CRANFIELD UNIVERSITY

ALEXANDER LUBIS

LINKING MONETARY AND MACROPRUDENTIAL POLICIES IN THE PRESENCE OF EXTERNAL SHOCKS: THE CASE OF INDONESIA

SCHOOL OF MANAGEMENT
PhD Programme

Doctor of Philosophy
Academic Year: 2018-2019

Supervisor : Dr Constantinos Alexiou
Associate Supervisor: Professor Joseph G Nellis
September 2019

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This thesis is submitted in partial fulfilment of the requirements for the degree of Doctor of Philosophy

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To Mona, Alvaro and Aurora with love

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Abstract

The limited experience of practising monetary and macroprudential policies at the same time raises a question about the extent to which a macroprudential instrument – as a complement to monetary policy – affects the macroeconomic stabilisation in emerging markets, particularly in the presence of external shocks. By performing a systematic review of 125 articles, this thesis provides novel and insightful evidence on the interaction between monetary and macroprudential policies in emerging markets by refining what we already know on the extant relationship. It also provides a comprehensive synthesis of the theoretical arguments on the interaction between the two policy expedients. For the first time, we incorporate in our analysis the impact of policies embodied in the payment system – such as the limitation of the value that can be settled through large-value payment systems – hence making new inroads in the respective empirical literature. Further, it makes evident that a shift from currency- to electronic-based payments supports financial intermediation. In addition to that, the study draws insights from the benefits of FX intervention as an instrument in an emerging market that implements an inflation-targeting framework. Not only do we model the risk appetite of investors as a shock to the economy but we also take into account households with limited financial access. As a result, it is demonstrated that FX intervention can be employed by policymakers to stabilise an economy during a period of capital flow shocks. Finally, this thesis advances our knowledge by developing a framework – in the emerging market context – to analyse the impact of using reserve requirements combined with FX intervention as key instruments in an inflation-targeting framework. It suggests that reserve requirement can be utilised by policymakers to complement interest rate policy and FX intervention in stabilising the economy during a period of external shocks, particularly a risk appetite shock.

Keywords: Monetary policy; macroprudential policy; FX intervention; payment system; DSGE models; open economy;

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Abbreviations

ADB	Asian Development Bank
ATM	Automatic Teller Machine
BI	Bank Indonesia
BLBI	Bank Indonesia Liquidity Support
BPS	Indonesian Statistics Agency
CPI	Consumer Price Index
DSGE	Dynamic Stochastic General Equilibrium
ECB	European Central Bank
FX	Foreign Exchange
GDP	Gross Domestic Product
GMM	Generalized Method of Moments
GNNT	National Non-Cash Movement in Indonesia
IDR	Indonesian Rupiah
IMF	International Monetary Fund
ITF	Inflation Targeting Framework
LVPS	Large-value Payment System
OJK	Financial Service Authority of Indonesia (*Otoritas Jasa Keuangan*)
RTGS	Real Time Gross Settlement
TED Spread	The difference between the three-month Treasury bill and the three-month LIBOR based in US dollars
TFP	Total Factor Productivity
ToT	Terms of Trade
UIP	Uncovered Interest rate Parity
UK	United Kingdom
US	United States of America
USD	United States Dollar
VECM	Vector Error Correction Model
VIX	The Chicago Board Options Exchange Volatility Index

CHAPTER 1

Introduction

1.1 Research Background and Rationale

The prolonged effect of the recent global financial crisis has taught many policymakers a valuable lesson, particularly central bankers around the world to find a way to stabilise the economy and prevent the crisis from reoccurring. A newly-bourgeoning view that has been adopted is to implement both monetary policy and macroprudential policies to stabilise the economy (International Monetary Fund, 2013).

The adoption of macroprudential policies by central banks highlights the importance of modelling the connection between the real economy, the financial system and monetary policy, in order to provide a framework of how the monetary and macroprudential policies are implemented (International Monetary Fund, 2013). The fact that macroprudential policies appear to be invoked only after a major financial crisis has taken place is indicative of the limited experience policymakers have (Galati and Moessner, 2013). Nevertheless, a specific effort has been made in the literature to see how macroprudential policy has been implemented in an economy, which was mainly conducted in the context of advanced economies. A substantial range of macroprudential instruments has been discussed, although without recognising the primary instrument (Galati and Moessner,

2013).

The payment system also needs to be incorporated into the discussion of monetary and macroprudential policies framework. Providing a sound and efficient payment system to the financial system enhances the efficiency of financial markets and the financial system as a whole, boost consumer confidence and enable economic interaction and trade in both goods and services (Hasan et al., 2013). Innovation in the payment system also helps to stimulate the overall economy and growth. Engaging in the payment system services may expose a bank to a liquidity shock coming from the payment instructions from customers (Piazzesi and Schneider, 2018). Different liquidity management methods are required to manage the different types of payment systems, such as the Real-Time Gross Settlement System (RTGS) and clearing system.

Apart from the challenges that come from domestic pressures, a massive volatility of capital flows following unconventional monetary policy in advanced countries poses other challenges for policymakers to restrain capital flows from aggravating the overheating pressures and consequent inflation, as well as to mitigate the risks that protracted periods of easy financing conditions that will threaten the financial stability (Unsal, 2013). A massive capital flows volatility creates turmoil in the domestic financial market due to the shallow characteristics of the market to absorb shocks. One of the emerging market experiences from which a lesson can be taken is Indonesia, the financial system and macroeconomic stabilities of Indonesia of which are affected by the capital flow volatility (Warjiyo, 2014). A change in risk perception of market participants – a shock in the international capital market – also contributes to capital flow movement, by driving variation in the cost of capital to the economy (Alla et al., 2017).

Increasing volatility in capital flows has put pressure on the exchange rate, particularly in emerging markets (Agénor and Pereira da Silva, 2014; Korinek and Sandri, 2016; Svensson, 2000). Large volatility in the exchange rate distorts the exchange rate expectation and drives a reversal in the capital flows. A sudden reversal in the capital flows then causes volatility in domestic capital and debt market. Large volatility also impairs the domestic borrowers who hold large foreign currency liabilities with domestic currency income. These borrowers may find the availability of foreign funding deteriorating because the risk perception is worsening.

To deal with the pressure on the exchange rate, many emerging markets perform a foreign exchange (FX) intervention in order to stabilise the exchange rate (Calvo and Reinhart, 2002). Many of these operations were conducted on a discretionary basis (Chutasripanich and Yetman, 2015; Jun, 2008). Conducting the FX intervention relaxes the constraint on the degree of the exchange rate in responding to inflation and alleviates problems of indeterminacy and expected instability (Llosa and Tuesta, 2008). Further, the use of foreign exchange rate intervention helps achieve price stability by reducing the exchange rate pressures and can be used as a part of the inflation targeting framework central bank's instruments to stabilise the macroeconomy.

However, FX intervention does not come without no effect. Studies, such as that of Reinhart and Reinhart (1999), show that the selling or buying of FX reserves to influence the exchange rate will absorb or expand the money supply in the economy. To mitigate such impact, macroprudential policies can be applied one of them being the reserve requirement instrument. By regulating on reserve requirement, banks will be compelled to adjust their deposit and lending rates given that reserve requirements act as a tax on financial intermediation. Reserve requirement also facilitates the financial stability by restraining credit growth in the upswing of the business cycle and providing the reserve back to the banking sector in the downturn of the business cycle (Montoro and Moreno, 2011).

1.2 Research Aims and Objectives

In view of the above, this thesis aims to provide novel evidence on the interaction between monetary and macroprudential policies. The overarching research question can be stated as follows:
To what extent does a macroprudential instrument as a complement to monetary policy affect the macroeconomic stabilisation in emerging markets, particularly in the presence of external shocks?

In line with this overarching question, this study then set four research objectives. (1) provide a systematic literature review on how monetary and macroprudential policies interact; (2) to investigate the impact of payment system innovations on financial

intermediation; (3) to assess the impact of FX Intervention on the framework of monetary and macroprudential policies in the emerging market context; (4) to examine the impact of FX Intervention and reserve requirement on the framework of monetary and macroprudential policies in the emerging market context.

In order to respond to the overarching question, we explore the respective literature by focusing on the transmission mechanism of monetary and macroprudential policies. The channels through which monetary and macroprudential policies interact are also identified. By conducting research on how payment system innovation affects financial intermediation, this study identifies factors in the payment system that potentially affect the transmission of monetary and macroprudential policies. In addition, it explores the channels through which policies in the payment system affects financial intermediation. By understanding the effect of FX intervention in stabilising the macroeconomy, we gain further insights into the interaction between monetary policy and the FX intervention instruments. Finally, this thesis also sheds some light on the interaction between reserve requirement, FX intervention and interest rate policy.

1.3 Summary of Contribution

In addressing the four research objectives identified above, this thesis makes an important contribution to monetary and macroprudential policy studies.

Firstly, this thesis refines our knowledge of the interaction between monetary policy and macroprudential policy. By performing a systematic review of 125 articles, this review provides a comprehensive analysis of the theoretical foundation on the interaction between monetary and macroprudential policies. This study classifies the mechanisms in which monetary and macroprudential interact with borrowers' net worth mechanism and collateral constraint mechanisms in the borrowers' side; and balance sheet, risk appetite and payment system on the financial intermediaries' side. To the best of our knowledge, this is the first systematic literature review on the interaction between monetary and macroprudential policies. The comprehensive analysis of how monetary and macroprudential policies have been implemented helps identify the current policy discussion to support the policy design and implementation of monetary and macroprudential policies.

Secondly, this thesis advances our understanding by incorporating for the first time policies embodied in the payment system, such as the limitation of the value that can be settled through the large-value payment systems. It also develops a framework to analyse through excess reserves and currency holding channels the effect of payments systems to the financial intermediation. This thesis demonstrates that a shift from currency-based to electronic-based payments supports financial intermediation.

Thirdly, this thesis draws insights from the benefits of FX intervention as an instrument in an emerging market that implements an inflation-targeting framework. This is done by building a Dynamic Stochastic General Equilibrium (DSGE) model with a sticky price à la Calvo (1983) We also add to the model the risk appetite of investors as a shock to the economy, as well as taking into account households with limited financial access. Upon an estimation using this model, we demonstrate that FX intervention can be employed by policymakers to stabilise an economy during a period of capital flow shocks.

Finally, this thesis advances our knowledge by developing a framework – in the emerging market context – to analyse the impact of using the combination of reserve requirements and FX intervention as a key instrument in an inflation-targeting framework. This study uses a new DSGE model with a similar approach to the aforementioned above and adding a sticky wage and a banking sector with an imperfect substitution into it. Through this model, we find that reserve requirement can be utilised by policymakers to complement interest rate policy and FX intervention in stabilising the economy during a period of external shocks, particularly a risk appetite shock.

1.4 Thesis Structure

This thesis is organised in a 'paper format'. It is structured to deliver its intellectual contribution through a series of distinct chapters in the format of journal articles. Each paper contains related literature, methodology, results and discussion of key findings. Each paper can be considered independent, in the sense that it assesses the interaction between monetary and macroprudential policies and try to respond to the research objectives as stipulated in section 1.2. Altogether, the chapters display a single programme

of research and contribute towards the overall aim of the thesis.

In Chapter 2, this study presents a systematic literature review of the implementation of monetary and macroprudential policies as related to the first objective. The objective of this chapter is to provide an assessment of the literature about how a central bank promotes stability in the macroeconomy, specifically, on how monetary and macroprudential policies interact. In addition, it seeks a comprehensive understanding of how payment systems relate to monetary and macroprudential policies, and the impact of capital flows on monetary and macroprudential policies.

Going further, Chapter 3 is connected to the second objective. This chapter provides an assessment of the effect of payment system innovations on financial intermediation. This chapter aims to shed light on how improvement in the payment systems can affect the financial intermediation through the lens of excess reserves and currency demand. It also includes the impact of customer limitation in the large value payment system on the relationship, assessing it against the relationship between the innovation in payment systems and loan supply.

Linking to the third objective of this thesis, Chapter 4 presents the analysis of FX intervention and monetary policy in an Inflation Targeting Framework. This chapter intends to extend our understanding of using FX intervention to stabilise an economy during a period of capital flow shocks. The chapter also demonstrates the impact of risk appetite shock to the economy.

Finally, we present an analysis of the interaction between reserve requirement, FX intervention and interest rate in Chapter 5 as related to the fourth objective of this thesis. The purpose of this chapter is to draw insight on how the interaction of reserve requirement, FX intervention, and interest policy stabilise the economy, particularly in the presence of external shocks.

As previously discussed, this thesis is formed by journal articles. One of the advantages of this format is the dissemination of the thesis can be performed right away without the complication of reformatting. Further, each chapter can be taken away independently, and hence, easier to communicate the thesis without waiting for the whole thesis to be completed. Table 1.1 below presents the whole thesis structure along with its dissemination channels.

Table 1.1: Thesis Structure

Paper	Title	Intended Contribution	Dissemination
1	What Can We Learn from the Implementation of Monetary and Macroprudential Policies: A Systematic Literature Review	To provide a critical systematic review of the literature on the interaction of monetary and macroprudential policies	– Presented in 31st Business and Economics Society International Conference, 2017, Crete, Greece, 6-9 July 2017. – Published in Journal of Economic Surveys, 2019, Vol. 33, Iss. 4, pp. pp. 1123-1150
2	Gauging the Impact of Payment System Innovations on Financial Intermediation: Novel Empirical Evidence from Indonesia	To provide empirical evidence on how improvements in payment systems affects financial intermediation through excess reserves and currency holding	– Presented in Conference on Fintech, Social Finance, and Financial Stability Asian Development Bank Institute, Shenzhen, 11-12 December 2018. – Published in Asian Development Bank Working Paper Series No. 984 July 2019 – Published in Journal of Emerging Market Finance, early views online.
3	Monetary Policy and Foreign Exchange Intervention in an Emerging Market: The Case of Indonesia	To provide empirical estimations of FX intervention based on the DSGE model in an emerging market, which features households with limited financial access	– Presented in XX Conference on International Conference, Granada, Spain, 27-28 June 2019 – Presented in 14th Annual International Symposium on Economic Theory, Policy & Applications, Athens, Greece, 1-4 July 2019 – Under reviewed in International Journal of Finance & Economics
4	External Shock and the Implementation of Monetary and Macroprudential Policies in an Emerging Market	To provide empirical estimations of the DSGE model for emerging markets of the interaction of reserve requirement, FX intervention and interest rate policy.	Ready for submission

Reference

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Unsal, D. F. (2013), 'Capital Flows and Financial Stability: Monetary Policy and Macroprudential Responses', *International Journal of Central Banking* **9**(1), 233–285.

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CHAPTER 2

What Can We Learn from the Implementation of Monetary and Macroprudential Policies: A Systematic Literature Review

Abstract

The emergence of macroprudential policies, implemented by central banks as a means of promoting financial stability, has raised many questions regarding the interaction between monetary and macroprudential policies. Given the limited number of studies available, this paper sheds light on this issue by providing a critical and systematic review of the literature. To this end, we divide the theoretical and empirical studies into two broad channels of borrowers – consisting of the cost of funds and the collateral constraint – and financial intermediaries – consisting of risk-taking and payment systems. In spite of the existing ambiguity surrounding coordination issues between monetary and macroprudential policies, it is argued that monetary policy alone is not sufficient to maintain macroeconomic and financial stability. Hence, macroprudential policies are needed to supplement monetary. Additionally, we find that the role of the exchange rate is critical in the implementation of monetary and macroprudential policies in emerging markets, whilst volatile capital flows pose another challenge. In so far as how the arrangement of monetary and macroprudential policies varies across countries, key theoretical and policy implications have been identified.

Keywords: monetary policy, macroprudential policy, capital flows, payment system, capital flows, systematic literature review

2.1 Introduction

The prolonged effect of the recent global financial crisis has taught policymakers a valuable lesson, particularly central banks around the world, in their efforts to find a way to stabilise the economy and prevent the crisis from reoccurring. The emerging economic environment is believed to be subject to surges of financial imbalances that can potentially lead to economic stagnation and disinflation. A relatively new approach has been adopted, which is to implement both monetary and macroprudential policies to stabilise the economy. In this context, monetary policy is used as a means of achieving price stability; macroprudential policies predominantly focus on financial stability, whereas microprudential policy targets the safety and soundness of individual financial institutions.

The introduction of the new stabilisation policies raises a number of questions relating to their effectiveness when interacting with monetary policy. For instance, it would be interesting to examine how macroprudential and monetary policies respond to technological/financial shocks, or to identify the transmission channels through which these policies interact to withstand such shocks. It would also be interesting to establish the extent to which monetary and macroprudential policies need to be coordinated.

In spite of the growing number of studies in this area, there is very little support for the macroprudential policy framework. In a broader sense, we lack a conceptual mechanism relating the implementation of monetary and macroprudential policies to the real economy, and to the financial system (International Monetary Fund, 2013). A comprehensive framework of monetary and macroprudential policy is required in order to provide some guidance to policymakers as to how they might achieve their objectives and enhance the transparency and accountability of the central bank.

Moreover, in this context, it is argued that the payment system plays a significant role in promoting financial stability. The importance of payment system to the financial stability can be observed from how the central banks define the financial stability. Taking the definition of financial stability from the Bank of England as an example, which states financial stability is "the consistent supply of the vital services that the real economy demands from the financial system (which comprises financial institutions, markets and market infrastructures). Those services are: providing the main mechanism for paying; for goods, services and financial assets; intermediating between savers and borrowers,

and channelling savings into investment, via debt and equity instruments; and insuring against and dispersing risk" (Bank of England, 2017, p. 32). In other words, the payment system is part of the financial system that needs to be preserved in order to enhance the efficiency of the financial markets and the financial system as a whole, hence boosting consumer confidence as well as enhancing economic interaction and trade in goods and services (Hasan et al., 2013). It is therefore important that we incorporate into our discussion on monetary and macroprudential policies the payment system as well.

The right policy mix between monetary and macroprudential policies varies across countries. In the case of emerging markets, any external shocks – coupled with domestic shocks – affecting the financial system may disrupt the monetary transmission mechanism. In this context, capital flow volatility, which may be transmitted to the credit or exchange rate markets or both, needs to be taken into account.

These premises raise fundamental questions about how a central bank promotes stability in the macroeconomy, specifically, how monetary and macroprudential policies interact, how the payment system relates to monetary and macroprudential policies, and what the impact of capital flows on monetary and macroprudential policies is. Consistent with the overall purpose of our intended study, our overarching question can be stated as follows: *how the interaction of monetary and macroprudential policies achieves price stability and financial stability*?

To address the aforementioned questions, this paper provides a critical systematic review of the literature on the interaction of monetary and macroprudential policies. Our objective is to identify the current policy debate in order to assist researchers as well as policymakers in identifying the relevant research questions to support policy design and implementation for the interaction of monetary and macroprudential policies.

Based on the results of the systematic search, 125 articles are assessed to tackle the initial review question. After obtaining the relevant data and identifying the emergent themes and sub-themes, the articles reviewed in this section are classified into three broad categories. The first category discusses the mechanisms in which monetary and macroprudential interact. The second category includes papers which discuss the open-economy setting, which incorporates the role of the exchange rate and the impact of capital flows. The final category includes papers which discuss a framework of capital control measure following the current experience of the emerging markets. Although

some aspects of these categories may not be distinct but partially overlap, each represents the conceptual framework of how monetary policy connects to macroprudential policies, where financial intermediation has been identified as one of the critical elements in this framework of the policy mix (Bernanke et al., 1999; Goodfriend and McCallum, 2007).

This review makes three specific contributions. First, to the best of our knowledge, this is the first paper that utilises a systematic literature review approach in this area; secondly, it provides a comprehensive analysis of the theoretical foundations of the interaction of monetary and macroprudential policies; and thirdly it offers a comprehensive analysis of how monetary and macroprudential policies have been implemented in both advanced economies and emerging markets.

The rest of the paper is organised as follows: section 2.2 discusses the methodology utilised in the paper and specifies the main steps followed while planning and accomplishing the review. Section 2.3 touches on the elements linking monetary and macroprudential policies. Section 2.4 highlights the role of the exchange rate in the framework of monetary and macroprudential policies whilst section 2.5 assesses the implications of capital flow. Finally, section 2.6 provides some concluding remarks and ideas for future research.

2.2 Methodology

To assess the interaction of monetary and macroprudential policy, the Systematic Literature Review (SLR) approach was adopted. SLR is a methodology that pinpoints current studies, chooses and assesses analyses, contributions and synthesises data and reaches clear conclusions about what is known and unknown (Denyer and Tranfield, 2009). Unlike narrative reviews, the SLR offers a more rigorous and clear review process by following procedures that incorporate comprehensive searches for all possible significant studies (Thomé et al., 2016) and an audit trail of all research stages in a scientific and transparent manner (Tranfield et al., 2003).

SLR has been used in psychology, medical and social science to deliver in-depth answers to specific research questions in supporting policy-making and implementation (Thomé et al., 2016). Given the complexity of the assessment area and the need to deliver a comprehensive result to scholars, practitioners and policymakers, it is believed that the SLR approach is a suitable approach to respond to these challenges.

2.2.1 Review Strategy

Following the preceding positioning study, this paper focuses on tackling the review question of how do monetary and macroprudential policies interact to achieve price stability and financial stability in the economy. In line with the general principle supporting the SLR methodology, the above assessments were formulated into a review protocol (Tranfield et al., 2003).

This protocol covers information relating to our steps to conduct our reviews; which were performed in two stages. First, inclusion and exclusion criteria of the literature intended for survey were developed. Pursuing the review question and sub-questions, the literature needed to have an assessment of both monetary and macroprudential policies. However, we anticipated a limited size of this literature as this strand of literature is still developing (Galati and Moessner, 2013). Therefore, we also considered other forms of monetary policy or macroprudential literature that develop our knowledge of the interaction of monetary and macroprudential policies.

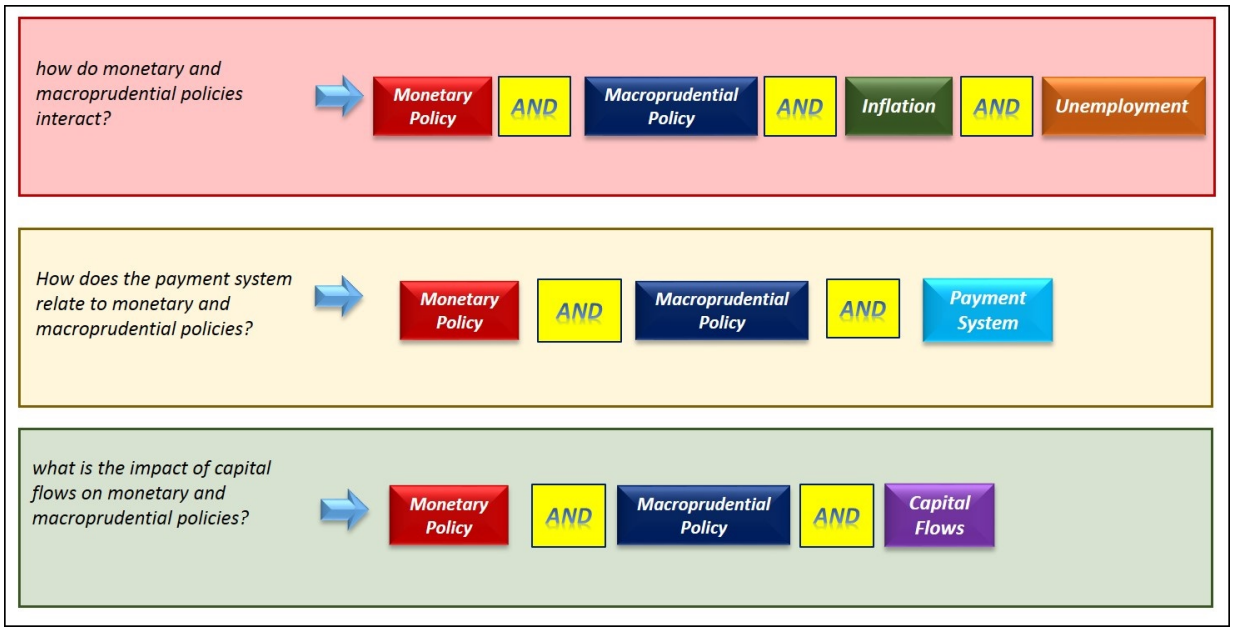
In order to provide a robust examination, sources were limited to English peer-reviewed journals as they generated high impact validated knowledge (Podsakoff et al., 2005). Moreover, an approach was followed which was somewhat similar to Meier (2011) and Savino et al. (2017) and considering only publications in scholarly journals with an Impact Factor greater than or equal to the Median Impact Factor for the related category (in this case: Economics, Business, Finance and Management) in the 2015 Journal Citation Reports (Thomson Reuters, 2015)[1]. There was no restriction regarding the definition of monetary regime in order to acquire a comprehensive understanding around this subject. Similarly, the search was not limited to a particular country or research method.

Second, keywords were designed which are consistent with the selection criteria. The search objective was to be as comprehensive as possible to prevent overlooking potentially important studies. In order to formulate the list of keywords, the author carefully scrutinised the keywords for the positioning study review. This process resulted in a list of 70 keywords which were divided into several groups that represent the exploratory areas: monetary policy, macroprudential policy, capital flows, inflation, unemployment

[1]See Appendix A.1 for the detailed inclusion and exclusion criteria.

and payment system[2]. Each group was combined with Boolean operator "AND" to perform the search strings according to the review question and sub-questions intended to be explored, as described in Figure 2.1.

Figure 2.1: Search Strings



2.2.2 Data Collection

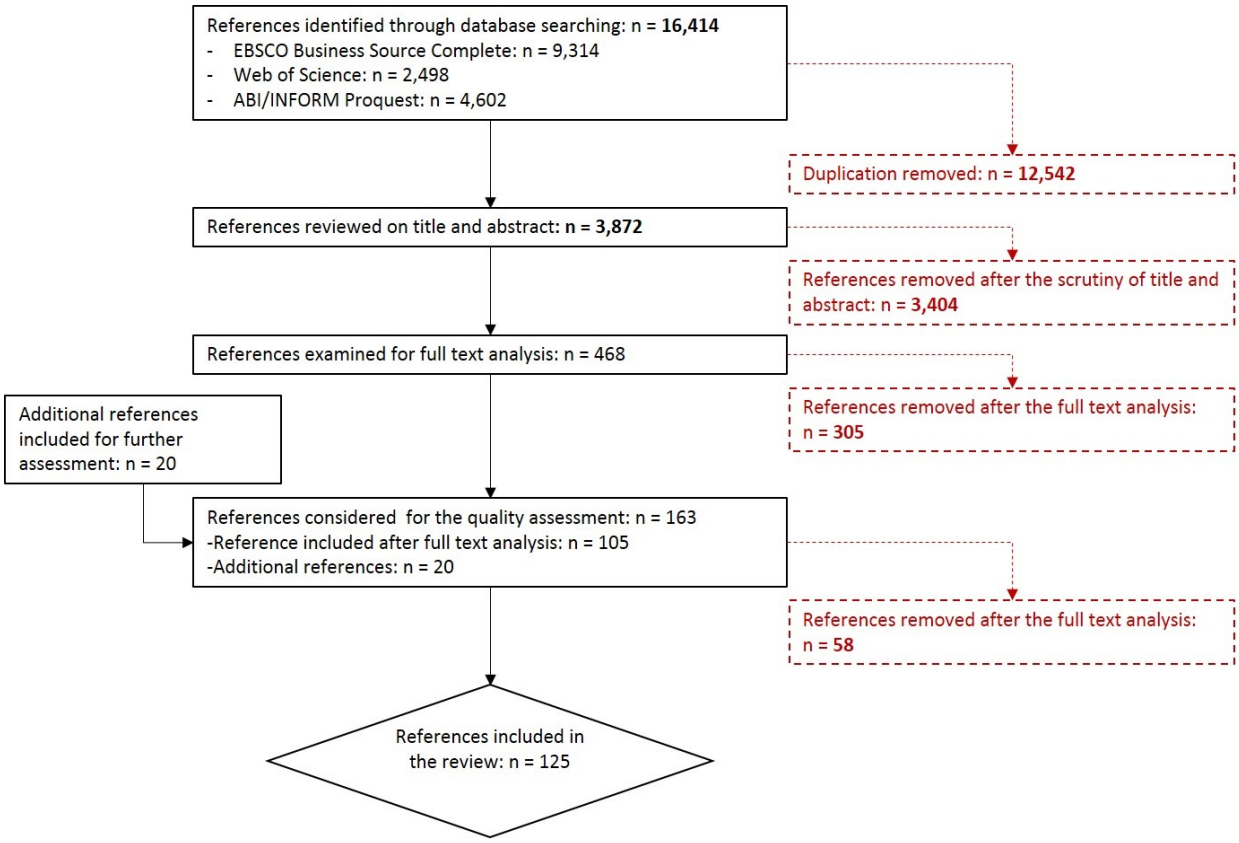
After defining a clear review strategy, the following step in the SLR process involved the selection of pertinent studies. A selection of keywords were applied to selected databases; consisting of ABI/INFORM Complete, EBSCO Business Source Complete and Web of Science. This initial search resulted in a total of 16,414 hits. This process resulted in 12,542 citations being excluded because of duplication and failure to meet the set criteria. The final sample comprised 3,872 references to be assessed on title and abstract. By examining the title and abstract based on the inclusion and exclusion criteria, 3,404 references had to be omitted.

The following step in our review was to perform a full-text analysis for the remaining group of 468 articles. After performing a careful assessment on the basis of the inclusion and exclusion criteria, we classified the references into A (highly relevant), B (moderately relevant) and C (non-relevant list). This resulted in 105 articles were classified as highly

[2]See Appendix A.2 for the detailed list of keywords.

relevant. To extend our search, given the aforementioned constraint, where there is a limited number of studies, an examination was performed of the reference section of all the included articles, to find relevant studies that were not obtained through our keyword search. This procedure added 20 more articles to our sample. Figure 2.2 presents a summary of our selection process.

Figure 2.2: Summary of the selection process

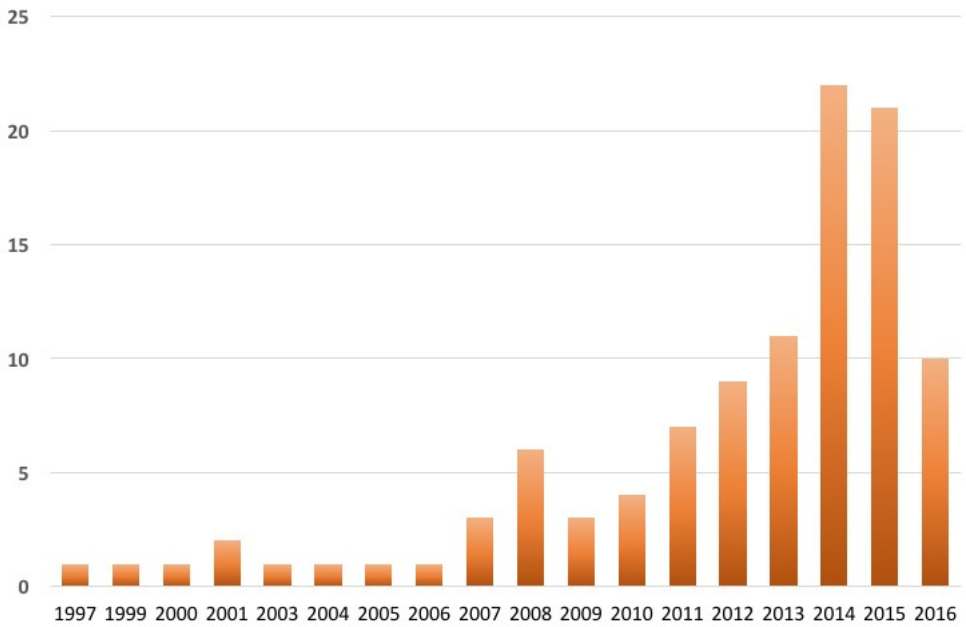


The distribution of the 125 articles in the final sample based on their source title is presented in Table 2.1. The Journal of International Money and Finance, the International Journal of Central Banking and The Economic Modelling are the dominant channels to discuss the research topic, accounting for 10%, 10% and 9% of the overall number of sample studies, respectively. Figure 2.3 portrays the number of articles in the samples by year of publication, ranging from 1997 to 2016. It can be argued that this review topic is a relatively new area and the increasing number of studies reflecting a growing interest in this topic indicates the importance of the attempt to shed light on the key issues surrounding this area.

Table 2.1: Articles according to their source title

Source Title (1)	**No. of Articles** (2)	**% of total Sample** (3)
Journal of International Money and Finance	11	10%
International Journal of Central Banking	11	10%
Economic Modelling	9	9%
Journal of Financial Stability	8	8%
Journal of Monetary Economics	7	7%
Journal of Money Credit and Banking	7	7%
Journal of Economic Dynamics & Control	6	6%
International Review of Economics & Finance	5	5%
Journal of Banking & Finance	5	5%
Journal of International Economics	5	5%
IMF Economic Review	4	4%
Scandinavian Journal of Economics	3	3%
Economic Policy	2	2%
American Economic Review	2	2%
Journal of Development Economics	2	2%
Journal of Policy Modeling	2	2%
European Economic Review	2	2%
Journal of Political Economy; *Economic Theory*; *Quarterly Journal of Economics*; *Review of Economic Studies*; *Journal of Financial Intermediation*; *Review of Financial Studies*; *Oxford Bulletin of Economics and Statistics*; *Annual Review of Economics; Economic Inquiry*; *Journal of Corporate Finance*; *Annual Review of Financial Economics*; *Journal of International Financial Markets Institutions & Money*; *Journal of Economic Surveys*	1	1%

Figure 2.3: Number of articles per year of publication



2.3 Interlink between Monetary and Macroprudential Policies

Broadly speaking, all the reviewed studies build their explanation of the interaction of monetary and macroprudential policies through the role of the financial sector in amplifying shocks to the economy. Previously, the financial sector was abandoned by mainstream business cycle models (see Christiano et al. (2005) and Smets and Wouters (2007) for example). However, the recent global financial crisis has delivered a very blunt message regarding how financial shocks may have implications for the economy. What we observe from all the reviewed studies is that the financial shocks affect the borrowers' side by limiting their credit eligibility, which in turn reduces credit demand. At the same time, financial shocks also affect the financial intermediaries, particularly through their balance sheet, which in turn affects their credit supply.

These two entities (borrowers, lenders/financial intermediaries) form the conduit through which the interlinking mechanism between monetary and macroprudential is explored. By virtue of the latter, we classify the studies we have reviewed accordingly, i.e. borrowers' cost of funds and collateral constraint mechanism on the borrowers' side, and balance sheet, risk appetite and payment system on the financial intermediaries' side. Figure 2.4 depicts the interaction channels of monetary and macroprudential policies whilst Tables 2.2 and 2.3 summarise selected theoretical and empirical studies in the area.

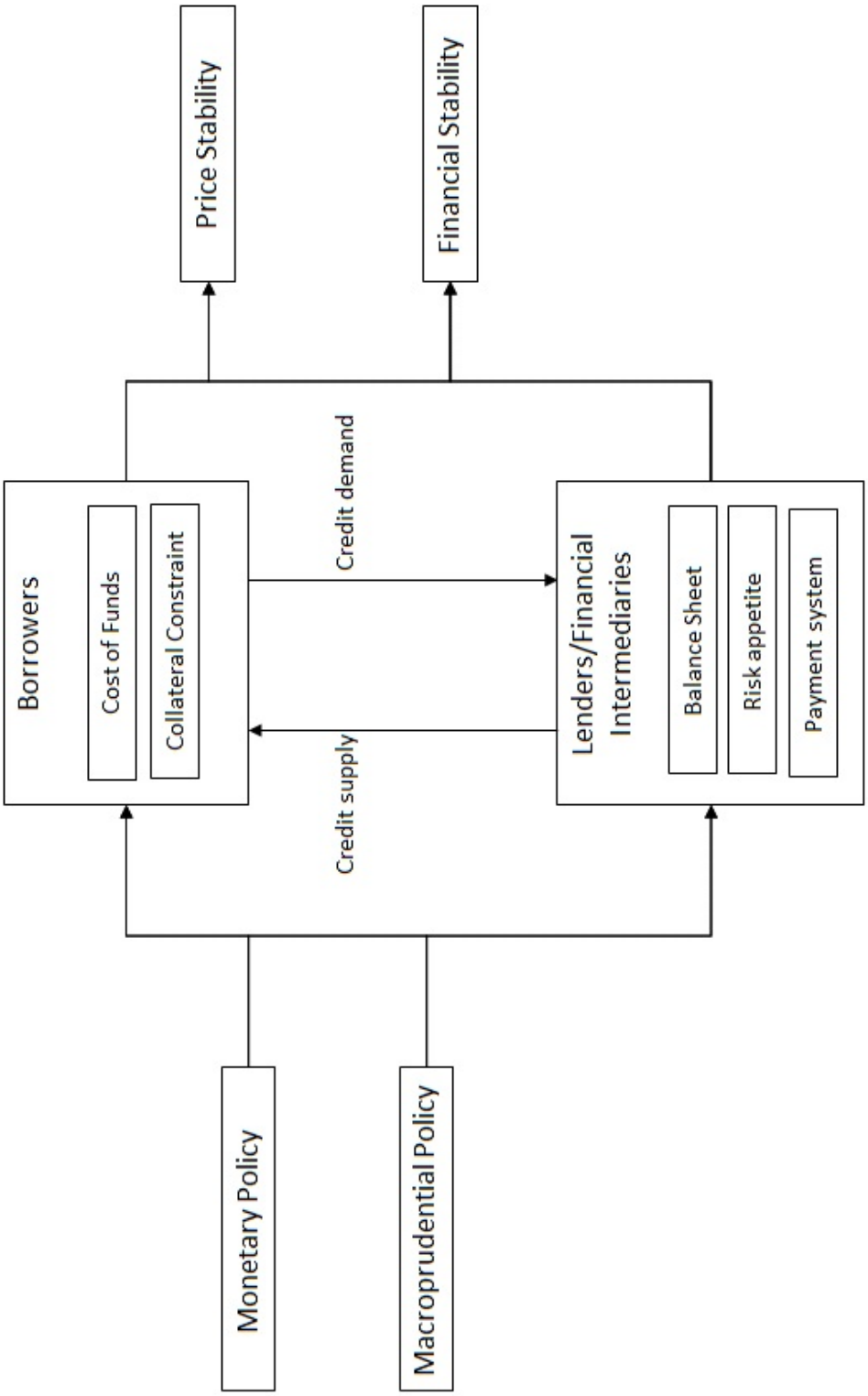


Figure 2.4: The interaction channels of monetary and macroprudential policies

Table 2.2: Interaction of monetary and macroprudential policies: selected theoretical studies

Study (1)	**Main Questions** (2)	**Channel** (3)	**Main Conclusion** (4)
Bailliu et al. (2015)	Should central banks also respond to financial imbalances, such as those associated with unsustainable credit expansion and asset-price bubbles?	Cost of funds	Welfare is higher where policy makers respond to financial imbalances using the policy rate and/or a macroprudential tool, compared to a standard Taylor rule, in regimes, particularly in the presence of financial shocks.
Merola (2015)	To what extent have financial factors accounted for the U.S. output collapse during the recent crisis?	Cost of funds	The recent crisis has enhanced the financial accelerator as a mechanism of propagation and amplification of business cycles.
De Paoli and Paustian (2013)	How should monetary and macroprudential policy be coordinated to stabilise the macroeconomy?	Cost of funds, collateral constraint	Policy authorities should cooperate and commit when the economy is hit by cost-push shocks. When monetary and macroprudential tools are set independently and under discretion, the economy needs to have one of the authorities act as a leader, as this can mitigate coordination problems. Choosing monetary and macroprudential tools that work in a similar fashion can increase such problems.
Bianchi et al. (2012)	What is the impact of the interaction between financial innovation, credit frictions and imperfect information on the design and effectiveness of macroprudential policy?	Collateral constraint	Financial innovation can overcome the collateral constraint. However, imperfect information in the new financial regimes may distort the debt decision and asset prices. The regulators need to acquire a better set of information than the private agents to issue a macroprudential policy that contains the amplitude of the boom-bust cycle.

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Table 2.2 – continued from previous page

Study (1)	Main Questions (2)	Channel (3)	Main Conclusion (4)
Shi (2015)	Can exogenous shocks to such liquidity be an important cause of the business cycle?	Collateral constraint	The paper argues that a negative shock to asset liquidity or firms' collateral constraint causes aggregate investment, employment and consumption to fall with the output
Iacoviello (2005)	How can financial frictions explain the aggregate time-series evidence and be used for monetary policy analysis?	Collateral constraint	The collateral constraint amplifies demand shocks but stabilises supply shocks to the economy. Monetary policy which reacts to asset prices does not give any significant welfare gain.
Rubio and Carrasco-Gallego (2014)	What are the implications of a macroprudential loan-to-value tool for business cycles, financial stability, and welfare, and what are those of its interaction with monetary policy?	Collateral constraint	The combination of macroprudential and monetary policies achieves a more stable financial situation and macroeconomy. Welfare is improving in the case of a non-cooperating situation between monetary and macroprudential policies.
Brzoza-Brzezina et al. (2015)	What is the impact of the introduction of occasionally binding constraints (OBC) into models with financial frictions and macroprudential policy?	Collateral constraint	A large macroprudential tightening can have a much stronger impact on the economy than a loosening of the same size.
Quint and Rabanal (2014)	What is the optimal mix of monetary and macroprudential policies in an estimated two-country model of the euro area	Collateral constraint	Macroprudential rule would help macroeconomic stability, enhance welfare, and partially substitute for the lack of national monetary policy. Macroprudential policy effects on borrowers depend on the shock that hits the economy.

Continued on next page

Table 2.2 – continued from previous page

Study (1)	Main Questions (2)	Channel (3)	Main Conclusion (4)
Borio and Zhu (2012)	What is the interaction between capital regulation, the business cycle and the transmission mechanism?	Risk-taking	Insufficient attention has so far been paid to the link between monetary policy and the perception and pricing of risk by economic agents—termed the "risk-taking channel" of monetary policy.
Angelini et al. (2014)	What are the consequences of introducing a time-varying capital requirement, on macroeconomic performance and stability, and what is its interaction with monetary policy?	Risk-taking	In the presence of supply shocks, time-varying capital requirements help to stabilise the fluctuation of the loan-to-output ratio. Lack of cooperation between monetary and macroprudential policies may cause excessive volatility in the policy instruments. In the presence of financial shocks, a time-varying capital requirement helps to stabilise the output and the loans-to-output ratio, regardless of their coordination.
Barnea et al. (2015)	To understand the connections between monetary and macroprudential policies.	Risk-taking	Monetary policy can be used to address financial stability, and macroprudential policy can also be employed to stimulate the economy, particularly in the situation where the interest rate reaches zero. There is a trade-off in the policy tools that needs to be understood by the policymaker.

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Table 2.2 – continued from previous page

Study (1)	**Main Questions** (2)	**Channel** (3)	**Main Conclusion** (4)
Gerali et al. (2010)	To understand the role of financial frictions and banking intermediation in shaping the business cycle in the euro area.	Risk-taking	Balance-sheet constraints establish a link between the business cycle, which affects bank profits and thus capital, and the supply and cost of loans. The banking sector and sticky rates diminish the effects of monetary policy shocks. Financial intermediation increases the propagation of supply shocks. A significant reduction in bank capital may have a significant effect on the economy.
Agénor and Aynaoui (2010)	What are the implications of excess bank liquidity for the effectiveness of monetary policy?	Risk-taking	Excess liquidity conveys greater stickiness to the deposit rate in response to a monetary contraction and induces an easing of collateral requirements on borrowers – which in turn may translate into a lower risk premium and lower lending rates.
Angeloni and Faia (2013)	How do bank regulation and monetary policy interact in a macroeconomy that includes a fragile banking system?	Risk-taking	Risk-based capital requirements amplify the cycle and reduce welfare. The best combination includes anticyclical capital ratios (Basel III) and the response of monetary policy to asset prices or bank leverage.

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Table 2.2 – continued from previous page

Study (1)	Main Questions (2)	Channel (3)	Main Conclusion (4)
Angelini et al. (2014)	What are the consequences of introducing a time-varying capital requirement on macroeconomic performance and stability?	Risk-taking	During the presence of a technology shock, the capital requirements may not be beneficial for stabilising the economy compared to monetary policy. In the presence of financial shocks, the capital requirement helps to stabilise the target variables. However, a lack of coordination between these two policies may cause excessive volatility in both the monetary policy and the capital requirement.
Agénor et al. (2013)	What are the roles of bank capital regulation and monetary policy in mitigating procyclicality and promoting macroeconomic and financial stability?	Risk-taking	A combination of a credit-augmented interest rate rule and a Basel III-type countercyclical capital regulatory rule may be optimal for promoting overall economic stability.
Benes and Kumhof (2015)	Developing theoretical models of banks and macroprudential policies such as the Basel III regime.	Risk-taking	A countercyclical capital buffer leads to a significant increase in welfare. It also reduces the need for countercyclical adjustments in policy interest rates.
Valencia (2014)	What is the link between monetary policy and banks' risk-taking incentives in a dynamic bank model and under what conditions can risk-taking be excessive?	Risk-taking	Lower monetary policy rates can worsen or reduce these incentives depending on the size of the shock when equity financing is ruled out. Capital requirements are closer to the source of the distortion and thus work better than loan-to-value caps in reducing excessive risk-taking.

Continued on next page

Table 2.2 – continued from previous page

Study (1)	**Main Questions** (2)	**Channel** (3)	**Main Conclusion** (4)
Piazzesi and Schneider (2018)	How to model the determination of securities prices and inflation in an economy with a layered payment system that supports trade in both goods and securities.?	Payment system	Securities markets matters for both the supply and the demand of inside money. Securities are held by banks to back inside money, which is in turn used by other investors to pay for securities. As a result, securities prices, inflation, and policy transmission depend on the institutional details of the payment system.
Williamson (2003)	To study the role of the central bank in a model which permits alternative types of payment arrangements.	Payment system	A private clearing house arrangement improves efficiency but produces a real indeterminacy. The pricing of daylight overdrafts is irrelevant for the equilibrium allocation.

Table 2.3: Interaction of monetary and macroprudential policies: selected empirical studies

Study (1)	**Main Questions** (2)	**Channel** (3)	**Methodology** (4)	**Data** (5)	**Main Conclusion** (6)
Chang and Dasgupta (2007)	How shocks to some business segments affect investment in a firm's non-shock segments.	Risk-taking	Multivariate regressions	Multi-segment firms (1979 to 1997)	A fall in the collateral value of assets contributes to the increase in financial constraints faced by these firms and the decline in investment in the non-shock segments.
Cecchetti et al. (2017)	Does prolonged monetary policy easing increase the vulnerability of the domestic and offshore financial system?	Risk-taking	Panel regression	22 countries (1998 Q1 to 2014 Q4)	The leverage ratio and other measures of firm-level vulnerability increase for banks and non-banks as domestic monetary policy easing persists. The increasing vulnerability is also found in the financial sector firms outside of the U.S. as the result of monetary easing in the U.S.

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Table 2.3 – continued from previous page

Study (1)	Main Questions (2)	Channel (3)	Methodology (4)	Data (5)	Main Conclusion (6)
Aiyar et al. (2016)	How does the credit supply respond to monetary policy and bank minimum capital requirements?	Risk-taking	Least square, panel Vector Auto Regression (VAR)	UK banks' minimum capital requirements(1999 Q1 to 2006 Q4)	There is little evidence of interaction between these two policy instruments. The findings do not confirm theoretical models that raise concerns about complex interactions between monetary policy and macroprudential variation in capital requirements.
Greenwood-Nimmo and Tarassow (2016)	What are the effects of both monetary shocks and macroprudential shocks on aggregate financial fragility in the US over the period?	Risk-taking	A sign - restricted VAR	US (1960 Q1 to 2007 Q4)	Contractionary monetary policy aggravates financial fragility whereas credit-constraining macroprudential shocks may be able to reduce the credit-to-GDP ratio in the short run when interest rates are fixed. However, when the interest rate is free to accommodate the macroprudential shock, this reduces financial fragility and suggests there may be gains from a coordinated approach to macroeconomic management.

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Table 2.3 – continued from previous page

Study (1)	Main Questions (2)	Channel (3)	Methodology (4)	Data (5)	Main Conclusion (6)
Merrouche and Nier (2012)	Are efficiency of interbank payment systems and credit creation linked?	Payment system	Regression, seemingly unrelated least squares (SURE)	Eastern European countries (1995 to 2005)	Payment reforms were an important precondition for the credit expansion in the sample countries. Payment system reforms also led to a shift away from cash (outside money) and towards demand deposits (inside money) as a medium of exchange, and this, in turn, enabled an expansion of credit in the sample countries.

2.3.1 Borrower Channel

Within the borrower channel, we identify from the surveyed literature two main mechanisms by which monetary policy interacts with macroprudential: the borrowers' cost of funds mechanism and the collateral constraint mechanism.

2.3.1.1 Cost of Fund Mechanism

Bernanke et al. (1999) offer an insight into how endogenous development in the credit market escalates and proliferates shocks to the macroeconomy – termed as the financial accelerator. This amplifying effect of credit markets can be explained by the relationship between the external finance premium (the difference between the cost of funds acquired externally and the opportunity cost of funds internally) and the net worth of potential borrowers (the difference between borrowers' liquid assets and the collateral value of illiquid asset excluding outstanding obligations). This financial accelerator may explain the output contraction in 2008 in the U.S., as well as the broadening in the spread between the central bank's policy rate and the cost of funds faced by entrepreneurs, and why financial conditions have amplified the U.S. business cycle and the intensity of the recession (Merola, 2015).

Using Bernanke et al. (1999) approach, Bailliu et al. (2015) examine the interaction of monetary and macroprudential policy. They assume that the financial shock affects the firms' cost of funds. Asymmetric information between the borrower and the lender causes the development of a financial market imperfection due to the inability of the lender to spot the idiosyncratic shock for the entrepreneur. Both monetary and macroprudential policy are activated by signs of developing financial imbalances, for which deviations of credit growth from its steady-state value are used as a proxy. Monetary policy uses Taylor's rule, which lets the policy interest rate also respond to deviations of credit growth from its steady-state value. The macroprudential policy is modelled as the exogenous component of the external finance premium and assumed to have a direct influence on the funding costs of firms (via the external finance premium).

Bailliu et al. (2015) report that the interaction between monetary and macroprudential policies improve welfare gains. Furthermore, macroprudential policy is a better tool with which to stabilise the macroeconomy than monetary policy in the presence of financial shocks. However, macroprudential policy neutralises the effect of monetary policy in

episodes of technology shocks. Therefore, monetary policy needs to respond more than it would without the presence of macroprudential policy.

In addition, De Paoli and Paustian (2013) argue that the insertion of macroprudential policy into the policy toolkit to manage the macroeconomy enhances the outcome regardless of shocks. However, they suggest that policymakers need to be cautious in selecting their monetary and macroprudential instruments. Choosing monetary and macroprudential tools that work in a similar way may lead to a significant welfare loss. They argue that the loan-to-value ratio is analogous with a time-varying tax on borrowing, which in turn increases/decreases the cost of funds. This characteristic works in a similar way to the interest rate, which can lead to a conflict between monetary and macroprudential policies and contribute to significant welfare losses.

2.3.1.2 Collateral Constraint Mechanism

Another strand of the non-financial borrowers channel literature focuses on the collateral restraint that borrowers have to face (Kiyotaki and Moore, 1997). In this model, fixed assets – such as land – act not only as input for production, but also as collateral. Lenders require collateral to reduce the risk of non-payment. Borrowers receive loans equal to the present value of their collateral. Thus, borrowers have to deal with the collateral constraint if they want to expand their project since their asset may be limited. Changes in borrowers' collateral values amplify the impact of monetary shocks on prices and the supply side. An increase in the lending rate increases the monitoring effort and increases the collateral-loan ratio. Chang and Dasgupta (2007) present empirical evidence of this collateral constraint channel. They find that a decrease in the collateral value exacerbates financial constraints faced by firms and reduces investment.

This constraint may cause an alteration in the composition of investment from long-term to short-term, while, in turn, decreasing the growth and amplifying the shock (Aghion et al., 2010). In addition, financial innovation[3]. allows the value of the collateral to increase while at the same time exposing the risk arising from volatility of collateral requirements or the loan-to-value ratio (Bianchi et al., 2012). A negative shock to asset liquidity or firms' collateral constraint can cause aggregate investment, employment and consumption to collapse with output (Shi, 2015). In addition, Abo-Zaid (2015)

[3]Bianchi et al. (2012) define financial innovation as "the introduction of a truly new financial regime"

concludes, using U.S. data in a New Keynesian model with collateral constraint, that long-run inflation is around 1.5% when the economy faces a total factor productivity (TFP) shock and about 2.5% when the economy is hit by mark-up shocks.

In the presence of a collateral constraint in the Euro Area, Quint and Rabanal (2014) demonstrate that macroprudential measures enhance welfare by reducing macroeconomic volatility; macroprudential measures help to reduce the leverage of both borrowers and banks. As a result, the real variables, such as output and consumption, are less volatile and generate cheaper lending rates and increased welfare.

Iacoviello (2005) connects the collateral constraint to the housing market, by using real estate as collateral for loans. He argues that, under a positive demand shock, the upswing in housing prices increases the borrowers' capacity to ask for higher loans so as to spend and invest more. However, Iacoviello (2005) only observes monetary policy, without the presence of macroprudential policy. He argues that monetary policy that responds to asset prices does not result in any significant advantages in terms of output or inflation stabilisation. Rubio and Carrasco-Gallego (2014) then take the Iacoviello (2005) approach further by combining monetary and macroprudential policy. They include the loan to values requirement, as a macroprudential instrument, in the context of the conventional Taylor rule of monetary policy. The loan-to-value requirement is a constraint on the value of a loan relative to the underlying collateral, which in this case is residential property. This macroprudential instrument acts as a rule that reduces the loan-to-value ratios, thereby discouraging credit expansion. Iacoviello (2005) find that the interaction of monetary and macroprudential policy enhances welfare.

The collateral constraint is assumed by Brzoza-Brzezina et al. (2015) to be occasionally binding, which means that it does not play a significant role near to the steady state, but becomes binding in the presence of large negative shocks in the economy. Brzoza-Brzezina et al. (2015) demonstrate asymmetric effects of financial frictions and find that significant tightening of the loan-to-value ratio can have a much stronger impact on the economy than a loosening of the same size. In contrast, small policy innovations, whether expansionary or contractionary, have effects of almost equal magnitude. The introduction of loan-to-value ratios along with monetary policy mildly decreases the volatilities of most variables, including house prices, while at the same time substantially reducing fluctuations in household debt.

2.3.2 Financial Intermediaries Channel

In this strand of the literature, the banking sector is found to play a major role in amplifying shocks to the macroeconomy. We identify two mechanisms in our surveyed literature through which financial intermediaries (such as banks) play a role in the interaction of monetary and macroprudential policy: banks' risk-taking (balance sheet) and payment systems.

2.3.2.1 Banks' Risk-Taking (Balance Sheet) Mechanism

The surveyed papers focus on how monetary and macroprudential policy affect the risk-taking behaviour of financial intermediaries which operate under restrained liability and asymmetric information. According to Borio and Zhu (2012), banks' risk perception and tolerance are influenced by changes in the policy rates. An easing of monetary policy leads banks to increase their leverage and lower their monitoring (Cecchetti et al., 2017; Dell'Ariccia et al., 2014).

Borio and Zhu (2012) argue that the capital position is the nexus of the banks' risk-taking attitude in terms of their lending and their leverage position. Given the capital position of the bank, a capital requirement influences bank behaviour through the capital threshold effect and the capital framework effect (Borio and Zhu, 2012)[4]. The capital threshold effect occurs due to the high cost banks have to pay, including the costs of restraining supervisory action, damage to reputation and negative market reaction, when a bank breaks the minimum capital requirement. The capital framework effect works on the basis that banks have to adjust their portfolios in response to changes in the capital requirement, given their attitude towards risk and their assessment of risks.

In order to provide further insights into the interaction between capital requirements and monetary policy, Angeloni and Faia (2013) point out that the risk-based capital requirement – a microprudential-based approach[5] – augments the cycle and causes an attenuation of welfare in its interplay with monetary policy during an economic downturn. Under a low-interest-rate environment, where risk-taking behaviour by banks can be excessive, a capital requirement constraint also works better than a loan-to-value ratio constraint (Valencia, 2014). The loan-to-value ratio regulates the leverage of borrowers,

[4]Borio and Zhu (2012) provide an extensive survey of the interaction of monetary policy and the capital requirement.

[5]The risk-based capital adequacy ratio as suggested in the Basel II accord.

while a capital requirement regulates the banks' leverage. Forcing banks to use their internal funding to finance the borrowers may restrain the excessive risk-taking behaviour of banks.

In the case of banks facing monopolistic competition, Gerali et al. (2010) argue that loan margins are determined by the banks' capital-to-asset ratios and by the degree of interest rate stickiness. Banks receive funding in return for issuing deposits, provide collateralised loans to both households and firms, and build up their capital from retained earnings. Excess liquidity may also convey greater stickiness on the deposit rate in response to a monetary contraction, and generate an easing of collateral requirements for borrowers – which in turn may transform into a lower risk premium and lower lending rates (Agénor and Aynaoui, 2010).

Banks may support a stable business cycle because their monopolistic position promotes the ability of financial intermediation to shield economic agents from fluctuations in market rates by moderating the impact of non-financial shocks. However, a bank may also introduce additional volatility into the business cycle due to the shocks that come from the credit market *vis-á-vis* collateral constraints and the relationship between the loan margin and capital-to-asset ratios (Gerali et al., 2010). In addition, Mimir (2016) finds that financial shocks to the banking sector contribute significantly, not only to financial variables such as bank credit and deposits, but also to the observed dynamics of macroeconomic variables such as output and consumption. In order to moderate the banks' tendency to amplify the cycle, a countercyclical capital requirement should be considered, and coordinated with the monetary policy (Agénor et al., 2013). Agénor et al. (2013) argue that a standard Taylor's rule interest rate policy, enhanced with credit growth and countercyclical capital requirements, may be an optimal option for achieving macroeconomic stability.

In more detail, the central bank is confronted with a policy trade-off when it uses either the policy interest rate or the capital requirements, but not both, in order to diminish the effect of the shock – either a shock to expected inflation or financial stability. The effectiveness of the monetary transmission mechanism from the policy rate to the bank lending and deposit rates is influenced by financial stability policy tools, such as reserve requirements and capital ratio requirements (Barnea et al., 2015). During the 'normal' period – when the dynamics of the economy are dominated by supply-side shocks

– the active use of capital requirements has an insignificant impact on the output volatility and inflation, despite generating a smaller loan-to-output ratio fluctuation (Angelini et al., 2014). During a period of financial shocks, countercyclical capital requirements provide beneficial support to monetary policy. Therefore, countercyclical capital requirements reduce the volatility of the policy rate (Benes and Kumhof, 2015).

A different view is taken, however, by Cao and Chollete (2017). More specifically, using the game-theory approach, they observe a reduction in the central bank's welfare due to the trade-off between maintaining price stability and financial stability. This approach links the bank's leverage to the financial and real shock. A positive real economy shock increases marginal productivity and moves the production function upward. The increasing marginal productivity drives the marginal return on capital and makes banks increase their credit supply. In a similar vein, a negative financial shock cuts the credit supply. Monetary policy contraction may reduce the financial imbalance, but monetary policy expansion may lower the probability of insolvency. Therefore, Cao and Chollete (2017) argue that the larger the correlation between real and financial shocks, the more likely it is that the central bank has to face the trade-off between maintaining price and financial stability.

2.3.2.2 Payment System

An alternative approach to analysing the role of the financial sector is offered by Goodfriend and McCallum (2007), an approach labelled as the banking accelerator. In contrast to the financial accelerator, the banking accelerator integrates the liabilities side of the banking sector to amplify shocks to the macroeconomy. The credit mechanism in this model is connected to the deposit side of the banking system. Given a negative shock in the macroeconomy which increases the external finance premium, a customer may have to liquidate his deposits in the banking sector. This reduction in the deposit side may cause the banking sector to increase the external finance premium even further.

Furthermore, this deposit side of banking liabilities is used as a payment medium (inside money) for customers, along with cash (outside money). Piazzesi and Schneider (2018) argue that banks will face a liquidity management problem due to their inability to protect themselves against liquidity shocks caused by payment instructions from the customer. Different types of payment systems, such as real-time gross settlement (RTGS)

or net settlement, may require different types of liquidity management. Banks' issuance of inside money determines the value of collateral held by banks, and the nominal price level required to cover the liquidity shocks. A loosening monetary policy may increase the asset price, which is the collateral the banking sector requires to engage in the payment system. Paying an interest rate on banks' reserves in the central bank offsets this effect, and increases welfare, but only when transaction costs are small (Bencivenga and Camera, 2011).

Merrouche and Nier (2012) argue that the efficiency of interbank payment systems relates to credit creation. Such efficiency may affect the creation of credit through at least one of the following two channels. First, innovations in the interbank payments technology enhance the reliability of inside money (holdings of deposits) as a payment medium for customers, and deposits are intermediated by the banking system. An increase in the supply of deposits to the banking system can, in turn, lead to a shift in the supply of credit to the economy. Second, innovations in interbank payment systems help to establish well-functioning interbank markets for end-of-day funds by reducing unsettled payments (Williamson, 2003). In addition, Hasan et al. (2013) find that moving to electronic retail payments has stimulated consumption and trade across the European Union.

Concerns about the risk associated with payment systems are increasing in tandem with the increased fragility of the banking industry following the recent global financial crisis. Freixas and Parigi (1998) demonstrate that the capital requirements of banks will provide a buffer in both RTGS and net settlement in terms of the necessary reserves and contagion risk[6]. To tackle the liquidity problem and avoid systemic risk, many central banks provide intraday overdrafts as collateral. Allowing banks to take out free intraday loans from the central bank relieves the credit constraints in the payment system. In combination with monetary policy, a central bank can explore the trade-off effects of liquidity constraints against the increases in priority afforded by collateralisation (Kahn and Roberds, 2001; Lacker, 1997). In addition, a surge in the implicit intraday interest rate suggests an increased opportunity cost of pledging collateral intraday, and can be used as an indicator to measure the pressure in the payment system (Jurgilas and Žikeš, 2014).

[6]Gross settlement means all payments are settled directly (real time) according to incoming/outgoing transactions, whereas net settlement means all payments are settled at the end of the day by deducting the outgoing from the incoming payments.

2.3.3 Policy Coordination between Monetary and Macroprudential Policy

One crucial factor that needs to be considered is the coordination between monetary policy and macroprudential policy. There is an increasing amount of discussion exploring this coordination (Smets, 2014). The current institutional arrangement of these two policies varies across countries. In advanced countries, such as the UK, the central bank is in charge of macroprudential policy. Meanwhile, the Financial Supervisory Authority takes this role in Sweden and Australia. Concern over the introduction of macroprudential policy may lead to a coordination problem, not only in countries where different institutions would be responsible for setting up monetary and macroprudential policy, but also in those with a single institution responsible for both. In addition, Tinbergen dogma states that only one policy is needed for one objective.

However, the abandonment of this Tinbergen rule has been called for by the Committee on International Economic Policy and Reform (2011). Close coordination between monetary and macroprudential policies needs to be ensure to enhance macroeconomic stability. During the presence of a cost-push shock, close coordination between them is needed to enhance welfare (De Paoli and Paustian, 2013). Even when these policies are set by two different institutions, there is a need for the leaders of these institutions to enhance welfare. A lack of coordination between macroprudential and monetary policy may generate unnecessary volatility of the policy instruments (Angelini et al., 2014). This unnecessary volatility occurs because these policy instruments work on the same channel with different objectives, and try to influence targeted variables such as bank rates and credit in conflicting directions. Therefore, the effect of one policy may cancel out the other's action.

This view is supported empirically by Greenwood-Nimmo and Tarassow (2016), who call for coordination between monetary and macroprudential policy. They argue that, in the absence of monetary policy, macroprudential policy may only be able to reduce one component of financial fragility in the short run. However, when used alongside monetary policy, macroprudential policy may diminish financial fragility.

However, this view is challenged by Rubio and Carrasco-Gallego (2014). They argue that monetary and macroprudential policy operated in a non-coordinated fashion improve welfare more than if they are coordinated. Moreover, allowing each policymaker

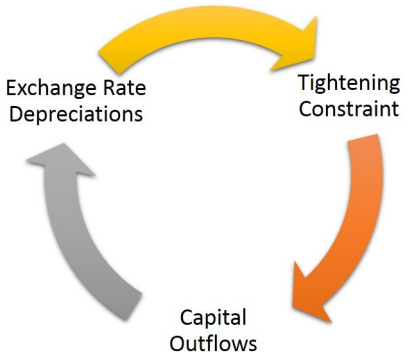
to concentrate on their own objective leads to more effective results in terms of achieving stability. In addition, Aiyar et al. (2016) do not find any complex relationship between monetary and macroprudential policy.

2.4 The Role of the Exchange Rate in a Monetary and Macroprudential Framework

One of the distinct characteristics of emerging markets is exchange rate volatility, especially for those countries that have substantial debt in foreign currency. Exchange rate volatility is less relevant for financial stability in advanced economies, but asset price volatility remains a threat (Korinek and Sandri, 2016). The exchange rate amplifies the shocks through both its volatility and level. The volatility of exchange rates poses a challenge to financial stability through three main channels (Agénor et al., 2014). First, large currency movements can disrupt exchange rate expectations which, in turn, lead to sudden changes in capital flows and generate high fluctuations in local-currency debt and equity markets. Second, currency depreciation can aggravate the currency mismatches of domestic borrowers with large foreign-currency debt exposures, which may undermine their creditworthiness. Third, large depreciation can be related to deterioration in external funding conditions during a crisis. The level of the exchange rate can amplify the shocks because it influences how much foreign lenders value domestic collateral (Korinek and Sandri, 2016).

A depreciation of the exchange rate reduces the value of collateral and initiates a feedback loop of tightening constraints and further exchange rate depreciation. This feedback loop is pictured in Figure 2.5.

Figure 2.5: Feedback loop of financial crises with exchange rate depreciation



Source: Korinek and Sandri (2016)

In order to respond to the question of whether a country should abandon a floating exchange rate regime in the case of large capital reversals, Fornaro (2015) introduces a theoretical framework that demonstrates that domestic agents borrow from the international markets using fixed assets as collateral. In the case of a sudden stop – significant capital outflows from the country – the value of this collateral shrinks. As a collateral constraint takes place, the economy falls into recession. Fornaro (2015) finds that monetary policy that responds to development in the financial system and spreads between domestic and foreign bonds delivers a better result for welfare compared to strict inflation targeting. In addition, there is a tendency for a central bank to deviate from its strict framework, allowing free exchange rate movement and engineering exchange rate depreciation, to maintain the value of collateral used to gain access to credit. Furthermore, a fixed exchange rate regime leads to substantially higher welfare losses during a financial crisis episode (Gertler et al., 2007).

Foreign exchange intervention has been actively used as a policy tool in many economies in Asia and elsewhere. Nevertheless, countries that employ foreign exchange intervention may still implement an inflation-targeting framework. The intervention itself can be communicated as restraining the exchange rate volatility or even targeting a certain level. However, it is found that intervention tends to be a discretionary action rather than a policy rule (Jun, 2008). A managed exchange rate regime relaxes the constraint on the degree of response to inflation, and alleviates problems of indeterminacy and expected instability (Llosa and Tuesta, 2008). Cavoli and Rajan (2015) state that, while sterilisation weakens the capital inflow effect on interest rates, it may even strengthen the

foreign interest rate effect. Small open economies that implement either a fixed exchange rate regime or strict inflation targeting manage to stabilize the real exchange rate and inflation at the expense of significant instability in the real economy (Alba et al., 2011).

Turning to the empirical evidence, on the basis of Norwegian data Akram and Eitrheim (2008) suggest that output stability and financial stability can be improved simultaneously. However, monetary policy faces a trade-off between inflation and output stability. Consistent with the theoretical approach, an interest rate response to excessive inflation of house prices, equity prices and credit will also increase stability in consumer price inflation and output. However, when interest rates react to a misalignment in the nominal exchange rate, the stabilising effect of the exchange rate on inflation and output is counteracted by the destabilising impact of increased interest rate volatility.

2.5 Capital Flows Volatility – A Challenge for Monetary and Macroprudential Policies

2.5.1 The Use of Macroprudential Instruments to Tackle Capital Flows Volatility

The massive volatility of capital flows, following the unconventional monetary policy applied in advanced countries, has provided challenges for policymakers, in terms of restraining capital flows from aggravating overheating pressures and consequent inflation, and mitigating the risk that protracted periods of easy financing conditions will threaten financial stability (Unsal, 2013). Under a restriction in foreign banking operations, international banking flows to the foreign non-bank private sector fall when the bank entry barriers increase, and interbank lending rises. After the liberalisation of capital inflows, domestic banks have to face fierce competition from foreign funds. Agents have to take on excessively risky forms of finance, and expose the economy to extreme systemic risk (Korinek, 2010). Domestic banks reallocate their lending to non-financial business, or they may take on riskier projects, and a few unlucky banks may become insolvent due to asymmetric information. If investors fail to appreciate the quality of bank assets, banks may accumulate losses even if investors expect a banking crisis. A few banks accumulating losses may, therefore, disrupt the credit market and even disrupt solvent projects.

This disruption is likely to lead to an output loss, even if there are no illiquidity problems (Giannetti, 2007). This capital inflow is subject to a 'sudden stop', which can be portrayed as reversals of international capital flows reflected in sudden increases in net exports and the current account. The reversal of capital inflows may precipitate a decline in production and absorption, and lead to corrections in asset prices (Mendoza, 2010).

In the case of volatile capital flows, monetary and macroprudential policies can supplement each other, and these policies are not perfect substitutes (Unsal, 2013). Broad macroprudential measures — such as the loan-to-value ratio -– are more effective than macroprudential measures that target capital flow. In addition, financial shocks have a more significant impact on inflation and output under a fixed exchange rate regime *vis-á-vis* a flexible exchange rate where appreciation of the nominal exchange rate facilitates a restraint on the overheating and inflationary pressures. In addition, macroprudential measures in the form of capital flow management contribute to a reduction in the elements that make up financial vulnerability, such as bank leverage, inflation expectations, bank credit growth, and exposure to portfolio liabilities (Forbes et al., 2015).

In seeking further insights into the international transmission of asymmetric shocks, Dedola and Lombardo (2012) build a two-country model with financial frictions along the same lines as Bernanke et al. (1999). They highlight that foreign exposure in interconnected balance sheets can, indeed, act as a powerful mechanism propagating asymmetric shocks across countries. Integration of asset markets will magnify the financial and real interdependence, even with minimal balance sheet exposure to illiquid foreign assets for financially constrained agents, provided that asset markets are integrated. A high degree of integration in the relevant asset classes stimulates a tendency towards the cross-border equalisation of external finance premia faced by financially constrained investors due to the no-arbitrage conditions it imposes, thus exposing a tight connection between leverage and macroeconomic dynamics across countries.

A somewhat different perspective is taken by Medina and Roldós (2014). In addition to the banking accelerator, they address a shock stemming from an extended period of zero-bound interest rates by introducing a simulation model. The simulation illustrates a long period of inflows – representing low interest rates – succeeded by capital outflows which reflect the normalisation of unconventional monetary policy in advanced economies. They argue that a countercyclical reserve requirement enhances the effectiveness of mon-

etary policy in reducing asset price volatility and, hence, improves welfare.

Looking at a different transmission channel, Agénor et al. (2014) develop a dynamic stochastic model of a small open economy. This model describes firms that are allowed to borrow from a domestic bank, while the bank borrows from the rest of the world, with a two-level banking intermediation structure, a risk-sensitive regulatory capital regime, and imperfect capital mobility. Countercyclical capital regulation is effective at promoting macro stability and financial stability. However, a countercyclical regulatory capital rule may need to be complemented by other, more targeted macroprudential instruments when shocks are large and persistent, because the advantage in terms of reduced economic volatility displays diminishing returns.

Glocker and Towbin (2012) advocate the use of a reserve requirement as an important policy instrument in many emerging economies. The interest rate complemented by the reserve requirement can be useful in stabilising economic activity in the context of a small open economy which is subject to sticky prices. The use of a reserve requirement becomes more effective when the banking sector is subject to legal reserve requirements – more specifically, when financial frictions, foreign currency debt and an objective of the authority to stabilise credit are all present. However, the presence of capital controls reduces the effectiveness of reserve requirements. This finding differs from those reported in earlier studies by De Gregorio et al. (2000), who argue that the effect of reserve requirements in terms of restraining capital inflows is limited, although they may alter the composition of capital inflows, from short-term to long-term.

Turning to the exchange rate variable, the exchange rate contributes in amplifying the shocks through both its volatility and level. The volatility of exchange rates poses a challenge to financial stability through three main channels (Agénor et al., 2014). First, large currency movements could disrupt the exchange rate expectations which, in turn, lead to sudden changes in capital flows and generate high fluctuation in local currency debt and equity markets (Evans, 2014). Second, currency depreciation could aggravate the currency mismatches of domestic borrowers with large foreign-currency debt exposures which lead to undermine their creditworthiness. Third, large depreciations could be related to a deterioration in external funding conditions during a crisis (Chu, 2015). The level of the exchange rate could amplify the shocks because it influences how much foreign lenders value domestic collateral (Blanchard et al., 2010; Kolasa and Lombardo,

2014; Korinek and Sandri, 2016). A depreciation of the exchange rate cuts the value of collateral and initiates a feedback loop of tightening constraints and further exchange rate depreciations. This feedback loop is pictured in Figure 2.5.

In order to respond to the question of whether a country should abandon their floating exchange rate in the case of large capital reversal, Fornaro (2015) introduces a theoretical framework that demonstrates that domestic agents borrow from the international market using fixed assets as collateral. In the case of a sudden stop – capital flows fly outside of the country – the value of the collateral shrinks. As collateral constraint takes place, the economy falls into a recession (In't Veld et al., 2014; Korinek and Mendoza, 2014). Fornaro (2015) found that monetary policy that responds to development in the financial system and spreads between domestic and foreign bonds delivers a better result for welfare compared to strict inflation targeting. In addition, there is a tendency for a central bank to deviate from its strict framework allowing free exchange rate movement and engineering an exchange rate depreciation to maintain the value of collateral in gaining access to credit (Alba et al., 2011). Furthermore, a fixed exchange rate regime leads to substantially higher welfare losses during a financial crisis episode (Gertler et al., 2007).

Foreign exchange intervention has been actively used as a policy tool in many economies in Asia and elsewhere (Canales-Kriljenko, 2003; Neely, 2008). Regardless, these countries that employed foreign exchange intervention may implement an inflation targeting framework (Mishkin, 2008). The intervention itself can be communicated as restraining the exchange rate volatility or even target a certain level. However, it is found that intervention tends to be a discretionary rather than a policy rule (Chutasripanich and Yetman, 2015; Jun, 2008). A managed exchange rate regime relaxes the constraint on the degree of response to inflation and alleviates problems of indeterminacy and expected instability (Llosa and Tuesta, 2008). Cavoli and Rajan (2015) stated sterilisation weakens the capital inflow effect on interest rates, but may even strengthen the foreign interest rate effect. Small open economies that implement either a fixed exchange rate regime or strict inflation targeting manage to stabilizes the real exchange rate and inflation at the expense of significant instability in the real economy (Alba et al., 2011).

2.5.2 Capital Flows Management vs Capital Control

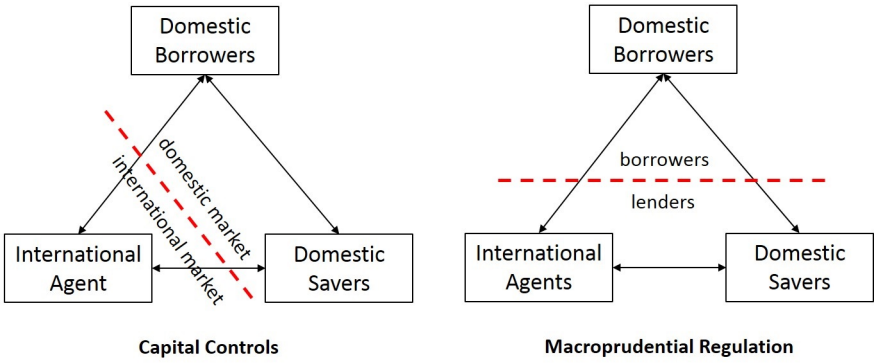
Samarina and Bezemer (2016) argue that capital flow controls can be implemented to tame massive capital inflows. However, such measures need to consider the effect of capital inflows on growth and financial system stability, and the importance of sectoral destination in determining the effects of capital flows. Foreign capital flows into economies with few investment opportunities may substitute for domestic bank lending to non-financial businesses, so that bank balance sheets become more dominated by household lending. In particular, greater dependence on domestic investment before crisis exacerbates the credit crunch that occurs during crisis, while exposure to foreign direct investment alleviates the liquidity constraint (Tong and Wei, 2011).

As noted above, Forbes et al. (2015) argue that macroprudential measures in the form of capital flow management may reduce financial vulnerabilities stemming from bank leverage, inflation expectations, bank credit growth, and exposure to portfolio liabilities. However, they also report that this reduction only lasts for six months and then reverses. In addition, such capital flow management measures have a limited effect on most other macroeconomic variables and financial market volatilities over the short and medium term, including equity indices, inflation, interest-rate differentials, and the volatility of exchange rates and portfolio flows. Based on data from India, Patnaik and Shah (2012) argue that the introduction of capital controls can reduce debt flows when price, quantitative and administrative controls are imposed, in the framework of a financial regulatory regime where all financial transactions are illegal unless explicitly permitted. There is a trade-off between lower unhedged foreign currency borrowing by households and firms, and a lower regulatory burden on financial markets.

Korinek and Sandri (2016) focus on the difference in impact between capital control and macroprudential policies. Capital controls are applied exclusively to financial transactions between residents and non-residents, whereas macroprudential regulation limits domestic agents to borrowing from either domestic or foreign lenders. The difference is shown in Figure 2.6.Korinek and Sandri (2016) argue that utilising both capital controls and macroprudential policies to complement monetary policy may moderate contractionary exchange rate depreciation. The macroprudential regulation aims to reduce the amount and riskiness of all financial liabilities, and capital controls aim to increase the aggregate net worth of the economy by restraining net inflows. These measures gener-

ate an interest differential between the domestic and international credit markets, and encourage domestic saving.

Figure 2.6: Capital Control versus Macroprudential Regulation



Source: Korinek and Sandri (2016)

Empirical testing of the impact of capital controls has yielded mixed results for different periods of observation. On the one hand, Edison and Reinhart (2001) observe that capital controls in Brazil and the Philippines, during the 1999 crisis and 1997-1998 Asian financial crisis respectively, did not succeed in restricting capital flow volatility. Furthermore, countries with capital controls have a high probability of experiencing a financial crisis (Glick and Hutchison, 2005). On the other hand, Chamon and Garcia (2016) find that capital controls in Brazil may have helped to tame a bubble in the economy. Restricting the access to foreign financing, however, may have contributed to the low investment and growth performance during that period, given the low domestic saving rate of the Brazilian economy. One of the characteristics of capital controls is that they tend to be kept in place for an extended period. Authorities seldom use this instrument to tackle short-term fluctuations in output, the terms of trade, or financial-stability considerations.

One of the small open economy frameworks is provided by Christiano et al. (2011) who argue that the financial shock to entrepreneurial wealth is essential for explaining business cycle fluctuations. From the output side, the unemployment affected by a sudden and temporary decrease in export demand or an increase in corporate interest rate spreads. Also, the relationship between the cost of increasing employment and the restrictions of the labour market in a way implied by search-matching models of the labour market. From the input side, the price of imported inputs and non-tradable sector pro-

ductivity play a significant role in driving investment and import fluctuations (Tiryaki, 2014).

In the presence of a monopolistic bank market and interest rate paid on excess reserves, collateral-constrained households' housing consumption moves procyclically with housing prices, domestic borrowing and lending rates. The availability of foreign borrowing amplifies the effect of declining housing prices (Chu, 2013). The financial integration intensifies the effect of temporary monetary shocks on output, consumption, investment, labour demand and loans. However, the impact of financial integration during the presence of a temporary technology shock is insignificant (Cakici, 2011). In addition, Poutineau and Vermandel (2015) argue that under banking globalisation, investment and current account imbalances are more sensitive to financial shocks while most national variables and the central bank interest rate are less sensitive to financial shocks. However, Hwang (2012) argues that financial openness may accommodate capital outflow without a greater volatility of the exchange rate in the case of domestic financial shocks.

Given that the context of external shocks are important in leading current account deficits that are followed by run-ups in house prices and household debt, Mendicino and Punzi (2014) conclude that the optimal policy is an interest-rate response to credit and a Loan-to-Value (LTV) ratio that countercyclically responds to house price dynamics. They argue that the monetary policy authority improves social welfare by allowing an interest-rate response to changes in financial variables due to the large welfare gains accrued to savers; the additional use of a counter-cyclical LTV ratio reacts to house prices.

Turning to the empirical evidence, Akram and Eitrheim (2008) suggest that output stability and financial stability can be improved simultaneously from the Norwegian data. However, monetary policy faces a trade-off between inflation and output stability. Consistent with the theoretical approach, interest rate response to excess growth in house prices, equity prices and credit also increases stability in inflation and output. However, when interest rates react to a misalignment in the nominal exchange rate, the stabilising effect of the exchange rate on inflation and output are compensated by the destabilising impact of increased interest rates volatility.

Capital flows also become a challenge to emerging markets in particular. Capital inflows are considered as a positive change in the perception of lenders when they become 'overoptimistic' about the domestic economy; hence, financing conditions become easier

(Unsal, 2013). Massive capital flows volatility creates turbulence in the domestic financial market due to the shallow characteristics of the market to absorb the shocks. Under a restriction in foreign banking operations, international banking flows to the foreign non-bank private sector fall when the bank entry barriers increase, and interbank lending rises (Gu and Huang, 2011; Kerl and Niepmann, 2015). After the liberalisation of capital inflows, domestic banks have to face fierce competition where they have to compete with the foreign fund. Agents have to take on excessively risky forms of finance and expose the economy to extreme systemic risk (Korinek, 2010). Domestic banks reallocate their lending to non-financial business or they may take on a riskier project and a few unlucky banks may become insolvent due to asymmetric information (Samarina and Bezemer, 2016). If investors do not observe the quality of bank assets, banks may accumulate losses even if investors expect a banking crisis. A few banks which accumulate losses may, thus, disrupt the credit market and cause an interruption for solvent projects. This involves an output loss even if there are no illiquidity problems (Giannetti, 2007). This capital inflow is subject to 'sudden stop' which can be portrayed as reversals of international capital flows that are reflected in sudden increases in net exports and the current account (Evans, 2014). The reversal of capital inflows drives declines in production and absorption, which lead to corrections in asset prices (Mendoza, 2010).

In the case of the capital flows volatility episode, monetary and macroprudential policies can supplement each other and these policies are not perfect substitutes (Unsal, 2013). Broad macroprudential measures – such as loan-to-value ratio – are more effective than capital flow macroprudential measures. In addition, financial shocks have a greater impact on inflation and output under the fixed exchange rate regime in contrast with the flexible exchange rate regimes where the nominal exchange rate appreciation facilitates a restraint to the overheating and inflation pressures. In addition, macroprudential measures in the form of capital flow management contribute to a reduction in financial vulnerabilities components, such as bank leverage, inflation expectations, bank credit growth, and exposure to portfolio liabilities.

Ostry et al. (2012) investigate whether macroprudential policies and capital controls can enhance financial stability in the face of the risks typically associated with large capital inflows. In order to analyse this, they compose new indices of foreign-currency-related prudential measures, domestic prudential measures, and financial-sector-specific

capital controls for 51 emerging market economies over the period 1995-2008. They point out that both capital controls and foreign-currency-related prudential measures are related to a decline in the proportion of foreign exchange lending within total domestic bank credit and in the proportion of portfolio debt within total external liabilities. Other prudential policies provide support in terms of limiting the intensity of aggregate credit booms.

The increasing number of central banks that employ capital flow management measures – in the form of either macroprudential measures or capital controls – need to take into account the adequacy of their international reserves (Jeanne, 2016). Massive capital inflows into emerging market countries are subject to reversal. Thus, the authorities must preserve the possibility of fire-sales, which can be caused by the Value-at-Risk constraint in the global banking system. Sudden stops in capital inflows are typically related to large contractions in real activity. Jeanne (2016) argues that the best policy for tackling this problem is to manage international reserves by absorbing the capital inflows and supplying the market during the outflow episode

2.6 Conclusions and Future Research Directions

In view of the preceding discussion, it becomes apparent that the extant body of literature on monetary and macroprudential policies is still in its infancy. An extensive debate between scholars is still ongoing as to whether financial friction affects the macroeconomy, and also how to factor financial stability into a framework of macroeconomic stability. The studies reviewed in this paper suggest that monetary policy alone is not sufficient to maintain the stability of the macroeconomy, given the complexity of the current economic environment.

As demonstrated above, financial intermediation appears to be playing a significant role in the achievement of financial system stability as well as macroeconomic stability. Despite the fact that macroprudential policies have, in many countries, played a major role since the global financial crisis, there is as yet limited experience of the practice of such policies (Galati and Moessner, 2013). A substantial range of macroprudential instruments has been discussed without a primary instrument having been recognised. Macroprudential instruments tend to be customised according to the challenges a partic-

ular country has to face (Claessens, 2015).

The systematic review of the literature performed in this study points to several empirical questions for future research: (a) How the inclusion of several macroprudential instruments, such as the loan-to-value ratio and the multiple versions of reserve requirements which are implemented in several countries, will affect the framework of monetary and macroprudential policies? (b) As the systematic literature review highlights the importance of maintaining the exchange rate – both its level and volatility – along with the stability of the economy, How the foreign exchange intervention is incorporated in the framework of monetary and macroprudential policies? As the review findings point out, such intervention is mainly performed on a discretionary basis. Central banks, particularly in emerging markets, need to factor foreign exchange operation into the framework of monetary and macroprudential policies. (c) Given the importance of the payment system in providing the foundation for settlement and credit supply, there is little evidence on the role of the payment system in the context of a monetary and macroprudential framework of analysis hence leading to the following question: would a policy regarding the payment system – such as electronic transfer fees or limitations on the nominal value to be settled in the large payment system in the central bank – have an impact on either macroeconomic or financial stability, or both?

Finally, it is also envisaged that a review paper on the implementation of monetary and macroprudential policies in an open-economy setting and the international aspect of macroprudential policy would be of great interest to both academics and policymakers..

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APPENDIX A

Inclusion & Exclusion Criteria and Keywords

A.1 Inclusion & Exclusion Criteria

Area (1)	Inclusion criteria (2)	Exclusion Criteria (3)	Justification (4)
Language	English	Any other language not formally translated	Limited resources for translation and may not be accessible to a wider audience
Peer Review	Peer review journals only	Non peer-reviewed documents	A peer review journal has undergone a peer review which assumes a minimum quality in terms of data quality and methodology applied
Country	All countries		Provide a comprehensive view of various practices
Monetary Regime	Broad definition of monetary policy that includes inflation targeting, monetary targeting or exchange rate targeting		Provide a comprehensive view of various regimes
Monetary and Macroprudential Instrument	All monetary instruments		Provide a comprehensive view of various instruments
Research Methods	All included		
Impact of the publication	Publication in a peer-review journal with an impact factor greater or equal to the median impact factor for the relevant category (in our case: Economics, business, finance and management) according to 2015 Journal Citation Reports© (Thomson Reuters, 2016)	Publication in a peer-review journal with an impact factor greater or equal to the median impact factor for the relevant category	An impact factor threshold may provide us a useful method to limit the number of relevant studies which arguably have a better contribution to the knowledge and better quality

A.2 Detail of Keywords

Group 1 Monetary Policy	Group 2 Macroprudential Policy	Group 3 Capital Flows	Group 4 Inflation	Group 5 Unemployment	Group 6 Payment System
"monetary polic*" OR "monetary shoc*" OR "monetary expansion*" OR "monetary impulse*" OR "monetary contraction*" OR "monetary transmission" OR "interest rate*" OR "policy rate*" OR "optimal interest rate rule" OR "interest rate rules" OR "financial accelerator" OR "monetary stability" OR "monetary operation*" OR "monetary theory" OR "non-standard monetary instrument*" OR "policy tradeoffs and monetary policy transmission"	"macroprudential polic*" OR "financial system*" OR "financial intermedia*" OR "financial institution*" OR "financial firm*" OR "financial sector*" OR "financial industr*" OR "financial friction*" OR "Financial instability" OR "Financial Stability" OR "credit friction*" OR "credit market*" OR “bank*" OR "credit market imperfection*" OR "capital requirement*" OR "financial fragility" OR "liability structure" OR "loan loss provisioning" OR "loan to value ratio" OR "macroprudential measures" OR "macroprudential regulation" OR "prudential policy"	"Capital flo*" OR "Capital flow m*" OR "Capital inflow*" OR "Capital inflows management" OR "Capital mo*" OR "Bank capital flow*" OR "Bond flow*" OR "Capital control*"	"inflation" OR "macroeconomic stability" OR "economic stabili?ation" OR "Inflation target*" OR "macroeconomic stability" OR "optimal long-run inflation rate" OR "price stability"	"unemployment" OR "income inequality" OR "wage bargaining" OR "welfare" OR "wealth effects" OR "consumption and wealth" OR "welfare analysis" OR "welfare economics"	"payment system" OR "payment" OR "financial transactions processing*" OR "electronic money" OR "electronic fund*" OR "debit card*" OR "credit card*" OR "credit card issuing" OR "money market" OR "wage payment system*"

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CHAPTER 3

Gauging the Impact of Payment System Innovations on Financial Intermediation: Novel Empirical Evidence from Indonesia

Abstract

A question of the role of payment systems in the economy is raised due to increasing innovations in this methodology. This paper presents an analytical framework and provides empirical evidence of how these innovations may affect the financial intermediation in Indonesia. The study elaborates the relationship by introducing a transmission mechanism where there are two channels: excess reserves and currency demand. This paper employs Generalised Method of Moments (GMM) and Vector Error Correction Model (VECM) techniques and finds that the financial intermediation is affected by the currency demand. In contrast, this study observes a limited role of excess reserves in affecting the financial intermediation. Credit card payments are found to have a statistically significant result in affecting currency demand, whereas debit card payments only influence the financial intermediation in the short-run. In addition, the Real Time Gross Settlement (RTGS) demonstrates an upward pressure on the excess reserves.

Keywords: payment systems, credit growth, monetary policy, financial intermediation

3.1 Introduction

The definition of a payment system has been identified as facilitating a settlement between economic agents to complete their transactions. Payment systems serve as the plumbing to the economy (Kahn and Roberds, 2009). Their production is subject to economies of scale due to the significant investment in infrastructure needed to start the operation (large fixed costs) and the relatively small marginal cost of services provided using the existing infrastructure (Hasan et al., 2013). A massive improvement in technology with the introduction of the credit card, debit card, automatic teller machines (ATM) and the recent introduction of the Internet has reshaped how people pay.

The development of the payment system itself is seen by the authorities as an opportunity to overcome the income inequality by providing the payment infrastructure to remote places, particularly in the emerging market countries (Martowardojo, 2015). However, as mentioned previously, the cost of these services and more importantly a perception that these payment services may not be sufficiently profitable for the business.

Innovations in the large value payment systems enhance excess reserves of the banking system as well as provide liquidity to the lending side. Furthermore, improvements in the retail payment systems can reduce the use of cash in transactions which enables banks to utilise the deposit side to the lending side. Given the validity of these premises, a set of research questions regarding the impact of payment systems innovation can be formulated in the following manner: First, how does improvement in payment systems affect currency holdings?, and secondly, what is the impact of customer limitation in the large value payment system on the relationship between the innovation of the payment system and loan supply?

Despite its relative importance and recent developments in the field of payment markets, the empirical literature on payments is rather sparse (Kahn and Roberds, 2009). This paper attempts to fill this gap. To tackle this question empirically, Indonesia is taken as the sample as it provides an interesting insight. As the biggest economy in South-East Asia, Indonesia needs to improve the involvement of the financial sector to the economy. Compared to other countries, Indonesia is relatively new to payment system innovations. The Automatic Teller Machine (ATM) card was firstly introduced in 1995 and Real Time Gross Settlement (RTGS) was launched in 2000. As recorded by the World Bank in the World Development Index, only 35.9% of the total population above 15 years old in the

country had bank accounts in 2014, increased from only 19.6%[1] in 2011. In addition, the loan to GDP, which suffered at the lowest value after the 1997-1998 Asian Crisis at 17.34% in Q1-2000, increases to 34.75% in Q2-2017[2]. Hence, Indonesia provides an interesting insight regarding the role of payment system innovations to the economy.

A novel element of this paper is that that for the first time we consider policies embodied in the payment system such as the limitation of the value that can be settled through the large value payment systems. It would have been interesting to incorporate the Internet banking data or other forms of telecommunication-based money such as 'Applepay', 'Googlepay' or 'GoPay' (Indonesia) to complement the analysis but due to the lack of availability of such data, only card-based transactions such as ATM/debit and credit cards were used. In this context, it can be argued that telecommunication-based money can be representative of a bank's deposit accounts since these services usually require a bank account or a debit card.

This paper makes several contributions. Firstly, it provides empirical evidence on how improvements in payment systems affects financial intermediation through excess reserves and currency holding; secondly, it gauges the impact of limitations in the amount of transaction value in payment systems as means of reducing uncertainty over the payment flows as well as bank's excess reserves; and thirdly, we demonstrate that a reduced currency holding may increase the loan supply whilst the increasing use of payment technology, such as debit cards and credit cards, contributes to the decreasing currency holding. Finally, this paper also tests the impact of innovation in the payment system on the interaction of monetary and macroprudential policies by linking the improvement in the payment system to the financial intermediation with both interest rate – the monetary policy instrument – and reserve requirement – the macroprudential policy instrument.

The remainder of the paper is organised as follows: Section 2 highlights the literature that has discussed the role of payment systems in financial intermediation. The third section presents a simple model that is used to examine the role of the payment system in financial intermediation. The fourth section provides an empirical estimation and a discussion of the results. The final section provides a conclusion to the work and policy recommendation.

[1] data available online at http://databank.worldbank.org/data/reports.aspx?source=2&country=IDN
[2] data from Indonesian Financial Statistics, Bank Indonesia

3.2 The Role of Payment Systems in Financial Intermediation

A payment is a transfer of monetary value which intends to free any liabilities that occur in exchanging goods and services (Kahn and Roberds, 2009). In a market economy, economic agents are independent to choose any forms of payment to settle a transaction. A payment system comprises the instruments, organisations, operating procedures, and information and communication systems used to initiate and transmit payment information from payer to payee and to settle payments (Bank for International Settlement, 2001). This payment system ensures the circulation of money, therefore, central banks as authorities in the issuing of money, are always interested in the smooth running of payment systems.

The payment system can be categorised into two types in terms of their end-customers; the wholesale payment systems and the retail payment systems (Kahn and Roberds, 2009). Wholesale payment systems deal with the intermediary institutions such as banks and/or other financial institutions in the form of a large-value payment system (LVPS). There are two types of LVPS based on their settlement process; i) gross settlement which is settled simultaneously in real time by using a platform called RTGS, and ii) the clearing system which operates on the net settlement basis where the settlement is performed after netting all the incoming and outgoing payments at the end of the day. Second is the retail payment system which serves the end customers such as households and firms. This retail payment system contains many forms of payment instruments including card-based systems such as ATM and debit and credit cards and digital payment such as Internet banking.

The role of the central bank depends on each mandate in the law of the relevant country[3]. This can range from issuing banknotes and currency, providing the settlement operations, the management of collateral and domestic currency reserves accounts.

The importance of the payment system to the economy has been documented by Hasan et al. (2013) who argue that innovation in the retail payment system helps to stimulate the overall economy and growth. This proposition is derived from their test of various retail payment instruments which include card payments and cheques. They find that card payments have the largest impact on the economy.

[3]Bank for International Settlement (BIS) provides a detailed survey of the payment systems in various countries in their website www.bis.org

Merrouche and Nier (2009) argue that improvement in payment systems technology encourages the use of banking deposits (inside money) as a payment medium for customers and thus influences the proportion between holding cash (outside money) and holding deposits (inside money). Furthermore, a well-functioning interbank market will be built to provide end-of-day funds. Therefore, this decreases the urgency of banks to maintain a large amount of excess reserves (outside money).

Banks play a major role in providing both financial intermediation and payment services. Hasan et al. (2012) point out that innovations in retail payment systems have a positive impact on the bank's performance through both fee-based income and interest income. The efficiency of payment systems may affect all banks in their ability to provide financial services to customers. It may, in turn, affect the ability of the banks to accumulate liquidity. By doing so, interest rates which are being paid by the bank to the customers may be affected (Merrouche and Nier, 2012). However, vast amounts of literature in banking and monetary policies rule out the interplay between these two activities. These studies, such as Fuerst (1992), focus on the role of the supply of money (outside money) from the central bank to the banking sector to ensure the financial intermediation.

The banking industry is dealing with the nature of liquidity mismatch. On the one hand, banks cannot easily liquidate their lending before maturity. On the other hand, they face liquidity shocks from the deposit withdrawals. An influential study from Diamond and Dybvig (1983) presents a discussion of the role of the banking system in creating liquidity by taking in short-term deposits and producing long-term investments.

However, the role of outside money is not being taken into account in this framework. The disturbance is only identified in the behaviour of the deposits in the banking system (inside money). The framework of how the conversion from inside money to outside money may influence the supply of loan is given by Bernanke and Blinder (1988). In a monetary contraction environment, banks will find that their deposits are deteriorating; hence the banks will also face decreasing reserves. With given reserve requirements, banks may also decrease their loan supply. If the loan supply decreases and banks are the main sources of financing then this will affect economic activity.

In the same vein, Diamond and Rajan (2006) highlight that a pressure in deposits withdrawal with a shift into the currency without any increase in money supply from

the central bank will diminish the credit supply. By ensuring that the claim of deposit withdrawal is inside the banking system, the bank can continue to ensure the supply of loan to the economy without facing a liquidity shock. When banks deal with a liquidity shock, they are generating a disintermediation effect by reducing their activities in the system. Moreover, they shift their portfolio of investments towards more liquid and less productive assets (Ennis and Keister, 2003).

By providing payment services to the customer in the large value settlement system, such as the RTGS, a bank can decrease its balance in the central bank reserves by investing in cash and liquidity management. With continuous and individual payment instructions, banks need to have sophisticated liquidity management. Banks depend on two sources in fulfilling their payment obligations: reserve balances and/or loan from the central bank and incoming funds acquired from other banks during the day (Galbiati and Soramäki, 2011). Using the reserve balance or taking loans from the central bank involves a cost which prompts economic incentives. Relying on incoming funds may not have a cost, yet it is beyond the bank's control. Therefore, it is very important to have sophisticated liquidity management in place. The more involvement a bank has in the payment system, the more investment in liquidity management pay-offs. This requires an active participation in the money market – by both borrowing and lending – to determine the balance in the central banks; therefore, it enhances the money market liquidity.

Nguyen and Boateng (2013) find that increasing excess reserves in China is a signal that banks are preparing for the increased risk which, in turn, reduces their loan supply. A contraction of the deposit division of the bank can be seen as an increased risk to reduce the loan supply. An uncertainty in payment flows in the large value payment system influences the transmission of the monetary policy by increasing the pressure for interbank market rates and the banks' reserves balance in the central bank for a precautionary reason (Kamhi, 2006). Another interesting result is also reported by studies that employed the U.S. data. Güntner (2015) points out that the excess reserves level in the U.S. data is not related to the loan supply. The level of excess reserves only crowds out the money market. The pivotal role of the money market to facilitate the continuation of payment flows and the level of excess reserves and lending to the economy became evident in the 2007-2009 financial crises.

On the retail payment systems level, Wang and Wolman (2016) take the U.S. data

from various locations in the country. They impose a nominal threshold whereby customers may use debit cards above that threshold and use cash below that threshold. They conclude that the use of debit cards reduces the demand for cash. This result is also supported by David et al. (2016) who use French data. They highlight the fact that the debit card provides two services for consumers – cash withdrawal and payment – that have contrasting effects on cash holdings and cash usage. They find that payment services through the card exceed the use of the ATM for cash withdrawals and have a negative impact on the currency demand. The same conclusion is also drawn by Lippi and Secchi (2009) by estimating from the Italian market.

Turning to the investigation on credit card holding and the household demands for currency, Duca and Whitesell (1991) argue that credit card ownership affects a lower demand for currency and demand deposits with no effect on small time deposits. However, Yang and King (2011) have a different view regarding the ability of credit cards to reduce currency demand. The presence of ATMs, online banking and electronic funds transfer reduce the cost of having to visit banks. Therefore, the credit card holding may not have an impact on the currency demand in aggregate.

3.3 Conceptual Framework and Data

3.3.1 Loan Supply, Reserves and Deposits

In order to gauge a comprehensive impact of payment system innovation on financial intermediation, we need to consider the role of bank deposit as a medium of payment. The framework proposed in the seminal work of Diamond and Dybvig (1983) is rather constrained in that it offers only an analysis of how credit creation is affected by the deposit withdrawal from the banking system and switched into the currency. Given the current innovation of the payment system, however, a payment can be performed by an economic agent not only through withdrawal from a bank deposit that was converted in the form of currency demand but also through using the bank deposit directly via the large value payment system, the retail payment system or both.

More recently, Rockoff (1993) and Merrouche and Nier (2009) offer a framework that takes into account both currency demand and bank deposit. Both of these approaches consider the impact of deposit withdrawal through currency conversion and through pay-

ment system on credit creation by linking the level of reserves that a bank needs to maintain in line with the loan supply. Thereby, any withdrawal in the bank deposit, either through conversion to currency or in the form of payment system services will affect the reserves of a bank.

In view of the above, in this study, we follow Rockoff (1993) and Merrouche and Nier (2009) which provide the basis on which we develop the conceptual framework of analysis in order to gauge the impact of payment system on credit. Unlike other approaches that focus on inside money to evaluate the credit creation, the two aforementioned approaches that constitute the building block in our research effort, are effectively utilised to explore the relationship between the efficiency of payment system services and financial intermediation by incorporating both the role of inside money and outside money.

This paper assumes that economic agents want to maintain a fraction of their nominal income in the form of liquid assets. These assets are represented by two assets, Deposit (D) and Cash (C) according to a constant elasticity of substitution production function. Hence, a modified quantity theory can be presented as:

$$[(\delta D^{-\alpha}) + C^{-\alpha}]^{-\frac{1}{\alpha}} = kY \tag{3.1}$$

where δ is an index of the quality of deposits that affect payments and Y is the nominal income and $\sigma = \frac{1}{(1+\alpha)}$ is the elasticity of substitution. This paper assumes that economic agents try to maximise utility from holding monetary assets by setting the marginal product of deposits, the currency deposits ratio $\frac{C}{D}$ may be expressed as a linear function of the quality deposits δ.

These two types of assets are lent out in two different channels. Currency is being lent directly without any financial intermediation and deposits are intermediated by the banking system. Previous literature such as Bernanke and Blinder (1988) is followed which assumes that loan cannot be perfectly substituted by bonds. This paper views that this assumption is practical in the context of the emerging market conditions, particularly Indonesia. The local bond market needs to be developed. As monitored by the Asia Development Bank, the corporate bond market in Indonesia is only 2.56% of total GDP[4].

[4]Data available online at https://asianbondsonline.adb.org, accessed on 18 Sep 2017

A representative bank's balance sheet is:

$$R + L_s = D \tag{3.2}$$

where R is the total bank's reserves, L_s is the supply of loans and D is the level of bank deposits. The bank is required to retain their reserves in the central bank in proportion to its deposit base based on certain reserve requirements, therefore total reserves R include required reserves and excess reserves ER so let ρ represent the reserve requirement rate thus:

$$ER = R - \rho D \tag{3.3}$$

Following the aforementioned discussion, the bank maintains excess reserves to prepare for the customer payments flows which may create a liquidity risk to the bank. The bank would require borrowing from the central bank at a high penalty rate to cover the payment obligations. This liquidity management can be performed in the interbank market to optimise the cost. Therefore, the interbank market becomes more liquid.

This study combined the equations 3.2 and 3.3 to get the loan supply function:

$$L_s = (1 - \rho)D - ER \tag{3.4}$$

The introduction of smooth and efficient payment systems can be considered as a permanent positive shock to ρ and D and a permanent negative shock to the banks' desired level of excess reserves ER. Furthermore, there is a positive feedback mechanism that is associated with a higher equilibrium output and loan, if the output is a function of the available supply of credit. Another channel of the payment system which affects credit in this framework is the reserves channel subject to the central bank not accommodating the commercial bank's demand or in the absence of massive quantitative easing policies.

3.3.2 Empirical Measure

Following the preceding conceptual framework, the first step of this paper's approach is to assess whether the presence of innovation in large-value payment systems, such as RTGS and the Clearing System, reduces excess reserves. Specifically, as explained previously, this paper uses a modified demand equation for excess reserves developed by Agénor

et al. (2004). We, therefore, purport to examine the level of excess reserves demand in the banking sector by capturing the impact of payment flows directly. It should also be emphasized that our approach takes into account the liquidity shock and macroeconomic condition to capture the dynamics of these factors to affect the excess reserves.

Other approaches such as Beaupain and Durré (2013) focuses on the price level of the interbank market to capture shocks to the reserves. According to Warjiyo (2014), however, this approach may not represent the interbank condition encountered in Indonesia i.e. shallow and concentration in several banks. In this sense, the interbank price level may represent the price premium that one bank charges another. Therefore, an empirical framework of analysis that is based on solely price information may not be adequate to provide a comprehensive answer to our research questions. Potentially, alternative approaches, such as the one by Güntner (2015) who employs the Dynamic Stochastic General Equilibrium (DSGE) model to assess the excess reserves, could have also been used. It should be stressed however, that this approach may not incorporate the payment flows and the payment system regulations that restrict the value of customer transactions in the large value payment systems that we want to investigate.

Our empirical approach is expressed as follows:

$$\begin{aligned} ED_t =& a_0 + a_1\, DRTGS_t + a_2\, RR_t + a_3\, IB_t + a_4\, Yshock_t + a_5\, RTGSREG\_01 + \\ & a_6\, RTGSREG\_02 + a_7\, HOLIDAY + a_8\, ED_{t-1} + \epsilon_t \end{aligned} \tag{3.5}$$

$$\begin{aligned} ED_t =& a_9 + a_{10}\, DCLEAR_t + a_{11}\, RR_t + a_{12}\, IB_t + a_{13}\, Yshock_t + \\ & a_{14}\, CLEARREG\_01 + a_{15}\, CLEARREG\_02 + a_{16}\, HOLIDAY + \\ & a_{17}\, ED_{t-1} + \epsilon_t \end{aligned} \tag{3.6}$$

where ED_t is the ratio of excess reserves ER over total bank deposit, D at time t, Similar with previous studies by Merrouche and Nier (2009, 2012) and Nguyen and Boateng (2013), both Rupiah (local currency) and foreign exchange deposits are included in this study. $DEVPS_t$ is the large value payment system (LVPS) transaction value at time t minus its 12-month moving average. This variable reflects the payment shocks to the bank. This study employs the total value of the LVPS to capture the overall performance of the liquidity management of the bank. A negative sign in the coefficient means that banks have already performed liquidity management and reduced the excess reserves.

RR_t is the reserve requirement ratio to capture the effect of the changes in the reserve requirement to the excess reserves. IB_t is the interest rate in the interbank market to capture the penalty rate if the bank needs to cover the liquidity when there is a shock in the payment flows. $Yshock$ is the deviation of output from the trend which represents the output shocks in the economy. As pointed out by Agénor et al. (2004) shocks in output will have a positive impact on the excess reserves. Because there is no monthly data available for output, this study uses the retail sales index as a proxy of output since this index is reported to have a correlation rate between the index and GDP which was 0.71% (Bank Indonesia, 2009).

The payment system regulation that restrict the value of customer transactions in the large value payment systems are included in the form of slope dummies $RTGSREG\_01$, $RTGSREG\_02$, $CLEARREG\_01$ and $CLEARREG\_02$. There are several instances when the central bank sets a limit for a customer to do a transaction in RTGS and Clearing in Indonesia[5]. The changes in the limits are captured in $RTGSREG\_01$ and $RTGSREG\_02$ for the RTGS transactions and $CLEARREG\_01$ and $CLEARREG\_02$ for the clearing transactions. Negative signs are expected in these variables which mean that limiting the value of individual transactions in both LVPS will help to minimise the payment shock to banks.

Also incorporated is the seasonal factor in Indonesia in $HOLIDAY$ to capture the cyclical factor because of the seasonal holiday of *Eid al-Fitr* which is a big celebration in Indonesia as suggested by Bank Indonesia (2017*b*) and ϵ_t is the error term.

The second approach is to investigate whether the innovation in the retail payments, such as debit cards and credit cards, affect the currency holding in the economy by constructing currency demand based on:

$$\begin{aligned} CS_t =& b_0 + b_1\, DEB\_CARD_t + b_2\, Y_t + b_3\, INF_t + b_4\, DEB\_CPOP_t + \\ & b_5\, INFRA_t + b_6\, DEPO_t + b_7\, HOLIDAY_t + \epsilon_t \end{aligned} \tag{3.7}$$

$$\begin{aligned} CS_t =& b_8 + b_9\, CC\_CARD_t + b_{10}\, Y_t + b_{11}\, INF_t + b_{12}\, CC\_CPOP_t + \\ & b_{13}\, INFRA_t + b_{14}\, DEPO_t + b_{15}\, HOLIDAY_t + \epsilon_t \end{aligned} \tag{3.8}$$

where CS_t is the ratio of the total currency in circulation outside of the banking sys-

[5]Appendix B.3 provides details of the regulations that Indonesia has imposed to limit the transaction value on the LVPS.

tem divided with the saving and demand deposits in the banking system at time t. DEB_CARD_t and CC_CARD_t are the number of card transactions which is derived from the number of transactions of each debit card or credit card divided by the number of debit or credit cards in the economy respectively. Rinaldi (2001) highlights that the number of card transactions could better represent the use of cards. However, this paper divides it by the number of cards to take into the account the introduction of new cards to the economy. The sign of this variable is expected to be negative to capture the substitution effect of card payment instruments and the transaction of the payment instruments. Y_t is the retail sales index which is used as a proxy of output and INF_t is the Customer Price Index (CPI) inflation. $DEPO_t$ is the nominal deposit interest rate in the banking system. DEB_CPOP_t and CC_CPOP_t is the number of debit and credit cards per 1000 population respectively. Similar with the DEB_CARD_t and CC_CARD_t, negative signs are also expected for these variables. $INFRA_t$ is the total number of ATM and Electronic Fund Transfer Point-of-Sales (EFTPOS) terminals.

Finally, this study tests whether the financial intermediation is related to the excess reserves and currency holding reductions with:

$$\begin{aligned} LG_t =& c_0 + c_1\, ED_t + c_2\, YG_t + c_3\, INF_t + c_4\, BI_t + \\ & c_5\, XR_t + c_6\, RR_t + c_7\, LG_{t-1} + \epsilon_t \end{aligned} \tag{3.9}$$

$$\begin{aligned} LG_t =& c_8 + c_9\, CS_t + c_{10}\, YG_t + c_{11}\, INF_t + c_{12}\, BI_t + \\ & c_{13}\, XR_t + c_{14}\, RR_t + c_{15}\, LG_{t-1} + \epsilon_t \end{aligned} \tag{3.10}$$

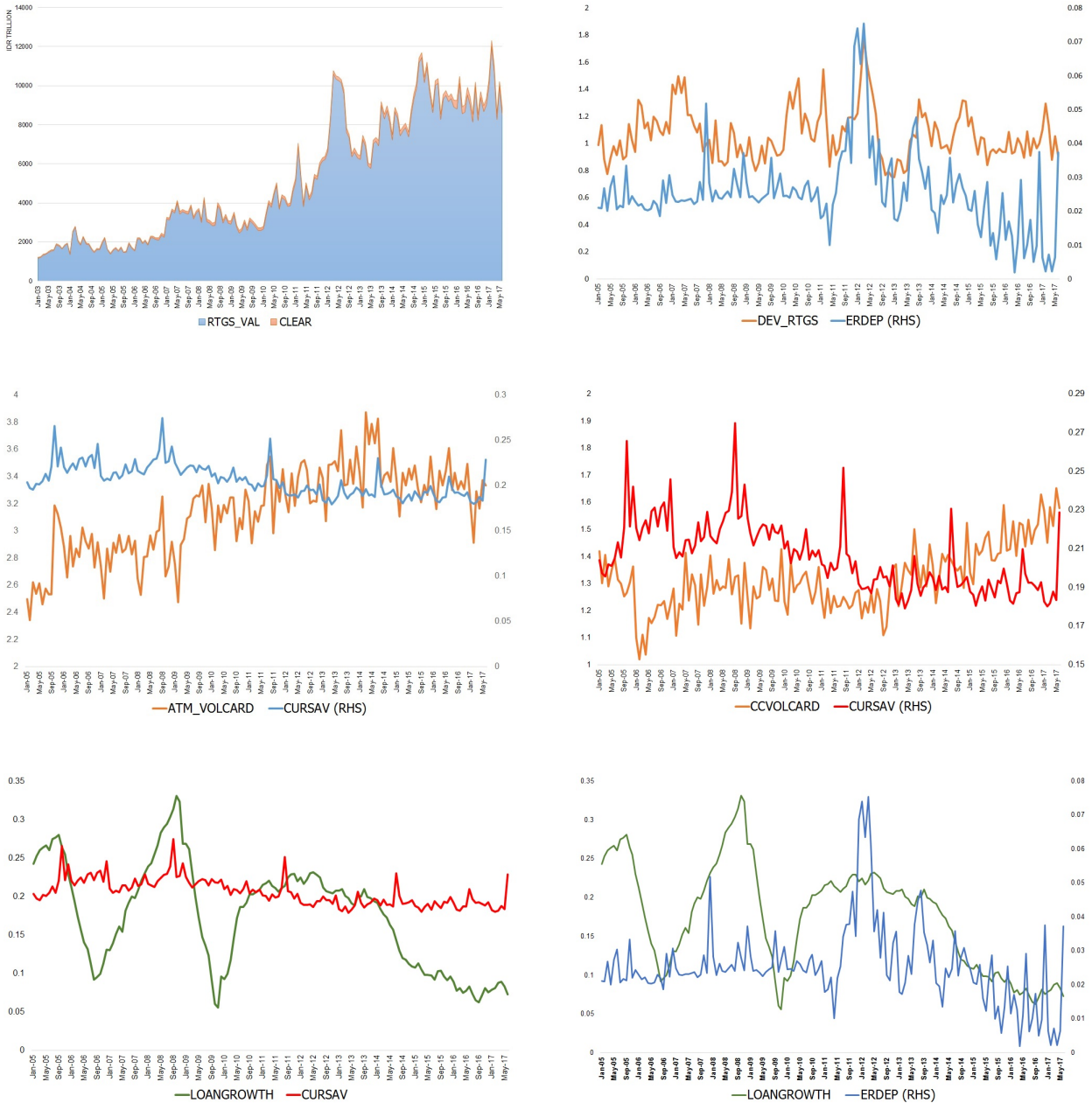
where LG_t is the financial intermediation which is represented by the year-on-year growth of loan in the banking system. ED_t is the ratio of excess reserves over the total deposit and CS_t the ratio of currency in circulation over total savings and demand deposits in the banking system. This variable is expected to have a negative sign to indicate the impact of payment system innovations to increase financial intermediation. YG_t is the year-to-year growth rate of the retail sales index. BI_t is the central bank's policy rate. It is interesting to see the impact of capital flow to the financial intermediation as represented by XR_t. Following other studies such as Korinek and Sandri (2016), the capital inflows will put an upward pressure to the exchange rate and the capital outflows will give a depreciation pressure to the exchange rate.

To test this relationship empirically, especially when estimating the link between financial development and economic development, several economic problems may occur such as problems in identifying causality, even if a significant relation is found to be in place and causality may run in both directions, possibility of autocorrelation (Hasan et al., 2013). In addition, the variables may correlate to the error term which indicates the presence of the endogeneity. Therefore, the study then used the Durbin-Wu-Test to test the endogeneity by evaluating the consistency of an estimator when compared to alternative one. Therefore, case of the presence of endogeneity, the investigation proposes to use Generalized Method of Moments (GMM) as suggested by Hasan et al. (2013) and Nguyen and Boateng (2013) in order to overcome this problem as an OLS estimation would be biased and inconsistent, being unable to account for the above issues. The GMM estimators are known to be consistent, asymptotically normal, and efficient in the class of all estimators that do not use any extra information aside from that contained in the moment conditions. However, in the absence of endogeneity then the OLS model is used as suggested by Bound et al. (1993, 1995) as OLS provides a better estimation when the excluded instruments are only weakly correlated with the endogenous variables.

3.3.3 Data

The monthly dataset is used from the Bank Indonesia's payment system statistics for RTGS, clearing and card payment transactions volume and value. The wholesale payment system is dominated by the RTGS which consists of 96.73% of the total transactions value in June 2017 whereas the debit card plays a major role in the retail payment system which is recorded 95.57% of the total transactions value in June 2017. Titiheruw and Atje (2009) provide an excellence survey of the payment systems in Indonesia. In addition, excess reserves data is taken from Monetary and Payment System Selected Indicators. The retail sales index can be found in the retail sales survey from Bank Indonesia. All other data are taken from Indonesia financial statistics. All of these data are available publicly from the Bank Indonesia website. The sample covers the period from January 2005 to June 2017 (150 observations). Figure 3.1 plots the time series used in this paper.

Figure 3.1: The Data



3.4 Estimation Result and Discussion

3.4.1 Payment system innovations and excess reserves

Following section 3.3.2, we start our investigation by using both RTGS and clearing turnover separately in order to see the impact of each LVPS on the excess ratio. The Durbin-Wu-Test test indicates a presence of endogeneity and therefore a GMM method-

ology is adopted to provide the estimates reported in Table 3.1.

Table 3.1: Estimation Result for Dependent Variable ED

	Dependent Variable:	
Independent Variable	**ED**	**ED**
(1)	(2)	(3)
C	-0.010856	0.004693
	(0.009982)	(0.015343)
DRTGS	0.011335**	
	(0.004681)	
DCLEAR		-0.009118
		(0.009544)
RR	0.125351**	0.057081
	(0.054077)	(0.060770)
IB	-0.000318*	-0.000206
	(0.000173)	(0.000214)
YSHOCK	0.008329	0.010482
	(0.005136)	(0.007651)
ED(-1)	0.382659***	0.576900***
	(0.120671)	(0.110606)
RTGSREG_01	-0.009361***	
	(0.002438)	
RTGSREG_02	-0.006460**	
	(0.002502)	
CLEARREG_01		0.002087
		(0.003657)
CLEARREG_02		-0.000658
		(0.003641)
HOLIDAY	0.005953***	0.005979***
	(0.00147)	(0.001547)
R^2	0.55	0.51
DW Stat	1.64	1.86
J-Statistics	9.95	8.89
No. of Observation	149	149
Instrument specification:	DRTGS(-1) DRTGS(-2) RR IB YSHOCK ED(-1) ED(-2) RTGSREG_01 RTGSREG_02 HOLIDAY	DCLEAR(-1) DCLEAR(-2) RR IB YSHOCK ED(-1) ED(-2) CLEARREG_01 CLEARREG_02 HOLIDAY

*Note: Robust standard errors in parentheses. ***, **, * denote statistical significance at 1%, 5% and 10% respectively.*

The yielded evidence suggests that payment shocks on RTGS (DRTGS) has a positive and significant impact on excess reserves which is in line with Kamhi (2006). Hence, implying that payment flows may exert an upward pressures on excess reserves but stands at stark contrast to Merrouche and Nier (2009) who find that payment innovations sig-

nificantly reduce the excess reserves ratio in a sample of Eastern Europe countries.

One factor that may contribute to why payment shocks cause an upward pressure in excess reserves is the shallowness of the interbank market in Indonesia (Warjiyo, 2014). The interbank money market has limited transactions and the liquidity is concentrated in certain banks (Bank Indonesia, 2017*a*) Thus, the ability of banks to access different source of funding may compel them to set up sophisticated liquidity management. The banking system may depend only on the central bank to access funding which causes reluctance in using such a facility because of the 'failure bank' stigma. Therefore, payment shocks that can happen anytime during the day due to the characteristic of the RTGS that requires a real-time settlement may drive the banks to accumulate reserves.

A limited ability of the interbank market to provide the liquidity makes the interbank market rates prone to a shock. A small demand in the market may cause the rate jumps. Therefore, we find that the interbank rate (IB) has a negative and significant impact on excess reserves as expected. Banks are lending their reserves to the interbank market when the interest rate raises and holding their reserves when the interest rate falls. We also find that the reserve requirement (RR) appears to have a significant positive result as expected. RTGS regulations to limit the amount of transaction value in payment systems (RTGSREG_01 and RTGSREG_02) show negative and significant coefficients as expected. This result indicates that regulations restrain the transaction value alleviate the impact of the payment shocks on excess reserves as expected.

In contrast, payment shocks in the clearing system in column 3 – Tabel 3.1 are found to have a negative impact on the excess reserves although these may be insignificant. It can be suggested that the limited size of the clearing system transaction contributes to this factor (3% of the total LVPS transactions).

3.4.2 The Effect of Card Usage to the Currency Holdings

In an attempt to gain an insight into the relationship between payment systems and financial intermediation, we extended our analysis to retail payment systems. We adopted a similar approach to the previous section and tested the impact of debit/ATM cards (DEB_CARD) and credit cards (CC_CARD) on the currency (CS) separately to examine their individual impacts. This approach intended to clarify the debate within the literature regarding the role of each card-based payment system.

We conducted an ADF test to check the stationarity of the variables, the results of which we report in Table 3.2

Table 3.2: ADF Test result

VARIABLES (1)	**I(0)** (2)	**I(1)** (3)	**I(2)** (4)
CS	**		
CC_CARD		***	
CC_CPOP	*		
DEB_CARD		***	
DEB_CPOP		***	
INFRA		*	

*Note: Robust standard errors in parentheses. ***, **, * denote statistical significance at 1%, 5% and 10% respectively.*

An inspection of the respective ADF tests indicated the presence of a unit root in the credit card transaction volume over the number of credit cards (CC_CARD), the debit card transaction volume over the number of debit cards (DEB_CARD), the number of credit cards over the population (CC_CPOP), and the number of debit cards over the population (DEB_CPOP). Following the standard methodological process when dealing with non-stationary variables, we proceeded to check for cointegration by utilizing a Johansen approach. The results of the Johansen test, which Table 3.3 and Table 3.4 provide, both unrestricted co-integration rank tests (trace and maximum eigenvalue statistics), reject the null of no co-integration at the 5% level of significance.

Table 3.3: Johansen Test Result for CS, DEB_CARD, Y, INF, DEPO, DEB_CPOP and INFRA

Hypothesized No. of CE(s) (1)	**Eigenvalue** (2)	**Trace Statistic** (3)	**0.05 Critical Value** (4)	**Prob.**** (5)
Unrestricted Cointegration Rank Test (Trace)				
None *	0.307382	179.4971	125.6154	0
At most 1 *	0.250084	125.8746	95.75366	0.0001
At most 2 *	0.223115	83.85679	69.81889	0.0025
At most 3	0.147883	46.99728	47.85613	0.0601
At most 4	0.094894	23.63276	29.79707	0.2164
At most 5	0.049085	9.076099	15.49471	0.3584
At most 6	0.011765	1.727873	3.841466	0.1887
Unrestricted Cointegration Rank Test (Maximum Eigenvalue)				
None *	0.307382	53.62247	46.23142	0.0069
At most 1 *	0.250084	42.01786	40.07757	0.0299
At most 2 *	0.223115	36.85951	33.87687	0.0214
At most 3	0.147883	23.36452	27.58434	0.1584
At most 4	0.094894	14.55666	21.13162	0.3212
At most 5	0.049085	7.348226	14.2646	0.4488
At most 6	0.011765	1.727873	3.841466	0.1887

** denotes rejection of the hypothesis at the 0.05 level by trace and max eigen value, **MacKinnon et al. (1999) p-values*

Table 3.4: Johansen Test Result for CS, CC_CARD, Y, INF, DEPO, CC_CPOP and INFRA

Hypothesized No. of CE(s) (1)	**Eigenvalue** (2)	**Trace Statistic** (3)	**0.05 Critical Value** (4)	**Prob.**** (5)
Unrestricted Cointegration Rank Test (Trace)				
None *	0.360157	206.14	125.6154	0
At most 1 *	0.321835	142.2859	95.75366	0
At most 2 *	0.260705	86.74985	69.81889	0.0013
At most 3	0.131105	43.5556	47.85613	0.1196
At most 4	0.083295	23.45939	29.79707	0.2242
At most 5	0.044666	11.0228	15.49471	0.2101
At most 6 *	0.030901	4.488554	3.841466	0.0341
Unrestricted Cointegration Rank Test (Maximum Eigenvalue)				
None *	0.360157	63.85405	46.23142	0.0003
At most 1 *	0.321835	55.53606	40.07757	0.0004
At most 2 *	0.260705	43.19425	33.87687	0.0029
At most 3	0.131105	20.09622	27.58434	0.3345
At most 4	0.083295	12.43659	21.13162	0.5052
At most 5	0.044666	6.534248	14.2646	0.5456
At most 6 *	0.030901	4.488554	3.841466	0.0341

** denotes rejection of the hypothesis at the 0.05 level by trace and max eigen value, **MacKinnon et al. (1999) p-values*

Having established the existence of cointegrating relationships, we used the VECM to examine the impact of the payment system innovation on the currency demand. To determine the number of lags, we used a range of standard criteria (see Appendix B.4).

We carried out an impulse response function analysis using the Cholesky decomposition of the matrix of covariance. In this approach, the order of the variables is important, because a shock to the previous variables has a contemporaneous effect on both the variable itself and the ones that follow Enders (2004). Following Rinaldi (2001), we assumed that the other variables affect money immediately, but it does not have a contemporaneous effect on any of them. Appendix B.6 presents the graphical representation of the impulse response function.

Table 3.5 and Table 3.6 provide the short-run as well as the long-run estimates.

Table 3.5: Short-run Dynamics for the impact of debit/ATM cards on the currency demand

Variables (1)	**Coefficient** (2)	**Std. Error** (3)	**t statistics** (4)
Ecm_{t-1}	-0.250523	0.116005	-2.159586**
ΔCS_{t-1}	-0.516013	0.175477	-2.940639***
ΔCS_{t-2}	-0.38522	0.188229	-2.046549**
ΔCS_{t-3}	-0.128986	0.17558	-0.734627
ΔCS_{t-4}	0.067105	0.129766	0.517125
ΔDEB_CARD_{t-1}	-0.000683	0.02665	-0.025627
ΔDEB_CARD_{t-2}	-0.012327	0.034528	-0.357023
ΔDEB_CARD_{t-3}	-0.022703	0.032314	-0.70258
ΔDEB_CARD_{t-4}	-0.009563	0.025121	-0.380674
ΔY_{t-1}	0.010701	0.019539	0.547687
ΔY_{t-2}	0.037045	0.020039	1.848679*
ΔY_{t-3}	0.016867	0.019044	0.885642
ΔY_{t-4}	-0.009222	0.018076	-0.510182
ΔINF_{t-1}	-0.133375	0.157203	-0.848428
ΔINF_{t-2}	-0.096249	0.146322	-0.657784
ΔINF_{t-3}	-0.072775	0.141127	-0.515669
ΔINF_{t-4}	-0.180271	0.129726	-1.389633
$\Delta DEPO_{t-1}$	0.015771	0.004898	3.219544***
$\Delta DEPO_{t-2}$	-0.004783	0.006078	-0.786821
$\Delta DEPO_{t-3}$	0.002638	0.006262	0.421209
$\Delta DEPO_{t-4}$	-0.003583	0.005084	-0.70486
ΔDEB_CPOP_{t-1}	0.080807	0.060752	1.330122
ΔDEB_CPOP_{t-2}	-0.090052	0.06739	-1.336284
ΔDEB_CPOP_{t-3}	0.045914	0.061455	0.747116
ΔDEB_CPOP_{t-4}	-0.039089	0.059046	-0.662018
$\Delta INFRA_{t-1}$	-0.006104	0.003391	-1.80002*
$\Delta INFRA_{t-2}$	-0.00295	0.003564	-0.827668
$\Delta INFRA_{t-3}$	-0.005725	0.003639	-1.573137
$\Delta INFRA_{t-4}$	-0.002079	0.003495	-0.594812
H_DUMMY	0.012083	0.002632	4.589937***
R^2	0.52		
S.E. of regression	0.010503		
F-statistic	4.242907 (0)		

*Note: Robust standard errors in parentheses. ***, **, * denote statistical significance at 1%, 5% and 10% respectively.*

Table 3.6: Long-run estimation results for the impact of debit/ATM cards on the currency demand

CS (1)	**Coefficient** (2)	**Std. Error** (3)	**t statistics** (4)
DEB_CARD_{t-1}	-0.084108	-0.03802	-2.21199**
Y_{t-1}	0.13182	-0.02574	5.12193***
INF_{t-1}	-0.058972	-0.04235	-1.3925
$DEPO1M_{t-1}$	0.001036	-0.0016	0.64893
DEB_CPOP_{t-1}	-0.032897	-0.02854	-1.15279
$INFRA_{t-1}$	-0.002671	-0.00169	-1.57618
C	-0.288833	-0.10735	-2.69060***

*Note: Robust standard errors in parentheses. ***, **, * denote statistical significance at 1%, 5% and 10% respectively.*

An inspection of the results presented in Table 3.5 suggests that, in the short run, the volume of debit card transactions over the number of debit cards (DEB_CARD) is not significant, hence implying that the use of debit/ATM cards to withdraw money is not as important as the use of cash in daily transactions. The currency demand will not be affected if occasional customers are the majority users of ATMs Stix (2003). In contrast, if regular customers use ATMs, then the impact of the volume of debit card transactions will have a negative and significant relationship with the aggregate currency demand. In line with this finding, although the number of debit cards per 1000 people (DEB_CPOP) appears to have an insignificant impact, the positive sign may suggest that customers primarily use debit cards to withdraw currency in the short run. However, the card-based payment infrastructure (INFRA) has a negative and significant coefficient, which implies that the availability of the infrastructure may reduce the demand for currency. The unbalanced number of terminals across the country may contribute to this slightly puzzling result (Snellman and Viren, 2009). Overall, the number of terminals reduces the aggregate currency demand; however, the use of cards and terminals in withdrawing large amounts of money may cause the conflicting result.

Retail sales (Y) bear a positive coefficient, which confirms that many transactions in the economy still use cash, as Titiheruw and Atje (2009) highlighted. Therefore, this puts upward pressure on currency when there is a positive shock to retail sales. The nominal interest rate (DEPO) has a positive and significant effect on the currency demand (CS), which is in line with Lippi and Secchi (2009). The positive coefficient of the nominal interest rate confirms that technology drives the ambiguous relationship between money and interest rates. Another factor that we may attribute to this relationship between

money and interest rates is the heterogeneity of the customers who use debit cards. Customers in rural or remote areas may withdraw a large amount of money to avoid the transaction costs of more frequent visits to the ATM, since the availability of machines is limited and most transactions are still cash based. As for the error correction term (ECM), it indicates that about 29% of the disequilibrium is corrected on a monthly basis.

Although a statistically significant relationship is not observable between the volume of debit card transactions (DEB_CARD) and the currency demand in the short run (CS), a negative and statistically significant relationship is apparent between these two variables in the long run, as Table 3.6 indicates. The preceding discussion about the short-run impact of debit/ATM cards on the currency demand provides the underlying reason behind this phenomenon. As Stix (2004) pointed out, regular customers may utilize debit cards to substitute cash by exploiting the features of the card through machines, such as transfer or payment. This verifies that regular customers utilize ATMs in the long run.

The card-based payment infrastructure (INFRA), which bears a negative coefficient in the long run, also supports this argument, hence suggesting that the availability of infrastructure may reduce the demand for currency. Furthermore, the variable reflecting the number of debit cards per 1000 people (DEB_CPOP) is consistent with the previous argument. The results obtained in the long run also confirm the dominance of cash in the economy, which we can observe through the positive coefficient for retail sales (Y).

On the basis of the preceding exposition, it has transpired that the currency demand and debit cards are inversely related. Next we explore the relationship between credit cards and the currency demand. Table 3.7 and Table 3.8 report the results.

Table 3.7: Short-run Dynamics for the impact of credit cards on the currency demand

Variables (1)	**Coefficient** (2)	**Std. Error** (3)	**t statistics** (4)
Ecm_{t-1}	-0.709561	0.151386	-4.687101***
ΔCS_{t-1}	-0.113333	0.168928	-0.670898
ΔCS_{t-2}	-0.068298	0.175192	-0.389849
ΔCS_{t-3}	0.108619	0.174124	0.623806
ΔCS_{t-4}	0.435473	0.171428	2.540262**
ΔCS_{t-5}	0.318441	0.160298	1.986558**
ΔCS_{t-6}	0.271074	0.125589	2.158426**
ΔCC_CARD_{t-1}	-0.027413	0.02026	-1.353088
ΔCC_CARD_{t-2}	-0.038114	0.02669	-1.428024
ΔCC_CARD_{t-3}	-0.048106	0.031089	-1.547367
ΔCC_CARD_{t-4}	-0.040271	0.030677	-1.31276
ΔCC_CARD_{t-5}	-0.040124	0.026334	-1.52366
ΔCC_CARD_{t-6}	-0.022474	0.017886	-1.256515
ΔY_{t-1}	0.03844	0.019039	2.019065**
ΔY_{t-2}	0.06512	0.01842	3.535315***
ΔY_{t-3}	0.052832	0.02022	2.61281**
ΔY_{t-4}	-0.006267	0.020002	-0.313302
ΔY_{t-5}	0.009728	0.0188	0.517439
ΔY_{t-6}	-0.028587	0.018627	-1.534661
ΔINF_{t-1}	0.010053	0.148104	0.067877
ΔINF_{t-2}	0.183119	0.139914	1.3088
ΔINF_{t-3}	0.029926	0.140219	0.213421
ΔINF_{t-4}	0.131875	0.17723	0.74409
ΔINF_{t-5}	-0.000812	0.156305	-0.005194
ΔINF_{t-6}	0.372353	0.176195	2.113302**
$\Delta DEPO1M_{t-1}$	0.009027	0.004901	1.841838*
$\Delta DEPO1M_{t-2}$	-0.007305	0.005719	-1.277438
$\Delta DEPO1M_{t-3}$	0.007371	0.005772	1.27711
$\Delta DEPO1M_{t-4}$	-0.007458	0.005753	-1.296271
$\Delta DEPO1M_{t-5}$	0.005953	0.00591	1.007358
$\Delta DEPO1M_{t-6}$	-0.003042	0.005373	-0.5662
ΔCC_CPOP_{t-1}	-0.202552	0.081772	-2.477038**
ΔCC_CPOP_{t-2}	0.000603	0.075796	0.007961
ΔCC_CPOP_{t-3}	-0.133471	0.079357	-1.681912*
ΔCC_CPOP_{t-4}	-0.00777	0.059581	-0.130413
ΔCC_CPOP_{t-5}	0.023237	0.051671	0.449714
ΔCC_CPOP_{t-6}	0.019426	0.050091	0.387824
$\Delta INFRA_{t-1}$	-0.012923	0.00451	-2.865446***
$\Delta INFRA_{t-2}$	-0.006618	0.003951	-1.675054**
$\Delta INFRA_{t-3}$	-0.005408	0.003831	-1.411709
$\Delta INFRA_{t-4}$	-0.001835	0.003918	-0.46822
$\Delta INFRA_{t-5}$	0.001227	0.003419	0.359039
$\Delta INFRA_{t-6}$	0.001021	0.003384	0.301821
$HOLIDAY$	0.014076	0.002415	5.828989***
R^2	0.66		
S.E. of regression	0.00946		
F-statistic	4.488029 (0)		

*Note: Robust standard errors in parentheses. ***, **, * denote statistical significance at 1%, 5% and 10% respectively.*

Table 3.8: Long-run estimation results for the impact of credit cards on the currency demand

CURSAV (1)	**Coefficient** (2)	**Std. Error** (3)	**t statistics** (4)
CC_CARD_{t-1}	-0.060407	-0.03651	-1.65444*
Y_{t-1}	0.082763	-0.0165	5.01690***
INF_{t-1}	0.221712	-0.10852	2.04299**
$DEPO1M_{t-1}$	0.004047	-0.00186	2.18070**
CC_POP_{t-1}	-0.159764	-0.06469	-2.46971**
$INFRA_{t-1}$	-0.009977	-0.00421	-2.37119**
C	-0.959045	-0.26911	-3.56380***

*Note: Robust standard errors in parentheses. ***, **, * denote statistical significance at 1%, 5% and 10% respectively.*

The results in Table 3.7 and Table 3.8 reveal a clearer picture of how card-based payment systems affect the currency demand. Table 3.7 indicates that the volume of credit card transactions over the number of cards (CC_CARD) is statistically significant in reducing the currency demand (CS) in the short run. This is supported by both the number of credit cards per 1000 people (CC_CPOP) and the card-based payment infrastructure (INFRA) having negative and significant coefficients, which suggest that the number of cards in circulation and the availability of the infrastructure may reduce the demand for currency.

Similar to the finding for debit cards, retail sales (Y) are positive, hence validating the dominance of the use of cash in the economy over other retail payment instruments. The nominal interest rate (DEPO) also has a positive and significant relationship with the currency demand (CS) in the short run. In addition, inflation (INF) exhibits a positive relationship with the currency demand in the short run. A significant and negative cointegrating relationship is also observed, that is, a speedy adjustment of around 68%.

In Table 3.8, the volume of credit card transactions (CC_CARD) is negatively related to the currency demand (CS) in the long run. This is consistent with the previous findings, such as those of Duca and Whitesell (1991) and differs from the finding of Yang and King (2011). The main difference between Yang and King (2011) and this study is the distinctive economic and banking structures in this paper's sample. Yang and King (2011) took their sample from the US economy, which has a strong cheque culture, whereas this study's sample is a cash-based economy. The use of cheques has been widespread for some time in the US. Hence, we can argue that a card-based system is not directly related. However, in the case of Indonesia, the substituting effect of cash and

card payments will occur directly without any intermediaries, such as cheques in the US.

The negative coefficient of the number of credit cards per 1000 people (CC_CPOP) and the number of terminals that customers can use (INFRA) in the long run also support the substituting effect of credit card and cash payment. An increase in credit card possession is associated with a decrease in the currency demand in the long run. Consistent with the short-run result, the nominal interest rate (DEPO) and inflation (INF) also put pressure on the currency demand, with a positive and significant coefficient in the long run.

The findings of this study regarding credit cards suggest that the card-based payment system has a negative impact on the currency demand. Although, the card transactions are dominated by the debit card, the use of this type of card may mainly be used to withdraw cash as suggested by Stix (2003) particularly in the cash-based economy such as Indonesia (Titiheruw and Atje, 2009). Therefore, credit card may have as large effects as the debit cards. The analysis of the impulse-response function and forecast error variance decomposition do not differ significantly from this proposition. A shock from debit cards has a negative impact on the currency. However, it will increase over time and then decrease to a level lower than the initial one (see Appendix B.6). Interestingly, the currency demand decreases in reaction to the volume of credit card transactions and starts to increase in the fourth period before returning to the initial level.

3.4.3 Financial Intermediation

In gauging the impact of excess reserves and currency demand on financial intermediation we employ a GMM specification (see Table 3.9).

Table 3.9: The Impact of Excess Reserves and Currency Demand on Financial Intermediation.

	Dependent Variable:	
Independent Variable	**LG**	**LG**
(1)	(2)	(3)
C	0.305485***	0.189406**
	(0.082831)	(0.077351)
ED		0.066699
		(0.124826)
CS	-0.255181***	
	(0.096705)	
YG	0.027836**	0.0229**
	(0.011163)	(0.010965)
INF	0.04273	0.080396
	(0.074952)	(0.075295)
BI	-0.297388*	-0.464078***
	(0.157337)	(0.146732)
XR	-0.021097***	-0.013177
	(0.007847)	(0.008009)
RR	-0.577625***	-0.533172***
	(0.10717)	(0.109832)
LG(-1)	0.988249***	0.966476***
	(0.022102)	(0.022737)
R^2	0.97	0.51
DW Stat	1.4	1.4
J-Statistics	65.13	75.54
No. of Observation	146	146
Instrument specification:	C CS(-1TO-4) Y(0TO-4) INF(0TO-4) BI(0TO-4) LG(-1TO-4) XR(0TO-4) HOLIDAY RR(0TO-4)	ED(-1TO-4) Y(0TO-4) INF(0TO-4) BI(0TO-4) LG(-1TO-4) XR(0TO-4) RR(0TO-4) HOLIDAY

*Note: Robust standard errors in parentheses. ***, **, * denote statistical significance at 1%, 5% and 10% respectively.*

We find a statistically negative relationship between the currency demand and financial intermediation, which is in line with our prior expectations. Output growth (YG) is related in a positive way to loan growth. In addition, the exchange rate (XR) has a negative and significant effect on loan growth, suggesting that exchange rate appreciation leads to an increase in loan growth. It is arguable that capital flows may be one of the factors that cause the exchange rate to fluctuate. Massive volatility of capital inflows, following the unconventional monetary policy in advanced countries, for instance, leads to appreciation of the currency because of a strong demand for domestic assets, such as stocks and bonds. The capital inflows provide an abundance of liquidity, which encourages banks to push their lending Unsal (2013). In contrast, large exchange rate depreciation could be related to deterioration in external funding conditions during a crisis that triggers capital outflows Chu (2015). Depreciation of the exchange rate cuts

the value of collateral and decreases loan growth Korinek and Sandri (2016). This result confirms that the credit supply may exhibit strong pro-cyclicality to the business cycle, as many studies, such as Rousseau and Wachtel (2002), have highlighted. The observation that this study discerns also confirms the role of the policy instruments – the policy rates (BI) and reserve requirements (RR) – from the central bank to restrict loan growth.

However, the findings fail to identify any impact of excess reserves (ED) on financial intermediation in column (3) Table 3.9, which is in line with the studies by Merrouche and Nier (2009, 2012). As Bathaluddin et al. (2012) highlighted, Indonesian banks prefer to liquidate their placement in the central bank to hold a large amount of excess reserves. Since the Asian Economic Crisis in 1997, due to Bank Indonesia Liquidity Support (BLBI) and the recapitalization program, excess liquidity has compelled the central bank to employ a borrowing operation instead of a lending operation. By using this type of operation, the banking industry has chosen to place funds in the form of the central bank's instruments with the interest rate income compared with investing funds in the unremunerated reserves account. This appears to be commonplace in many economies around the world, as studies have reported that banks place their excess reserves, which are acquired during the unconventional monetary policy, within the financial system, particularly in the form of government bonds, rather than granting loans Kregel (2009).

Furthermore, such a development appears to be amplified by the volatility of capital flows following the current global financial crisis. After the emergence of capital inflows, domestic banks have had to face fierce competition whereby they have to compete with foreign funds. Domestic banks need to take on higher-risk forms of finance and face exposure to a liquidity risk when a payment shock occurs or default to the financing side Korinek (2010). Furthermore, these capital inflows are subject to a sudden reversal, which may cause turbulence in the domestic financial market. As already mentioned in the previous section, the shallowness of the domestic financial market drives banks to maintain a certain amount of reserves with a preference to liquidate their placement in the central bank. Indonesian banks prefer placements in the central bank's monetary operation instruments in the short-term tenor to anticipate the volatility of the capital flows and the currency demand (Bank Indonesia, 2017*a*).

The overall results explain why the currency ratio plays a major role in the credit supply. A shock to the currency ratio, such as a large number of deposit withdrawals and

conversion into cash, can affect the credit supply immediately. As demonstrated previously, card-based payment systems may be significant in preventing a rapid contraction in the credit supply by reducing the demand for currency and placing liquidity within the banking system.

3.5 Concluding Remarks

This study provides a comprehensive analysis of the importance and significance of payment systems to financial intermediation in Indonesia and demonstrates how regulations that limit the amount of customers' transactions value through payment systems affect this role. The paper evaluates this relationship through both large-value payment systems and retail payment system channels by using the excess reserves and the currency demand.

On the large-value payment systems channels, evidence is found that the RTGS generates a positive pressure towards the excess reserves. However, regulations that limit the value of customers' transactions help to alleviate this pressure by reducing the payment volatility. The Clearing System is found to be relatively insignificant in affecting the financial intermediation, along with its limitation. It can be argued that the small proportion of this payment system compared to the RTGS may cause this insignificant result. In addition, the regulations to limit the value of transactions, which have been imposed since the introduction of the RTGS, also contribute to the result.

Following the findings in the large-value payment systems channels, this paper highlights the importance of card-based payment systems in reducing currency demand in the retail payment systems channel. Credit cards are observed to have a statistically significant impact on the reduction of the currency demand. Debit cards, however, influence the decreasing of the currency demand only in the short-run. The distribution of the infrastructure within the country may play a major part to this finding.

Finally, this study pinpoints empirical evidence of how the decrease in the currency demand leads to an increase in the financial intermediation. The findings provide a foundation study to support a policy which encourages a payment migration to an electronic platform, particularly card-based payment systems, such as a 'less-cash society (GNNT)', which has been implemented by the central bank of Indonesia. In addition, innovations

in the retail payment system may increase banking competition and create an increase in efficiency (Sokołowska, 2015). In so far as this study adopts a macro-based framework, its analysis is limited to aggregate behaviour. It would also be interesting to observe the customers' payments behaviour based on primary data and explore how different demographic factors may have an impact on the currency demand.

Another interesting finding can also be drawn from the impact of the excess reserves on financial intermediation. Similar to the preceding studies, such as Merrouche and Nier (2009, 2012) and Bathaluddin et al. (2012), this finding contributes to the enrichment of the debate on the view that monetary policies may have an impact on the supply of credit through influencing the excess reserves as suggested by Bernanke and Blinder (1988). In the presence of excess liquidity, banks may be less reactive to the tightening of monetary policy (Nguyen and Boateng, 2013). In passing, it should be mentioned that this study does not incorporate the dynamics in the interbank market whilst the role of capital flows is potentially attributed to amplifying the domestic business cycle.

These empirical findings allow market participants and policymakers to gain further insight into the payment system services and the credit supply, both in the large value payment systems and retail payment systems. Policymakers can utilise the regulation to limit the transaction value to prevent the liquidity shocks to the banking sector. However, one should be cautious with this limit because a regulation that sets a very high transaction limit may cause the customers convert their payment into currency (cash-basis) which may be another source of shock to the banking system. Furthermore, a massive campaign in using the credit card to substitute the currency demand can also be carefully examined because of the creditworthiness of the customers which is beyond the scope of this paper.

In addition, our empirical findings suggest the central bank needs to enhance its monetary operation framework to contain excess reserves, capital flows and integrate with the presence of the newly-developed macroprudential policies. However, this strategy needs to be aligned with the overall long-term objectives of the central bank such as the inflation target. Focusing on the short-term fluctuation of the capital flows may distort the inflation expectation in the market whereas ignoring the short-term volatility may have the implication for the long-term objective of the central bank. This is also another debate that will be interesting to explore in the future.

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APPENDIX B

B.1 List of Variables

List of Variables

Variable (1)	Desription (2)	Source (3)
Excess Reserves Ratio (ED)	The ratio of excess reserves held by private banks over total deposits over total deposits	Bank Indonesia
Currency ratio (CS)	The ratio of currency in circulation (outside the banking system) over saving and demand deposits in the banking sector	Bank Indonesia
Deviation of RTGS Transaction from average 1 year (DRTGS)	RTGS transactions value over moving average of RTGS transactions in 12 months	Bank Indonesia
RTGS Limit 1 (RTGSREG_1)	Dummy for Nominal limit for Customer transfer in RTGS system, 0 means no limit, 1 means there is limit	Bank Indonesia
RTGS Limit 2 (RTGSREG_2)	Dummy for Nominal limit for Customer transfer in RTGS system, 0 means no limit, 1 means there is limit	Bank Indonesia

continues on next page

Appendix B.

List of Variables

Variable (1)	**Desription** (2)	**Source** (3)
Deviation of Clearing Transaction from average 1 year (DCLEAR))	learing transactions value over moving average of clearing transactions in 12 months	Bank Indonesia
Clearing Limit 1 (CLEARREG_1)	Dummy for Nominal limit for credit transfer in clearing system, 0 means no limit, 1 means there is limit	Bank Indonesia
Clearing Limit 2 (CLEARREG_2)	Dummy for Nominal limit for credit transfer in clearing system, 0 means no limit, 1 means there is limit	Bank Indonesia
Number of ATM/Debit Card transactions (DEB_CARD)	The number of debit cards transactions divided by number of the number of debit cards in the economy	Bank Indonesia
Number of Credit Card transactions (CC_CARD)	The number of credit cards transactions divided by number of the number of credit cards in the economy	Bank Indonesia
Total number of ATM/Debit Card (DEB_CPOP)	Total number of debit cards over 1000 population	Bank Indonesia
Total number of Credit Card (CC_CPOP)	Total number of credit cards over 1000 population	Bank Indonesia
Reserve requirement ratio (RR)	The ratio of Reserve Requirement for Commercial Banks held at Bank Indonesia in Rupiah over total deposits	Bank Indonesia
BI rate (BI)	Bank Indonesia Policy Rate	Bank Indonesia
Inflation (INF)	year-on-year CPI Inflation in Indonesia	BPS
Retail Sales (Y)	Retail sales index based on the retail sales survey which is a monthly survey to obtain prior information about the moving trend of Gross Domestic Product by Private Consumption. This survey is conducted by Bank Indonesia	Bank Indonesia
Exchange Rate (XR)	the average monthly USD/IDR exchange rate	Bank Indonesia
Loan (LG)	loan made by the banking sector	Bank Indonesia

continues on next page

List of Variables

Variable (1)	**Desription** (2)	**Source** (3)
Total ATM, EFTPOS number (INFRA)	Natural logarithm of total number of Automatic Teller Machine and EFTPOS in Indonesia	Bank Indonesia
Holiday Dummy (HOLIDAY)	Dummy to capture the Indonesian Holiday of *Eid al-Fitr*	

B.2 Descriptive Statistics

Descriptive Statistics

Variables (1)	**Mean** (2)	**Median** (3)	**Maximum** (4)	**Minimum** (5)	**Std. Dev.** (6)	**Skewness** (7)	**Kurtosis** (8)
ED	0.0255	0.0240	0.0754	0.0019	0.0119	1.4817	4.7442
DRTGS	1.0675	1.0400	1.7843	0.7511	0.1886	0.9047	0.9916
DCLEAR	1.0671	1.0459	1.571	0.7187	0.1369	1.1810	2.889
YS	1.0057	0.9905	1.3176	0.7760	0.0881	0.9404	2.0067
CS	0.2058	0.2039	0.275	0.1791	0.0177	0.9161	1.2161
DEB_CARD	3.1431	3.1895	3.8738	2.3445	0.3186	-0.2956	-0.4309
Y	119.37	106.5	232.4	55.91	49.00	0.5684	-0.99
CPI	95.12	94.48	129.72	58.40	20.12	0.0289	-1.0734
DEPO	7.5703	7.145	12.01	5.35	1.5771	1.0933	0.8359
DEB_CPOP	272.09	231.39	574.02	112.88	134.27	0.6049	-0.906
INFRA	2.1494	0.1412	7.882	0.0631	2.9016	0.8525	-1.0693
CC_CARD	1.3184	1.2993	1.6523	1.0212	0.1187	0.3565	0.1468
CC_CPOP	52.6	57.726	68.271	25.216	12.121	-0.7004	-0.729
LG	0.175	0.1919	0.3312	0.0557	0.0679	0.0214	-0.9878
YG	0.0993	0.1024	0.339	-0.3052	0.108	-1.0053	3.0905
INF	0.0656	0.0609	0.1687	0.0239	0.0322	1.4442	1.9333
BI	0.0762	0.0747	0.1275	0.0575	0.0175	1.4697	1.8868
XR	10507	9610	14657	8508	1724	0.7787	-0.9249
RR	0.0684	0.075	0.08	0.05	0.0131	-0.5452	-1.5054

B.3 Customers' Transaction Limit in Indonesian Large Value Payment Systems

Customers' Transaction Limit in Indonesian Large Value Payment Systems

Reg No (1)	**Date** (2)	**Title** (3)	**Clearing Limit** (4)	**RTGS Limit** (5)
4/12/ DASP	24-Sep-02	Clearing Schedule and Final Settlement Date of the Local Clearing System and Nominal limit of a Note	- max Rp100 million for credit transfer	
6/45/ DASP	25-Oct-04	Nominal limit for Customer transfer for RTGS		Min Rp25 million for following dates: - 8-22 Nov 2004 - 20-31 Dec 2004
7/43/ DASP	07-Sep-05	Nominal Limit for debit note and credit transfer in clearing	- max Rp10 million for debit note - Max Rp100 million for credit transfer	
7/47/ DASP	13-Oct-05	Nominal limit for Customer transfer for RTGS		Min Rp25 million for following dates: - 24 Oct-9 Nov 2005 - 19-30 Dec 2005
11/13/ DASP	04-May-09	Nominal value limit of a Debit Note and Credit Transfer	- max Rp10 million for debit note - Max Rp100 million for credit transfer	
15/18/ DASP	30-Apr-13	Amendment of Nominal value limit of a Debit Note and Credit Transfer	- Max Rp500 million for credit transfer started from 31 May 2013	
16/18/ DPSP	28-Nov-14	Amendment of RTGS System		Min Rp100 million for Customer transfer
17/35/ DPSP	13-Nov-15	Nominal value limit for fund transfer through RTGS and Clearing	- 16 Nov 2015-30 Jun 2016 ->no limit - 1 Jul 2016 ->max Rp500million per transaction	- 16 Nov 2015-30 Jun 2016: min Rp500 million per transaction - 1 Jul 2016 ->min Rp100 million per transaction
18/7/ DPSP	02-May-16	Fund Transfer and Scheduled Clearing	Debit note unlimited	
18/40/ DPSP	30-Dec-16	Amendment of Fund Transfer and Scheduled Clearing	Debit note max Rp500 million per transaction	

B.4 Lag Order Selection Criteria Test

VAR Lag Order Selection Criteria

Endogenous variables: CS DEB_CARD Y INF DEPO DEB_POP INFRA
Exogenous variables: C HOLIDAY

Lag	LogL	LR	FPE	AIC	SC	HQ
0	626.1704	NA	4.25E-13	-8.622119	-8.330699	-8.503697
1	1803.992	2206.343	5.29E-20	-24.52102	-23.20963*	-23.98812
2	1904.372	178.139	2.58E-20	-25.24468	-22.91332	-24.29731*
3	1958.437	90.61501*	2.44e-20*	-25.31601*	-21.96468	-23.95417
4	1998.091	62.55251	2.85E-20	-25.18437	-20.81308	-23.40806
5	2030.497	47.92575	3.75E-20	-24.95067	-19.55941	-22.75988
6	2066.405	49.56187	4.80E-20	-24.76626	-18.35503	-22.161
7	2109.241	54.90254	5.71E-20	-24.67944	-17.24825	-21.65971
8	2149.393	47.50432	7.29E-20	-24.55483	-16.10366	-21.12062

* indicates lag order selected by the criterion
LR: sequential modified LR test statistic (each test at 5% level)
FPE: Final prediction error
AIC: Akaike information criterion
SC: Schwarz information criterion
HQ: Hannan-Quinn information criterion

VAR Lag Order Selection Criteria

Endogenous variables: CS CC_CARD Y INF DEPO CC_CPOP INFRA
Exogenous variables: C HOLIDAY

Lag	LogL	LR	FPE	AIC	SC	HQ
0	698.9899	NA	1.52E-13	-9.647745	-9.356325	-9.529324
1	1758.247	1984.242	1.01E-19	-23.87672	-22.56533	-23.34383
2	1887.541	229.4503	3.27E-20	-25.00761	-22.67626*	-24.06024*
3	1938.968	86.19586	3.21E-20	-25.04181	-21.69048	-23.67996
4	1994.434	87.49515	3.00e-20*	-25.13287	-20.76158	-23.35656
5	2032.326	56.0376	3.66E-20	-24.97642	-19.58516	-22.78563
6	2088.398	77.39498	3.52E-20	-25.07603	-18.6648	-22.47076
7	2141.734	68.36056*	3.61E-20	-25.13710*	-17.7059	-22.11736
8	2189.761	56.81985	4.13E-20	-25.12339	-16.67222	-21.68918

* indicates lag order selected by the criterion
LR: sequential modified LR test statistic (each test at 5% level)
FPE: Final prediction error
AIC: Akaike information criterion
SC: Schwarz information criterion
HQ: Hannan-Quinn information criterion

B.5 Robustness Test

Endogeneity Test

Null hypothesis: DRTGS are exogenous			
Specification:	ED C DRTGS RR IB YSHOCK ED(-1) RTGSREG_1 RTGSREG_2 HOLIDAY		
Instrument specification:	C DRTGS(-1) DRTGS(-2) RR IB YSHOCK ED(-1) ED(-2) RTGSREG_1 RTGSREG_2 HOLIDAY		
Endogenous variables to treat as exogenous: DRTGS			
	Value	**df**	**Probability**
Difference in J-stats	3.051261	1	0.0807
J-statistic summary:			
	Value		
Restricted J-statistic	12.17313		
Unrestricted J-statistic	9.121868		

Endogeneity Test

Null hypothesis: DCLEAR are exogenous			
Specification:	ED C DCLEAR RR IB YSHOCK ED(-1) CLEARREG_1 CLEARREG_2 HOLIDAY		
Instrument specification:	C DCLEAR(-1) DCLEAR(-2) RR IB YSHOCK ED(-1) ED(-2) CLEARREG_1 CLEARREG_2 HOLIDAY		
Endogenous variables to treat as exogenous: DCLEAR			
	Value	**df**	**Probability**
Difference in J-stats	0.241072	1	0.6234
J-statistic summary:			
	Value		
Restricted J-statistic	9.098977		
Unrestricted J-statistic	8.857905		

Heteroskedasticity and Serial Correlation Test for CS DEB_CARD Y INF DEPO DEB_CPOP INFRA

Test		**Test Stat**		**P value**
Heteroskedasticity: White test				
Chi-sq		1603.927	Prob. Chi-Square(1652)	0.7976
VEC Residual Serial Correlation LM Tests			Probs from chi-square with 49 df.	
Lags:	1	50.15354		0.4274
	2	42.15553		0.7448
	3	57.74944		0.1834
	4	42.767		0.7225

Appendix B.

Heteroskedasticity and Serial Correlation Test for CS DEB_CARD Y INF DEPO DEB_CPOP INFRA

Test		**Test Stat**		**P value**
Heteroskedasticity: White test				
Chi-sq		2397.211	Prob. Chi-Square(2436)	0.7085
VEC Residual Serial Correlation LM Tests			Probs from chi-square with 49 df.	
Lags:	1	50.35882		0.4195
	2	65.12036		0.0613
	3	65.76833		0.0551
	4	56.31361		0.2202
	5	53.40957		0.3087
	6	56.49819		0.2152
	7	55.64499		0.2389

Endogeneity Test

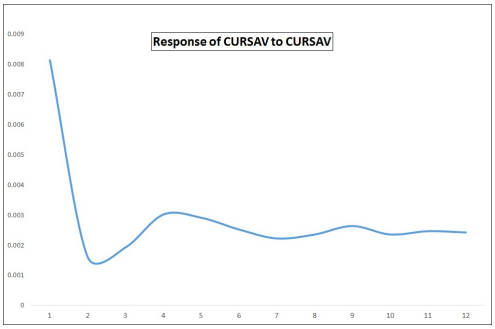
Null hypothesis: CS are exogenous			
Specification:	LG C CS YG INF BI XR RR LG(-1)		
Instrument specification:	C CS(-1) CS(-2) CS(-3) CS(-4)		
	YG YG(-1) YG(-2) YG(-3) YG(-4) INF INF(-1)		
	INF(-2) INF(-3) INF(-4) BI(-1) BI(-2) BI(-3) BI(-4)		
	LG(-1) LG(-2) LG (-3) LG (-4) XR XR(-1) XR (-2)		
	XR (-3) XR (-4) RR RR(-1) RR(-2) RR(-3) RR(-4) HOLIDAY		
Endogenous variables to treat as exogenous: CS			
	Value	**df**	**Probability**
Difference in J-stats	5.838016	1	0.0157
J-statistic summary:			
	Value		
Restricted J-statistic	72.93654		
Unrestricted J-statistic	67.09852		

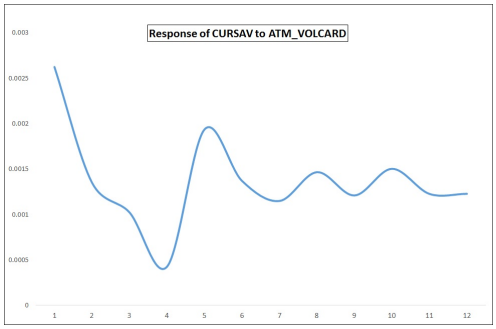
Endogeneity Test

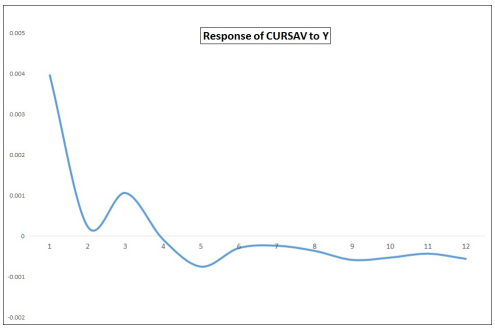
Null hypothesis: ED are exogenous			
Specification:	LG C ED YG INF BI XR RR LG(-1)		
Instrument specification:	C ED(-1) ED(-2) ED(-3) ED(-4) YG YG(-1) YG(-2) YG(-3) YG(-4) INF INF(-1) INF(-2) INF(-3) INF(-4) BI BI(-1) BI(-2) BI(-3) BI(-4) LG(-1) LG(-2) LG (-3) LG (-4) XR XR(-1) XR (-2) XR (-3) XR (-4) RR RR(-1) RR(-2) RR(-3) RR(-4) HOLIDAY		
Endogenous variables to treat as exogenous: ED			
	Value	**df**	**Probability**
Difference in J-stats	0.203625	1	0.6518
J-statistic summary:			
	Value		
Restricted J-statistic	75.83774		
Unrestricted J-statistic	75.63412		

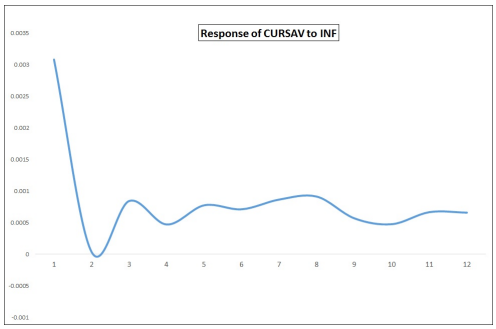
B.6 Impulse Response of Variable CS

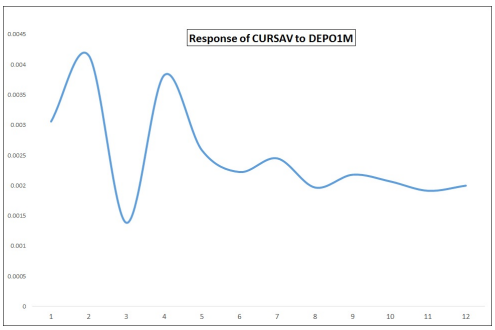
Figure B.1: Selected Impulse Response of Variable CS (1)

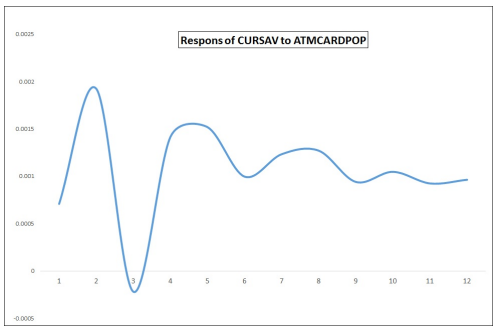












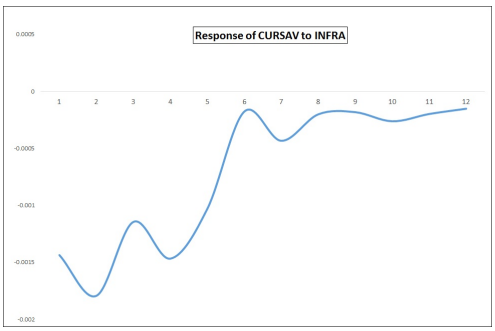
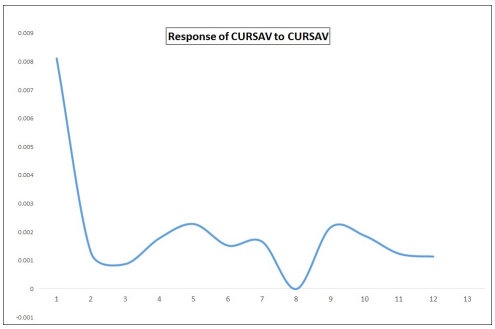
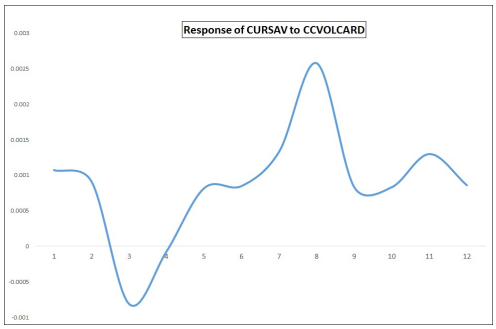
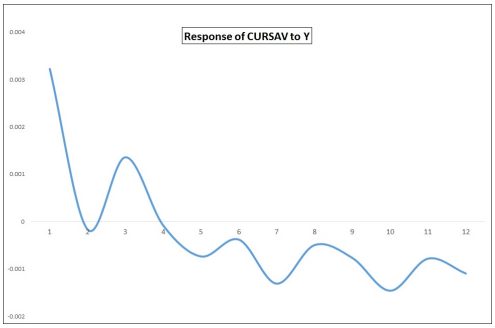
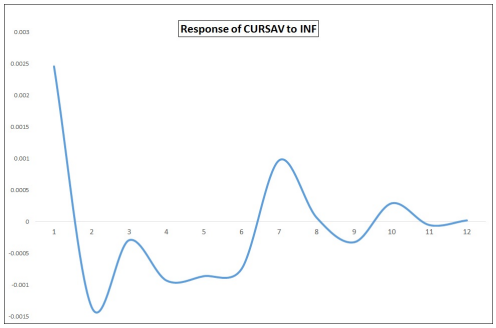


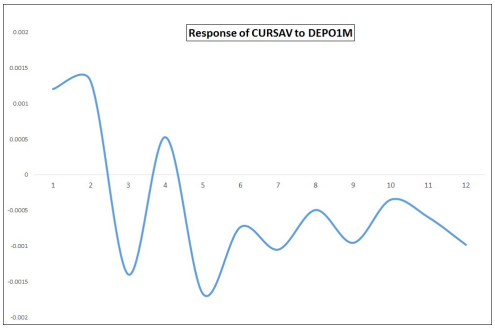
Figure B.2: Selected Impulse Response of CURSAV (2)

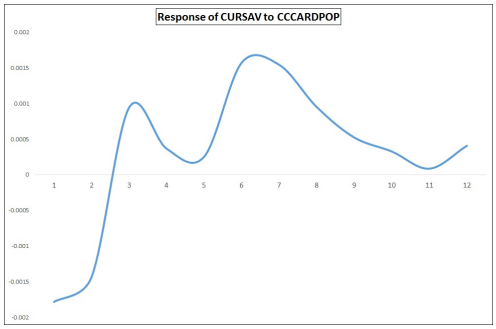


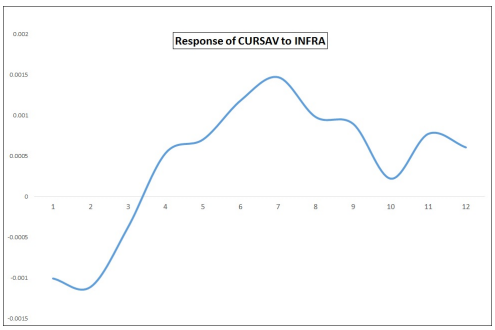












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CHAPTER 4

Monetary Policy and Foreign Exchange Intervention in the Emerging Market: The Case of Indonesia

Abstract

The use of foreign exchange intervention in an inflation-targeting framework raises a question regarding its role. In addition, in an environment of volatile capital flows, how the risk appetite of foreign investors might affect the economy is worth exploring. This paper examines these issues by developing and estimating a Dynamic Stochastic General Equilibrium (DSGE) model with Indonesian data. This study finds that the foreign exchange intervention affects the macroeconomic variables through the portfolio channel. The risk appetite also affects the economy by increasing the capital price. The foreign exchange intervention helps to stabilise the economy during the presence of risk appetite shocks and monetary policy shocks.

Keywords: monetary policy, foreign exchange intervention, DSGE

4.1 Introduction

Foreign intervention has regained wide attention after the global financial crisis particularly in the emerging market. Massive volatility of capital flows, following the unconventional monetary policy in advanced countries, has provided challenges for policymakers to restrain capital flows from aggravating the overheating pressures and consequent inflation, and to mitigate the risk that protracted periods of easy financing conditions will threaten the financial stability (Unsal, 2013). Many emerging market economies depend on this instrument to tackle the capital flows volatility Adler et al. (2016).

One of the emerging market economies that has been affected by the capital financial volatility is Indonesia. During the episode of surge capital inflows in the aftermath of quantitative easing in the advanced economies, the exchange rate appreciated strongly. The interest rate was decreased. Following the Fed's announcement to begin tapering its quantitative measures, the exchange rate was under depreciation pressures. This pressure combines with the increased of the inflation rate forced the central bank to increase the interest rate. During these periods, foreign exchange intervention has been used to complement the interest rate to maintain the stability (Warjiyo, 2014).

Despite the implementation and there is a host of pertinent studies on foreign exchange intervention, the findings in this area are still inconclusive. In addition, the study of foreign exchange intervention in emerging countries – particularly in Indonesia – is still inadequate, due to the unavailability of a dataset. It is essential to put the foreign intervention within the framework of the central bank. Therefore, it is still ambiguous if central banks should use the interest rate policy or combine it with the foreign exchange rate intervention to achieve their targets.

In this paper, we explore the issue of the benefits of having the FX intervention as an instrument in an emerging market context which implements an inflation targeting framework. According to Bank for International Settlements (2018), FX intervention can be used to support the financial system. FX intervention in the phase of capital inflows may increase the international reserves stock which can be used in the episode of capital outflows. This intervention helps to bind the financial imbalances which may occur if an appreciating domestic exchange rate causes the increasing of foreign currency denominated loan. Therefore, this paper intends to shed some light of the interaction of monetary policy and FX intervention. We are interested in examining whether the FX

intervention is a substitution or a complement to the monetary policy.

We examine this issue by building a Dynamic Stochastic General Equilibrium (DSGE) model with a sticky price *à la* Calvo (1983). We incorporate in our model the risk-appetite of the investor as a shock to the economy. We then estimate the model by using the Indonesian data. Moreover, We also examine different impact from three different policies: interest rate policy is used to stabilise the inflation and output, interest rate policy is used to stabilise the inflation, output and exchange rate and finally, interest rate and foreign exchange intervention are used to stabilise the inflation, output and exchange rate.

This paper makes three contributions. Firstly, it provides empirical estimations of foreign exchange intervention DSGE model in the emerging market, particularly Indonesia; secondly, we incorporate a limited financial access household which is one of the characteristics of the emerging market; and thirdly, we demonstrate that a change of the risk appetite of the foreign investors have an impact on the domestic macroeconomic stability.

The remainder of the paper is organised as follows: Section 2 highlights the related literature in foreign exchange intervention whilst section 3 presents the small-open economy model. Section 4 touches on the empirical estimation as well as discusses generated evidence, and finally, section 5 provides some concluding remarks.

4.2 Related Literature

The early literature on inflation targeting framework (ITF) suggests that the exchange rate should be allowed to float without any intervention. The central bank needs to focus on achieving the target of inflation as the overriding objective (Bernanke and Mishkin, 1997). Bernanke et al. (1999) argues that foreign exchange intervention could confuse the public and interfere with expectations. Furthermore, Ramakrishnan and Vamvakidis (2002) argue that using the exchange rate as an indicator of monetary policy will decrease the value of the significance of other indicators, such as money supply or interest rates. This implies that the central bank should focus on either the exchange rate or non-exchange rate indicators. The use of both the exchange rate and non-exchange rate indicators simultaneously as the anchor of monetary policy, would lead to the decrease of monetary policy effectiveness. Thus, Amato and Gerlach (2002) suggest that the central

bank should only consider the exchange rate as a monetary target, if, and only if, the exchange rate is deemed capable of interfering with the achievement of its inflation target.

However, Svensson (2000) argues that the exchange rate plays a significant role in the open economy context. The real exchange rate affects the aggregate demand through the price of domestic and foreign goods in the economy and the wage setting. Moreover, the exchange rate reflects the expectation of the forward-looking asset price. External shocks, such as foreign inflation, foreign interest rate or the risk premium of foreign investor will be channelled through the exchange rate.

For this reason, Calvo and Reinhart (2002) has documented the tendency of the central banks – particularly in the emerging market countries – which quietly intervening the exchange rate market. These findings have refuelled the lengthy debate on the role of the exchange rate in the ITF countries to employ that free-float regime. This intervention in the foreign exchange markets intends to create a more stable exchange rate (Calvo and Reinhart, 2002). In addition, by incorporating the exchange rate into the policy rule function, Svensson (2000) finds that the inflation will be stabilised without massive volatility in the real exchange rate or other variables. On the basis of a somewhat different approach, this view was also supported by Juhro and Mochtar (2009). They explain that the exchange rate addition to the policy rule describes the Indonesian policy rate better than the standard Taylor Rule. Aizenman et al. (2011) also demonstrate that central banks in emerging markets did not follow strict inflation targeting. These central banks use interest rates as a response to the exchange rate movement more frequently, particularly those central banks that come from commodity-based export economies.

In addition, foreign exchange rate intervention can be implemented as a complementary policy to the interest rate policy in an ITF central bank (Ghosh et al., 2016). In the aftermath of the financial crisis of 2008, the fear of floating has become a global theme for many central banks. This is partly driven by the impact of the quantitative easing policy, which is conducted by most of the central banks in the developed countries, namely The Federal Reserve and European Central Bank. The excess liquidity in the global market needs to be channelled, mainly to the emerging markets. Ghosh et al. (2016) finds that the use of foreign exchange rate intervention helps to achieve the price stability. Blanchard et al. (2015) also finds that the foreign exchange intervention helps to dampen the exchange rates pressures and can be considered as a part of the ITF central bank's tool

to stabilise the macroeconomy.

The volatility of the exchange rate is also amplified by the volatility of the market participants' risk appetite. The media dub this phenomenon as 'Risk On/Risk Off' phenomenon (Smales, 2016). Smales (2016) finds that this changing of risk perception relates to large volatility in foreign exchange assets. Cadarajat and Lubis (2012) finds that the impact of the volatility of the Indonesian exchange rate increase after the global financial market. This volatility increased is driven mainly by the off-shore market which represents the foreign investors' risk appetite. Early studies such as Henderson and Rogoff (1982) has documented the change in risk appetite in the market participant may affect the stability.

Early New-Keynesian DSGE models such as Galí and Monacelli (2005) assumes that the exchange rate will be floated and the interest rate is the only policy for the central bank. Benes et al. (2014) put the foreign exchange intervention to a New-Keynesian DSGE Framework which is often used by the central bank. They use foreign reserves in the central bank as an instrument of foreign exchange rate intervention to complement the interest rate policy. They simulate the economy based by fixing the nominal exchange rate either through fixing the interest rate or performing a foreign exchange intervention. They find that under the pure ITF implementation, the initial level of the nominal exchange rate is not restored. The nominal exchange rate is ended in a more depreciated level. This depreciated level of the nominal exchange rate is not found in both fixing through interest rate and through inflation. Another model is provided by Alla et al. (2017) which incorporate the shocks in the international capital markets that cause the variation of the cost of capital to the economy. They show that the use of foreign intervention helps to stabilise the economy during the international capital market shocks episodes. Adler et al. (2016) propose a model which examine the use of foreign exchange intervention under two conditions where agents perceive the use of foreign exchange intervention as an additional tool for the policy rate to achieve the inflation stability and where agents perceive that the use of foreign exchange intervention as a tool to achieve the exchange rate stability. They suggest that the use of foreign exchange intervention is better in an environment where monetary policy gears toward the inflation and output stabilisation.

The discussion of empirical evidence of the effectiveness of foreign exchange intervention itself has been provided by vast range literature. Some of the recent examples of

these empirical studies are provided by Berganza and Broto (2012), Daude et al. (2016), Chang et al. (2017) and Buffie et al. (2018) who argue that the foreign exchange intervention helps the effectiveness of the ITF by stabilising the exchange rate which in turn stabilise the imported price. The effectiveness of this policy is found to be more important in the context of the emerging market. However, Kubo (2017) and Catalán-Herrera (2016) argue that foreign exchange intervention may have a small impact on the output and monetary policy. Kubo (2017) suggest that a prolonged episode of foreign exchange intervention may induce a higher cost to the economy. Drawing from these recent studies, we can see that the discussion of the impact of foreign of exchange intervention is still far from reaching a conclusion.

4.3 A Small Open Economy Model

We consider a continuous-time model with infinite horizon which features nominal and real rigidities along the lines of Smets and Wouters (2007) and Christiano et al. (2005) among others. Since the focus of this paper is on the policy of a single economy, we describe the model from the point of view of one country, which we call the *Home* or domestic country. We will describe the problem of each of the agents in the following sections.

4.3.1 Household

We set the households to consist of two types: regular ones which pay taxes and do not face any constraints in the financial market, and credit-constrained ones which consume purely from their wages. We create this set-up to represent the conditions of Indonesia, which has a proportion of households that may not have access to the financial market. According to The World Bank (2010), about 60% of the population of Indonesia has access to formal financial services.

4.3.1.1 Regular (Non-Credit-Constrained) Household

There are $(1-\lambda)$ regular households that have access to financial markets. These uniform households seek to maximise the following objective function:

$$\max_{C_{1,t},L_{1,t}} \mathbb{E}\left[\sum_{s=0}^{\infty} \beta^s U(C_{1,t+s}, L_{1,t+s})\right] \tag{4.1}$$

where $C_{1,t}$ is a consumption index for regular households, $L_{1,t}$ is the leisure which we define as $L_{1,t} = 1 - N_{1,t}$. $N_{1,t}$ is the total time that the regular households supplies the labour work. The parameter β is the discount factor. We then define the consumption function as:

$$U_{1,t} = U(C_{1,t}, L_{1,t}) = \frac{\left(C_{1,t} - \chi C_{1,t-1}\right)^{(1-\eta)(1-\sigma)} \left(1 - N_{1,t}\right)^{\eta(1-\sigma)} - 1}{1-\sigma} \tag{4.2}$$

The parameter η represents the *Frisch elasticity of labour supply*, σ represents risk aversion and χ represents the consumption habit formation.

The households then face a nominal budget constraint which is given by:

$$P_t^B B_{H,t} + P_t^{B*} S_t B_{F,t}^* = B_{H,t-1} + S_t B_{F,t-1}^* + P_t W_t (1 - T_t^w) N_{1,t} - P_t C_{1,t} + \Gamma_t \tag{4.3}$$

where W_t is the pre-tax real wages in the formal and informal sector respectively and a proportional labour tax given by T_t^w with nominal firm's profits transfer given by Γ_t. $B_{H,t}$ is domestic bonds which bought at nominal price P_t^B and denominated in home currency and $B_{F,t}^*$ is foreign bonds which bought at nominal price P_t^{B*} in foreign currencies. S_t is the nominal exchange rate.

Maximising equation (4.1) subject to the budget constraint we have:

$$P_t^B = \mathbb{E}_t\left[\frac{\Lambda_{t,t+1}}{\Pi_{t,t+1}}\right] \tag{4.4}$$

$$P_t^{B*} = \mathbb{E}_t\left[\frac{\Lambda_{t,t+1}}{\Pi_{t,t+1}} \frac{S_{t+1}}{S_t}\right] \tag{4.5}$$

$$\frac{U_{L,1,t}}{U_{C,1,t}} = \frac{\eta}{1-\eta} \frac{C_{1,t} - \chi C_{1,t-1}}{1 - N_{1,t}} = -W_t(1 - T_t^w) \tag{4.6}$$

where $\Lambda_{t,t+1} \equiv \beta \frac{U_{C,1,t+1}}{U_{C,1,t}}$. We then define the nominal return on home bonds is $R_t = \frac{1}{P_t^B}$,

where R_t is set by the central bank. Following Adler et al. (2016) and Chang et al. (2015), we also assume that foreign bonds are subject to a risk premium that depends on the exposure to foreign debt:

$$R_t^* = \frac{1}{P_t^{B*}\Theta\left(\frac{S_t\left(\psi\, B_{F,t}^* - (1-\psi)\, B_{G,t}^*\right)}{P_{H,t}\, Y_t}\right)} \tag{4.7}$$

where $B_{G,t}$ is the amount of government debt denominated in foreign currency. Parameter ψ represents the share of government and private debt. If $\psi = 0.5$ then government and private debt can be substituted perfectly and the composition has no real or nominal effects. if $\psi > 0.5$ then the market perceives government debt to be less risky than private debt and if $\psi < 0.5$ it is the other way around.

The endogenous risk premium Θ induces imperfect asset substitutability between domestic and foreign bonds which allows the foreign exchange (FX) intervention to have real effects in the economy. Subsequently, we rewrite equation (4.4) as:

$$1 = \mathbb{E}_t\left[\frac{\Lambda_{t,t+1}}{\Pi_{t,t+1}}\right] R_t \tag{4.8}$$

We define $\Pi_{t,t+1} = \frac{P_{t+1}}{P_t}$ and $\Pi_{t,t+1}^* = \frac{P_{t+1}^*}{P_t^*}$ as home and foreign CPI inflation rates and $\Pi_{t,t+1}^S = \frac{S_{t+1}}{S_t}$ as the rate of change of the nominal exchange rate[1]. We then can rewrite the Equation (4.5) as:

$$1 = R_t^*\Phi\left(\frac{S_t B_{F,t}^*}{P_{H,t}Y_t}\right)\mathbb{E}_t\left[\frac{\Lambda_{t,t+1}}{\Pi_{t,t+1}}\Pi_{t,t+1}\right] \tag{4.9}$$

Equations (4.8) and (4.9) also represent the uncovered interest parity (UIP) condition.

4.3.1.2 Credit-constrained Households

There are λ credit-constrained households that have to consume out of their wage income. Their consumption can be written as follows::

$$C_{2,t} = W_t\left(1 - T_t^w\right) N_{2,t} \tag{4.10}$$

[1]Since, the currency of emerging markets countries usually is the term currency, we interpret a positive Π^S as the depreciation rate and a negative one as the appreciation rate.

These credit-constrained consumers need to choose $C_{2,t}$ and $L_{2,t} = 1 - N_{2,t}$, to maximise the utility function, which is the same to equation (4.1), subject to equation (4.10). The first order conditions are now the same for both types of households:

$$\frac{U_{L,2,t}}{U_{C,2,t}} = \frac{\eta}{1-\eta}\frac{C_{2,t} - \chi C_{2,t-1}}{1 - N_{2,t}} = -W_t(1 - T_t^w) \tag{4.11}$$

4.3.1.3 Aggregate Consumption and Labour Supply

Summing the regular and credit-constrained households, we write the total consumption and labour supply as follows:

$$C_t = \lambda C_{2,t} + (1-\lambda)C_{1,t} \tag{4.12}$$

$$N_t = \lambda N_{2,t} + (1-\lambda)N_{1,t} \tag{4.13}$$

4.3.1.4 Consumption Demand

The consumption of both households consists of domestic and foreign goods (imports), which form a composite index of

$$C_t = \left[\gamma_C^{\frac{1}{\mu_C}} C_{H,t}^{\frac{\mu_C - 1}{\mu_C}} + (1-\gamma_C)^{\frac{1}{\mu_C}} C_{F,t}^{\frac{\mu_C - 1}{\mu_C}}\right]^{\frac{\mu_C}{1-\mu_C}} \tag{4.14}$$

with $C_{H,t}$ and $C_{F,t}$ representing the consumption of home and foreign goods respectively. γ_C represents the share of domestic goods within the economy, which is also known as the 'home bias'. The parameter of μ_C represents the elasticity of substitution between domestic goods and imported goods.

Here we assume that the price of imported goods will be directly passed on to the price domestically. This view is supported empirically by Rahadyan and Lubis (2018). They argue that, even though the level of nominal exchange rate pass-through may not have transmitted directly to inflation, the volatility of the nominal exchange rate amplifies the effect of the pass-through. Therefore, we may assume that the nominal exchange rate has a perfect pass-through to the inflation. The corresponding price index is denoted by:

$$P_t = \left[\gamma_C P_{H,t}^{1-\mu_C} + (1-\gamma_C)P_{F,t}^{1-\mu_C}\right]^{\frac{1}{1-\mu_C}} \tag{4.15}$$

where $P_{H,t}$ and $P_{F,t}$ are the price of domestic goods and import goods in the home country respectively.

Maximising total consumption in (4.14) subject to a given aggregate expenditure of $P_t C_t = P_{H,t} C_{H,t} + P_{F,t} C_{F_t}$ results:

$$C_{H,t} = \gamma_C \left(\frac{P_{H,t}}{P_t} \right)^{-\mu_C} C_t \tag{4.16}$$

$$C_{F,t} = (1 - \gamma_C) \left(\frac{P_{F,t}}{P_t} \right)^{-\mu_C} C_t \tag{4.17}$$

4.3.2 Firms

Firms consists of wholesale sector, retail, and capital producers. Wages are taxed at proportional rate of T^w. We follow Galí and Monacelli (2005) in assuming that the price setting behaviour of firms is Calvo pricing and the Law of One Price holds.

4.3.2.1 Wholesale Sector

First we define the production technology which follows the Cobb-Douglas function as:

$$Y_t^w = F\left(A_t, N_t, K_{t-1}\right) = \left(A_t N_t^{\alpha}\right) K_{t-1}^{1-\alpha} \tag{4.18}$$

where Y_t^w is the output of wholesale sector, A_t is the total factor of productivity, N_t is the labour input and K_t is the capital input. The wholesale firms sell goods to the retailers at nominal price of P_t^W. The wholesale profit maximisation is written as:

$$F_{N,t} = \alpha \frac{Y_t}{N_t} \frac{P_t^w}{P_t} = W_t \tag{4.19}$$

$$F_{K,t} = (1 - \alpha) \frac{Y_t}{K_{t-1}} \frac{P_t^w}{P_t} = r_t^K \tag{4.20}$$

where P_t is price index of final consumption goods.

4.3.2.2 Retail Sector

There are a continuum of retailer indexed by $j \in (0, 1)$ which converts goods by purchasing from the wholesale sector and produced a differentiated output $Y_t(j)$ and sells at price $P_{H,t}(j)$. The final good is a constant elasticity of substitution (CES) aggregate of a

continuum of intermediaries:

$$Y_t(j) = \left(\int_0^1 Y_t(j)^{\frac{\epsilon-1}{\epsilon}} dj \right)^{\frac{\epsilon}{\epsilon-1}} \tag{4.21}$$

The profit maximisation problem for this type of firm is:

$$\max_{Y_t(j)} P_{H,t} \left(\int_0^1 Y_t(j)^{\frac{\epsilon-1}{\epsilon}} dj \right)^{\frac{\epsilon}{\epsilon-1}} \left(\int_0^1 P_{H,t}(j) Y_t(j) dj \right) \tag{4.22}$$

where ϵ is the elasticity of substitution.

These goods are bundled into a final goods and lead to a total demand for home good j given by:

$$Y_t(j) = \left(\frac{P_{H,t}(j)}{P_{H,t}} \right)^{-\epsilon} Y_t \tag{4.23}$$

where we can define the aggregate price index of home-produced goods as follows:

$$P_{H,t} = \left[\int_0^1 P_{H,t}(j)^{1-\epsilon} \right]^{\frac{1}{1-\epsilon}} \tag{4.24}$$

Every period, each firm faces a fixed probability $1-\phi$ that it will be able to update its prices. Denoting the optimal price at time t for home good j as $P^{\#}_{H,t}(j)$, the firms allowed to re-optimise prices and maximise expected discounted profits by solving:

$$\max_{P^{\#}_{H,t}(j)} \mathbb{E} \sum_{s=0}^{\infty} \phi^k \frac{\Lambda_{t,t+k}}{P_{H,t+k}} Y_{t+k}(j) \left[P^{\#}_{H,t}(j) - P^W_{t+k} \right] \tag{4.25}$$

Substituting in the demand Y from equation (4.23) taking first-order conditions with respect the new price and rearranging leads to

$$P^{\#}_{H,t} = \frac{\epsilon}{\epsilon - 1} \frac{\mathbb{E} \sum_{k=0}^{\infty} \phi^k \frac{\Lambda_{t,t+k}}{P_{H,t+k}} \left(P_{H,t+k} \right)^{\epsilon} Y_{t+k} P^W_{t+k}}{\mathbb{E} \sum_{k=0}^{\infty} \phi^k \frac{\Lambda_{t,t+k}}{P_{H,t+k}} \left(P_{H,t+k} \right)^{\epsilon} Y_{t+k}} \tag{4.26}$$

We then dropped the j index because all firms face the same marginal cost and update to the same reset price. Hence, the right-hand of the equation is independent of firm size or price history. The real marginal cost is defined by $mc_t = \frac{P^W_t}{P_{H,t}}$, and we also introduce

k period of price inflation as:

$$\Pi_{H,t,t+k} = \frac{P_{H,t+k}}{P_{H,t}} = \frac{P_{H,t+1}}{P_{H,t}} \frac{P_{H,t+2}}{P_{H,t+1}} \cdots \frac{P_{H,t+k}}{P_{H,t}} \tag{4.27}$$

Subsequently we rewrite equation (4.26) become:

$$\frac{P^{\#}_{H,t}}{P_{H,t}} = \frac{\epsilon}{\epsilon - 1} \frac{\mathbb{E} \sum_{k=0}^{\infty} \phi^k \Lambda_{t,t+k} \left(\Pi_{H,t,t+k}\right)^{\phi} Y_{t+k} MC_{t+k}}{\mathbb{E} \sum_{k=0}^{\infty} \phi^k \Lambda_{t,t+k} \left(\Pi_{H,t,t+k}\right)^{\phi} \left(\Pi_{H,t,t+k}\right)^{-1} Y_{t+k}} \tag{4.28}$$

We introduce a mark-up shock MS_t to the real marginal cost MC_t and write the expression (4.28) more compactly by denoting the numerator and denominator as $X_{1,t}$ and $X_{2,t}$ respectively. Write the result in recursive form gives

$$\frac{P^{\#}_{H,t}}{P_{H,t}} = \frac{X_{1,t}}{X_{2,t}} \tag{4.29}$$

where

$$X_{1,t} - \phi\beta\, \mathbb{E}_t \left[{\Pi_{t+1}}^{\epsilon}\right] = \frac{1}{1 - \frac{1}{\epsilon}} Y_{t+k}\, U_{C,t}\, MC_{t+k}\, MS_t \tag{4.30}$$

$$X_{2,t} - \phi\, \beta\, \mathbb{E}_t[\Pi_{t+1}^{\epsilon-1}] = Y_{t+k}\, U_{C,t} \tag{4.31}$$

Using the aggregate producer price index $P_{H,t}$ and the fact that all resetting firms will choose the same price, by the Law of Large Numbers we can find the evolution of the price index as given by:

$${P_{H,t}}^{1-\epsilon} = \phi\, {P_{H,t-1}}^{1-\epsilon} + (1 - \phi)\, {P^{\#}_{H,t}}^{1-\epsilon} \tag{4.32}$$

which can be written in the following form:

$$1 = \phi\, \left(\Pi_{H,t-1,t}\right)^{\epsilon-1} + (1 - \phi) \left(\frac{P^{\#}_{H,t}}{P_{H,t}}\right)^{1-\epsilon} \tag{4.33}$$

Using the demand of output, we can then write the price dispersion that gives the average loss in output as

$$\Delta_t = \frac{1}{J} \sum_{j=1}^{J} \left(\frac{P_{i,t}(j)}{P_{i,t}}\right)^{-\epsilon} \tag{4.34}$$

for non-optimising firms $j = 1, \ldots, J$. It is not possible to track all $P_{j,t}$ but as it is known that a proportion $1 - \phi$ of firms will optimise prices in period t, and from the Law of Large Numbers, that the distribution of non-optimised prices will be the same in as the overall distribution. Therefore, price dispersion can be written as a law of motion:

$$\Delta_{i,t} = \phi \Pi^{\epsilon}_{H,t-1,t} \Delta_{t-1} + (1 - \phi) \left(\frac{X_{1,t}}{X_{2,t}} \right)^{-\epsilon} \tag{4.35}$$

Using this, aggregate final output is given as a proportion of the intermediate output:

$$Y_t = \frac{Y^W_t}{\Delta_t} \tag{4.36}$$

4.3.2.3 Capital Producers

Capital Producers purchase investment goods from home and foreign firms at real price $\frac{P^I_t}{P_t}$ selling at real price Q_t to maximise expected discounted profits:

$$\mathbb{E} \sum_{k=0}^{\infty} \Lambda_{t,t+k} \left[Q_{t,t+k} \left(1 - S \left(\frac{I_{t+k}}{I_{t+k-1}} \right) \right) I_{t+k} - \frac{P^I_t}{P_t} I_{t+k} \right] \tag{4.37}$$

where total capital accumulates according to

$$K_t = (1 - \delta) K_{t-1} + (1 - S(X_t)) I_t \tag{4.38}$$

The first-order condition yields

$$Q_t (1 - S(X_t) - X_t S'(X_t)) + E_t \left[\Lambda_{t,t+1} Q_{t,t+1} S'(X_{t+1}) \frac{I^2_{t+1}}{I^2_t} \right] = \frac{P^I_t}{P_t} \tag{4.39}$$

where we define

$$S(X_t) \equiv \phi_x (X_t - X)^2 \tag{4.40}$$

The relative price of capital Q_t will equal $\frac{P^I_t}{P_t}$. Finally we define R^K_t as gross real return of capital given by:

$$R^K_t = \frac{(1 - \alpha) \frac{Y^W_t}{K_{t-1}} \frac{P^W_t}{P_t} \left(1 - T^K_t \right) + (1 - \delta) Q_t}{Q_{t-1}} \tag{4.41}$$

where T^K_t is a tax on corporate profits which we assume exogenous in this model.

4.3.2.4 Investment Demand

Parallel with the consumption goods, the domestic, export and import demand for investment goods will have the same conditions. We express the aggregate price for investment goods as P_t^I.The investment demand is satisfied by domestic and foreign good (imports), maximising

$$I_t = \left[\gamma_I^{\frac{1}{\mu_I}} I_{H,t}^{\frac{\mu_I-1}{\mu_I}} + (1-\gamma_I)^{\frac{1}{\mu_I}} I_{F,t}^{\frac{\mu_I-1}{\mu_I}}\right]^{\frac{\mu_I}{1-\mu_I}} \tag{4.42}$$

with $I_{H,t}$ and $I_{F,t}$ representing the investment using home and foreign goods respectively. γ_I represents the share of domestic goods used for investment in the economy. The parameter of μ_I represents the elasticity of substitution between domestic goods and import goods. The corresponding price index is denoted by

$$P_t^I = \left[\gamma_I {P_{H,t}^I}^{1-\mu_I} + (1-\gamma_I) {P_{F,t}^I}^{1-\mu_I}\right]^{\frac{1}{1-\mu_I}} \tag{4.43}$$

where $P_{H,t}^I$ and $P_{F,t}^I$ are the price of domestic goods and import goods in the home country respectively.

Maximising total investment in equation (4.42) subject to a given aggregate investment of $P_t I_t = P_{H,t}^I I_{H,t} + P_{F,t}^I I_{F_t}$ results in

$$I_{H,t} = \gamma_I \left(\frac{P_{H,t}^I}{P_t}\right)^{-\mu_I} I_t \tag{4.44}$$

$$I_{F,t} = (1-\gamma_I) \left(\frac{P_{F,t}^I}{P_t}\right)^{-\mu_I} I_t \tag{4.45}$$

4.3.3 External Demand

As in a standard literature of small-open economy, we take the foreign aggregate consumption and investment, denoted by C_t^* and I_t^* respectively, as exogenous. The exogenous approach is taken because we focus on emerging markets, which have the same features as the small open economy. We formulate the demand of the export of consumption goods from the foreign as:

$$C_{H,t}^* = (1-\gamma_C^*) \left(\frac{P_{H,t}^*}{P_t^*}\right)^{-\mu_C^*} C_t^* \tag{4.46}$$

We define the real exchange rate of consumption goods as the relative aggregate consumption price $s_t \equiv \frac{P_t^* S_t}{P_t}$. We then rewrite the demand for exports as

$$C_{H,t}^* = (1 - \gamma_C^*) \left(\frac{P_{H,t}^*}{P_t^* s_t} \right)^{-\mu_C^*} C_t^* \tag{4.47}$$

where $P_{H,t}^*$ and P_t^* indicate the price of domestic goods and foreign aggregate consumption in the foreign currency. In addition, we assume that the Law of One Price for differentiated goods in the traded sector holds. Therefore, the exchange rate will have perfect pass-through to export prices and the price of consumption goods will be $P_t = S_t P_{H,t}^*$. Similarly, we assume that the home country has a perfect exchange rate pass-through for imports which implies $P_t^* = P_{F,t}$, $S_t P_t^* = P_{F,t}$, thus $s_t = \frac{P_{F,t}}{P_t}$. We then write

$$C_{H,t}^* = (1 - \gamma_C^*) \left(\frac{1}{ToT_t} \right)^{-\mu_c^*} \tag{4.48}$$

where $ToT_t \equiv \frac{P_{F,t}}{P_{H,t}}$ are the terms of trade.

We formulate the foreign demand for exported investment goods as follows:

$$I_{H,t}^* = (1 - \gamma_I^*) \left(\frac{P_{H,t}^{I*}}{P_t^{I*}} \right)^{-\mu_I^*} I_t^* \tag{4.49}$$

We define the real exchange rate for investment as the relative aggregate investment price $s_t^I \equiv \frac{P_t^{I*} S_t}{P_t^I}$. Then, we adjust the demand for exported investment goods to be

$$I_{H,t}^* = (1 - \gamma_I^*) \left(\frac{P_{H,t}^{I*}}{P_t^{I*} s_t} \right)^{-\mu_I^*} I_t^* \tag{4.50}$$

where $P_{H,t}^{I*}$ and P_t^{I*} indicate the prices of domestic goods and foreign aggregate investment in the foreign currency. As with consumption, we assume that the Law of One Price for differentiated goods holds for investment goods. Therefore, the price of investment goods will be $P_t^{I*} = S_t P_{H,t}^{I*}$. Similarly, We also assume that the home country has a perfect exchange rate pass-through for imports, which implies $P_t^{I*} = P_{F,t}^{I*}$, $S_t P_T^{I*} = P_{F,t}^I$, thus $s_t = \frac{P_{F,t}^I}{P_t^I}$. We then write

$$I_{H,t}^* = (1 - \gamma_I^*) \left(\frac{1}{ToT_t} \right)^{-\mu_I^*} I_t^* \tag{4.51}$$

Therefore the total exports are given by

$$EX_t \equiv C^*_{H,t} + I^*_{H,t} \tag{4.52}$$

4.3.4 Market Clearing, Fiscal and Monetary Policy

A resource constraint implies:

$$Y_t = C_{H,t} + C^*_{H,t} + I_{H,t} + I^*_{H,t} + G_t \tag{4.53}$$

where G_t is the government spending.

For our policy setting, we consider exogenous distortionary tax rates on wage and capital income to pay for exogenous government spending, with a government balanced budget constraint. We also allow the government to run a fiscal deficit, use government spending as a stabilisation instrument and borrow from domestic and foreign investors.

We assume foreign bonds are subject to a premium that depends on the exposure to total foreign debt, as we have already defined in equation (4.7), where $B_{G,t}$ is the amount of government debt denominated in foreign currency. We assume $\Theta(0) = 0$ and $\Theta' < 0$ and the following functional form with these properties:

$$\Theta(x) = \exp(-\Theta_B x); \Theta_B > 0 \tag{4.54}$$

We contribute in introducing an exogenous *risk-appetite* shock (Ξ_t) in order to determine the impact of the 'Risk On/Risk Off' phenomenon of the global financial system. This phenomenon affects emerging markets, particularly since the global financial crisis (Farhi and Werning, 2014; Alla et al., 2017). The equation (4.7) can be rewritten as:

$$R^*_t = \frac{1}{P^{B*}_t \Theta\left(\frac{S_t\left(w_t B^*_{F,t} - (1-w_t) B^*_{G,t}\right)}{P_{H,t} Y_t}\right) + \Xi_t} \tag{4.55}$$

Furthermore, government borrowing is the combination of nominal domestic bonds $B_{H,t}$ held by foreign investors. The total stock of government bonds held in home country consumption units is defined as

$$B_{G,t} = \frac{B_{H,t}}{P_t} + \frac{S_t B^*_{G,t}}{P_t} = B_{GH,t} + B_{GF,t} \tag{4.56}$$

Foreign bond holdings are a sum of assets held by households $B_{F,t}$ and liabilities held by the government $B^*_{G,t}$ home and evolve according to

$$P^{B*}_t \left(S_t \left(B^*_{F,t} - B^*_{G,t}\right)\right) = S_t \left(B^*_{F,t-1} - B^*_{G,t-1}\right) + P_t TB_t \tag{4.57}$$

where the nominal trade balance is the difference between domestic output and private and public consumption and investment, which can be written as

$$P_t TB_t = P_{H,t} Y_t - P_t C_t - P_{I,t} I_t - P_{H,t} G_t \tag{4.58}$$

We then define $B_{F,t} \equiv \frac{S_t B^*_{F,t}}{P_t}$ to be the stock of foreign bonds held by households, in home country consumption units. Therefore,

$$\begin{aligned} P^{B*}_t P_t \left(B_{F,t} - B_{GF,t}\right) &= \frac{S_t}{S_{t-1}} P_{t-1} \left(B_{F,t-1} - B_{GF,t-1}\right) + P_t TB_t \Rightarrow \\ P^{B*}_t \left(B_{F,t} - B_{GF,t}\right) &= \frac{\Pi^S_{t-1,t}}{\Pi_{t-1,t}} \left(B_{F,t} - B_{GF,t}\right) + TB_t \end{aligned} \tag{4.59}$$

Then, by analogy with the national budget constraint given in equation (4.59), the government budget constraint is:

$$P^B_t B_{GH,t} + P^{B*}_t B_{GF,t} = \frac{1}{\Pi_{t-1,t}} B_{GH,t-1} + \frac{\Pi^S_{t-1,t}}{\Pi_{t-1,t}} B_{GF,t-1} + D_t \tag{4.60}$$

where the nominal government deficit is given by:

$$P_t D_t = P_{H,t} G_t - W_t N_t T^W_t - (1-\alpha) Y^W_t P_{H,t} MC_t T^k_t \tag{4.61}$$

Bond price will be written as

$$P^{B*}_t \left(B_{F,t} - B_{GF,t}\right) = \frac{\Pi^S_{t-1,t}}{\Pi_{t-1,t}} B_{GF,t-1} \left(B_{F,t} - B_{GF,t}\right) + TB_t \tag{4.62}$$

Fiscal policy tax rates T_t^W is given by

$$T_t^W = \frac{\frac{P_{H,t}}{P_t} G_t - D_t - (1-\alpha) Y_t \frac{P_{H,t}}{P_t} MC_t T_t^k}{W_t H_t} \tag{4.63}$$

We then define FX intervention as

$$FX_t \equiv \frac{B_{GH,t}}{B_{G,t}} \tag{4.64}$$

The nominal interest rate R_t is the monetary policy variable given by a standard Taylor-type rule (Taylor, 1993). Beside the standard inflation and output deviation response, we add an exchange rate depreciation term following Juhro and Mochtar (2009) and Kolasa and Lombardo (2014):

$$\begin{aligned} \log\left(\frac{R_t}{R}\right) =& \rho_R \log\left(\frac{R_{t-1}}{R}\right) + \\ & (1-\rho_r)\left[\theta_\pi \log\left(\frac{\Pi_{t-1,t}}{\bar{\Pi}}\right) + \theta_y \log\left(\frac{Y_t}{\bar{Y}}\right) + \theta_s \log\left(\frac{\Pi^S_{t-1,t}}{\bar{\Pi}^S}\right)\right] + \epsilon_{M,t} \end{aligned} \tag{4.65}$$

The fiscal stabilisation also follows a Taylor-type rule which can be written in the following form:

$$\begin{aligned} \log\left(\frac{G_t}{\bar{G}}\right) =& \rho_G \log\left(\frac{G_{t-1}}{\bar{G}}\right) + \\ & (1-\rho_G)\left[\theta_{B_{G,\Pi}} \log\left(\frac{B_{G,t-1,t}}{\bar{B}_G}\right) + \theta_{G,\Pi} \log\left(\frac{\Pi_{t-1,t}}{\bar{\Pi}}\right) + \theta_{G,y} \log\left(\frac{Y_t}{\bar{Y}}\right)\right] + \epsilon_{g,t} \end{aligned} \tag{4.66}$$

Finally, FX_t is set at $FX > 0$ in the steady state. Then FX_t responds to changes in the exchange rate depreciation rate Π_t^S and to R_t^* as follows:

$$\begin{aligned} \log\left(\frac{FX_t}{FX}\right) =& \rho_{FX} \log\left(\frac{FX_{t-1}}{FX}\right) + \\ & (1-\rho_{FX})\left[\theta_{FX,\Pi^S} \log\left(\frac{\Pi^S_{t-1,t}}{\bar{\Pi}^S}\right) + \theta_{FX,R^*} \log\left(\frac{R^*_{t-1,t}}{\bar{R}^*}\right)\right] + \epsilon_{FX,t} \end{aligned} \tag{4.67}$$

4.3.5 Shock Processes

The structural shock processes in log-linearised form are assumed to follow AR(1):

$$\log A_t - \log A = \rho_A \left(\log A_{t-1} - \log A\right) + \varepsilon_{A,t} \tag{4.68}$$

$$\log G_t - \log G = \rho_G \left(\log G_{t-1} - \log G\right) + \varepsilon_{G,t} \tag{4.69}$$

$$\log MS_t - \log MS = \rho_{MS} \left(\log MS_{t-1} - \log MS\right) + \varepsilon_{MS,t} \tag{4.70}$$

$$\log C_t^* - \log C_t^* = \rho_{C^*} \left(\log C_{t-1}^* - \log C_t^*\right) + \varepsilon_{C^*,t} \tag{4.71}$$

$$\log I_t^* - \log I_t^* = \rho_{I^*} \left(\log I_{t-1}^* - \log I_t^*\right) + \varepsilon_{I^*,t} \tag{4.72}$$

$$\log \Pi_t^* - \log \Pi_t^* = \rho_{\Pi^*} \left(\log \Pi_{t-1}^* - \log \Pi_t^*\right) + \varepsilon_{\Pi^*,t} \tag{4.73}$$

Variables without subscription denote the steady state value of the variable.

4.4 Empirical Analysis and Result

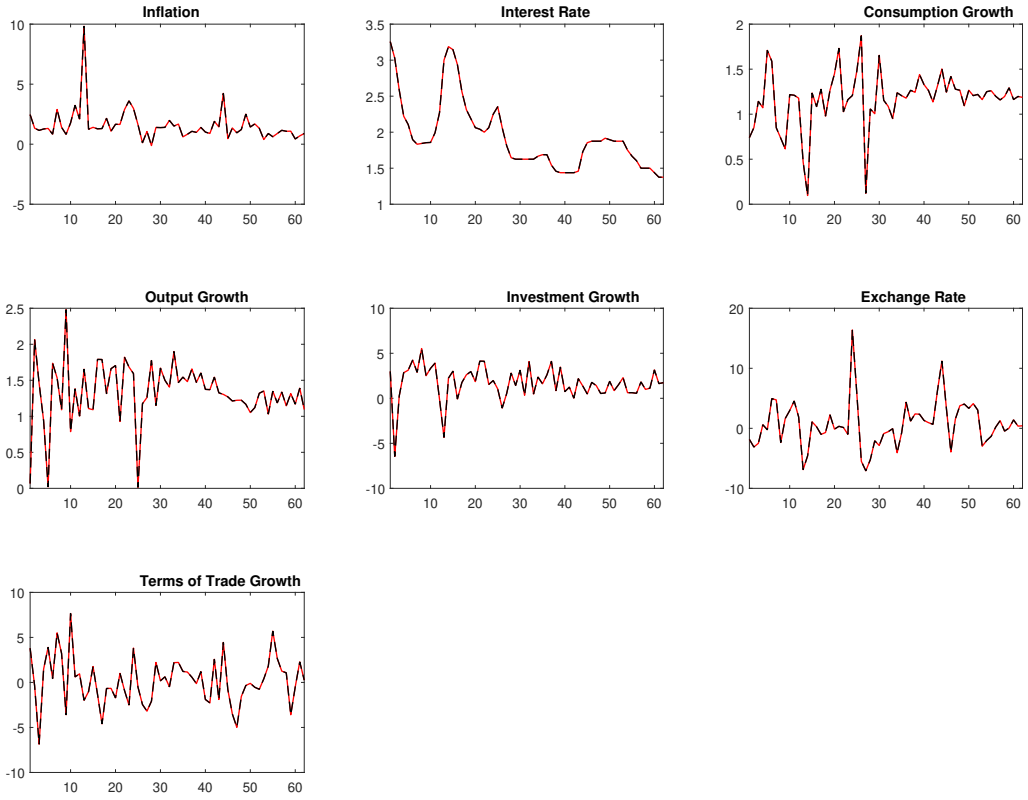
In order to gain the result, we estimate the model by using the Indonesian data. This section will elaborate our data and estimation techniques by using the Bayesian estimation procedure, the data and priors used in estimation, a selection of the resulting impulse responses and the variance decomposition.

4.4.1 Data

Following our model construction, we use Bayesian techniques to estimate the model's parameters. We employ quarterly data for Indonesia from the period 2000Q1 to 2018Q1. We take our sample after the Asian Financial crisis. We use output growth, consumption growth, investment growth, domestic inflation which are taken from Indonesian Statistics (BPS). We also use policy rate and exchange rate growth from the central bank (Bank Indonesia) and terms of trade growth from Thomson-Reuters.

The output, consumption and investment are in real terms. Whereas, policy rate and exchange rate are in nominal terms. The exchange rate is using the USD/IDR exchange rate. Domestic inflation is using the CPI index with 2012 base year. Terms of trade are using the index of export prices and import prices which is constructed by Thomson-Reuters. Figure 4.1 illustrates the historical and smoothed variables.

Figure 4.1: Historical And Smoothed Variables



We construct measurement equations to incorporate the measurement error of our observable variables. Table 4.1 describes our measurement approach.

Table 4.1: Measurement Equations

Observable (1)	Model variables (2)
Output growth	$\Delta \ln Y_{obs,t} = \Delta (\ln Y_t - \ln Y) + \varepsilon_{Y,t}$
Consumption growth	$\Delta \ln C_{obs,t} = \Delta (\ln C_t - \ln C) + \varepsilon_{C,t}$
Investment growth	$\Delta \ln I_{obs,t} = \Delta (\ln I_t - \ln I) + \varepsilon_{I,t}$
CPI Inflation	$\Pi_{obs,t} = \Pi_t - \Pi$
Interest rate	$R_{obs,t} = \ln R_t - \log R$
Change in the exchange rate	$S_{obs,t} = \ln \left(\Pi_t^S / \Pi^S \right)$
Terms of trade growth	$\Delta \ln ToT_{obs,t} = \Delta (\ln ToT_t - \ln ToT) + \varepsilon_{y,t}$

4.4.2 Parameter Calibration

To estimate the model, we calibrate some parameters according to previous studies and to be consistent with the mean values in the data. The discount factor (β) is set to 0.99, which gives an annual steady-state real interest rate around 4% which with many studies (e.g. Smets and Wouters (2007)). The home bias parameter (γ_C) is set to 0.62 and labour share (α) is set to 0.66 according to Harmanta et al. (2014). We take the annual labour work for Indonesia data in Feenstra et al. (2015) and calibrate the parameter of Frisch elasticity of labour to 0.25. Following Schmitt-Grohé and Uribe (2003), we also set the elasticity of the risk premium to the level of debt (ϕ_B) to 0.001. We also take into the account the data from the Asian Development Bank (ADB) which reports the bond market in Indonesia[2]. We then calibrate the share of government bond (Ψ) to 0.9 to reflect the average share of government bond in the market. Tabel 4.2 lists the parameter calibrated values.

Table 4.2: The Parameter Value of Calibration Result

Parameter (1)	**Symbol** (2)	**Values** (3)
Labour share	α	0.66
Domestic household discount factor	β	0.99
Home bias parameter for consumer goods	γ_C	0.62
Home bias parameter for Investment goods	γ_I	0.62
Inverse Frisch elasticity of labour	η	0.25
Elasticity of substitution between domestic & import consumer goods	μ_C	1.5
Elasticity of substitution between domestic & import investment goods	μ_I	1.5
Depreciation rate of capital	δ	0.025
Government bond's share	Ψ	0.9
Risk premium	Θ_B	0.001

4.4.3 Result and Analysis

We estimate the posterior mode, by numerically maximising the log posterior density function; a combined of prior information and the likelihood of the data. Then, we estimate the full posterior distribution using the Metropolis-Hastings algorithm. This section we elaborate our findings along with some selected impulse-response analysis. We begin with our prior and posterior results which are displayed in Table 4.3.

[2]Data can be downloaded from `https://asianbondsonline.adb.org/data-portal/`

Table 4.3: Estimation Result

List of parameter	**Symbol**	**Prior Mean**	**Post Mean**	**90% HPD Interval**		**Prior**	**pstdev**
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Persistence of Total Factor Productivity shock	ρ_A	0.5	0.282	0.1314	0.417	beta	0.2
Persistence of Monetary Policy Shock	ρ_m	0.5	0.5975	0.1426	0.8873	beta	0.2
Persistence of Mark-Up Shock	ρ_{MS}	0.5	0.4881	0.1611	0.7577	beta	0.2
Persistence of Government Spending shock	ρ_G	0.5	0.4706	0.1793	0.8	beta	0.2
Persistence of Foreign Consumption shock	ρ_C	0.5	0.4684	0.1726	0.7678	beta	0.2
Persistence of Foreign Investment shock	ρ_I	0.5	0.5367	0.2514	0.8432	beta	0.2
Persistence of Foreign Interest Rate shock	ρ_R	0.75	0.7541	0.5164	1	beta	0.2
Persistence of FX Intervention shock	ρ_{FX}	0.5	0.8541	0.7859	0.9243	beta	0.2
Persistence of Foreign Inflation shock	ρ_{π^*}	0.5	0.1369	0.0543	0.2136	beta	0.2
Share of Credit Constrained Household	λ	0.5	0.4102	0.3392	0.4788	norm	0.05
Internal habit formation	χ	0.6	0.9646	0.9343	0.998	beta	0.2
Calvo parameter	ϕ	0.5	0.3814	0.2224	0.558	beta	0.2
Risk premium in investment	ϕ_I	4	4.2627	3.5941	5.1461	norm	1.5
Labour share in production function	α	0.54	0.5596	0.4821	0.6354	norm	0.05
Elasticity of substitution among goods	ϵ	7	6.7352	6.1852	7.1592	norm	1.5
Risk premium in Bond	Θ_B	0.001	0.1166	0.0782	0.1559	norm	1.5
Risk aversion in household	σ	2	1.9913	1.9072	2.0722	norm	0.05
Interest rate smoothing	ρ_r	0.7	0.9303	0.9133	0.9487	beta	0.1
Inflation weight parameter	θ_π	2	1.9094	1.498	2.3426	norm	0.25
Output weight parameter	θ_Y	0.1	0.1129	0.0377	0.1846	norm	0.05
Government spending weight parameter	θ_G	0.1	0.1251	0.0717	0.1747	norm	0.05
Foreign inflation weight parameter	θ_{FX,Π^S}	0.1	0.104	0.022	0.1851	norm	0.05
Foreign interest rate weight parameter	θ_{FX,R^*}	0.1	0.1008	0.0182	0.1824	norm	0.05
Feedback from exchange rate depreciation	θ_s	0.1	0.0111	0.0035	0.0187	norm	0.05

Our finding in table 4.3 indicates that the persistence of FX intervention (ρ_{FX}) is relatively high with the posterior mean value of 0.85 compared to our first prior mean of 0.5. This finding confirms the tendency of the central bank to intervene in the exchange rate as stated in Calvo and Reinhart (2002). Moreover, the feedback of the exchange rate in the interest rate policy rule is found to be low. We interpret this as the policy rate may be targeted to address the inflation as Bank Indonesia is an Inflation Targeting central bank. Besides, Table 4.3 indicates that the mean value of posterior inflation weight parameter in the Taylor rule (θ_π) is 1.8625 which is in line with Harmanta et al. (2014). We also find that the share of credit-constrained household (λ) is 0.4102 or 41% of the total household. This number is slightly above the Indonesian Financial Services Authority (OJK)'s report which stated that the percentage of households who do not have access to the financial services is ±33% in 2017 (The Financial Services Authority (OJK), 2017) or the World Bank's report .

4.4.3.1 Impulse Response Analysis

Another analysis that needs to be put forward is the impulse responses analysis. This analysis explains the transmission mechanism in the model.We focus our discussion on describing the impact of the monetary policy shock, the FX intervention shock and the risk premium shock.

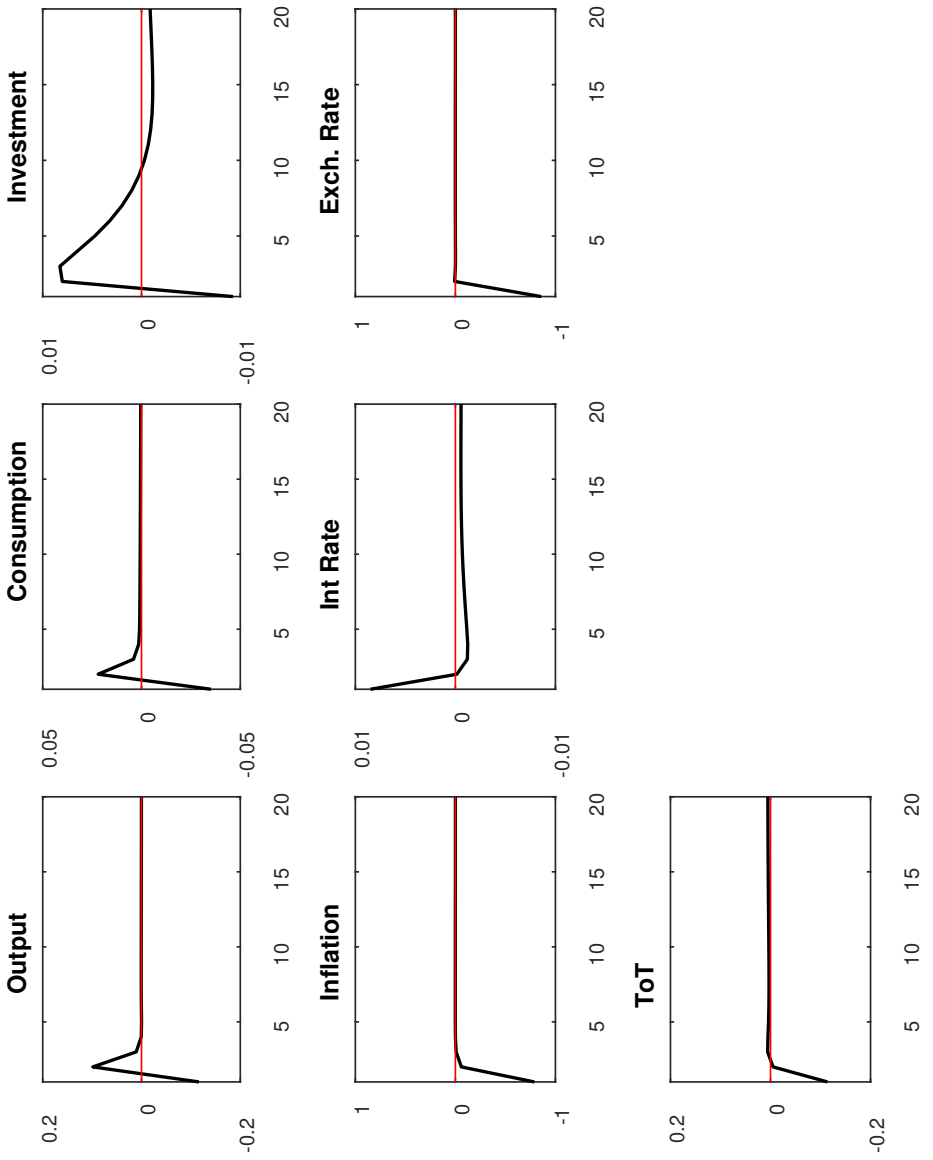


Figure 4.2: Impulse Response to Monetary Policy Shock

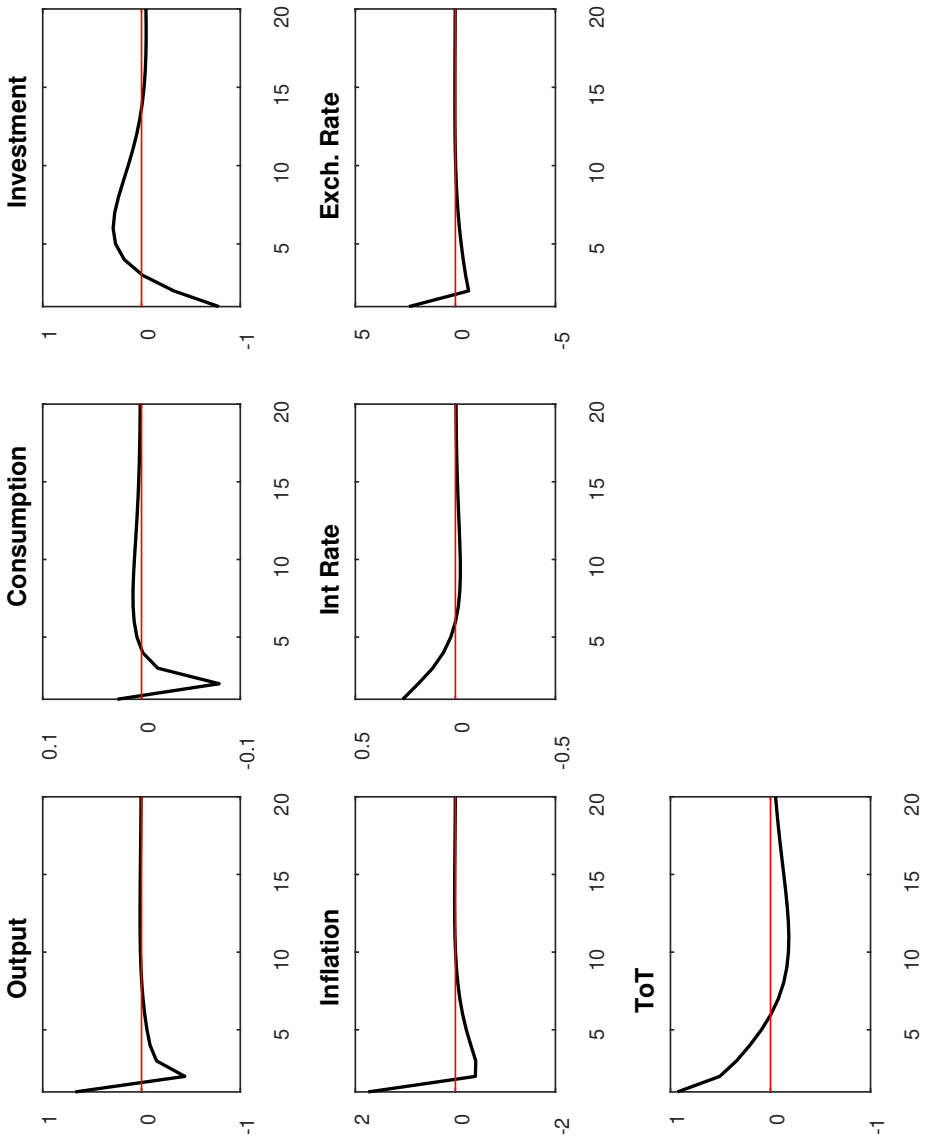


Figure 4.3: Impulse Response to FX intervention Shock

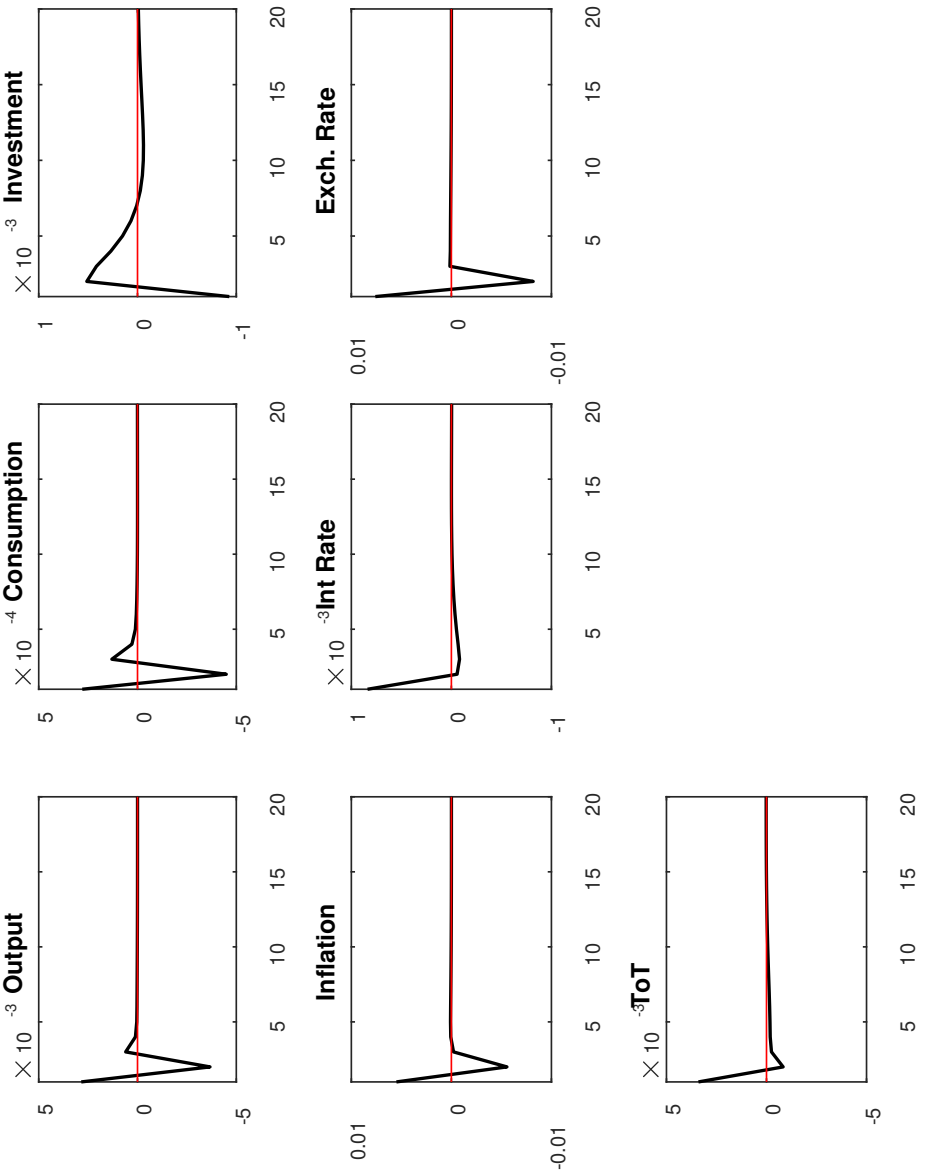


Figure 4.4: Impulse Response to Risk Appetite Shock

Here we interpret monetary policy shock as the surprising positive shock to the interest rate which is taken by the authority. Figure 4.2 shows that the monetary policy shock affects all the observable variables. Nominal interest rate increases as a result of the positive shock and subsequently the exchange rate appreciates, given the foreign interest rate remains the same, because the UIP holds. Consequently, the terms of trade (ToT) is declining. As the cost of fund increases, the household adjusts its consumption downward hence causing inflation to dwindle. As consumption goes down, investment and output also decrease. However, the appreciation of the exchange rate drives the import goods to become cheaper which brings the consumption back to the steady-state in the second round. When imports increase and the economy demands more foreign assets (or foreign currency), without FX intervention, nominal exchange rate adjusts to the steady-state. As the nominal interest rate decreases investment starts to go up and subsequently the output is back to its steady-state.

During an episode of positive FX Intervention shock, Figure 4.3 indicates that the positive FX intervention causes the exchange rate to depreciate and the ToT to increase. As a result, the output and consumption increase at the time of the shock. However, sudden upsurge in consumption and output causes the inflation to move up and interest rate to follow in the same fashion. Subsequently, investment goes down as the cost of borrowing increases. Following the increased of inflation, output and consumption are contracted below their steady-state value. As the nominal interest rate increases, the exchange rate appreciates given the UIP holds and investment starts to increase as a result. The appreciation of the exchange rate also alleviates the pressure on domestic inflation as the price of the imported goods becomes cheaper. The reduction of inflation drives consumption up with output moving in the same direction.

Here we model risk appetite as an addition to the risk premium. Figure 4.4 reveals the impact of the risk appetite shock on the observed variables. As the risk premium increases, the nominal interest rate is also increasing. The upward movement of the domestic interest rate causes the exchange rate to appreciate and the inflation increases. However, the increase in the interest rate drives investment down. As both the inflation and the interest rate increase, households adjust their consumption and drives output down. In addition, the exchange rate is also appreciating following the increased domestic interest rate. The appreciation of the exchange rate causes imported goods to become

cheaper whilst the adjustment in consumption along with the appreciating exchange rate alleviates inflation pressures. As a result, inflation and interest rate go down, whilst consumption, investment and output increase.

4.4.3.2 Variance Decomposition

We also examine the variance decomposition which are portrayed in Figure 4.5 to 4.11.

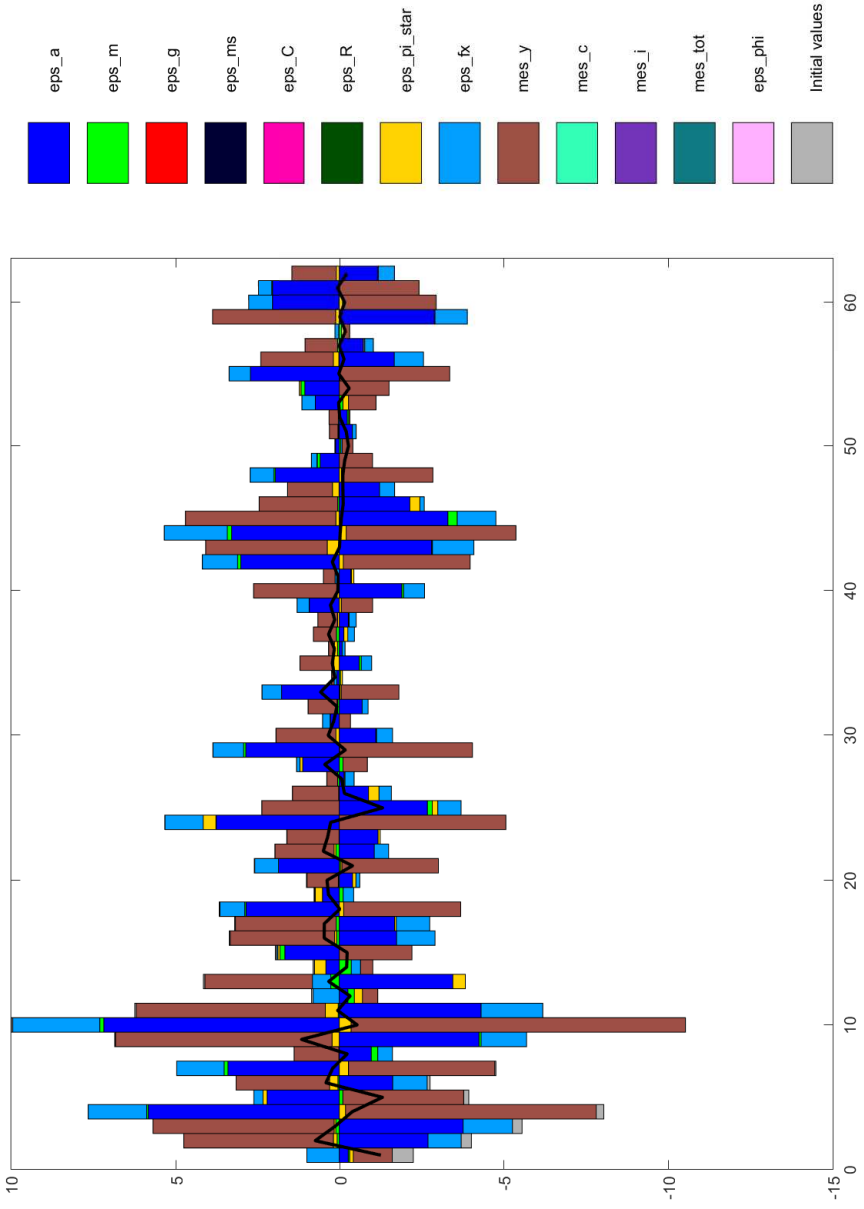


Figure 4.5: Variance Decomposition: Output

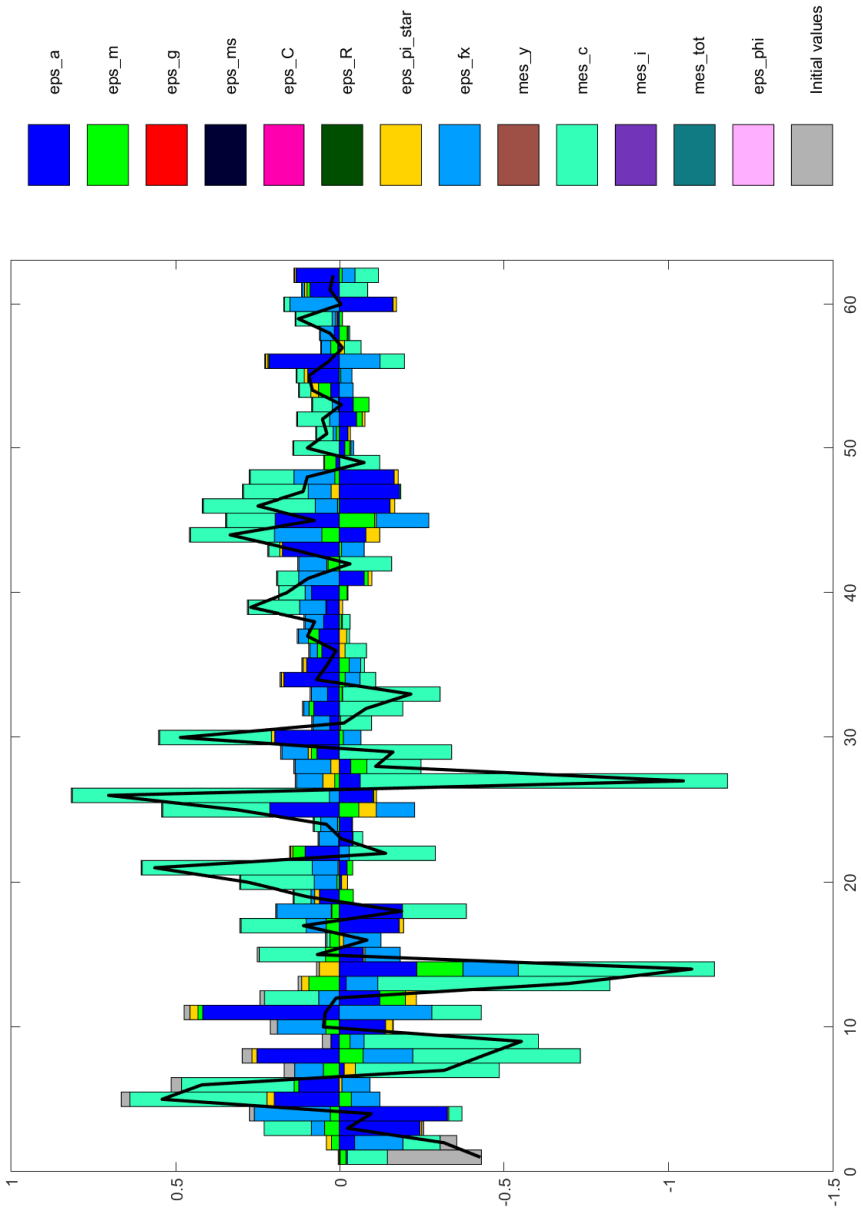


Figure 4.6: Variance Decomposition: Consumption

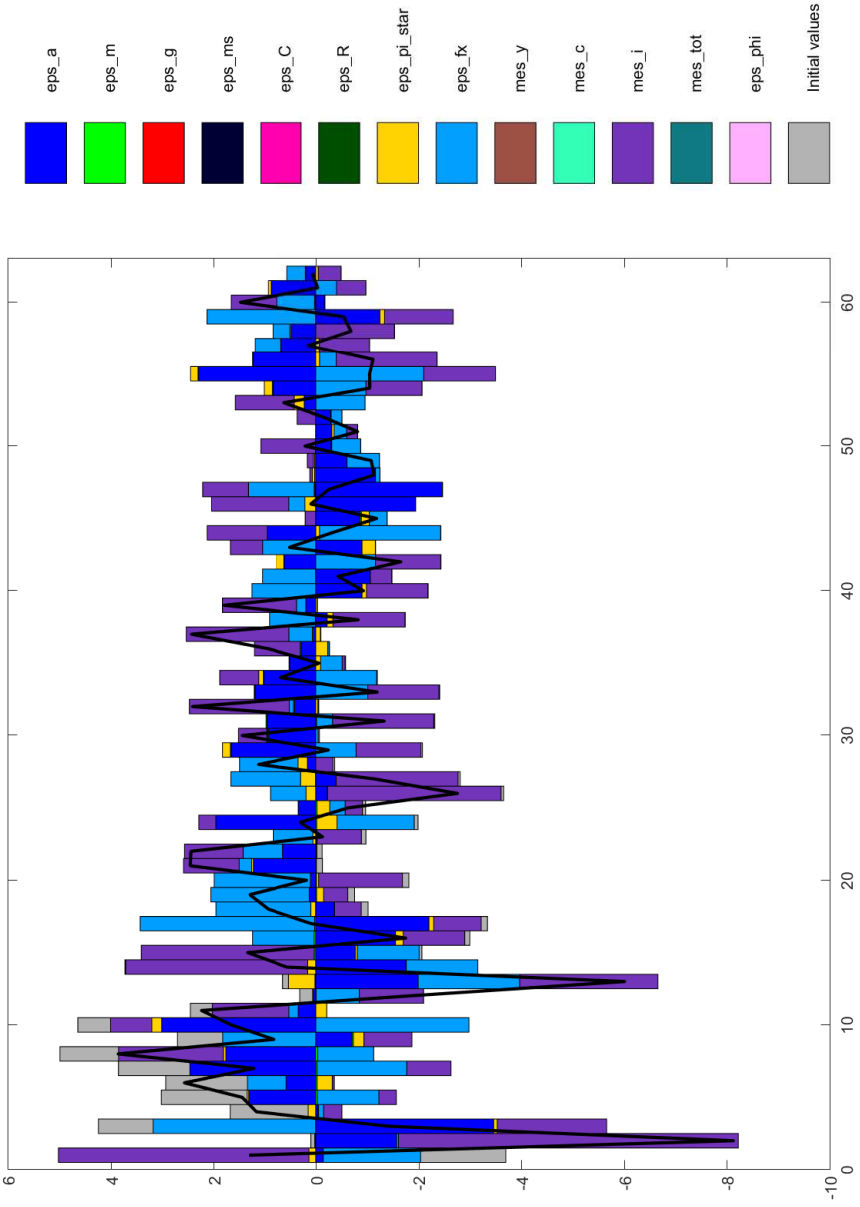


Figure 4.7: Variance Decomposition: Investment

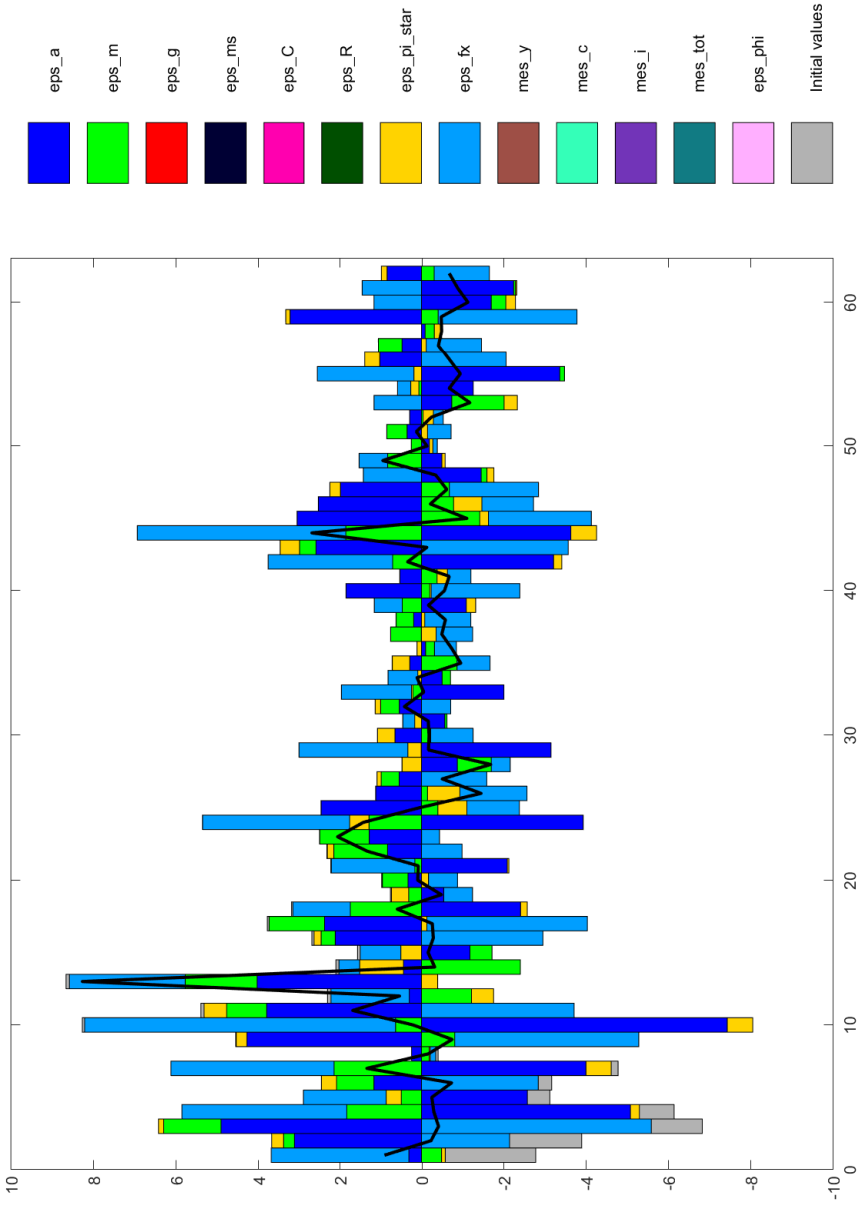


Figure 4.8: Variance Decomposition: Inflation

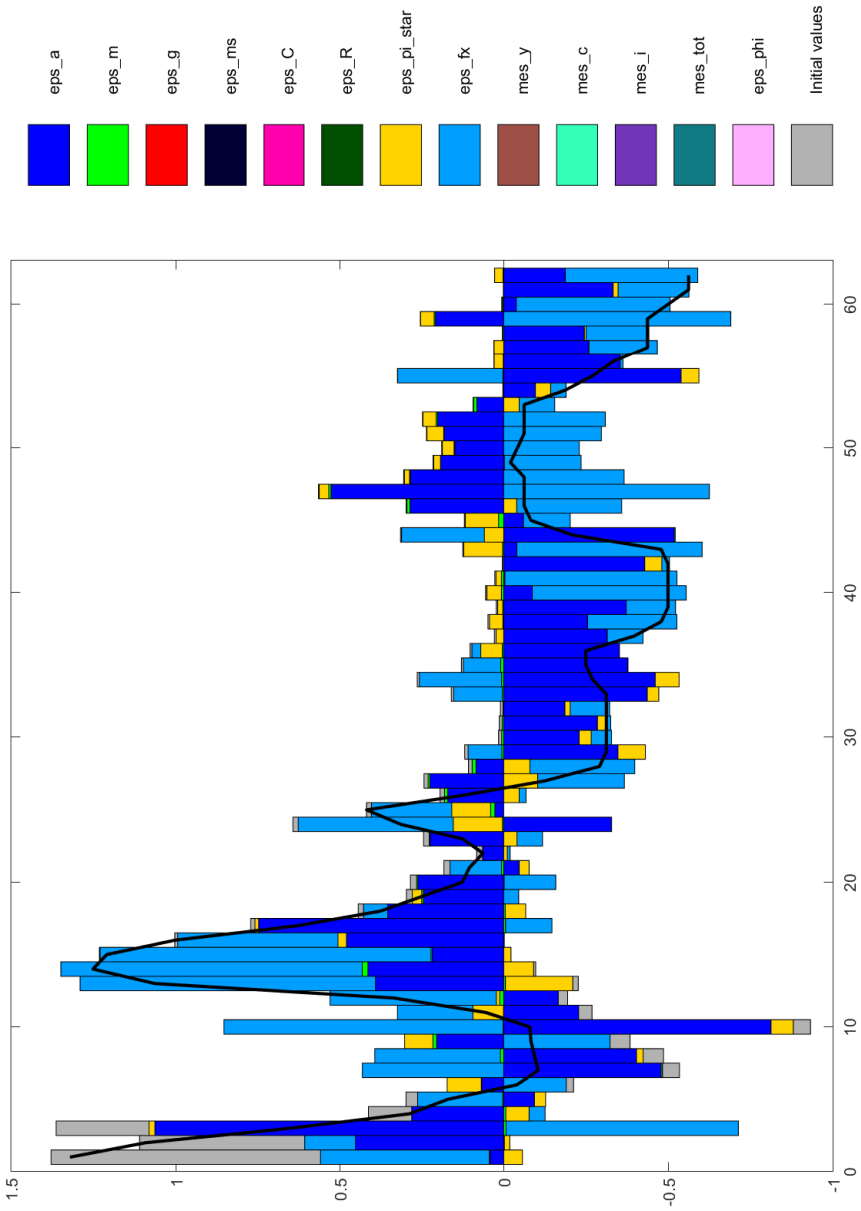


Figure 4.9: Variance Decomposition: Interest Rate

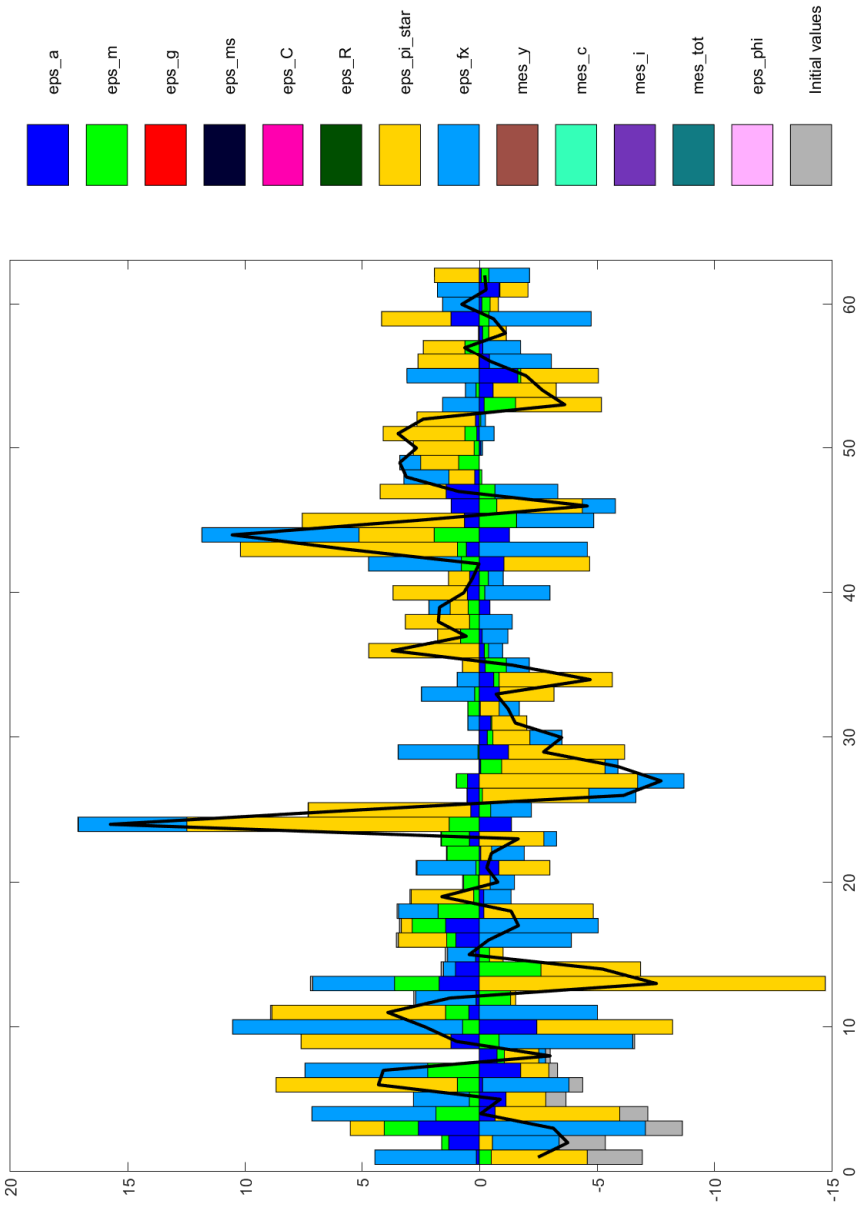


Figure 4.10: Variance Decomposition: Exchange Rate

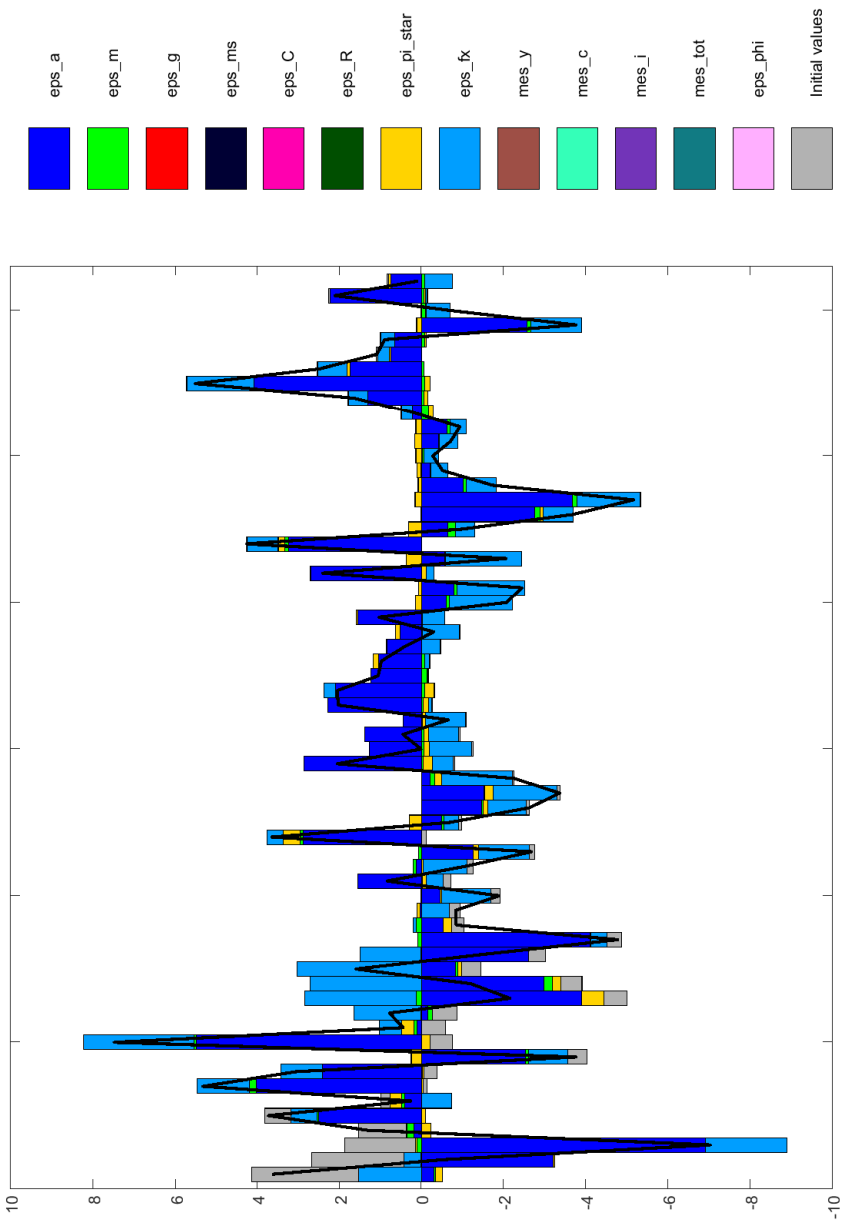


Figure 4.11: Variance Decomposition: Terms of Trade

Contrary to Kubo (2017), we find that the FX intervention may affect real variables such as output (Figure 4.5), consumption (Figure 4.6), investment (Figure 4.7) and inflation (Figure 4.8). Figure 4.5 displays that technology shock (eps_a), similar to the standard New-Keynesian DSGE model, and FX intervention (eps_fx) are the dominating shocks that affect the output. We may observe the presence of error measurements in output (mes_y) in certain periods. Other effects are relatively small compare to the technology shock and FX intervention shock. A similar situation can also be observed in Figure 4.6 to 4.8. Technology shock and FX intervention are the major factors in affecting consumption, investment and inflation.

The effect of FX intervention comes through the interest rate and the exchange rate and finally the ToT. Figure 4.9 illustrates that the FX Intervention (eps_fx) and technology shock (eps_a) affect the interest rate. Since we set the Taylor rule that responds to the exchange rate, foreign inflation shock (eps_pi_star) also has a strong presence in the interest rate. As previously mentioned, the exchange rate in Figure 4.10 is affected by the FX Intervention directly. Moreover, the foreign inflation has also affected the exchange rate strongly. FX intervention affects inflation by lowering the import price through the perfect exchange rate pass-through to inflation. Figure 4.11 also shows that ToT is affected by technology shock (eps_a) and FX Intervention (eps_fx).

4.4.4 Model Comparison

In order to gain more insight into how FX intervention to the economy, we compare our model without the presence of the intervention. We construct two modified models to compare with our existing model. First, we take the same model and experiment with the monetary policy that only the interest rule presence or the full-pledge ITF. Second, we also modified the same model by incorporating the exchange depreciation to the Taylor rule. This the case of flexible ITF as suggested by Kolasa and Lombardo (2014). The rest of the equations will be similar to our FX intervention model. We then take these two models and compare the results with the FX intervention model results. The impulse response of some selected variables is presented in Figure 4.12, 4.13 and 4.14. We focus our analysis on the impact of these selected variables on the technology, monetary policy, and risk appetite shocks to observe different implications of these policy options to these specific variables.

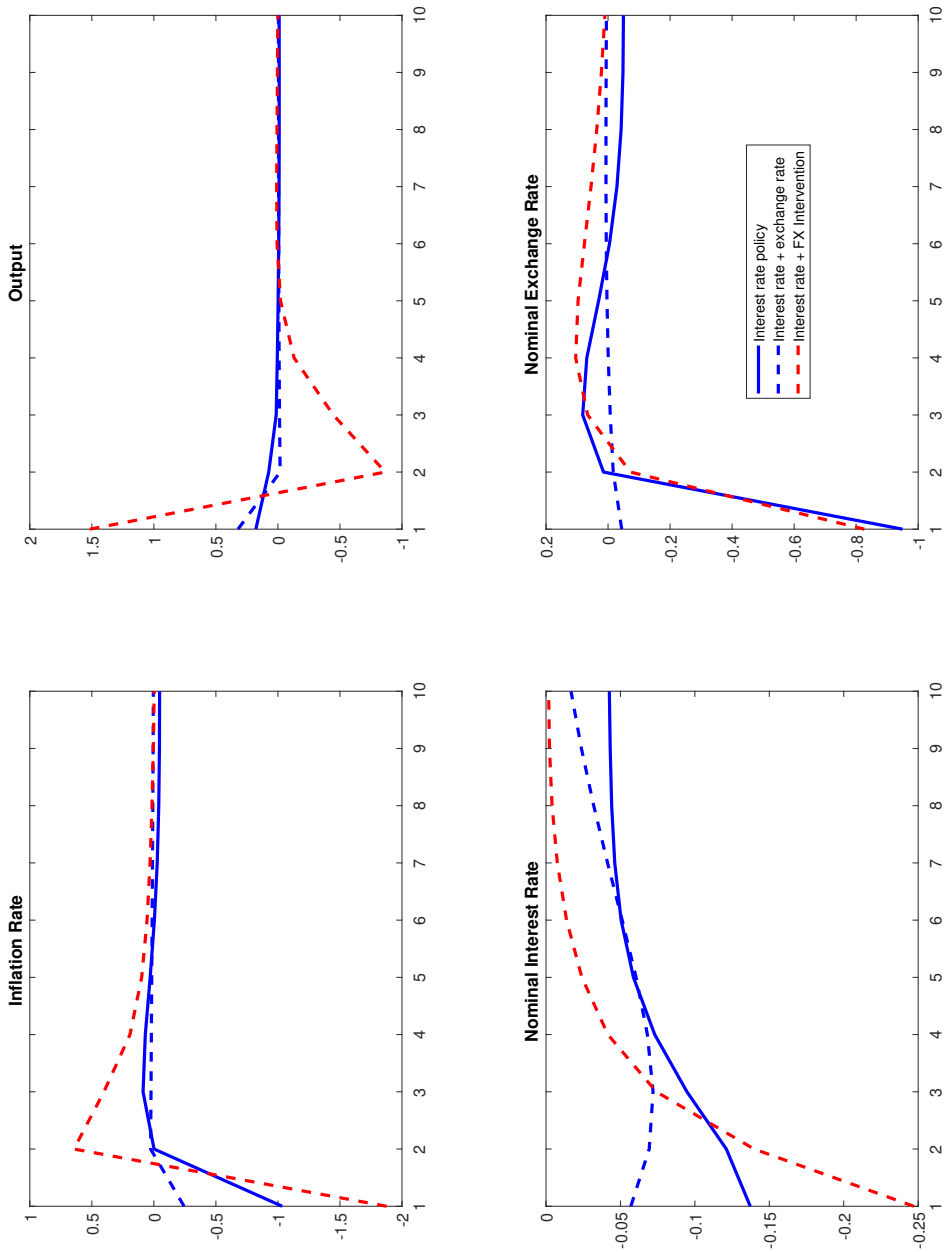


Figure 4.12: Impulse Response Comparison to TFP Shock

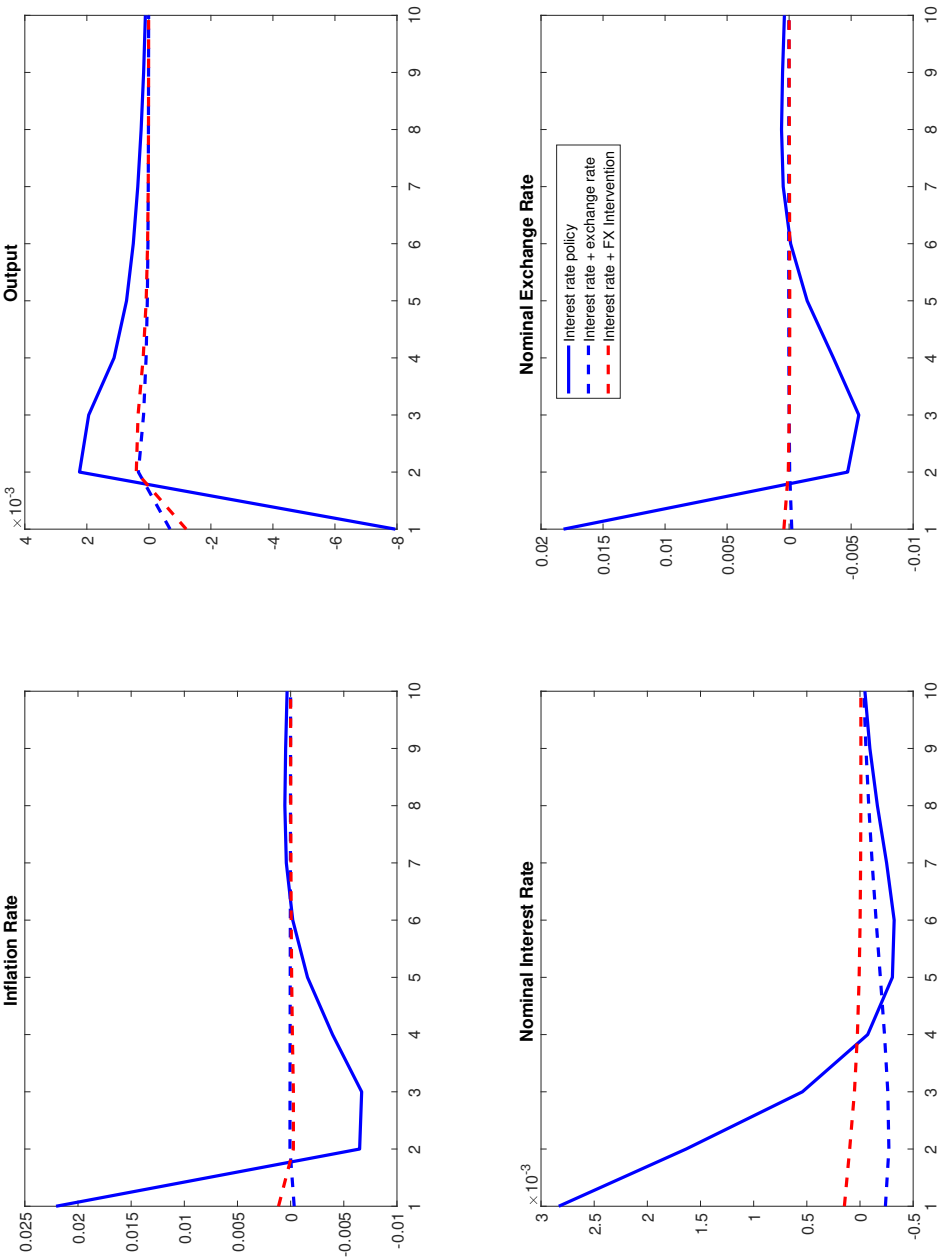


Figure 4.13: Impulse Response Comparison to Monetary Policy Shock

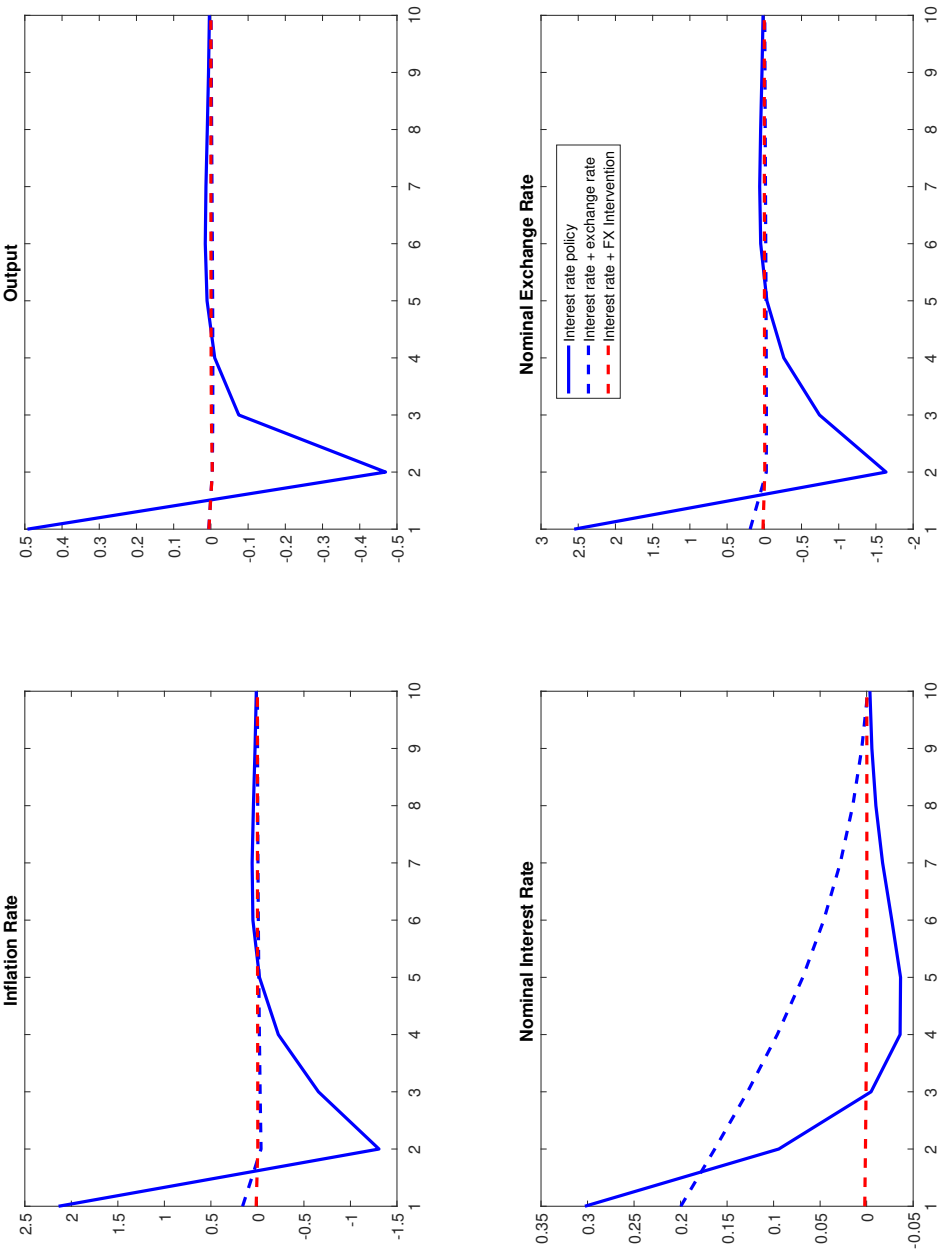


Figure 4.14: Impulse Response Comparison to Risk Appetite Shock

Figure 4.12 shows that the selected variables are more volatile in the presence of FX intervention. Unlike in Wimanda et al. (2012), our results indicate that monetary policy that incorporates the exchange rate depreciation in the Taylor rule displays more stable variables in the presence of a Total Factor Productivity (TFP) shock. Meanwhile, the FX intervention amplifies the risk perception and expectation during the TFP shock. A keen appreciation in the exchange rate leads to a lower price in the midst of a low interest rate period.

A strict Taylor rule has a tremendous impact on the presence of positive monetary policy shock in the Figure 4.13. The nominal exchange rate, particularly, appreciates a quite large as expected. The similar impact can be witnessed from other variables. Without the presence of the exogenous risk appetite, the monetary policy is sufficient to influence all the variables.

In the presence of risk appetite shock, the selected variables swing quite large under the strict Taylor rule policy regime, as displayed in Figure 4.14. FX intervention helps to stabilise the variable during this shock, particularly the exchange rate. This, in turn, helps to stabilise the inflation rate and the output growth.

4.4.5 Policy Implications

Our findings may have several implications for the central bank. Our estimations suggest that FX intervention helps to stabilise the economy during an episode of capital flows. Without the FX intervention, the central bank has to increase the policy rate to contain the impact of the risk appetite shocks. Otherwise, the central bank needs to allow the nominal exchange rate to appreciate (in the case of capital inflows) or to depreciate (in the case of capital outflows) rapidly (Ghosh et al., 2016). Using the interest rate as the only instrument is demonstrated to be costlier to the economy, in our findings. This FX intervention, however, needs to take into account the availability of the foreign reserves of a country. An FX sale intervention requires sufficient foreign reserves and an FX buy intervention will increase the foreign reserves. Investigating the adequate amount of foreign reserves is beyond the scope of this research.

In addition, our findings highlight that FX intervention is not a generic solution for every shock in the economy. For instance, during an episode of positive productivity shock, the use of both interest rate and FX intervention will amplify the shock to the

economy. By reducing the cost of borrowing through both the interest rate and the exchange rate policymakers will aggravate the optimistic view of the agent, which will in turn intensify the impact of the shock on the economy. Our model comparison indicates that a Taylor rule that increases with the exchange rate depreciation response is the best policy option to stabilise the economy. This paper supports Juhro and Mochtar (2009) in suggesting that a policy rule in Indonesia needs to incorporate the exchange rate.

One other point that needs to be stressed is that the use of FX intervention should not undermine the commitment of the central bank to achieve a pre-set target for inflation. An inflation-targeting central bank, within its communication strategy framework, needs to communicate clearly its strategy with regard to the intentions of the FX intervention, which is to tackle specific shocks, in particular the capital flow shocks (Ghosh et al., 2016).

4.5 Conclusion

This study provides a comprehensive analysis of the use of FX intervention by building a DSGE model and producing estimates based on Indonesian data. We find that the central bank actively intervenes in the exchange rate. The FX intervention affects the macroeconomic variables through the portfolio channel. The risk appetite also affects the economy by increasing the capital price.

To have a better understanding of the use of FX intervention, we also compare the estimation results with a policy simulation based on two conditions: an interest rate policy which strictly follows the Taylor rule and an interest rate policy that addresses inflation, output and the exchange rate. We find that the FX intervention helps to stabilise the economy during the presence of risk appetite shocks and monetary policy shocks. However, the interest rate policy that addresses the exchange rate as well as following the standard Taylor rule is found to be more effective in stabilising the macroeconomy during TFP shocks.

These findings have a direct implication for policymakers. Our results suggest that FX intervention can be used to complement interest rate policy, particularly in tackling external shocks such as risk appetite shocks. However, policymakers need to be cautious in identifying shocks so as to provide the right policy mix to tackle the issue. We simulate

the economy under three different shocks, a positive productivity shock, monetary policy shock and risk appetite shock, and our findings indicate that FX intervention may not be the best complement for handling positive productivity shocks to the economy.

Although this study provides interesting findings, it also leaves avenues for future research. First, it would be interesting to incorporate the availability of foreign reserves into the FX intervention. On the one hand, piling up foreign reserves while performing an FX buy intervention may incur investment costs. On the other hand, implementing an FX sale intervention may be restricted by the amount of foreign reserves available. Second, macroprudential instruments such as capital flow management may strengthen or diminish the effect of FX intervention. Furthermore, macroprudential tools aimed directly at the banking system, such as loan-to-value or reserve requirements, may have different implications. It would be worth combining this analysis with our framework.

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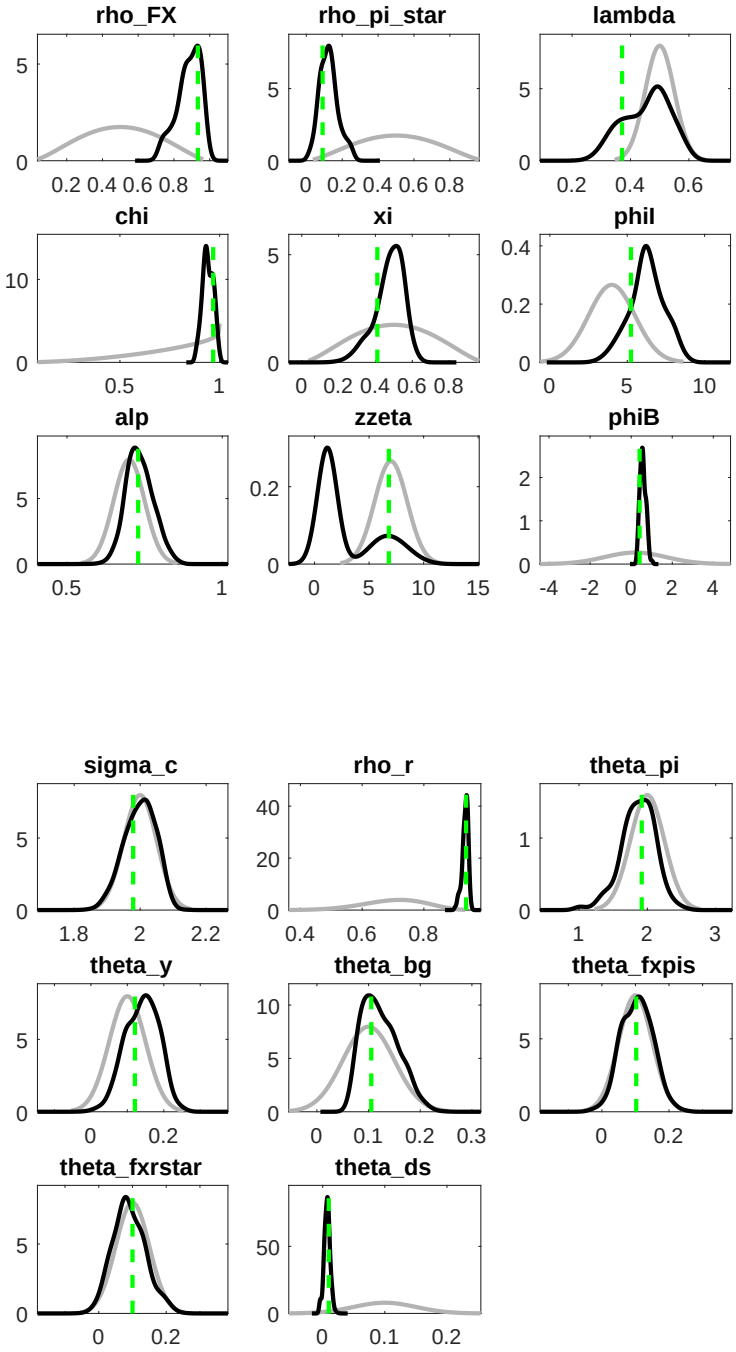
APPENDIX C

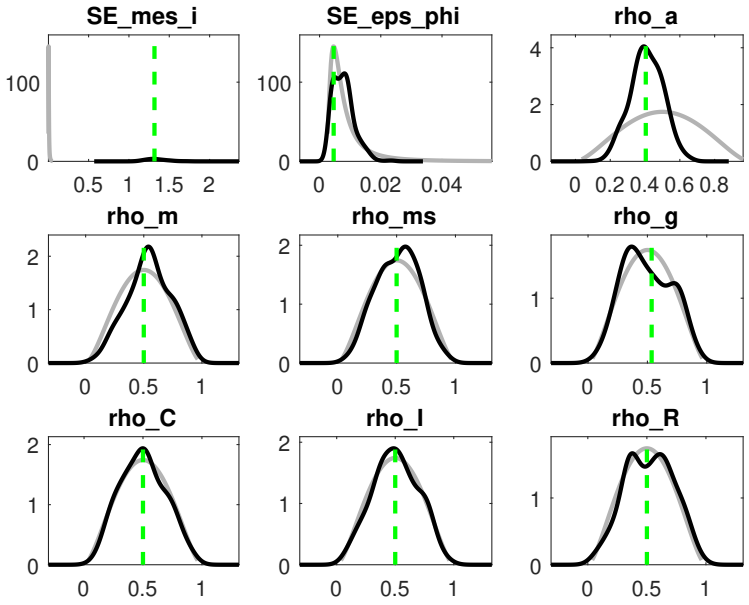
C.1 Standard Deviation of Shocks

Standard Deviation of Shocks Result

Std. dev of shocks	**Prior mean**	**Post. mean**	**90% HPD interval**		**Prior**	**Pstdev**
(1)	(2)	(3)	(4)	(5)	(6)	(7)
ϵ_A	0.01	2.1909	1.5459	2.7825	invg	2
ϵ_M	0.01	0.113	0.0898	0.1318	invg	2
ϵ_{MS}	0.01	0.0321	0.003	0.0578	invg	2
ϵ_G	0.01	0.0057	0.0025	0.0087	invg	2
ϵ_C	0.01	0.0064	0.0024	0.0111	invg	2
ϵ_R	0.01	0.0079	0.0024	0.0146	invg	2
ϵ_{π^*}	0.01	4.1176	3.5616	4.8036	invg	2
Ξ	0.01	0.0078	0.0032	0.0131	invg	2
$m\epsilon_Y$	0.01	1.6633	1.4536	1.8882	invg	2
$m\epsilon_C$	0.01	0.2838	0.2397	0.3219	invg	2
$m\epsilon_I$	0.01	1.339	1.1421	1.5389	invg	2

C.2 Prior and Posterior Distributions

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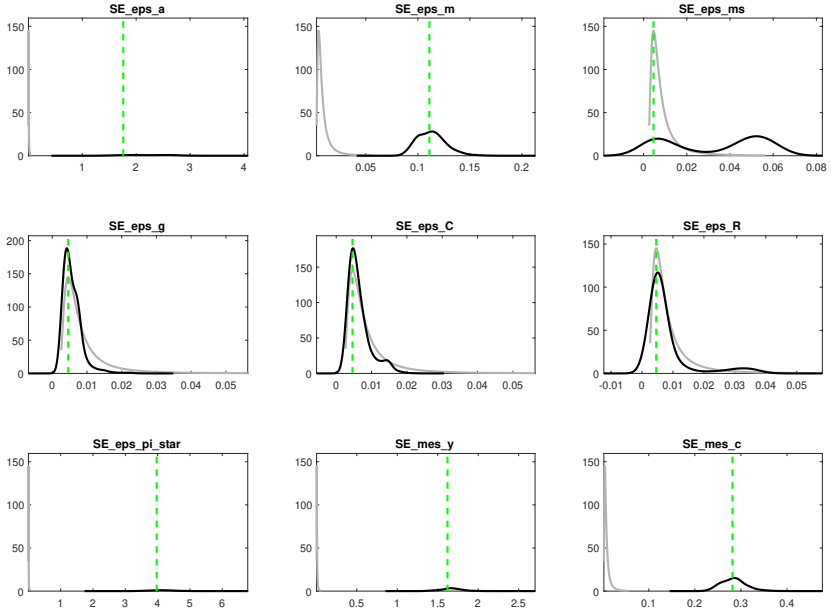
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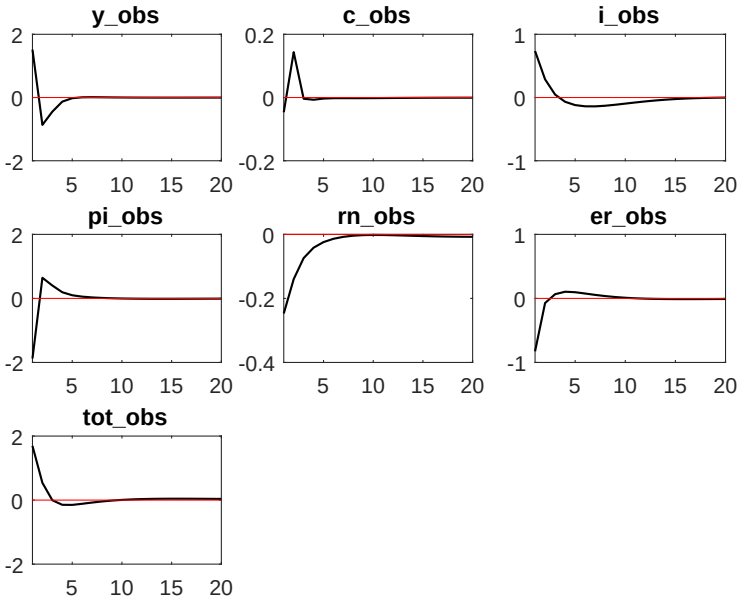
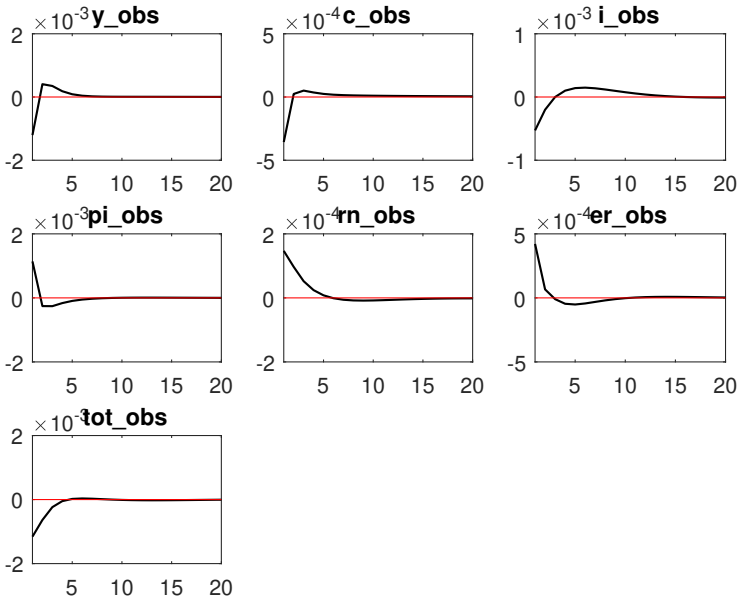
C.3 Impulse Response

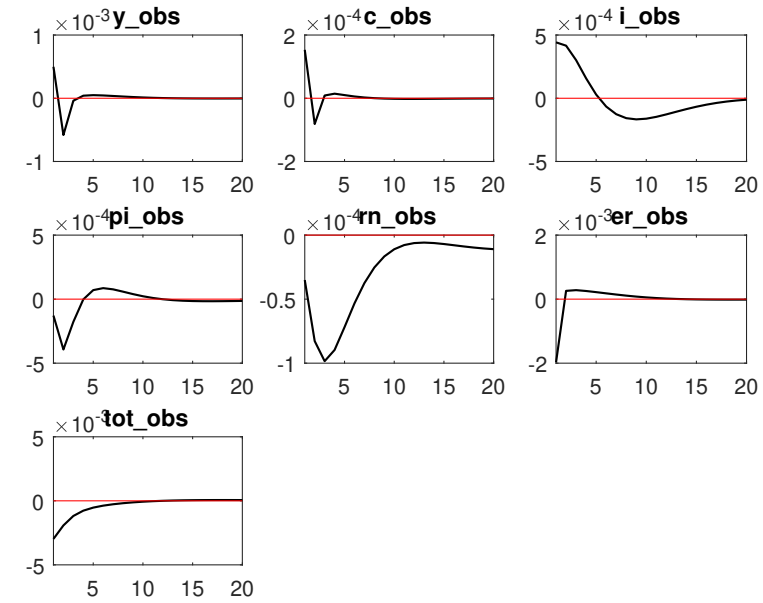
Impulse Response to Productivity Shock



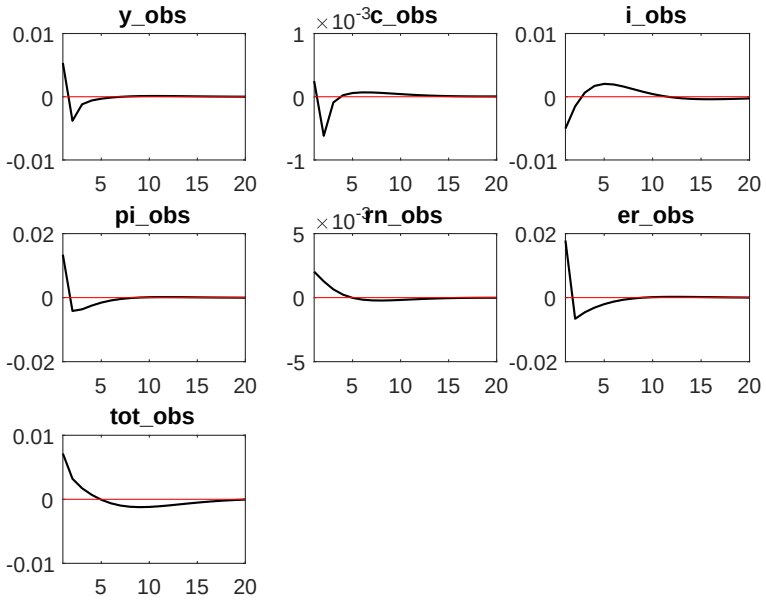
Impulse Response to Mark-Up Shock



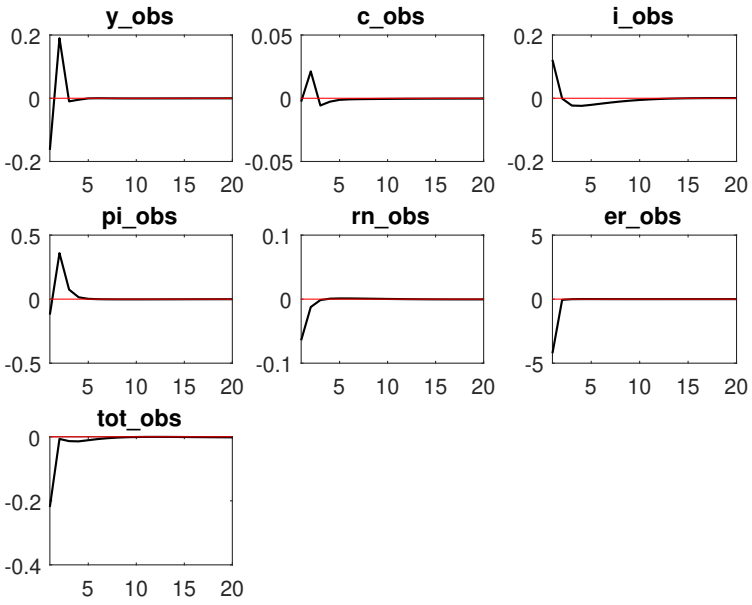
Impulse Response to Foreign Consumption Shock



Impulse Response to Foreign Interest Rate Shock



Impulse Response to Foreign Inflation Shock



CHAPTER 5

External Shock and the Implementation of Monetary and Macroprudential Policies in an Emerging Market

Abstract

External shocks pose a substantial challenge for emerging markets to maintain economic stability. Amidst a number of factors – foreign interest rates, foreign consumption, etc. – that potentially affect the domestic economy, changes in risk appetite of market participants can also be a factor that conditions the domestic economy. Many instruments have been utilised to tackle these challenges, including the reserve requirement. However, the question of the effectiveness of the reserve requirement to stabilise the economy, particularly during episodes of risk appetite shocks, begs an answer. This paper addresses this issue by developing and estimating a Dynamic Stochastic General Equilibrium (DSGE) model using Indonesian data. This study finds that the reserve requirement provides a complementary role to the interest rate policy and FX intervention when used to stabilise the macroeconomy.

Keywords: monetary policy, macroprudential policy, foreign exchange intervention, reserve requirement, DSGE

5.1 Introduction

The role of reserve requirements has been revived in the aftermath of the recent global financial crisis. This instrument is being utilised to achieve price and financial stability. Some recent examples can be drawn from China that frequently uses the reserve requirement to curb domestic credit growth (Ma et al., 2013; Mora, 2014). Reserve requirement is also used to absorb excess or else extend liquidity following a foreign exchange rate (FX) intervention. Similar experience can also be seen in other Asian as well as Latin American countries (Federico et al., 2014; Montoro and Moreno, 2011).

The use of reserve requirements can also be attributed to the volatility of capital flows in emerging markets. Many policymakers use this instrument to tackle the volatility of capital flows. In the event of massive capital inflows, many countries resort to the reserve requirement because increasing the policy rate to tackle the pressure of domestic inflation will instead attract more capital inflows (Montoro and Moreno, 2011). During the period of capital outflows, reserve requirement can be used to neutralise the increasing policy rate due to the 'free of falling' or the need to defend the currency (Federico et al., 2014).

This extensive utilisation of the reserve requirement instrument triggers a long and extensive debate on the use of reserve requirement. As previously mentioned, it may be difficult to determine the main objective of the reserve requirement since it varies across countries (Gray, 2011). In addition, the reserve requirement has also served as a macroprudential instrument in several countries, such as Malaysia and Turkey (Glocker and Towbin, 2012), in an attempt to reduce the intensity of the financial cycle and therefore restrain financial vulnerabilities that may occur as a result.

In another case, Indonesia introduced in 2010 an additional measure to the reserve requirement, linking it to the loan-to-deposit ratio (LDR) of banks on top of their primary reserve requirements. This measure is imposed a reserve requirement penalty if a bank has a LDR below or above target (Bank Indonesia, 2010). This measure is now called macroprudential intermediary ratio (Bank Indonesia, 2018)[1] . The macroprudential intermediary ratio is intended to drive the banking intermediation function to the real sector in accordance with their capacity and macroeconomic stability while maintaining the precautionary principles. The LDR target can function as a signalling tool regarding

[1]Detail regarding the Bank Indonesia's macroprudential instrument can be accessed at `https://www.bi.go.id/id/peraturan/ssk/Pages/PBI_200418.aspx`

the credit condition that is preferable for the central bank (Satria et al., 2016).

Despite the implementation and the long and extensive debates regarding the effectiveness of using reserve requirement, the findings in this area are still far from reaching a conclusion. On the other hand, Lubis et al. (2019) highlight that foreign exchange (FX) intervention complements interest rate policy, particularly in tackling external shocks such as risk appetite shocks, in order to stabilise the macroeconomy. Therefore, it is critical to analyse the reserve requirement within the framework of the central bank, along with interest rate and FX intervention.

In this paper, we try to explore – in the context of an emerging market – the impact of using the reserve requirements combined with FX intervention as key instruments in an inflation-targeting framework. The paper also purports to examine the interaction of monetary policy and macroprudential policy in the context of countercyclical reserve requirement as well as investigates whether the reserve requirement helps the monetary policy to stabilise the economy or causes the instability.

In doing so, we set up a Dynamic Stochastic General Equilibrium (DSGE) model with a sticky price and wage *à la* Calvo (1983), a banking sector with an imperfect substitution and the presence of FX intervention and reserve requirement to complement interest rate policy. Different from the previous paper in Chapter 4, here we incorporate the banking sector in our model and assume that all the household will have no restrictions to access the financial sector. However, similar to Chapter 4, we also incorporate in our model the risk-appetite of investors as a shock to the economy. Further, we estimate the model by using data from Indonesia, one of the emerging economies that have been affected by capital flows volatility. Finally, we examine the impact under three different regimes: where an interest rate policy used to stabilise inflation and output or the full-fledged Inflation Targeting Framework (ITF); where an interest rate policy is combined with FX intervention to stabilise inflation, output and exchange rate, and; where an interest rate and foreign exchange intervention is used to stabilise inflation, output and exchange rate.

This paper contributes to this research area, firstly, by providing empirical estimations of the DSGE model for emerging markets that employ a combination of reserve requirement and FX intervention. Secondly, it demonstrates that the reserve requirement can be utilised by policymakers to complement interest rate policy and FX intervention in stabilising the economy during a period of external shocks, particularly a risk appetite

shock.

The remainder of the paper is organised as follows: Section 2 highlights the related literature in reserve requirement whilst section 3 presents the small open-economy model. Section 4 touches on the empirical estimation as well as discusses generated evidence, and finally, section 5 provides some concluding remarks.

5.2 Related Literature

A commercial bank is required to maintain a minimum reserve against their liability mainly in the form of balances at the central bank (Gray, 2011). This practice is already abandoned by some developed countries but is still largely practised in emerging markets. Gray (2011) highlights that the reserve requirement serves several purposes: (i) as a prudential measure that protects banks against a liquidity shock; (ii) as a form of monetary control, either by altering the level of unremunerated reserve requirement hence affecting monetary growth or affecting the spread of deposit interest and lending rates, and; (iii) as a liquidity management that can affect the behaviour of banks.

Federico et al. (2014) find that most of the emerging markets use reserve requirements as a countercyclical policy tool to stabilise the macroeconomy whilst policy rate assumes the procyclical role. According to Federico et al. (2014), this reflects the fact that many emerging economies use policy rates to defend their exchange rate whilst the reserve requirement acts as a substitute for the policy rate.

The use of reserve requirement has become increasingly complex and it becomes very difficult to delineate its main objective. Policymakers in emerging markets have been using reserve requirement to cope with the implications of capital flows. Early observation can be drawn from Reinhart and Reinhart (1999), which document the use of reserve requirement to absorb or expand the monetary base in a particular country during a foreign exchange operation that follows an episode of capital flows. They suggest that during the 1990s, many countries in Asia and Latin America, such as Malaysia, Thailand, and Chile, increased their reserve requirement ratio to deal with a surge in capital inflows, whilst Argentina lowered its reserve requirement during a massive capital outflow period. Brazil even used reserve requirement to cope with both capital inflows and outflows during the same years, according to this study.

The practice of using reserve requirements to tackle massive capital flows episodes can also be spotted in the most recent global financial crisis. Glocker and Towbin (2012) point out that China actively used the reserve requirement in 2010, while Turkey increased its reserve requirement in the same year. Several Latin American countries are also observed using this instrument, such as Brazil, Colombia and Peru (Montoro and Moreno, 2011).

Using reserve requirement may restrict the expansion of financing conditions but without drawing more capital flows as it is with increasing policy rate (Montoro and Moreno, 2011). Banks can adjust their deposit and lending rates as reserve requirements act as a tax on financial intermediation without having to make adjustments on policy rate. Lowering the reserve requirement during an episode of capital outflows provides relief in the liquidity and it also directly affects credit supply. This is helpful particularly in an emerging country where the financial market is still less developed and a pass-through from the policy rate (Moreno, 2008). In addition, reserve requirement may achieve financial stability by restraining credit growth in the upswing of the business cycle and providing the reserve back to the banking sector in the downturn of the business cycle (Montoro and Moreno, 2011)

This practice has attracted new interest in studying the impact of using reserve requirement in macroeconomy. Analytical contributions regarding the use of reserve requirement can be drawn from Glocker and Towbin (2012). They construct a small open-economy model with sticky prices, financial frictions and a banking sector in which reserve requirement is being imposed. They find that the reserve requirements help stabilise the macroeconomy in the presence of a financial stability objective. The presence of a foreign currency debt also increases the effectiveness of the reserve requirements.

However, FX intervention is absent from Glocker and Towbin (2012) model. Agénor et al. (2018) then complement the analysis with a FX intervention combined with the imperfect substitutions for deposit and other funding sources for the banks, such as central bank and foreign loans. They also introduce a time-varying reserve requirement that links counter-cyclically to a credit-based measurement. They find that this credit-based reserve requirement instrument helps stabilise the macroeconomy and financial volatilities. Further, they argue that the reserve requirement and FX sterilisation are partial substitutes.

In addition, in the aftermath of the 2008 financial crisis, many inflation-targeting

framework (ITF) central banks implement foreign exchange rate intervention as a complementary policy to the interest rate (Ghosh et al., 2016). This is partly driven by the impact of the quantitative easing policy, which is conducted by most of the central banks in developed countries, namely the Federal Reserve and the European Central Bank. The excess liquidity in the global market needs to be channelled, mainly to emerging markets. Ghosh et al. (2016) find that the use of foreign exchange rate intervention helps achieve price stability. Blanchard et al. (2015) also find that the foreign exchange intervention helps dampen exchange rates pressures and can be considered as a part of the ITF central bank's tool to stabilise the macroeconomy.

The volatility of the exchange rate is also amplified by the volatility of the market participants' risk appetite. This phenomenon is popularly called 'Risk On/Risk Off' phenomenon (Smales, 2016). Smales (2016) finds that this change of risk perception relates to the large volatility in foreign exchange assets. In the case of Indonesia, Cadarajat and Lubis (2012) find that the impact of the exchange rate volatility increases after the global financial crisis. This volatility increase is driven mainly by the off-shore market which represents foreign investors' risk appetite. Early studies such as Henderson and Rogoff (1982) have documented that the change in risk appetite of market participants may affect the stability of the exchange rate.

In other studies, Bustamante and Hamann (2015) and Leduc and Natal (2018) provide a close-economy model to investigate the role of countercyclical reserve requirement to macroeconomy. Bustamante and Hamann (2015) build a dynamic stochastic general equilibrium (DSGE) model with the presence of two policy instruments, interest rate and reserve requirements. This model is also equipped with risk-averse financial intermediaries and heterogeneous agents who face uninsurable idiosyncratic risks. Their key finding is that countercyclical reserve requirements help in reducing consumption volatility when banks become increasingly risk-averse. The imperfect substitution between bank deposit and loan from the central bank attributes to the effectivity of reserve requirements.

In addition, Leduc and Natal (2018) investigate the use of reserve requirement linked to the financial cycle. They find that in the absence of macroprudential policy, monetary policy needs to be equipped with the 'lean against the wind' instrument. This can be performed by adding asset price to the standard Taylor rule. One of the arguments that they put forward is that the economy is subject to a feedback loop between asset

prices and economic fluctuations. Adding macroprudential instruments such as reserve requirement, which is connected to credit growth, Leduc and Natal (2018) argue that the introduction of macroprudential instruments helps in diminishing the endogenous feedback loop between asset price and economic fluctuations. This condition helps monetary policy focus on tackling price stability.

Agénor et al. (2018), similar to Iacoviello (2005), also use housing as credit collateral. This is important as housing collateral backs up many credits. This link provides the collateral effect that allows the model to match the positive feedback of real spending to housing price.

Turning to empirical evidence, extensive work has been performed to examine the role of reserve requirement in the economy. Several works can shed light on the use of this instrument, particularly in an emerging market setting. These include Reinhart and Reinhart (1999), Armas et al. (2014),Loeffler (2015), Crespo Cuaresma et al. (2019) and Tovar et al. (2014). Reinhart and Reinhart (1999) find that the reserve requirement helps prevent a monetary expansion during an episode of massive capital outflows in sample countries such as Malaysia, Kenya and Chile. It is also observed that the deposit interest rate is lowered, the lending rates are increased, and therefore, the spread between these rates is widened.

Armas et al. (2014) find that the reserve requirement in Peru helps curb the effect of large capital inflows that follows an expansion policy from developed countries. In addition, Armas et al. (2014) argue that using this instrument also helps develop the capital market in Peru by increasing the cost of credit. Firms are instead encouraged to use the capital market when seeking funding.

Loeffler (2015) examines the impact of the use of reserve requirement on real exchange rate. He performs tests on data from Latin American, East Asian and Eastern European countries to find whether reserve requirement drives undervalued real exchange rates to enhance international competitiveness. Loeffler (2015) finds that reserve requirement drives real exchange rate to depreciate. He continues to argue that a high reserve requirement measure may cause a shift from formal banking services to shadow banking since the cost of financial intermediation increases in the formal banking sector.

On the relationship with output and credit growth, Crespo Cuaresma et al. (2019) perform an analysis using quarterly data on reserve requirements in 60 countries. They

find that reserve requirement affects output growth negatively during tranquil times and positively during crises. They also argue that the impact of reserve requirement on credit over GDP is presented positively in the long run. Tovar et al. (2014), in another study, report that based on data from Latin America, reserve requirement has an effect to credit growth. They also argue that reserve requirement is a complement to monetary policy.

5.3 A Small Open Economy Model

We consider a continuous-time model with infinite horizon that features nominal and real rigidities along the lines of Agénor et al. (2013, 2018), Smets and Wouters (2007) and Christiano et al. (2005), among others. We assume that wage and price have nominal rigidity. We also set the banking sector to have an imperfectly competitive environment. We include an interest policy combined with FX intervention, and reserve requirement as the stabilisation policies. However, we assume that the central bank may not be able to fully utilise the FX reserves and has to maintain a certain amount of FX reserves.

We will describe each problem of the agents in these following sections.

5.3.1 Household

There is a continuum of households, which is indexed by $j \in [0, 1]$. These households are exposed to the Calvo-style wage-setting friction, in which they will have heterogeneous wages and labour supply and therefore income. This paper assumes that there is no presence of an idiosyncratic wage risk. In addition, the utility of consumption, C_t, and labour N_t is separated. Therefore, households will be identical in other decisions. They own the final, intermediary and capital good producers, and commercial banks. They will receive a profit transfer from each firm.

The household problem can be written as:

$$\max_{C_t, N_t, B_{t+1}, B^*_{t+1}, M_{t+1}, D_t, H_t} \mathbb{E}_0 \left[\sum_{s=0}^{\infty} \beta^s \ln \left(C_{t+s} - \chi C_{t+s-1} \right) - \psi_N \frac{N(j)_{t+s}^{1+\eta}}{1+\eta} + \psi_x \ln x_{t+s} + \psi_H \ln H_{t+s} \right] \tag{5.1}$$

where H_t is the housing stock, x_t is the composite monetary asset of the household, which can be generated by combining cash balances, M_t^p and bank deposit D_t:

$$x_t = (M_t^p)^{\omega}\ D_t^{1-\omega} \tag{5.2}$$

Parameter β is the discount factor, χ is the internal habit parameter and η is the inversed Frisch labour disutility function. Parameter ψ_N is labour disutility while ψ_x and ψ_H are the liquidity and housing utility parameters respectively. Households then face a nominal budget constraint, which is given by:

$$\begin{aligned} P_t C_t + S_{t+1} B_{t+1}^* + M_t + D_t =& W_t N_t - T_t + \Gamma_t^{IG} + \Gamma_t^{CG} + \Gamma_t^B + (1 + r_{t-1})\, B_t + S_t \left(1 + r_{t-1}^*\right) B_t^* \\ &+ M_{t-1} + \left(1 + r_t^D\right) D_{t-1} - P_t^H \left(H_t - H_{t-1}\right) \end{aligned}$$

P_t is the price of goods sold in the domestic market, S_t is the exchange rate, B_t^* is the foreign bond holding, B_t is the government bond holding while T_t is the lump-sum tax. Γ_t^{IG}, Γ_t^{CG}, Γ_t^B are the profit transfer from intermediate good producer, capital good producer and commercial bank respectively. r_t is the nominal interest rate and is set by the central bank, while r_t^D is the nominal interest rate paid to the bank's deposit. r_t^* is the foreign interest rate which in this paper will be assumed following an exogenous process.

Following Schmitt-Grohé and Uribe (2003), Adler et al. (2016) and Chang et al. (2015), the foreign bonds are subject to a risk premium that depends on the net exposure to foreign assets (NFA_t):

$$\Phi_t^B = \theta_B \left[\exp\left(\frac{NFA_t}{\frac{P_{D,t}}{P_t} Y_t} - \frac{\bar{NFA}}{\bar{Y}}\right) - 1\right] + \varepsilon_{\phi^*,t} \tag{5.3}$$

where $NFA_t = B_t^* - L_t^F + FX_t$ and $\varepsilon_{\phi^*,t}$ represents the exogenous risk appetite shock.

Maximising equation (5.1) subject to the budget constraint, the first-order conditions will be:

$$\lambda_t = \frac{1}{C_t - \chi C_{t-1}} - \beta\chi\, \mathbb{E}_t \frac{1}{C_{t+1} - \chi C_t} \tag{5.4}$$

$$\lambda_t = \beta\, \mathbb{E}_t \left(1 + r_t\right) \left(1 + \pi_{t+1}\right)^{-1} \tag{5.5}$$

$$m_t^p = \frac{\psi_X\, \omega}{\lambda_t \frac{r_t}{1+r_t}} \tag{5.6}$$

$$d_t = \frac{\psi_X\ (1-\omega)}{\lambda_t \frac{r_t - r_t^D}{1+r_t}} \tag{5.7}$$

$$P_t^h = \lambda_t \left(1 - \frac{\frac{P_{t+1}^h}{P_t^h}}{1 + r_t}\right)^{-1} \psi_H \, {h_t}^{-1} \tag{5.8}$$

$$\pi_{t+1}^S = \frac{1 + r_t}{(1 + r_t^*)\ \Phi_t^B} - 1 \tag{5.9}$$

where λ_t is the Lagrange multiplier, π_t is the price inflation and π_t^S is the exchange rate inflation[2].

5.3.1.1 Consumption Demand

The consumption of both households consists of domestic and foreign goods (import) which are a composite index of:

$$C_t = \left[{\nu_C}^{\frac{1}{\mu_C}} \, {C_{D,t}}^{\frac{\mu_C - 1}{\mu_C}} + (1 - \nu_C)^{\frac{1}{\mu_C}} \, {C_{F,t}}^{\frac{\mu_C - 1}{\mu_C}}\right]^{\frac{\mu_C}{1 - \mu_C}} \tag{5.10}$$

with $C_{D,t}$ and $C_{F,t}$ representing the consumption of home and foreign goods respectively. The shares of ν_C in the consumption represents the share of domestic goods and import goods in the economy, which is also known as the 'home bias'. The parameter of μ_C represents the elasticity of substitution between domestic goods and import goods.

Here, we assume that the price of import goods will be directly passed to the price domestically. This view is supported empirically by Rahadyan and Lubis (2018). They argue that although the level of nominal exchange rate pass may not transmit directly to inflation, the volatility of the nominal exchange rate amplifies the effect of the pass-through. Therefore, we may consider that the nominal exchange rate has a perfect through to inflation. The corresponding price index is denoted by:

$$P_t = \left[\nu_C \, {P_{D,t}}^{1 - \mu_C} + (1 - \nu_C) \, {P_{F,t}}^{1 - \mu_C}\right]^{\frac{1}{1 - \mu_C}} \tag{5.11}$$

where $P_{D,t}$ and $P_{F,t}$ are the price of domestic goods and import goods in the home country respectively.

Maximising total consumption in (5.10) with regard to a given aggregate expenditure

[2]Since the currency of emerging markets is usually the term currency, we interpret a positive π^S as the depreciation rate and a negative one as the appreciation rate.

of $P_tC_t = P_{D,t}C_{D,t} + P_{F,t}C_{F_t}$ results:

$$C_{Dt} = \nu_C \left(\frac{P_{D,t}}{P_t}\right)^{-\mu_C} C_t \tag{5.12}$$

$$C_{Ft} = (1-\nu_C) \left(\frac{P_{F,t}}{P_t}\right)^{-\mu_C} C_t \tag{5.13}$$

We define $ToT_t \equiv \frac{P_{F,t}}{P_{H,t}}$ are the terms of trade. ToT_t can be written:

$$ToT_t = \frac{1+\pi_{F,t}}{1+\pi_{D,t}} ToT_{t-1} \tag{5.14}$$

Therefore, the price of domestic goods and foreign imported price can be defined as:

$$\frac{P_{D,t}}{P_t} = \left[\nu_C + (1-\nu_C)\ {ToT_t}^{1-\mu_C}\right]^{-\frac{1}{1-\mu_C}} \tag{5.15}$$

$$\frac{P_{F,t}}{P_t} = \left[(1-\nu_C) + \nu_C\, {ToT_t}^{\mu_C-1}\right]^{-\frac{1}{1-\mu_C}} \tag{5.16}$$

5.3.1.2 Labour Supply

The labour supply will be set similar to the standard New-Keynesian DSGE model. As previously mentioned, there is a continuum of households, which indexed by $j \in [0,1]$. These households will provide differentiated labour to a 'labour supplier', who bundles the differentiated labour supply into a homogeneous labour input available for the firm, which is denoted by $N_{d,t}$. The labour supplier will bundle the labour supply according to:

$$N_{d,t} = \left(\int_0^1 N_t(j)^{\frac{\epsilon_w-1}{\epsilon_w}} dj\right)^{\frac{\epsilon_w}{\epsilon_w-1}} \tag{5.17}$$

The elasticity of substitution among different types of labour is measured by ϵ_w. This parameter is assumed grater than one so that different types of labour are substitutes.

The labour supplier will try to maximise the profit which can be written as:

$$\max_{N_t(j)} W_t \left(\int_0^1 N_t(j)^{\frac{\epsilon_w-1}{\epsilon_w}} dj\right)^{\frac{\epsilon_w-1}{\epsilon_w}} - \int_0^1 W_t(j) N_t(j)\, dj$$

The nominal wage is denoted by W_t and $W_t(j)$ is the nominal wage of labour of variety j. The first-order condition will give the demand of each variety of labour, which can be

written:

$$N_t(j) = \left(\frac{W_t(j)}{W_t}\right)^{-\epsilon_w} N_{d,t}$$

The aggregate wage index is defined as:

$$W_t\, N_{d,t} = \int_0^1 W_t(j)^{1-\epsilon_w}\, {W_t}^{\epsilon_w}\, N_{d,t}\, dj \tag{5.18}$$

Aggregate labour supply is defined as the sum of labour by variety:

$$N_t = \int_0^1 N_t(j)\, dj$$

The demand for each variety of labour can then be derived as:

$$N_t = \int_0^1 \left(\frac{W_t(j)}{W_t}\right)^{-\epsilon_w} N_{d,t}\, dj \tag{5.19}$$

Similar to price, the wage also has nominal rigidity. We assume that households are not freely able to choose their wage each period. In particular, in each period, they face the probability $1-\phi_w$ of being able to adjust their wage. With probability ϕ_w they are stuck with a wage for one period. The first-order condition related to wage can be written as:

$$\hat{w}_t = \frac{\epsilon_W}{\epsilon_W - 1}\, \frac{z_{1,t}}{z_{2,t}} \tag{5.20}$$

where $\hat{w}_t$ is the reset wage. Whereas $z_{1,t}$ and $z_{2,t}$ are the auxiliary variables for wages which can be expanded to:

$$z_{1,t} = \psi_N \left(\frac{w_t}{\hat{w}_t}\right)^{\epsilon_W\,(1+\eta)} {N_t}^{1+\eta} + \beta\, \phi_W\, (1+\pi_t)^{-\zeta_W\,\epsilon_W\,(1+\eta)}\, (1+\pi_{t+1})^{\epsilon_W\,(1+\eta)} \left(\frac{\hat{w}_{t+1}}{\hat{w}_t}\right)^{\epsilon_W\,(1+\eta)} z_{1,t+1} \tag{5.21}$$

$$z_{2,t} = N_t\, \lambda_t \left(\frac{w_t}{\hat{w}_t}\right)^{\epsilon_W} + \beta\, \phi_W\, (1+\pi_t)^{\zeta_W\,(1-\epsilon_W)}\, (1+\pi_{t+1})^{\epsilon_W - 1} \left(\frac{\hat{w}_{t+1}}{\hat{w}_t}\right)^{\epsilon_W} z_{2,t+1} \tag{5.22}$$

Therefore, the real wage w_t can be formulated as:

$$w_t = \left[(1-\phi_W)\, \hat{w}_t^{1-\epsilon_W} + \phi_W\, (1+\pi_{t-1})^{\zeta_W\,(1-\epsilon_W)}\, (1+\pi_t)^{\epsilon_W - 1}\, {w_{t-1}}^{1-\epsilon_W}\right]^{\frac{1}{1-\epsilon_W}} \tag{5.23}$$

5.3.2 Firms

In this model, the firm is divided into a representative final good producer, a continuum of monopolistically competitive intermediate goods firm who have power but are subject to price stickiness *à la* Calvo (1983), and a capital good producer.

5.3.2.1 Final Good Producer

The final good producer is assumed to be perfectly competitive. The final output good Y_t is a constant elasticity of substitution aggregate of a continuum of intermediaries $Y_t(k)$:

$$Y_t = \left(\int_0^1 Y_t(k)^{\frac{\epsilon_p - 1}{\epsilon_p}} \right)^{\frac{\epsilon_p}{\epsilon_p - 1}} \tag{5.24}$$

The parameter of ϵ_p is the elasticity substitution between different intermediary goods. We assume that $\epsilon_P > 1$.

Profit maximisation by the final good producer results in a demand curve for each intermediate:

$$Y_t(k) = \left(\frac{P_{D,t}(k)}{P_{D,t}} \right)^{-\epsilon_P} Y_t \tag{5.25}$$

The aggregate domestic price level $P_{D,t}$ is derived from the definition of nominal output as the sum of prices multiplied with the quantities of intermediary goods, and can be written as:

$$P_{D,t} = \left(\int_0^1 P_{D,t}(k)^{1-\epsilon_P} dk \right) \tag{5.26}$$

5.3.2.2 Intermediate Good Producer

Production function in the intermediary good producer is operated by a constant return to scale technology in labour, with a common productivity shock, A_t, by following Cobb-Douglas function:

$$Y_t = A_t \, {K_t}^{\alpha} \, {N_t}^{1-\alpha} \tag{5.27}$$

Intermediate good producer faces a common wage. A proportion of wages, $[\kappa_w \in 0, 1]$, needs to be paid in advance and requires funding from the commercial bank in the form of bank's loan l_t^w:

$$l_t^w(k) = \kappa_w w_t N_t \tag{5.28}$$

This bank loan will cost the intermediate good producer the interest rate of bank loan r_t^L. This type of loan is assumed to bear no risk, and hence, will be repaid at the end of the period t in the full amount.

Intermediate good producer is not able to adjust price independently to maximise profit for each profit. Besides the loan interest rate, intermediate good producer also needs to pay the wages and rental cost of the capital (R_t^K) Therefore, intermediate good producer will always try to minimise its cost. The cost minimisation problem of the intermediary good producer is:

$$\min_{K_t(k),N_t(k)} \kappa_w \left(1 + r_t^L\right) W_t \, N_t(k) + R_t^K K_t$$

subject to

$$A_t \, K_t(j)^{\alpha} \, N_t(j)^{1-\alpha} \geqslant \frac{P_D(j)}{P_t}^{-\epsilon_P} Y_t$$

First order condition for the intermediate good producer can be written as:

$$mc_t = \frac{w_t \, \left(1 + r_t^L\right) \, \kappa_W}{(1-\alpha) \, A_t \, \left(\frac{K_t}{N_t}\right)^{\alpha}} \tag{5.29}$$

$$w_t = \frac{1-\alpha}{\alpha} R_t^K \, \left(\frac{K_t}{N_t}\right) \, \left[\left(1 + r_t^L\right) \, \kappa_w\right]^{-1} \tag{5.30}$$

where mc_t is the real marginal cost.

Intermediate good producers are not able to adjust their price independently. The domestic good price is defined as $P_{D,t}$. Each period, there is a fixed probability of $1 - \phi_p$ that a firm can adjust its price. If the firms cannot adjust, they partially index their price to lagged aggregate inflation at $\zeta_p \in [0, 1]$. The gross inflation rates then can be written as:

$$P_{D,t+s}(k) = \left(\frac{P_{D,t+s-1}}{P_{D,t-1}}\right)^{\zeta_p} \hat{P_{D,t}}(k)$$

where $\hat{P_{D,t}}(k)$ is the reset price.

Firms will discount profits s periods into the future by $\tilde{M}_{t+s} \, \phi_p^s$, where $\tilde{M}_{t+s} = \mathbb{E}_t \, \beta^s \frac{\lambda_{t+s}^n}{\lambda_t^n}$. Putting this in the demand for goods, we get:

$$\max_{\hat{P}_{D,t}(k)} \mathbb{E}_t \sum_{s=0}^{\infty} (\beta\phi_p)^s \frac{\lambda_{t+s}^s}{\lambda_t^n} \left[\left(\frac{P_{D,t+s-1}}{P_{D,t-1}} \right)^{\zeta_p(1-\epsilon_p)} \hat{P}_{D,t}(k)^{1-\epsilon_p} P_{D,t+s}^{\epsilon_p} Y_{t+s} - \varphi_{t+s} \left(\frac{P_{D,t+s-1}}{P_{D,t-1}} \right)^{\zeta_p \epsilon_p} \hat{P}_{D,t}(k)^{\epsilon_p} Y_{t+s} \right]$$

The first-order condition is:

$$\hat{P}_{D,t} = \frac{\epsilon_p}{\epsilon_p - 1} \frac{\mathbb{E}_t \sum\limits_{s=0}^{\infty} (\beta\phi_p)^s \lambda_{t+s}^s \varphi_{t+s} \left(\frac{P_{D,t+s}}{P_{D,t-1}} \right)^{-\zeta_p \epsilon_p} P_{t+s}^{\epsilon_p} Y_{t+s}}{\mathbb{E}_t \sum\limits_{s=0}^{\infty} (\beta\phi_p)^s \lambda_{t+s}^s \left(\frac{P_{D,t+s}}{P_{D,t-1}} \right)^{\zeta_p(1-\epsilon_p)} P_{t+s}^{\epsilon_p} Y_{t+s}}$$

We define $\varphi_t = mc_t$ and rewrite the price setting condition as:

$$\hat{P}_{D,t} = \frac{\epsilon_p}{\epsilon_p - 1} \frac{F_{1,t}}{F_{2,t}}$$

Where:

$$F_{1,t} = \lambda_t \, mc_t \, P_{D,t}^{\epsilon_p} Y_t + \phi_p \, \beta \left(\frac{P_{D,t}}{P_{D,t-1}} \right)^{-\zeta_p \epsilon_p} \mathbb{E}_t \; F_{1,t+1}$$

$$F_{2,t} = \lambda_t \, P_{D,t}^{\epsilon_p - 1}, Y_t + \phi_p \, \beta \left(\frac{P_{D,t}}{P_{D,t-1}} \right)^{\zeta_p(1-\epsilon_p)} \mathbb{E}_t \; F_{2,t+1}$$

We then can express in terms of domestic price inflation $\pi_{D,t}$ as:

$$1 + \hat{\pi}_{D,t} = (1 + \pi_{D,t}) \; \frac{\epsilon_p}{\epsilon_p - 1} \frac{f_{1,t}}{f_{2,t}} \tag{5.31}$$

Subsequently, the auxiliary variables are written become:

$$f_{1,t} = \lambda_t \, mc_t \, Y_t + \beta \, \phi_P \; (1 + \pi_{Dt})^{\epsilon_P(-\zeta_P)} \; (1 + \pi_{Dt+1})^{\epsilon_P} \; f_{1,t+1} \tag{5.32}$$

$$f_{2,t} = \lambda_t \, Y_t + \beta \, \phi_P \; (1 + \pi_{D,t})^{\zeta_P(1-\epsilon_P)} \; (1 + \pi_{D,t+1})^{\epsilon_P - 1} \; f_{2,t+1} \tag{5.33}$$

Therefore, domestic price inflation can be defined as:

$$1 + \pi_{D,t} = \left[(1 - \phi_P) \; (1 + \hat{\pi}_{D,t})^{1-\epsilon_P} + \phi_P \; (1 + \pi_{D,t-1})^{\zeta_P(1-\epsilon_P)} \right]^{\frac{1}{1-\epsilon_P}} \tag{5.34}$$

Price dispersion vp_t is defined as:

$$vp_t = (1 - \phi_P) \left(\frac{1 + \pi_{D,t}}{1 + \hat{\pi}_{D,t}} \right)^{\epsilon_P} + \phi_P \; (1 + \pi_{D,t-1})^{-\zeta_P \epsilon_P} \; (1 + \pi_{D,t})^{\epsilon_P} \; vp_{t-1} \tag{5.35}$$

Therefore, output can be written as:

$$Y_t = \frac{A_t \, {K_t}^{\alpha} \, {N_t}^{1-\alpha}}{vp_t} \tag{5.36}$$

5.3.2.3 Capital Good Producer

Capital good producer purchases capital goods from domestic and foreign retail firms. The aggregate capital accumulation is

$$K_{t+1} = \left[\frac{I_t}{K_t} - \frac{\phi_K}{2} \left(\frac{K_{t+1} - K_t}{K_t} \right)^2 \right] K_t + (1 - \delta) \, K_t \tag{5.37}$$

The investment needs to be paid in advance and therefore capital goods producers need to borrow from the bank:

$$l_t^I = I_t \tag{5.38}$$

This study assumes that giving loan to the capital good producer is a bit risky and the repayment is uncertain. The probability of the loan will be repaid is $q_t \in (0, 1)$. This loan is also covered by housing stock owned by the household as collateral. Following Agénor et al. (2018), we assume that the household does not require any fee for pledging their housing stock as the collateral. Expected loan repayment from the capital goods producers is $q_t \left(1 + r^L\right) I_t + (1 - q_t) \, \gamma P_t^H \bar{H}$, where $\gamma = \int_0^1 \gamma^i di \leq 1$ and $\gamma \in [0, 1]$ is the collateral which the fraction of the housing stock.

The capital good producer chooses the level of capital K_{t+1} and investment I_t to maximise the value of the profit transfer to the household. The profit maximisation problem of the intermediary good producer is:

$$\max_{K_{t+1}} R_t^K K_t - q_t(1 + r_t^L) I_t + (1 - q_t) \gamma P_t^H \bar{H}$$

subject to

$$K_{t+1} = \left[\frac{I_t}{K_t} - \frac{\phi_K}{2} \left(\frac{K_{t+1} - K_t}{K_t} \right)^2 \right] K_t + (1 - \delta) \, K_t$$

The first-order condition yields:

$$r_t^K = q_{t-1}\left[\left(1+r_{t-1}^L\right)\left(1+\phi_K\left(\frac{K_t}{K_{t-1}}-1\right)\frac{1+r_{t-1}}{1+\pi_{t-1}}\right)-\left(1+r_t^L\right)q_t\left(1-\delta+\frac{\phi_K}{2}\left(\left(\frac{K_{t+1}}{K_t}\right)^2-1\right)\right)\right] \tag{5.39}$$

where r_t^K is the rental rate of capital.

5.3.2.4 Investment demand

Parallel with the consumer goods, the domestic, export and import demand for investment goods will have the same conditions. We express the aggregate price of investment goods as P_t^I. The investment demand goods from domestic and foreign (imports) to maximise:

$$I_t = \left[\nu_I{}^{\frac{1}{\mu_I}}\, I_{D,t}{}^{\frac{\mu_I-1}{\mu_I}} + (1-\nu_I)^{\frac{1}{\mu_I}}\, I_{F,t}{}^{\frac{\mu_I-1}{\mu_I}}\right]^{\frac{\mu_I}{1-\mu_I}} \tag{5.40}$$

with $I_{D,t}$ and $I_{F,t}$ represent the investment by using home and foreign goods respectively. The shares of ν_I in the investment represent the share of domestic goods and import goods in the economy. The parameter of μ_I represents the elasticity of substitution between domestic goods and import goods. The corresponding price index is denoted by:

$$P_t^I = \left[\nu_I\, P_{D,t}^I{}^{1-\mu_I} + (1-\nu_I)\, P_{F,t}^I{}^{1-\mu_I}\right]^{\frac{1}{1-\mu_I}} \tag{5.41}$$

where $P_{D,t}^I$ and $P_{F,t}^I$ are the price of domestic goods and import goods in the home country respectively.

Maximising total investment in equation (5.40) with regard to a given aggregate investment of $P_t^I\, I_t = P_{D,t}^I\, I_{D,t} + P_{F,t}^I\, I_{F_t}$ results:

$$I_{Dt} = \nu_I\left(\frac{P_{D,t}}{P_t^I}\right)^{-\mu_I} I_t \tag{5.42}$$

$$I_{Ft} = (1-\nu_I)\left(\frac{P_{F,t}}{P_t^I}\right)^{-\mu_I} I_t \tag{5.43}$$

$$\frac{P_{D,t}}{P_t^I} = \left(\nu_I + (1-\nu_I)\, ToT_t{}^{1-\mu_I}\right)^{-\frac{1}{1-\mu_I}} \tag{5.44}$$

$$\frac{P_{F,t}}{P_t^I} = \left(1-\nu_I+\nu_I\, ToT_t{}^{\mu_I-1}\right)^{-\frac{1}{1-\mu_I}} \tag{5.45}$$

$$\frac{P_t^I}{P_t} = \left(\frac{P_{D,t}}{P_t}\right) / \left(\frac{P_{D,t}}{P_t^I}\right) \tag{5.46}$$

5.3.3 Commercial Bank

Commercial bank supplies loan, l_t, to intermediary good producer and capital good producer and collects deposit d_t from the household. To support its funding, the commercial bank can borrow from abroad,$L_{F,t}$, and from the central bank L_t^C.Therefore, the bank balance sheet in real terms is:

$$l_t + RR_t = d_t + \frac{\left(1+\pi_t^S\right)}{\left(1+\pi_t\right)} L_{F,t} + L_t^C \tag{5.47}$$

where RR_t is the reserve requirement that needs to be placed in the central bank and derived from:

$$RR_t = \rho_{RR}\, d_t \tag{5.48}$$

rr_t is the reserve requirement ratio which is determined by the central bank.

The cost of borrowing from the abroad is the foreign interest rate r_t^F and measured in the foreign currency terms. The cost of borrowing is a function of the foreign interest rate r_t^* and a premium, which can be written as:

$$1 + r_t^F = \left(1 + r_t^*\right)\left(1 + \Phi_t^F\right) \tag{5.49}$$

where Φ_t^F is the premium of borrowing which increases according to the amount borrowed:

$$\Phi_t^F = \frac{\theta_F}{2}\, l_t^F \tag{5.50}$$

Total lending to the intermediate good producer and capital good producer will be:

$$l_t = \kappa_W\, w_t\, N_t + I_t \tag{5.51}$$

The aggregate supply of loan is a basket of differentiated loan each supplied by a bank i with constant elasticity of substitution $\epsilon_L > 1$:

$$l_t = \left[\int_0^1 \left(l_t^i\right)^{\frac{1+\epsilon_L}{\epsilon_L}} di\right]^{\frac{\epsilon_L}{1+\epsilon_L}} \tag{5.52}$$

Whereas, the aggregate supply of deposits by the household is a basket of differentiated deposits, each supplied to a bank i with a constant elasticity of substitution $\epsilon_D > 1$

between different type of deposits:

$$d_t = \left[\int_0^1 \left(d_t^i\right)^{\frac{1+\epsilon_D}{\epsilon_D}} di\right]^{\frac{\epsilon_D}{1+\epsilon_D}} \tag{5.53}$$

The commercial banks chooses the level of loan's interest rate r_t^L, the level of deposit's interest rate r_t^D and foreign loan L_t^F to maximise the value of the profit transfer to the household. The profit maximisation problem of the commercial bank i is:

$$\max_{r_t^D, r_t^L, L_t^F} \left(1+r_t^L\right) l_t^w(i) + q_t(i)(1+r_t^L) I_t^I(i) + (1-q_t(i))\gamma(i) P_t^H \bar{H} - \\ \left(1+r_t^D\right) d_t(i) - \left(1+r_t^C\right) L_t^C - \mathbb{E}_t(1+\pi_{t+1}^S)\left(1+r_t^F\right) L_t^F$$

subject to equation (5.47) to (5.53).

First order condition of the bank's problem can be written as:

$$1 + r_t^D = \frac{\epsilon_D}{1+\epsilon_D}\left(1-\rho_{RR}\right)\left(1+r_t^C\right) \tag{5.54}$$

$$1 + r_t^L = \frac{\epsilon_L}{q_t\left(\epsilon_L - 1\right)}\left(1+r_t^C\right) \tag{5.55}$$

$$l_t^F = \frac{1 + r_t^C - \left(1+r_t^*\right)\left(1+\pi_{t+1}^S\right)}{\phi_0^F\left(1+r_t^*\right)\left(1+\pi_{t+1}^S\right)} \tag{5.56}$$

Following Agénor et al. (2014, 2018)'s approach, the repayment probability depends positively on the effective collateral-capital good producer loan ratio and the cyclical position of the economy:

$$q_t = \left(\frac{\gamma\, P_t^h\, \bar{h}}{I_t}\right)^{\varphi_1}\left(\frac{Y_t}{\bar{Y}}\right)^{\varphi_2} \tag{5.57}$$

Borrowing from the central bank is determined residually from the balance sheet constraint in equation (5.47):

$$l_t^C = l_t - l_t^F\left(\frac{1+\pi_t^S}{1+\pi_t}\right) - \left(1-\rho_{RR}\right) d_t \tag{5.58}$$

5.3.4 External Demand

As in a standard literature of small-open economy,the foreign aggregate consumption and investment, denoted by C_t^* and I_t^* respectively, is taken as exogenous. The exogenous approach is taken because we focus on emerging markets, which have the same features

as the small open economy. The demand of the export of consumption goods from the foreign can be formulated as:

$$C^*_{D,t} = (1-\nu^*_C)\left(\frac{P^*_{D,t}}{P^*_t}\right)^{-\mu^*_C} C^*_t$$

The real exchange rate of consumption goods is defined as the relative aggregate consumption price $s_t \equiv \frac{P^*_t S_t}{P_t}$. We then rewrite the demand for exports as

$$C^*_{D,t} = (1-\nu^*_C)\left(\frac{P^*_{D,t}}{P^*_t\, s_t}\right)^{-\mu^*_C} C^*_t \tag{5.59}$$

where $P^*_{D,t}$ and P^*_t indicate the price of domestic goods and foreign aggregate consumption in the foreign currency. In addition, we assume that the Law of One Price for differentiated goods in the traded sector holds. Therefore, the exchange rate will have perfect pass-through to export prices and the price of consumption goods will be $P_t = S_t P^*_{D,t}$. Similarly, it is assumed that the home country has a perfect exchange rate pass-through for imports which implies $P^*_t = P_{F,t}$, $S_t P^*_t = P_{F,t}$, thus $s_t = \frac{P_{F,t}}{P_t}$. We then write

$$C^*_{D,t} = (1-\nu^*_C)\left(\frac{1}{ToT_t}\right)^{-\mu_C} C^*_t \tag{5.60}$$

We define the real exchange rate in investment as the relative aggregate investment price $s^I_t \equiv \frac{P^{I*}_t S_t}{P^I_t}$. Subsequently, the demand for the export of investment goods is adjusted as:

$$I^*_{D,t} = (1-\nu^*_I)\left(\frac{P^{I*}_{D,t}}{P^{I*}_t}\right)^{-\mu^*_I} I^*_t$$

we then define the real exchange rate for investment as the relative aggregate investment price $s^I_t \equiv \frac{P^{I*}_t S_t}{P^I_t}$. Then, we adjust the demand for exported investment goods to be

$$I^*_{D,t} = (1-\nu^*_I)\left(\frac{P^{I*}_{D,t}}{P^{I*}_t\, s_t}\right)^{-\mu^*_I} I^*_t$$

where $P^{I*}_{D,t}$ and P^{I*}_t indicate the prices of domestic goods and foreign aggregate investment in the foreign currency. Similar to consumption, we continue to assume that the law of one price for differentiated goods in the investment goods holds. Therefore, the price of

investment goods will be $P_t^{I*} = S_t P_{D,t}^{I*}$. The foreign country is also assumed to have a perfect exchange rate pass-through for imports, which implies $P_t^{I*} = P_{F,t}^{I*}$, $S_t P_t^{I*} = P_{F,t}^{I}$, thus $s_t = \frac{P_{F,t}^{I}}{P_t^{I}}$. The foreign demand for exported investment goods can be reformulated as follows:

$$I_{D,t}^{*} = (1 - \nu_I^{*}) \left(\frac{1}{ToT_t} \right)^{-\mu_I} I_t^{*} \tag{5.61}$$

Therefore, the total exports are given by:

$$EX_t = C_{D,t}^{*} + I_{D,t}^{*} \tag{5.62}$$

5.3.5 Central Bank

The central bank is responsible to set the monetary policy. The nominal interest rate r_t is the monetary policy variable given by a standard Taylor-type rule (Taylor, 1993), which we incorporate a response to an exchange rate depreciation term (Kolasa and Lombardo, 2014):

$$\begin{aligned} r_t = &(1 - \rho_M)\ \bar{r} + \rho_M\, r_{t-1} + \\ &(1 - \rho_M)\ \left[\phi_\pi\ (\pi_t - \bar{\pi}) + \phi_Y\ (\ln(Y_t) - \ln(Y_{t-1})) + \phi_{\pi^s}\ \left(\pi_t^S - \bar{\pi}^S \right) \right] + \varepsilon_{M,t} \end{aligned} \tag{5.63}$$

In order to implement the monetary policy, the central bank is operating a standing facility containing the lending facility. We construct the interest rate of this lending facility, r_t^C, to be set based on the policy rate:

$$1 + r_t^C = (1 + r_t)\ \left(1 + \Phi_t^C \right) \tag{5.64}$$

where Φ_t^C is the premium of the lending facility. We view this construction reflects the practical application where the central bank, such as Indonesian central bank, conducts its monetary operation both in the standing facility and open market operations[3]. The lending facility usually has premium which is a spread over the base policy rate. In this model, this premium is determined endogenously and can be written as:

$$1 + \Phi_t^C = \theta_C\, \frac{l_t^C}{d_t} \tag{5.65}$$

[3]Detail on Bank Indonesia's monetary operation can be found at
`https://www.bi.go.id/en/moneter/operasi/penjelasan/Contents/Default.aspx`

In addition to interest rate operation, the central bank also engages in the foreign exchange (FX) intervention to smooth the exchange rate. This FX intervention is operated through the buying and selling of FX reserves (FX_t) in the central bank, which can be described as:

$$FX_t = \left(1+\pi_t^S\right)^{-\epsilon_{fx,1}} \; {FX_{t-1}}^{\epsilon_{fx,2}} \left[\phi_{FX} \left(\frac{P_{F,t}}{P_t} C_{F,t} + \frac{P_{F,t}}{P_t^I} I_{F,t}\right)\right]^{1-\epsilon_{fx,2}} \exp\left(\varepsilon_{FX,t}\right) \tag{5.66}$$

In conducting the FX intervention, the central bank maintains some limitation according to the total import which is reflected in $\left[\phi_{FX} \left(\frac{P_{F,t}}{P_t} C_{F,t} + \frac{P_{F,t}}{P_t^I} I_{F,t}\right)\right]^{1-\epsilon_{fx,2}}$.

To sterilise this FX intervention, the central bank issues bonds (B_t^C) according to:

$$B_t^C = \frac{B_{t-1}^C}{1+\pi_t} - \kappa_F \left(FX_t - FX_{t-1}\right) \left(\frac{1+\pi_t^S}{1+\pi_t}\right) \tag{5.67}$$

with $\kappa_F \in [0,1]$ reflects the sterilisation coefficient. Whereas, $\kappa_F = 1$ means that the FX intervention is fully sterilised.

We assume that all commercial banks' loans to the firms will be disbursed in the form of cash and therefore, we then define $m_t = m_t^p + l_t$ to be the money supply, which evolves according to:

$$\begin{aligned} m_t = \frac{m_{t-1}}{1+\pi_t} + \left(1-\kappa_F\right) \left(FX_t - FX_{t-1}\right) \left(\frac{1+\pi_t^S}{1+\pi_t}\right) + \\ l_t^C - \frac{l_{t-1}^C}{1+\pi_t} - \left(RR_t - \frac{RR_{t-1}}{1+\pi_t}\right) \end{aligned} \tag{5.68}$$

This paper introduces the macroprudential policy with the instrument of the countercyclical reserve requirement which imposed by the central bank on the commercial bank. As highlighted in Federico et al. (2014), Gray (2011) and Obrien (2007), many emerging markets implement multiple reserve requirements. The countercyclical reserve requirement acts as a time-varying component to the primary reserve requirement, which is applied the same measure throughout the time. The countercyclical reserve requirement is modelled to be a measure that depends on a ratio of loan to deposit (LDR) in the commercial bank that reflects the banking intermediation which is the simplification of macroprudential intermediary ratio setting of Bank Indonesia. However, our approach differs to Satria et al. (2016) where the LDR has been set to have an upper limit and lower limit. For simplification, we assume that the central bank will only react to the

LDR. This can be written as:

$$rr_t = \rho_{rr,1} + \rho_{rr,2} \left(\frac{l_t}{Y_t} \right) + \varepsilon_{RR,t} \tag{5.69}$$

where $\rho_{rr,1}$ is the primary reserve requirement and $\rho_{rr,2}$ is the secondary reserve requirement and $\varepsilon_{RR,t}$ is the reserve requirement shock.

Finally, the central bank's balance sheet can be defined as:

$$nw_t = l_t^C + \frac{1+\pi_t^S}{1+\pi_t} FX_t + B_t^C - m_t - RR_t \tag{5.70}$$

with NW_t is the central bank's net wealth.

5.3.6 Government

In this model set up, the government consumes a portion of the final goods and its spending, G_t, follows an exogenous process:

$$\ln G_t = \rho_G \ln \bar{G} + (1-\rho_G) \ln G_{t-1} + \varepsilon_{Gt} \tag{5.71}$$

The government then generates the lumpsum tax, T_t, and issues one time period bond, B_t, to finance its spending. We assume that all government bonds will be issued domestically and in domestic currency. Beside levying tax and issuing bond, the government also receives revenue from the central bank's interest income that comes from the foreign exchange reserves and loan to the commercial bank. In addition, the government needs to pay the interest for its bond to the bondholder. The government budget constraint is defined as:

$$T_t = G_t + B_t - B_{t-1} \frac{1+r_{t-1}}{1+\pi_t} - l_{t-1}^C \left(\frac{r_{t-1}}{1+\pi_t} \right) - FX_{t-1} r_{t-1}^* \frac{1+\pi_t^S}{1+\pi_t} \tag{5.72}$$

where B_t is the stock of government bond which is the total of private-holding bond ($B_{H,t}$) and sterilisation bond (B_t^C)which can be written as:

$$B_t = B_{H,t} + B_t^C \tag{5.73}$$

In this paper the government is maintaining the tax revenue to be constant and the

government will adjust their bond to cover the spending.

5.3.7 Equilibrium and Market Clearing

A resource constraint implies:

$$Y_t = C_t + I_t + G_t + EX_t - IM_t \tag{5.74}$$

where import, IM_t, can be written as:

$$IM_t = C_{F,t} + I_{F,t} \tag{5.75}$$

Trade balance, TB_t, can be formulated as:

$$TB_t = \frac{P_{D,t}}{P_t} C^*_{D,t} + \frac{P_{D,t}}{P^I_t} I^*_{D,t} - \frac{P_{F,t}}{P_t} C_{F,t} - \frac{P_{F,t}}{P^I_t} I_{F,t} \tag{5.76}$$

The stock of foreign bonds held by households in home country consumption units ($B_{F,t}$) accumulates according to:

$$B^*_t = TB_t + \left(1 + i^*_{t-1}\right) \Phi^B_{t-1} B^*_{t-1} \frac{1 + \pi^S_t}{1 + \pi_t} - R_t \frac{1 + \pi^S_t}{1 + \pi_t} \left(1 + i^*_t\right) + R_{t-1} \left(1 + i^*_{t-1}\right) \frac{1 + \pi^S_t}{1 + \pi_t} \tag{5.77}$$

Then the price inflation of the total consumption goods (π_t) can written as:

$$1 + \pi_t = \left[\nu_C \left(1 + \pi^D_t\right)^{1-\mu_C} + (1 - \nu_C) \left(1 + \pi^F_t\right)^{1-\mu_C}\right]^{\frac{1}{1-\mu_C}} \tag{5.78}$$

While the price inflation of imported consumption goods (π^F_t) is given by:

$$1 + \pi^F_t = \left(1 + \pi^S_t\right) \left(1 + \pi^*_t\right) \tag{5.79}$$

5.3.8 Shock Processes

The structural shock processes in log-linearised form are assumed to follow AR(1):

$$\ln\left(A_t\right) = \rho_A \ln\left(A_{t-1}\right) + \varepsilon_{a,t} \tag{5.80}$$

$$\ln\left(C_t^*\right) = \left(1-\rho_C\right)\,\ln\left(\bar{C^*}\right) + \rho_C\,\ln\left(C_{t-1}^*\right) + \varepsilon_{C,t} \tag{5.81}$$

$$\ln\left(I_t^*\right) = \left(1-\rho_I\right)\ln\,\left(\bar{I^*}\right) + \rho_I\,\ln\left(I_{t-1}^*\right) + \varepsilon_{I,t} \tag{5.82}$$

$$r_t^* = \left(1-\rho_{r^*}\right)\,\bar{r^*} + \rho_{r^*}\,r_{t-1}^* + \varepsilon_{r^*,t} \tag{5.83}$$

$$\pi_t^* = \left(1-\rho_\pi\right)\,\bar{\pi^*} + \rho_\pi\,\pi_{t-1}^* + \varepsilon_{\pi^*,t} \tag{5.84}$$

Variables without subscription denote the steady state value of the variable.

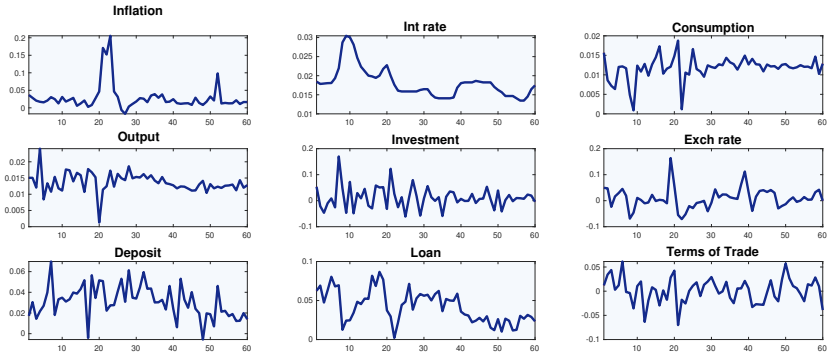
5.4 Empirical Analysis and Result

5.4.1 Data

Following our model construction, we use the Bayesian techniques to estimate the model's parameters. We employ quarterly data of Indonesia from 2001Q1 to 2018Q4. We take our sample after the Asian Financial crisis. We use output growth, consumption growth, investment growth, and domestic inflation, all taken from the Indonesian Statistics Agency (BPS). We also use policy rate, exchange rate growth, commercial bank's deposit and commercial bank's loan from the central bank (Bank Indonesia) and terms of trade growth from Thomson-Reuters.

The output, consumption, investment, commercial bank's deposit and commercial bank's loan are in real terms. Whereas, the policy rate and exchange rate are in nominal terms. The exchange rate uses the USD/IDR exchange rate. Domestic inflation uses the CPI index with 2012 base year. Terms of trade use the index of export and import prices that are constructed by Thomson-Reuters. Figure 1 illustrates the historical and smoothed variables.

Figure 5.1: Historical and Smoothed variables



In addition, we construct measurement equations to incorporate the measurement error of our observable variables. Table 5.1 describes our measurement approach.

Table 5.1: Measurement Equations

Observable	Model variables
Output growth	$\Delta \ln Y_t^{obs} = \Delta\left(\ln Y_t - \ln \bar{Y}\right) + \varepsilon_{Y,t}$
Consumption growth	$\Delta \ln C_t^{obs} = \Delta\left(\ln C_t - \ln \bar{C}\right) + \varepsilon_{C,t}$
Investment growth	$\Delta \ln I_t^{obs} = \Delta\left(\ln I_t - \ln \bar{I}\right) + \varepsilon_{I,t}$
CPI Inflation	$\pi_t^{obs} = \pi_t - \bar{\pi}$
Interest rate	$r_t^{obs} = r_t - \bar{r}$
Change in the exchange rate	$\pi_t^{S,obs} = \pi_t^S - \bar{\pi}^s$
Loan growth	$\Delta \ln l_t^{obs} = \Delta\left(\ln l_t - \ln \bar{l}\right) + \varepsilon_{l,t}$
Deposit growth	$\Delta \ln d_t^{obs} = \Delta\left(\ln d_t - \ln \bar{d}\right) + \varepsilon_{d,t}$
Terms of trade growth	$\Delta \ln ToT_{obs,t} = \Delta\left(\ln ToT_t - \ln \bar{ToT}\right) + \varepsilon_{y,t}$

5.4.2 Parameter Calibration

To estimate the model, we calibrate some parameters based on previous studies so that they are consistent with the mean values in the data. The discount factor β is set at 0.99, which gives an annual steady-state real interest rate of around 4%, in line with many studies (e.g. Smets and Wouters (2007)). The capital share α is set at 0.33 according to Harmanta et al. (2014). Following Schmitt-Grohé and Uribe (2003), we also set the elasticity of the risk premium to the level of debt θ_B at 0.001. Table 5.2 lists the parameters' calibrated values.

Table 5.2: the Parameter Value of Calibration Result

Parameter	Value	Description
α	0.330	exponent of capital in the production function
β	0.990	discount rate
ψ_X	0.020	liquidity utility parameter
ψ_H	0.020	housing utility parameter
ω	0.350	money and deposit preference parameter
θ_B	0.001	bond risk premium parameter
η	1.000	Frisch elasticity of labour supply
ϵ_p	10.000	the elasticity of domestic goods demand
ϵ_w	10.000	the elasticity of wage demand
ν_C^*	0.700	foreign consumption degree of openness
ν_I^*	0.700	foreign investment degree of openness
μ_{C^*}	1.500	the elasticity subs of domestic & foreign cons goods in foreign countries
μ_{I^*}	1.500	the elasticity subs of domestic & foreign inv goods in foreign countries
ϕ_K	14.000	investment adjustment cost parameter
δ	0.020	capital depreciation
ρ_{RR}	0.050	reserve requirement
$\phi_F X$	4.000	multiplication of import value for self insurance

5.4.3 Analysis of the results

We estimate the posterior mode by numerically maximising the log posterior density function; a combination of prior information and the likelihood of the data. Then, we estimate the full posterior distribution using the Metropolis-Hastings algorithm. We begin with our prior and posterior results, which are displayed in Table 5.3, and shocks that are presented in Table 5.4.

Table 5.3: Estimation Result: Parameters

Parameters	prior mean	post. mean	90% HPD interval		prior	pstdev	Description
ψ_N	7.055	7.0532	6.9719	7.1383	norm	0.05	labor disutility parameter
θ_C	0.046	0.0469	0.0304	0.0624	beta	0.01	Central bank lending premium parameter
χ	0.5	0.4922	0.3205	0.6606	beta	0.1	internal habit parameter
ϕ_w	0.7	0.6414	0.4726	0.8131	beta	0.1	probability of wage adjustment
ϕ_p	0.7	0.6573	0.5403	0.7881	beta	0.1	probability of price adjustment
ζ_w	0.7	0.6869	0.5242	0.858	beta	0.1	wage persistence
ζ_p	0.7	0.6149	0.4288	0.8037	beta	0.1	price persistence
ν_C	0.5	0.6089	0.5024	0.7183	beta	0.1	consumption degree of openness
ν_I	0.5	0.5327	0.3628	0.6897	beta	0.1	investment degree of openness
μ_C	1.5	1.4774	1.1592	1.7966	norm	0.2	the elasticity subs of domestic & foreign cons goods in domestic country
μ_I	1.5	1.4961	1.1656	1.8244	norm	0.2	the elasticity subs of domestic & foreign inv goods in domestic country
φ_1	0.1	0.1062	-0.0558	0.2689	norm	0.1	Elasticity of repayment probability for collateral
φ_2	0.3	0.2275	0.095	0.3579	beta	0.1	Elasticity of repayment probability for cyclical output
ϵ_D	3	2.9769	2.8077	3.1416	norm	0.1	the elasticity of deposit substitution
ϵ_L	4.5	4.5006	4.3383	4.6656	norm	0.1	the elasticity of loan substitution
$\epsilon_{fx,1}$	0.5	0.4992	0.3364	0.6657	beta	0.1	exchange rate smoothing for foreign reserves rule
$\epsilon_{fx,2}$	0	0.0001	-0.0804	0.0818	norm	0.05	persistence for foreign reserves rule
κ_F	0.8	0.7995	0.6399	0.9656	norm	0.1	sterilisation coefficient
κ_W	0.8	0.8078	0.6436	0.9665	norm	0.1	proportion of working capital loan
γ	0.2	0.214	0.0561	0.3677	norm	0.1	proportion of collateral
θ_F	0.35	0.513	0.3609	0.6616	beta	0.1	foreign loan risk premium parameter
ρ_1	0.1	0.1427	0.0407	0.2386	beta	0.05	autocorrelation reserve requirement
ρ_A	0.7	0.5504	0.3927	0.7101	beta	0.1	autocorrelation technology shock
ρ_G	0.5	0.5019	0.337	0.6673	beta	0.1	autocorrelation goverment spending shock
ρ_M	0.5	0.557	0.4311	0.6963	beta	0.1	autocorrelation monetary policy shock
ϕ_π	1.75	1.841	1.4445	2.2445	norm	0.25	Taylor rule coeff of inflation
ϕ_Y	0.2	0.2145	0.1303	0.2944	norm	0.05	Taylor rule coeff of output gap
ϕ_{π^S}	0.2	0.2165	0.1388	0.2978	norm	0.05	Taylor rule coeff of exchange rate
ρ_C	0.5	0.4986	0.3386	0.661	beta	0.1	autocorrelation foreign consumption shock
ρ_I	0.5	0.5003	0.3327	0.6623	beta	0.1	autocorrelation foreign investment shock
ρ_π	0.5	0.1758	0.1098	0.2392	beta	0.1	autocorrelation foreign inflation shock
ρ_{r^*}	0.5	0.5029	0.338	0.6643	beta	0.1	autocorrelation foreign int rate shock

Table 5.4: Estimation Result: Shocks

shocks	prior mean	post. mean	90% HPD interval		prior	pstdev	description
ε_a	0.1	0.024	0.0173	0.0303	invg	2	technology shock
ε_M	0.1	0.0162	0.0127	0.0197	invg	2	monetary policy shock
ε_G	0.1	0.0725	0.0244	0.1261	invg	2	Government spending shock
ε_C	0.1	0.0377	0.0226	0.0526	invg	2	foreign consumption shock
ε_I	0.1	0.064	0.0243	0.1067	invg	2	foreign investment shock
ε_{r^*}	0.1	0.0797	0.0252	0.1449	invg	2	foreign int rate shock
ε_{π^*}	0.1	0.0301	0.0239	0.0361	invg	2	foreign inflation shock
ε_{ϕ^*}	0.1	0.0158	0.0125	0.0189	invg	2	foreign risk premium shock
ε_{FX}	0.1	0.0833	0.0227	0.1512	invg	2	FX intervention shock
ε_{RR}	0.1	0.0199	0.0151	0.0246	invg	2	RR shock
$m\varepsilon_Y$	0.1	0.0269	0.0203	0.0334	invg	2	Output measurement error
$m\varepsilon_C$	0.1	0.0192	0.0154	0.0232	invg	2	consumption measurement error
$m\varepsilon_I$	0.1	0.0424	0.0319	0.0525	invg	2	investment measurement error
$m\varepsilon_d$	0.1	0.0234	0.0173	0.0297	invg	2	deposit measurement error
$m\varepsilon_L$	0.1	0.0216	0.0164	0.0267	invg	2	loan measurement error
$m\varepsilon_{ToT}$	0.1	0.0239	0.0183	0.0293	invg	2	terms of trade measurement error

The findings in Table 5.3 indicate that all of the parameter values are slightly lower than their priors. Our results indicate that the inflation coefficient (ϕ_π) in the Taylor rule equation is higher than its prior. We interpret this as the commitment of the Central Bank of Indonesia – as an ITF central bank – to assign policy rates to focus more on price stability rather than defending exchange rate. Therefore, in the context of Indonesia, we fail to agree with Federico et al. (2014) who argue that policy rate is being utilised to defend currency.

This interpretation is supported by the results of the standard deviation of shocks in Table 5.4. Although slightly lower than the prior, the standard deviation of FX intervention shock is relatively higher than others. We interpret this as the Central Bank of Indonesia using this instrument to stabilise exchange rate. This can also be justified by the period of the data that we use, which is 2005-2018. During this period, the global environment has put great pressure on the emerging markets' exchange rate, particularly during the global financial crisis in 2007-2009 and in the aftermath of the crisis.

Another interesting finding in Table 5.3 is that the parameter foreign loan risk premium (θ_F) is higher than its prior. This indicates that the cost of a domestic bank to acquire foreign loan is more expensive than previously expected. By highlighting the existence of a cross-border bank portfolio channel as suggested by Correa et al. (2018), domestic banks may expect an increase in the cost of foreign funding when applied a tighter monetary condition in source countries and subject to a funding relocation to other countries. This may increase the cost of their lending and, to some extent, cause a contraction in lending.

5.4.3.1 Impulse Response Analysis

We now turn to the impulse responses analysis in an attempt to explore the transmission mechanism in our model. We focus our discussion on describing the impacts of positive external shocks, particularly on foreign consumption, foreign interest rate and risk premium. These shocks are portrayed in Figure 5.2 to Figure 5.4.

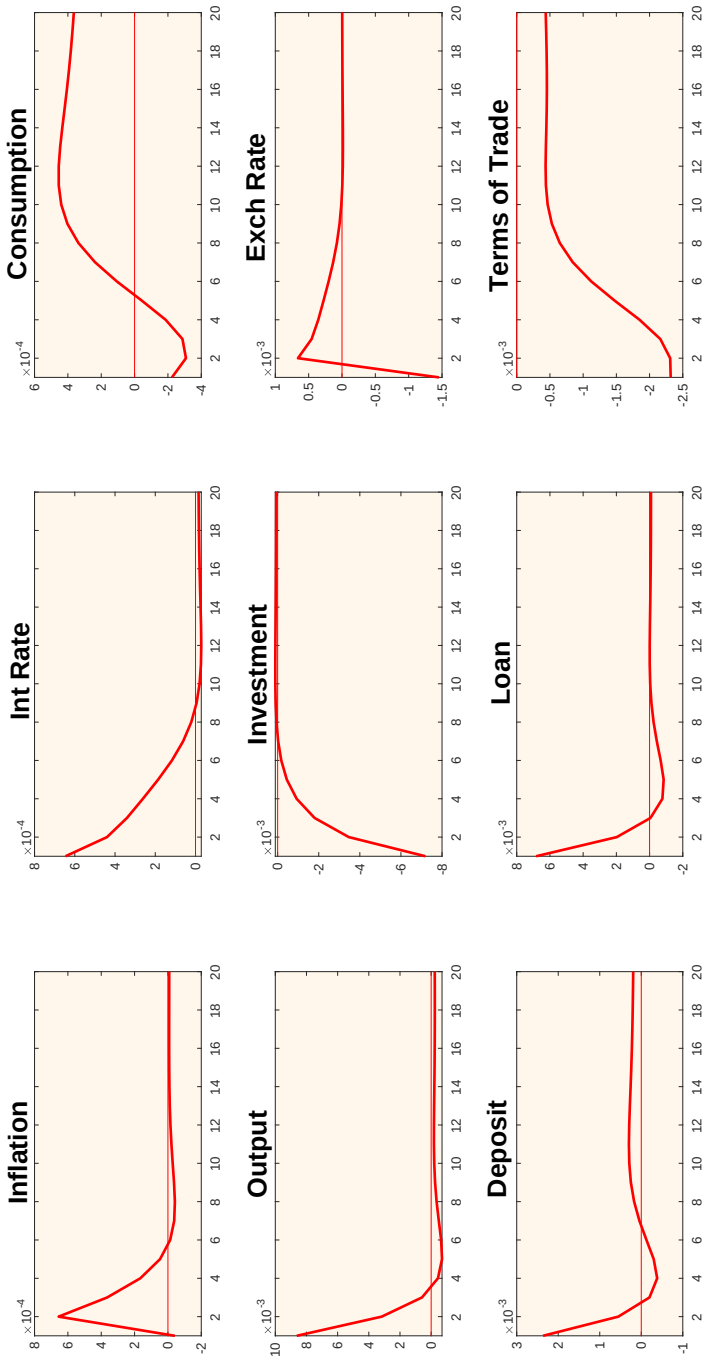


Figure 5.2: Impulse Response to Foreign Consumption Shock

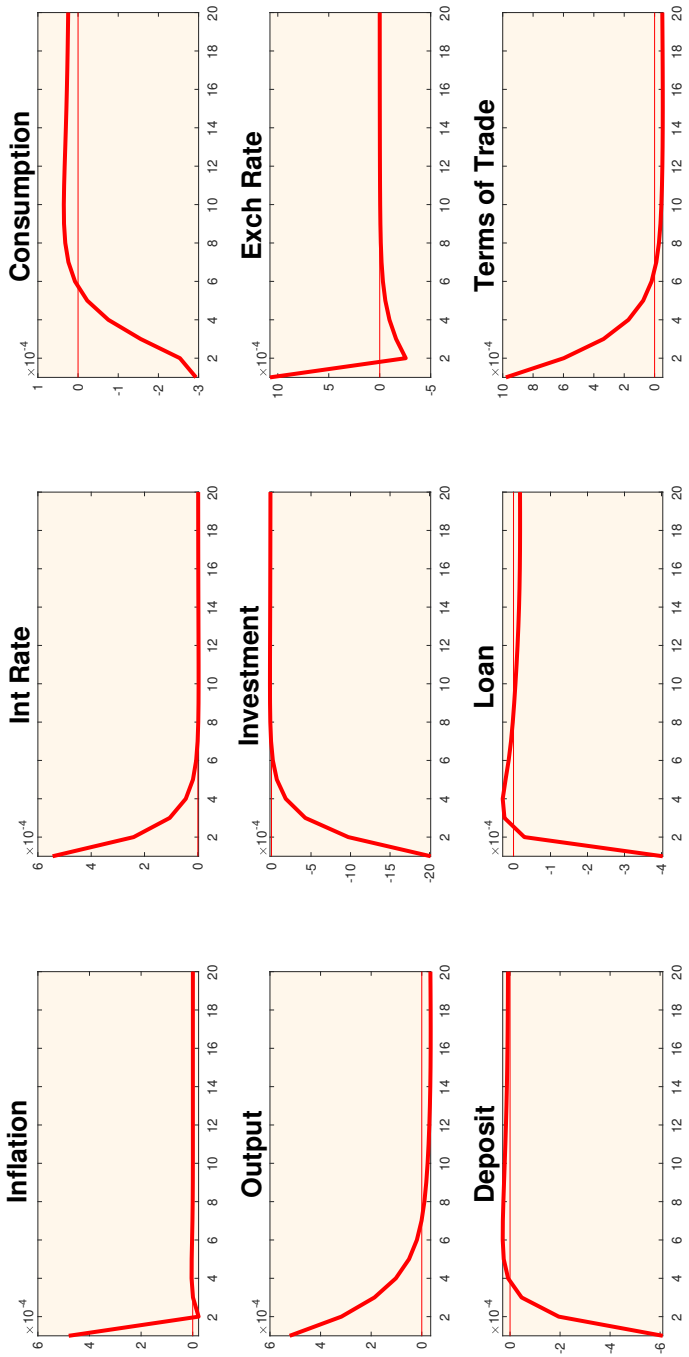


Figure 5.3: Impulse Response to Foreign Interest Rate Shock

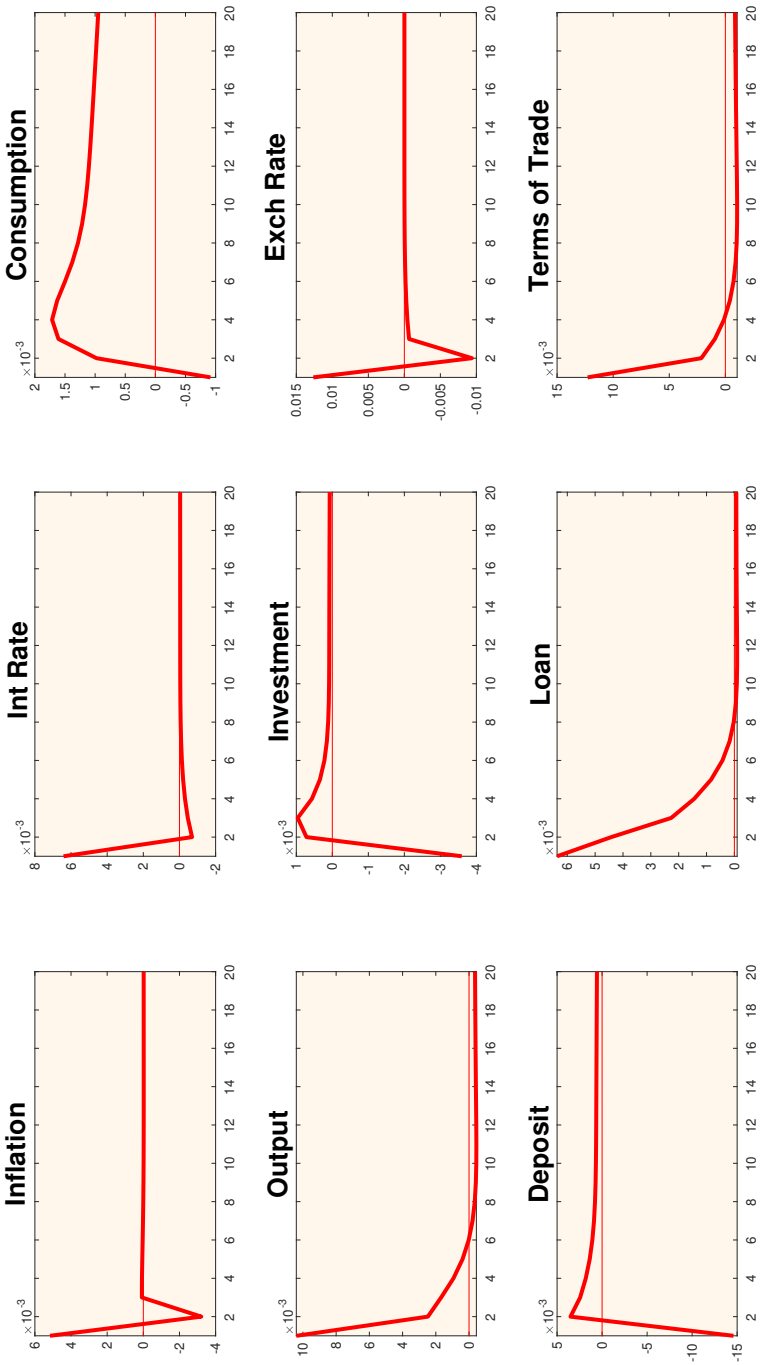


Figure 5.4: Impulse Response to Risk Appetite Shock

From Figure 5.2, we observe that increasing foreign consumption raises the demand for export, which in turn increases the domestic price. The bank's loan also increases to facilitate the production. The bank's loan also increases to facilitate the production. The interest rate increases in response to inflation. As both inflation and interest rate increase, the incentive to consume declines which causes bank's deposit to move up.

Meanwhile, positive foreign interest rate shock in Figure 5.3 drives the portfolio rebalancing, as highlighted by Correa et al. (2018), which in turn decreases the supply of loan. Inflation expectations rise because foreign goods become more expensive and the source of funding becomes limited. This prompts the interest rate to increase and the exchange rate to depreciate (Warjiyo, 2014).

Here, we model risk appetite as an addition to risk premium. As explained by Cerutti et al. (2017), interest rate is not the only factor that triggers portfolio balance but also other factors such as the stock market's expectation of volatility (VIX), the TED spread which accounted to the risk appetite of the market participants. The risk appetite shock has the most significant impact on investment growth. An increase in the risk appetite, as displayed in Figure 5.4, causes the price to go up which in turn stifles investment.

5.4.3.2 Variance Decomposition

We also examine the variance decomposition of the observed variables. The results are as presented in Figure 5.5 below.

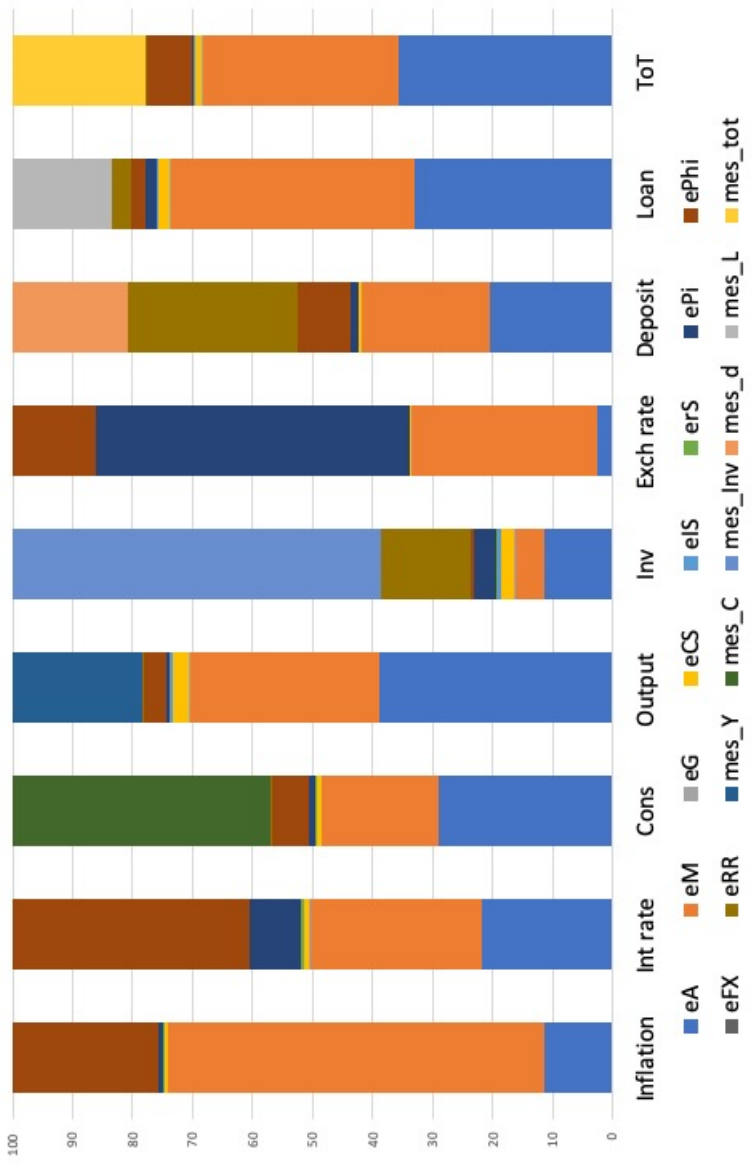


Figure 5.5: Variance Decomposition

Figure 5.5 5 indicates that inflation, interest rate and exchange rate are affected by the risk appetite shock (ePhi) in a relatively strong manner. A positive shock in risk appetite, which we interpret as market participants becoming more risk-averse and the cost of funds from abroad increase, which is followed by exchange rate increase, is expected to depreciate. This, in turn, increases the inflation expectation due to the increasing price of imported goods. Therefore, the interest rate is responding to the increasing inflation expectation.

We also observe that a shock on the counter-cyclical reserve requirement affects the bank's deposits and bank's loans. Increasing the 'secondary part' of the reserve requirement may render deposits unattractive as the price drops, thus affecting the loan supply. With a higher premium on funding from abroad, contraction in deposits may impinge on investment.

5.4.4 Model Comparison

To emphasise the importance of the interaction between monetary and macroprudential policies with the countercyclical reserve requirement instrument, we compare our model with other models which have no presence of the macroprudential instrument. In order to do that, we develop two modified models based on our current model and perform an experiment. First, we only use the monetary policy, which has the interest rule present or the full-pledge ITF and secondly, we incorporate the FX intervention in the first model. Other variables and equations remain the same as our current model. We then take these two modified models and compare them to our model. The impulse response of some selected variables is presented in Figure 5.6, 5.7 and 5.8. We focus our analysis on the impact of these selected variables on foreign consumption, foreign interest rate, and risk appetite shocks.

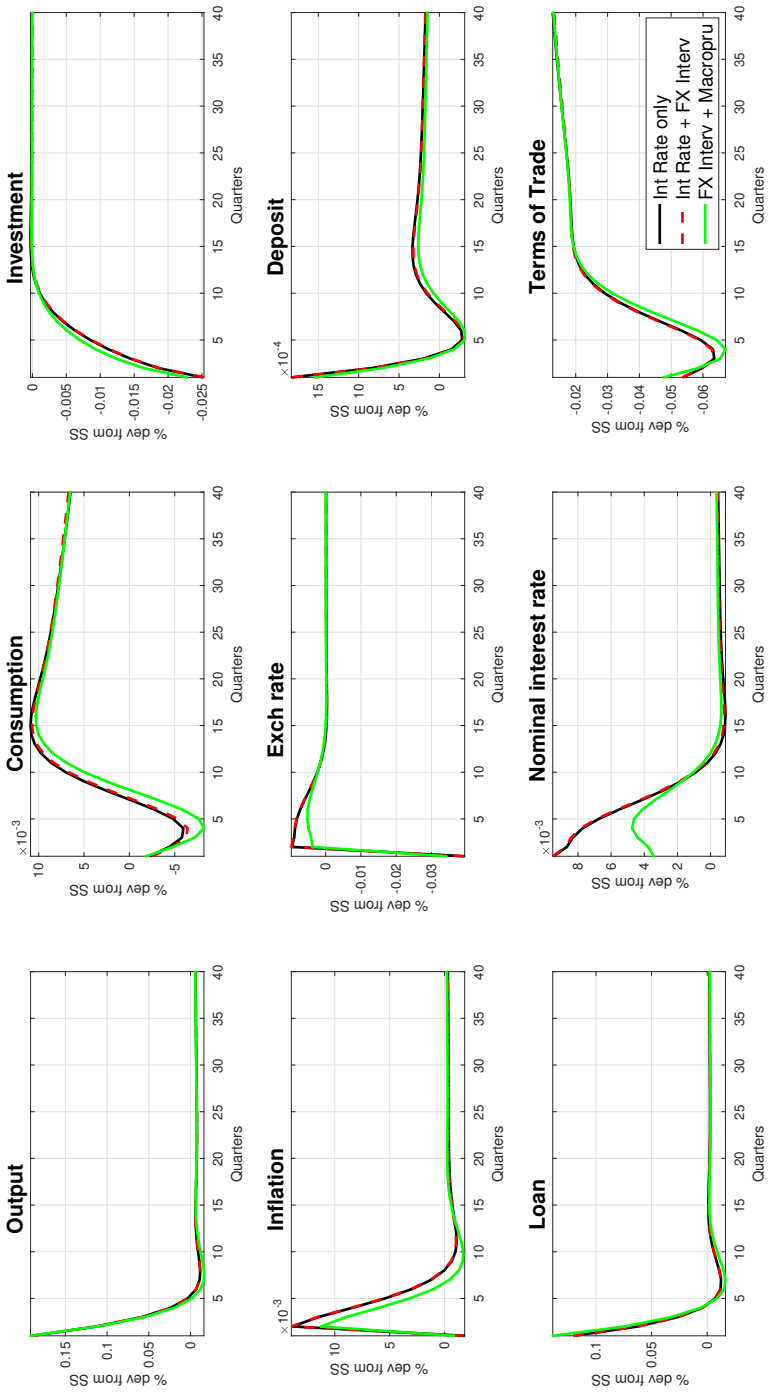


Figure 5.6: Impulse Response Comparison to Foreign Consumption Shock

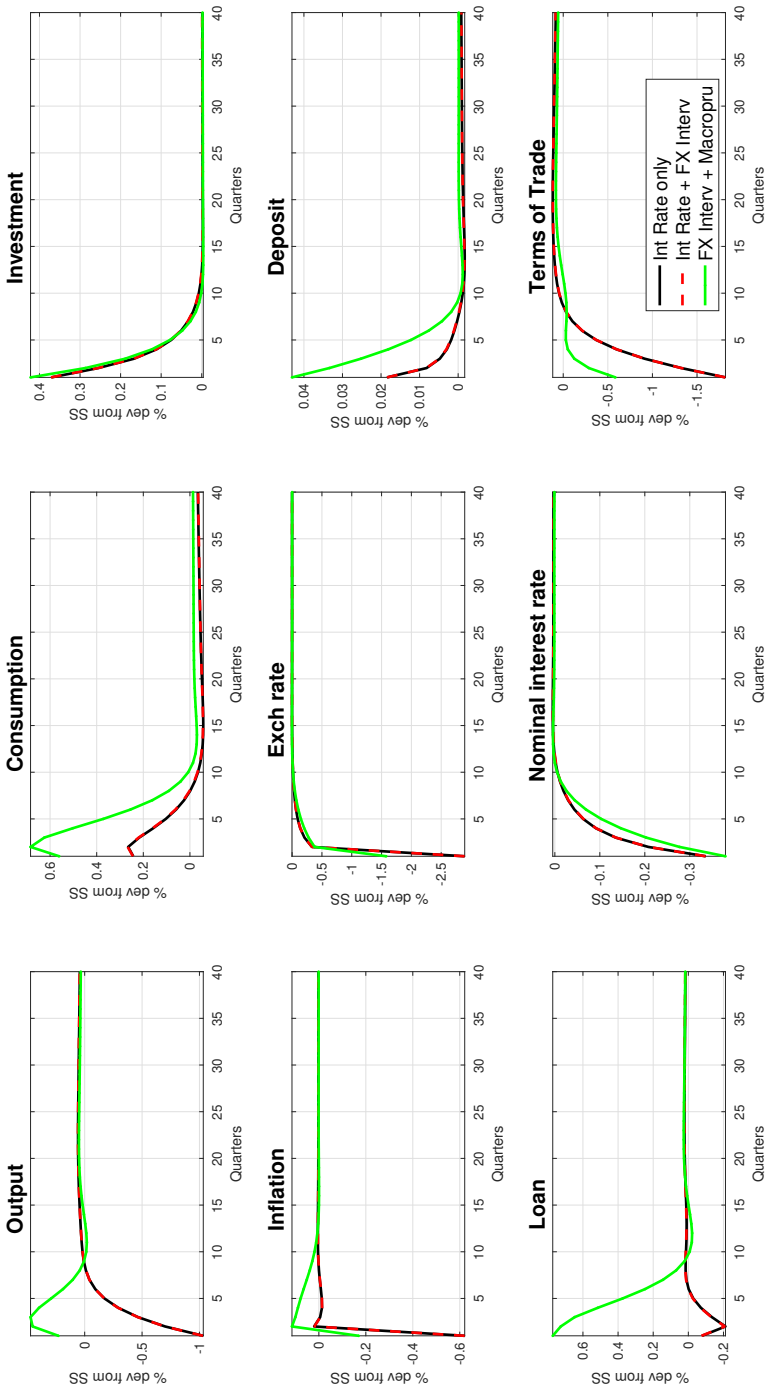


Figure 5.7: Impulse Response Comparison to Foreign Interest Rate Shock

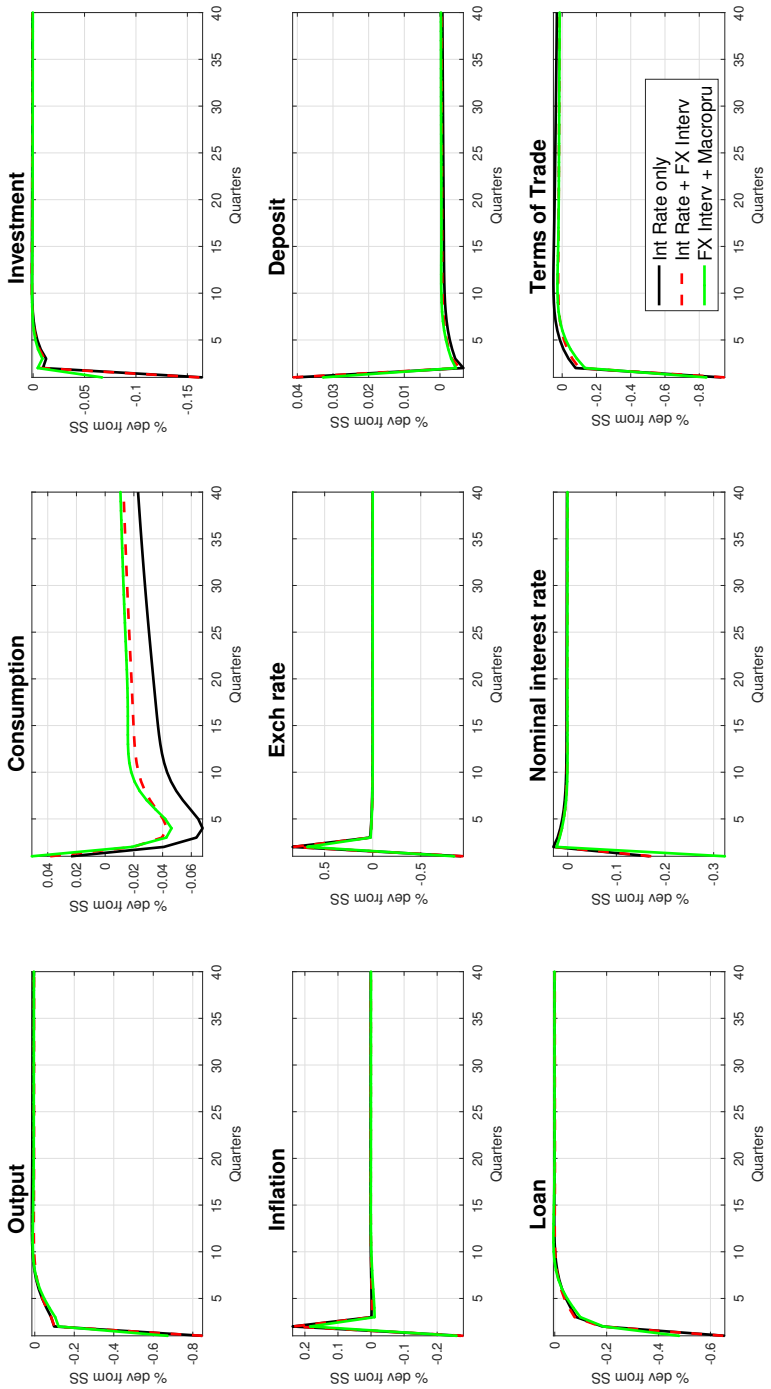


Figure 5.8: Impulse Response Comparison to Risk Appetite Shock

Figure 5.6 shows that the presence of macroprudential instrument in the form of a countercyclical reserve requirement linked to LDR helps reduce the degree of the nominal interest rate increasing during an expansion. Initial expansion in credit drives the reserve requirement rate to respond, which in turn leads to a drop in the deposits. Following a contraction on the deposit, the central bank lending rate facility also decreases and therefore, the magnitude of the interest rate increase is limited compared to the absence of a reserve requirement instrument. Under the foreign consumption shock, adding a reserve requirement to the FX intervention indicates a limited effect on output and inflation (Agénor et al., 2018).

However, the countercyclical reserve requirement helps increase the consumption and output during positive shock of foreign interest rate as presented in Figure 5.7. The foreign interest rate increase leads the exchange rate to appreciate and the terms of trade to fall. Subsequently, the import prices become cheaper and the consumption increases. By reducing the reserve requirement, banks may have an extra supply of loan, particularly when the bank may have an expensive premium borrowing from abroad. This additional supply of loan can be used to consume and increase the output.

During a risk appetite shock, which is shown in Figure 5.8, the reserve requirement helps prevent consumption from falling deeper. As loan falls, LDR decreases and cash expands more than when reserve requirement is applied. Given the expectation that inflation will increase, the household will have an incentive to consume. Different from (Loeffler, 2015), we find that the ability of the reserve requirement to influence exchange rate is limited during the episode of positive foreign interest rate and risk appetite shock. Combining reserve requirement with interest rate policy and FX intervention may not have a significant impact.

5.4.5 Policy Implication

Our findings, particularly during an episode of risk appetite shock, may have several implications for the central bank. Our estimations suggest that combined with FX Intervention, macroprudential policy that uses reserve requirement as one of the instruments helps stabilise the macroeconomy. During a period of increasing risk appetite episode, the cost of funds will be withdrawn and reallocated from domestic financial markets toward borrowers in safer countries, such as advanced economies or economies with an invest-

ment grade sovereign rating (Correa et al., 2018). As commonly observed in emerging markets, financial markets are less developed and the ability of banks to access different sources of funding may compel them to set up a sophisticated liquidity management. Moreover, our finding confirms that in the case of Indonesia, banks also cope with a higher premium when borrowing from abroad. During this period of pressure, lowering reserve requirements may be beneficial in order to provide additional liquidity.

In addition, the central bank needs to be cautious in using the reserve requirement instrument to influence some variables. Our findings highlight that, under the risk appetite shock, the reserve requirement may be inadequate to influence exchange rate. However, FX intervention may be able to perform this task. The presence of reserve requirement may support the macroeconomy and financial stabilisation by isolating the money supply from the FX intervention operations (Agénor et al., 2018). As previously discussed, managing reserve requirement during episodes of massive capital flows may affect liquidity and credit supply (Montoro and Moreno, 2011).

5.5 Conclusion and Recommendation

This study provides a comprehensive analysis of the use of reserve requirement by developing a small open economy DSGE model with the nominal rigidity in both wage and price. We complement the model with an interest rate policy based on the Taylor rule and FX intervention. We also add an imperfectly competitive banking sector into the model. Further, we estimate the model using the Bayesian techniques and data on Indonesia over the period of 2001Q2–2018Q4. We find that the counter-cyclical reserve requirements influence banks' deposits and loans. In addition to that, banks also encounter a higher premium when they seek funding from abroad. Therefore, a disruption in the deposit side may affect the loan supply.

We proceed by comparing the estimation results with a policy simulation based on two conditions: an interest rate policy that strictly follows the Taylor rule and an interest rate policy complemented by the FX intervention. Our analysis indicates that reserve requirement helps stabilise the economy by detaching the supply of money behaviour from the foreign exchange operations. This instrument helps maintain consumptions and outputs, particularly during a contraction period, by providing an additional supply of

loan.

These findings may be beneficial to policymakers, particularly in emerging markets where reserve requirement is still widely implemented. These policymakers also face a strong challenge from external shocks in order to stabilise the economy. Our results suggest that reserve requirement serves as a practical complementary for the interest rate policy and FX intervention when used to tackle these shocks. However, policymakers need to remain vigilant in implementing the reserve requirement to make a direct effect on exchange rate. Our results confirm that the use of this instrument, in addition to FX intervention, may not add any further impact to the exchange rate, compared to the use of interest rate and FX intervention without the reserve requirement.

Although this study provides interesting findings, further directions of future researches in this area is warranted. We assume that the working capital loan bears zero risks to the banks. It is thought-provoking to see whether this may apply in practice and whether different classes of risk assets may affect the effectiveness of the reserve requirement and FX intervention instruments in emerging markets. Secondly, it would be stimulating to see the impact of an active fiscal policy with the presence of both FX intervention and reserve requirement. A distortionary tax applied to the economy may affect the behaviour of economic agents. In addition, many emerging markets are also issuing government bonds in foreign currency denominations.

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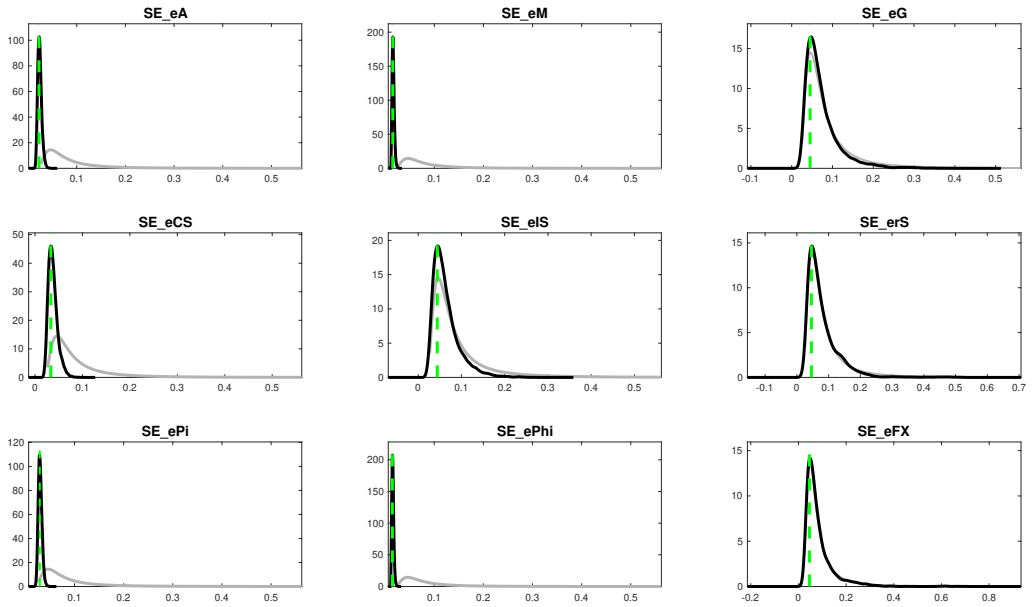
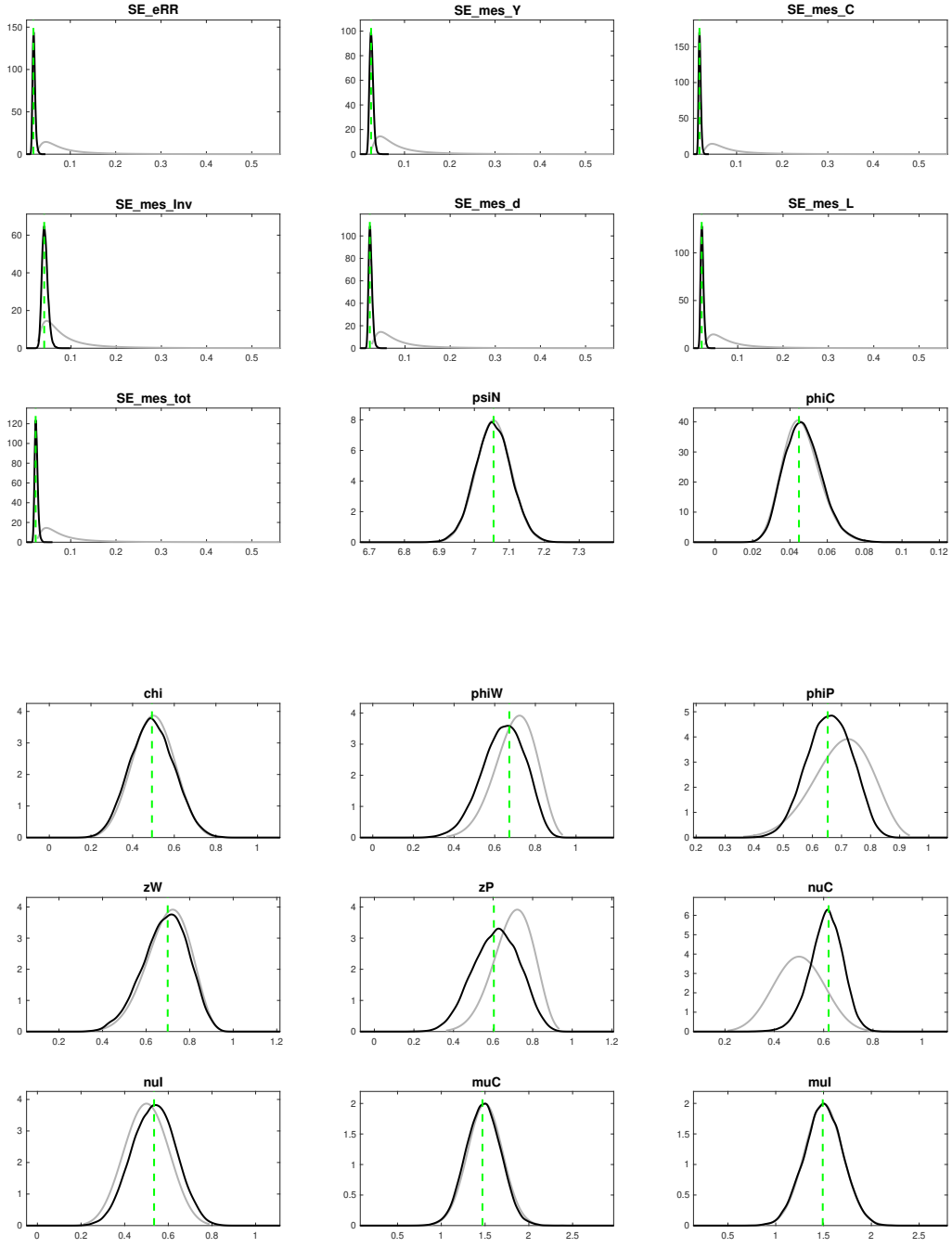
APPENDIX D

D.1 Prior and Posteriors Distribution

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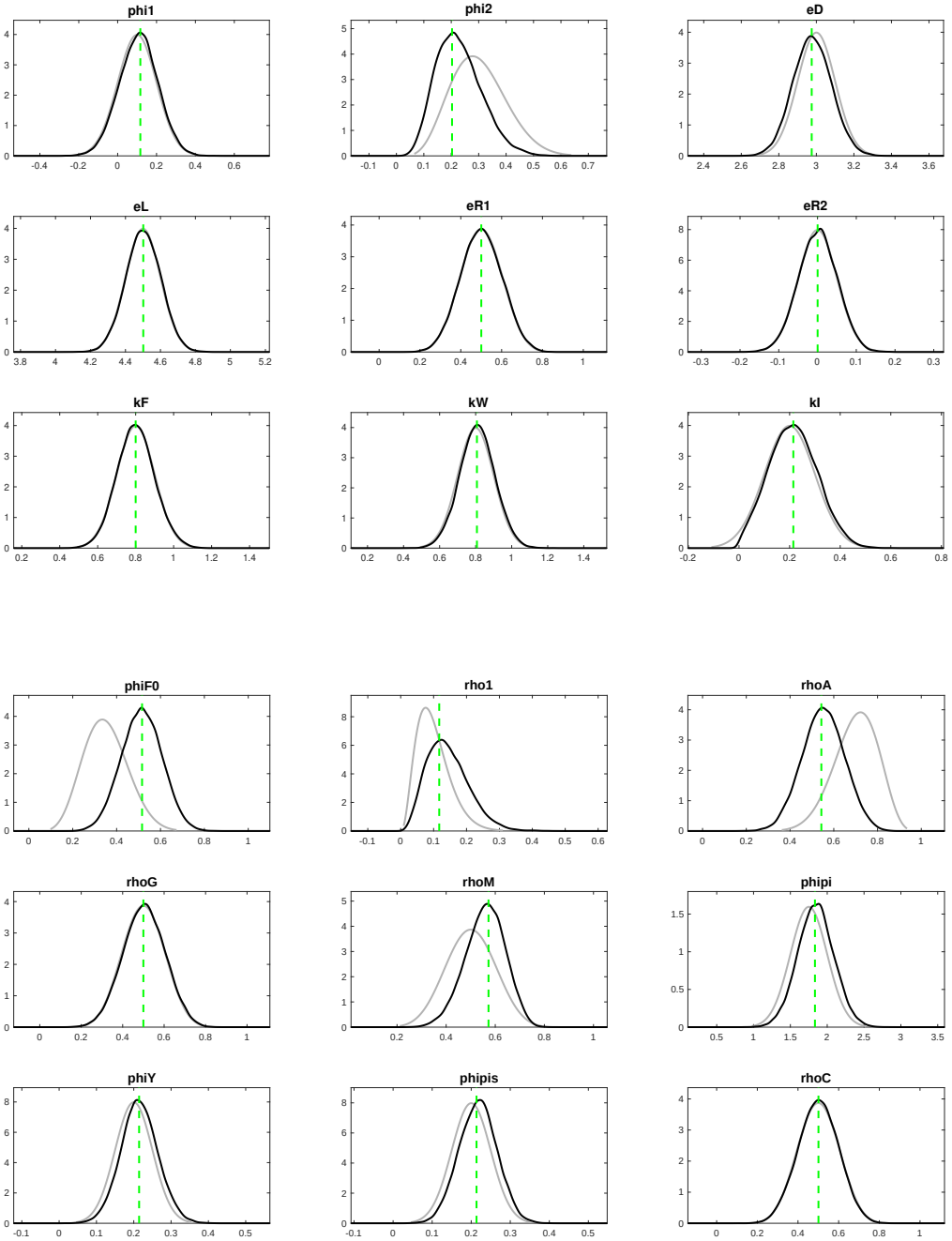
phi1
phi2
eD
eL
eR1
eR2
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kW
kI
phiF0
rho1
rhoA
rhoG
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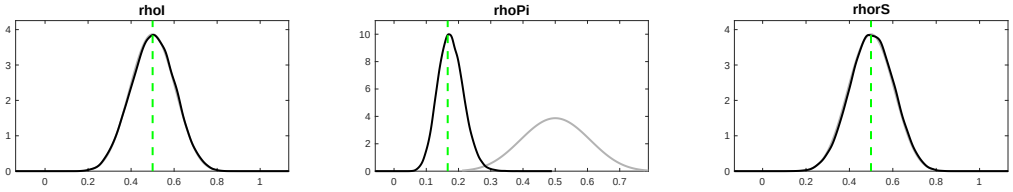
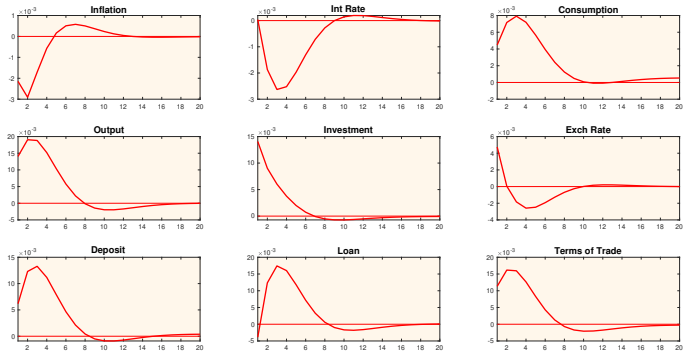
phipi
phiY
phipis
rhoC

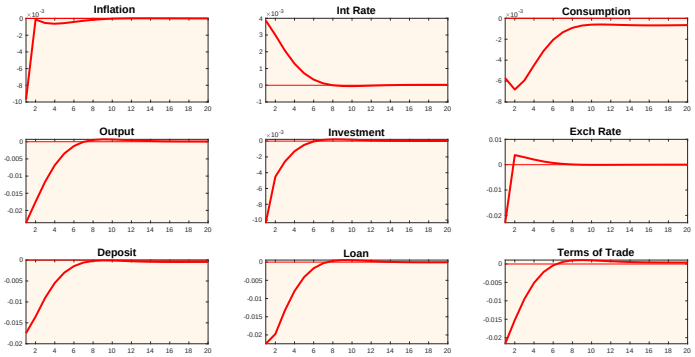

rhoI
rhoPi
rhorS

D.2 Impulse Response

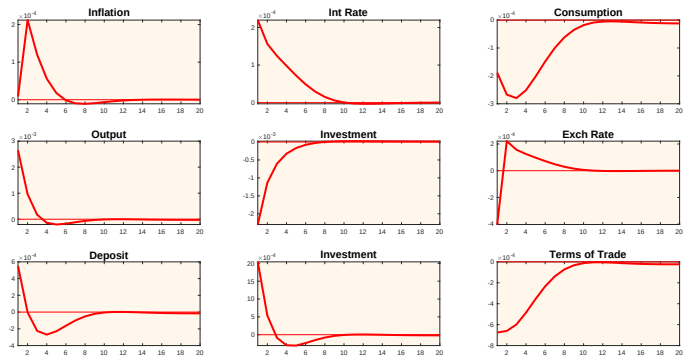
Impulse Response Comparison to Technology Shock



Impulse Response Comparison to Monetary Policy Shock

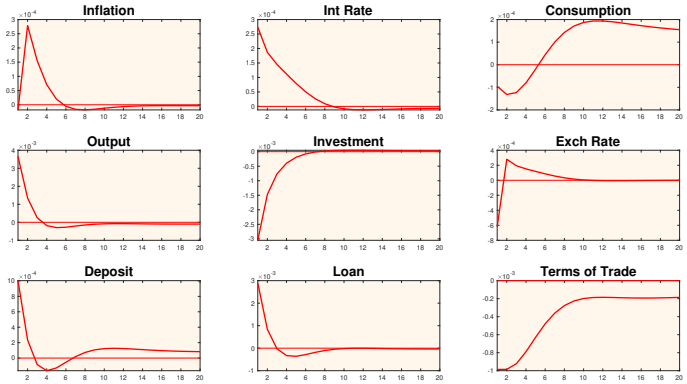


Impulse Response Comparison to Government Spending Shock

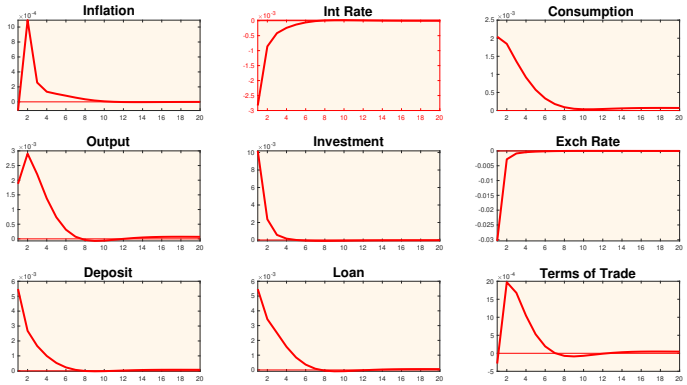


Appendix D.

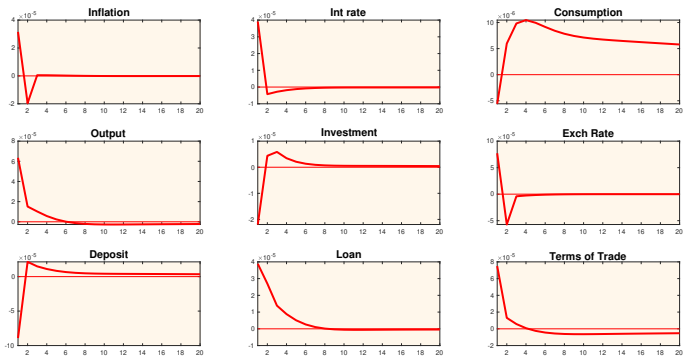
Impulse Response Comparison to Foreign Investment Shock



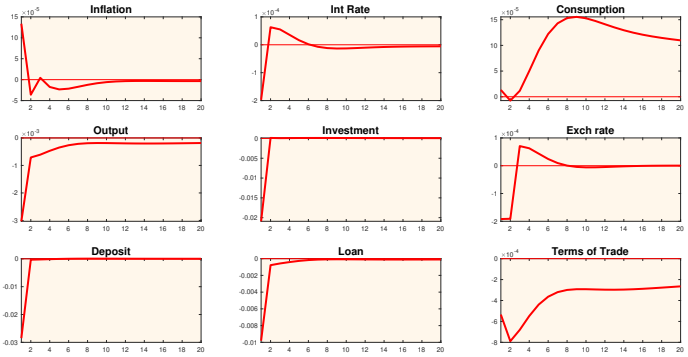
Impulse Response Comparison to Foreign Inflation Shock



Impulse Response Comparison to FX Intervention Shock



Impulse Response Comparison to Reserve Requirement Shock



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CHAPTER 6

Conclusion

6.1 Summary of Research Findings

In view of the preceding chapters, this thesis intends to shed light on how the interaction between monetary and macroprudential policies can be utilised in the presence of external shocks. The adoption of macroprudential policies by central banks highlights the importance of modelling the connection between the real economy, the financial system and monetary policies in providing a framework about how the monetary and macroprudential policies can be implemented (International Monetary Fund, 2013). Amidst the many macroprudential instruments, however, policymakers now have limited experience in the practice of such policies as some appear to be invoked only after the recent global financial crisis took place (Galati and Moessner, 2013).

This thesis also offers a novel analysis by incorporating the FX intervention instrument, which is regularly featured in the context of emerging markets. As of today, there have been many monetary and macroprudential policy frameworks are established based on developed country situations where the exchange rate is less pertinent for financial stability. However, such impertinence may not be the case for emerging markets, particularly those that have significant foreign currency exposure (Korinek and Sandri, 2016). By designing the thesis in a journal article format, this study explores the literature gap

in detail.

To begin the study, the first paper develops a comprehensive analysis of three main issues: i) how monetary and macroprudential policies interact; ii) how payment systems relate to monetary and macroprudential policies; and; iii) what are the impacts of capital flows on monetary and macroprudential policies. The analyses of these issues are done through a systematic literature review, identifying the gaps that exist in the existing literature. By following the approaches from Tranfield et al. (2003) and Denyer and Tranfield (2009), the literature review takes a final sample of 125 articles published between 1997 and 2016.

The review points out that the interaction between monetary and macroprudential policies can be seen from the perspective of both the borrowers and the financial intermediaries. From the borrowers' point of view, the literature expands the channel by looking through the cost of funds and the collateral constraints. Meanwhile, from the perspective of financial intermediaries, the literature can be divided into risk-taking and payment systems channels. Aside from these findings, the first paper points out that the payment system plays a major role in the interaction between monetary and macroprudential policies by providing the foundations for settlement and credit supply. However, the paper also suggests that there is a lack of discussion regarding payment systems in the context of monetary and macroprudential policies.

Another important finding from the first paper is on the importance of the exchange rate variable in a monetary and macroprudential policies framework, particularly in emerging economies. Many emerging economies have utilised foreign exchange (FX) intervention to manage the pressure on the exchange rate. This review, however, finds that the FX interventions have been performed only on a discretionary basis. On this note, we highlight the importance of putting this instrument in the framework of monetary and macroprudential policies. In addition, the inclusion of several macroprudential instruments, such as loan-to-value ratio and the multiple versions of reserve requirements implemented in several countries, will improve the knowledge of the framework. Overall, this review asserts that the literature will be benefited from further discussions regarding the effectiveness of monetary and macroprudential policies to affect the macroeconomic and financial stabilities.

To follow up on one of the findings in the first paper, the second paper explores the

issue of how payment system innovation affects financial intermediation, which in turn, influence the effectiveness of the monetary transmission mechanism. In this section, we provide a comprehensive analysis that covers both large value payment systems and retail payment systems. We perform an analysis of excess reserves and currency demand channel to see the relationship between these payment systems with financial intermediation. One of the novel elements in this paper is the assessment of the impact of customers' limitation in large value payment systems on the relationship between payment systems innovation with loan supply.

This paper demonstrates that payment systems are important to financial intermediation. It is shown that regulations that limit the value of customers' transactions help ease the pressure on banking liquidity by reducing the payment volatility. Further in this paper, we observe the importance of card-based payment systems in curtailing currency demand in the retail payment systems channel. By reducing the currency demand, it is indicated that the financial intermediation can be improved. Furthermore, we also highlight that the exchange rate relates to financial intermediation in a procyclical manner. The exchange rate appreciation leads to an increase in loan growth, whereas, the exchange rate depreciation decreases loan growth. Capital flows volatility may be one of the factors that contribute to this dynamic. Massive volatility of capital inflows, following unconventional monetary policies in advanced countries, for instance, leads to the appreciation of the currency because of strong demand for domestic assets, such as stocks and bonds. A sudden reversal in capital flow, in turn, will drive a contraction in the loan supply. However, the second paper fails to establish a significant relationship between the excess reserves and financial intermediation, which may due to excess liquidity. In the presence of excess liquidity, banks prefer to liquidate their placement in the central bank to hold a large number of excess reserves.

Going forward, the third paper investigates the use of FX intervention in the framework of an inflation-targeting central bank. By including the credit-constrained households, which is the salient features of the emerging market, this section elaborates the impact of a change in foreign investors' risk appetite towards macroeconomic stability, and whether FX intervention can be used to stabilise the economy during this turbulence. Upon investigation, we find that FX intervention affects macroeconomic variables. This instrument can be utilised to stabilise the economy during a risk appetite shock episode.

In addition, this study also points out that under a positive shock, FX intervention may not be the best complement to monetary policy, and instead suggests the incorporation of the exchange rate to interest rate functions as a possible scenario.

Finally, the fourth paper presents an assessment of the impact of using reserve requirements, combined with FX intervention and interest rate policy, on the macroeconomy. This paper also investigates the interaction between these instruments under the presence of external shocks. This investigation is performed by developing a DSGE model that features wage and price rigidities and a banking sector that has an imperfectly competitive environment. In addition, we highlight the commitment of the Central Bank – as an ITF central bank – to focus policy rates more on price stability rather than defending the exchange rate, in which case the assignment of FX intervention is a preferable option. The result also shows that domestic banks pay a relatively higher foreign loan premium than previously projected, indicating that they may depend on the foreign loan. This is consistent with our previous findings.

The results in the fourth paper suggest that risk appetite shock considerably affects the interest rate and exchange rate. During this episode of shock, reserve requirement provides extended liquidity to the banking system. This extra cash can be converted by commercial banks to supply loan, which in turn, helps prevent consumption to decline further. However, the reserve requirement does not indicate a significant direct impact on the exchange rate. In this case, FX intervention performs better to directly affect the exchange rate whilst reserve requirement may contribute to isolating the money supply from the effect of the exchange rate.

6.2 Contributions to the Existing Literature

Overall, this thesis provides beneficial contributions to the literature in a number of important ways. These contributions can be seen from theoretical, methodological and practical perspectives. Firstly, from a theoretical perspective, this thesis contributes to the scarce literature of the impact of payment systems on financial intermediation and the economy (Hasan et al., 2012, 2013; Merrouche and Nier, 2009, 2012). It also demonstrates that payment innovations may affect currency demand, which in turn, affects financial intermediation (Hasan et al., 2012, 2013). Findings on the inability of

excess reserves to affect financial intermediation also contribute to the literature around excess liquidity (Agénor et al., 2004; Bathaluddin et al., 2012). Further, this thesis reveals the impact of risk appetite shock to the economy ((Cadarajat and Lubis, 2012; Henderson and Rogoff, 1982; Smales, 2016). Our analysis on the interaction between monetary and macroprudential policies adds another contribution, especially to the fast-growing literature around this topic (De Paoli and Paustian, 2013; Bailliu et al., 2015; Agénor et al., 2018). Finally, by demonstrating that reserve requirement complements interest rate policy, we made contributions to the discussions around the role of reserve requirement in stabilising the economy (Loeffler, 2015; Montoro and Moreno, 2011)

Secondly, from a methodological angle, this thesis provides the conceptual as well empirical underpinnings on how payment systems affect financial intermediation (Rocheteau and Rodriguez-Lopez, 2014; Agénor et al., 2004; Rockoff, 1993).. Moving to other sections of the study, we also provide a framework in assessing FX intervention by adding the salient feature of emerging markets, which features households with limited financial access (Alla et al., 2017; Benes et al., 2014; Daude et al., 2016). On this, we provide the argument of adding the exchange rate to the interest rate function (Juhro and Mochtar, 2009; Svensson, 2000).

Thirdly, from a practical point of view, this research provides a novel element – limiting customers' transaction value in large-value payment systems – to central banks' policy toolkit on liquidity management (Jurgilas and Žikeš, 2014; Freixas and Parigi, 1998; Kahn and Roberds, 2001; Lacker, 1997) . The discussion then extends to the use of FX intervention as an instrument of an ITF central bank (Ghosh et al., 2016; **?**). We also present a fresh element to the discussion by using FX intervention to complement interest rate policy and reserve requirement (Glocker and Towbin, 2012; Leduc and Natal, 2018) and using countercyclical reserve requirement that is linked to the loan-to-deposit ratio (Agénor et al., 2018; Moreno, 2008).

6.3 Implications and Recommendations

Our findings may have several implications for policymakers, particularly central banks. The study provides empirical evidence on how currency demand is inversely related to financial intermediation. The implication of these findings is of paramount importance in

that it provides support to policies that promote payment migration to electronic platforms, particularly card-based payment systems, such as a 'less-cash society (GNNT)', which has been implemented by the central bank of Indonesia. In addition, the conclusions around innovations in the retail payment system may increase banking competition and create an increase in efficiency (Sokołowska, 2015).

We also demonstrate that policymakers can use the customers' transaction value limit in payment systems to prevent liquidity shocks to the banking sector. However, there is a trade-off in this arrangement. A regulation that sets a very high transaction limit may cause customers to convert their payment into currency (cash-basis), which may be another source of shock to the banking system. This condition contradicts our previous finding to promote conversion from cash into electronic payment platforms.

To contain excess reserves and capital flows, our empirical findings suggest that central banks need to enhance their monetary operation framework and integrate them with the newly-developed macroprudential policies. However, this strategy needs to be aligned with the overall long-term objectives of the central bank such as the inflation target. One of the instruments that can be utilised to tackle this challenge is the reserve requirement. During a period of increasing risk appetite episodes, the cost of funds will be withdrawn and reallocated from domestic financial markets towards borrowers in safer countries, such as advanced economies or economies with an investment-grade sovereign rating (Correa et al., 2018). Financial markets are less developed and the ability of banks to access different sources of funding may require them to set up sophisticated liquidity management. Moreover, our finding confirms that in the case of Indonesia, banks also deal with a higher premium when borrowing from abroad. During this period of pressure, lowering reserve requirements may be beneficial in order to provide additional liquidity.

Further, the study suggests that FX intervention helps stabilise the economy during an episode of capital flows. Without the FX intervention, central banks have to increase their policy rate in order to contain the impact of risk appetite shocks. Otherwise, central banks need to allow the nominal exchange rate to appreciate (in the case of capital inflows) or to depreciate (in the case of capital outflows) rapidly. The exchange rate affects the economy through both its volatility and level. Large volatility of exchange rate distorts the exchange rate expectation and drives a reversal in capital flows. A sudden reversal in capital flows causes volatility in domestic capital and debt markets.

Large volatility also impairs domestic borrowers who hold large foreign currency liabilities with domestic currency income. Furthermore, these borrowers may find the availability of foreign funding deteriorating because of the risk perception worsens. Our findings demonstrate that using the interest rate as the only instrument is costlier to the economy. This FX intervention, however, needs to take into account the availability of foreign reserves of the country. A FX sale intervention will drain the foreign reserves stock and therefore requires adequate foreign reserves. In addition, an FX buy intervention will expand the foreign reserves which may require a cost of investment.

Taken as a whole, this thesis is not in favour of an 'one-size-fits-all' policy approach. Our results highlight that FX intervention, interest rate policy or reserve requirement are not the generic solutions for every shock in an economy. For instance, under risk appetite shock, adding reserve requirement to interest rate and FX intervention may be inadequate to influence the exchange rate. FX intervention may work better to affect the exchange rate directly. Another example can be drawn from an episode of positive productivity shock where the use of both interest rate and FX intervention will instead amplify the shock to the economy. By reducing the cost of borrowing through both the interest rate and the exchange rate, policymakers will aggravate the optimistic view of agents, which in turn will intensify the impact of the shock on the economy. This study also provides evidence of a Taylor rule that increases responded with an exchange rate depreciation is the best policy option to stabilise the economy. Therefore, the central bank needs to specify its instruments to influence specific targets. An inflation-targeting central bank, within its communication strategy framework, needs to communicate clearly its strategy with regard to the use these instruments, which is to mitigate specific shocks, in particular, the capital flow shocks (Ghosh et al., 2016). This is an important message in the context of the ongoing debate about the choice and implementation of macroprudential instruments.

6.4 Limitations and future research

Despite augmenting the knowledge about the interaction between monetary and macroprudential policies, this thesis is subject to some limitations. Here, we present an assumption that there is no barrier for agents to convert their payment basis from cash to electronic. They may also move easily across the market and convert their assets without

the presence of a high transaction cost. However, this may be challenged in the case of emerging economies. Converting assets from one form to another may not be as simple as that in a developed market. There is a significant transaction cost that may be present. The convenience of using cash, as stipulated in our second paper, may be observed in emerging markets. Also, the lack of infrastructure in providing efficient transaction may be attributed to this factor (Titiheruw and Atje, 2009). However, this is beyond the scope of this study or even the scope of monetary and macroprudential policies. This study may benefit from a study identifying the determinants of cash in the economy, and on policies that enhance the infrastructure condition in the emerging market.

In addition to the above, we employ reserve requirement as the only macroprudential instrument in this study. It may be limited to see the impact of macroprudential policy in managing external shocks. Other macroprudential instruments, such as capital flow measures, can be applied to relieve massive capital flows. However, such measures need to consider the effect of capital flows on growth and financial system stability and the importance of sectoral destination in determining the effects of capital flows (Samarina and Bezemer, 2016). Restricting access to foreign financing may have contributed to the low investment and growth performance (Chamon and Garcia, 2016) In addition, capital flow measures may strengthen or diminish the effect of FX intervention. It is thought-provoking to see the interaction of these instruments to stabilise the economy.

Finally, we focus our discussion on the interaction between monetary and macroprudential policies. By doing so, fiscal policy is absent from the discussion. As indicated in the fourth study, a macroprudential instrument in the form of reserve requirement acts as a tax on the financial intermediaries. It affects the financial intermediation by influencing the deposit rate as the funding cost for the banks. Fiscal policy may also work in a similar channel, which is through a distortionary tax on the income of depositors or banks (depending on the tax structure of the country). It would be worth combining such analysis with our framework.

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