctoral Thesis

ESSAYS ON INFORMAL CREDIT INTERMEDIATION AND MONETARY POLICY EFFECTIVENESS

Richard K. Ayisi
Candidate

Prof. Alessandro Flamini
Supervisor

Declaration

I hereby declare that this thesis submitted to the Department in partial fulfillment of the requirement for the award of the degree of Doctorate in Economics, is a record of original work carried out by me under the supervision of Prof. Alessandro Flamini. Appropriate credit has been given where references were made to other works.

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Richard K. Ayisi

Dedication

To my parents - Emmanuel and Agnes Kwabi ...
... my lovely Siblings...
... and my adorable wife - Ama

Acknowledgment

I would like to express my deepest appreciation to all those who provided me the possibility to complete my PhD program. A special gratitude I give to my supervisor, Prof. Alessandro Flamini, who used his worth of knowledge to shape and guide my thesis through his contribution in stimulating suggestions and encouragement.

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Summary

This thesis presents two distinct essays on informal credit intermediation in developing economies and its implication for the conduct of monetary policy. Broadly, the study investigated the implication of informal credit intermediation on effective monetary policy. Available data reveal that informal credit intermediation has increased over the period. The IMF Financial Stability Board (2014) report revealed that the volume of financial intermediation via the non-bank sector in several economies has been increasing over the past decades. The report estimated informal intermediation to be about 40 per cent of total bank intermediation in the world. Notwithstanding the growth of the informal financial sector in most economies, the literature is salient on their role in monetary transmission. Therefore, this topic has become most relevant in the literature and for policymakers to understand the role played by these financial intermediaries in transmitting monetary impulses to the real sector.

The first chapter presented a brief review of relevant literature on monetary effectiveness in developing economies. The chapter further presented the financial structure of Ghana and discussed its implication for monetary transmission.

The second chapter empirically investigated the effect of informal credit intermediation on monetary transmission process in Ghana. Given the growth of informal credit activities in Ghana coupled with their interrelationship with the traditional banking system, their operations could have some direct or indirect effect on monetary policy. Particularly because, informal credit institutions are seen to operate similar to the traditional (formal) banks, even though their operations are not fully regulated by the central bank like traditional banks. The study employed a Factor Augmented Vector Auto-regression modeling approach and found that though interest rate pass-through is very weak, the presence of informal credit intermediation further dampens it. This suggests that informal credit intermediation contributes to the less effective monetary policy evident in Ghana.

The third chapter set-up a Dynamic Stochastic General Equilibrium (DSGE) model to include formal and informal banks. In line with their operations, the formal bank is modeled to operate with the rich agents in the economy whiles the informal bank operates with the poor agents. The banks operate parallel with each other in the intermediation process except that the formal bank is regulated by

the central bank whiles the informal bank is not. This modeling strategy helped to identify the effect of monetary shocks in the presence of informal credit intermediation. Also, the study investigated how credit shock from both the informal and formal sector affect the aggregate economy. The study found that monetary shocks affect the formal financial sector differently from the informal sector. However, credit shock from the formal and informal sector has similar effect on the economy.

The thesis concluded by discussing further possible applications and extension.

Lists of Original Papers

1. Does Informal Credit Intermediation Influence Monetary Policy? Some Empirical Evidence for Ghana.

2. The Effect of Exogenous Shocks with Informal Credit Intermediation.

1 Background

1.1 Introduction

MONETARY policy, following the pioneer work of Friedman and Schwartz (1963), has remained an integral part of modern theoretical and empirical economic research. Particularly because, monetary policy remains the major tool used by government of various countries to achieve low inflation, favorable interest rate and exchange rate, and sustained economic growth.

The financial sector forms an integral part in the conduct of monetary policy. Particularly because, financial institutions mediate in monetary implementation strategy by transmitting monetary impulses to the real economy. This role is founded on the robust positive relationship between long-term movement in broad money growth and its association with risks to price stability which borders enormously on banks' behavior. Therefore, the behavior of financial institutions- particularly the banks, are instrumental in the conduct of effective monetary policy.

The financial sector of most economies especially that of developing countries are characterized by large informal credit activities. There are evidences of formal financial institutions co-existing with large informal financial institutions in African, Asia and other part of the world. Studies show that the informal financial sector is large and growing (Chipeta & Mkandawire, 1991; African development report, 1994; Aryeetey, 1994; Chipeta, 1998). The pace of growth of the informal sector even outweighs that of the formal sector. This is established by field surveys carried out in Malawi by Chipeta and Mkandawire (1991), in Ghana by Aryeetey (1994), and in Nigeria by Soyibo (1997). The growth in size of the informal credit sector is also reflected in the share of total credit intermediation. In recent times, the IMF Financial Stability Board (2014) report estimated the size of the global shadow banking system to be about 40 percent of the total financial system. Although data is sparse, anecdotal evidences suggest similar trend in Ghana. For example, the amount of loans extended by Non-Bank Financial Institutions (NBFIs) increased from GHc70.63 million in 2003 to GHc72.85 million in 2004, suggesting 3.1 percent growth. In 2006, a total of GHc160.47 million was extended to clients, which represents 48.8 percent higher than the previous year's total loans and advances granted by these micro-finance institutions. The upward-trend of NBFI's credits to individuals, small businesses, groups and others indicate

marked improvements in the level of micro-finance and the gradual growth in total financial assets in the country. Overall, figures from Bank of Ghana indicate that the share of micro-finance loans and advances as a percentage of total assets of banks and NBFI loans and advances has increased from 4.8 percent in 2008 to 9.8 percent in 2013.

The share and size of informal credit, and their interaction with the formal sector, may cause the response of formal sector to policy to be non-trivial, with the consequent effect on economic activities not obviously determined. The response may vary depending on whether the informal financial sector is autonomous or reactive to the formal sector (Rahman, 1992, 1994); whether the two sectors exist as complementary or competitive; and whether the nature of their interaction frustrates or strengthens monetary policy. Unfortunately, the literature is salient on the role of informal finance in the monetary transmission process. Questions that remain unanswered include: does informal credit mar or ease monetary transmission? Does the existence of informal credit affects the trajectory of shocks in an economy? This thesis contributes to the literature by investigating these questions.

The term informal credit is used in this thesis to refer to financial activities of deposit and non-deposit taking institutions that mobilize and lend financial resources, that take place outside universal banking, and are not directly amenable to the required reserve regulation of the central bank of Ghana. Encompassed in this definition are Non-Bank Financial Institutions (NBFIs), Rural and Community Banks (RCB), rotating savings and credit associations (ROSCAs), micro-finance institutions, among others.

The thesis is structured in three chapters, each tackling relevant portion of the questions raised above. This chapter one reviews the literature on monetary transmission and describes the financial structure of Ghana by presenting the interactions among the financial institutions that provides the foundation for this study. Chapter two empirically investigates factors that influence monetary effectiveness and identify the effect of informal credit intermediation on monetary transmission. Chapter three studies the effect of exogenous shocks in an economy with informal credit intermediation using a Dynamic Stochastic General Equilibrium (DSGE) framework.

The rest of this chapter is structured as follows: Section 1.2 briefly reviews some literature on monetary policy effectiveness. Section 1.3 presents the financial structure of Ghana and discuss its implication for the conduct of effective monetary policy in Ghana.

1.2 Literature Review

Monetary policy all over the world is conducted using an indirect approach. In the indirect framework, monetary authorities through their influence on money market conditions as the issuer of reserve money (currency in circulation and deposit balances with the central bank) adjust the underlying supply conditions of bank reserves to affect a desired outcome. In this regards, policy effectiveness requires that the link between monetary policy instrument and its target, i.e. the transmission mechanism, should be smooth. Monetary transmission, which is also referred as the pass-through, is the quantitative measure of monetary authorities actions on their policy target. There are five channels of monetary transmission, which include the exchange rate, assets effect, credit, expectation, and interest rate channels. Which channel is the most important depends on the economy under consideration, since the literature is inconclusive on the channel that is most effective in transmitting monetary impulses.

Notwithstanding this, there is an upsurge interest in the interest rate channel since most central banks across the globe use price-related anchor for conducting monetary policy. Interest rate pass-through is generally defined as, the extent to which either changes in central bank policy interest rates or money market interest rates or both are reflected in changes in commercial banks' interest rates, in both the short-run and the long run. From the definition, there are two stages of interest rate pass-through. The first stage describes how changes in the monetary policy rate is transmitted to short and long term market rates, while the second stage measures how changes in the market rates influence bank lending and deposit rates. Based on this, the literature distinguishes between the "cost of funds approach" and "monetary policy approach" as two distinct stages of interest rate-pass-through. Nonetheless, the second stage is largely influenced by the stability of the yield curve, which makes it possible to take a shortcut by looking directly at the relationship between policy rates and retail (deposit and loan) rates i.e. focusing on how changes in policy rates affect retail interest rates.

The empirical literature on interest rate pass-through has grown enormously with focus on both developed and developing economies. These studies have tried to estimate the pass-through to identify the effectiveness of monetary policy. The common aim shared by these studies include among others, identifying the channel which is most effective for monetary policy by discovering the degree and speed of adjustment of policy target to changes in policy rate.

The studies on monetary effectiveness can be categorized into country specific or cross-country analysis. Cross-country analyses try to understand interest rate transmission by relating possible variations to institutional framework or structural breaks. In addition to examining the degree of adjustment of bank interest rate

in response to changes in monetary policy rate, some studies also explored the possibility of asymmetric adjustment in the market rates.

The empirical studies on pass-through differ from one another based on the choice of policy rate proxy used, the econometric approach adopted and the time coverage of the studies. Methodologically, Vector Auto-regression (VAR) modeling technique has been the main approach adopted by researchers to estimates pass-through (Cottarelli & Kourelis, 1994; Borio & Fritz, 1995; Cottarelli et al., 1995). Recently however, studies are regularly based on Auto-Regressive Distributed Lag (ARDL) model or on error correction model (Mojon, 2000; Aziakpono & Wilson, 2010; Samba & Yan, 2009). Irrespective of the approach used, the context and time span, studies on pass-through concluded that

- The transmission of monetary impulses from policy rate to intermediate and final targets are incomplete.
- There exists substantial heterogeneity in the pass-through mechanism across countries and across bank products.

For example, Kwapil et al. (2009) found the long run pass-through to be lower in the Euro area than the United States. Analyzing data from January 1995 to September 2003 for various deposit and lending rates, they observed that most categories of deposit rates were nearly complete (i.e. one-to-one) in the United States whereas that of the Euro area range between 0.32 and 0.58. This means that whiles policy change transmits proportionally to deposit rates in the United States, only between 32 and 58 per cent transmit to deposit rates in the Euro area. The long run pass-through to lending rates was also lower in the Euro area compared to the United States ranging between 0.48 and 0.73. The findings of the study show that whiles pass-through estimates are small, differences in magnitude exist among countries.

Various factors have been identified to be responsible for pass-through heterogeneity among countries. Cross-country studies identified differences in macroeconomic conditions and other country specific factors including financial structure, banking competition, monetary policy regime, extent of money market development and degree of development of the financial system among others as the cause of differences in pass-through among countries. Gropp et al. (2014) investigated the dynamics of pass-through between market interest rate and bank interest rate in the Euro area as a function of cyclical and structural difference in the financial system using panel econometric approach including bank and market rates for the individual Euro area countries. Their results show that the overall speed of adjustment for loans is significantly faster than that of deposit, and as such, the pass-through is especially sluggish for demand deposit and savings deposit. Bank soundness, credit risk, and interest rate risk exert significant influence on the speed

of pass-through. Exploring the possibility of asymmetry adjustment in the pass-through process, the result suggests asymmetry in the pass-through process, as banks tend to adjust loan rates quicker to changes in policy rates when rates are going up than when they are going down- and vice versa for deposit rates.

The literature on pass-through in emerging economies seems to confirm results of incomplete pass-through in advanced economies. Samba and Yan (2009) examined the monetary transmission mechanism in the countries of the Central Africa Economic and Monetary Community (CAEMC) focusing on the interest rates pass-through from short-term interest rates towards long-term rates. The study employed an autoregressive distribute lag (ARDL) model in a panel setting and found a very low and incomplete long run pass-through from the policy rate to deposit rate. The study also found evidence of overshooting effect of lending rate reaction to changes in the policy rate. The findings of this study conforms with others such as Aziakpono and Wilson (2010) which found very low pass-through signaling weak monetary transmission among developing countries.

The weak monetary policy identified among developing countries are attributed to various institutional reasons. Mishra and Montiel (2013), took a stock of systematic evidence on the effectiveness of monetary transmission in developing countries to determine the extent a central bank action affects aggregate demand. In the paper, they sought to determine whether the evidence of ineffective monetary policy is based on methodological deficiencies. The study concluded that a wide range of empirical approaches have failed to yield evidence of effective monetary transmission in developing countries, and that the strongest evidence for effective monetary transmission has arisen for relatively prosperous and more institutionally developed countries such as some central and Eastern European transition economies (at least in the later stages of their transition).

From the literature surveyed thus far, we showed that interest rate pass-through are sticky with evidences of cross-country differences and within country variations over time. The differences in pass-through estimate are as result of the differences that exist in the economic structure pertaining to a country's financial system. Although, the literature have showed that different financial market characteristics[1] do influence pass-through, the evidence that informal credit activities affect pass-through rarely exist. The only notable study is by Ngalawa and Viegi (2013)[2]. Ngalawa and Viegi (2013) investigated the interaction of formal and informal financial markets and their impact on economic activity in quasi-emerging market economies. Using a DSGE model, the study showed that interest rates in the formal and informal financial sectors do not always change together in the same

[1] see for example Gropp et al. (2014).

[2] From the literature surveyed on determinant on pass-through and monetary transmission, no study is found on informal credit activities on monetary effectiveness.

direction to a response to policy. The study demonstrated that in some instances, interest rates in the two sectors change in diametrically opposed directions with the implication that the informal financial sector may frustrate monetary policy, the extent of which depends on the size of the informal financial sector. Thus, the larger the size of the informal financial sector the lower the likely impact of monetary policy on economic activity. The findings from this study suggest that informal credit activities may frustrate monetary transmission. However, from the literature surveyed on determinant on pass-through and monetary transmission, no study is found on informal credit activities on monetary effectiveness. Therefore, this thesis contributes to the literature in this regards by empirically investigating the effect of informal credit activities on monetary transmission.

In conclusion, the literature has identified several factors that could influence interest rate pass-through. These factors are country specific that vary from country to country. The notable factors are associated with the financial environment of the country, which changes overtime. One such financial development worth investigating is the recent upsurge of informal credit intermediation in developing economies. This thesis therefore investigates monetary effectiveness by identifying the potential effect of informal credit intermediation on monetary effectiveness. In the section that follows, the study presents the structure of the Ghanaian banking system and its implication for the role of banks in monetary transmission.

1.3 The Structure of the Ghanaian Banking System and its Implication for the Role of Banks in Monetary Transmission

Monetary policy effectiveness depends significantly on the idiosyncratic and institutional environment in which monetary policy is conducted. Paramount among these features is the structure of the banking system which is pivotal in conducting monetary policy. Therefore, in assessing the empirical effectiveness of monetary policy in any country, it is important to comprehend the institutional environment surrounding the implementation of monetary policy. To put the objective of this study in perspective, this section briefly reviews the banking sector to show the interrelations between the formal and informal financial sector.

1.3.1 The Structure of the Banking Industry

The central bank of Ghana categorizes the banking institutions into deposit taking and non-deposit taking institutions. The deposit taking institution are financial institutions that are allowed to both collect deposits in the form of savings from

surplus spending agents and similarly advance credit facilities to deficit spending agents in the economy. This category of institutions includes the universal banks (commercial banks), non-bank financial institutions (NBFIs), rural and community banks (RCBs), and savings and loans companies, and some micro-finance institutions.

The non-deposit taking institutions do not have the privilege to accumulate deposit from surplus spending agents, rather they only provide financial services that extends credit facilities to deficit spending agents in the economy. This institutional category includes the finance houses, leasing companies, forex bureau, credit bureau and some micro-finance institution. Figure 1.1 shows the pictorial representation of the structure of the financial sector of Ghana.

In Ghana, financial services are provided in a formal or informal ways. In the formal way, financial services are provided through the universal (commercial) banking activities. This categorizes the universal banking activities as the formal sector. On the other hand, the micro-financing institutions provide financial services informally in the economy, hence constituting the informal sector. The micro-finance is further categorized into formal, semi-formal and informal. The formal sector comprises of Rural Banks, Savings and Loan (S&L) companies and Credit Unions. Rural Banks are public companies owned by communities (with capitalization assistance from the BOG), registered and licensed as unit banks. They, however, do not have branching privileges under the provisions of the Banking Law. Their operations are also limited to a well-defined geographical (rural) area and are permitted to offer banking services limited to loans and to chequeing, savings and time deposits.

The savings and loans Companies are registered and licensed under the NBFI Law and are permitted to offer banking services limited to loans, savings and time deposits and unlike the Rural Banks, they have branching privileges.

The informal sector is mainly made of money lenders and Susu collectors[3]. The susu collectors provide safekeeping services for the savings collected and they are not allowed to provide loan services from the money collected. However, clients are able to access “loans” from their own Susu collectors in the form of "advance draw-downs" against the total amount of savings they have contracted to deposit weekly for a set period. In most cases, these advances have been made possible by commercial and development banks, rural banks, and S&L companies with

[3]Susu means savings collection and is a system that offers products to help clients accumulate their own savings over periods ranging from a month to two years. Susu is collected in the form of clubs or cooperative scheme. The clubs are smaller units engaging in funds mobilization. The cooperative susu collectors, through regulations have incorporated susu methodology into formal financial institution. The co-operative association was formed and registered under co-operative societies degree, 1968 (NLCD 252) with the name Ghana Cooperative Susu Collectors Association (GCSCA)

which the Susu collectors deposit the saving funds they collect and manage. The Susu collectors help mobilize the savings for the clients and form an integral part of the financial system in Ghana. Money-lenders, rotating savings and credit associations (ROSCAs) and accumulating savings and credit associations (ASCAs) also constitute the informal segment of the market for micro-finance in Ghana.

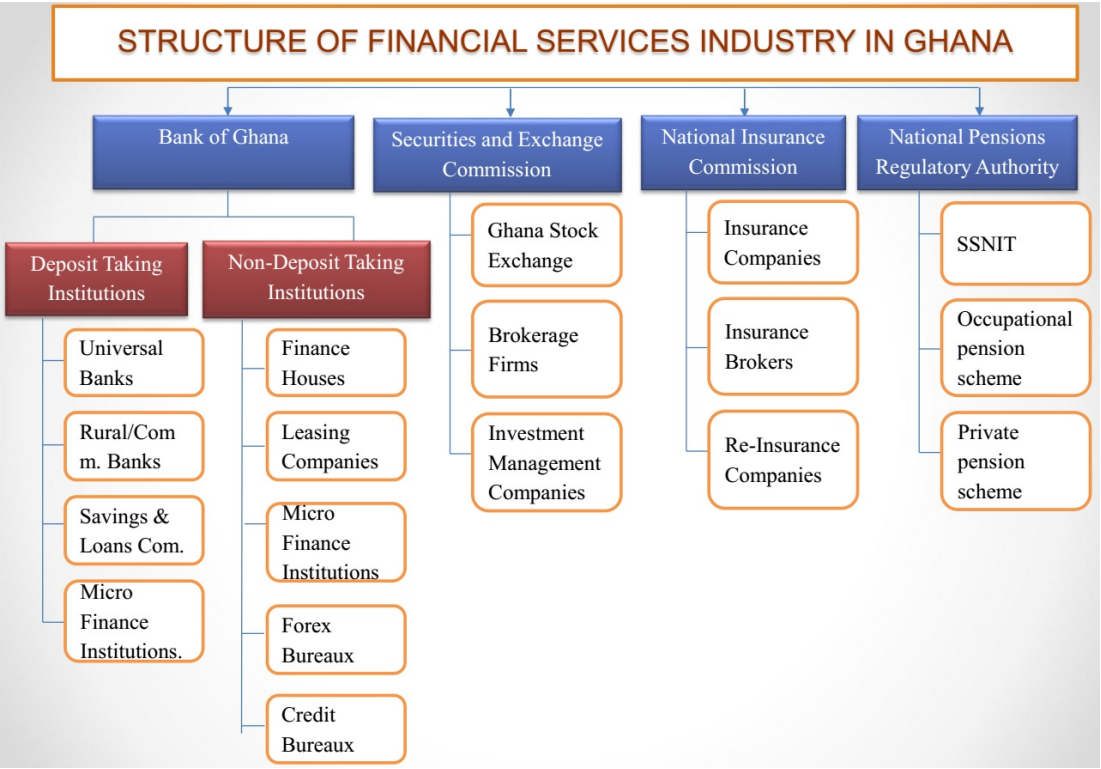

Figure 1.1: Structure of Financial Sector of Ghana

The banking industry has seen significant developments over the last few years. Evolving from just three main banks at independence, the banking system as at end of March 2016 comprised the Bank of Ghana, 29 Universal banks , 139 rural and community banks(RCBs), 61 NBFIs, and 555 MFIs. Table 1.1 shows the developments of the respective banks between the period 2012 and 2018. As evident from the table, the industry has witnessed phenomenal growth, and also the emergence and significant growth of the micro-finance industry.

The industry has not only increased in the number of institution, but also in total assets. Total assets of the industry at the end of March 2016, was GHc76.27 billion, up by 18.8% over the period of March 2015 level of GHc64.16 billion. Within the period, total assets of the universal banks formed 84.7%, the NBFIs held 10.1% while the RCBs took up 3.5% and MFIs 1.7% of the industry assets. Table 1.2 and 1.3 shows the statistics.

Table 1.1: Classification of the Banking Industry

Type	2016	2015	2014	2013	2012
Banks	29	27	27	27	27
NBFIs	61	57	57	52	50
RCBs	139	139	140	136	135
MFIs	555	337	135	-	-
TOTALS	784	560	560	214	212

Source: Bank of Ghana database

Table 1.2: Asset Classification of the Banking Industry

Type	2016 GHc'M	2015 GHc'M	2014 GHc'M	2013 GHc'M	2012 GHc'M
BANKs	64,556.76	55,087.22	39,128.47	27,996.11	22,935.56
NBFIs	7,722.92	5,803.23	4,236.20	2,768.55	1,914.19
RCBs	2,672.53	2,160.59	1,832.89	1,559.38	1,149.20
MFIs	1,316.19	1,113.87	342.47		
TOTAL	76,268.39	64,164.91	45,520.24	32,324.04	25,998.96

Source: Bank of Ghana database

Table 1.3: Asset Share Classification of the Banking Industry

Type	2016	2015	2014	2013	2012
BANKs	84.7	85.9	86.0	86.6	88.2
NBFIs	10.1	9.0	9.2	8.6	7.4
RCBs	3.5	3.4	4.0	4.8	4.4
MFIs	1.7	1.7	0.8		
TOTAL	100	100	100	100	100

Source: Bank of Ghana database

The composition and development in the assets of the banking industry signals favorable inter and intra sector competitions. The increase in the number and assets of banks signal some level of competition among banks. The degree of market concentration as measured by assets of the top five banks has fallen steadily overtime. Stanley (2008) found that market concentration declined from 77.6 per cent in March 2000 to less than 55 percent and further to 45 percent in 2013. The total advances held by the top five banks have also fallen. As shown in Figure 1.2, the total advances of the top five have declined marginally from 42.5 percent in 2010 to 41.5 percent in 2013. Deposits, however, have increased from 46.7 per cent to 48.2 per cent.

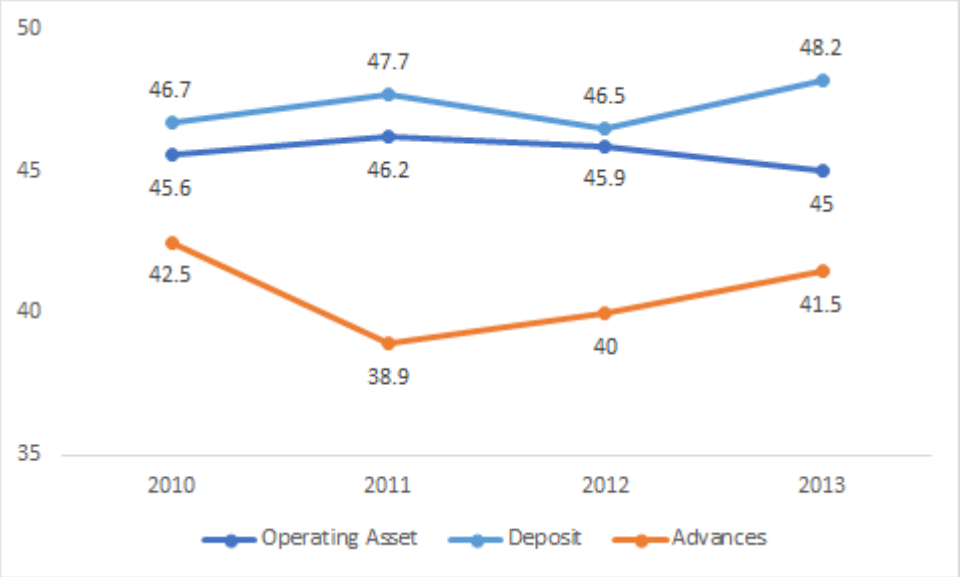

Figure 1.2: Asset Classification of Banks

Source: Compilation from 2014 Ghana Banking Survey by PriceWaterCoopers Inc.

Although competition in the banking sector has improved over the years, there are several reasons to question the extent to which banks actually compete. While bank concentration appears to be moderate by the sub-region's standards, market power still concentrates among few dominant banks. Competition between banks in Ghana can be said to be very low, because more than 60 percent of the assets of the banking sector are owned by at most four banks. In 2003, the three largest commercial banks accounted for 55 percent of total assets of the banking sector.

By the year 2008, the dominant state-owned bank (GCB) enjoyed a substantial market power, with 20 percent of total deposits and 44 percent of total branches - a situation that may influence price setting among banks and distort competition. This situation changed after the takeover of The Trust Bank (TTB) by Ecobank

Table 1.4: Cross Market Analysis of Deposit and Loans of selected MFIs in Ghana

Year	MFI Count	Average Deposit Bal	Deposit per GNI per capita	Loan per GNI per capita
2005	31	98	21.92	48.29
2006	33	119	22.75	52.91
2007	34	146	23.66	64.41
2008	32	116	15.93	48.3
2009	39	99	13.82	48.6
2010	30	112	6.97	22.03
2011	22	96	12.84	36.93
2012	10	151	9.76	2.68
2013	6	152	8.61	15.55
2014	7	68	4.2	3.94

Source: Micro-finance Information Exchange, Inc. Washington DC.

Ghana. However, the top five banks still hold about 45 percent of the industry's assets.

Empirical studies conducted on the level of competition in the banking sector confirm low level of competitions with the possible existence of monopolistic behavior. Buchs and Mathisen (2005) found evidence of non-competitive market structure in the Ghana banking system. This evidence was further confirmed by Biekpe (2011). The study identified very high overhead cost and economic of scale among the key factors which indirectly serves as barriers to entry, hence hampering competition among banks.

Though banks compete marginally among themselves, recent trends as showed in Table 1.2 and 1.3 indicate increasing competition between banks and non-bank financial institutions. The increase in micro-finance institution in the country over the years is reflected in the share of micro-finance loans in both the loan and deposit market. From Table 1.3, the share of micro-finance loans and advances as a percentage of total assets of banks and NBFI has been increasing. From a percentage share of 4.8 per cent in 2008, the share of (NBFI, RCBs, & MFIs) loans and advances have increased to 15.3 percent as the end March 2016. This is also evident in the average increase in both deposit accounts and loans among the MFIs. Table 1.4 shows the trend in deposit and loans for some selected MFIs. As showed in the table, in 2005 about 31 MFIs held an average of USD98m in deposit representing 21.92 per cent deposit per GNI per capita but only 7 MFIs in 2014 held USD68m representing 4.2 per cent. Loan advance also shows similar magnificent improvement. The above indicates that MFI intermediation is gaining momentum in Ghana.

The forgoing discussions reveal that the structure of the Ghanaian banking industry signals both inter and intra sector competition. Intra competition among banks is however, very low with few major banks holding unto the industry's assets. Also, the universal banks face some competition from the micro-finance sector. The structural relationship and competition between formal and informal banks may have some important implications for the conduct of monetary policy. This, as a result, is the focus of this study.

1.3.2 Some Conjectures on the Role of Informal Banks in Monetary Policy Transmission

The structure of the banking industry as espoused above is likely to determine the response of banks interest pricing to monetary policy.

Relevant to the pricing decision of banks is competition. Intra-sector competition among banks engenders efficiency, causing banks to respond to monetary signals from the central bank. This consequently leads to smooth monetary transmission. From the descriptions in the above section, the development in the banking industry is likely to enhance competition. Hence, banks are likely to respond favorably to monetary signals from the central bank, thereby enhancing monetary transmission.

Even though competition in industry is required and good, given the different regulatory environment the various institutions operate, inter-sector competition is likely to affect the pricing decisions of the banking sector. As noted, the formal banking sector operates under a legal framework different from that of the non-banks and micro-finance institutions.

In the provisions of the Non-bank Financial Institutions Act, 2008 (Act 774) and the Banking Act, 2004 (Act 673) as amended by Act 738, the universal banks are required to keep reserves with central bank, whereas NBFI and MFIs are not mandated to do so. Notwithstanding this, both universal banks and NBFIs are deposit taking institutions, with no clear defined market segment for them. Therefore, an inter-sector competition (i.e. competition between universal banks and NBFIs in the deposit and loan market) has the tendency to influence how universal banks respond to monetary signals from the central bank. This is because, when the central bank raises its policy rate, it does not affect informal interest rate directly. Therefore, borrowers can switch credit demand to the informal banks in response to higher interest rates in the formal system. The potential shift in credit demand from formal bank to informal banks could cause retail interest rates in the formal system to be less responsive to policy rate, consequently affecting the interest rate transmission. How valid this assertion would be is the focus of the first paper of the thesis.

1.4 Conclusion

In view of the above discussion, it is found that the informal banking sector plays an important role in the Ghanaian financial system. The sector, apart from increasing in its size in credit intermediation process, it is interrelated with the formal banking sector with evidence of inter-sector competition. As a result, the thesis produced two papers to investigate informal credit activities in the Ghanaian economy. The first paper explored the validity of the assertion that the presence of informal credit intermediation could influence how retail interest pricing respond to monetary signals. This followed from the discussion espoused in section 1.3.1 that signaled that inter-sector competition between the formal and informal credit sectors could influence monetary transmission.

The second paper investigated the effect of exogenous shocks on an economy with informal credit activities. This is against the backdrop that most economic turmoils emanates from credit intermediation. Hence, since informal credit intermediation are gaining prominence in most economies, it is important to understand how shocks behave in this scenario. This will guide and shape policy formulation to mitigate potential future economic unrest.

Does Informal Credit Intermediation Influence Monetary Policy? Some Empirical Evidence for Ghana.

2

Abstract

Monetary transmission is found very weak in many developing economies. Identifying the factors responsible for the weak transmission is important for an effective monetary policy design. Thus, this study explored the factors that affect monetary transmission. Particularly, it hypothesized that the growth of informal credit intermediation and it linkages with the formal banking system could affect monetary transmission. This is because, informal banking does not fall directly under the regulatory framework for which central banks conduct monetary policy. This notwithstanding, informal and formal banks co-exist in the credit intermediation process. Therefore, this study used a Factor Augmented Vector Auto-regression to investigate the determinants of pass-through in Ghana. Particularly, the study explored the effect of informal banking on monetary transmission. Using data sourced from the World Bank and Bank of Ghana databases, the study found that monetary pass-through is very weak in Ghana. The study found that factors such as non-performing loans, excess liquidity and the level of financial development influence pass-through. Also, informal banking is found to affect transmission, however the effect is minimal. Informal banking reduces pass-through estimates from 0.033 to 0.024.

Keywords: Interest Rate Pass-through, Informal Credit Intermediation and Ghana
JEL Classification: E52, E54, G210

2.1 Introduction

The Ghanaian financial sector has undergone gradual reforms since the introduction of the Financial Sector Adjustment Program[1] (FINSAP) in 1988.

[1] FINSAP is the financial sector reform component of the broad Economic Recovery Program introduced in the country between 1983 and 1986 to restructure the economy to path of economic growth. The reform introduced a market based approach in economic management thereby replacing the hitherto control system which had characterized the economy.

Pre-reform banking sector, as noted by Gockel et al. (1997), was characterized by a low capital base, weak management and accounting information, and inadequate legal and regulatory framework. These challenges engendered the financial sector reforms in 1988 which resulted in the introduction of new banking law [2] of 1989. The reform involved among others: the liberalization and deregulation of the financial sector, development of capital and security market, and the promotion of non-bank financial institutions.

The financial system, in the aftermath program, witnessed enormous growth and structural transformation. Credit intermediation also increased. Notwithstanding these developments in the financial sector, the financial coverage was very limited leaving vast of the Ghanaian populace un-banked[3]. This was prevalent among the informal traders and individuals who could not access financial services from the formal banks[4]. The concomitant effect was the emergence of informal institutions to address the needs of the un-banked.

Over the years, the informal sector[5] has grown considerably in Ghana and in many other countries. For example, the IMF Financial Stability Board (2014) report estimated the size of the global shadow banking system to be about 40 percent of the total financial system. Although data is sparse, anecdotal evidence suggest a similar trend in Ghana. For example, the amount of loans extended by Non-Bank Financial Institutions (NBFIs) increased from GHc70.63 million in 2003 to GHc72.85 million in 2004, suggesting 3.1 percent growth. In 2006, a total of GHc160.47 million was extended to clients, which represents 48.8 percent higher than the previous year's total loans and advances granted by these micro-finance institutions. The upward-trend of NBFI's credits to individuals, small businesses, groups and others indicate marked improvements in the level of micro-finance and the gradual growth in total financial assets in the country. Overall, figures from

[2] This new law was to govern the establishment and operation of the banking sector. Also, it stipulated how to conduct monetary policy giving rise to monetary targeting framework.

[3]As at 2014, the total population of Ghanaian above 15 years that bank with a financial institution stood at 34.618 percent. The proportion of the poor increased from 16.66 percent in 2011 to 24.35 2014. This proportion is very low especially amidst the huge development in the financial sector that has witnessed a significant increase in both the total number of universal banks and non-bank institutions alike.

[4] Most formal banks were not willing to extend credit to these categories because they are perceived as high risk.

[5]For the purpose of this study and in consonant with the data used for this study, we follow Bank of Ghana distinction where financial services are provided formally via the universal banks and informally via micro-financing. As a result, formal banks in this study represent universal banks that operate under the required reserve regulatory of the Bank of Ghana, whiles informal banks consist of the Non-Bank Financial Institution (NBFI), the RCBs, and Micro-Finance Institution (MFI) that do not operate under required reserve regulatory framework of BoG. The share of NBFI& MFI credits in total bank credit is used as the proxy which captures the presence of informal credit intermediation.

Bank of Ghana indicate that the share of micro-finance loans and advances as a percentage of total assets of banks and NBFI loans and advances has increased from 4.8 percent in 2008 to 9.8 percent in 2013.

The banking sector plays a pivotal role in the conduct of monetary policy. It performs this role by transmitting monetary impulses to the real sector by intermediating between borrowers and depositors. This is achieved through the banks' regulatory relationship with the central bank,which enables monetary authorities to influence the pricing decisions of banks, and subsequently influence credit demand and supply conditions to achieve desired outcome on the economy. The banking sector however, as noted above[6], has overtime evolved to include both formal and informal banks. These two types of banks however, are related with the central bank on different regulatory environment. Whiles the formal banks (universal banks) are mandated by law to keep reserves[7] with the central bank, the informal banks are not. Notwithstanding the different regulatory environment the two types of banks operate, their activities are linked in the intermediation process. This distinct relationship with the central bank causes the central bank to have direct influence on the pricing decision of formal banks but not that of informal banks. This may have some implications for monetary transmission. For instance, when the central bank raises its policy rate, it does not affect informal interest rate directly. Borrowers thus can switch credit demand to the informal banks in response to higher interest rates in the formal system. The potential shift in credit demand from formal bank to informal banks could cause retail interest rates in the formal system to be less responsive to policy rate, consequently affecting the interest rate transmission.

Although the literature provides evidence on the role of formal banks in transmitting monetary impulses to the real sector, the evidence on the role of informal banks is largely absent. Notwithstanding this, informal banking activities have been increasing over the past decades. As a result, this study fills the gap in the literature by exploring the potential effect of informal banking activities on monetary transmission.

The novelty of this study is twofold. Foremost, it is the first study to empirically investigate the role of informal credit intermediation on monetary transmission process[8]. Secondly, the study provides evidence on the possible role that informal banking activities plays in the monetary transmission process. Thus, it will help to shape monetary design and regulation design of the formal and informal banks.

Using a factor augmented vector autoregressive approach with interaction terms,

[6]See section 1.3.1 of Chapter 1 for the description of the Ghanaian banking sector.

[7]The reserve requirement is regulatory tool the central bank uses to affect the banking system, and, ultimately, the economy by influencing the proportion of total assets that depositories hold as cash assets (either vault cash or balances with the central bank).

[8]This is supported by the literature surveyed so far.

the study found that monetary transmission is very weak in Ghana with very low estimated long-run pass-through. Also, the study identified factors such as non-performing loans, excess liquidity and the level of financial development to hinder smooth monetary transmission. Further, the study found that informal credit intermediation influence pass-through marginally. Informal activities is estimated to decrease pass-through estimates from 0.033 to 0.024.

The rest of the paper is structured as follows: Section 2.2 reviews brief theoretical and empirical literature, whiles section 2.3 describes the econometric approach used for the analysis. Section 2.4 presents and discusses the results, and section 2.5 summarizes the work and provides some policy recommendations.

2.2 Theoretical Background

This study investigates the role of informal finance on monetary transmission by assessing the effect of informal banking on bank's interest rate response to monetary policy shock. This is captured by the impact informal finance has on interest rate pass-through (IRPT). Theoretically, the analyses of IRPT in the literature are generally based on the marginal cost pricing model. This model relates the retail interest rate as a mark-up of the marginal cost which may be represented by the policy rate (Borio & Fritz, 1995; G. De Bondt, 2002).

There are various theories that explain banks' lending decisions, which result in the derivation of marginal cost pricing. These theories are separated based on the assumption about the market structure- whether perfect or imperfect competition. In models of perfect competition, firms are price takers and are unable to change their prices hence equilibrium is achieved when price equal marginal cost. In imperfect markets, firms have the market power to change their own prices. The appropriateness of any particular model depends on the structure of the market under consideration. The typical derivation of the mark-up equation determines its component, which ultimately determines the pass-through. In the section that follows, the study presented the derivation of the marginal cost pricing which incorporates the objective of the studies. This follows the standard theory of bank's pricing decision, where banks are confronted by agents who demand both formal and informal credits. The resulting equation establishes a relationship between interest rate and monetary policy instrument where the elasticity of substitution between formal and informal credit determines the pass-through.

2.2.1 The Model

A monopolistic competitive banking industry capable of changing retail prices is assumed. The banking sector consists of a formal bank and an informal bank

that provide varieties of credit facilities to households. As a result, the aggregate credit demand is given by a composite CES basket of slightly differentiated products which are each supplied by formal bank and informal bank. To capture the market power that characterize the banking industry, the credit market is treated analogously as the standard Dixit-Stieglitz framework for the goods market, in which each agent demands loan contract from each single financial institution (i.e. formal and informal) in order to borrow one unit of resources. The aggregate loan demand by an agent is expressed as

$$B_t = \left[\alpha^{\frac{1}{\epsilon}} B_t^{f\,\frac{\epsilon-1}{\epsilon}} + (1-\alpha)^{\frac{1}{\epsilon}} B_t^{I\,\frac{\epsilon-1}{\epsilon}} \right]^{\frac{\epsilon}{\epsilon-1}}, \tag{2.1}$$

where α is the share of agent loan obtained from the formal sector, B_t^f and B_t^I are the credit demand from the formal and informal bank respectively, and ϵ is the elasticity of substitution between the formal and informal credit. The elasticity of substitution captures the level of competition between formal and informal credit in the agents' basket of credit demand. An elasticity of one shows perfect substitution. The degree of elasticity indicates the willingness of an agent to trade formal credit with informal credit. The agents' aim is to choose credit bundles that minimize total loan payment. If r_t^f and r_t^I are the interest rate facing agents from formal and informal bank respectively, then the optimizing condition results in the following demands for credit

$$B_t^f = \alpha B_i \left[\frac{r_t^f}{r_t} \right]^{-\epsilon}, \tag{2.2}$$

$$B_t^I = (1-\alpha) B_i \left[\frac{r_t^I}{r_t} \right]^{-\epsilon}, \tag{2.3}$$

where r_t is the aggregate interest rate facing the agent.

The formal bank engages in the production of deposit and loan services with a given technology represented by a cost function C. The cost function satisfies the usual assumptions of convexity. Taking into account the management cost, the formal bank maximizes its profit subject to the loan demand schedule. Formally,

$$\underset{\{r_{f,t}\}}{\text{Max}} \left\{ r_t^f B_t^f - R_t B_t^f - C_t \right\}, \tag{2.4}$$

subject to equation 2.2. R_t is the inter-bank or wholesale interest rate. The cost function C is assumed to follow a quadratic function of the form

$$C_t = \frac{\kappa}{2}\Big(\frac{r_t^f}{r_{t-1}^f} - 1\Big)^2 r_t^f B_t^f, \tag{2.5}$$

where κ is the adjustment cost, which indicates the cost the bank incurs in an attempt to change retail price (i.e. interest rate). Solving the bank's problem result in the FOC that stipulates the loan pricing equation for the formal bank. The pricing equation is given as

$$1 - \epsilon + \epsilon\frac{R_t}{r_t^f} - \kappa\Big(\frac{r_t^f}{r_{t-1}^f} - 1\Big)\frac{r_t^f}{r_{t-1}^f} + \Delta_t = 0, \tag{2.6}$$

where the Δ_t represents the expectation component of the equation. The Log-linear version of the pricing equation is given as

$$\widehat{r_t}^f = \frac{\kappa}{\epsilon_t - 1 + (1+Q_p)\kappa}\widehat{r_{t-1}}^f + \frac{Q_p\kappa}{\epsilon - 1 + (1+Q_p)\kappa}E_t\widehat{r_{t+1}}^f + \frac{\epsilon - 1}{\epsilon - 1 + (1+Q_p)\kappa}\widehat{R_t}, \tag{2.7}$$

where Q_p is the discount factor the bank attached to its streams of profits. The equation indicates that banks set their loan rates by taking into account the policy rate, which is the relevant marginal cost. The interest rate pass-through is given by

$$IRPT = \frac{dr}{dR} = \frac{\epsilon - 1}{\epsilon - 1 + (1+Q_p)\kappa}. \tag{2.8}$$

Equation shows that the pass-through depends on the elasticity of substitution between formal and informal loans ϵ, banks discount factor Q_p and the cost of changing interest rate κ. If $\epsilon = 1$, implying that informal credits are perfect substitute to formal credits in the agents' credit demand basket, then

$$IRPT = \frac{dr}{dR} = 0 \tag{2.9}$$

From the above, it is showed that monetary effectiveness depends on the degree of substitution of informal and formal credit in an agent's credit basket. That is, the presence of informal credit and its degree of substitution to formal credits influence the effectiveness of monetary policy. Based on this, it is hypothesized in this study that the growth in informal intermediation in most developing economies raises concern for effective monetary policy implementation. This is because, high informal financing serves as an alternative to formal credit financing. The presence of this alternative curtails the ability of banks to change their rates in response to changes in the policy rate. This has potential effects on the transmission process consequently affecting the effectiveness of monetary policy. Therefore, the role of informal finance in monetary transmission process can be captured by the impact it has on interest rate pass-through.

2.2.2 Determinants of Pass-through

Apart from informal credit, which is hypothesized in this study to influence retail pricing decisions of commercial banks, hence interest rate pass-through, the literature identifies various factors that influence interest rate pass-through. These factors are captured theoretically by the market power and elasticity that affect the pricing decision of banks. Though, studies such as Biefang-Frisancho Mariscal and Howells (2002) and Espinosa-Vega et al. (2004) emphasized the availability of alternative instrument (i.e. substitutes) as the key determinant of banks' pricing behavior, others like Greenwood-Nimmo et al. (2010) and G. De Bondt (2002), G. J. De Bondt (2005) noted the role of elasticity in the pass-through process. These factors are however mutually reinforcing. For example, the existence of substitutes directly affects the demand elasticity of a product and this elasticity increases with the degree of substitutability. Hence, the availability of substitutes increases elasticity and competition while reducing banks' market power. As noted by Hannan and Berger (1991), the lack of market contestability and a high degree of financial market underdevelopment limit the substitute for money and credit thereby affecting their respective elasticity and the overall monetary policy pass-through. The foregoing discussion thus suggests that determinants of interest rate pass-through are identified by factors that influence banks mark ups and elasticity.

These mainly include the economy's financial structure, which sets the right incentives for banks to pass on policy rate changes to customers. For instance, a market power which explains interest rate adjustment behavior of banks depends on the opportunity cost of making such adjustment. Banks would only adjust (i.e. transmit changes to its customers) if the associated opportunity cost is less than the gain. Consequently, the existence of opportunity cost would increase the stickiness of bank's retail rates (Berger & Udell, 1992; Alien & Gale, 2004; Kwapil et al., 2006).

However, other structural characteristics such as an economy's overall regulatory environment can also influence an effective interest rate transmission (Mishra et al., 2012; Mishra & Montiel, 2013). These potential constraints to effective interest rate transmission process are thus described below.

- ***Liquidity Ratio:*** Changes in policy rate have limited influence on the credit supply in the presence of high excess liquidity. This subsequently does not cause changes in retail lending rates. Therefore, interest rate transmission may be less effective in a financial market with abundant liquidity. This is because the liquidity serves as a buffer against market fluctuations and monetary shocks. Excess liquidity results from a lack of adequate investment opportunities.

- ***Asset Quality:*** The presence of bad loans which translate into weak bal-

ance sheet restrict banks to react to expansive monetary policy. Rather than increasing credits, banks shore up liquidity. In this regard, retail interest rate becomes less responsive to policy shock.

- ***Financial Development:*** The structure of the financial market and the level of development are identified to affect pass-through (Hannan & Berger, 1991; Borio & Fritz, 1995; Ozdemir, 2009; Gigineishvili, 2011). According to Hannan and Berger (1991) and Ozdemir (2009), more developed markets are expected to have a variety of financial products and derivatives so that there is increased substitutability and higher competition among various sources and/or uses of funds. As a result, the degree of financial development should relate directly with the degree of pass-through. This has been confirmed by studies such as (Sander & Kleimeier, 2004; Gropp et al., 2014).

- ***Banking Sector Competition:*** Market contestability and inter-industry and intra-industry competition have an effect on pass-through. Competition results in diversified financial instruments. This creates an available substitute for money and credit thereby affecting respective elasticity and the overall transmission process.

- ***Regulatory Environment:*** Poor regulatory environment is identified to influence monetary transmission. This is because a poorly functioning regulatory environment creates uncertainty in the financial system, which leads to de-formalization of financial transactions and a higher cost of financial intermediation. Mishra et al. (2012) related the small size of financial intermediation in many developing economies to a weak regulatory environment. The concomitant effect is that bank rates may become less sensitive to changes in the policy rate.

In conclusion, monetary effectiveness depends on the degree of interest rate pass-through. This however, depends largely on the elasticity, and inter and intra competition among financial intermediaries in the financial industry at large.

2.3 Empirical Strategy

The study used Factor-Augmented Vector Autoregressive (FAVAR) approach to estimate the pass-through and evaluate its determinants. Vector Auto-Regression (VAR) and Auto-Regression Distributed Lag (ARDL) modeling approach are the main techniques used in the literature to estimate pass-through. The appropriate technique depends on the data structure under consideration. Following the data structure used, this study used the VAR approach.

Though the VAR approach generates empirical plausible assessments of the dynamic responses of macroeconomic variables to monetary policy innovations, it does not lack criticism. The standard VAR approach addresses the effect of unanticipated changes in monetary policy by identifying monetary policy innovation. Different identifications lead to different inferences about the shape and timing of the responses of economic variables. However, there is no consensus among researchers on the appropriate identification strategy to ascertain exogenous effect to monetary shocks[9].

Also, the VAR approach is more efficient with endogenous variables not exceeding four. VAR models with large (i.e. greater than four) endogenous variables result in a degree of freedom problem. However, using only a small variables in the VAR to investigate monetary impulses does not capture fully the large range of factors considered in monetary policy decisions. This has a potential adverse effect on the results. The "price puzzle"[10] is a known example derived from VAR models with limited information.

In practice, monetary policy decisions are conditioned on a large information set. Similarly, apart from the policy rate, there are range of conditions such as risk perception, liquidity, and economic conditions that influence interest rates. All these factors, however, cannot be accommodated in a standard VAR modeling. To overcome this, the study adopted the FAVAR approach. FAVAR models are shown as useful to resolve the information set problem by making it possible to practically summarize and observe a large number of time series information using a comparatively small number of factors (Stock & Watson, 2002; Bernanke & Boivin, 2003; Bernanke et al., 2005).

2.3.1 Modeling Approach

FAVAR is a generalized VAR that models the dynamic interaction among economic observable variables and factor scores generated from a factor analysis. The modeling strategy used to identify the determinants of pass-through followed the approach described in Towbin and Weber (2013). In the approach by Towbin and Weber (2013), the dynamic interactions among the economic variables are allowed to vary deterministically with potential factors that may influence pass-through.

The FAVAR model is specified as joint dynamic of (F_t, Y_t) that is defined by a

[9]Refer to Christiano et al., (2000) and Bernanke and Mihov (1998) for the survey of some identification alternatives.

[10] A fundamental tenet of monetary policy making is that an increase in the short-term interest rate will lower price inflation. Contrary, empirical estimates of the relationship between the policy rate and inflation have suggested that an interest rate hike is followed immediately by a sustained increase in the inflation rate. This result has become known in the literature as the "price puzzle,"

transition equation given by

$$\begin{pmatrix} F_t \\ Y_t \end{pmatrix} = \omega(l) \begin{pmatrix} F_{t-1} \\ Y_{t-1} \end{pmatrix} + v_t \tag{2.10}$$

where v_t is a vector of noise. Y_t is an $Mx1$ vector of observable economic variables which are assumed to influence retail rates. For this study, the set Y_t includes the policy rate and retail lending rates. $\omega(L)$ is a conformable lag polynomials of finite order d.

Equation 2.10 is a VAR in (F_t, Y_t). The equation reduces to unrestricted VAR, a structural VAR, or some other multivariate time series when the terms of $\omega(L)$ that relate Y_t to F_{t-1} are all zero. That is, equation 2.10 reduces to VAR when only Y_t is used. However, estimating the VAR using only Y_t may result in an omitted variable bias that may influence the estimates. This is because, Y_t may not capture exhaustively all the relevant economic information that may explain the dynamics in the model. For example, loan pricing policy includes factors such as credit market and other macroeconomic conditions that may not be appropriately captured by Y_t.

To circumvent the potential omitted variable effect on the estimations, equation 2.10 incorporates additional information set to the VAR through a vector of unobserved factors F_t. F_t is a $Kx1$ unobserved factors that captures fluctuations in retail rates or reflects a theoretically motivated concept such as credit conditions that cannot be easily represented by one or two series but rather are reflected in a wide range of economic variables.

Given that F_t is unobserved, equation 2.10 cannot be estimated directly. However, suppose there exist a set of N time series denoted by Z_t, such that N may be greater than the number of time periods T, then it can be assumed that the number of factors and observed variables in the FAVAR system are greater than N (i.e. $K + M > N$,). If the time series Z_t are related to the unobserved factor F_t and sometimes, but not always- the observable Y_t, then a relational equation can be specified as

$$Z_t = B^f F_t + B^y Y_t + \epsilon_t, \tag{2.11}$$

where B^f and B^y are factor loading of NxK and NxM dimensions that conforms to Z_t, F_t, and Y_t, while ϵ_t is the vector of$Nx1$ idiosyncratic noise that are weakly serially and cross-sectional correlated with mean zero[11]. If the factor model is

[11]Note that both Y_t and F_t, which in general can be correlated, represent common forces that drive the dynamics of Z_t. As a result, Z_t are noisy measures of the underlying unobserved factors F_t which makes it depends not only on the current values but also lagged values of the factors. However, as noted by Stock and Watson [2002], the principal component estimation allows for some cross-correlation in ϵ_t that must vanish as N goes to infinity.

expressed without an inclusion of the observable variable Y_t, then the static relation is specified as

$$Z_t = BF_t + \epsilon_t \tag{2.12}$$

In a dynamic factor, the factor F_t are related over time, typically according to a linear process as

$$Z_t = A(l)BF_t + \epsilon_t, \tag{2.13}$$

where A(l) denotes a polynomial in the lag operator.

Following Stock and Watson (1998, 1999), the factors Z_t and F_t in the dynamic factor model is estimated using the principal component technique. As discussed in Stock and Watson (1998, 1999), this method is numerically robust and computationally efficient, and is econometrically consistent for the latent factor F_t under standard technical conditions.

To estimate the pass-through coefficients, the lending rate is modeled as a function of its own regressors and the lag of the policy rate as well as factors. The model is given as

$$\begin{pmatrix} 1 & 0 & 0 \\ \delta_1^0 & 1 & \delta_2^0 \\ \beta_1^0 & \beta_2^0 & 1 \end{pmatrix} \begin{pmatrix} \Delta i_t \\ \Delta r_t \\ \Delta f_t \end{pmatrix} = \sum_0^t \begin{pmatrix} w_{11} & w_{12} & w_{13} \\ \delta_{11}^1 & \delta_{12}^1 & \delta_{13}^1 \\ \beta_{11}^1 & \beta_{12}^1 & \beta_{13}^1 \end{pmatrix} \begin{pmatrix} \Delta i_{t-1} \\ \Delta r_{t-1} \\ \Delta f_{t-1} \end{pmatrix} + \begin{pmatrix} v_t \\ u_t \\ e_t \end{pmatrix} \tag{2.14}$$

$$\delta_{pq}^1 = \alpha_{pq}^1 + \theta_{pq}^1 X_t \tag{2.15}$$

i_t is the policy rate, r_t is the retail rate and f_t is the factor loadings that capture other variables that potentially influence retail pricing. The variables used for such purpose included inflation, exchange rate, interbank lending rate and treasury bill rates. Following equation 2.15 , the estimated pass-through coefficients are further regressed on X_t (which captures potential determinants of interest rate pass-through). The impulse response functions are estimated using the Cholesky ordering where policy rates are assumed to be unaffected by changes in retail rates and the factors.

2.3.2 Data

The study used two data-sets: one sampled at the monthly frequency and the other on an annual frequency. A sample of 106 data points sampled over the period 2005 to 2013 was used for the analysis. The key variables used for the analysis are the policy rate and the retail lending rate. As per the study's objective another

Table 2.1: Data Description

Variable	Frequency	Proxy	Source
Monetary Policy Rate (MPR)	Monthly	Policy Rate	BoG
Commercial Base Rate (BR)	Monthly	Retail lending Rate	BoG
Non-Performing Loans (NPLR)	Annual	Asset Quality	WDI
Liquidity Reserve (LR)	Annual	Liquidity Ratio	WDI
Private Credit to GDP (DCP)	Annual	Financial Development	WDI
Share of MFI & NBF loans to Total Bank & NBFI loans (NBLR)	Annual	Informal intermediation	BoG
GDP	Annual		WDI

important variable used is the Share of micro-finance and non-bank loans to the total bank & non-bank loans (hereafter NBLR). This ratio captures the proportion of informal credit intermediation in total credit intermediation hence representing the effect of informal activities in the credit market. In addition, the study included theoretically identified variables that influence pass-through estimates. These variables include private credit to GDP, liquidity ratio and non-performing loan which are used as proxies for financial development, liquidity reserves and asset quality respectively. The study sourced data from Bank of Ghana and World Bank databases. The interest rate variables are sourced at monthly frequency while the structural characteristics are sourced at annual frequency since they are not available at a higher frequency (i.e. monthly frequency). However, the annual data were linearly interpolated to monthly frequency [12]. We acknowledge that, though the interpolation could have some potential influence on the estimates, we guide against this by ensuring that the variance in the data structure is minimized, and also, the time series properties of the data is not immensely affected. The description of the data is further explained in Table 2.1:

2.4 Results and Discussion

2.4.1 Results

The study began by subjecting the series to a unit root test. The rationale is to avoid any spurious regression. Amidst the numerous test procedures, the study

[12]Saborowski and Weber (2013) interpolated lower frequency data for similar analysis. Also, the World Development Indicator (WDI) data by the World Bank is often interpolated to fill the data gap for countries whose data are not available at the required frequency. The interpolation were conducted gauging against any distortion that will affect the time series properties of the data.

Table 2.2: Unit Root Test

Variable	Level	First Difference
Base Rate	−1.3865	−5.2172
	[0.5858]	[0.000]***
MPR	−1.6899	−5.0791
	[0.7482]	[0.000]***

P-values are reported in the parenthesis [ ]. (***) indicates rejection of unit root at 1% level

relied on the Augmented Dickey-Fuller(ADF) test procedure. The ADF test suffers from two caveats: (1) the inclusion of additional deterministic components in the regression model used for testing the presence of unit roots results in an increased probability that the null hypothesis of non-stationary will be accepted when in fact the true data generating process is stationary. (2) The presence of unnecessary nuisance parameters (constant and trend terms) has the effect of lowering the power of the test against stationary alternatives. As a result, the study adopted the sequential testing procedure suggested by Peron (1988). The number of lags introduced in the ADF regression was chosen considering the general to specific procedure suggested by Hall (1994). The results of the ADF unit root test for the main variables are presented in Table 2.2. The results indicate that all the variables are non-stationary at level and integrated of order one I (1).

In the literature on interest rate pass-through, the appropriateness of the VAR approach depends on the feedback from policy rate to movements in the lending rate. Based on this, the study presents in Table 2.3 a causality test to ascertain the direction of causality. The test results suggest that the lags of the lending rate are jointly significant in the entire variety of model specifications supporting bi-causality and thus favoring the VAR approach.

Table 2.3: Granger Causality Test

	Chi-square	P-Value
Retail Rate		
Policy Rate	32.4628	0.000***
Policy Rate		
Retail Rate	7.4933	0.023**

*** (**) indicate rejection of null hypothesis of no causality at 1% and 5% respectively

A preliminary correlation analysis is presented to show the initial behavior

of the variables. Figure 2.1 shows the plot of the policy rate and retail lending rate. The graph shows some variations indicating that the policy rate has been changing over the period in response to the dynamics of the economy. Again, the graph shows that policy rate and lending move in tandem.

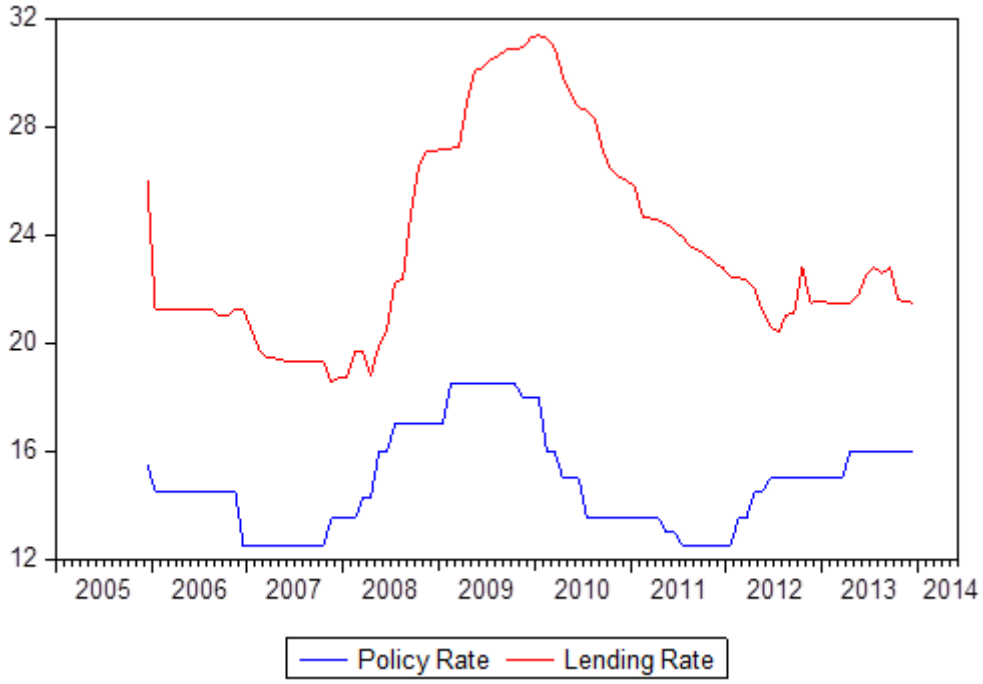

Figure 2.1: The Graph of Lending and Policy Rates between 2005 and 2014

The covariance analysis results as presented in Table 2.4 indicates that the retail rate reacts to policy rate. The correlation coefficient is estimated to be about 60 percent and significant suggesting a positive relation between the policy rate and interest rate. The study further decomposed the policy rate change into positive and negative changes representing an increase and decrease in policy rate respectively. The correlation results for the decomposition showed that the correlation between interest rate and positive policy rate change is greater than that of a negative change. Also, the correlation with a positive change is statistically significant while that of a negative change is insignificant. This shows that policy rate only contributes to an increase in interest rate but not a decrease. Hence, this provides an indication to support the case that interest rates are rigid downwards in Ghana and that, monetary authorities cannot reduce the high interest rates with policy rate. The section that follows presents the formal econometric analysis.

Table 2.4: A Covariance Analysis Results between the policy rate and the lending rate

Policy Rate		Retail Lending Rate
Default	Covariance	4.1645
	Correlation	0.5981
	P-value	0.0000***
Negative change	Covariance	-0.1567
	Correlation	-0.0135
	P-value	0.8953
Positive change	Covariance	4.3212
	Correlation	0.3557
	P-value	0.0003***

2.4.2 Estimating the Pass-through

To ascertain the pass-through estimates, the study first estimated the simple VAR model without factor. Using lag length of two[13], the VAR was estimated to generate an impulse response function identified by assuming that policy rate is contemporaneously unaffected by changes in retail lending rate [14]

Figure 2.2 shows the impulse response function to one standard deviation shock with 95 percent confidence bandwidth drawn around the point estimates. The long pass-through is estimated at 0.035 and this is presented in Figure 2.2. As Figure 2.2 illustrates, monetary shock does not affect the lending rate at the initial stage (i.e. between the first and second month of perturbation). The full long-run pass-through materializes after about the fifteen months (approximately four quarters) with about 90 per cent of the estimates materializing after twelve months (i.e. a year).

The estimated long-run pass-through suggests incomplete pass-through. This incomplete pass-through is consistent with other empirical studies that focused on developing economies[15]. However, the estimate is far below the estimated values for countries that share similar characteristics with Ghana. The low estimate of long-run pass-through gives indications that the central bank of Ghana has weak

[13]The optimal lag length of two was chosen based on the Akaike and Schwartz information criteria.

[14] The study also experimented with the Cholesky ordering assuming that the retail lending rate is contemporaneously unaffected by policy rate. This was conducted to check if identification is a problem. The estimates however, did not show any significant difference.

[15] See for example; (Wu et al., 2007; Chandan et al., 2005) for Mauritius, and (Samba & Yan, 2009) for Central Africa Economic and Monetary Community. Mishra and Montiel (2013) used a sample of 94 countries and find that the correlation between policy rates and lending rates in the long term is 0.35 for advanced economies, 0.61 for emerging economies and 0.29 for LDCs.

influence on the retail pricing of commercial banks.

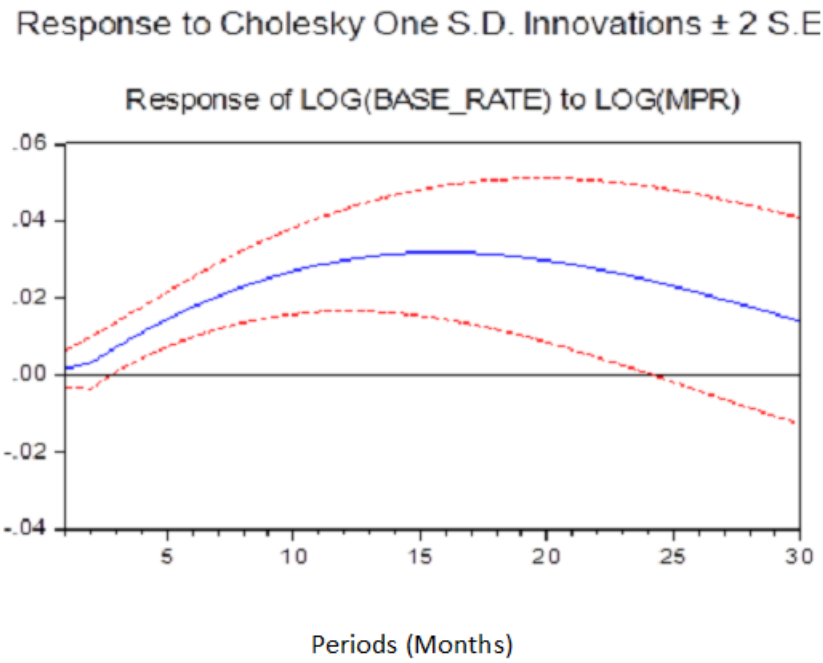

Figure 2.2: IRF of Lending Rate to Policy Rate

Again, the pass-through is estimated using the FAVAR modeling technique. This is because, aside the policy rate, the literature identifies a range of determinants of interest rate. However, as explained in section 2.3.1, the consistency of the VAR estimates beyond some required variables becomes questionable and not implementable. Hence, to prevent the problem of omitted variable bias which might influence the pass-through estimates, the factor approach is adopted. The approach follows two stages. First, estimate the factor from potential determinants of interest rate using factor analysis. In this regard, factor scores were derived from inflation rate, treasury bill rate, exchange rate and inter-bank lending rate.The factor score together with the policy rate is used to estimate a VAR model both with and without interaction terms from factor and policy rate to determine the average pass-through.

Figure 2.3 shows the impulse response function generated from the FAVAR model. A qualitative inspection of figure 2.2 and 2.3 suggests that the estimated pass-through from the FAVAR model is not different from that of the VAR model. This may suggest that the impact of a potential omitted variable bias in the model without the factor will probably be minimal. Hence, proceeding even with the model without the factor will not produce any bias analysis. However, the study proceeded with the factor approach.

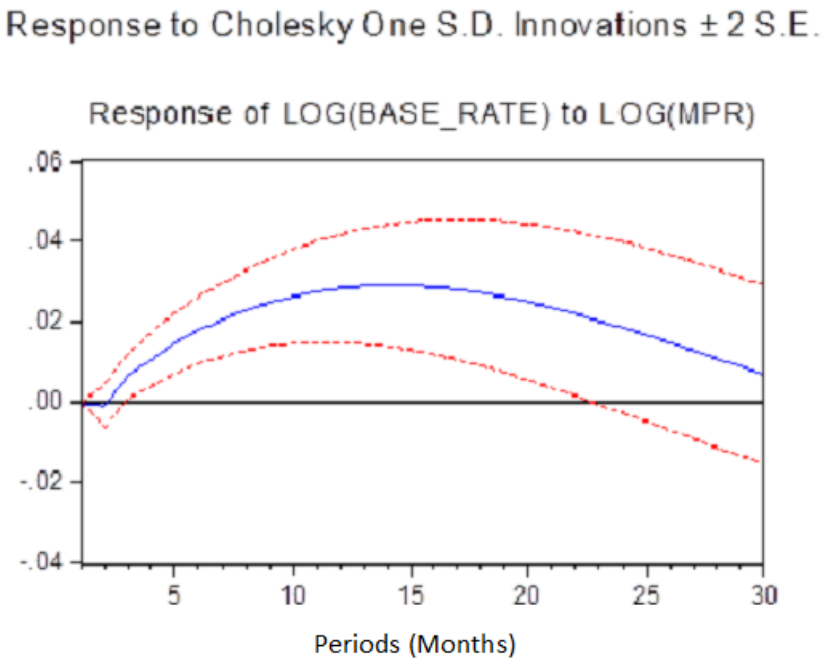

Figure 2.3: IRF of Lending Rate to Policy Rate for the factor model

2.4.3 Determinants of Pass-through

To identify the pass-through determinants, the model in Equations 2.14 is estimated by adding to the set X_t, one at a time, the economic characteristics assumed to influence the pass-through. By this specification, the conditional coefficients estimates imply that the retail rate is not only a function of its own lags and the policy rate, but also, it includes the interaction terms between all these regressors and the structural characteristic in set X_t. Thus, the transmission from the policy rate to the lending rate is a function of the structural characteristics in X_t.

To assess the impact of thees characteristics on the pass-through estimates, the study contrasts the impulse response function generated from the simple model without the structural characteristics with that of the model with the structural characteristic. The IRF is then evaluated to identify whether the pass-through increases, decreases or remains unchanged with the introduction of the structural characteristic. Table 2.5 presents the pass-through estimates for the various models.

To ascertain the overall effect of the structural characteristics on the pass-through, we estimated the unrestricted (full) model in equation 2.14. Figure 2.4 is the IRF generated from the FAVAR estimation with all the structural characteristics in set X_t. The IRF presents both the point estimates and 95 per cent

Table 2.5: Pass-through Estimation Results

variable	Estimated PT	*Change in PT
Restricted VAR	0.035	-
Restricted FAVAR	0.033	-
Unrestricted FAVAR with		
All determinants	0.012	0.021
Informal Credit	0.024	0.009
Financial Development	0.022	0.011
Liquidity Ratio	0.030	0.003

* *The change in PT is in respect with deviation from the PT estimate from the Restricted FAVAR*

confidence intervals around them. Contrasting the IRFs in figures 2.3 and 2.4 shows that, the pass-through estimate is lower in the unrestricted model (model estimated with all the potential determinants) compared with the fully-restricted model (model with only policy rate as a regressor). Figure 2.4 revealed that the

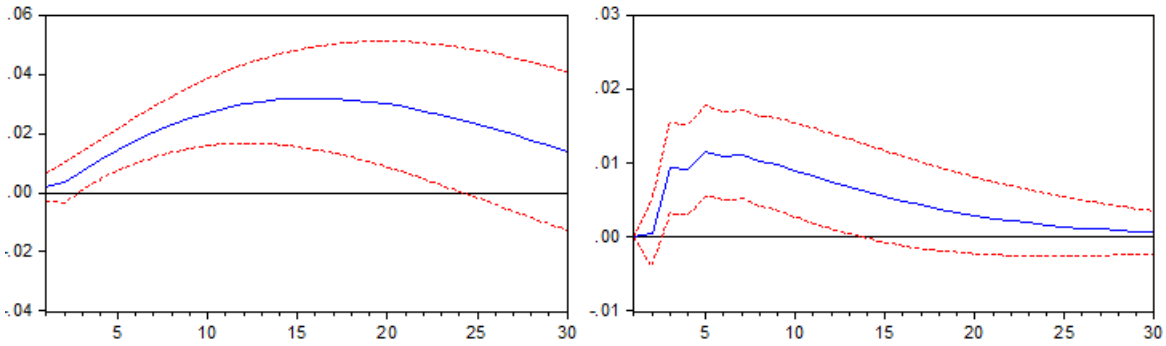

Figure 2.4: IRF: Variations with all Determinant[a]

[a] The figure to the left is the IRF generated for the fully restricted model while the right-hand figure is the IRF of the fully unrestricted model

long run pass-through reduces by 0.021 from 0.033 to 0.012 when the full model is estimated. Further, the figures revealed that whereas it takes approximately fifteen months for the long run estimates to fully materialize in the restricted model (figure 2.3), it takes only about five months for the unrestricted model (figure 2.4). This suggests that the pass-through is weakened by the presence of these characteristics. The assessment of the individual characteristics as suggested by the results is thus espoused below:

Informal Credit Intermediation

The main objective of this study is to investigate informal credit activities as a potential determinant of the pass-through. Following the theoretical background developed above, we assumed that the elasticity between formal and informal credit affects the interest rate pass-through. The elasticity captures the rivalry between formal and informal credit in the consumer's credit basket. That is, informal credit serving as an alternative to formal credits, creates real or potential competition between MFI's and universal banks. This real or potential competition restricts universal banks to respond to policy rate changes.This is because, rather than passing on the full burden of cost (increase in policy rate) to customers in the form of higher retail prices, commercial banks accommodate proportional amount due to the fear that consumer will shift to MFI's who provide similar services. By means of this, informal credit intermediation reduces pass-through estimates. The share of MFI & NBF loans to Total Bank & NBFI loans (NBLR) is used to capture the rivalry between the types of credit facing the consumer

Figure 2.5 presents the IRF contrasting the fully restricted model to an unrestricted model with proxy for informal credit intermediation as the only structural characteristic in set X_t. As showed in figure 2.5, informal credit intermediation reduces long-run pass-through estimates from 0.033 to 0.024. This gives an indication that the presence of informal credit could restrict commercial banks to fully pass on policy shock to retail prices.

It is worth noting that the above result is plausible for a policy rate increase. On the contrary, a decrease policy rate might not have the same effect. This is because, when policy rate decreases, commercial banks can decrease the lending rate to gain a competitive advantage over MFIs since they have access to extra funds from the central bank. By implication, a policy rate decrease should result in higher pass-through than a policy rate increase.

To investigate this asymmetry, the study decomposed the policy rate into positive change and negative change representing increase and decrease in policy rate respectively. The study then estimated the pass-through for each change and analyzed the effect of informal intermediation on the respective pass-through estimate. Figure 2.6 presents the IRF for the asymmetry model.

The study estimated the pass-through to be 0.024 and 0.021 respectively for a positive change and negative change. The generated IRFs revealed that, for a positive policy rate change, informal credit intermediation reduces pass-through by 0.011. However, for a negative policy rate change, informal intermediation reduce pass-through by 0.003. This finding is in contrast to the expectation that the presence of informal intermediation should cause pass-through to change by greater margin for a negative change than a positive change since formal banks with competitive advantage would like to explore the negative policy change to

their advantage. However, this is not surprising because, the exploratory analysis in Table 2.4 showed that while there exist a significant correlation between interest rate and positive policy change, there is no significant correlation between interest rate and negative policy rate change. The reason mainly could be because the profits of commercial banks depend mainly on interest income [16]. As a result, banks easily increase the retail rate when policy rate increases but are reluctant to decrease them in order not to cut down on interest income. Also, the counter phenomenon might be due to low competition and inefficiencies in the formal sector which prevents banks to take advantage of policy rate fall.

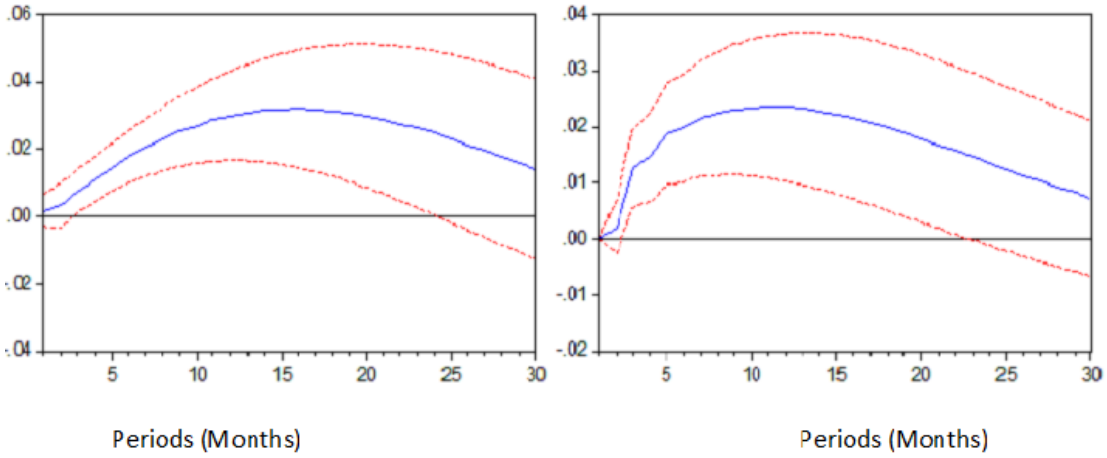

Figure 2.5: IRF: Variation with Informal Intermediation[a]

[a] The figure to the left is the IRF generated for the fully restricted model while the right-hand figure is the IRF of the unrestricted model with informal credit intermediation.

Financial Development

The study used the ratio of private credit to GDP as a proxy for financial development. Theory predicts financial development to bring about competition among financial products. Hence, high level of financial development enhances monetary transmission process. As suggested by the results depicted in Figure 2.7, financial development decreases the pass-through estimates to 0.022. This fully materializes in about a nine-month period. Contrasting with the estimates from the restricted model, the estimates indicate that financial development reduces pass-through marginally. This suggests that the level of competition among financial products is very low in Ghana.

[16] See the various issues of BoG financial stability reports

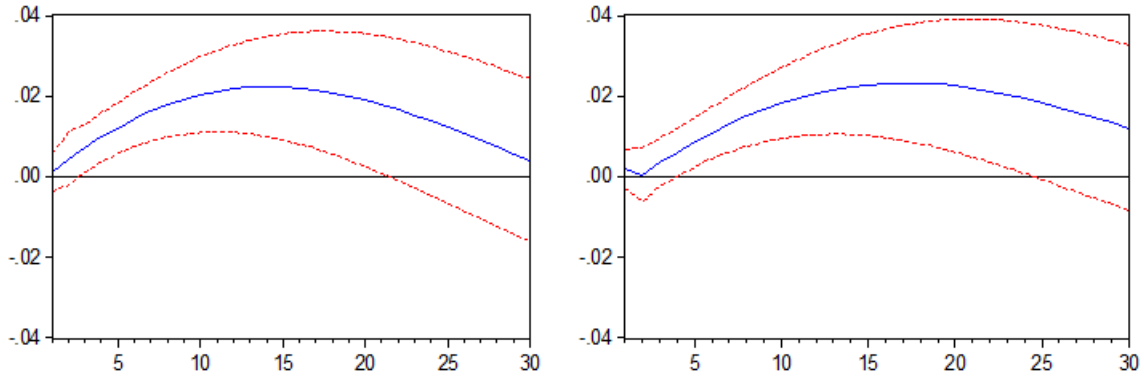

Figure 2.6: IRF for Asymmetric VAR[a]

[a] The figure to the left is the IRF generated for the fully restricted symmetric model while the right-hand figure is the IRF of the fully restricted asymmetric model.

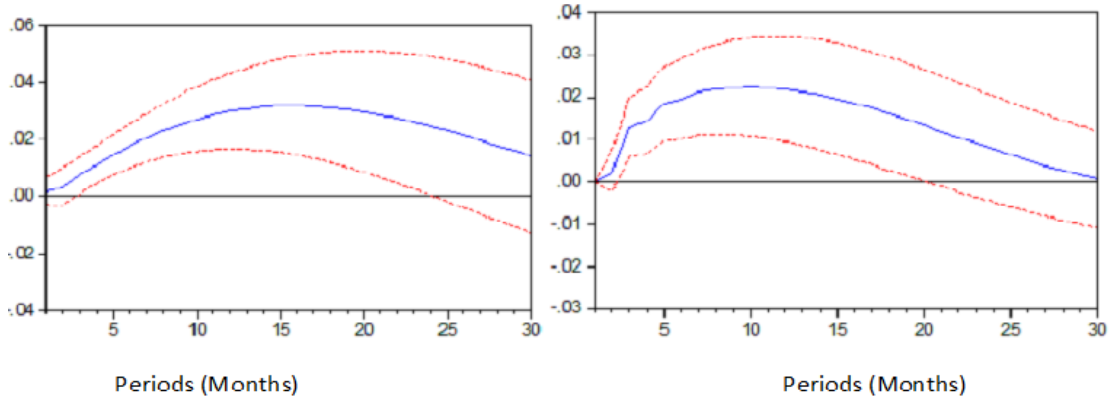

Figure 2.7: IRF: Variation with Financial Development[a]

[a] The figure to the left is the IRF generated for the fully restricted model while the right-hand figure is the IRF of the unrestricted model with financial development.

Asset Quality:

As an important determinant of pass-through, theory predicts countries with quality asset to have high long-term pass-through. Using the banking sector's non-performing loan share in total loans to measure asset quality, the study did not find any significance on pass-through estimates. As depicted by figure 2.8, the results of the study could not establish any significant differences for the two comparing models.

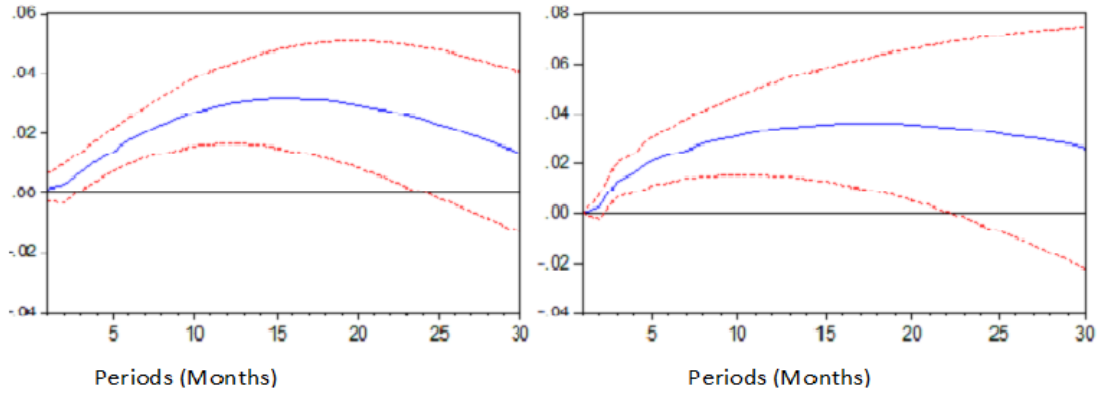

Figure 2.8: IRF: Variation with Asset Quality[a]

[a] The figure to the left is the IRF generated for the fully restricted model while the right-hand figure is the IRF of the unrestricted model with Asset Quality.

Liquidity Ratio

The study also found liquidity ratio has a substantial impact on pass-through. The results as depicted in figure 2.9 suggests that liquidity ratio reduced the pass-through estimates to 0.030.

In addition to the above VAR analysis, the study further estimated equation 2.15. As specified in the equation, we regress the pass-through coefficients obtained on the different set of explanatory variables. The rationale is to establish a relationship and identify those variables that are statistically significant and have meaningful signs.

Given the objective of the study, the emphasis is thus placed on the informal credit indicator, which is the share of the non-bank financial institution (NBFI) and micro-finance loans in the total banking, NBFI and micro-finance loan. Since informal credit serves as a substitute to formal credit, the availability of informal credit will restrict how commercial banks change the prices (retail rates) on their

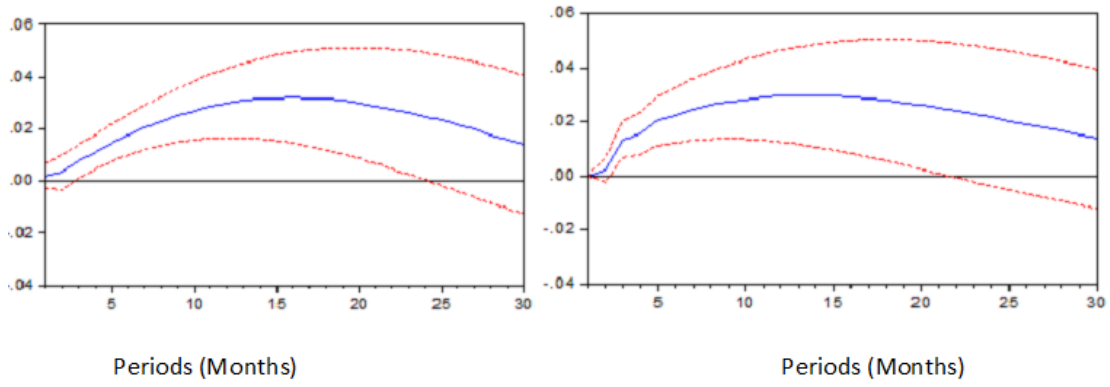

Figure 2.9: IRF: Variation with Liquidity Ratio[a]

[a] The figure to the left is the IRF generated for the fully restricted model while the right-hand figure is the IRF of the unrestricted model with Liquidity Ratio.

products. As a result, a policy rate increase will not translate the one-to-one increase in retail rate. Thus, a negative relationship between informal intermediation and pass-through estimates is expected.

Table 2.6 presents the regression results. As expected and consistent with figure 2.5 a negative relationship was identified for informal activities. This suggests that informal credit intermediation restrict the commercial banks' ability to pass on policy actions to the real sector via an increase in retail rates.

Regarding the other determinants, the results from the estimation are consistent with other studies. Similar to studies like Sorensen and Werner (2006), the estimation results of this study found a negative relationship between bank's liquidity and the strength of pass-through. This is also consistent with theoretical predictions. In excessively liquid markets, when all banks are structurally on the same side of the market, interbank trading in short-term funds dries up, and interest rates fail to reflect the true marginal cost of financial resources. Naturally, retail pricing of loans becomes less responsive to money market rates and the connection between the two weakens.

However, some of the estimates are in contrast to findings from related studies. For example, whilst studies such as Sander and Kleimeier (2004); Gigineishvili (2011); Saborowski and Weber (2013) identified asset quality (NPLR) to improve pass-through, the findings of this study did not find any significant relationship. Given that non-performing loans reflect the degree of credit risk, the risk premium demanded by banks will be higher if NPLR is higher. The already high lending rate has the possibility of attracting riskier projects if banks respond to rising short-term rates. The likelihood of incurring additional losses will restrain banks to respond to increase in short-term rates. Therefore, profit maximizing banks will

not respond to policy rate when its asset quality is already poor. But the result from this study suggests that banks in Ghana possibly might not factor NPLR in their retail pricing decision.

Table 2.6: Regression Results

variable	coefficient	P-Value
NPLR	-0.039	0.3017
NBLR	-0.357	0.0000***
LR	-1.394	0.0000***
DCP	-0.697	0.0000***
GDP	0.063	0.0151**
C	0.0130	0.0000***

** (***) indicates significance at 5% and 1% respectively.

2.5 Conclusion and Policy Recommendation

In conclusion, the study found weak pass-through for Ghana. Estimated average pass-through is approximately 3.5 percent, which is far lower than the one found for developing economies with characteristics similar to Ghana. The weak pass-through shows that monetary policy is very weak in Ghana. This indicates limited monetary authority's control on economic variables especially interest rates. The weak pass-through is further dampened by factors such as excess liquidity ratio and non-performing loans as the study identified them to adversely influence the transmission process. Informal credit intermediation is found to have minimal impact on monetary transmission. Thus, the study concludes that the impact of informal credit intermediation on monetary transmission is small, hence informal credit activities cannot be a major factor in explaining monetary ineffectiveness in Ghana. However, this not withstanding, the impact cannot be underestimated.

The findings of the study have a number of policy implication for the conduct of monetary policy in developing economies, particularly Ghana. Generally, the weak pass-through casts doubts on the effectiveness of the hitherto approach of implementing monetary policy in Ghana. The effectiveness of the traditional framework relies on the ability of the central bank to influence the intermediate target (i.e. interest rates). The inability to control interest rates limit the ability to influence the real economy. This thus warrants a new approach that can circumvent the intermediate target. To achieve this, the central bank can adopt some unconventional approaches that bypass the intermediate targets.

Also, the findings of the study beget some revelations that require further investigation. The asymmetry results suggest that the effect of informal intermediation on pass-through change for policy rate fall is very low compared to that of a policy rate rise. This counter phenomenon might be due to low efficiency in the financial sector or possible behavioral characteristics of the banks that support it. This requires an investigation into the financial structure of Ghana amidst the development of informal credit activities to produce a policy framework that will ensure monetary effectiveness.

The Effect of Exogenous Shocks with Informal Credit Intermediation.

Abstract

Informal banking has gained prominence in the financial market of many countries. Its contributions to economic growth cannot be underestimated. Even though, it emerged in response to the credit needs of some sectors of the economy, it activities are interrelated with the formal banking system. This study therefore, investigates the effect of shocks on an economy given the co-existing relationship between formal and informal banks. Using a Dynamic Stochastic General Equilibrium (DSGE) model with an informal bank, the study showed that the effect of monetary policy on the informal banks is different from the effect on the formal banks. While the formal bank reacts to monetary tightening by decreasing credit issuance, the informal bank reacts by increasing credit issuance. However, a credit shock to the informal bank has a similar effect on the economy as a credit shock to the formal bank. Therefore, the study recommends that informal credit activities should be fully regulated and monitored to prevent potential risk emanating from this sector.
Keywords: Informal Credit Intermediation, DSGE and Ghana
JEL Classification: E52, E54, G210

3.1 Introduction

Within the past decades, the world's economy has been characterized by various economic and financial turmoils. Post-crisis evidence suggests that credit restrictions and banking activities are potential factors that trigger financial crisis and economic downturns (Vogiazas & Alexiou, 2013). This evidence heightened interests of business cycle theorists to incorporate banking sector activities in the traditional macroeconomic frameworks. The purpose is to understand the interactions between the real economy and the financial system for policy evaluation and forecasting.

Following this, the hitherto workhorse of General Equilibrium Models used in studying the dynamics of macroeconomic variables, which lacked interactions

between the financial and credit markets and the real economy, incorporated financial frictions in different forms (Iacoviello, 2005; Gertler & Karadi, 2011; Gerali et al., 2010). These models provided the financial market with an explicit role in analyzing monetary impulses in most advanced economies.

Notwithstanding this theoretical advancement, the existing models have inadequately addressed the peculiarities that characterize the financial system of many developing and emerging economies. A common characteristic of the financial system of these economies is financial dualism[1] in the context of formal and informal financial(banking) activities.

Informal financial activities have overtime grown to become a major characteristic of the financial system of most developing economies. Informal banking emerged to provide products that are flexible and tailored to offer adequate financial services to the large percentage of people who do not fit into the main formal or commercial banking system. It was to serve as a tool to mop up extra liquidity while offering other social intervention services to bring economic empowerment to the poor. These activities, overtime, have grown to become very prominent not only in the financial system of developing countries but developed countries alike. Its share of volume in total financial system intermediation is estimated to be about 40 percent in total world financial intermediation (Financial Stability Board (2014)).

The co-existence of formal and informal banks has begotten some characteristic in the economies they are found. First, this financial duality has resulted in the co-existence of different financial instruments and their associated interest rates. Second, it also has implication for fiscal and monetary policies[2] with possible adverse outcome on the aggregate economy. Also, financial development and the evolution of the financial sector have engendered some interrelationship between the formal and informal sector. For instance, the structure and mode of operations underpinning the establishment of informal banks have transformed magnificently over the years. The core activities of informal banks have transformed into major financial activities whose activities do not only cater for the poor but also include

[1]Financial dualism is the co-existence of organized and unorganized money market. The organized money market consists of the central bank, the commercial banks and other formal financial institutions. The unorganized money market includes informal financial institutions such as indigenous bankers, moneylenders, and micro-finance activities. By this, the study defines formal bank to be the universal or commercial banks that are required to keep reserves with the central bank, while informal bank include micro-finance and Non-bank Financial Institution (NBFI).

[2]With dualism, fiscal and monetary policy tends to affect the real sector differently with possible adverse outcome on the aggregate economy. For example, expansionary monetary policy tends to favor the formal sector by creating cheap money in this sector, thus suffocating agents that operate with the informal sector (Altunbas et al., 2009).

activities which were previously solely performed by formal banks[3]. Despite the transformation in informal bank's activities, which overlaps that of the formal bank, these banks operate under different regulatory framework of central banks.

The foregoing discussion begets some important questions: I) How are monetary impulses transmitted through the economy when there is informal banking activity? II) Given that informal banking falls outside the regular banking system, however linked to the regular banking system, does a shock from the informal credit market has any consequential effect on monetary aggregates? This is because, the literature documents that credit shocks that affect financial market have important repercussion on the real sector.

Following the above questions, the study investigated the probable implication of shocks when there is informal banking. Particularly, the study explored the effect of monetary shock on the aggregate economy with or without the informal financial market and under different interrelationship that exist between the formal and informal banks. Though, the effect of an exogenous shock has been analyzed in the literature for the formal bank, the case for an informal bank is limited. This study thus contributes to the evidence in this regard.

Through the model analysis, the study showed that monetary actions affect informal banks and formal banks differently. Whiles formal banks react to monetary tightening by decreasing credit issuance, informal banks on the other hand react by increasing credit issuance. As a result, the aggregate effect of monetary tightening on credit depends on the relative size of the formal or informal credit market. Also, the study showed that credit shock from the informal sector has similar effect on the economy as credit shock emanating from the formal sector.

The rest of the paper is structured as follows. Section 3.2 provides a brief literature review whiles section 3.3 developed the model. Section 3.4 presents the analysis of the study by numerically solving for the model properties. Section 3.5 concludes the study and provides some policy recommendation from the results of the study.

3.2 Brief Literature Review

The literature identifies few papers that model informal (shadow) credit intermediation using the DSGE approach. The notable ones include Verona and Martins (2013); Meeks et al. (2013); Mazelis (2014); Funke et al. (2015). Though, these

[3]Though, the activities of informal banking has transformed overtime, which has seen informal banks performing similar activities to that of formal banks, thus they competing in a common credit market, the study did not consider it in the modeling. Rather, the study modeled the two banks to operate in separate credit markets with informal and formal banks operating with the poor and rich households respectively.

papers are closely related and complement each other in modeling the shadow banking sector, they differ in some dimensions, particularly the role of shadow banks in the economy. Verona and Martins (2013) was concerned with the adverse selection effect of shadow banking on boom bust events caused by persistent low interest rate level. By this, they considered a financial accelerator DSGE model with formal banks investing in low risky projects whiles informal retail banks provide funding to riskier firms.

Mazelis (2014) explored the impact of monetary policy shocks on aggregate loan supply with both commercial and shadow banks. The paper extended Gertler and Karadi (2011) model with a non-bank financial intermediary to distinguish between bank and non-bank intermediaries based on the liquidity of their credit claims. In the model, banks could endogenously create deposits to fund their loans, however, non-banks had to raise deposits on the funding market to function as intermediaries. The funding market is modeled via search and matching by non-banks for available deposits of households. The paper showed that because deposit creation responds to economy-wide productivity automatically, bank reaction to shocks correspond to the balance sheet channel whiles non-banks are constrained by the available deposits making their behavior better explained by the lending channel. However, the two credit channels are affected differently following a monetary policy shock. By these counteracting effects, the study showed that an increasing non-bank sector leads to a reduced reaction of aggregate loan supply following a monetary policy shock, which is consistent with the data.

Meeks et al. (2013) modeled the shadow sector similar to Mazelis (2014). However, unlike Mazelis (2014), Meeks et al. (2013) investigated how financial instability emanating from commercial banks was unloaded as risky loans to off-balance sheet shadow banks through securitization.

Funke et al. (2015) modeled multifaceted interactions between non-standard monetary policy, the traditional banking sector and shadow banking sector in China to analyze monetary policy transmission with parallel shadow banking and different degrees of interest rate controls. Comparing different interest rate liberalization scenarios, the study revealed that monetary policy shock increase feed-through to the lending rate and investment under complete liberalization. Also, tighter regulation of interest rates in the commercial banking sector in China led to an increase in loans provided by the shadow banking sector.

This paper differs from the above existing studies in different dimensions. The above studies modeled the financial market to include both formal and informal banks operating separately in different markets according to its associated risk. In their set-up, formal banks operate in the low risk enterprise markets whiles informal banks deal with the high risk market. In this paper however, the study modeled the formal bank to supply credit to rich household type and firms, while the informal

bank supplies credits to the poor household type. Unlike the existing studies that allowed only the formal bank to accumulates deposit, this study allowed the informal bank to also accumulate deposit but only from the poor household type. By this, though both the formal and the informal banks operate in a different credit market, the banks exhibit similar characteristics in terms of credit intermediation. The only difference is that unlike the formal bank that can access extra fund from the inter-bank market, the informal bank has no such privilege. The study thus explored how shocks propagate through the economy in the presences of informal banks.

3.3 The Model

This section describes the model and explains its underlying assumptions. Since the model developed was calibrated for the Ghanaian economy, the study modeled the interplay of the agents especially the financial sector to mimic the characteristics of the Ghanaian economy. Notwithstanding this, the study made no attempt to model the complexities of the Ghanaian economy.

The model consists of a formal and an informal bank[4]. As noted in the introductory section, informal banks emerged in response to the credit needs of some agents in the economy who cannot access credit facilities from the universal or the formal banks. Hence, the informal banks emerged to provide financial services for the "disadvantage" agents whose characteristics do not allow them to operate with the universal banks. Given this, the study classified the household into two types - an "r" and "p" household types, who operate with formal and informal bank respectively. While the r household type only accesses credit facilities from the formal bank, the p household type only accesses credit facilities from the informal bank. The available loan a household can access is constrained by the household's future collateral holdings determined by their future labor income[5]. This assumption by which the banks collateralize debt with future labor income is different from studies such as Iacoviello (2005) and Gerali et al. (2010) that used the housing stock as collateral to borrowing.

Both the formal and the informal bank exhibit similar characteristics except that the formal bank operates under a constrained capital requirement regulations of the central bank. As a result, this bank has a wholesale branch that participates in the interbank market, thus linking their activities directly to the central bank.

[4]The distinction between formal and informal banks follows the descriptions espoused in section 1.3.1

[5]The study adopted this assumption because it is consistent with how financial institutions advance loans to households in Ghana. Even though, formal banks accept fixed assets as collateral, we assume both banks accept future income as collateral for simplicity.

Contrary, the informal bank is not under the constrained regulation of the central bank. Their activities are rather linked indirectly to the central bank via the formal bank as the intermediate route.

Since the formal bank has a wholesale branch, it can obtain extra deposits from the inter-bank market. Contrary, the informal bank cannot participate in the interbank market, however, when the bank is liquidity constrained, it can obtain extra funds from the formal bank. Similarly, the informal bank deposits its excess fund with the formal bank in the form saving for the informal bank. Given this relationship, the capital structure of the formal bank is thus directly linked to the central bank via the interbank activities while that of the informal is linked indirectly through the formal bank. By this means, the central bank can directly control the credit supply of formal bank but that of informal bank indirectly.

Also, both banks operate in a monopolistic competitive setting where they set interest rates on deposits and loans to maximize profits. The banks accumulate deposits from and offer loans to their respective household type.

The rest of the sector is modeled to follow the standard approach in the literature. From the description above, the economy consists of four major blocks. These are the household (rich and poor type), the financial sector (formal and informal), the entrepreneur, and the government. Figure 3.1 presents the schematic description of the model. In the sections that follow, the behavior of the respective agents is analyzed.

3.3.1 Household

The household block consists of p and r household type. The household consumes and sells its labor services to the entrepreneur and accumulates wealth by engaging with the financial sector. Each household type saves (deposit) and secures loans from its respective bank.The representative agent maximizes the expected utility given by

$$E_0 \sum_{t=0}^{\infty} \beta_s^t \left(\frac{C_{s,t}^{1-\theta}}{1-\theta} - \frac{N_{s,t}^{1+\phi}}{1+\phi} \right), \tag{3.1}$$

where $s \in \{p, r\}$ is the household type, β_s is the discount factor which the agent applies to its stream of utility, θ is the risk averse coefficient which measures the risk nature of the agent, ϕ is Fricsh inverse elasticity of labor supply, and C_t and N_t denote consumption bundle and labor supply respectively. The household resource constraint is given by

$$C_{s,t} + D_{s,t} + \left(\frac{1 + r_{s,t-1}^b}{\Pi_t} \right) B_{s,t-1} = W_t N_{s,t} + \left(\frac{1 + r_{s,t-1}^d}{\Pi_t} \right) D_{s,t-1} + B_{s,t}. \tag{3.2}$$

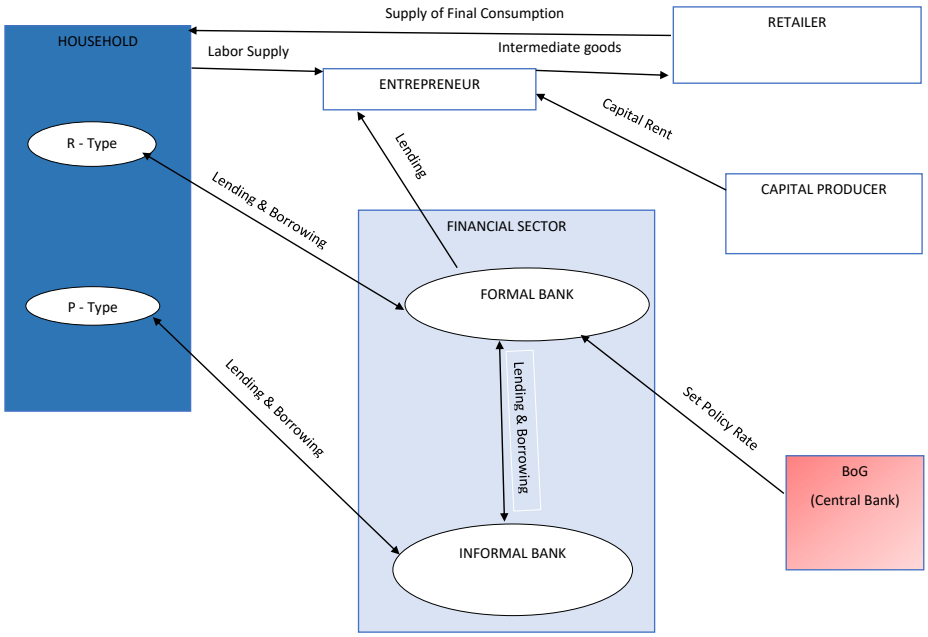

Figure 3.1: Schematic Model Description

Π_t is the gross inflation defined as P_t/P_{t-1}, W_t is the wage rate, $r^b_{s,t}$, $r^d_{s,t}$, $D_{s,t}$, and $B_{s,t}$ denote lending rate, deposit rate, deposit, and loan respectively for each household type $s \in \{r, p\}$. The household also faces a liquidity constraint given by

$$(1 + r^b_{s,t})B_{s,t} \leq \mu_{s,t} E_t \left(W_{t+1} N_{s,t} \Pi_{t+1}\right), \tag{3.3}$$

where $\mu_{s,t}$ is the loan-to-value ratio (LTV). At its mean value, it measures the value of credit amounts banks make available to each type of agents for a given discounted value of the collateral. Following Gerali et al. (2010), the LTVs are treated as shocks which behave stochastic. We study the effect of credit supply restrictions on the real economy using the stochastic behavior of the LTVs. The shock follows an AR(1) stochastic process specified as

$$\mu_{s,t} = \rho_{\mu_s} \mu_{s,t-1} + \epsilon^{\mu_s}_t,$$

where ρ_{μ_s} is the autoregressive coefficient and $\epsilon^{\mu_s}_t$ is an iid error term.

The household maximizes utility by choosing optimal loan bundle $B_{s,t}$, deposit bundle $D_{s,t}$, consumption bundle $C_{s,t}$ and labor $N_{s,t}$. Using $\lambda_{s,t}$ and $v_{s,t}$ as the budget constraint multiplier and borrowing constraint multiplier respectively, the FOCs are then given as

$$\lambda_{s,t}{C_{s,t}}^{\theta} = 1 \tag{3.4}$$

$${N_{s,t}}^{\phi} = \lambda_{s,t}W_t + v_{s,t}\mu_{s,t}E_t\left(W_{t+1}\pi_{t+1}\right) \tag{3.5}$$

$$\lambda_{s,t} = \beta_s E_t\left(\lambda_{s,t+1}\left(\frac{1+r^d_{s,t}}{\Pi_{t+1}}\right)\right) \tag{3.6}$$

$$(1+r^b_{s,t})v_{s,t} + \beta_s E_t\left(\lambda_{s,t+1}\left(\frac{1+r^b_{s,t}}{\Pi_{t+1}}\right)\right) = \lambda_{st} \tag{3.7}$$

3.3.2 Entrepreneur

The paper followed Gerali et al. (2010) approach to model the behavior of the entrepreneur. The entrepreneur e aimed at maximizing its lifetime consumption using income derived from output production. That is, the entrepreneur maximizes its lifetime consumption given by equation 3.8.

$$E_o\sum_{t=o}^{\infty}\beta_e^t\left(\frac{C_{e,t}^{1-\theta}}{1-\theta}\right). \tag{3.8}$$

Where β_e and $C_{e,t}$ are the entrepreneur's discount factor and consumption respectively. The entrepreneur produces intermediate good by combining effective labor and capital using a Cobb-Douglas production technology function given as

$$Y_t = A_t K_t^{\alpha} N_{e,t}^{1-\alpha}, \tag{3.9}$$

where Y_t, K_t and N_{et} denote intermediate good, capital and labor demand respectively. α is the capital share in output production. $N_{e,t}$ at equilibrium equals the total labor supply from the rich and the poor household (i.e. $N_{e,t} = N_{r,t} + N_{p,t}$). A_t is technology shock which is exogenous determined according to an AR(1) stochastic process of the form

$$A_t = \rho_A A_{t-1} + \epsilon_{A,t}, \tag{3.10}$$

where $\epsilon_{A,t}$ is the innovation component which is an iid.

The intermediate good is produced in a competitive market at a wholesale price P_t^w. The entrepreneur uses the realized income to finance its consumption patterns.

The entrepreneur also borrows from the formal bank to finance its production activities. Therefore, the resource constraint of the entrepreneur is given as

$$C_{e,t} + W_t N_{e,t} + \left(\frac{1 + r^b_{e,t-1}}{\pi_t}\right) B_{e,t-1} + q_t K_t = \frac{Y_t}{x_t} + B_{e,t} + q_t(1-\delta)K_{t-1}, \quad (3.11)$$

where x_t^{-1} is the price in terms of consumption good of the intermediate good produced by each entrepreneur with x_t defined as p_t/p_t^w. q_t is the rental price of capital and δ is the rate of capital depreciation. $r^b_{e,t}$ is the lending rate facing the entrepreneur and $B_{e,t}$ represents the entrepreneur loan. Also, the entrepreneur borrowing is constrained by its holdings of physical capital (i.e. the balance sheet constraint) given by

$$\left(1 + r^b_{e,t}\right) B_{e,t} \leq \mu_{e,t} E_t \left(q_{t+1}\Pi_{t+1}(1-\delta)K_t\right) \quad (3.12)$$

Like the household, $\mu_{e,t}$ is the LTV shock that follows AR(1) stochastic process of the form specified in equation (3.13) and it is used to study credit restriction to the entrepreneur.

$$\mu_{e,t} = \rho_{\mu_e}\mu_{e,t-1} + \epsilon_t^{\mu_e} \quad (3.13)$$

where $\epsilon_t^{\mu_e}$ is an iid error term.

The entrepreneur's problem is to maximize lifetime consumption given in equation 3.8 subject to Equations 3.9, 3.11 and 3.12. The resulting FOCs, where $\lambda_{e,t}$ and $v_{e,t}$ represent the budget and liquidity constraint multipliers respectively, are given as

$$\lambda_{e,t} q_t = \frac{\lambda_{e,t}\alpha Y_t}{x_t K_t} + v_{e,t}\mu_{e,t} E_t \left(q_{t+1}\Pi_{t+1}(1-\delta)\right) + \beta_e E_t \left[\lambda_{e,t+1} q_{t+1}(1-\delta)\right] \quad (3.14)$$

$$\lambda_{e,t} = v_{e,t}(1 + r^b_{e,t}) + \beta_e E_t \left(\lambda_{e,t+1}\left(\frac{1 + r^b_{e,t}}{\Pi_{t+1}}\right)\right) \quad (3.15)$$

$$W_t = (1-\alpha)\frac{Y_t}{x_t N_{e,t}} \quad (3.16)$$

Loans Demand and Deposit Supply

Loan Demand: r and P households purchase loan (credit) contract supplied by their respective formal and informal banks. The credit bundle $B_{s,t}$ is the total credit demand of a continuum of credits types (j) represented on the interval $[0, 1]$. The credit bundle $B_{s,t}$ follows a CES function given as

$$B_{s,t} = \left(\int_0^1 B_{s,t}(j)^{\frac{\epsilon_{b,s}-1}{\epsilon_{b,s}}} dj\right)^{\frac{\epsilon_{b,s}}{\epsilon_{b,s}-1}} \quad (3.17)$$

$\epsilon_{b,s}$ is the elasticity of substitution between credits. The expenditure (interest payment) associated with the credit demand is given by

$$\int_0^1 r^b_{s,t}(j)B_{s,t}(j)dj \tag{3.18}$$

where $r^b_{s,t}$ is the interest rate facing the household. The problem of the household is to choose credit vector that minimizes total interest payment. The resulting credit demand schedule is given by aggregating f.o.c's across agent

$$B_{s,t}(j) = B_{s,t}\left(\frac{r^b_{s,t}(j)}{r^b_{s,t}}\right)^{-\epsilon_{b,s}} \tag{3.19}$$

The average interest rate on loans to household is given by the composite aggregation

$$r^b_{s,t} = \left(r^b_{s,t}(j)^{1-\epsilon_{b,s}}\right)^{\frac{1}{1-\epsilon_{b,s}}} \tag{3.20}$$

The loan demand schedule for the entrepreneur is obtained in a similar fashion and is equal to

$$B_{e,t}(j) = B_{e,t}\left(\frac{r^b_{e,t}(j)}{r^b_{e,t}}\right)^{-\epsilon_{b,e}}. \tag{3.21}$$

Deposit Supply: Analogous to the way credits are contracted, each household type purchases deposits from its respective bank in order to save. Following the Stiglitz-Dixit framework, the aggregate deposit demand ($D_{s,t}$) of each household type $s \in \{p, r\}$ is the sum total of individual units ($D_{s,t}(j)$). The aggregate deposit demand thus follows a CES form specified as

$$D_{s,t} = \left(\int_0^1 D_{s,t}(j)^{\frac{\epsilon_{d,s}-1}{\epsilon_{d,s}}}dj\right)^{\frac{\epsilon_{d,s}}{\epsilon_{d,s}-1}}, \tag{3.22}$$

where $\epsilon_{d,s}$ is the elasticity between deposits. The interest return on deposit is given by

$$\int_0^1 r^d_{s,t}(j)D_{s,t}(j)dj, \tag{3.23}$$

where $r^d_{s,t}$ is the deposit rate the household receive on its deposit. The household chooses deposit bundle that maximizes total interest return. The deposit demand schedule is thus given as

$$D_{s,t}(j) = D_{s,t}\left(\frac{r^d_{s,t}(j)}{r^d_{s,t}}\right)^{-\epsilon_{d,s}}. \tag{3.24}$$

Accordingly, the average deposit rate is given as

$$r^d_{s,t} = \left(r^d_{s,t}(j)^{1-\epsilon_{d,s}}\right)^{\frac{1}{1-\epsilon_{d,s}}}. \tag{3.25}$$

3.3.3 Financial Sector

The financial sector is the key component of this model. The sector consists of a formal and an informal bank. The formal bank accumulates deposits from the patient r household type and supplies credits to the impatient r household type, the entrepreneur and the informal bank (when it is liquidity constrained). Similarly, the informal bank accumulates deposits from the patient p household type and supplies credit to the impatient p household type. Both banks have retail branches: deposit branch and loan branch responsible for collecting deposits and issuing loans respectively. Also, the formal bank has a wholesale branch in addition while the informal bank does not. A further distinctive feature is that the formal bank is regulated by the central bank while the informal bank is not. The formal bank is regulated via capital requirements of the central bank, hence it has a higher cost than the informal bank.

From the above characteristics, the flow of funds is given as follows. The formal bank collects deposits from patient r household via the deposit branch and then passes the raised funds to the wholesale unit, which pays the branch at a rate. The loan branch then takes loan from the wholesale branch, differentiate them at no cost and resell them to the impatient r household, the entrepreneur, and to the loan branch of the informal bank. Similarly, the informal deposit branch takes deposit from the patient p household and passes the raised fund to the formal deposit branch. The informal loan branch then takes the deposit generated by the informal deposit branch, differentiate at no cost and resell them to the p household[6]. Figure 3.2 shows the fund flow among the various sector of the economy. Following these relations, the central bank can directly control the credit supply of the formal bank by influencing the capital structure and interest rate of formal banks but not that of the informal bank directly.

Both banks operate in a monopolistic competitive environment, which enable them to set prices (rates) on their instruments. The goal of each bank is to maximize profit from their intermediation process. Another key feature of the financial sector is that the banks adhere to the balance sheet identity which postulates that total loans should be equivalent to total deposits and bank equity.

[6]In this model we assumed that the formal bank serves as a "vault" (i.e. a wholesale banker) to the informal bank. The relationship between the formal bank and the informal bank is the same as the relationship between the retail branches of the formal bank and its wholesale branch. This assumption though conforms to practice, it helps link informal activities to formal activities and consequently the central bank.

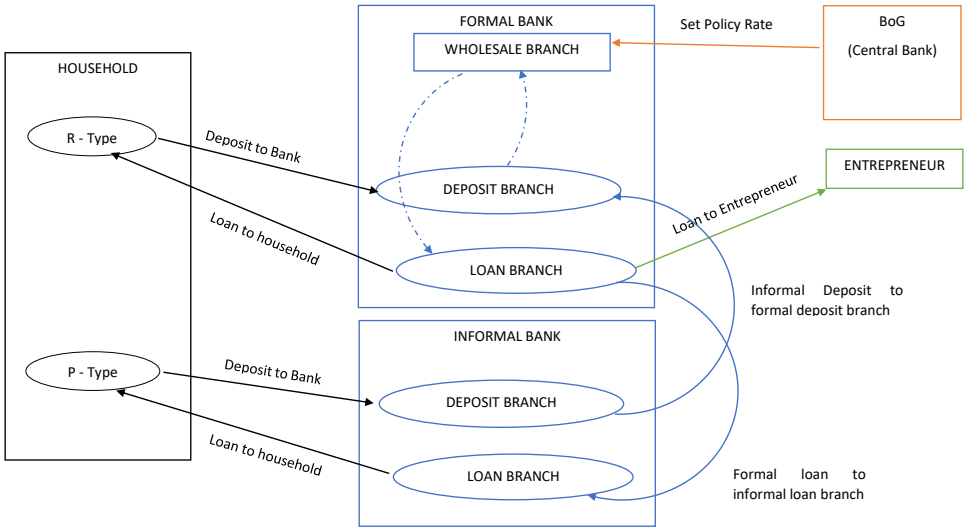

Figure 3.2: Funds Flow in the Economy

Formal Bank

The formal bank consists of a wholesale and retail branches[7]. The wholesale unit manages the capital position and raises wholesale deposits and loans in the inter-bank market. The retail branch consists of a deposit and loan branch which are respectively responsible for raising differentiated deposits from the r household and giving out differentiated loans to the r household, the entrepreneur, and the informal loan branch. To ease the notation and consistently with the fact that the formal sector deals with the r household indexed by r, deposits issued by the formal bank is $D_{r,t}$. Total formal bank loan $B_{f,t}$ is the sum of loans the formal bank issued to the r household $B_{r,t}$, entrepreneur $B_{e,t}$ and the informal bank $B_{p,t}$.

[7]It should be noted that the branches are not separated from one another. The wholesale branch acts on behalf of the bank in the interbank market. As a result, the deposit it can offer on the interbank market must be the same as the deposit accumulated from the household. Similarly, the total loan it is willing to access from the inter-bank should be equivalent to the total loans the retail branch offer to its clients or agents.

Thus,

$$B_{f,t} = B_{e,t} + B_{p,t} + B_{r,t}. \tag{3.26}$$

Wholesale Branch: The wholesale branch combines net worth (capital and deposit) to issue loans on the interbank market. The branch decides optimally the liquidity to supply and the deposits to issue. It takes the interbank lending interest rate as given and also, takes the policy rate set by the central bank as given and remunerate deposits at that rate.

The wholesale activity is assumed to generate a cost related to the capital position of the bank. That is, the bank pays a quadratic cost whenever the capital to asset ratio $\left({}^{K_t^b}/_{B_{f,t}}\right)$ deviates from the required value V^b. The required value V^b is the regulatory capital requirement set for universal banks.

The capital K_t^b of the bank accumulates according to

$$K_t^b = (1-\delta^b)K_{t-1}^b + \omega^b J_{t-1}^b. \tag{3.27}$$

where J^b is the bank's profit derived from retail intermediation process, ω^b is the ratio of retained profit, and δ^b is the resources used in managing bank capital and conducting overall intermediation process.

The problem of this branch is to maximize profit subject to a balance sheet constraint. Specifically,

$$\begin{aligned} \underset{\{B_{f,t},D_{r,t}\}}{\text{Max}} \quad & E_0 \sum_{t=0}^{\infty} \beta_r^t \left(\left(1+R_t^b\right) B_{f,t} - \left(1+R_t^d\right) D_{r,t} - K_t^b - \frac{k_{kb}}{2}\left(\frac{K_t^b}{B_{f,t}} - V^b\right)^2 K_t^b \right) \\ \text{s.t.} \quad & B_{f,t} = D_{r,t} + K_t^b, \end{aligned} \tag{3.28}$$

where β_r is the discount factor the bank applies to its income stream[8], R_t^b and R_t^d are the wholesale lending and deposit rates respectively, and k_{kb} is the wholesale intermediation cost.

Since this branch operates under perfect competitive environment, it takes the lending and deposit rates as given. The decision of the branch is therefore, to determine the total credits to access from the inter-bank market and also the total deposit to extend to the market. The resulting foc is

$$\frac{\partial}{\partial B_{f,t}} : \beta_r^t \left[\left(1+R_t^b\right) + k_{kb}\left(\frac{K_t^b}{B_{f,t}} - V^b\right)\left(\frac{K_t^b}{B_{f,t}}\right)^2 \right] = \lambda_t^b,$$

$$\frac{\partial}{\partial D_{r,t}} : -\beta_r^t \left[\left(1+R_t^d\right) \right] = \lambda_t^b,$$

[8]This paper assumed that the banks apply the discount factor of the rich household to their profit. This follows the assumption that the r household owns both formal and informal banks in the economy.

where λ_t^b is the Lagrange multiplier. Combining the above focs results in the relation that links the spread between wholesale rates on loans and deposit with the leverage ratio. The relation is given as

$$R_t^b = R_t^d - k_{kb}\left(\frac{K_t^b}{B_{f,t}} - V^b\right)\left(\frac{K_t^b}{B_{f,t}}\right)^2. \tag{3.29}$$

It is assumed that banks remunerate deposit at an interest rate equal to the policy rate r_t set by the central bank, that is $R_t^d = r_t$. The policy rate r_t is used to conduct monetary policy, and it follows a Taylor rule as specified and explained in section 3.3.6. Given the above relation, the wholesale loan rate prevailing in the interbank market becomes

$$R_t^b = r_t - k_{kb}\left(\frac{K_t^b}{B_{f,t}} - V^b\right)\left(\frac{K_t^b}{B_{f,t}}\right)^2. \tag{3.30}$$

Equation 3.30 prescribes the role of capital in determining loan supply. The relation indicates that as far as there exist wedge between loan and the policy rate the bank would increase loan supply, which will consequently increase leverage and profit per unit capital (i.e. return on equity). At the same time, increasing leverage reduces profit since the capital-to-asset ratio moves away from the capital required ratio V^b. This trade-off causes the bank to choose loan level such that the marginal cost for reducing the capital-to-asset ratio is exactly equal to the loan-deposit interest rate spread.

Loan Branch: This branch takes wholesale loans from the wholesale unit at the rate R_t^b, differentiates them at zero cost and resell them to impatient r household and entrepreneurs. The branch also gives loans facilities to the informal loan branch in the event the latter is liquidity constrained. The branch advances loan to the informal bank at the same rate as the entrepreneur[9]. The bank faces quadratic adjustment cost for changing interest rates. The rational is to introduce stickiness to capture imperfect pass-through. Parameterizing the cost the branch incur while extending loans to household and entrepreneur as k_{br} and k_{be} respectively, then the branch will optimize its profit specified as:

$$\underset{r_{r,t}^b(j), r_{e,t}^b(j)}{\text{Max}} E_0 \sum_{t=0}^{\infty} \beta_r^t \Bigg(r_{r,t}^b(j) B_{r,t}(j) + r_{e,t}^b(j) B_{e,t}(j) + r_{e,t}^b(j) B_{p,t} - R_t^b B_{f,t} -$$

$$\frac{k_{br}}{2}\left(\frac{r_{r,t}^b(j)}{r_{r,t-1}^b(j)} - 1\right)^2 r_{r,t}^b(j) B_{r,t}(j) - \frac{k_{be}}{2}\left(\frac{r_{e,t}^b(j)}{r_{e,t-1}^b(j)} - 1\right)^2 r_{e,t}^b(j) B_{e,t}(j)\Bigg). \tag{3.31}$$

[9]In practice, formal banks operate with informal banks on special arrangements. However, in this study, it is assumed that formal banks operate with informal banks as business entity, hence the formal bank advances loans to the informal bank at the same rate as the entrepreneur.

It is worth recalling that $B_{r,t}$, $B_{e,t}$ and $B_{p,t}$ represent loan credits that the formal bank offers the rich household, the entrepreneur and informal bank respectively. The profit maximization problem of the branch is to choose retail interest rates $r^b_{r,t}(j)$ and $r^b_{e,t}(j)$ subject to the demand schedules respectively for the household and entrepreneur as

$$B_{r,t}(j) = \left(\frac{r^b_{r,t}(j)}{r^b_{r,t}}\right)^{-\epsilon_{br}} B_{r,t}, \tag{3.32}$$

$$B_{e,t}(j) = \left(\frac{r^b_{e,t}(j)}{r^b_{e,t}}\right)^{-\epsilon_{e}} B_{e,t}, \tag{3.33}$$

where $B_{f,t} = B_{r,t} + B_{e,t} + B_{p,t}$. The resulting FOCs stipulate the lending interest rate equation for the entrepreneur and rich household respectively as

$$\begin{aligned} &1 - \epsilon_e + \left(\frac{B_{p,t}}{B_{e,t}}\right) + \left(\frac{R^b_t}{r^b_{e,t}}\right)\epsilon_e - k_{be}\left(\frac{r^b_{e,t}}{r^b_{e,t-1}} - 1\right)\frac{r^b_{e,t}}{r^b_{e,t-1}} + \\ &\beta_r E_t\left(\left(\frac{\lambda^p_{t+1}}{\lambda^p_t}\right) k_{be}\left(\frac{r^b_{e,t+1}}{r^b_{e,t}}\right)^2\left(\frac{r^b_{e,t+1}}{r^b_{e,t}} - 1\right)\left(\frac{B_{e,t+1}}{B_{e,t}}\right)\right) = 0, \end{aligned} \tag{3.34}$$

$$\begin{aligned} &1 - \epsilon_{br} + \left(\frac{R^b_t}{r^b_{r,t}}\right)\epsilon_{br} - k_{br}\left(\frac{r^b_{r,t}}{r^b_{r,t-1}} - 1\right)\frac{r^b_{r,t}}{r^b_{r,t-1}} + \\ &\beta_r E_t\left(\left(\frac{\lambda^p_{t+1}}{\lambda^p_t}\right) k_{br}\left(\frac{r^b_{r,t+1}}{r^b_{r,t}}\right)^2\left(\frac{r^b_{r,t+1}}{r^b_{r,t}} - 1\right)\left(\frac{B_{r,t+1}}{B_{r,t}}\right)\right) = 0, \end{aligned} \tag{3.35}$$

Deposit Branch: The deposit branch performs its operations in reversed form. This branch collects deposits $D_{r,t}(j)$ from the savers of the r household and then passes the accumulated funds to the wholesale unit at rate R^d_t. The deposit branch also accepts deposit $D_{p,t}$ from the informal bank, and pays the bank the same interest rate it pays savers of the rich household. Analogous to the loan branch, the deposit branch incurs a quadratic adjustment cost k_{dr} for changing the deposit rate. The aim of the branch is to choose the retail deposit rate $r^d_{r,t}(j)$ to maximize profit. Formally,

$$\begin{aligned} \underset{r^d_{r,t}(j)}{\text{Max}} E_0 \sum_{t=0}^{\infty} \beta^t_r \Bigg(& R^d_t\Big(D_{r,t}(j) + D_{p,t}\Big) - r^d_{r,t}(j)D_{r,t}(j) - r^d_{r,t}(j)D_{p,t} \\ & - \frac{k_{dr}}{2}\left(\frac{r^d_{r,t}(j)}{r^d_{r,t-1}(j)} - 1\right)^2 r^d_{r,t}(j)D_{r,t}(j)\Bigg) \end{aligned} \tag{3.36}$$

$$\text{s.t.} D_{r,t}(j) = \left(\frac{r^d_{r,t}(j)}{r^d_{r,t}}\right)^{-\epsilon_{dr}} D_{r,t} \tag{3.37}$$

The FOC for optimal deposit interest rate setting is

$$-1+\epsilon_{dr}-\left(\frac{D_{p,t}}{D_{r,t}}\right)-\epsilon_{dr}\left(\frac{R_t^d}{r_{r,t}^d}\right)-k_{dr}\left(\frac{r_{r,t}^d}{r_{r,t-1}^d}-1\right)\frac{r_{r,t}^d}{r_{r,t-1}^d}+$$
$$\beta_r E_t\left(\left(\frac{\lambda_{t+1}^p}{\lambda_t^p}\right)k_{dr}\left(\frac{r_{r,t+1}^d}{r_{r,t}^d}\right)^2\left(\frac{r_{r,t+1}^d}{r_{r,t}^d}-1\right)\left(\frac{D_{r,t+1}}{D_{r,t}}\right)\right)=0 \tag{3.38}$$

Informal Bank

The informal bank intermediates between borrowers and depositors of the p household by accepting deposits from savers, and also providing loan to borrowers. The bank exhibits similar characteristics to that of the formal bank in its operations except that it does not engage in inter-bank market activities. Rather, the bank deposits its fund with the formal bank deposit branch at the prevailing deposit rate, and also, takes funds from the loan branch of the formal bank at the same interest rate that faces the entrepreneur[10]. As a result of this, the informal bank interest rate setting condition is not directly affected by central bank's action (i.e. policy rate), rather via the intermediate route of formal banks. Following a similar modeling approach in the formal sector, the informal bank has two retail branches - a loan and deposit branch responsible for extending loans and collecting deposits respectively. Since the informal bank deals with the poor household indexed p, loans and deposits issued by the informal bank are denoted respectively $B_{p,t}$ and $D_{p,t}$ to ease notation.

Deposit Branch: This branch collects deposit $D_{p,t}(j)$ from the p household savers at an interest rate $r_{p,t}^d(j)$ and then passes the raised fund to the formal deposit branch at rate $r_{r,t}^d$. The bank incurs a quadratic adjustment cost (k_{dm}). The profit maximization problem of the branch is give as

$$\underset{r_{p,t}^d(j)}{\text{Max}}E_0\sum_{t=0}^{\infty}\beta_r^t\left(r_{r,t}^d D_{p,t}(j)-r_{p,t}^d(j)D_{p,t}(j)-\frac{k_{dm}}{2}\left(\frac{r_{p,t}^d(j)}{r_{p,t-1}^d(j)}-1\right)^2 r_{p,t}^d(j)D_{p,t}(j)\right) \tag{3.39}$$

$$\text{s.t.}D_{p,t}(j)=\left(\frac{r_{p,t}^d(j)}{r_{p,t}^d}\right)^{-\epsilon_{dp}}D_{p,t} \tag{3.40}$$

where $r_{r,t}^d D_{p,t}(j)$ is the total value of deposits passed to the formal deposit branch, $r_{r,t}^d$ is the formal deposit rate the branch received as return on its deposit. and

[10]The mechanism where informal bank passes its deposits to the formal bank, and also takes loan from it, is similar to the relationship that exists between the retail branches of the formal bank and the wholesale branch. By this means, the formal bank serves as "vault" for the informal bank. Though, this mechanism is evident in practice, it is also a modeling device to link informal banking activities to that of the formal bank

$r^d_{p,t}(j)D_{p,t}(j)$ is total value of deposit collected from the poor household. The branch optimizes with respect to the deposit rate $r^d_{p.t}(j)$. The first order condition results in the pricing relation for informal deposit rate specified as

$$-1+\epsilon_{dp}-\epsilon_{dp}\frac{r^d_{r,t}}{r^d_{p,t}}-k_{dm}\left(\frac{r^d_{p,t}}{r^d_{p,t-1}}-1\right)\frac{r^d_{p,t}}{r^d_{p,t-1}}+$$

$$\beta_r\left(\left(\frac{\lambda^p_{t+1}}{\lambda^p_t}\right)k_{dm}\left(\frac{r^d_{p,t+1}}{r^d_{p,t}}\right)^2\left(\frac{r^d_{p,t+1}}{r^d_{p,t}}-1\right)\left(\frac{D_{p,t+1}}{D_{p,t}}\right)\right)=0 \tag{3.41}$$

Loan Branch: This branch takes accumulated deposits from the deposit branch, differentiates them at no cost and resell them to the p household borrowers. It takes loan from the formal loan branch in the advent of cash shortage. It incurs cost k_{bm} to advance the loans. The profit of the branch is specified as

$$\underset{r^b_{p,t}(j)}{\text{Max}}E_0\sum_{t=0}^{\infty}\beta^t_r\left(r^b_{p,t}(j)B_{p,t}(j)-r^b_{e,t}B_{p,t}(j)-\frac{k_{bm}}{2}\left(\frac{r^b_{p,t}(j)}{r^b_{p,t-1}(j)}-1\right)^2 r^b_{p,t}(j)B_{p,t}(j)\right) \tag{3.42}$$

where $r^b_{e,t}B_{p,t}$ is the value of loan accessed from the formal loan bank, and $r^b_{e,t}$ is the interest cost of the loan. The branch maximizes its profit by choosing interest rate $r^b_{p,t}(j)$ subject to the demand schedule

$$B_{p,t}(j)=\left(\frac{r^b_{p,t}(j)}{r^b_{p,t}}\right)^{-\epsilon_{bp}}B_{p,t} \tag{3.43}$$

The FOC from the above problem gives the retail pricing equation for the poor household. This is specified as

$$1-\epsilon_{bp}+\epsilon_{bp}\frac{r^b_{e,t}}{r^b_{p,t}}-k_{bm}\left(\frac{r^b_{p,t}}{r^b_{p,t-1}}-1\right)\frac{r^b_{p,t}}{r^b_{p,t-1}}+$$

$$\beta_r\left[\left(\frac{\lambda^p_{t+1}}{\lambda^p_t}\right)k_{bm}\left(\frac{r^b_{p,t+1}}{r^b_{p,t}}\right)^2\left(\frac{r^b_{p,t+1}}{r^b_{p,t}}-1\right)\left(\frac{B_{p,t+1}}{B_{p,t}}\right)\right]=0 \tag{3.44}$$

From the equation, the loan rate in this sector does not depend directly on the interbank rate, rather, indirectly through $r^b_{e,t}$. The speed of adjustment depends on the cost of changing interest rate and the discount factor. This is different from that of the formal sector whose pricing decisions directly depend on the policy rate and the elasticity of substitution. This unique characteristic makes the informal sector price-setting directly dependent on formal activities but indirectly dependent of monetary authorities.

3.3.4 Retailers

Retailers are only brander who purchase intermediate goods from entrepreneurs at wholesale price P_t^w. They operate in a monopolistic competitive environment and differentiate the goods at zero cost. Retailers set price at a mark-up over wholesale price and index prices to past prices at a degree. Retailers are assumed to index prices to a combination of past and steady state inflation, with relative weights parametrized by l. They also face quadratic price adjustment cost κ_p when changing prices. The rational is to introduce prices stickiness in the model. Retailers thus choose optimal price level $p_{j,t}$) by solving the problem

$$\begin{aligned} \underset{p_{j,t}}{\text{Max}} \quad & E_t \sum_{t=0}^{\infty} \beta_e^t \left(p_{j,t} y_{jt} - P_t^w y_{j,t} - \frac{k_p}{2} \left(\frac{p_{j,t}}{p_{j,t-1}} - \pi_{t-1}^{l} \pi^{1-l} \right)^2 p_t y_t \right) \\ \text{s.t} \quad & y_{j,t} = \left(\frac{p_{j,t}}{p_t} \right)^{-\epsilon_t^y} y_t \end{aligned} \tag{3.45}$$

Imposing symmetric equilibrium, the FOC results in a non-linear Philip curve for price inflation specified as

$$1 - \epsilon_t^y + \epsilon_t^y \frac{P^w}{P} - \kappa_p \left(\pi_t - \pi_{t-1}^{l} \pi^{1-l} \right) \pi_t + \beta_p E_t \left(\frac{\lambda_{t+1}^p}{\lambda_t^p} \kappa_p \left(\pi_{t+1} - \pi_t^{l} \pi^{1-l} \right) \pi_{t+1} \frac{y_{t+1}}{y_t} \right) = 0 \tag{3.46}$$

3.3.5 Capital Producers

Capital producers provide the capital demanded by the entrepreneur. Modeling the capital producer helps to derive the market price for capital, which is necessary to determine the value of entrepreneurs' collateral, against which banks concede loans. The problem of the capital producer follows the standard approach with detailed description in Dib (2009). The firm at beginning of each period purchases final good (I_t) from retailers and stock of un-depreciated capital $(1-\delta)K_{t-1}$ from entrepreneurs. Old capital is converted on one-to-one into new capital, but transforming final good involves quadratic adjustment cost (κ_i). The firm maximizes the objective function

$$\underset{I_t}{\text{Max}} \quad E_t \sum_{0}^{\infty} \beta_e^t \left(q_t \left(I_t - \frac{\kappa_i}{2} \left(\frac{I_t}{I_{t-1}} - 1 \right)^2 \right) - I_t \right) \tag{3.47}$$

The aggregate capital stock evolves according to

$$K_{t+1} = (1-\delta) K_t + \left(1 - \frac{\kappa_i}{2} \left(\frac{I_t}{I_{t-1}} - 1 \right)^2 \right) I_t \tag{3.48}$$

The real price of capital q_t resulting from the maximization problem is given by

$$1 = q_t \Bigg(1 - \frac{\kappa_i}{2} \left(\frac{I_t}{I_{t-1}} - 1 \right)^2 - \kappa_i \left(\frac{I_t}{I_{t-1}} - 1 \right)^2 \frac{I_t}{I_{t-1}} + \beta_e E_t \left(\frac{\lambda^E_{t+}}{\lambda^E_t} q_{t+1} \kappa_i \left(\frac{I_{t+1}}{I_t} - 1 \right) \left(\frac{I_{t+1}}{I_t} \right)^2 \right) \Bigg) \tag{3.49}$$

3.3.6 Monetary Policy

The central bank conducts monetary policy through a Taylor-rule function. It sets the short-term nominal interest rate r_t in response to a deviation of output y_t and inflation π_t from their respective target level. The interest rate reaction function is thus given as:

$$r_t = \epsilon^r_t r \left(\frac{\pi_t}{\pi} \right)^{\phi_\pi} \left(\frac{y_t}{y_{t-1}} \right)^{\phi_y} \tag{3.50}$$

where ϕ_π and ϕ_y are the weights assigned to inflation and output stabilization respectively. r is the steady state nominal interest rate and ϵ^r_t is an exogenous monetary policy shock, which follows AR(1) stochastic process.

Monetary Transmission

Monetary transmission is the mechanism through which the central bank influences the economy. The financial sector plays a major role in this regard. The process involves the central bank using its policy rate to influence retail interest rates and consequently influencing the real economy. From the model description, there are various interest rates in the economy. Table 3.1 gives the interest rates in the model and their descriptions.

Conducting monetary policy in the model description, the central bank uses a Taylor rule specification as in equation 3.50. A monetary shock via equation 3.50 affects the inter-bank (wholesale) lending rate through equation 3.30. This subsequently influences the lending rate of the formal bank via equations 3.35 and 3.34. Further, monetary policy affects the lending rate of informal banks through the lending rate of formal banks as indicated in equation 3.44. Analogously, monetary transmission to the deposit rate follows the same mechanism.

The effect of monetary policy on the real sector is through the intermediate effect that interest rate has on consumption through the Euler equation in the household sector.

Table 3.1: Variable Description

Interest Rate	Description
$r^b_{r,t}$	formal bank lending rate to rich household
$r^b_{e,t}$	Formal bank lending rate to entrepreneur
$r^d_{r,t}$	Formal bank deposit rate to rich household
$r^b_{p,t}$	Informal bank lending rate to poor household
$r^d_{p,r}$	Informal bank deposit rate to poor household
R^b_t	Interbank lending rate
R^d_t	Interbank deposit rate
r_t	Monetary policy rate

3.3.7 Aggregation

In the model set-up, there are two type of households and financial intermediaries. As a result, the total available credit is given by the sum of credits advanced by both formal and informal banks. At equilibrium, the total credit advanced by the financial intermediaries must equal the total credit demand by the household and firm. Given the total share of informal banks in the economy as z, then aggregate credit is given by

$$B_t = B^z_{pt}(B_{rt}B_{et})^{(1-z)}.$$

Also, aggregate consumption is given by

$$C_t = C^g_{pt}C^v_{rt}C^{(1-v)}_{et},$$

where g is the share of poor household, and v is the share of rich household.

3.4 Model Analysis

The preceding sections focused on the model descriptions. In the sections that follow, the quantitative properties of the model are investigated. First, the study presents the model parameterization and explains the numerical solution method used. Next the dynamics of the linearized model are investigated using impulse responses. The study then analyzes the effect of monetary, technology, and credit shocks considering how the shocks propagate through the economy, both with and without informal banks. Further, we investigate the effect of monetary policy on aggregate loan supply depending on the relative share of intermediation through the informal banking system in the economy.

3.4.1 Calibration

The model was calibrated to closely match the Ghanaian economy, drawing parameter estimates from a wide range of available information. The parameter estimates were selected to capture specific ratios in the Ghanaian economy as closely as possible, by ensuring the adherence to the model properties. However, parameters that were not easily calibrated or available for Ghana were sourced from the literature.

As described above, the model is characterized by heterogeneous agents in the economy. Agents differ according to the discount factor they attached to their lifetime utility, the elasticity of substitution for both credit and deposit. These differences are associated with the different interest rate banks charge to their client. The banks charge different interest rates[11] because of factors such as the different risk rich and poor agents posed to their respective banks. This is captured in different numerical value attached to β_p, β_r, β_e, ϵ_{bp} and ϵ_{dp}

The calibration for the informal sector concentrated on some major players in the sector. This is because, the sector is characterized by heterogeneous players hence, it is difficult to pin down a parameter value that is acceptable, applicable or both for every part of the sector. The study chose calibrated parameters based on available data and ensured that the chosen estimates conforms to the underlying steady state relationship prescribed by the model. Accordingly, ϵ_{bp} and ϵ_{dp} were set to 0.3 and -99 respectively. This is done to match the spread as provided by the steady state relation which stipulates that the steady state spread between informal lending rate and formal lending rate to the entrepreneur depends on ϵ_{bp}. Thus, the value is calibrated between the two rates to ensure a markup of 20 percent. Following the same analogy, we calibrate for the other elasticities.

The cost parameters of the formal bank, k_{dr}, k_{kb} and k_{br} were set respectively at 110, 5 and 70. These parameters were estimated by Gerali et al. (2010) for the euro market, hence, they were adopted for this study. The cost parameters of the informal bank were calculated using data from Micro-finance Information Exchange. We estimated the log-linearized relation of the informal lending rate (equation 3.44) using Micro-finance Information Exchange data. The cost parameters were then deduced from the estimated coefficient. These parameters, k_{dm} and k_{bm} were set respectively at 100 and 60.

We set the proportion of household who are poor g in the economy to 0.25. This is in line with the extreme poverty ratio in Ghana estimated by GLSS V. The discount factors β_p and β_r are set respectively to 0.975 and 0.990 to match a steady-state deposit rate slightly above 5.4% and 5.2% for the informal and formal

[11] Interest rates charged by the informal banks are higher than that of the formal banks. Whiles the average lending rate among the commercial banks is about 35% in the year 2014, that of micro-finance is about 70% for the same year.

bank respectively. Similarly, β_e is set to 0.925.

The capital requirement V^b of the formal bank is set at 0.09 according to the capital requirement imposed by Basel II. This value is however, set slightly higher than the Basel requirement. This is because most central banks peg their requirement slightly above that of Basel requirements.

In the literature, there is not yet commonly accepted estimate for risk aversion θ. However, the commonly accepted measure lies between 1 and 3, though there are wide range of estimates in the literature[12]. Therefore, in accordance to the literature, the risk averse coefficient θ is set at 2. Similarly, the capital share α is set at 0.5. The auto-regressive coefficients ρ of the shocks were each set to 0.95. The calibrated values are provided in Table 3.2

3.4.2 Numerical Solution

The non-linear model was solved with the occasional binding constraint for various agents. That is, households' total income must be equivalent to its expenditures. Also, the total loan loans an impatient agent can access must in equilibrium be equivalent to the expected value of collateral.

Using appropriate initial values, the study estimated the steady state values using a nonlinear equation solver. The nonlinear equation solver used is the Newton method with quadratic searching. Further, the non-linear model was log-linearized around the steady state using first order Taylor approximation. The steady states relations and the log-linearized equations are provided in the technical appendix.

3.4.3 Response to Monetary Shock

This section presents the results of the behavior of the generated impulse response function (IRF) for some selected aggregate variables to an unexpected monetary tightening. We investigate the IRF to determine whether the inclusion of the informal banks alters monetary transmission.

In the model description, there are various types of interest rates in the economy. These rates emanate from formal bank supplying credit to the rich household and the entrepreneur; and informal bank supplying credit to the poor household. As presented in Tale 3.1, the retail interest rates prevailing in the economy are formal bank lending rate to rich household $r^b_{r,t}$, formal bank lending rate to entrepreneur $r^b_{e,t}$, formal bank deposit rate $r^d_{r,t}$, informal bank lending rate to poor household $r^b_{p,t}$, and informal bank deposit rate $r^d_{p,t}$. The formal bank activity is linked directly to the central bank via the inter-bank market while the informal bank is linked indirectly via the formal bank.

[12]See among others, Chetty (2006); Campo et al. (2011); Kapteyn and Teppa (2011)

The behavior of credits and interest rates to a monetary tightening is depicted by the IRF shown in figure 3.3. Monetary tightening causes the interbank rate to increase. This increase translates into increased funding cost of formal banks, which simultaneously causes interest rate to rise for rich household and firms. The rise in interest rate tightens credit availability to these agents. Regarding the behavior in the informal market, the interest rate that poor household face by banking with the informal bank is not affected by monetary shocks immediately. It takes about a quarter before monetary shock causes interest rate in the informal banks to increase. This is because, monetary shock influences informal bank indirectly only via their interrelationship with the formal bank, thus creating some lag in monetary transmission. Hence it is not surprising the effect of monetary shock is not immediate on informal bank activities.

The effect of a monetary shock on formal bank credit is different from the effect on informal bank credit. In line with the conventional view, contraction monetary shock which results in interest rate increase leads to credit tightening to both the rich household and the firm. In contrast, contraction monetary shock eases credit availability to the poor household. The counter effect of monetary policy on credit among informal banks could be due to the fact that informal banks' credit intermediation is not directly constrained by the central bank. This situation was identified by studies such as Altunbas et al., 2009, Den Haan and Sterk, 2010, and Igan et al., 2013, which showed that while universal banks react to monetary tightening by reducing credit lending, non-banks conversely react by increasing lending.

The overall effect of monetary tightening on aggregate credit is an initial increase which declines steadily to approximately fourth quarters before rising again. Hence, from the above its evident that the immediate effect of monetary contractions on loans in the presences of informal banking is an increase in credit availability. This is in contrast to situation without informal banking. This suggests that the relative size of the formal and informal banking sector determines the direction and effect of monetary policy in an economy with dual financial market.

3.4.4 Response to Technology Shock

In this section we investigate the IRF following a positive technology shock. We consider the case of one standard deviation corresponding to 1% increase of the goods producer's productivity.

Following the standard mechanism, a positive technology shock increases the marginal productivity of both labor and capital, which further causes investment to increase. Increased investments raise the price of capital, consequently increasing net worth whiles decreasing the desire for external finance.

In order to undertake investment activities (due to increase in investment),

the entrepreneur's demand for credit from the formal bank increases. This consequently leads to interest rate increase. The resulting IRF function is showed in figure 3.4. The figure shows that the presences of informal credit intermediation do not affect how technology shock influences the economy.

3.4.5 Response to Credit Shock in the Informal Sector

The literature has identified credit restrictions to affect and influence aggregate variables. The evidences are well documented for formal baning activities. Given the interrelations between formal and informal credit activities, we investigated the situation with both credit intermediation processes.

To achieve this, we treated the loan-to-value ratio as stochastic. We then shocked the LTV and investigated the behavior of the IRFs generated. We considered a positive shock to the LTVs, a situation of one standard deviation corresponding to 1% increase of credit availability from the banking sector. The generated IRFs for the credit supply shock to the rich household, poor household and the entrepreneur are provided in figures 3.5, 3.6 and 3.7 respectively. A qualitative inspection of the graphs reveals that the effect of credit shocks (i.e. formal and informal credit shocks) are the same across all sectors. However, the IRFs show that whiles credit shock to the rich household and entrepreneur has similar quantitative effect on aggregate credit, this effect (which is about 0.5) is greater than the effect of credit shock in the informal sector (which is about 0.13).

3.5 Conclusion

In conclusion, this study investigated the effect of monetary, credit, and technology shocks in an economy with informal banks co-existing with formal banks. This follows from the evidence that the activities of informal banks form an important component of the financial sector of many developing economies. Notwithstanding, this issue is not much investigated in the literature. Thus, this study contributes to the literature in this regard.

The study found that monetary shock affect formal bank differently from the informal bank. Whilst the formal bank react to monetary tightening by restricting credit, informal banks on the other hand react by increasing credit. Whether the aggregate credit will increase or decrease depends on whether informal activities dominates or formal activities.

Further, the study found that a credit restriction in the informal sector has similar effect as a credit restriction in the formal sector.

Appendix

Table 3.2: Calibrated Parameters

Parameters	Definition	Value
θ	Risk Averse coefficient	2
ϕ	Fricsh inverse elasticity of labor supply	1.5
α	Capital share in output production	0.5
ϕ_π	Inflation Stabilization weight	1.8
ϕ_y	Output Stabilization weight	0.2
V^b	Optimal Capital Requirement	0.09
δ_b	Bank Capital depreciation	0.15
k_{kb}	Wholesale Intermediation cost	5
k_{br}	Loan adjustment cost to r household	70
k_{dr}	Deposit adjustment cost to r	110
k_{bm}	loan adjustment cost to p household	60
k_{dm}	deposit adjustment cost to p	100
ϵ^{dp}	Elasticity of substitution for p deposit	99
ϵ^{bp}	Elasticity of substitution for p credits	0.3265
ϵ^{br}	Elasticity of substitution for r credits	3
ϵ^{dr}	Elasticity of substitution for r deposits	0.588
ϵ^{e}	Elasticity of substitution for entrepreneur credits	5
ϵ^{y}	Elasticity of substitution for final goods	2
ρ_A	AR coefficient of capital shock	0.95
ρ^{er}	AR coefficient of Entrepreneur LTV shock	0.95
ρ^{mur}	AR coefficient of r LTV shock	0.95
ρ^{mup}	AR coefficient of p LTV shock	0.95
ρ^{r}	AR coefficient of monetary shock	0.95
g	Proportion of P	0.25
v	Proportion of R	0.1849
β_p	P Discount Factor	0.990
β_r	R Discount Factor	0.975
β_e	Entrepreneur Discount factor	0.925
k_p	Retailers Adjustment cost	2

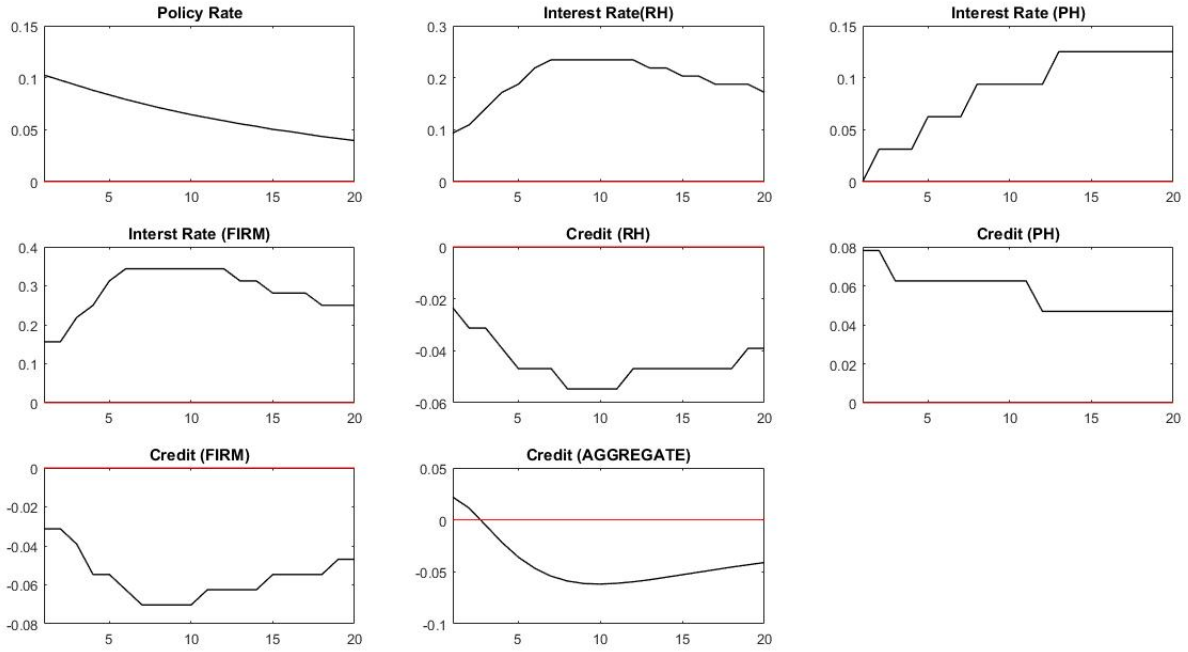

Figure 3.3: IRFs to Monetary Shock

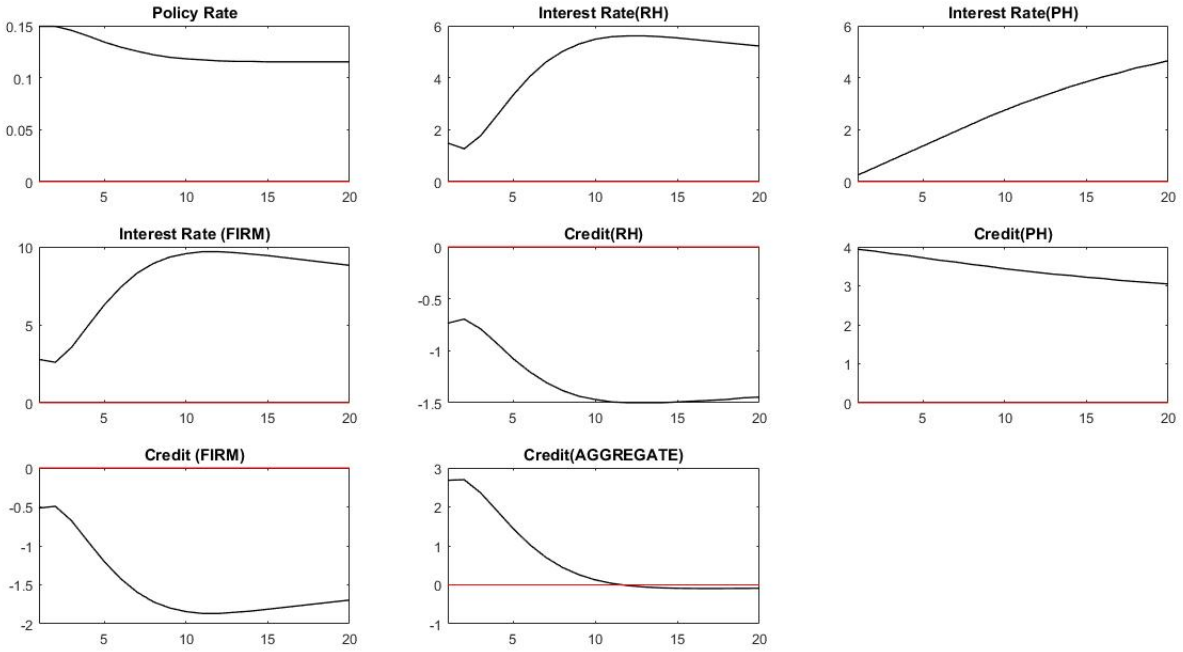

Figure 3.4: IRFs to Technology Shock

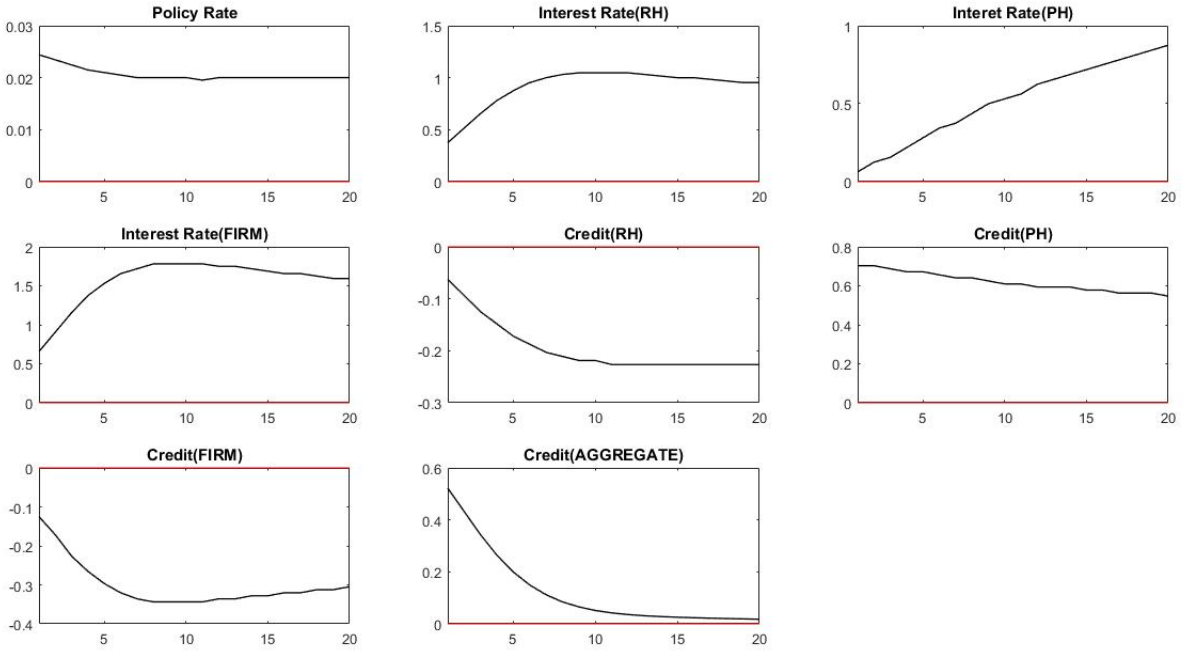

Figure 3.5: IRFs to R Household Credit Shock

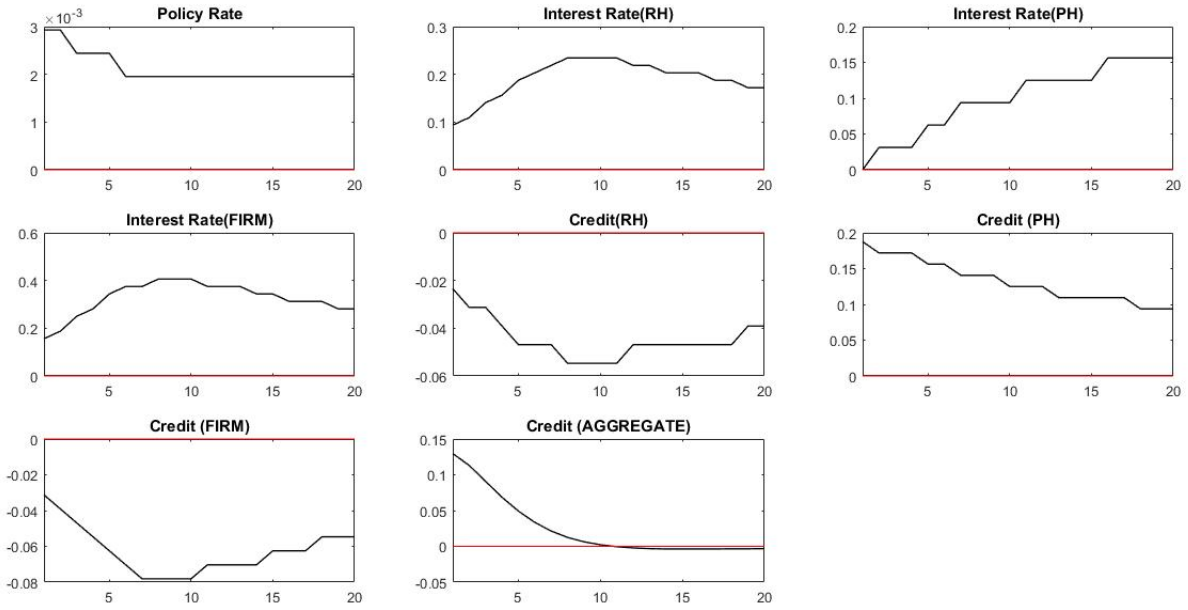

Figure 3.6: IRFs to P Household Credit Shock

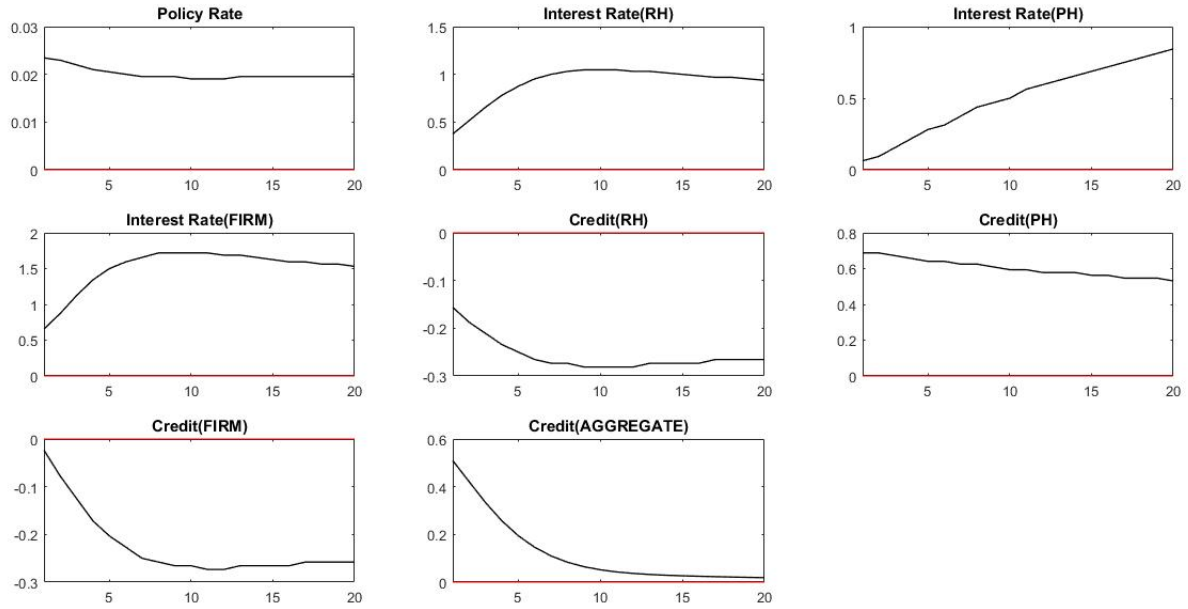

Figure 3.7: IRFs to Firm Credit Shock

4 Conclusion and Recommendation

The thesis presented two original papers on monetary policy effectiveness. It began the investigation by reviewing the literature and highlighting the weakness embedded in monetary implementation. Chapter one provided the literature on effective monetary policy. From the literature surveyed, the chapter showed that monetary policy is weak in influencing its target. As a result, this study is conducted to identify factors that may affect monetary effectiveness.

Following from the evidence of weak monetary policy in developing economies as identified in the literature presented in Chapter one, the thesis followed to investigate the potential reason for the weak pass-through. In view of this, this study assumed that the relationship between formal and informal banks in the credit intermediation process could influence monetary pass-through. This is because while the central bank through its policy tool can directly influence the credit issuance of formal banks, it cannot do same to the informal bank. This is as result of informal bank's activities not related directly with the central bank. This relationship between the two type of banks could play an important role in the pricing decision and credit issuance of formal banks, thus influencing the pass-through. This relationship was investigated empirically in chapter two using a Ghanaian data. The findings from this chapter revealed that though pass-through estimates are very low for Ghana, the presence of informal credit intermediation further dampens it. The pass-through without informal credit intermediation is estimated at 0.033 and that with informal credit at 0.024. Therefore, it can be concluded that though informal activities further dampen pass-through, its inclusion marginally affected pass-through in Ghana.

Chapter three developed a DSGE model with informal credit intermediation. The purpose was to study the effect of monetary and credit shocks on the economy with the presence of informal credit activities. The study found that though monetary shock affected the informal bank and formal bank differently, the effect of credit shock from either the formal or informal bank is the same on the economy

Overall, the findings from the thesis highlights the need to strengthen the current monetary policy design in Ghana to be more effective. Also, there is the need to guide the activities of informal credit intermediaries to prevent possible spillover effect from this sector. This study can be advanced in the following dimensions

- In the DSGE framework, the financial market was modeled to consist of both formal and informal banks operating in different credit market. This assumption followed the theoretical foundation that supported the establishment of informal banks. However, recent trend in the financial market of Ghana shows that both formal and informal banks operate in a common credit market. Hence, the paper can be extended to incorporate the case where banks operate in common credit market. This is actually under consideration in my next paper.

- Also, the paper can be extended to deal with optimal policy in the presence of informal credit serving as leakages in the money multiplier process.

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Technical Appendix to "The Effect of Exogenous Shocks with Informal Credit Intermediation"

This appendix provides additional material for the study. It presents the full set of equations, discusses the calibrations, provide details on the model construction and describe the behavior through the log-linear version.

A.1 THE MODEL

A.1.1 Household

The household consists of the rich and Poor household type. The rich type accumulates wealth by banking with the formal bank. Likewise, the poor also accumulates wealth banking with the informal bank.

Poor Household (p):

Maximization problem

$$\begin{aligned} \underset{C_{p,t},N_{p,t},B_{p,t},D_{p,t}}{\text{Max}} \quad & E_0 \sum_{t=0}^{\infty} \beta_p^t \left(\frac{{C_{p,t}}^{1-\theta}}{1-\theta} - \frac{{N_{p,t}}^{1+\phi}}{1+\phi} \right) \\ \text{s.t.} \quad & C_{p,t} + D_{p,t} + \frac{1+r^b_{p,t-1}}{\pi_t} B_{p,t-1} = W_t N_{p,t} + \frac{1+r^d_{p,t-1}}{\pi_t} D_{p,t-1} + B_{p,t} \\ & \left(1+r^b_{p,t}\right) B_{p,t} \leq \mu^p_t E_t \left(W_{t+1} N_{p,t} \pi_{t+1}\right) \end{aligned} \tag{A.1}$$

Using λ^p_t and v^p_t as the budget constraint and borrowing constraint multipliers respectively, the FOCs are then given by

$$
\begin{aligned}
1 &= \lambda_t^p C_{p,t}^{\theta} \\
N_{p,t}^{\phi} &= \lambda_t^p W_t + V_t^p \mu_t^p E_t[W_{t+1}\pi_{t+1}] \\
\lambda_t^p &= \beta_p E_t\left(\lambda_{t+1}^p\left(\frac{1+r_{p,t}^d}{\pi_{t+1}}\right)\right) \\
\lambda_t^p &= (1+r_{p,t}^b)V_t^p + \beta_p E_t\left[\lambda_{t+1}^p\left(\frac{1+r_{p,t}^b}{\pi_{t+1}}\right)\right]
\end{aligned}
\tag{A.2}
$$

Rich Household (r)

Maximization problem

$$
\begin{aligned}
\underset{C_{r,t},N_{r,t},B_{r,t},D_{r,t}}{\text{Max}} \quad & E_0\sum_{t=0}^{\infty}\beta_r^t\left(\frac{{C_{r,t}}^{1-\theta}}{1-\theta}-\frac{{N_{r,t}}^{1+\phi}}{1+\phi}\right) \\
\text{s.t.} \quad & C_{r,t}+D_{r,t}+\frac{1+r_{r,t-1}^b}{\pi_t}B_{r,t-1} = W_t N_{r,t}+\frac{1+r_{r,t-1}^d}{\pi_t}D_{r,t-1}+B_{r,t} \\
& \left(1+r_{r,t}^b\right)B_{r,t} \leq \mu_t^r E_t\left(W_{t+1}N_{r,t}\pi_{t+1}\right)
\end{aligned}
\tag{A.3}
$$

Using λ_t^r and v_t^r as the budget constraint and borrowing constraint multipliers respectively, the FOCs are then given by

$$
\begin{aligned}
1 &= \lambda_t^r C_{r,t}^{\theta} \\
N_{r,t}^{\phi} &= \lambda_t^r W_t + V_t^r \mu_t^r E_t[W_{t+1}\pi_{t+1}] \\
\lambda_t^r &= \beta_r E_t\left(\lambda_{t+1}^r\left(\frac{1+r_{r,t}^d}{\pi_{t+1}}\right)\right) \\
\lambda_t^r &= (1+r_{r,t}^b)V_t^r + \beta_r E_t\left[\lambda_{t+1}^r\left(\frac{1+r_{r,t}^b}{\pi_{t+1}}\right)\right]
\end{aligned}
\tag{A.4}
$$

A.1.2 Entrepreneur (e)

The entrepreneur solves the problem

$$
\begin{aligned}
\text{Max} \quad & E_o\sum_{t=o}^{\infty}\beta_e^t\left[\frac{C_{e,t}^{1-\theta}}{1-\theta}\right] \\
\text{s.t.} \quad & Y_t = A_t K_t^{\alpha}{N_{e,t}}^{1-\alpha} \\
& C_{e,t}+W_t N_{e,t}+\left(\frac{1+r_{e,t-1}^b}{\pi_t}\right)B_{e,t-1}^e+q_t K_t = \frac{Y_t}{x_t}+B_{e,t}+q_t(1-\delta)K_{t-1} \\
& \left(1+r_{e,t}^b\right)B_{e,t} \leq \mu_t^e E_t\left(q_{t+1}\pi_{(t+1)}(1-\delta)K_t\right)
\end{aligned}
\tag{A.5}
$$

The resulting FOCs are given by

$$\lambda_e q_t = \frac{\lambda_t^e \alpha Y_t}{x_t k_t} + v_t^e \mu^e E_t \left(q_{t+1}\pi_{t+1}(1-\delta)\right) + \beta_e E_t \left(\lambda_{t+1}^e q_{t+1}(1-\delta)\right)$$

$$\lambda_t^e = V_t^e(1+r_{e,t}^b) + \beta_e E_t \left(\lambda_{t+1}^e \left(\frac{1+r_{e,t}^b}{\pi_{t+1}}\right)\right) \tag{A.6}$$

$$W_t = (1-\alpha)\frac{Y_t}{x_t N_{e,t}}$$

A.1.3 Informal Banks

The representative informal bank consist of loan and deposit market

Loan market In this market banks do not participate in the inter bank market i.e. wholesale market. The bank's problem is thus given as Maximize

$$E_0 \sum_{t=0}^{\infty} \beta_t^r \left(r_{jt}^{bi} B_{jt}^i - r_{jt}^{be} B_{jt}^i - \frac{k_{bi}}{2}\left(\frac{r_{jt}^{bi}}{r_{jt-1}^{bi}} - 1\right)^2 r_{jt}^{bi} B_{jt}^i\right) \tag{A.7}$$

The branch maximizes its' profit to choose retail rate r_t^{bi} subject to the demand schedules

$$B_{jt}^i = \left(\frac{r_{jt}^{bi}}{r_t^{bi}}\right)^{-\epsilon_t^{bp}} B_t \tag{A.8}$$

Imposing a symmetric equilibrium condition of $r_t(j) = r_t$, the FOCs reduces to retail rate pricing equation for household

$$1-\epsilon_t^{bp}+\epsilon_t^{bp}\frac{r_t^{be}}{r_t^{bi}}-k_{bi}\left(\frac{r_t^{bi}}{r_{t-1}^{bi}}-1\right)\frac{r_t^{bi}}{r_{t-1}^{bi}}+\beta^r\left(\left(\frac{\lambda_{t+1}^p}{\lambda_t^p}\right)k_{bi}\left(\frac{r_{t+1}^{bi}}{r_t^{bi}}\right)^2\left(\frac{r_{t+1}^{bi}}{r_t^{bi}}-1\right)\left(\frac{B_{t+1}^i}{B_t^i}\right)\right)=0 \tag{A.9}$$

Deposit market Here the bank aim to minimize the cost of accumulating deposit. The problem of the representative bank is given by:

$$Min E_0 \sum_{t=0}^{\infty} \beta_t^r \left(r_{jt}^{dr} D_{jt}^i - r_{jt}^{di} D_{jt}^i - \frac{k_{di}}{2}\left(\frac{r_{jt}^{di}}{r_{jt-1}^{di}} - 1\right)^2 r_{jt}^{di} D_{jt}^i\right) \tag{A.10}$$

subject to the demand schedule

$$D_{jt}^i = \left(\frac{r_{jt}^{di}}{r_t^{di}}\right)^{-\epsilon_t^{dp}} D_t \tag{A.11}$$

Using the condition that $r_{jt} = r_t$ at equilibrium, the FOCs result in the pricing relation for deposit given as

$$-1+\epsilon_t^{dp}-\epsilon_t^{dp}\frac{r_t^{dr}}{r_t^{di}}-k_{di}\left(\frac{r_t^{di}}{r_{t-1}^{di}}-1\right)\frac{r_t^{di}}{r_{t-1}^{di}}+\beta^r\left(\left(\frac{\lambda_{t+1}^p}{\lambda_t^p}\right)k_{di}\left(\frac{r_{t+1}^{di}}{r_t^{di}}\right)^2\left(\frac{r_{t+1}^{di}}{r_t^{di}}-1\right)\left(\frac{D_{t+1}^i}{D_t^i}\right)\right)=0 \tag{A.12}$$

A.1.4 Formal Bank

Wholesale Market The problem of this branch is thus to choose loans (B_t) and deposit (D_t) so as to maximize profit subject to a balance sheet constraint. Specifically,

$$MaxE_0\sum_0^\infty \lambda_{0,t}^p\left((1+R_t^b)B_{jt}-(1+R_t^d)D_{jt}-K_{jt}^b-\frac{K_{kb}}{2}\left(\frac{K_{jt}^b}{B_{jt}}-V^b\right)^2K_{jt}^b\right) \tag{A.13}$$

s.t.

$$B_{jt}^f = D_{jt}^f + K_{jt}^b \tag{A.14}$$

$$K_{jt}^b = (1-\delta^b)K_{jt-1}^{b,n} + \omega^b J_{jt-1}^{b,n} \tag{A.15}$$

The interbank lending rate is obtained through the FOC as

$$R_t^b = R_t^d - k_{kb}\left(\frac{K_t^b}{B_t}-V^b\right)\left(\frac{K_t^b}{B_t}\right)^2$$

Loan Market The formal bank engages in the inter bank market. The problem of the representative agent is to maximize

$$E_0\sum_{t=0}^\infty \beta_t^r\left(r_{jt}^{br}B_{jt}^r+r_{jt}^{be}B_{jt}^e+r_{jt}^{be}B_{jt}^i-R_t^bB_t^f-\frac{k_{br}}{2}\left(\frac{r_{jt}^{br}}{r_{jt-1}^{br}}-1\right)^2r_{jt}^{br}B_{jt}^r-\frac{k_{be}}{2}\left(\frac{r_{jt}^{be}}{r_{jt-1}^{be}}-1\right)^2r_{jt}^{be}B_{jt}^e\right) \tag{A.16}$$

The bank optimizes the profit by choosing $\{r_t^{br}\}$ and $\{r_t^{be}\}$ subject to the demand schedules respectively for the household and entrepreneur as

$$B_{jt}^r = \left(\frac{r_{jt}^{br}}{r_t^{br}}\right)^{-\epsilon_t^{br}}B_t^r \tag{A.17}$$

$$B_{jt}^e = \left(\frac{r_{jt}^{be}}{r_t^{be}}\right)^{-\epsilon_t^{e}}B_t^e \tag{A.18}$$

With $B^f_{jt} = B^r_{jt} + B^e_{jt}$. The resulting FOC from the optimization problem is given by

$$1-\epsilon^e_t+\left(\frac{B^i_t}{B^{ef}_t}\right)+\left(\frac{R^b_t}{r^{be}_t}\right)\epsilon^e_t-k_{be}\left(\frac{r^{be}_t}{r^{be}_{t-1}}-1\right)\frac{r^{be}_t}{r^{be}_{t-1}}+\beta^r E_t\left(\left(\frac{\lambda^p_{t+1}}{\lambda^p_t}\right)k_{be}\left(\frac{r^{be}_{t+1}}{r^{be}_t}\right)^2\left(\frac{r^{be}_{t+1}}{r^{be}_t}-1\right)\left(\frac{B^e_{t+1}}{B^e_t}\right)\right)=0 \tag{A.19}$$

$$1-\epsilon^{br}_t+\left(\frac{R^b_t}{r^{br}_t}\right)\epsilon^{br}_t-k_{br}\left(\frac{r^{br}_t}{r^{br}_{t-1}}-1\right)\frac{r^{br}_t}{r^{br}_{t-1}}+\beta^r E_t\left(\left(\frac{\lambda^p_{t+1}}{\lambda^p_t}\right)k_{br}\left(\frac{r^{br}_{t+1}}{r^{br}_t}\right)^2\left(\frac{r^{br}_{t+1}}{r^{br}_t}-1\right)\left(\frac{B^r_{t+1}}{B^r_t}\right)\right)=0 \tag{A.20}$$

Deposit Market The aim is to maximize the return it obtain from the inter bank market and deposit accumulation from household. The bank maximize its objective function

$$MaxE_0\sum_{t=0}^{\infty}\beta^r_t\left\{R^d_t D_{jt}-r^{dr}_{jt}D^r_{jt}-\frac{k_{dr}}{2}\Big(\frac{r^{dr}_{jt}}{r^{dr}_{jt-1}}-1\Big)^2 r^{dr}_{jt}D^r_{jt}\right\} \tag{A.21}$$

subject to the supply

$$D^r_{jt}=\left(\frac{r^{dr}_{jt}}{r^{dr}_t}\right)^{-\epsilon^{dr}_t}D_t \tag{A.22}$$

$$-1+\epsilon^{dr}_t-\epsilon^{dr}_t\left(\frac{R^d_t}{r^{dr}_t}\right)-k_{dr}\left(\frac{r^{dr}_t}{r^{dr}_{t-1}}-1\right)\frac{r^{dr}_t}{r^{dr}_{t-1}}+\beta^r E_t\left\{\left(\frac{\lambda^p_{t+1}}{\lambda^p_t}\right)k_{dr}\left(\frac{r^{dr}_{t+1}}{r^{dr}_t}\right)^2\left(\frac{r^{dr}_{t+1}}{r^{dr}_t}-1\right)\left(\frac{D^f_{t+1}}{D^r_t}\right)\right\}=0 \tag{A.23}$$

A.1.5 Retailer

The retailer solves

$$E_t\sum_{t=0}^{\infty}\lambda^P_t\left[p_{jt}y_{jt}-P^W_t y_{jt}-\frac{k_p}{2}\Big(\frac{p_{jt}}{p_{jt-1}}-\pi^l_{t-1}\pi^{1-l}\Big)^2 p_t y_t\right] \tag{A.24}$$

subject to a consumption aggregate

$$y_{jt}=\left(\frac{p_{jt}}{p_t}\right)^{-\epsilon^y_t}y_t \tag{A.25}$$

Imposing symmetric equilibrium, the FOC result in a non-linearized Philip curve specified as

$$1-\epsilon^y_t+\frac{\epsilon^y_t}{x_t}-k_p(\pi_t-\pi^l_{t-1}\pi^{1-l})\pi_t+\beta_p E_t\left[\frac{\lambda^p_{t+1}}{\lambda^p_t}k_p(\pi_{t+1}-\pi^l_t\pi^{1-l})\pi_{t+1}\frac{y_{t+1}}{y_t}\right]=0 \tag{A.26}$$

A.1.6 Capital Market

This sector solves the problem

$$E_t \sum_{0}^{\infty} \lambda_t^E \left[q_t^k \Big(I_t - \frac{k_i}{2} \Big(\frac{I_t}{I_{t-1}} - 1 \Big)^2 \Big) - I_t \right] \tag{A.27}$$

which generates the capital stock which evolves according to

$$K_{t+1} = (1-\delta)K_t + \left(1 - \frac{k_i}{2} \Big(\frac{I_t}{I_{t-1}} - 1 \Big)^2 \right) I_t \tag{A.28}$$

The real price of capital q_t^k is given by

$$1 = q_t^k \left[1 - \frac{k_i}{2} \Big(\frac{I_t}{I_{t-1}} - 1 \Big)^2 - k_i \Big(\frac{I_t}{I_{t-1}} - 1 \Big)^2 \frac{I_t}{I_{t-1}} + \beta_E E_t \Big[\frac{\lambda_{t+}^E}{\lambda_t^E} q_{t+1}^k k_i \Big(\frac{I_{t+1}}{I_t} - 1 \Big) \Big(\frac{I_{t+1}}{I_t} \Big)^2 \Big] \right] \tag{A.29}$$

A.2 Full Model Equations

Poor Household

$$C_t^{p\theta} N_t^{p\phi} = W_t + C_t^{p\theta} V_t^p \mu_t^p E_t \left[W_{t+1} \pi_{t+1} \right] \tag{A.30}$$

$$1 = \beta_p E_t \left(\left(\frac{C_t^p}{C_{t+1}^p} \right)^{\theta} \left(\frac{1 + r_t^{dp}}{\pi_{t+1}} \right) \right) \tag{A.31}$$

$$1 = \left(1 + r_t^{bp} \right) V_t^p C_t^{p\theta} + \beta_p E_t \left[\left(\frac{C_t^p}{C_{t+1}^p} \right)^{\theta} \left(\frac{1 + r_t^{bp}}{\pi_{t+1}} \right) \right] \tag{A.32}$$

$$\left(1 + r_t^{bp} \right) B_{it}^p = \mu_t^p E_t \left[W_{t+1} N_{it}^p \pi_{t+1} \right] \tag{A.33}$$

Rich Household

$$C_t^{r\theta} N_t^{r\phi} = W_t + C_t^{r\theta} V_t^r \mu_t^r E_t \left[W_{t+1} \pi_{t+1} \right] \tag{A.34}$$

$$1 = \beta_r E_t \left(\left(\frac{C_t^r}{C_{t+1}^r} \right)^{\theta} \left(\frac{1 + r_t^{dr}}{\pi_{t+1}} \right) \right) \tag{A.35}$$

$$1 = \left(1 + r_t^{br} \right) V_t^p C_t^{r\theta} + \beta_r E_t \left[\left(\frac{C_t^r}{C_{t+1}^r} \right)^{\theta} \left(\frac{1 + r_t^{br}}{\pi_{t+1}} \right) \right] \tag{A.36}$$

$$\left(1 + r_t^{br} \right) B_{it}^r = \mu_t^r E_t \left[W_{t+1} N_{it}^r \pi_{t+1} \right] \tag{A.37}$$

Entrepreneur

$$q_t^k = \frac{\alpha Y_t}{x_t k_t} + C_t^{e\theta} v_t^e \mu^e E_t\left[q_{t+1}^k \pi_{t+1}(1-\delta)\right] + \beta_e E_t\left[\left(\frac{C_t^e}{C_{t+1}^e}\right)^{\theta} q_{t+1}^k (1-\delta)\right] \quad \text{(A.38)}$$

$$1 = C_t^{e\theta} V_t^e (1 + r_t^{be}) + \beta_e E_t\left\{\left(\frac{C_t^e}{C_{t+1}^e}\right)^{\theta}\left(\frac{1+r_t^{be}}{\pi_{t+1}}\right)\right\} \quad \text{(A.39)}$$

$$W_t = (1-\alpha)\frac{Y_t}{x_t N_t} \quad \text{(A.40)}$$

$$(1 + r_t^{be}) B_t^e = \mu_t^e E_t\{q_{t+1}^K \pi_{(t+1)}(1-\delta) K_{it}\} \quad \text{(A.41)}$$

$$1 = q_t^k\left[1 - \frac{k_i}{2}\Big(\frac{I_t}{I_{t-1}} - 1\Big)^2 - k_i\Big(\frac{I_t}{I_{t-1}} - 1\Big)^2 \frac{I_t}{I_{t-1}} + \beta_E E_t\Big[\frac{\lambda_{t+}^E}{\lambda_t^E} q_{t+1}^k k_i\Big(\frac{I_{t+1}}{I_t} - 1\Big)\Big(\frac{I_{t+1}}{I_t}\Big)^2\Big]\right] \quad \text{(A.42)}$$

$$1 - \epsilon_t^y + \frac{\epsilon_t^y}{x_t} - k_p(\pi_t - \pi_{t-1}^{l}\pi^{1-l})\pi_t + \beta_p E_t\left[\frac{\lambda_{t+1}^p}{\lambda_t^p} k_p(\pi_{t+1} - \pi_t^{l}\pi^{1-l})\pi_{t+1}\frac{y_{t+1}}{y_t}\right] = 0 \quad \text{(A.43)}$$

Financial Sector

$$R_t^b = R_t^d - k_{kb}\left(\frac{K_t^b(j)}{B_t(j)} - V^b\right)\left(\frac{K_t^b(j)}{B_t(j)}\right)^2 \quad \text{(A.44)}$$

$$B_t^f = D_t^r + K_t^b \quad \text{(A.45)}$$

$$K_t^b = (1-\delta^b) K_{t-1}^{b,n} + \omega^b J_{t-1}^{b,n} \quad \text{(A.46)}$$

$$1 - \epsilon_t^e + \left(\frac{B_t^i}{B_t^{ef}}\right) + \left(\frac{R_t^b}{r_t^{be}}\right)\epsilon_t^e - k_{be}\left(\frac{r_t^{be}}{r_{t-1}^{be}} - 1\right)\frac{r_t^{be}}{r_{t-1}^{be}} + \beta^e E_t\left\{\left(\frac{\lambda_{t+1}^p}{\lambda_t^p}\right) k_{be}\left(\frac{r_{t+1}^{be}}{r_t^{be}}\right)^2\left(\frac{r_{t+1}^{be}}{r_t^{be}} - 1\right)\left(\frac{B_{t+1}^e}{B_t^e}\right)\right\} = 0 \quad \text{(A.47)}$$

$$1 - \epsilon_t^{br} + \left(\frac{R_t^b}{r_t^{br}}\right)\epsilon_t^{br} - k_{br}\left(\frac{r_t^{br}}{r_{t-1}^{br}} - 1\right)\frac{r_t^{br}}{r_{t-1}^{br}} + \beta^e E_t\left\{\left(\frac{\lambda_{t+1}^p}{\lambda_t^p}\right) k_{br}\left(\frac{r_{t+1}^{br}}{r_t^{br}}\right)^2\left(\frac{r_{t+1}^{br}}{r_t^{br}} - 1\right)\left(\frac{B_{t+1}^r}{B_t^r}\right)\right\} = 0 \quad \text{(A.48)}$$

$$-1 + \epsilon_t^{dr} - \epsilon_t^{dr}\left(\frac{R_t^d}{r_t^{dr}}\right) - k_{dr}\left(\frac{r_t^{dr}}{r_{t-1}^{dr}} - 1\right)\frac{r_t^{dr}}{r_{t-1}^{dr}} + \beta^e E_t\left\{\left(\frac{\lambda_{t+1}^p}{\lambda_t^p}\right) k_{dr}\left(\frac{r_{t+1}^{dr}}{r_t^{dr}}\right)^2\left(\frac{r_{t+1}^{dr}}{r_t^{dr}} - 1\right)\left(\frac{D_{t+1}^f}{D_t^r}\right)\right\} = 0 \quad \text{(A.49)}$$

$$1 - \epsilon_t^{bp} + \epsilon_t^{bp}\frac{r_t^{be}}{r_t^{bi}} - k_{bi}\left(\frac{r_t^{bi}}{r_{t-1}^{bi}} - 1\right)\frac{r_t^{bi}}{r_{t-1}^{bi}} + \beta^e\left\{\left(\frac{\lambda_{t+1}^p}{\lambda_t^p}\right) k_{bi}\left(\frac{r_{t+1}^{bi}}{r_t^{bi}}\right)^2\left(\frac{r_{t+1}^{bi}}{r_t^{bi}} - 1\right)\left(\frac{B_{t+1}^i}{B_t^i}\right)\right\} = 0 \quad \text{(A.50)}$$

$$-1 + \epsilon_t^{dp} - \epsilon_t^{dp}\frac{r_t^{dr}}{r_t^{di}} - k_{di}\left(\frac{r_t^{di}}{r_{t-1}^{di}} - 1\right)\frac{r_t^{di}}{r_{t-1}^{di}} + \beta^e\left\{\left(\frac{\lambda_{t+1}^p}{\lambda_t^p}\right) k_{di}\left(\frac{r_{t+1}^{di}}{r_t^{di}}\right)^2\left(\frac{r_{t+1}^{di}}{r_t^{di}} - 1\right)\left(\frac{D_{t+1}^i}{D_t^i}\right)\right\} = 0 \quad \text{(A.51)}$$

A.2.1 Steady States

Poor Household

$$C^{p\theta}N^{p\phi} = W + C^{p\theta}V^{p}\mu^{p}W\pi \tag{A.52}$$

$$1 = \beta_{p}\left(\frac{1+r^{dp}}{\pi}\right) \tag{A.53}$$

$$1 = (1+r^{bp})V^{p}C^{p\theta} + \beta_{p}\left(\frac{1+r^{bp}}{\pi}\right) \tag{A.54}$$

$$(1+r^{bp})B^{p} = \mu^{p}\left[WN^{p}\pi\right] \tag{A.55}$$

Rich Household

$$C^{r\theta}N^{r\phi} = W + C^{r\theta}V^{r}\mu^{r}W\pi \tag{A.56}$$

$$1 = \beta_{r}\left(\frac{1+r^{dr}}{\pi}\right) \tag{A.57}$$

$$1 = (1+r^{br})V^{p}C^{r\theta} + \beta_{r}\left(\frac{1+r^{br}}{\pi}\right) \tag{A.58}$$

$$(1+r^{br})B^{r} = \mu^{r}\left[WN^{r}\pi\right] \tag{A.59}$$

Entrepreneur

$$q^{k} = \frac{\alpha Y}{xk} + C^{e\theta}v^{e}\mu^{e}\left[q^{k}\pi(1-\delta)\right] + \beta_{e}\left[q^{k}(1-\delta)\right] \tag{A.60}$$

$$1 = C^{e\theta}V^{e}(1+r^{be}) + \beta_{e}\left(\frac{1+r^{be}}{\pi}\right) \tag{A.61}$$

$$W = (1-\alpha)\frac{Y}{xN} \tag{A.62}$$

$$(1+r^{be})B^{e} = \mu^{e}\{q^{K}\pi(1-\delta)K\} \tag{A.63}$$

$$q^{k} = 1 \tag{A.64}$$

$$1 - \epsilon^{y} + \frac{\epsilon^{y}}{x} = 0 \tag{A.65}$$

Financial Sector

$$R^{b} = R^{d} - k_{kb}\left(\frac{K^{b}}{B^{f}} - V^{b}\right)\left(\frac{K^{b}}{B^{f}}\right)^{2} \tag{A.66}$$

$$B^{f} = D^{r} + K^{b} \tag{A.67}$$

$$K^b = (1-\delta^b)K^b + \omega^b J^b \tag{A.68}$$

$$\frac{R^b}{r^{be}} = \frac{\epsilon^e - 1}{\epsilon^e} - \frac{B^i}{\epsilon^e B^{ef}} \tag{A.69}$$

$$\frac{R^b}{r^{br}} = \frac{\epsilon^{br} - 1}{\epsilon^{br}} \tag{A.70}$$

$$\frac{R^d}{r^{dr}} = \frac{\epsilon^{dr} - 1}{\epsilon^{dr}} \tag{A.71}$$

$$\frac{r^{be}}{r^{bi}} = \frac{\epsilon^{bp} - 1}{\epsilon^{bp}} \tag{A.72}$$

$$\frac{r^{dr}}{r^{di}} = \frac{\epsilon^{dp} - 1}{\epsilon^{dp}} \tag{A.73}$$

A.2.2 Log-linearized Equations

Poor Household

$$r_* \widehat{r}_t^{bp} + \widehat{B}_t^p = \widehat{\mu}_t^p + \widehat{N}_t^p + E_t \widehat{w}_{t+1} + E_t \widehat{\pi}_{t+1} \tag{A.74}$$

$$1 + \theta E_t \widehat{c}_{t+1}^p + E_t \widehat{\pi}_{t+1} = \theta \widehat{c}_t^p + \left(\frac{r_{ss}^{dp}}{(1+r_{ss}^{dp})^2} \right) \widehat{r}_t^{dp} \tag{A.75}$$

$$\widehat{w}_t = PH_0(\phi \widehat{n}_t^p + \theta \widehat{c}_t^p) + PH_1(\widehat{\mu}_t^p + \theta \widehat{c}_t^p + \widehat{v}_t^p + E_t \widehat{w}_{t+1} + E_t \widehat{\pi}_{t+1}) \tag{A.76}$$

$$1 = PH_{00}(1 + \theta \widehat{c}_t^P + \widehat{v}_t^p + r_* \widehat{r}_t^{bp}) + PH_{11}[\theta(\widehat{c}_t^p - \widehat{c}_{t+1}^p) + r_* \widehat{r}_t^{bp} - \widehat{\pi}_{t+1}] \tag{A.77}$$

$$PH_0 = \frac{C_{ss}^{p\ \theta} N_{ss}^{p\ \phi}}{W_{ss}}, \qquad PH_1 = C_{ss}^{p\ \theta} V_{ss}^p \mu_{ss}^p \pi_{ss}, \qquad PH_{00} = C_{ss}^{p\ \theta} V_{ss}^p (1 + r_{ss}^{bp}),$$
$$PH_{11} = \beta_p \left[\frac{1 + r_{ss}^{bp}}{\pi_{ss}} \right], \qquad r_* = \left(\frac{r_{ss}^{bp}}{(1+r_{ss}^{bp})^2} \right)$$

Rich Household

$$r_{**} \widehat{r}_t^{br} + \widehat{B}_t^r = \widehat{\mu}_t^r + \widehat{N}_t^r + E_t \widehat{w}_{t+1} + E_t \widehat{\pi}_{t+1} \tag{A.78}$$

$$1 + \theta E_t \widehat{c}_{t+1}^r + E_t \widehat{\pi}_{t+1} = \theta \widehat{c}_t^r + \left(\frac{r_{ss}^{dr}}{(1+r_{ss}^{dr})^2} \right) \widehat{r}_t^{dr} \tag{A.79}$$

$$\widehat{w}_t = RH_0(\phi \widehat{n}_t^r + \theta \widehat{c}_t^r) + RH_1(\widehat{\mu}_t^p + \theta \widehat{c}_t^r + \widehat{v}_t^r + E_t \widehat{w}_{t+1} + E_t \widehat{\pi}_{t+1}) \tag{A.80}$$

$$1 = RH_{00}(1 + \theta \widehat{c}_t^r + \widehat{v}_t^r + r_* \widehat{r}_t^{br}) + RH_{11}[\theta(\widehat{c}_t^r - \widehat{c}_{t+1}^r) + r_* \widehat{r}_t^{br} - \widehat{\pi}_{t+1}] \tag{A.81}$$

$$RH_0 = \frac{C_{ss}^{r\ \theta} N_{ss}^{r\ \phi}}{W_{ss}}, \qquad RH_1 = C_{ss}^{r\ \theta} V_{ss}^r \mu_{ss}^r \pi_{ss}, \qquad RH_{00} = C_{ss}^{r\ \theta} V_{ss}^r (1 + r_{ss}^{br}),$$
$$RH_{11} = \beta_r \left[\frac{1 + r_{ss}^{br}}{\pi_{ss}} \right], \qquad r_{**} = \left(\frac{r_{ss}^{br}}{(1+r_{ss}^{br})^2} \right)$$

Firm

$$\widehat{q}_t^k = FS_0(\widehat{y}_t - \widehat{k}_t) + FS_1\left(\theta\widehat{c}_t^e + \widehat{v}_t^e + \widehat{\mu}_t^e + E_t\widehat{q}_{t+1}^k + E_t\widehat{\pi}_{t+1}\right) + \beta_e(1-\delta)\left(\theta(\widehat{c}_t^e - E_t\widehat{c}_{t+1}^e) + E_t\widehat{q}_{t+1}^k\right) \tag{A.82}$$

$$o = FS_{00}\left(\theta\widehat{c}_t^e + \widehat{v}_t^e + r^{be}\widehat{r}_t^{be}\right) + FS_{11}\left(\theta(\widehat{c}_t^e - E_t\widehat{c}_{t+1}^e) + r^{be}\widehat{r}_t^{be} - E_t\widehat{\pi}_{t+1}\right) \tag{A.83}$$

$$\widehat{w}_t = ln(1-\alpha) + lnx + \widehat{y}_t - \widehat{n}_t^e \tag{A.84}$$

$$r^*\widehat{r}_t^{be} + \widehat{B}_t^e = \widehat{\mu}_t^e + \widehat{k}_t + E_t\widehat{q}_{t+1}^k + E_t\widehat{\pi}_{t+1} \tag{A.85}$$

$$FS_0 = \frac{\alpha y_{ss}}{x k_{ss}}, \qquad FS_1 = c_{ss}^{e\ \theta} v_{ss}^e \mu_{ss}^e \pi_{ss}(1-\delta), \qquad FS_{00} = c_{ss}^{e\ \theta} v_{ss}^e (1 + r_{ss}^{be}),$$

$$FS_{11} = \left(\frac{1 + r_{ss}^{be}}{\pi_{ss}}\right)$$

Financial Sector

$$\widehat{r}_t^{be} = \frac{k_{be}}{R^*\epsilon^e + (1+\beta_e)k_{be}}\widehat{r}_{t-1}^{be} + \frac{\beta_e k_{be}}{R^*\epsilon^e + (1+\beta_e)k_{be}}E_t\widehat{r}_{t+1}^{be} + \frac{\epsilon^e R^*}{\epsilon^e + (1+\beta_e)k_{be}}\widehat{R}_t^b + \frac{B^*}{R^*\epsilon^e + (1+\beta_e)k_{be}}(\widehat{B}_t^i - \widehat{B}_t^e) \tag{A.86}$$

$$\widehat{r}_t^{dr} = \frac{k_{dr}}{R_d^*\epsilon^{dr} + (1+\beta_e)k_{dr}}\widehat{r}_{t-1}^{dr} + \frac{\beta_e k_{dr}}{R_d^*\epsilon^{dr} + (1+\beta_e)k_{dr}}E_t\widehat{r}_{t+1}^{dr} + \frac{R_d^*\epsilon^{dr}}{R_d^*\epsilon^{dr} + (1+\beta_e)k_{dr}}\widehat{r}_t + \frac{D^*}{R_d^*\epsilon^{dr} + (1+\beta_e)k_{dr}}(\widehat{D}_t^i - \widehat{D}_t^r) \tag{A.87}$$

$$R^* = \frac{R_{ss}^b}{r_{ss}^{be}}, \qquad B^* = \frac{B_{ss}^i}{B_{ss}^e}, \qquad R_d^* = \frac{r_{ss}}{r_{ss}^{dr}} \qquad D^* = \frac{D_{ss}^i}{D_{ss}^r}$$

$$\widehat{r}_t^{br} = \frac{k_{br}}{\epsilon^{br} - (1+\beta_e)k_{br}}\widehat{r}_{t-1}^{br} + \frac{\beta_e k_{br}}{\epsilon^{br} - (1+\beta_e)k_{br}}E_t\widehat{r}_{t+1}^{br} + \frac{\epsilon^{br} - 1}{\epsilon^{br} - (1+\beta_e)k_{br}}\widehat{R}_t^b \tag{A.88}$$

$$\widehat{r}_t^{bi} = \frac{k_{bi}}{\epsilon^{bp} - (1+\beta_e)k_{bi}}\widehat{r}_{t-1}^{bi} + \frac{\beta_e k_{bi}}{\epsilon^{bp} - (1+\beta_e)k_{bi}}E_t\widehat{r}_{t+1}^{bi} + \frac{\epsilon^{bp} - 1}{\epsilon^{bp} - (1+\beta_e)k_{bi}}\widehat{r}_t^{be} \tag{A.89}$$

$$\widehat{r}_t^{di} = \frac{k_{di}}{\epsilon^{dp} - (1+\beta_e)k_{di}}\widehat{r}_{t-1}^{di} + \frac{\beta_e k_{di}}{\epsilon^{dp} - (1+\beta_e)k_{di}}E_t\widehat{r}_{t+1}^{di} + \frac{\epsilon^{dp} - 1}{\epsilon^{dp} - (1+\beta_e)k_{di}}\widehat{r}_t^{dr} \tag{A.90}$$