ESSAYS ON MONETARY POLICY, MONETARY TRANSMISSION AND INFLATION OF INDONESIA USING GENERAL EQUILIBRIUM MODEL

Thesis submitted for the degree of

Doctor of Philosophy

at the University of Leicester

by

Akhis Reynold Hutabarat

Department of Economics

University of Leicester

April 2010

To my wife, Diana,
my daughters, Audrey, Sarah and Victoria
and my son, Adrian

*So don't throw it all away now. You were sure of yourselves then. It's still a sure thing!
But you need to stick it out, staying with God's plan so you'll be there for
the promised completion.*

Hebrews 10:35-36 (The Message)

Abstract

Essays on Monetary Policy, Monetary Transmission and Inflation of Indonesia using General Equilibrium Model

Akhis Reynold Hutabarat

The first essay attempts to explain how the economy responds to transient exogenous exchange rate and cost-push shocks using a small open economy New Keynesian dynamic general equilibrium model that incorporates prices and wage stickiness and cost channel of interest rate to inflation. The model shows that a low degree of prices and wage rigidity, high reliance on imports and inflation-biased monetary policy, increases exchange rate pass-through to domestic and consumer prices. The model demonstrates that the transient nature of cost-push shock, combined with rational expectation behaviour of price setter and full policy credibility, does not require the monetary authority in developing economy to respond to the shock by tightening monetary policy.

The second essay investigates the relative importance of monetary transmission channel to inflation of passing persistent shock to the risk premium. The findings show that nominal exchange rate depreciation, triggered by a more persistent shock to interest risk premium, worsens the state of the economy in the short- and long-run. Such distinctive shocks effect is transmitted through the economy that typifies lack of response of consumer price disinflation to interest rate tightening caused by high real rigidity, strong cost channel of interest rate, strong cost channel of exchange rate pass-through and weak demand-side channel of exchange rate pass-through.

The final essay analyses Indonesia's inflation determinant using a model that links banking to real sector, central bank and government. It explores interest rate cost-push channel in terms of cost of equity and cost of borrowing, enhances the previous findings about the lack of response of disinflation to interest rate policy tightening and discusses the nexus between monetary and banking policy. The strong interest rate cost channel has some implications for the behaviour of and policy for banking related to the achievement of the inflation target.

Acknowledgments

I lift up praise and gratitude to the Lord Jesus for everything in my life is fully under his consent and control, including this study. I thank you God for sending me to Leicester, helping me in times of difficulties, providing me with abundant wisdom and understanding, and eventually opening the doors widely of completing this thesis. May your name be exalted, honoured and glorified.

This project would not have been possible without the support of many people. I am heartily thankful to my supervisor, Professor Stephen Hall, who has been exceptionally kind, patient, optimistic, responsive and resourceful in guiding and supporting me from the initial phase to the full completion of this thesis. I am also grateful to my supervisor and the members of the thesis committee, Professor Kevin Lee and Dr. Martin Hoskins, who offered me challenging insights and superb advice for the direction and progress of my study.

I would like to convey my thankfulness to Bank Indonesia, particularly the management and staff of Human Resources Development Directorate and London Representative Office, for giving me the scholarship as well as providing outstanding assistance and guidance. I would also like to thank my colleagues at the Directorate of Economic Research and Monetary Policy and my fellow Bank Indonesia's student in the UK for sharing data and information as well as technical and nontechnical help.

I would like to thank the academic and support staff of the Department of Economics, Graduate Office, Library and IT services University of Leicester for excellent provision and arrangement of academic and study life environment. I am thankful to my fellow PhD student and office mates for their warm attention, encouragement and invaluable advice. I wish you all good luck with your study and career and have a successful life.

I am grateful to Bob and Mina Coffey, Fiona Hamilton and my fellow home group at Knighton Evangelical Free Church for their constant prayer, attention, encouragement, advice and even a one-time worry that stimulated turning point and breakthrough to my study progress. I extend my thankfulness to Stephanus Mudjiono and Henry Susanto, and their family, for supporting me and my family through spiritual advice and prayer.

I owe my deepest gratitude and love to my wife, Diana. She deserves utmost special mention for her remarkable and inseparable support, love and prayers throughout this journey. I also thank my children, Audrey, Sarah, Adrian and Victoria for bringing me joy and persistently praying for me. I extend my gratitude to my parent-in-law, Mr. and Mrs. Sidabutar, and to my sisters, Esther, Ernita and Nora, for keep putting me and my family into their prayer time slot. I offer my regards and blessings to all of those who supported me in any respect during the completion of this project.

Last but not least, I am deeply indebted and grateful to my late mother, Elise Rosmin, who instigated my decision to undertake this study through her visionary suggestion and supported me with bountiful love and continual prayer throughout her last painful years. I wish she could have seen me accomplish the job she 'assigned' me to do years ago.

Leicester, 16 April 2010
Akhis Reynold Hutabarat

List of Contents

List of Tables

List of Figures

Chapter 1

Introduction

Monetary management needs to establish on a more comprehensive knowledge about monetary transmission mechanism and the relative strength among monetary channels. The omission of important channel in the framework of monetary policy formulation could put the monetary policy makers in a greater risk of making an inappropriate policy conduct in pursuing their target, particularly the overarching target of inflation.

The interest rate cost channel is a controversial monetary transmission channel that has not been included in the Bank Indonesia's policy and forecasting system of modelling. Yet the indication of its significance could have been drawn from the so called “price puzzle” phenomenon in the bank’s study about monetary transmission of bank lending channel (Agung, 2001), as well as from the weak sensitivity of disinflation to interest rate increases in the bank’s small macroeconometric model (Majardi, 2004).

The channel has also received trivial awareness in the framework of thinking in policy decision making within the central bank. Aslim Tadjuddin, the Bank Indonesia’s deputy governor in 2002-07, was the prominent critics in the central bank of the common approach to combat inflation by raising the interest rate. He considered that there is a positive causality from policy interest rate to inflation due to strong interest cost channel. He also often raised concern about distinguishing economic environment differences between Indonesia and advanced economies.

However, there have been a growing research interest about cost channel of interest rate policy to inflation since early of the last decade (see for instances, Barth and Ramey 2001, Linnemann 2005, Chowdhury et al. 2006, Ravenna & Walsh 2006, Castelnuovo & Surico (2006), Henzel et al. 2008, Lima and Setterfield 2010). Agénor and Montiel (2008) noted that the interest rate cost channel has been proposed as an explanation of the “price puzzle” phenomenon, which was labelled by Eichenbaum (1992) referring to the existence of a positive correlation between increases in the short-term interest rate and the price level in Sims' (1992) empirical anomaly finding.

The issue about the positive effect of interest rate on price or inflation has even been of the subject of interest for some macroeconomist since the nineteenth century originated in the work of Thomas Tooke (1838). Smith (2006) summarised Tooke's work in his argument that Thomas Tooke's most important legacy to economics was his original proposition that the long-run "average" rate of interest entered into the normal cost of production and, therefore, the normal prices of commodities, reflecting the notion that the interest rate systematically governs the normal rate of profit.

Gibson (1923), in an article for Banker's Magazine, noted that the positive correlation existed between interest rates and prices in the UK over a period of 200 years. John Maynard Keynes, in his 1930 work, A Treatise on Money, labelled the correlation as 'Gibson paradox' because the economic theory of the time, the Irving Fisher's theorem, suggested that the interest rate should move with the inflation or the expected inflation rather than the price level itself.

Seelig (1974) develops the theoretical model that underlies the econometric analysis to examine the impact of interest rate changes on price changes via mark-up pricing. His work was a response to the "Wright Patman effect", the more recent name related to the interest cost-push channel, after the US Congressman's view that it is senseless "to fight inflation by raising interest rates. Throwing gasoline on a fire to put out the flames would be as logical." The statistical and economic insignificance of his results does not support the hypothesis that increases in interest rates lead to higher prices via mark-up pricing during 1950s and 1960s. However, the positive correlation between interest rate and inflation occurs when interest rates is doubled.

Driskill and Sheffrin (1985) examined the disputed relations between interest rates and prices, by introducing interest costs into John Taylor's model of overlapping wage contracts. They found that the presence of interest costs does affect the stabilization process and can make the tradeoffs between output and price variability less favourable. However, their analysis does not substantiate the view that monetary policy cannot lower the inflation rate because of the price effects on interest rates.

Another name for the interest rate cost-push channel is the ‘Cavallo-effect’ after the Argentine minister of the economy during the 1990s, Domingo Cavallo, who found empirical support for the channel of the real cost of working capital in his Harvard PhD thesis (Taylor 2004). S. van Wijnbergen (1981) applied the Cavallo-effect for South Korea. He developed a quarterly macroeconometric model that had a linkage between financial and real sector explicitly and incorporated the transmission channel of monetary policy into the supply side of the economy via the real costs of working capital. His model simulation showed a strong stagflationary effect of monetary policy tightening in the short-run. This interest rate cost-push channel is the key insight of the Structuralist model developed most notably by Lance Taylor in the context of his criticism of the stabilization program in developing countries (Agénor and Montiel 2008).

I put the interest rate cost channel of monetary policy and its relative importance compared to other channel of monetary policy into the heart of this study. The rationale for the choice lays on the fact that Indonesia’s capital share is greater than its labour share. According to Input-Output Table 2005, the share of return on equity in value added is 57%, while the employee’s salary contributes 31% to the total value added. In contrast, gross domestic income of the United Kingdom comprises 62% of compensation of employees and 36% of gross operating surplus (Mahajan, 2006). This structural difference between a developing and an advanced country suggests different agent behaviour and policy implication between Indonesia and advanced economy.

This study also investigates how the channel works in the existence of transient and elongated shock to the exchange rate. How monetary policy should responds when interest rate cost-channel interacts with exchange rate pass-through and other demand and cost channels, is the ultimate concern of this research. Investigating the monetary policy response to exchange rate shocks in Indonesia is noteworthy for several reasons. First, adverse exchange rate shock frequently occurs and it has a high possibility of recurrence. Second, the economy has experienced severe elongated exchange rate shock that altered the equilibrium exchange rate and other macroeconomic variables. Third, macroeconometric modelling found a contractionary effect of depreciation possibly due to high import contents in production structure. Thus, it is interesting to identify the direction and extent of exchange rate effect on output and factors driving the effect.

Monetary policy is transmitted to the real sector mainly through the banking system, particularly in developing economies where financial markets are dominated by commercial banks. Thus, banking intermediary should have a role in a macroeconomic model as a significant economic player, and the model should provide linkage between the financial and real sector. However, there has been little attention paid to putting financial institution into general equilibrium model and in incorporating financial friction. When such a model does not incorporate banking, there is only one interest rate that represents policy rate and all market rates. The Economist magazine (April 3rd 2010) noted that this condition like the convenient fiction of a model of the economy that is defensible as long as different rates moves in concert. Unfortunately, they do not.

As a reflection on the global financial crisis, Cecchetti et al. (2009) raised the challenge for macroeconomist to construct macroeconomic models that can create severe financial stress endogenously. For the initial step, it requires the extension of the current macroeconomic modelling approach that ignored financial intermediaries and focused on rigidities in goods and labour market. There have been few researches that encompass a link between financial sector and the real economy. Among such limited researches are Goodfriend and McCallum (2007), Atta-Mensah and Dib (2008), Curdia and Woodford (2009) and Gerali et al. (2010). In the third part of this study, I attempted to contribute to such research needs by designing the linkage between financial and real sector through consolidated budget and balance sheet constraints for all agents. The model also links the banking sector to the central bank and government. The study then investigated how the monetary policy channel works in the presence of banking intermediary.

This research also aims to gain a more solid analytical economic framework and learn modelling techniques as tools for policy analysis instead of forecasting purposes. Thus, it is intended to offer an additional conceptual support for monetary policy decision making at the central bank of Indonesia. With regard to this objective, I choose to use dynamic general equilibrium models as tools to conduct shocks simulation in the first two studies. The third study formulated the financial dynamics general equilibrium model but uses the steady-state stage of the model to conduct parameter and policy simulations. The models were built on the framework of Christiano et al. (2005), Smets and Wouters (2003), Erceg and Levin (2003), Woodford (2003), Murchison (2004) and Freixas and Rochet (2008).

Hamann (2004) offered arguments in favour of using dynamic stochastic general equilibrium models for policy decisions. First, the model can overcome most of the limitation of the semi-structural models, i.e there are no market clearing conditions and the aggregate description of the economy is consistent with different microeconomic stories. Second, the models define clearly what economic actors do when they and interact meet in the markets. Third, the outcomes in these models is consistent with explicit constrained optimization problems for each agent and the restrictions imposed by markets. Therefore, he argued that there is little room for inconsistencies within the stock-flow accounting (provided the model is correctly designed). These features enable dynamic general equilibrium models to function more effectively as a tool for communicating the economy's characteristics and policy decisions to the stakeholders.

The organization of this thesis is as follows. Chapter 2 discusses the initial development of a small open economy New Keynesian dynamic general equilibrium model that incorporates prices and wage stickiness and the cost channel of interest rate to inflation. The model is applied to assess how the economy responds to temporary exogenous nominal exchange rate and cost-push shocks and the appropriate monetary policy implication in two different economies. Chapter 3 describes the model extension and discusses the findings on the relative importance of monetary transmission channel to inflation of passing the elongated shock to the risk premium for the case of Indonesia. Chapter 4 exposes a more comprehensive model extension that include financial intermediary and link financial sector to the real sector, the central bank and government. This chapter describes further exploration of interest rate cost-push channel of monetary transmission to inflation in terms of cost of equity and cost of borrowing, enhances the previous findings about the inattentiveness of disinflation to interest rate policy tightening, and discusses the nexus between monetary and banking policy. Chapter 5 draws concluding remarks for all thesis chapters.

Chapter 2

Monetary policy response to transient exchange rate and cost shocks

2.1 Introduction

The occurrence of disturbances to exchange rate and inflation often pose dilemma to monetary policy management. While a shock to production cost generally moves the economy along the short-run trade-off curve between output and inflation, exchange rate shock is usually expected to shift the curve as the later has an output expansionary and cost-push effect. However, there is a possibility that both shocks affect output-inflation trade-off in the same direction[1]. Thus, it is interesting to identify the direction and extent of exchange rate effect on output and factors driving the effect. Moreover, monetary policy makers are usually concerns on the magnitude of inflationary effect of such shock, which is also known as degree of exchange rate pass-through to inflation. The degree of exchange rate pass-through and the direction and scale of output effect of such shocks affect monetary policy flexibility in achieving an inflation target.

There are several factors that motivate another focus on cost shocks. First, both developing and advanced economies have been frequently hit by series of cost-push shocks, i.e. due to adverse weather conditions and oil prices shocks. In addition, some developing economies might often experience shocks to administered price or distribution of goods and their source of inflation might be highly dominated by cost-push rather than demand-pull inflation. Finally, central bank generally faces a predicament in responding to cost-push shocks because this kind of shock tends to worsen both prices and output. Therefore, it is intriguing to study the appropriate policy response to such shocks[2].

In this paper I develop a small open economy New Keynesian dynamic general equilibrium model to explore two issues. First, how two distinct economies, which are,

---

[1] See Edward (1986) that conducted regression analysis of twelve developing economies for 1965-1980 to find that devaluations have a small contractionary effect in the short-run but are neutral in the long-run.

[2] See Clarida et al. (1999) that consider monetary policy response on exogenous cost-push shock.

accordingly, intended to represent the structure and behavior of advanced and emerging economies, differ in responding to temporary exogenous nominal exchange rate and cost-push shocks. In particular, the second issue investigates how monetary policy should respond to the particular type of shocks, when the price setter has fully forward looking behaviour and when wage setting decision also depends on lagged inflation.

The model characterizes the household's money-in-the-utility function, Cobb-Douglas production function with labour, capital and imported goods input; new Keynesian Phillips curve, cost channel of monetary policy, uncovered interest rate parity, forward looking interest rate policy rule with interest rate inertia, and fiscal deficit tax rule. The model, which assumes the existence of staggered wages, import prices, and domestic price setting as sources of nominal rigidities, is a variant of optimizing models with staggered price-setting, which have been widely used in literatures on inflation and monetary policy and emerged as tools for policy analysis in central banks[3].

The paper shows that a low degree of prices and wage rigidity, high reliance on imports, and inflation-biased monetary policy increases exchange rate pass-through to domestic and consumer prices. To answer the question regarding how the central bank should conduct monetary policy in the presence of such shocks, this paper shows that the transitory nature of cost-push shock combined with rational expectation behaviour of price setter, full policy credibility, symmetric low rigidity of domestic price and low persistence of inflation does not lead monetary authority in 'developing' economy to immediately respond to the shock by conducting tight monetary policy.

The organization of the paper is as follows. Section 2.2 presents a dynamic equilibrium model with prices and wage stickiness. Section 2.3 presents the simulation

---

[3] See, for example, Ravenna and Walsh (2006), Christiano et al. (2005), Smets and Wouters (2003), Erceg and Levin (2003), Woodford (2003), and Murchison (2004). The first two incorporated a cost channel for monetary policy.

scenarios, parameter calibration and model solution. Section 2.4 analyses the simulation result. Section 5 concludes.

2.2 The model

The model assumes that the economic activity involves four domestic economic players, namely the household, the firm-producer, the government, and the central bank, which interact with the foreign economy. The household acts as a consumer, supplier of labour (workers), firm's owner, importer, exporter, supplier of the firm's rental capital goods, supplier of government consumption and investment goods, capital goods' investor, financial assets' investor and borrower, money holder, and tax payer. It makes a direct transaction with the government and foreign sector to hold government bond and international asset or liabilities (no banks or financial institution).

The firm-producer sells consumption goods to the household, intermediate goods to itself (other firms), capital goods to the household as supplier of rental capital goods, and exported goods to the foreign economy through the household as exporters. The firm employs workers and pay wages, purchases imported goods from the household-importer, rents capital goods from households that act as capital goods' lessor and purchases domestic intermediate goods from itself (other firms).

The government finances its budget through collecting labour income tax, borrowing money from the household and foreign economy, and generating seignorage income. It uses a tax policy rule in order to maintain a desired ratio of primary fiscal deficit. The central bank follows an interest rate policy rule in order to achieve the target of consumer inflation. The commercial bank does not exist in the model. Thus, it implies that the central bank is part of the government, which extend the supply of money through government purchases of domestic goods from the household as the supplier of goods.

2.2.1 The household

The economy is composed of a continuum of household that derives satisfaction from consuming goods, holding money and having leisure. The instantaneous utility function is additively separable in the real consumption of goods, (c_t), real money demand (m_t^d), and leisure (disutility of work, l_t^s) in the form of constant elasticity of substitution function.

$$u(c_t, m_t, l_t) = \frac{c_t^{1-\sigma}}{1-\sigma} + \frac{m_t^{d^{1-\rho}}}{1-\rho} - \frac{l_t^{s^{1+\lambda}}}{1+\lambda} \tag{1.1}$$

Lower case letters denote real variables. Upper case letters denote nominal variables. Parameter $\sigma \geq 0, \sigma \neq 1$ denotes the inverse of intertemporal consumption elasticity of substitution, while $\rho \geq 0, \rho \neq 1$ is the inverse of interest rate elasticity of real money holding, and $\lambda \geq 0$ is the inverse of real wage elasticity of labour supply. Therefore, the household maximizes its expected lifetime money-in-the-utility function $E_{t-1}\sum_{t=0}^{\infty} \vartheta^t u(c_t, m_t^d, l_t^s)$ subject to its dynamic budget constraint, and two additional constraints for initial and terminal condition. The dynamic budget constraint is expressed in domestic currency's nominal and real terms as follows.

$$\begin{aligned} &P_t c_t + M_t^d + B_t^{HG} + s_t B_t^{H*} + P_t k_t = M_{t-1}^d + (1+i_{t-1})B_{t-1}^{HG} + (1+i_{t-1}^*)s_t B_{t-1}^{H*} \\ &+ P_t(1-\delta)k_{t-1} + (1-\tau_t)W_t l_t + z_{t-1}P_t k_{t-1} + P_t^m im_t^{rm} + P_t \Pi_t \end{aligned} \tag{1.2}$$

$$\begin{aligned} c_t + m_t^d + b_t^{HG} + q_t b_t^{H*} + k_t - (1-\delta)k_{t-1} &= \frac{m_{t-1}^d}{1+\pi_t} + (1+r_{t-1})b_{t-1}^{HG} + (1+r_{t-1}^*)q_t b_{t-1}^{H*} \\ &+ (1-\tau_t)w_t l_t + z_{t-1}k_{t-1} + p_t^m im_t^{rm} + \Pi_t \end{aligned} \tag{1.3}$$

where s_t is nominal exchange rate (the price of a unit of foreign currency in terms of domestic currency), q_t is real exchange rate, i_t is domestic nominal interest rate, which is assumed equals the central bank's key policy rate, i_t^* is world nominal interest rate,

z_t is the real rental rate of capital, P_t is price level, p_t^m is real import price, ϑ is the household's discount factor, and δ is the depreciation rate of capital. E_{t-1} is the expectation operator, conditional on information up to time $t-1$. I assume that the government imposes tax on household's wage. Variable m_t^d is real money demand, b_t^{HG} denotes real domestic currency-denominated bonds, b_t^{H*} is real foreign currency-denominated bonds, r_t is domestic real interest rate, and r_t^* is the world's real interest rate.

The household purchases goods and services (c_t), provides labour services (l_t^s) to the firm and earns wage income (w_t). Some households are firm owners, who get dividend income. Christiano, et al. (2005) assumes that some households are the lessor, who has leasing company that rents out capital goods (k_{t-1}) to the firm-producer at a given variable utilization rate (u_t) demanded by the firm ($u_t k_{t-1}$). The lessor earns the firm's rental fee of utilized capital goods ($z_{t-1} u_t k_{t-1}$) minus the cost facing household of setting utilization rate $(\psi(u_t) k_{t-1})$.

Variable z_t denotes the rental rate of capital charged to the firm, which should cover the opportunity cost of putting money on financial asset and the depreciation of capital goods. Function $\psi(u_t)$ is the cost of setting the utilization rate of a unit of capital good (cost of adjusting capital utilization).

There is an alternative intuition for the capital rental assumption. We can assume that the firm owns capital goods. It finances capital purchase through borowing money from the household-lenders (Sorensen & Whitta-Jacobsen, 2005). Instead of paying a direct real 'leasing cost', the firm bears real 'user cost', which is the real cost of using a unit of capital goods associated with debt's real interest rate and capital depreciation rate. However, since lending rate does not depend on the utilization of capital purchased by the firm, I assume that the rental fee earned by the household-lessor is independent of capital utilization rate.

The firm might also bear cost of adjusting capital utilization. This cost corresponds to the time allocated for adjusting or preparing capital goods and supporting resources that forgone output. The examples are the time to re-layout production facilities and re-train workers. Under the rental-capital assumption, the foregone capital working hours, due to output loss during the utilization adjustment, reduces rental fee received by the household. However, in this model I assume that this cost is negligible, and capital utilization adjustment can be done after working hours so that it does not sacrifice the existing production. Therefore, I suppose the absence of adjustment cost of capital utilization.

As a capital goods supplier, the household also invests additional capital goods to be leased out to the firm (iv_t). I assume that physical investment is fully financed by the household-entrepreneur who foregone consumption and opportunity income from investing money on financial asset, by switching his retained profit into additional capital goods to be further rented to the firm. Therefore, there is no role of financial intermediary in providing fund through converting saving into investment. I also assume the absence of adjustment costs of investment. Thus, the household's expenditure on capital goods investment is simply the difference between current period's capital stock and the last period's depreciated capital stock, $iv_t = k_t - (1-\delta)k_{t-1}$[4].

[4] Christiano et.al (2005) and Smets & Wouters (2002) assume the presence of investment adjustment cost so that capital stock evolves according to $\boldsymbol{k_t} = (1-\delta)\boldsymbol{k_{t-1}} + [1-\boldsymbol{S}(\boldsymbol{iv_t}, \boldsymbol{iv_{t-1}})]\boldsymbol{iv_t}$, where $\boldsymbol{S}(.)$ is the adjustment cost function, which is a positive function of changes in investment and it equals zero in the steady-state.

The household-importer purchases imported intermediate goods ($s_t P_t^* im_t^{rm}$) and sells them to the firm at domestic import price, P_t^m. The household also stands as financial investor, who buys new domestic currency-denominated bonds (B_t^{HG}) and foreign currency-denominated bonds ($s_t B_t^{H*}$) and has income from the principal and interest income from selling matured government domestic bonds [$(1+i_{t-1})B_{t-1}^{HG}$] and foreign bonds [$(1+i_{t-1}^*)s_t B_{t-1}^{H*}$]. Finally, the household holds money (M_t^d) and has previous period money holding.

The two additional constraints are that the initial condition $\{b_0^{HG}, b_0^{H*}, m_0, z_0, k_0\}$ is given, and terminal condition on stocks $\{b_{T+1}^{HG}, b_{T+1}^{H*}, m_{T+1}, z_{T+1}, k_{T+1}\}$ is nonnegative. The first order conditions with respect to real consumption, real money demand, supply of labour, real physical capital goods, real imported intermediate goods, real domestic bond, nominal government bond and nominal foreign bond at $t = s+1$, for s=0, 1, 2,..., T, accordingly give the following optimality conditions:

$$u_c(c_t, m_t^d, l_t) = \xi_t \tag{1.4}$$

$$u_m(c_t, m_t^d, l_t) = \xi_t - \frac{\vartheta E_t \xi_{t+1}}{1+\pi_{t+1}} \tag{1.5}$$

$$u_l(c_t, m_t^d, l_t) = -\xi_t w_t (1-\tau_t) \tag{1.6}$$

$$\vartheta\big((1-\delta) + z_t\big) = \frac{\xi_t}{E_t \xi_{t+1}} \tag{1.7}$$

$$p_t^m = q_t \tag{1.8}$$

$$\vartheta(1+r_t) = \frac{\xi_t}{E_t \xi_{t+1}} \tag{1.9}$$

$$\vartheta(1+i_t) = \frac{\xi_t}{E_t \xi_{t+1}} \tag{1.10}$$

$$s_t = \vartheta(1+i_t^*)E_t s_{t+1}\frac{E_t\xi_{t+1}}{\xi_t} \tag{1.11}$$

where ξ_t is Lagrangean multiplier for budget constraint, and ϑ is discount factor. The optimal choices for the stock of capital, money, and bonds must satisfy the transversality condition, which is a condition on stocks of wealth and their shadow prices at terminal date.

$$\lim_{T\to\infty}\vartheta^T k_{T+1}\frac{\partial L}{\partial k_{T+1}} = \lim_{T\to\infty}\vartheta^T m_{T+1}\frac{\partial L}{\partial m_{T+1}} = \lim_{T\to\infty}\vartheta^T b_{T+1}^{HG}\frac{\partial L}{\partial b_{T+1}^{HG}} = \lim_{T\to\infty}\vartheta^T b_{T+1}^{H*}\frac{\partial L}{\partial b_{T+1}^{H*}} = 0 \tag{1.12}$$

Kamihigashi (2008) provides interpretation of (1.12) as the condition that rules out overaccumulation of wealth. It requires that the present discounted value of wealth at infinity must be zero, or, if any positive stocks of wealth are left at terminal date, they should not grow too fast compared with their discounted marginal value.

From the first order condition of utility maximization with respect to consumption (1.4), we get $\xi_t = u_c(c_t)$ and $E_t\xi_{t+1} = u_c(E_t c_{t+1})$, where ξ_t is marginal utility of consumption. By combining them with the first order condition with respect to real domestic bond (1.11), we obtain the Euler condition for the intertemporal consumption allocation of the form

$$\frac{u_c(c_t)}{u_c(E_t c_{t+1})} = (1+r_t)\vartheta \tag{1.13}$$

Using the utility function (1.1), consumption Euler condition can be expressed as

$$c_t = E_t c_{t+1}[(1+r_t)\vartheta]^{-\frac{1}{\sigma}} \tag{1.14}$$

Real money demand equation is derived by combining first order condition of the household's utility maximization with respect to real consumption (1.4), real money demand (1.5), and real domestic bond (1.9), and the definition of nominal interest rate, $(1+i_t) = (1+r_t)(1+E_t\pi_{t+1})$. The resulting equation expresses marginal rate of substitution between real money demand and real consumption, which is equal to the opportunity cost of holding money.

$$\frac{u_m(c_t, m_t^d, l_t)}{u_c(c_t, m_t^d, l_t)} = \frac{i_t}{1+i_t} \tag{1.15}$$

We can then partially derive utility function (1.1) with respect to money and consumption and incorporate them with (1.15) to get real money demand equation.

$$m_t^d = c_t^{\sigma/\rho}\left(\frac{i_t}{1+i_t}\right)^{-\frac{1}{\rho}} \tag{1.16}$$

In monopolistically competitive labour market, it is assumed that each household sells his endowment of a differentiated labour skill, which is an imperfect substitute for the other types of labour. Consequently, each household-worker has some monopoly power as a nominal wage setter and takes other wages and prices of goods as given. One might argue that the assumption of the worker as a wage setter is too strong for the typical economy in which labour market is characterized by abundant supply of labour, weak bargaining position of labour union and low appreciation for leisure. However, as some household-workers do have such monopoly power, I assume that for such economy this theoretical assumption of modelling wage determination and labour supply is still valid but with a weak positive real wage elasticity of labour supply. The household's supply of labour to the firm is then derived by combining the optimality condition with respect to consumption (1.4) and labour (1.6) that yields the following equation.

$$\frac{u_l(c_t, m_t^d, l_t)}{u_c(c_t, m_t^d, l_t)} = -w_t(1-\tau_t) \tag{1.17}$$

The above equation represents marginal rate of substitution between the household's supply of labour and real consumption (marginal disutility of work), which is equal to disposable real wage income. By taking partial derivative of utility function

(1.1) with respect to labour and consumption, we can obtain labour supply equation as follows:

$$l_t^s = \left(\frac{w_t(1-\tau_t)}{c_t^{\sigma}} \right)^{\frac{1}{\lambda}} \tag{1.18}$$

where the household's supply of working hours (l_t^s) is negatively affected by its leisure time derived from consumption (c_t), positively depends on real wage (w_t) and is a decreasing function of income tax rate (τ_t).

If labour market is perfectly competitive, nominal wage adjust instantaneously to balance labour supply (1.18) and labour demand, derived later. Flexible real wage then takes the form

$$w_t^n = \left(\frac{c_t^{n^{\sigma}} (\alpha_L y_t^n)^{\lambda}}{1-\tau_t^n} \right)^{\frac{1}{\lambda+1}} \tag{1.19}$$

where y_t^n is flexible-price level of output, c_t^n flexible-price level of consumption, τ_t^n is flexible-price tax rate and α_L is labour share that is explained later.

Blanchard and Kiyotaki (1987) explain the intuition behind the real wage as an increasing function of output. It positively depends on output presumably that workers have increasing marginal disutility of work. Under this household's working behaviour, an increase in output demand, followed by an increase in labour demand, requires an increase in real wage so that the supply of labour can satisfy its demand. The assumption of increasing marginal disutility of work $(\lambda > 0)$ can also give reason for negative relation between real wage and income tax rate. As tax rate increases, disposable income falls and, therefore, the household needs to have higher real wage than its steady-state level.

In addition to the assumption of monopolistic competition, I introduce nominal wage rigidities in the form of Calvo-type price setting. I replaced the equilibrium equation, which equates the firm's demand for labour and the household's supply of labour, with an equation that describes nominal wage determination. I follow Christiano et al. (2005), Smets and Wouters (2002) and Woodford (2003) that assume that in each period, the household-worker has a constant probability $1-\theta^{w}$ to get their wage re-set, while a fraction θ^{w} of them has their wage fixed. Among the workers that have their wage re-set, a fraction γ^{w} of them have their wage indexed to the previous period's aggregate wage inflation, $\widetilde{W}_t^b = \pi_{t-1}^{w} \widetilde{W}_{t-1}^{b}$. The other $1-\gamma^{w}$ fraction of workers has its wage re-set optimally, $\widetilde{W}_t^f$, by forecasting the present discounted value of marginal cost of working, given the constraint on the timing of wage adjustment and all other available information. When γ^{w}= 0 all workers re-set their wages optimally, while γ^{w} =1 means that all new nominal wages are simply based on past wage inflation. This assumption follows an augmented Calvo contract model for goods prices as in Gali & Gertler, 1999.

The wage-setter maximizes the expected real return on working, $E_t\left(\frac{\Delta_{t+s}(\widetilde{W}_t\ )}{P_{t+s}}\right)$, with respect to re-set wage, $\widetilde{W}_t$ [5].

$$\max_{\widetilde{W}_t^f} L = E_t \sum_{s=0}^{\infty} \beta^s \theta^{w^s} \frac{\Delta_{t+s}(\widetilde{W}_t\ )}{P_{t+s}} \tag{1.20}$$

where $E_t \Delta_{t+s}(\widetilde{W}_t\ )$ is the worker's nominal return on working at period t+s, given that the wage is re-set to be equal to $\widetilde{W}_t$ at period t and kept fixed from period t to t+s. I take

[5] The following derivation of new Keynesian Philips curve type of wage inflation benefits from Ascari (2003) and Whelan (2010).

into account that real return on working is real revenue minus real cost of working (real marginal cost of working multiplied by number of employment) when formulating the objective function.

$$\max_{\widetilde{W}_t^f} L = E_t \sum_{s=0}^{\infty} \beta^s \theta^{w^s} \left\{ \frac{\widetilde{W}_t}{P_{t+s}} l_{t+s}(\widetilde{W}_t) - \frac{MC_{t+s}^w}{P_{t+s}} l_{t+s}(\widetilde{W}_t) \right\} \tag{1.21}$$

subject to labour demand schedule,

$$l_{t+s}(\widetilde{W}_t) = \left(\frac{\widetilde{W}_t}{P_{t+s}} \right)^{-\varepsilon_t} l_{t+s} \tag{1.22}$$

where $l_{t+s}(\widetilde{W}_t)$ is the individual household's employment in period t+s, which corresponds to the wage set in the presence of nominal-wage rigidity, and l_{t+s} is the aggregate labour demand. Parameter θ^{w^s} is the probability of retaining the same wage for s period ahead, ε_t>1 is price elasticity of demand and β^s is discount factor. By substituting (1.22) into (1.21) we get the further form of worker's maximization problem in real term of the form

$$\max_{\widetilde{W}_t^f} L = E_t \sum_{s=0}^{\infty} \beta^s \theta^{w^s} l_{t+s} \left\{ \left[\frac{\widetilde{W}_t}{P_{t+s}} \right]^{1-\varepsilon} - \frac{MC_{t+s}^w}{P_{t+s}} \left[\frac{\widetilde{W}_t}{P_{t+s}} \right]^{-\varepsilon} \right\} \tag{1.23}$$

The optimal nominal wage set by each worker for the period between *t* and *s* is the solution for the following first order condition

$$E_t \sum_{s=0}^{\infty} \beta^s \theta^{w^s} l_{t+s} \left\{ \frac{1-\varepsilon}{P_{t+s}} \left[\frac{\widetilde{W}_t}{P_{t+s}} \right]^{-\varepsilon} - \frac{\varepsilon}{P_{t+s}} \frac{MC_{t+s}^w}{P_{t+s}} \left[\frac{\widetilde{W}_t}{P_{t+s}} \right]^{-(1+\varepsilon)} \right\} = 0 \tag{1.24}$$

where $\widetilde{W}_t$ is wage re-set in period t based on the firm's backward looking and forward looking wage setting behaviour, $\hat{\widetilde{W}}_t = \gamma^w \hat{\widetilde{W}}_t^b + (1-\gamma^w)\hat{\widetilde{W}}_t^f$. Wage that is re-set optimally takes the form

$$\hat{\hat{W}}_t^f = (1-\beta\theta^w)[m\hat{c}_t^w + \hat{P}_t] + \beta\theta^w E_t \hat{\hat{W}}_{t+1}^f \tag{1.25}$$

After some algebra, the linearised aggregate wage inflation in log deviation from steady-state can be expressed as

$$\hat{\pi}_t^w = \gamma^{wb}\hat{\pi}_{t-1}^w + \gamma^{wf} E_t \hat{\pi}_{t+1}^w + \lambda m\hat{c}_t^w \tag{1.26}$$

Where $\pi_t^w = \ln W_t - \ln W_{t-1}$, $\hat{\pi}_t^w = \hat{W}_t - \hat{W}_{t-1}$, $\lambda_w = \dfrac{(1-\gamma^w)(1-\theta^w)(1-\beta\theta^w)}{\theta^w + \gamma^w[1-\theta^w(1-\beta)]}$,

$\gamma^{wf} = \dfrac{\beta\theta^w}{\theta^w + \gamma^w[1-\theta^w(1-\beta)]}$, and $\gamma^{wb} = \dfrac{\gamma^w}{\theta^w + \gamma^w[1-\theta^w(1-\beta)]}$.

It implies from the household's utility maximization with respect to labour-supply and consumption, that real marginal cost of working is marginal rate of substitution between consumption and working divided by disposable income rate, $\dfrac{-u_l}{u_c(1-\tau_t)}$. Real marginal cost equals real wage when labour market clears (w_t^n).

$$mc_t^w = \left(c_t^\sigma \left(y_t \alpha_L\right)^\lambda / (1-\tau_t)\right)^{\frac{1}{\lambda+1}} \tag{1.27}$$

The household rents out capital goods to the firm with real rental rate of capital, z_t, which is obtained by combining the first order condition of utility maximization with respect to real capital stock (1.7) and real domestic bond (1.9) as follow

$$z_t = r_t + \delta \tag{1.28}$$

The rental price of capital that the household-lessor charges to the firm should cover the real interest rate, as the real cost of capital, and capital depreciation rate.

The household plays a role as an importer that procures intermediate goods from abroad and sells them to the firm. I assume that imported-goods price is temporary rigid in the currency of importing countries. In order to keep its demand stable, the importer may absorb fluctuations in exchange rate by allowing its profit margin moves flexibly. I follow Murchison et al. (2004) in allowing incomplete exchange rate pass-through to import prices in the short-run.

Import price setting follows Calvo's staggered price setting mechanism (Calvo, 1983). In this model it is assumed that a θ^m fraction of importer keeps their import price fixed in a given period. Thus, θ^m represents degree of import price stickiness implying that average time between price changes equals $1/(1-\theta^m)$. The $1-\theta^m$ fraction of the importer re-sets their price optimally, $\tilde{P}_t^m$, to the level that maximizes the present discounted value of expected future profits. The importer has forward-looking behaviour in setting their import price optimally, by forecasting the present discounted value of future marginal cost of importing goods given the constraint on the timing of import price adjustment and all other available information. The re-optimized import price set by the importer at period t, $\hat{\tilde{P}}_t^m$, is defined similar to wage equation (1.24).

$$\hat{\tilde{P}}_t^m = (1-\beta\theta^m)\hat{MC}_t^m + \beta\theta^m E_t \hat{\tilde{P}}_{t+1}^m \tag{1.29}$$

where nominal marginal cost of importing goods is domestic price of imported goods, $MC_t^m = P_t^* s_t$. It implies that real marginal cost of imports equals real import price when prices are fully flexible, which is equal to real exchange rate.

$$mc_t^m = p_t^{mn} = q_t \tag{1.30}$$

Imported goods inflation in deviation from steady-state can finally be expressed as follows.

$$\hat{\pi}_t^m = \beta E_t \hat{\pi}_{t+1}^m + \left(\frac{(1-\theta^m)(1-\beta\theta^m)}{\theta^m}\right)\hat{q}_t \tag{1.31}$$

where $\pi_t^m = \ln P_t^m - \ln P_{t-1}^m$ and $\hat{\pi}_t^m = \hat{P}_t^m - \hat{P}_{t-1}^m$

As a portfolio investor, the household's decision on holding domestic and foreign financial asset depends on exchange rate and interest rate. Nominal exchange rate is obtained by combining the first order condition of household's utility maximization with respect to nominal domestic bond (1.10) and to nominal foreign bond (1.11), which implies the uncovered interest rate parity.

$$s_t = E_t s_{t+1}\left(\frac{1+i_t^*}{1+i_t}\right) \tag{1.32}$$

2.2.2 The firm-producer

The economy contains a number of firms that produce a specific good, which is an imperfect substitute for the other goods. Firms sell their output to the domestic household and the foreign economy in a monopolistically competitive goods market. The firm produces output using a Cobb-Douglas production technology that utilizes labour, capital, and foreign and domestically-produced intermediate goods as production inputs. Output can be used for domestic consumption (both final and intermediate goods consumption), transformed into capital stock through investment, and exported. The model is a one-sector model that has no distinction between the production of final goods, intermediate goods, and capital goods. The individual firm's real output equation is given by

$$\tilde{y}_{it} = (A_{it} l_{it}^d)^{\tilde{\alpha}_L} (u_{it} k_{it-1})^{\tilde{\alpha}_K}\, im_{it}^{rm\,\tilde{\alpha}_M}\, \tilde{y}_{jt}^{rm\,\tilde{\alpha}_D} \tag{2.1}$$

where $\tilde{\alpha}_L, \tilde{\alpha}_K, \tilde{\alpha}_M, \tilde{\alpha}_D$ are the share of labour, capital goods, foreign and domestically-produced intermediate input in the firm's output, respectively, which are assumed to be constant and form a constant return-to-scale technology of production. The aggregate real output (value added) is given by

$$y_t = (A_t l_t^d)^{\alpha_L} (u_t k_{t-1})^{\alpha_K} (im_t^{rm})^{\alpha_M} \tag{2.2}$$

where k_t is capital stock, l_t^d is labour demand, im_t^{rm} is imported intermediate goods, u_t is capital utilization rate, and A_t is labour augmenting technological progress that evolves according to the first-order autoregressive process

$$\ln A_t = (1-\varsigma)\ln \overline{A} + \varsigma \ln A_{t-1} + \varepsilon_{A,t} \qquad ; \ \varepsilon_{A,t} \sim N(0,\sigma_A^2) \tag{2.3}$$

Parameter $\alpha_L, \alpha_K, \alpha_M$ are the labour share, capital share and import share, respectively, which are assumed to be constant and form a constant return-to-scale technology of production ($\alpha_L + \alpha_K + \alpha_M = 1$). Capital stock follows perpetual inventory approach as

$$k_t = (1-\delta)k_{t-1} + iv_t \tag{2.4}$$

The firm's objective is to choose the level of labour (l_t^d), imported intermediate inputs (im_t^{rm}), capital goods (k_{t-1}), and its utilization rate (u_t) that maximize its present discounted values of lifetime real profit, $\Pi = E_t \sum_{t=0}^{\infty} \beta^t \Pi_t$, where β denotes discount factor and Π_t is real profit at time *t*, which is the deviation of total real revenues from total real cost,

$$\Pi_t = (A_t l_t)^{\alpha_L} (u_t k_{t-1})^{\alpha_K} (im_t^{rm})^{\alpha_M} - w_t l_t - p_t^m im_t^{rm} - z_{t-1} k_{t-1} \tag{2.5}$$

The employment equation is given by the first order conditions with respect to labour demand

$$l_t^d = \frac{\alpha_L y_t}{w_t} \tag{2.6}$$

From the first order conditions of firms' profit maximization we can obtain the demand for intermediate goods imports of the form

$$im_t^{rm} = \frac{\alpha_M y_t}{p_t^m} \tag{2.7}$$

The firm’s stock of capital goods required for production is obtained from the first order conditions of the firm’s profit maximization with respect to capital goods.

$$k_t = \frac{\beta \alpha_K E_t y_{t+1}}{z_t} \tag{2.8}$$

The above equation facilitates strong aggregate demand channel of monetary policy through cost of capital. I assume that all capital goods used for production are rented from the household at prices that depend on interest rate. Analogously, when firms purchase, instead of rent, capital goods with borrowed money, demand for capital goods depends on loan or corporate bond's interest rate. When capital goods are purchased using the household-owner’s retained earnings, demand of capital goods depends on interest cost of equity capital. The additional level of capital that the firm should rent from the household, which is equal to the level of household’s net physical investment, is the difference between current period’s capital stock and last period’s depreciated capital stock.

Real marginal cost of domestically produced goods is derived from the firm’s real cost minimization problem in which the aggregate firm chooses l_t, k_t, u_t, im_t^{rm} to minimize aggregate real total cost, $tc_t = w_t l_t + p_t^m im_t^{rm} + z_{t-1} k_{t-1}$[6], subject to Cobb-Douglas production function (2.2). The first order conditions yield the following shadow price, Ω_t, in real terms:

$$p_t^d \Omega_t = \frac{w_t l_t}{\alpha_L y_t} = \frac{p_t^m im_t^{rm}}{\alpha_M y_t} = \frac{z_{t-1} k_{t-1}}{\alpha_K y_t} \tag{2.9}$$

---

[6] The real total cost is the aggregation of identical individual firm’s real total cost, which is equal to the total firms’ real output minus total firms’ real profit.

$$tc_t = p_t^d \sum_{i=1}^{M} \tilde{y}_{it} - \sum_{i=1}^{M} \Pi_{it} = \sum_{i=1}^{M} tc_{it} = w_t \sum_{i=1}^{M} l_{it} + z_{t-1} \sum_{i=1}^{M} k_{it-1} + p_t^m \sum_{i=1}^{M} im_{it}^{rm} + p_t^d \sum_{j=1}^{N} \tilde{y}_{jt}^{rm}$$

$$tc_t = p_t^d y_t - \Pi_t = w_t l_t + z_{t-1} k_{t-1} + p_t^m im_t^{rm}$$

The Lagrangean multiplier times real domestic price, $p_t^d \Omega_t$, represents aggregate firm's real marginal cost, mc_t^d, which is the derivative of total cost with respect to output, y_t. Substituting (2.9) for output, we can express real marginal cost as a function of real wage, real rental price, real import price and the level of technology of the form:

$$mc_t^d = \left(\frac{w_t}{\alpha_L A_t} \right)^{\alpha_L} \left(\frac{z_{t-1}}{\alpha_K} \right)^{\alpha_K} \left(\frac{p_t^m}{\alpha_M} \right)^{\alpha_M} \tag{2.10}$$

The price of domestically-produced goods set by a given firm at period *t*, $\hat{\tilde{P}}_{i,t}^d$, also follows Calvo's staggered price setting mechanism (Calvo, 1983), taking into account of price rigidity. It is in the same form with the re-optimized import goods price (1.29).

$$\hat{\tilde{P}}_t^d = (1-\beta\theta) M\hat{C}_t^d + \beta\theta E_t \hat{\tilde{P}}_{t+1}^d \tag{2.11}$$

The new Keynesian Phillips curve in deviation from steady-state is defined as

$$\hat{\pi}_t^d = \beta E_t \hat{\pi}_{t+1}^d + \left(\frac{(1-\theta)(1-\beta\theta)}{\theta} \right) m\hat{c}_t^d \tag{2.12}$$

where $\pi_t^d = \ln P_t^d - \ln P_{t-1}^d$, $\hat{\pi}_t^d = \hat{P}_t^d - \hat{P}_{t-1}^d$, and θ is degree of price stickiness.

The Calvo contract model assumes that the firm has a fixed probability of changing prices each period. Price and wage setters keep prices and wages constant unless they receive a signal at the beginning of each period to revise the price. Wren-Lewis (2006) argued that Calvo contract models have indirect, rather than pure, internal consistency with basic microeconomic assumptions. He pointed out that, in most cases, it is a reasonable judgment to claim that a microfounded model that includes Calvo contract model is internally consistent. It is partly because the Calvo contract model appears to mimic the implication of complicated models based on menu costs in very simple models. Therefore, Calvo contract model is used as a shortcut for menu costs in microfounded models.

Consumer price inflation, (π_t), is a weighted sum of domestic inflation and imported consumption goods inflation (π_t^m). Domestic inflation consists of inflation of goods produced in monopolistic competition market, (π_t^d), and infrequent price changes of goods and services controlled by the government (ε_t^a), which take the form

$$1+\pi_t = [(1+\pi_t^d)(1+e_t^{\varepsilon_t^a})]^{(1-\alpha_{mcg})}(1+\pi_t^m)^{\alpha_{mcg}} \tag{2.13}$$

where α_{mcg} denotes the share of imported consumption goods in total households' consumption.

Finally, we can obtain the level of output that would prevail if nominal rigidities are absent in the economy. Such output is often called as "natural output", "potential output", or "efficient output". For example, Clarida, Galí, and Gertler (1999, p. 1665) define the "natural level of output" as "the level of output that would arise if wages and prices were perfectly flexible." We can interpret natural output as the output that corresponds to the condition where all firms act competitively by setting their price at nominal marginal cost $(P_t^d = MC_t^d)$, implying a constant unit mark-up, $\mu = 1$. Hence in this model we can get natural output equation by setting real marginal cost equals the inverse of unit mark-up, $mc_t^d = p_t^d$. First, I substitute flexible real wage (1.19) and flexible real import price (1.30) into real marginal cost equation (2.10) to get

$$mc_t^{dn} = A_t^{n^{-\alpha_L}} \left(\frac{c_t^{n^{\sigma}} y_t^{n^{\lambda}}}{\alpha_L(1-\tau_t^n)} \right)^{\frac{\alpha_L}{\lambda+1}} z_{t-1}^{n^{\alpha_K}} q_t^{n^{\alpha_M}} \alpha_K^{-\alpha_K} \alpha_M^{-\alpha_M} = 1 \tag{2.14}$$

Then, unit real marginal cost implies that flexible-price inflation equals its expected inflation, which is its steady-state value, $\bar{\pi}$. As inflation target equals the steady-state inflation, monetary policy keeps nominal interest rate at its steady-state rate and subsequently real interest rate and real rental rate of capital are equivalent to their steady-state rates. As a result, consumption is equal to its steady-state value of expected consumption and exchange rate is independent of monetary policy. Therefore, given the unit real marginal cost, we can solve for natural output, y_t^n, of the form

$$y_t^n = \left(\frac{\alpha_L(1-\tau_t^n)}{\bar{c}^{\sigma}}\right)^{\frac{1}{\lambda}} \left(\frac{A_t^n}{\left(\bar{z}^{\alpha_K} q_t^{n\alpha_M}\right)^{\frac{1}{\alpha_L}}}\right)^{\frac{\lambda+1}{\lambda}} \left(\alpha_K{}^{\alpha_K} \alpha_M{}^{\alpha_M}\right)^{\frac{\lambda+1}{\lambda\alpha_L}} \tag{2.15}$$

where τ_t^n is the rate of taxation that would be set if wages and prices were perfectly flexible, that depends on the government spending and natural output. As flexible price and flexible-price nominal exchange rate are independent of monetary policy, natural output is, therefore, only dependent of productivity, government spending, foreign interest rate and foreign price. Given its definition, natural output (y_t^n) in the class of dynamic general equilibrium model does not stand for trend level of actual output $(\tilde{y}_t)$ in monopolistically competitive market with nominal rigidity. Thus, the corresponding output gap (y_t / y_t^n) is not a measure of business cycle that can be linked to the movement of real marginal cost in new Keynesian Phillips curve.

2.2.3 The fiscal and monetary authority

The government is responsible for public spending and its expenditure is financed by collecting tax or issuing domestic- and foreign-denominated bonds. Nominal dynamic budget constraint of the government is expressed as

$$B_t^{GH} + s_t B_t^{G*} + \tau_t W_t l_t^d + M_t^s - M_{t-1}^s = (1+i_{t-1})B_{t-1}^{GH} + (1+i_{t-1}^*)s_t B_{t-1}^{G*} + P_t g_t \tag{3.1}$$

where $B_t^G = B_t^{GH} + s_t B_t^{G*}$ is nominal government revenue from issuing domestic bonds (B_t^{GH})) and government foreign debts (B_t^{G*}), $\tau_t W_t l_t^d$ is nominal tax revenue,

$(M_t^s - M_{t-1}^s)$ is seignorage revenue, g_t is real government consumption, and s_t is nominal exchange rate. In real term, the government budget constraint is given by

$$b_t^{GH} + q_t b_t^{G*} + \tau_t w_t l_t^d + m_t^s - \frac{m_{t-1}^s}{1+\pi_t} = (1+r_{t-1})b_{t-1}^{GH} + (1+r_{t-1}^*)q_t b_{t-1}^{G*} + g_t \tag{3.2}$$

The real budget constraint says that the government balances its expenditure budget for public sector spending and the payment of previous period's debts' principal and interest with tax revenue, $\tau_t w_t l_t^d$, seigniorage income, $m_t^s - \frac{m_{t-1}^s}{1+\pi_t}$, and debt financing, $b_t^G = b_t^{GH} + q_t b_t^{G*}$. The fiscal deficit is given by

$$g_t - \tau_t w_t l_t^d = \left(b_t^{GH} - (1+r_{t-1})b_{t-1}^{GH}\right) + q_t\left(b_t^{G*} - (1+r_{t-1}^*)b_{t-1}^{G*}\right) + \left(m_t^s - \frac{m_{t-1}^s}{1+\pi_t}\right) \tag{3.3}$$

Government consumption grows constantly and fiscal policy rule takes the form of tax rate reaction function that ensures the sustainability of fiscal balance. The government's objective is to achieve and maintain a fixed ratio of primary fiscal deficit-to-GDP.

$$\tau_t = \tau_{t-1} + \Theta\left(\frac{g_t - \tau_t y_t}{y_t} - \psi\right) \tag{3.4}$$

where τ_t is tax rate policy response, g_t is real government consumption, y_t is real output, Θ is fiscal policy response parameter, and ψ is a constant parameter representing the target of real primary fiscal deficit-to-GDP ratio.

As the central bank is implicitly a part of the government that supply money to the household through government consumption, bank lending channel is nonexistent in this model. The central bank affects inflation through aggregate demand, aggregate supply, exchange rate, and cost channel of interest rate policy. It employs a forward-looking Taylor-type interest rate policy rule as defined in Clarida, et al. (1999). It is a short term nominal interest rate response to the forecast of next period inflation gap, which is the deviation of the forecast of future inflation from its inflation target, while also taking into account the smoothness of interest rate movement.

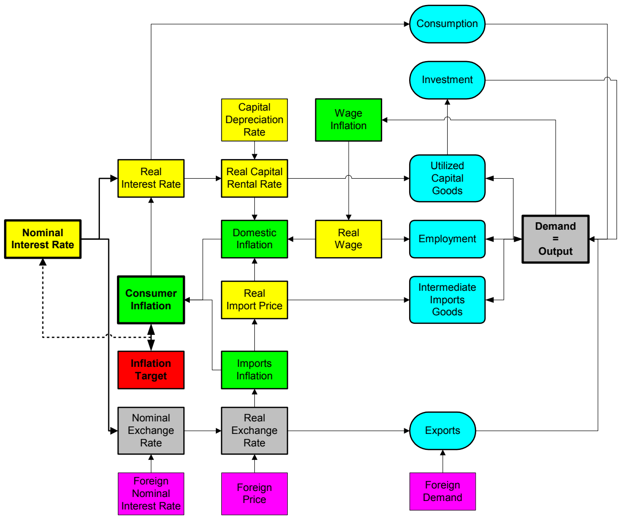
$$i_t = \chi i_{t-1} + (1-\chi)[\bar{r} + \bar{\pi} + \alpha_\pi(\pi_{t+1} - \pi_{t+1}^T)] \tag{3.5}$$

where $\bar{r}$ is the steady-state level of real interest rate and π_t^T is inflation target path at period *t*, χ is interest rate smoothing parameter, and α_π is monetary policy response parameter.

Monetary policy does not respond to the discrepancy between actual output and natural output. If monetary policy responds to such measure of output gap it aims to achieve the flexible price level of output, which is higher than the trend of actual output under monopolistically-competitive market ($y_t^n > \tilde{y}_t$). If monetary authority achieves the target of natural output, it will tend to conduct an inflationary-biased policy because it could continuously generate accelerating inflation ($\pi_t > E_t\pi_t$), given zero average value of supply shock (Sorensen et al., 2005). By using policy rule that only respond to inflation gap, it is assumed that monetary policy is not only aimed to achieve inflation target directly but also the target of output indirectly. However, the target of output for stabilization policy provided by new Keynesian Phillip curve is the trend level of actual output $(\tilde{y}_t)$.

Figure 2.1 shows the transmission channel of monetary policy to aggregate demand and inflation. Interest rate policy is passed-through to aggregate demand via three transmission channels. First, real interest rate affects consumption through substitution and income effect. Second, real interest rate determines capital goods procument cost hence influence demand for investment. Third, policy rate has an effect on nominal exchange rate and then is transmitted to real exchange rate as a determinant of foreign demand for domestic good. The latter is also called as monetary transmission through indirect pass-through effect of exchange rate.

Figure 2.1 Monetary Policy Transmission



Monetary policy is transmitted to consumer inflation through three channels. First, aggregate demand channel of interest rate policy is passed-through to domestic inflation through wages. The second channel is interest rate cost of production channel, which is specifically the interest rate cost of procuring capital goods, either financed by equity or loan capital. Third, monetary policy affects consumer inflation through two exchange rate channels. The first one is through the cost of imported intermediate goods in domestic prices and the other one is through consumption imported-goods inflation. They are named intermediate and immediate direct pass-through effect of exchange rate to consumer price, accordingly.

2.2.4 The foreign economy

Foreign demand for domestic goods (exports) is given by the following import demand function for the foreign economy.

$$x_t = im_t^* = \alpha_M^* \left(\frac{P_t^{m*}}{P_t^*} \right)^{-\eta} y_t^* \tag{4.1}$$

where P_t^{m*} is the foreign country's import price, which is equal to the foreign price of domestic country's exports, $\left(P_t^{m*} = \frac{P_t^x}{s_t}\right)$, where P_t^x is domestic price of domestic exports and s_t is nominal exchange rate in terms of domestic currency per unit of foreign currency. P_t^* is foreign general price level, y_t^* is foreign output, α_M^* is the share of domestic country's export in the rest of the world's total demand, and η is price elasticity of exports. By assuming that domestic price of domestic exports, P_t^x, equals general price level, P_t, and substituting for real exchange rate equation $q_t = s_t \frac{P_t^*}{P_t}$, we have

$$x_t = \alpha_M^* q_t^{\eta} y_t^* \tag{4.2}$$

Foreign output, y_t^*, evolves according to stochastic process of the form

$$\ln y_t^* = (1-\omega_{y*})\ln \bar{y}^* + \omega_{y*} \ln y_{t-1}^* + \varepsilon_{y*,t} \tag{4.3}$$

Where 1> ω_{y*} >0 and $\varepsilon_{y*,t}$ is serially uncorrelated shock, which is normally distributed with zero mean and standard deviation σ_{y*}

Foreign nominal interest rate, i_t^*, evolves according to the following stochastic process:

$$\ln i_t^* = (1-\omega_{R*})\ln \bar{i}^* + \omega_{R*} \ln i_{t-1}^* + \varepsilon_{R*,t} \tag{4.4}$$

Where 1> ω_{R*} >0 and $\varepsilon_{R*,t}$ is serially uncorrelated shock, which is normally distributed with zero mean and standard deviation σ_{R*}

Foreign inflation, π_t^*, evolves according to the following stochastic process:

$$\ln \pi_t^* = (1-\omega_{\pi*})\ln \bar{\pi}^* + \omega_{\pi*} \ln \pi_{t-1}^* + \varepsilon_{\pi*,t} \tag{4.5}$$

Where 1> ω_{π^*} >0 and $\varepsilon_{\pi^*,t}$ is serially uncorrelated shock, which is normally distributed with zero mean and standard deviation σ_{π^*}.

2.2.5 Markets equilibrium

The equilibrium of output goods market is defined by resource constraint that equate aggregate demand for output with aggregate supply of output (2.2) of the form

$$c_t + g_t + iv_t + x_t - im_t = (A_t l_t^d)^{\alpha_L} (u_t k_{t-1})^{\alpha_K} (im_t^{rm})^{\alpha_M} \qquad (5.1)$$

I assume a constant technology and constant stock of goods inventory (zero changes in inventory). The adjustment of capital utilization makes sure that goods market is always cleared in the face of shocks. Unlike goods market, labour market is not necessarily cleared after the occurrence of shocks hence causing the possibility of higher or lower level of unemployment. Other input goods and money and bond markets are assumed always cleared.

2.2.6 The steady-state equations

In steady-state real variables have zero growth, nominal variables grow at constant rates and growth variables are stable. Assuming no technological progress or labor force growth in steady-state, the diminishing returns of capital implies that new capital produced in steady-state must only need to compensate the existing capital lost due to depreciation. Therefore, real capital stock stops growing as well, causing the economy to produce constant real output.

As nominal rigidity vanishes in steady-state, price level is perfectly flexible and is set at its nominal marginal cost hence real marginal cost stays constant at unity. Thus, inflation equals changes in nominal marginal cost. The steady-state form of monetary policy rule equation describes the equality between consumer inflation and exogenous inflation target, reflecting the persistent component of inflation in steady-state. The full steady-state equations take the form

Nominal exchange rate $\bar{s}_t = E_t \bar{s}_{t+1}\left(\frac{1+\bar{i}^*}{1+\bar{i}}\right); \ \bar{r} = \bar{r}^*$

Real exchange rate $\bar{q} = \bar{s}_t \frac{\bar{P}_t^*}{\bar{P}_t}$

Real money demand $\bar{m}^d = \bar{c}^{\sigma/\rho}\left(\frac{\bar{i}}{1+\bar{i}}\right)^{-\frac{1}{\rho}}$

Labour supply $\bar{l}^s = \bar{c}^{-\frac{\sigma}{\lambda}} \bar{w}^{\frac{1}{\lambda}} (1-\bar{\tau})^{\frac{1}{\lambda}}$

Labour demand $\bar{l}^d = \frac{\alpha_L \bar{y}}{\bar{w}}$

Real marginal cost of domestic goods $\overline{mc}^d = \bar{A}^{-\alpha_L}\left(\frac{\bar{w}}{\alpha_L}\right)^{\alpha_L}\left(\frac{\bar{z}}{\alpha_K}\right)^{\alpha_K}\left(\frac{\bar{p}^m}{\alpha_M}\right)^{\alpha_M}$

Real marginal cost of imported goods $\overline{mc}^m = \bar{q}$

Real marginal cost of working $\overline{mc}^w = \left(\frac{\bar{c}^{\sigma}(\bar{y}\alpha_L)^{\lambda}}{(1-\bar{\tau})}\right)^{\frac{1}{\lambda+1}}$

Technology $\bar{A} = 1$

Capital utilization rate $\bar{u} = 1$

Real capital stock $\bar{k} = \frac{\beta \alpha_K \bar{y}}{\bar{z}}$

Real investment $\overline{iv} = \delta \bar{k}$

Real consumption $\bar{r} = \vartheta^{-1} - 1$

Real consumption of imported

finished goods $\bar{c}^{mcg} = \alpha_{mcg}\bar{c}$

Real government consumption $\bar{g} = g_r \bar{y}$

Real exports $\bar{x} = \alpha_M^* \bar{q}^\eta \bar{y}^*$

Real imports $\overline{im} = \overline{im}^{rm} + \overline{im}^{cg} + \overline{im}^{kg}$

Real imports of raw material $\overline{im}^{rm} = \dfrac{\alpha_M \bar{y}}{\bar{p}^m}$

Real imports of consumption goods $\overline{im}^{cg} = \bar{c}^{mcg} = \alpha_{mcg} \bar{c}$

Real imports of capital goods $\overline{im}^{kg} = \alpha_{mkg} \overline{iv}$

Real demand for goods $\bar{y} = \bar{c} + \bar{g} + \overline{iv} + \bar{x} - \overline{im}$

Real output $\bar{y} = (\bar{A}\bar{l}^d)^{\alpha_L} (\bar{u}\bar{k})^{\alpha_K} \overline{im}^{rm\alpha_K}$

Flexible price of output

$$\bar{y}^n = \left(\frac{\alpha_L(1-\bar{\tau})}{\bar{c}^\sigma}\right)^{\frac{1}{\lambda}} \left(\frac{\bar{A}}{\left(\bar{z}^{\alpha_K} \bar{q}^{\alpha_M}\right)^{\frac{1}{\alpha_L}}}\right)^{\frac{\lambda+1}{\lambda}} \left(\alpha_K{}^{\alpha_K} \alpha_M{}^{\alpha_M}\right)^{\frac{\lambda+1}{\lambda\alpha_L}}$$

Consumer goods inflation $1 + \bar{\pi} = (1 + \bar{\pi}^d)^{(1-\alpha_{mcg})} (1 + \bar{\pi}^m)^{\alpha_{mcg}}$

Domestic goods inflation $\bar{\pi}^d = \log \overline{MC}_t^d - \log \overline{MC}_{t-1}^d$

Imported goods inflation $\bar{\pi}^m = \log \overline{MC}_t^m - \log \overline{MC}_{t-1}^m$

Wage inflation $\bar{\pi}^w = \log \overline{MC}_t^w - \log \overline{MC}_{t-1}^w$

Domestic goods' nominal marginal cost $\overline{MC}_t^d = \bar{P}_t \overline{mc}^d$

Imported goods' nominal marginal cost $\overline{MC}_t^m = \bar{P}_t \overline{mc}^m$

Nominal marginal cost of working $\overline{MC}_t^w = \bar{P}_t \overline{mc}^w$

Consumer price $\bar{P}_t = \bar{P}_{t-1}(1 + \bar{\pi})$

Domestic goods price	$\overline{P}_t^d = \overline{P}_{t-1}^d(1+\overline{\pi}_t^d)$
Import price	$\overline{P}_t^m = \overline{P}_{t-1}^m(\grave{}1+\overline{\pi}^m)$
Nominal wage	$\overline{W}_t = \overline{W}_{t-1}(1+\overline{\pi}^w)$
Real domestically-produced good price	$\overline{p}^d = \dfrac{\overline{P}_t^d}{\overline{P}_t}$
Real import price	$\overline{p}^m = \overline{q}$
Real wage	$\overline{w} = \left(\dfrac{\overline{c}^\sigma(\overline{y}\alpha_L)^\lambda}{(1-\overline{\tau})}\right)^{\frac{1}{\lambda+1}}$
Real rental price of capital	$\overline{z} = \overline{i} + \delta$
Fiscal policy rule	$\overline{\tau} = \dfrac{\overline{g}}{\overline{y}} - \psi$
Monetary policy rule	$\overline{\pi} = \overline{\pi}^T$
Real interest rate	$1+\overline{r} = \dfrac{1+\overline{i}}{1+\overline{\pi}}$; $\overline{r} = \overline{r}^*$

2.2.7 The log-linearised dynamic equations in deviation from steady-state

Since all variables grow constantly in steady-state, all nonlinear and linear dynamic equations need to be log-linearised and be expressed as deviations of dynamic equilibriums from their corresponding steady-state equilibriums.

Nominal exchange rate	$\hat{s}_t = E_t\hat{s}_{t+1} + (1+\hat{i}_t^*) - (1+\hat{i}_t)$
Real exchange rate	$\hat{q}_t = \hat{s}_t + \hat{P}_t^* - \hat{P}_t$
Real money demand	$\hat{m}_t^d = \dfrac{\sigma}{\rho}\hat{c}_t - \dfrac{1}{\rho}\hat{i}_t^{'}$ where $i_t^{'} = \dfrac{i_t}{1+i_t}$
Labour supply	$\hat{l}_t^s = \dfrac{1}{\lambda}\left(\hat{w}_t + (1-\hat{\tau}_t) - \sigma\hat{c}_t\right)$
Labour demand	$\hat{l}_t^d = \hat{y}_t - \hat{w}_t$

Real marginal cost of domestic goods $m\hat{c}_t^d = \alpha_L \hat{w}_t + \alpha_K \hat{z}_{t-1} + \alpha_M \hat{p}_t^m - \alpha_L \hat{A}_t$

Real marginal cost of imported goods $m\hat{c}_t^m = \hat{q}_t$

Real marginal cost of working $m\hat{c}_t^w = \frac{1}{\lambda+1}\left(\sigma\hat{c}_t - (1-\hat{\tau}_t) + \lambda\hat{y}_t\right)$

Technology $\hat{A}_t = \varsigma\hat{A}_{t-1}$

Real capital stock $\hat{k}_t = E_t\hat{y}_{t+1} - \hat{z}_t$

Real investment $i\hat{v}_t = \frac{1}{\delta}\left(\hat{k}_t - (1-\delta)\hat{k}_{t-1}\right)$

Real consumption $\hat{c}_t = E_t\hat{c}_{t+1} - \frac{1}{\sigma}(1+\hat{r}_t)$

Real consumption of imported finished goods $\hat{c}_t^{mcg} = \hat{c}_t$

Real government consumption $\hat{g}_t = \hat{g}_{t-1}$

Real exports $\hat{x}_t = \eta\hat{q}_t + \hat{y}_t^*$

Real imports $i\hat{m}_t = \frac{\overline{im}^{rm}}{\overline{im}} i\hat{m}_t^{rm} + \frac{\overline{im}^{cg}}{\overline{im}} i\hat{m}_t^{cg} + \frac{\overline{im}^{kg}}{\overline{im}} i\hat{m}_t^{kg}$

Real imports of raw material $i\hat{m}_t^{rm} = \hat{y}_t - \hat{p}_t^m$

Real imports of consumption goods $i\hat{m}_t^{cg} = \hat{c}_t^{mcg} = \hat{c}_t$

Real imports of capital goods $i\hat{m}_t^{kg} = i\hat{v}_t$

Real demand for goods $\hat{y}_t = \frac{\bar{c}}{\bar{y}}\hat{c}_t + \frac{\bar{g}}{\bar{y}}\hat{g}_t + \frac{\overline{iv}}{\bar{y}} i\hat{v}_t + \frac{\bar{x}}{\bar{y}}\hat{x}_t - \frac{\overline{im}}{\bar{y}} i\hat{m}_t$

Real output $\hat{y}_t = \alpha_L\hat{A}_t + \alpha_L\hat{l}_t^d + \alpha_K\hat{u}_t + \alpha_K\hat{k}_{t-1} + \alpha_M i\hat{m}_t^{rm}$

Flexible price of output

$$\hat{y}_t^n = \frac{1}{\lambda}\left((1-\hat{\tau}_t^n) - \sigma\hat{c}_t^n\right) + \frac{(\lambda+1)}{\lambda}\left(\hat{A}_t^n - \frac{\alpha_K}{\alpha_L}\hat{z}_t^n - \frac{\alpha_M}{\alpha_L}\hat{q}_t^n\right)$$

Consumer goods inflation $\hat{\pi}_t = (1-\alpha_{mcg})(\hat{\pi}_t^d + e_t^{\varepsilon_t^a}) + \alpha_{mcg}\hat{\pi}_t^m$

Domestic goods inflation $\hat{\pi}_t^d = \beta E_t \hat{\pi}_{t+1}^d + \left(\frac{(1-\theta)(1-\beta\theta)}{\theta}\right) m\hat{c}_t^d$

Imported goods inflation $\hat{\pi}_t^m = \beta E_t \hat{\pi}_{t+1}^m + \left(\frac{(1-\theta^m)(1-\beta\theta^m)}{\theta^m}\right)\hat{q}_t$

Wage inflation
$$\hat{\pi}_t^w = \frac{1}{\theta^w + \gamma^w[1-\theta^w(1-\beta)]}\left[\begin{array}{l}\left(\beta\theta^w\hat{\pi}_{t-1}^w + \gamma^w E_t\hat{\pi}_{t+1}^w\right)\\ + \frac{(1-\gamma^w)(1-\theta^w)(1-\beta\theta^w)}{\lambda+1}\left(\sigma\hat{c}_t - (1-\hat{\tau}_t) + \lambda\hat{y}_t\right)\end{array}\right]$$

Domestic goods' nominal marginal cost $M\hat{C}_t^d = \hat{P}_t + m\hat{c}_t^d$

Imported goods' nominal marginal cost $M\hat{C}_t^m = \hat{P}_t + m\hat{c}_t^m$

Nominal marginal cost of working $M\hat{C}_t^w = \hat{P}_t + m\hat{c}_t^w$

Consumer price $\hat{P}_t = \hat{P}_{t-1} + \hat{\pi}_t$

Domestically-produced goods price $\hat{P}_t^d = \hat{P}_{t-1}^d + \hat{\pi}_t^d$

Import price $\hat{P}_t^m = \hat{P}_{t-1}^m + \hat{\pi}_t^m$

Nominal wage $\hat{W}_t = \hat{W}_{t-1} + \hat{\pi}_t^w$

Real domestic good price $\hat{p}_t^d = \hat{P}_t^d - \hat{P}_t$

Real import price $\hat{p}_t^m = \hat{P}_t^m - \hat{P}_t$

Flexible real import price $\hat{p}_t^{mn} = \hat{q}_t^n - (1-\hat{\tau}_t^n)$

Real wage $\hat{w}_t = \hat{W}_t - \hat{P}_t$

Flexible real wage $\hat{w}_t^n = \frac{1}{\lambda+1}\left(\sigma\hat{c}_t - (1-\hat{\tau}_t) + \lambda\hat{y}_t\right)$

Rental rate of capital $\hat{z}_t = \frac{\bar{r}}{\bar{z}}\hat{r}_t$

Fiscal policy rule $\hat{\tau}_t = \frac{1}{1+\Theta}\left[\hat{\tau}_{t-1} + \frac{\Theta\overline{g}}{\overline{\tau y}}\left(\hat{g}_t - \hat{y}_t\right)\right]$

Fiscal policy rule (flexible price) $\hat{\tau}_t^n = \frac{1}{1+\Theta}\left[\hat{\tau}_{t-1}^n + \frac{\Theta\overline{g}}{\overline{\tau y}}\left(\hat{g}_t^n - \hat{y}_t^n\right)\right]$

Monetary policy rule $\hat{i}_t = \chi\hat{i}_{t-1} + \frac{(1-\chi)\alpha_\pi\overline{\pi}}{\overline{i}}\left[\pi_t - \pi_t^T\right]$

Monetary policy rule (flexible price) $\hat{i}_t^n = \chi\hat{i}_{t-1}^n$

Real interest rate $1+\hat{r}_t = (1+\hat{i}_t) - (1+E_t\hat{\pi}_{t+1})$

2.3 Calibration and Solution

2.3.1 Simulation Scenario and Parameter Calibration

I conducted two one-time positive shocks simulations, which are a one percentage temporary increase in nominal exchange rate and real marginal cost. The former stands for one percentage depreciation of nominal exchange rate shock from its steady-state baseline value. The latter represents a certain adverse shock to production cost other than changes in cost of capital, labour, and importing goods. It is also named as price mark-up shock as the shock changes the mark-up variable of monopolistically-competitive domestic producer.

I applied both shocks on two distinct economies, which are different in production structure, demand structure and degree of domestic and import price rigidities. They are also different in terms of the sensitivity of labour supply, consumption and money demand with respect to real wage, real interest rate and nominal interest rate, respectively, and the level of monetary and fiscal policy target. The feature of the first economy characterises the structure of advanced economies. The economy has a high labour input share relative to capital, moderate import content in production and runs a trade deficit. I suppose that nominal wage, import price and domestic price have the same rigidity, with wages and prices reviewed every year. Monetary authority target is 2 percent of CPI inflation and fiscal authority set the target of fiscal deficit at 1% of GDP. I henceforth name this economy as ‘advanced’ economy.

In contrast, the second economy typifies emerging and less developed economies. Compared to the first economy, the second one has a lower labour share relative to capital goods in its production structure, but with higher import content in production and investment. However, it runs a trade surplus as the export-to-GDP ratio is higher and the share of finished goods imports in total consumption is lower. Consumption intertemporal elasticity of substitution, wage elasticity of labour supply and interest elasticity of real money holding are much lower. Import and domestic price are less rigid than in an ‘advanced’ economy but have the same degree of rigidity for nominal wages. However, I assume that import price is less rigid than domestic price, and domestic price is less rigid than nominal wage. Finally, I assume CPI inflation target and fiscal deficit ratio are higher than in the previous economy, set at 3% and 2% respectively. I name this economy as a ‘developing’ economy, hereafter[7].

I subsequently perform monetary policy simulation in order to observe the role of monetary policy to stabilize the economy following a transient shocks to the nominal rate of exchange and cost of producing domestic goods. Table 1 describes how the two economies differ in parameters. All parameter values are fixed by calibration. I follow other findings on the elasticity of substitution and apply the values for ‘advanced’ economy. Consumption intertemporal elasticity of substitution is set at σ^{-1}=0.5, interest elasticity of real money holding ρ^{-1}=0.5, and real wage elasticity of labour

[7] The word ‘advanced’ and ‘developing’ are in quotes because their economic characteristic are not intended to be considered as those of the representative advanced and developing economies.

supply at λ^{-1}=0.67. I calibrate the elasticity paramater for 'developing' economy to lower than those for 'advanced' economy.

Capital, labour and imported intermediate goods share for 'advanced' economy are set at 0.28, 0.62, and 0.10. The government spending-to-GDP ratio is 0.18 and export-to-GDP ratio 0.2. They are closely infered from average ratio of investment-, import-, export-, and government-to-GDP ratio of UK and US economy. The corresponding parameter values for 'developing' economy borrow the structure of Indonesia's economy, in which capital's, labour's and imported intermediate goods' share are 0.5, 0.35, and 0.15. The higher share of real capital stock in 'developing' than in 'advanced' economy, $(\alpha_K^d > \alpha_K^a)$, implies that although the 'developing' economy is less capital intensive than 'advanced' economy $\left(\frac{k^d}{y^d} < \frac{k^a}{y^a}\right)$, real capital stock in 'developing' economy follows $nmk^a < k^d < mk^a$, where $n = \frac{z^a}{z^d}$ is ratio of 'advanced' to 'developing' economy's real rental rate of capital and $m = \frac{y^d}{y^a}$ is ratio of 'developing' to 'advanced' economy's real output.[8] The ratios are less than unity because the 'developing' economy's interest rate is normally higher than that in 'advance' economy and the 'advanced' economy's output is greater than the 'developing' economy's. Therefore, capital share differential between 'developing' and 'advanced' economy depends on interest rate and income differential.

A larger capital share than labour share corresponds to a higher cost of capital than labor cost. We can find that, in the example of Indonesia's economy, capital share is greater than labour share $(zPk > Wl)$ for capital-to-output ratio equals 3, per capita

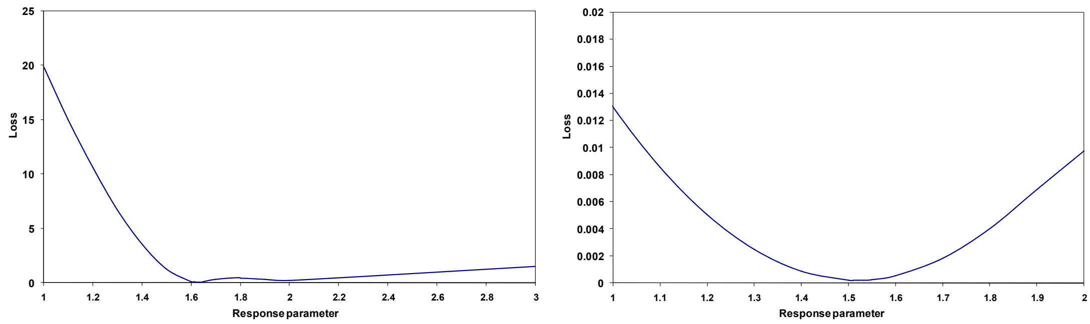
[8] Capital share: $\alpha_K = zk / y$

annual income (W) equals \$1824 and associated values of real GDP and number of employment. This is consistent with the country's gross domestic income that comprises 64% of gross operating surplus and 34% of compensation of employees. In contrast, we can find that in a developed economy like the UK, the cost of capital is lower than labour cost (labour share is greater than capital share), by assuming that the capital-to-output ratio equals 2.26 (Metz et.al, 2004), nominal wage is approximated by per capita annual income of twenty three thousand pounds, and lending rate 7.5 APR. This is in line with the country's gross domestic income that comprises 62% of compensation of employees and 36% of gross operating surplus (Mahajan, 2006).

The firm's, importer's and wage setter's discount factor, β, is set at unity. From consumption Euler equation we get steady-state real interest rate that equals the household's rate of time preference. The setting of real interest rate at 0.02 corresponds to household discount factor, ϑ, at 0.98. Monetary policy response parameter to inflation gap is set at a value that minimizes the present discounted value of dynamic welfare loss over fifty quarters after the shock. The loss function is symmetric of the form $L = E_t \sum_{s=0}^{\infty} \beta_L^{\,s} \left((\pi_{t+s} - \bar{\pi})^2 + (y_{t+s} - \bar{y})^2 \right)$, where monetary policy makers have equal preferences on both inflation and output stabilization. The inflation feedback parameters are contingent on the type of shock that hit the economy. The parameter has also to conform the "Taylor principles" of α_π>1, that the central bank should raise its policy rate more than one-for-one with increases in inflation.

Figure 2.2 and 2.3 illustrate the welfare loss associated with the range of inflation response parameter of monetary policy rules that respond to the future inflation gap in each type of economies. From Figure 2.2 we can calculate that a 0.01 point departure from the optimal values of inflation response coefficient of monetary policy rules costs additional welfare loss of 0.007 and 0.000005, respectively, in ‘developing’ and ‘advanced’ economy. In the case of cost shock in Figure 2.3 the same coefficient difference from the optimal one increases welfare loss by 0.006 and 0.00015 in ‘developing’ and ‘advanced’ economies, correspondingly. It implies that monetary authority in ‘developing’ economy faces a higher risk of making non optimal policy response.

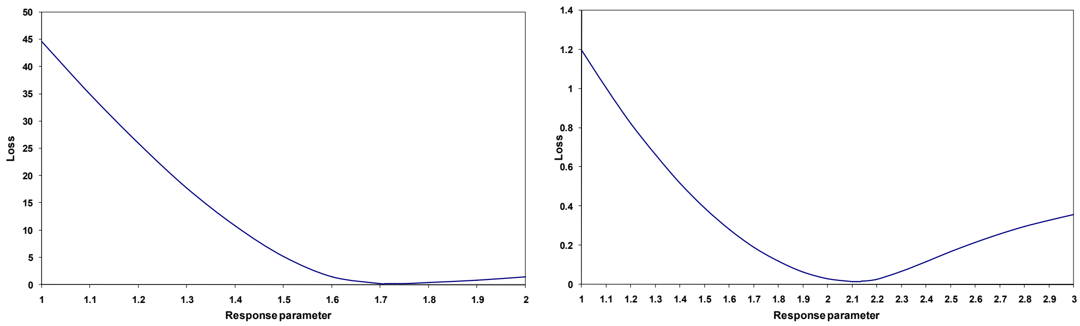
Figure 2.2 Response Parameters and Welfare Loss (Exchange Rate Shock)



‘developing’ economy ‘advanced’ economy

The search of optimal inflation feedback parameter is conducted under fixed interest rate smoothing parameter set at χ=0.5. This parameter values reflect monetary authority behaviour that is equally backward- and forward-looking in setting policy rate. Fiscal policy response parameter is set at Θ=0.5.

Figure 2.3 Response Parameters and Welfare Loss (Cost Shock)



‘developing’ economy ‘advanced’ economy

Degree of domestic price rigidity, θ, is 0.75 for ‘advanced’ economy and 0.5 for ‘developing’ economy implying that the average times between domestic price adjustment are one year and half a year, accordingly. The same rigidity applies for import price setting in 'advanced' economy (θ^m =0.75), but import price is much less rigid in 'developing' economy (θ^m =0.3), implying that the average duration of import price is four months[9]. The parameter setting is mostly based on and adjusted from two surveys. Blinder (1991) found that, on average, US prices stay unchanged in one year. Similar survey for Indonesia's economy by Darsono et al. (2002) found that manufacturing goods prices stay on average of 4.6 months and that exchange rate changes is passed-through to import price in the same quarter. Finally, wage rigidity is presumably the same in both economies (θ^w =0.75), corresponding to yearly nominal wage changes. However, wage changes in 'developing' economy is assumed to heavily based on previous wage inflation and wage setting behavior in 'advanced' economy is more forward looking. These assumptions lead me to set parameter γ^w equals 0.9 and 0.25 correspondingly.

Table 2.1
Model Calibration

Parameter	Description	Values	
		'advanced'	'developing'
ϑ	household's discount factor	0.98	0.98
β	firm's, importer's and wage setters' discount factor	1	1
σ^{-1}	consumption intertemporal elasticity of substitution	0.5	0.008
ρ^{-1}	interest elasticity of real money holding	0.6	0.04
λ^{-1}	real wage elasticity of labour supply	0.67	0.02
δ	depreciation rate of capital	0.01	0.01
α_K	dapital share	0.28	0.5
α_L	labour share	0.62	0.35
α_M	imported intermediate input share	0.10	0.15
α_M^*	share of domestic country's export in the rest of the world's total demand	0.01	0.01
α_{mcg}	share of imported consumption good	0.18	0.14
α_{mkg}	share of imported capital goods investment	0.1	0.14

[9] Devereux and Yetman (2005) noted that pass-through in a small open economy is determined by structural features of the economy, such as the persistence of shocks, and the degree of price stickiness.

α_g	ratio of government expenditure-to-output	0.18	0.08
α_x	ratio of exports-to-output	0.2	0.3
η	price elasticity of exports	0.5	0.1
θ	degree of domestic price stickiness	0.75	0.5
θ^m	degree of import price stickiness	0.75	0.3
θ^w	degree of wage stickiness	0.75	0.75
γ^w	degree of wage indexation to lag inflation	0.25	0.9
ψ	target of fiscal deficit ratio	1%	2%
π^T	target of consumer inflation	2%	3%
χ	degree of interest rate inertia	0.5	0.5
α_π	monetary policy response parameter		
	- exchange rate shock	1.52	1.63
	- cost shock	2.11	1.6
Θ	fiscal policy response parameter	0.5	0.5

2.3.2 Model Solution

In this research I solved the static steady-state model and the log-linearised dynamic model in deviation from steady-state using CONOPT solver under GAMS system. This solver employs Generalized Reduced Gradient method of solution for nonlinear programming problems defined as:

min or max $\boldsymbol{f}(\mathbf{z})$=J=0 (performance index) (6.1)

subject to vector of implicit log-linear functions

$$g(z) = g_t(\mathbf{y}_{t-1},\mathbf{y}_t,\mathbf{y}_{t+1},\mathbf{x}_t;\boldsymbol{\theta},\bar{\mathbf{y}},\bar{\mathbf{x}}) = \begin{bmatrix} g_{1,t}(\mathbf{y}_{t-1},\mathbf{y}_t,\mathbf{y}_{t+1},\mathbf{x}_t;\boldsymbol{\theta},\bar{\mathbf{y}},\bar{\mathbf{x}}) \\ \vdots \\ g_{m,t}(\mathbf{y}_{t-1},\mathbf{y}_t,\mathbf{y}_{t+1},\mathbf{x}_t;\boldsymbol{\theta},\bar{\mathbf{y}},\bar{\mathbf{x}}) \end{bmatrix} = \boldsymbol{0} \qquad (6.2)$$

$$\boldsymbol{l} < \boldsymbol{z} < \boldsymbol{u} \qquad (6.3)$$

where $\boldsymbol{z}$ is vector of optimization variables, $\boldsymbol{l}$ and $\boldsymbol{u}$ are vectors of lower and upper bounds, some of which may be minus or plus infinity, and $\boldsymbol{f}$ and $\boldsymbol{g}$ are differentiable nonlinear functions that define the model. Constraint (6.2) is general constraints and (6.3) is boundary of variables. The objective function $\boldsymbol{f}$ is the variable to be minimized or maximized; $\boldsymbol{m}$ is the number of equations and $\boldsymbol{n}$ denotes number of variables. Vector

z consists of $\mathbf{y}_{t-1}$, $\mathbf{y}_t$, $\mathbf{y}_{t+1}$ and $\mathbf{x}_t$, which are vector of endogenous lag variables, endogenous contemporaneous variables, endogenous lead variables and predetermined exogenous variables, accordingly. $\boldsymbol{\theta}$ is vector of parameter, $\bar{\mathbf{y}}$ is vector of steady-state values of endogenous variables, and $\bar{\mathbf{x}}$ is vector of steady-state values of exogenous variables. For T solution period, the implicit equations for all period are stacked to have a system containing $\boldsymbol{M} = \boldsymbol{mT}$ equations and $\boldsymbol{N} = \boldsymbol{nT}$ variables.

$$\mathbf{g(z)} = \begin{bmatrix} \mathbf{g}_1(\mathbf{y}_0,\mathbf{y}_1,\mathbf{y}_2,\mathbf{x}_1;\boldsymbol{\theta},\bar{\mathbf{y}},\bar{\mathbf{x}}) \\ \mathbf{g}_2(\mathbf{y}_1,\mathbf{y}_2,\mathbf{y}_3,\mathbf{x}_2;\boldsymbol{\theta},\bar{\mathbf{y}},\bar{\mathbf{x}}) \\ \vdots \\ \mathbf{g}_T(\mathbf{y}_{T-1},\mathbf{y}_T,\mathbf{y}_{T+1},\mathbf{x}_T;\boldsymbol{\theta},\bar{\mathbf{y}},\bar{\mathbf{x}} \end{bmatrix} = \begin{bmatrix} g_{1,1}(\mathbf{y}_{1,0},\mathbf{y}_{1,1},\mathbf{y}_{1,2},\mathbf{x}_{1,1}) \\ \vdots \\ g_{m,1}(\mathbf{y}_{m,0},\mathbf{y}_{m,1},\mathbf{y}_{m,2},\mathbf{x}_{m,1}) \\ g_{1,2}(\mathbf{y}_{1,1},\mathbf{y}_{1,2},\mathbf{y}_{1,3},\mathbf{x}_{1,2}) \\ \vdots \\ g_{m,2}(\mathbf{y}_{m,1},\mathbf{y}_{m,2},\mathbf{y}_{m,3},\mathbf{x}_{m,2}) \\ \vdots \\ \vdots \\ g_{1,T}(\mathbf{y}_{1,T-1},\mathbf{y}_{1,T},\mathbf{y}_{1,T+1},\mathbf{x}_{1,T}) \\ \vdots \\ g_{m,T}(\mathbf{y}_{m,T-1},\mathbf{y}_{m,T},\mathbf{y}_{m,T+1},\mathbf{x}_{m,T}) \end{bmatrix} = \mathbf{0} \qquad (6.4)$$

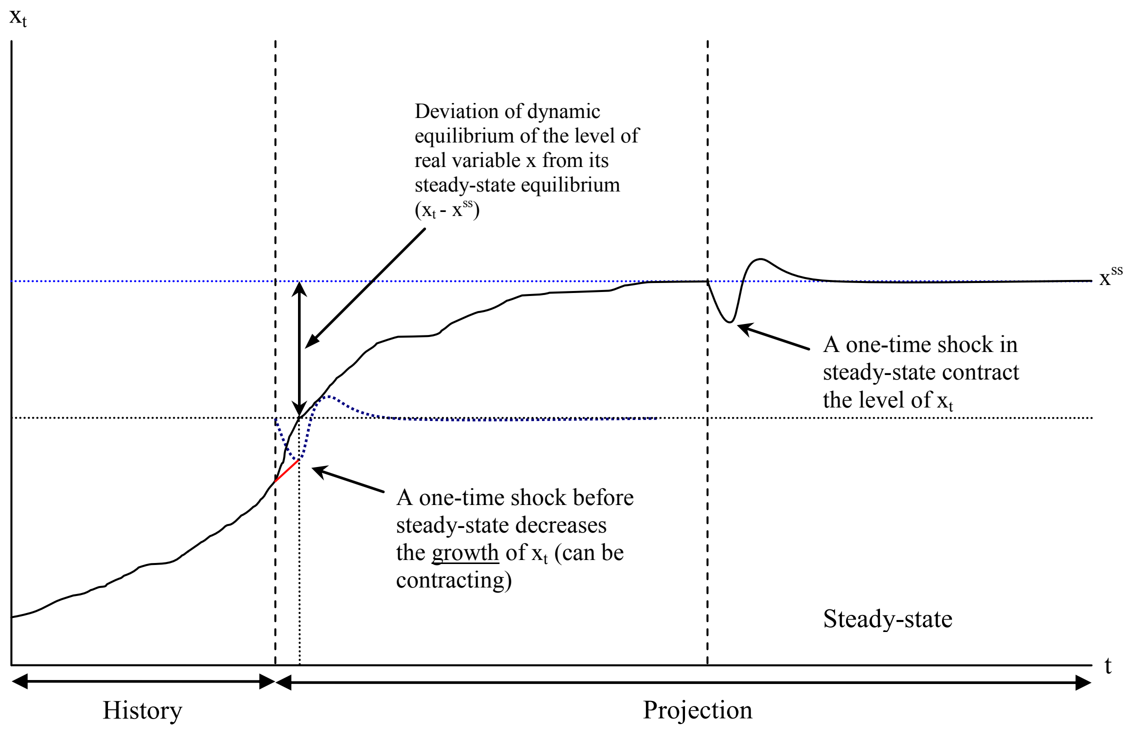
Where $\mathbf{y}_0$ and $\mathbf{y}_{T+1}$ are vector of endogenous lag variables at t=1 and vector of endogenous lead variables at $\boldsymbol{t=T}$, accordingly, which are pre-determined at steady-state values.

2.4 Simulation Results

I examine three issues in this simulation related to how both type of economies differ in their response to temporary exogenous nominal exchange rate and cost-push shock. First, how a transient shock to nominal exchange rate is differently passed-through to import price, domestic price and consumer price in both economies. Second, what is the effect of the two types of shock on output and inflation. Finally, how should monetary policy respond to these shocks.

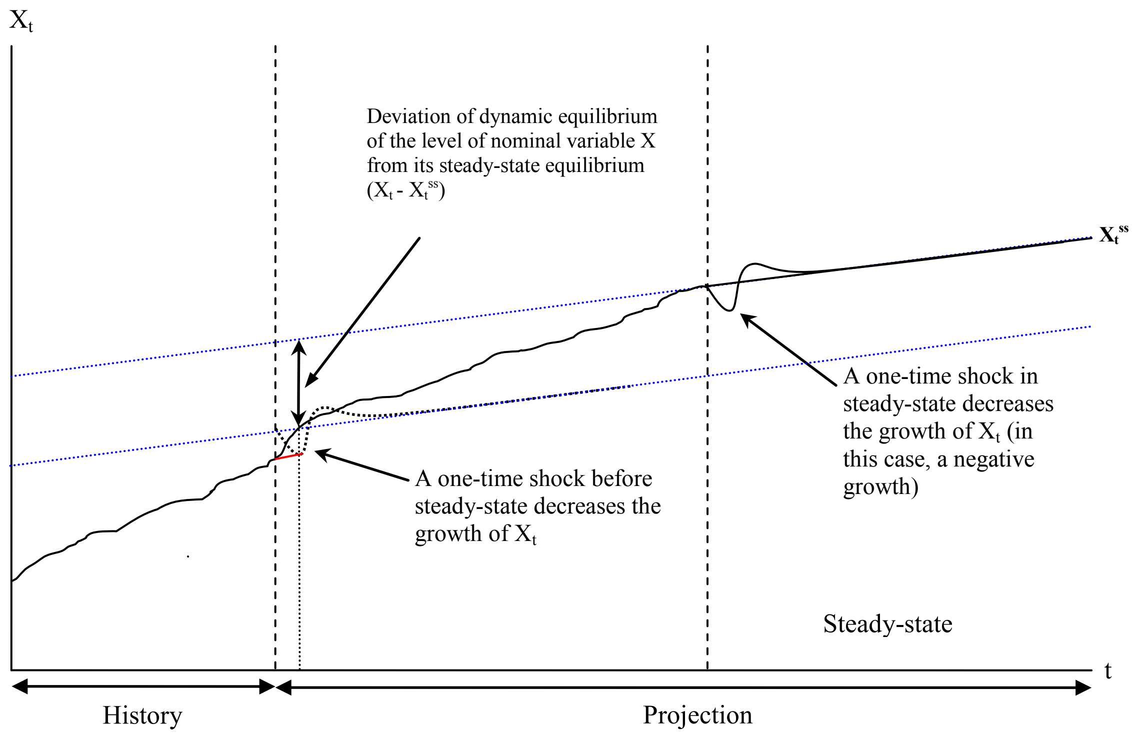
I apply shock simulation to the log-linearised version of the model in deviation from steady-state values. As the lag dependent variables take their steady-state values, it means the shocks simulatedly occur in the steady-state of the economy, in which the level of real variables and growth variables, i.e. inflation, are constant, and the level of nominal variables grows at nonzero constant rates. Hence we need to interpret the simulation result for the actual shocks that occur in the economy before the steady-state, in which the level of real and nominal variables can grow at nonzero rates and the level of growth variables are not necessarily constant.

Figure 2.4 Illustration of shock simulation to a real variable



When we apply a one-time shock in steady-state, the resulted deviation of a real variable from its constant steady-state equilibrium value means either an expansion or a contraction of the level of such real variable. However, when the shock occurs in dynamic state of the economy, which is before steady-state, it will generally result in either an accelerated or a decelerated level of a real variable except that the magnitude of shock is large enough to contract real variables. Therefore, one may interpret an expansion or a contraction of a real variable in steady-state as an increasing or a decreasing growth of a real variable before steady-state. Figure 2.4 illustrates the interpretation of the contraction effect on a given real variable of a one-time simulated shock in steady-state. We can infer similar interpretation for a nominal variable in the case of a one-time shock, in steady-state (Figure 2.5). Meanwhile, the interpretation of the effect on a growth variable of a one-time shock in steady-state is the same with of a one-time actual shock before the steady-state.

Figure 2.5 Illustration of shock simulation to a nominal variable



2.4.1 One-Time Nominal Exchange Rate Shock

We can define exchange rate pass-through in several ways as in the literature. The first one is the narrow definition as, for example, in Campa and Goldberg (2001) that define exchange rate pass-through as how changes in exchange rate are transmitted to imported goods prices. The broader definition of exchange rate pass-through as, for example, in

Devereux (2001) and Devereux and Yetman (2003) is the transmission of exchange rate changes to domestic inflation. It reflects indirect pass-through of exchange rate to CPI price level through changes in aggregate demand and cost of production. Finally, the most general definition reflects the farthest and complete transmission of exchange rate to CPI inflation through the price of imported intermediate goods, domestically produced goods, and imported consumption goods. It covers both direct and indirect pass-through through domestic inflation and direct pass-through through imported consumption goods inflation.

Figure 2.8 shows the simulation result under the assumption of fully forward looking price setter. The short-run exchange rate pass-through to import price in ‘developing’ economy is much higher than that in ‘advanced’ economy. It is due to the effect of lower import price rigidity in ‘developing’ economy. One percent of nominal exchange rate depreciation from steady-state level increases import price by 1.41 percent in the quarter when the shock occurs. However, import price decreases below its steady-state level in the quarters following the shock as real exchange rate appreciates from its steady-state value. In ‘advanced’ economy, the immediate short-run exchange rate pass-through to import price is 0.077 meaning that only 7.7% of one-time nominal exchange rate shock is passed-through to import price at the immediate quarter.

Domestic price in ‘developing’ economy increases to a peak level of 0.22 percent deviation from steady-state at 9^{th} quarters. It finally stays slightly below initial steady-state in the long run. The price of domestically produced goods in ‘advanced’ economy gradually increases to a peak level of 0.0053 percent deviation from its steady-state at 18^{th} quarters, then decreases to a slightly new higher steady-state in the long run. The existence of nominal wage stickiness amplifies the role of domestic price rigidity in absorbing the impact of nominal exchange rate shock to domestic price. In domestic price setting, exchange rate pass-through to import prices is off-set by lowered real wages in both economies. Exchange rate pass-through to import prices is also overrided by policy response in ‘advanced’ economy of reducing interest rate that decreases cost of capital.

The immediate exchange rate pass-through to consumer prices is less than the pass-through to import price. It is due to the presence of direct exchange rate pass-through from import prices to consumer prices through consumption imported goods. The discrepancy between exchange-rate pass-through to domestic prices and to consumer prices is higher in the ‘developing’ economy than that in 'advanced' economy because of large difference in import price rigidity. The immediate exchange rate pass-through to consumer price in ‘developing’ economy is 0.26, much lower than the immediate pass-through to import price (1.41). The pass-through to consumer prices in ‘advanced’ economy is only 0.014, compared to the immediate pass-through to import price of 0.077 and immediate pass-through to domestic price of 0.0006. The discrepancy will even be higher in ‘developing’ economy if the share of imported consumption goods in total consumption is larger.

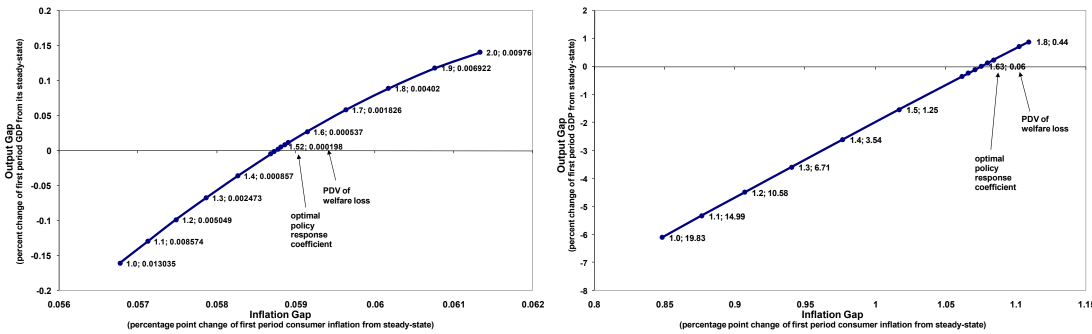
The results that the exchange rate pass-through to import, domestic and overall consumer prices in ‘developing’ economy are higher than in ‘advanced’ economy conform the view highlighted by Calvo and Reinhart (2002), and empirically supported by, for example, Devereux and Yetman (2005). They found that exchange rate shocks in emerging market economies tended to feed into aggregate inflation at a much faster rate than in industrial economies. Furthermore, the result on exchange rate pass-through is consistent with Ambler, et al. (2004). They conclude that sticky imported-goods prices due to pricing to market are sufficient to generate slow exchange rate pass-through, but not necessary as nominal wage and domestic prices rigidities also result in slow exchange rate pass-through to consumer price.

The central bank in ‘advanced’ economy needs to respond to the after-shocks lowered expected inflation by decreasing interest rate contemporaneously and returning it back to around the steady-state level in the long run. However, the ex-ante real interest rate increases due to expected future lower inflation that is less than decreases in nominal interest rates. The upward adjustment in real interest rate lowers consumption and investment. Nominal exchange rate shock boosts exports but reduces imports causing an increase in net exports that outweighs decreases in consumption and investment. Therefore, one-time exchange rate depreciation can have expansionary effect on output in ‘advanced’ economy.

Nominal interest rate in ‘developing’ economy is slightly increased and stays above the steady-state in the early periods after shock. On the other hand, consumer inflation is still above the steady-state several periods after the shocks resulting in an immediate slightly lower real interest rate. However, the smaller real interest rate has an insignificant effect on consumption as consumption intertemporal elasticity of substitution is exceedingly small. Thus, consumption slightly decreases. Investment also contracts since the expected lower future demand for output is larger than the decreases in real rental rate of capital. Unfortunately, exchange rate depreciation does not boost up exports much while imports suffer. The immediate net effect of depreciation on ‘developing’ economy’s output is expansionary followed by contractionary.

By varying monetary policy response parameters, we can find short run trade-off between inflation gap and output gap (Figure 2.6). A more active monetary policy, in this case the one that result in a larger nominal interest rate decline, leads to a higher short run output expansion but at the cost of higher increase in inflation. This finding is inline with what Ravenna & Walsh (2006) found that, in the presence of cost channel of monetary policy, any shock to the economy generates a trade-off between stabilizing inflation and stabilizing discrepancy between actual output and its flexible-price level. The figures also illustrate that short run trade-off between output gap and inflation gap is larger in 'developing' economy. Sacrifice ratio, which is the output gap reduction for one percentage point decrease in inflation, in 'developing' economy is about 2.4 times higher than in 'advanced' economy. It reflects output contraction and output expansion effect of depreciation in 'developing' and 'advanced' economy, respectively.

Figure 2.6 Short run trade-off between output gap and inflation gap



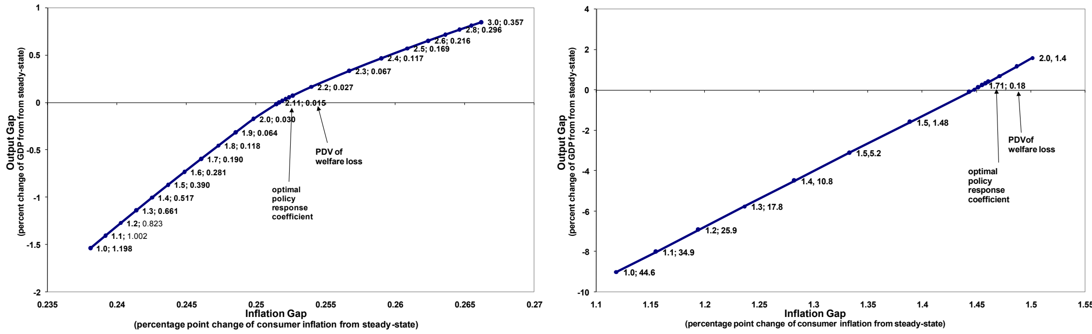
'advanced' economy 'developing' economy

2.4.2 One-Time Cost-Push Shock

Figure 2.9 exhibit the response of economic variables to a one-time cost-push shock under the assumption that inflation expectation is fully forward looking. The shock causes domestic and consumption inflation to jump contemporaneously, followed by quarters of lowered inflation below the steady-state level in 'developing' economy. Higher rigidity of prices in 'advanced' economy leads to a more persistent inflation. The effect of the shock on domestic and consumer inflation is reduced by smaller imported goods inflation. The economy with a low nominal rigidity experiences a higher inflation effect of the shock.

The recommended monetary authority response to the cost shock in 'developing' economy is lowering interest rate. However, ex-ante real interest rate increases because expected future inflation is much lower than decreases in nominal interest rate. Inflation in 'developing' economy is easier to get lower than in 'advanced' economy since domestic price in this economy is assumed to be symmetrically less rigid than in 'advanced' economy. As a result, investment and consumption go down contemporaneously. As the shock lowers the relative price between foreign and domestic goods in larger magnitude than nominal exchange rate depreciation, real exchange rate appreciates. Consequently, external demand for domestic goods declines. Thus, the cost shock effect on output and employment is contractionary.

Figure 2.7 Short run trade-off between output gap and inflation gap



'advanced' economy 'developing' economy

Following the price increases caused by a shock to marginal cost, monetary authority in 'advanced' economy should slightly increase nominal interest rate. However, inflation is more persistent in the subsequent period that results in an immediate lower real interest rate. However, consumption goes down because the effect of expected future consumption is greater than of real interest rate. Expected output also dominates real rental rate of capital in affecting demand for capital goods and investment. Combined with the effect of real exchange rate appreciation on exports, the cost shock effect on 'advanced' economy's output is also contractionary.

This shock simulation also found a short-run trade-off between inflation gap and output gap in both economies (Figure 2.7). A higher monetary policy response coefficient, which corresponds to a larger decline in nominal interest rate, leads to a higher output expansion and a higher inflation. Sacrifice ratio in ‘developing’ economy is about 3 times higher than in ‘advanced’ economy.

2.5 Conclusion

In this paper I investigate how economic players in two distinctive open economies behave differently in responding to one-time exogenous shock to nominal exchange rate and cost of production, using a new Keynesian dynamic general equilibrium model that features wage and prices stickiness and includes cost channel of monetary policy to inflation. The economies differ in the structure of economic output, sensitivity of agents’ economic decision on price of money, goods and labour, and most importantly, in degree of nominal prices and wage rigidity.

Regarding the effect of exchange rate shocks on inflation, I found that degree of import price rigidity is not the only factor that affects the strength of exchange rate pass-through to consumer inflation. It is also affected by degree of nominal wage and domestic price stickiness, degree of production dependency on imported input, share of imported consumption goods in total consumption, and monetary policy response. A lower wage and prices stickiness, higher dependency on imports and a more loose monetary policy, will worsen the effect of temporary nominal exchange rate depreciation to consumer prices.

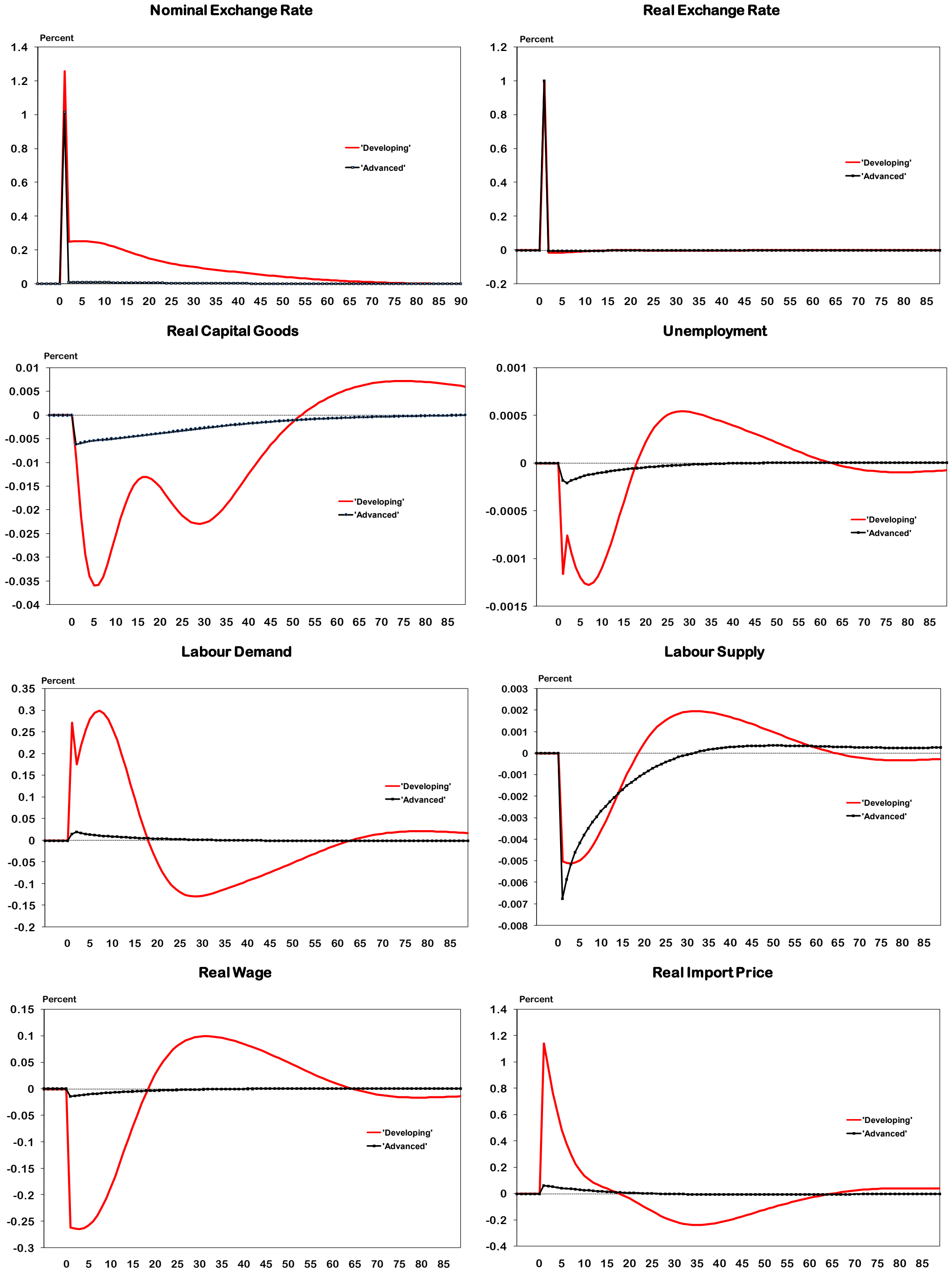
The finding with regard to monetary policy response to cost shock is different with the result in Clarida et al. (1999). They show that in the presence of exogenous cost-push shock, the near-term inflation can only be reduced by increasing interest rate. Consequently, they conclude that an extreme inflation targeting, in the sense that the policy is adjusted to reach an inflation target immediately, is optimal under only one of two circumstances: (1) cost push inflation is absent; or (2) there is no concern for output deviations. In contrast, this paper shows that the transitory nature of cost-push shock combined with rational expectation behaviour of price setter, symmetric low rigidity of domestic price and less persistence of inflation does not lead the monetary authority in 'developing' economy to immediately respond to the shock by conducting tight monetary policy.

Finally, it is essential to point out that, the findings in this paper, particularly on the monetary policy implication, might be dissimilar under the presence of covered interest rate parity and when the shock is more persistent. Moreover, it could be intriguing to investigate the policy implication under lower input price elasticity of demand for factor input.

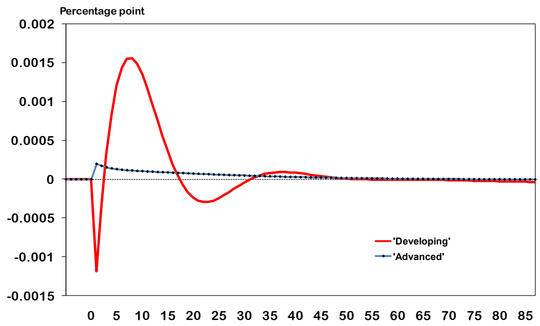
Appendix

A. Figures of Simulation Results

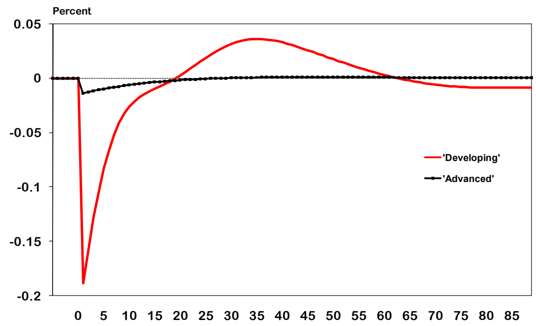
Figure 2.8 Responses to One-Time Nominal Exchange Rate Shock



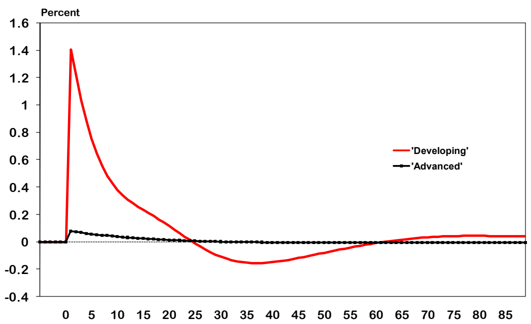
Real Rental Rate of Capital



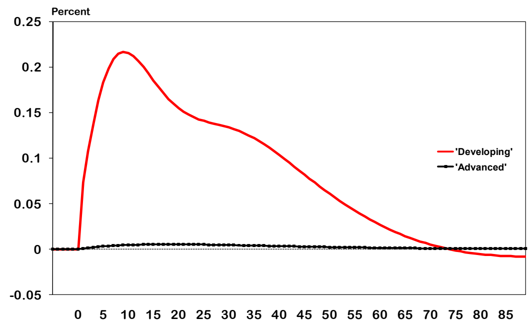
Real Domestic Price



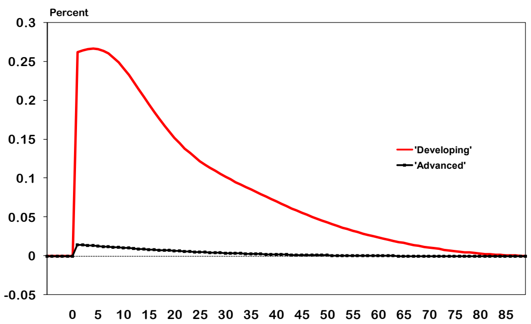
Import Price



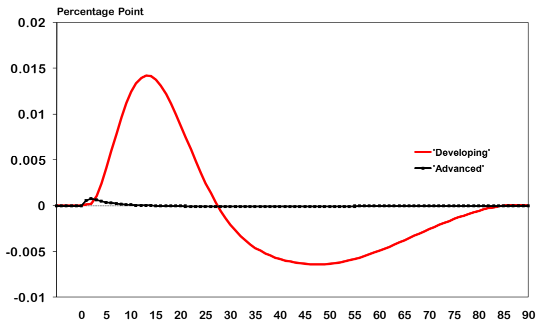
Domestic Price



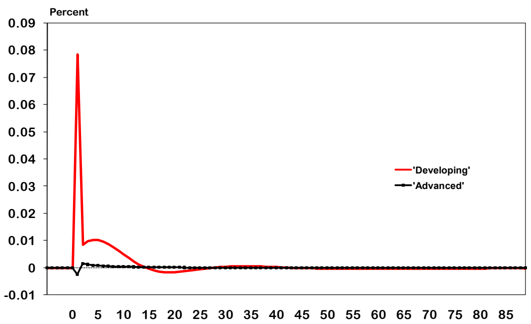
Consumer Price



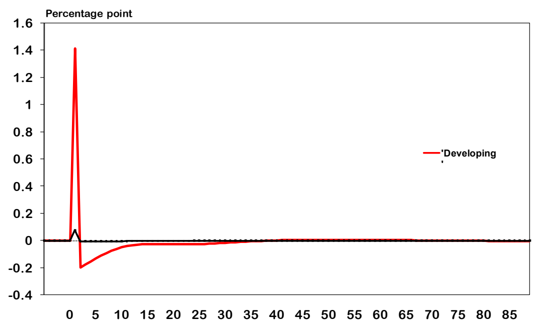
Wage Inflation (qtq)



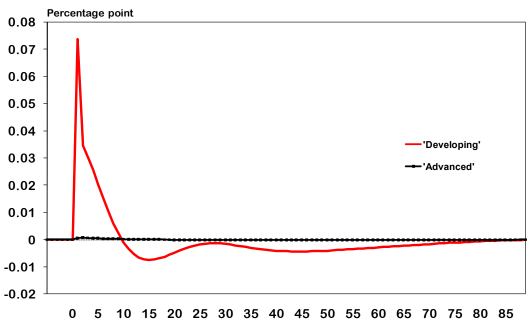
Real Marginal Cost



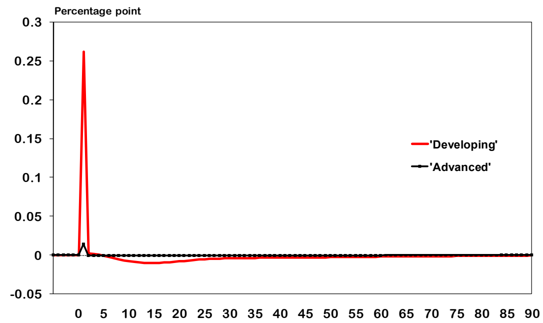
Imported Goods Inflation (qtq)



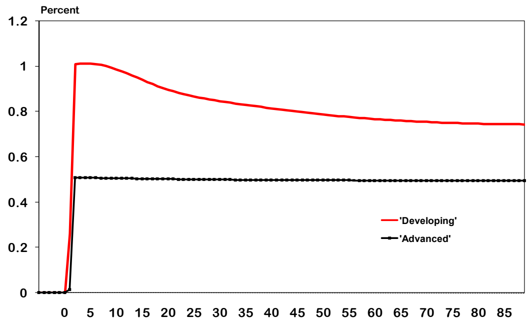
Domestic Inflation (qtq)



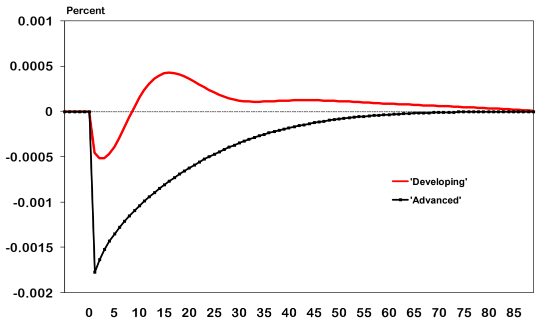
Consumer Inflation (qtq)



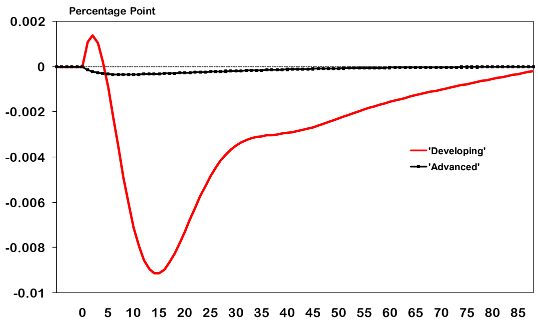
Money Balance



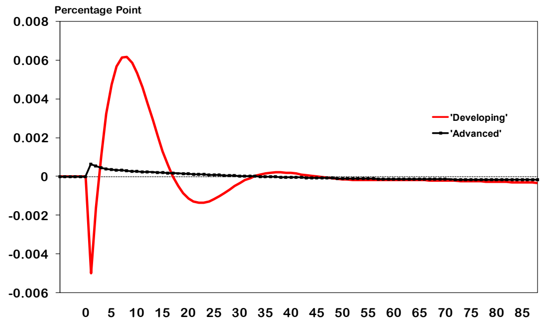
Real Money Balance



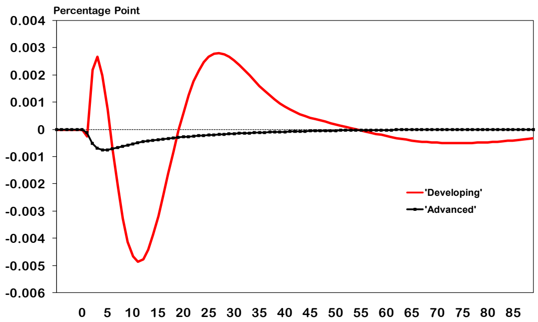
Nominal Interest Rate (p.a)



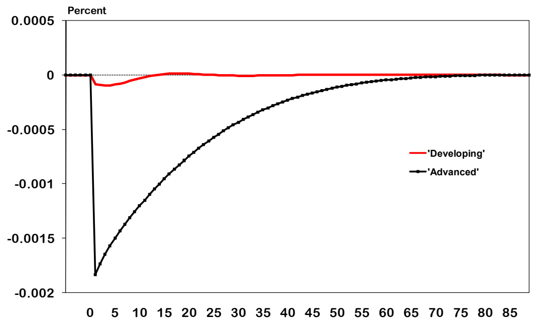
Real Interest Rate (p.a)



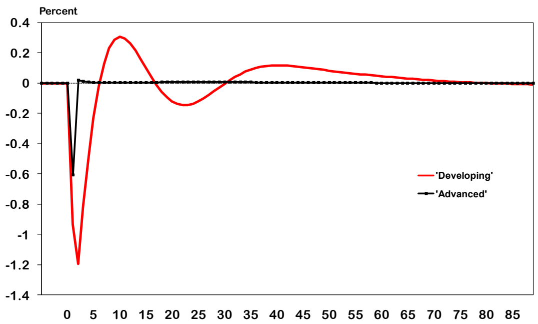
Tax Rate



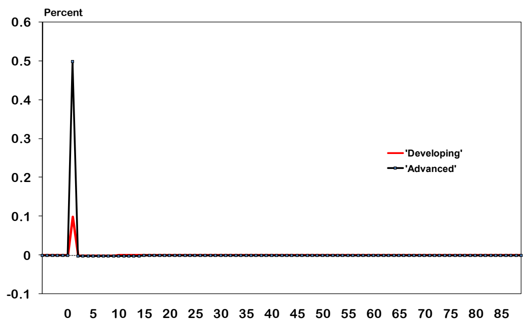
Real Consumption



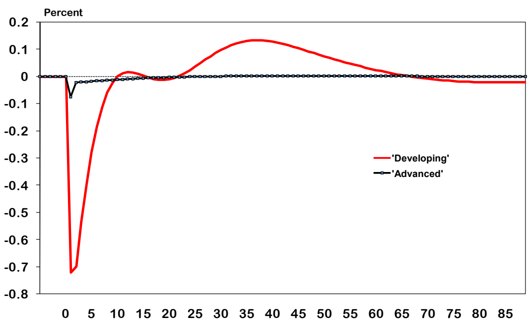
Real Investment



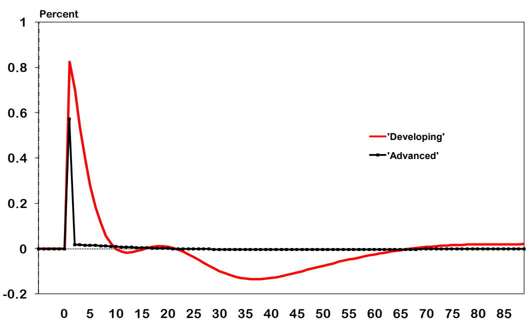
Real Exports



Real Imports



Export to Import Ratio



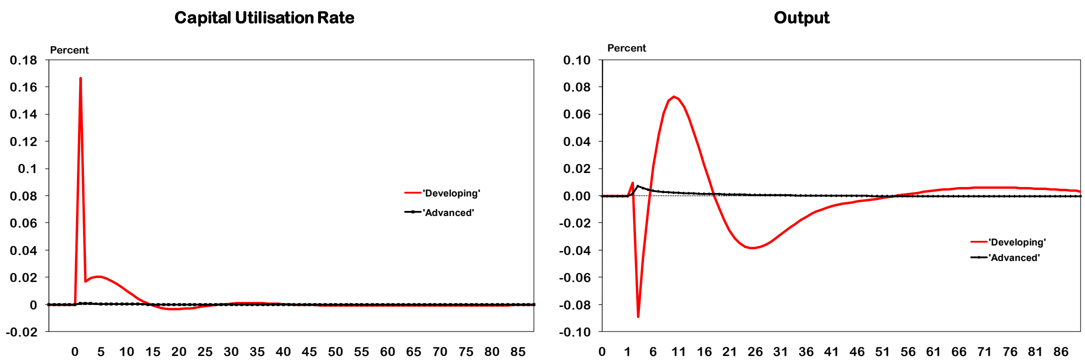
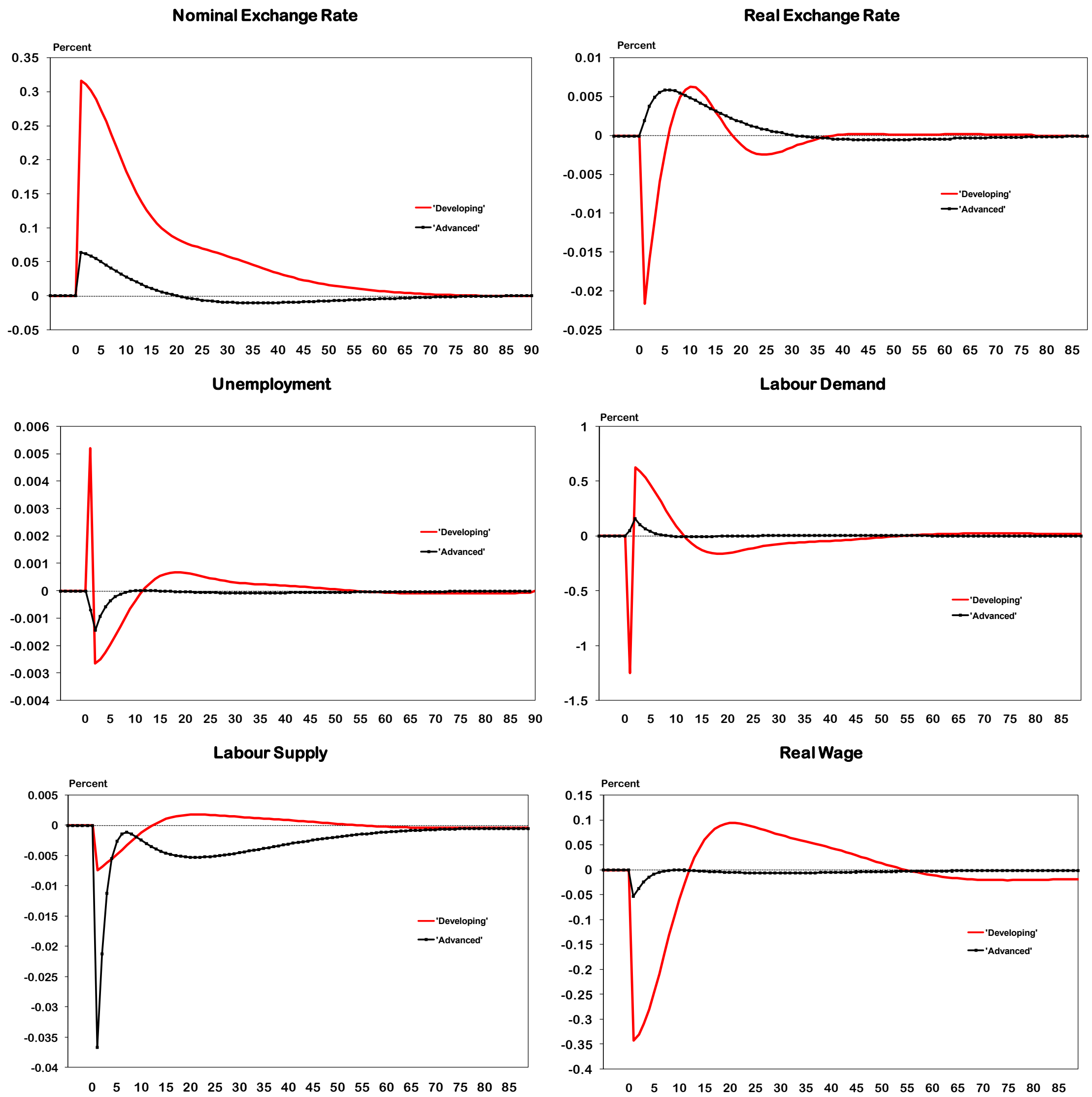
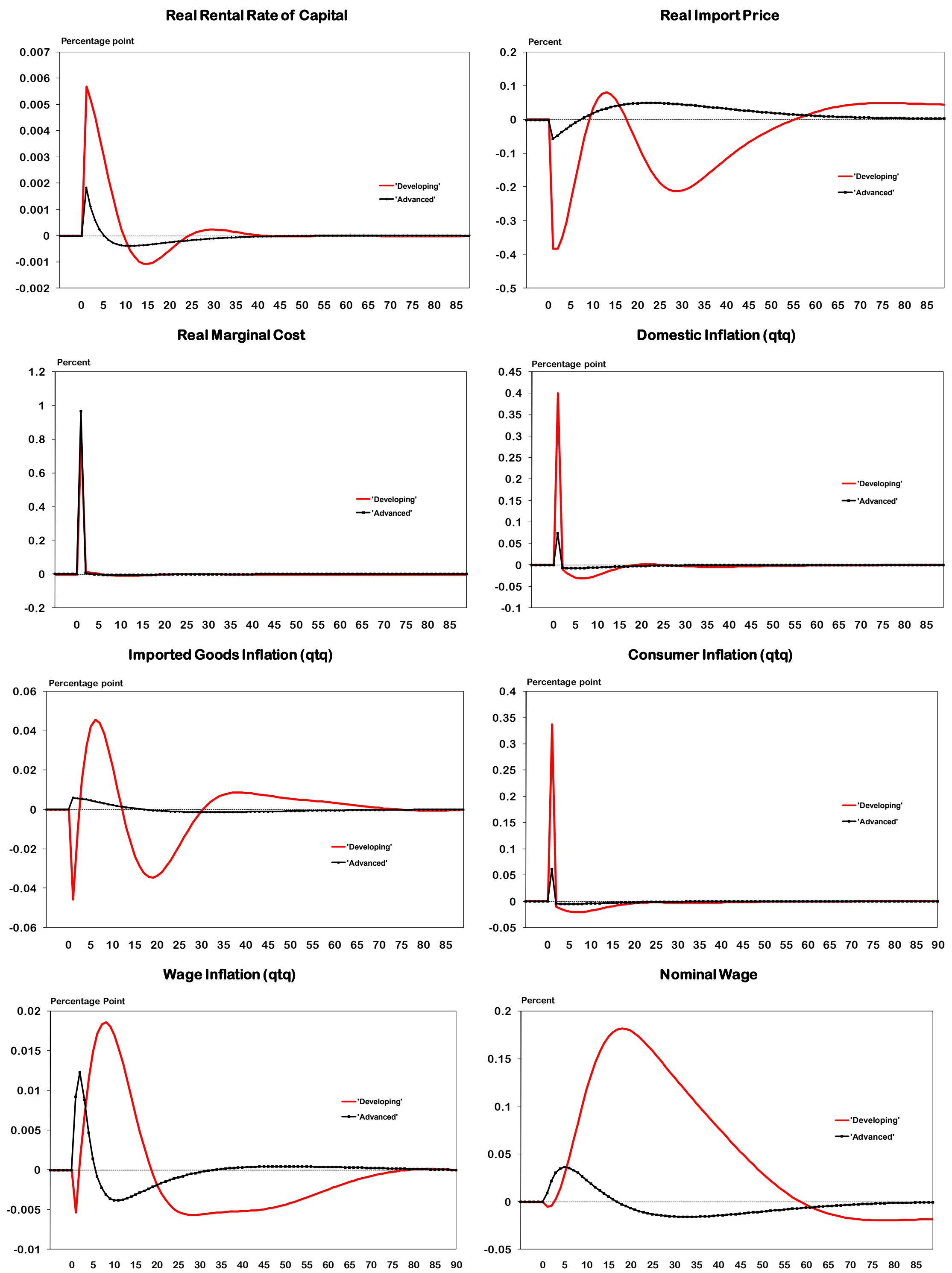
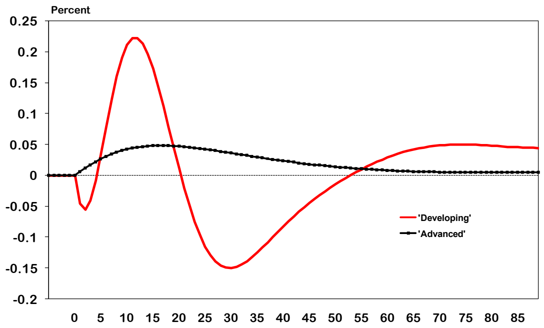


Figure 2.9 Responses to One-Time Cost-Push Shock

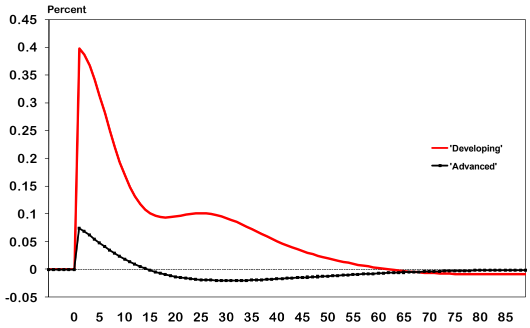



Real Rental Rate of Capital
Percentage point
'Developing'
'Advanced'
Real Import Price
Percent
'Developing'
'Advanced'
Real Marginal Cost
Percent
'Developing'
'Advanced'
Domestic Inflation (qtq)
Percentage point
'Developing'
'Advanced'
Imported Goods Inflation (qtq)
Percentage point
'Developing'
'Advanced'
Consumer Inflation (qtq)
Percentage point
'Developing'
'Advanced'
Wage Inflation (qtq)
Percentage Point
'Developing'
'Advanced'
Nominal Wage
Percent
'Developing'
'Advanced'

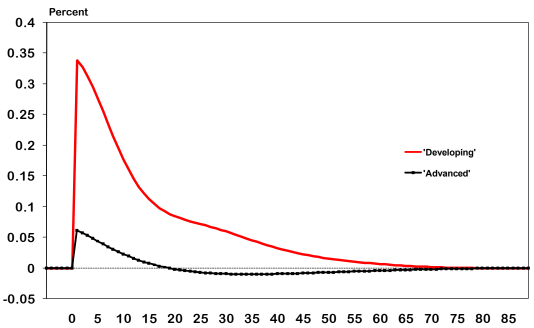
Import Price



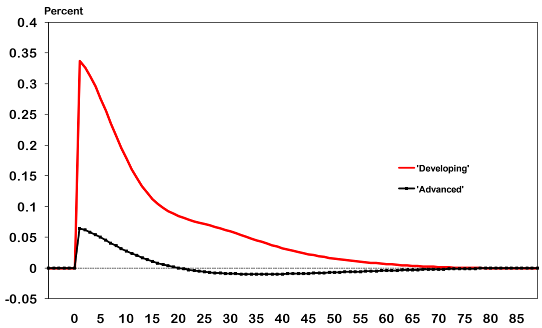
Domestic Price



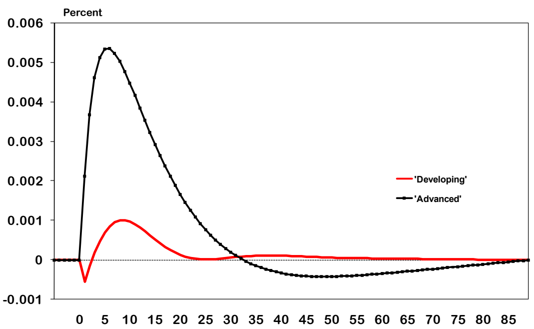
Consumer Price



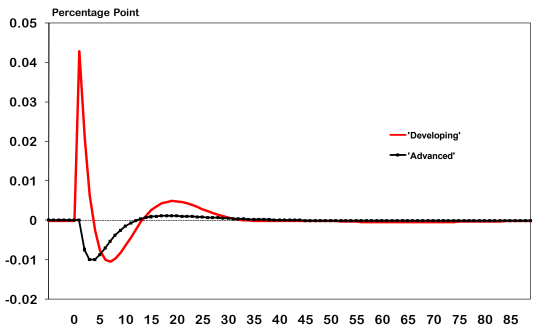
Money Balance



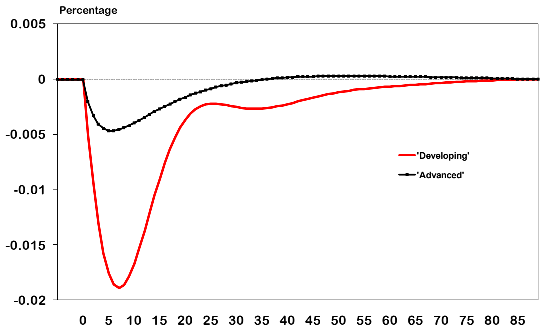
Real Money Balance



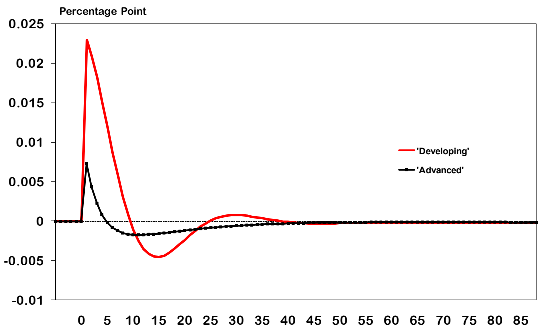
Tax Rate



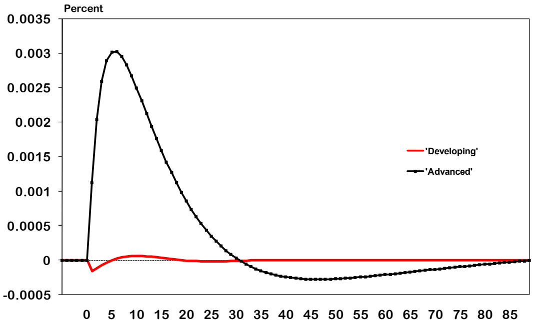
Nominal Interest Rate (p.a)



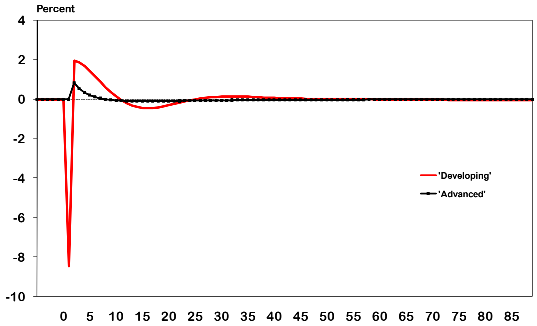
Real Interest Rate (p.a)



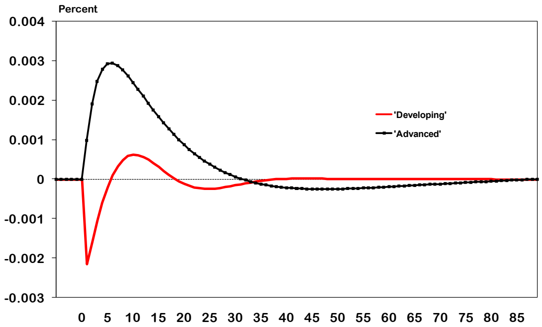
Real Consumption



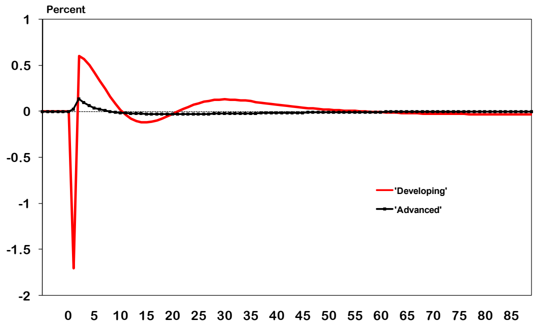
Real Investment



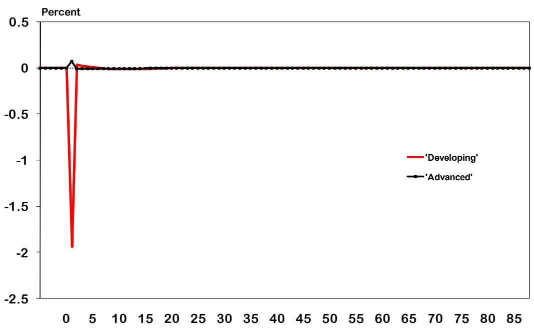
Real Exports



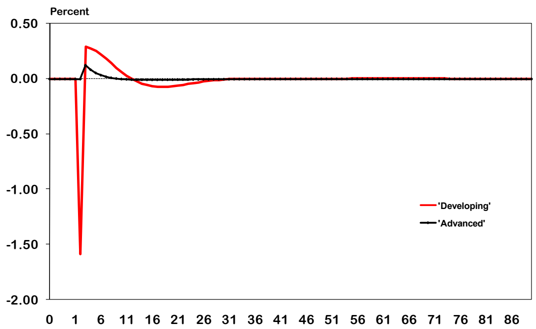
Real Imports



Capital Utilisation Rate



Output



B. Source code

B.1 Dynamic Model in deviation from steady-state

```
***********************************************
* SECTION 1 : DEFINITION & VALUES OF PARAMETER *
***********************************************
SCALARS
*----------------------------------------------------------
* Steady-state values
*----------------------------------------------------------
mss             money demand                    /1.287125/
Ldss            labour demand                   /0.7866524/
Lsss            labour supply                   /0.7866524/
wss             real wage                       /1.406705/
Ass             technology                      /1/
kss             capital stock                   /24.923273/
ivss            investment                      /0.24923273/
css             consumption                     /1.29361/
gss             government expenditure          /0.321267/
xss             exports                         /0.356964/
imss            imports                         /0.436255/
imcgss          imports of consumption goods    /0.23285/
imrawss         imports of intermediate goods   /0.178482/
imkgss          imports of capital goods        /0.024923/
yss             aggregate demand = output       /1.784819/
ynss            natural output                  /1.784819/
piss            CPI inflation                   /0.02/
piqss           CPI inflation qtq               /0.004963/
pidss           domestic inflation              /0.02/
pidqss          domestic inflation qtq          /0.004963/
pimss           import price inflation          /0.02/
pimqss          import price inflation qtq      /0.004963/
piwss           wage inflation                  /0.02/
piwqss          wage inflation qtq              /0.004963/
pifss           foreign inflation               /0.02/
pifqss          foreign inflation qtq           /0.004963/
pitargetss      inflation target                /0.02/
pitargetqss     inflation target qtq            /0.004963/
tauss           tax rate                        /0.17/
taunss          tax rate                        /0.17/
rss             real interest rate              /0.020408/
rqss            real interest rate qtq          /0.005063/
rfss            foreign real int. rate          /0.020406/
rfqss           foreign real int. rate qtq      /0.005063/
iss             nominal interest rate           /0.040818/
iqss            nominal interest rate qtq       /0.010052/
irfss           foreign nominal int. rate       /0.040818/
irfqss          foreign nom int rate qtq        /0.010052/
qss             real exchange rate              /1/
mcdss           real marginal cost of domestically-produced goods /1/
mcmss           real marginal cost of imported goods /1/
mcwss           real marginal cost of working   /1.406705/
pmss            real import price               /1/
pdss            real domestic price             /1/
zss             real rental price               /0.082651/
zqss            real capital rental qtq         /0.020052/
yfss            foreign output                  /35.696383/
uss             capital utilization rate        /1/
unemss          unemployment                    /0/
*---------------------------------------------------------------------------
* Policy parameter
*---------------------------------------------------------------------------
chi             degree of interest rate inertia                        /0.5/
alphapi         monetary policy response to inflation gap              /1.1/
uptheta         fiscal policy response parameter                       /0.5/
psi             target of fiscal deficit ratio                         /0.01/
s_teta          household discount factor /0.98/
beta            producers's and importer's and wage setter's discount factor /1/
sigma           relative risk aversion (inverse of consumption intertemporal elasticity of
substitution) /2/
rho             inverse of interest rate elasticity of real money balance /2/
lambda          inverse of wage elasticity of labour supply     /1.5/
delta           depreciation rate                               /0.01/
aK              capital share                                   /0.28/
aL              labor share                                     /0.62/
aM              intermediate import share                       /0.10/
aMf             share of export in foreign economy total demand /0.01/
eta             price elastity of export                        /0.5/
simcg           share of finished goods imports in consumption  /0.18/
sa              technology AR parameter /0/
syf             foreign output AR parameter /0/
spif            foreign inflation AR parameter /0/
sirf            foreign interest rate AR parameter /0/
```

```
smu              markup shock AR parameter /0/
sg               govt spending shock AR parameter /0/
ser              nominal exchange rate shock AR parameter /0/
sq               real exchange rate shock AR parameter /0/
sc               consumption shock AR parameter /0/
spitgt           inflation target shock AR parameter /0/
aa               preference weight for inflation stabilization in loss function /0.5/
discfactor       discount factor for loss function                              /0.98/
theta            degree of price stickiness                                     /0.75/
gamma            degree of price backward lookingness                           /0/
thetaim          degree of import price stickiness                              /0.75/
gammaim          degree of import price backward lookingness                    /0/
thetaw           degree of wage stickiness                                      /0.75/
gammaw           degree of wage indexation                                      /0.25/
theta_flex       degree of price stickiness when price is perfectly flexible
/0.0000000000000000000000000001/
gamma_flex       degree of backward looking when price is perfectly flexible    /0/
si               constant for NKPC
gammab           parameter backward looking in NKPC
gammaf           parameter forward looking in NKPC
lambdakros       parameter of real marginal cost in NKPC
sim              constant for NKPC
gammaimb         parameter backward looking in NKPC import goods inflation
gammaimf         parameter forward looking in NKPC import goods inflation
lambdakrosim     parameter of real marginal cost in NKPC import goods inflation
siw              constant for NKPC
gammawb          parameter backward looking in NKPC wage inflation
gammawf          parameter forward looking in NKPC wage inflation
lambdakrosw      parameter of real marginal cost in NKPC wage inflation
si_flex          constant for flexible NKPC
gammab_flex      parameter backward looking in flexible NKPC
gammaf_flex      parameter forward looking in flexible NKPC
lambdakros_flex  parameter of flexible real marginal cost in flesible NKPC ;
si               = theta   + gamma  *(1-theta*(1-beta));
gammaf           = beta*theta*(1/si);
gammab           = gamma*(1/si);
lambdakros       = (1-gamma)*(1-theta)*(1-beta*theta)*(1/si);
sim              = thetaim + gammaim*(1-thetaim*(1-beta));
gammaimf         = beta*thetaim*(1/sim);
gammaimb         = gammaim*(1/sim);
lambdakrosim     = (1-gammaim)*(1-thetaim)*(1-beta*thetaim)*(1/sim);
siw              = thetaw  + gammaw *(1-thetaw*(1-beta));
gammawf          = beta*thetaw*(1/siw);
gammawb          = gammaw*(1/siw);
lambdakrosw      = (1-gammaw)*(1-thetaw)*(1-beta*thetaw)*(1/siw);
si_flex          = theta_flex + gamma_flex  *(1-theta_flex*(1-beta));
gammaf_flex      = beta*theta_flex*(1/si_flex);
gammab_flex      = gamma_flex*(1/si_flex);
lambdakros_flex  = (1-gamma_flex)*(1-theta_flex)*(1-beta*theta_flex)*(1/si_flex);
************************************
* SECTION 2 : SOLUTION TIME HORIZON *
************************************
SETS
t                extended solution horizon         /0*50/
te(t)            effective solution horizon        /1*49/
ttemporer(t)     period for temporary shocks       /1*1/
ttemporer1(t)    period for after one time shocks  /2*2/
tpermanen(t)     period for permanent shocks       /1*50/
tloss(t)         period for calculating total loss /1*49/
t0(t)            period zero
tf(t)            final period;
t0(t)            = yes$(ord(t) eq 1);
tf(t)            = yes$(ord(t) eq (card(t)));
*****************************************************
* SECTION 5: DEFINITION OF ENDOGENOUS & POLICY VARIABLE
*****************************************************
JD(t)..          J =E= 0;
eq1(t+2)..       log(er(t+1))        =E= log(erss(t+1)) + (log(er(t+2))-log(erss(t+2))) +
(log(1+irfq(t+1))-log(1+irfqss)) - (log(1+iq(t+1))-log(1+iqss)) + eps_er(t+1);
eq1n(t+2)..      log(ern(t+1))       =E= log(erss(t+1)) + (log(ern(t+2))-log(erss(t+2))) +
(log(1+irfqn(t+1))-log(1+irfqss)) - (log(1+iqn(t+1))-log(1+iqss)) + eps_er(t+1);
eq2(t+2)..       log(q(t+1))         =E= log(qss) + (log(er(t+1))-log(erss(t+1))) + (log(pf(t+1))-
log(pfss(t+1))) - (log(p(t+1))-log(pss(t+1))) + eps_q(t+1);
eq2n(t+2)..      log(qn(t+1))        =E= log(qss) + (log(ern(t+1))-log(erss(t+1))) + (log(pf(t+1))-
log(pfss(t+1))) - (log(pn(t+1))-log(pss(t+1))) + eps_q(t+1);
eq3(t+2)..       log(m(t+1))         =E= log(mss) + (sigma/rho)*(log(c(t+1))-log(css)) -
(1/rho)*(iq(t+1)-iqss);
eq4(t+2)..       log(Ls(t+1))        =E= log(Lsss) - sigma/lambda*(log(c(t+1))-log(css)) +
(1/lambda)*(log(w(t+1))-log(wss)) + (1/lambda)*(log(1-tau(t+1))-log(1-tauss));
eq4n(t+2)..      log(Lsn(t+1))       =E= log(Lsss) - sigma/lambda*(log(cn(t+1))-log(css)) +
(1/lambda)*(log(wn(t+1))-log(wss)) + (1/lambda)*(log(1-taun(t+1))-log(1-tauss));
eq5(t+2)..       log(Ld(t+1))        =E= log(Ldss) + (log(y(t+1))-log(yss)) - (log(w(t+1))-log(wss));
eq5n(t+2)..      log(Ldn(t+1))       =E= log(Ldss) + (log(yn(t+1))-log(yss)) - (log(wn(t+1))-
log(wss));
eq6(t+2)..       log(A(t+1))         =E= log(Ass) + sa*(log(A(t))-log(Ass)) + log(1+eps_A(t+1));
eq6n(t+2)..      log(An(t+1))        =E= log(Ass) + sa*(log(A(t))-log(Ass)) + log(1+eps_A(t+1));
eq7(t+2)..       log(k(t+1))         =E= log(kss) + (log(y(t+2))-log(yss)) - (log(zq(t+1))-
log(zqss));
```

```
eq7n(t+2)..      log(kn(t+1))       =E= log(kss) + (log(yn(t+2))-log(yss)) - (log(zqn(t+1))-
log(zqss));
eq8(t+2)..       log(iv(t+1))       =E= log(ivss) + (kss/ivss)*((log(k(t+1))-log(kss)) - (1-
delta)*(log(k(t))-log(kss)));
eq8n(t+2)..      log(ivn(t+1))      =E= log(ivss) + (kss/ivss)*((log(kn(t+1))-log(kss)) - (1-
delta)*(log(kn(t))-log(kss)));
eq9(t+2)..       log(c(t+1))        =E= log(c(t+2)) - (1/sigma)*(log(1+rq(t+1))-log(1+rqss)) +
eps_c(t+1);
eq9n(t+2)..      log(cn(t+1))       =E= log(cn(t+2)) - (1/sigma)*(log(1+rqn(t+1))-log(1+rqss)) +
eps_c(t+1);
eq10(t+2)..      log(g(t+1))        =E= log(gss) + sg*(log(g(t))-log(gss)) + eps_g(t+1);
eq10n(t+2)..     log(gn(t+1))       =E= log(gss) + sg*(log(gn(t))-log(gss)) + eps_g(t+1);
eq11(t+2)..      log(x(t+1))        =E= log(xss) + eta*(log(q(t+1))-log(qss)) + (log(yf(t+1))-
log(yfss));
eq11n(t+2)..     log(xn(t+1))       =E= log(xss) + eta*(log(qn(t+1))-log(qss)) + (log(yf(t+1))-
log(yfss));
eq12(t+2)..      log(imraw(t+1))    =E= log(imrawss) + (log(y(t+1))-log(yss)) - (log(pm(t+1))-
log(pmss));
eq12n(t+2)..     log(imrawn(t+1))   =E= log(imrawss) + (log(yn(t+1))-log(yss)) - (log(pmn(t+1))-
log(pmss));
eq13(t+2)..      log(imkg(t+1))     =E= log(imkgss) + (log(iv(t+1))-log(ivss));
eq13n(t+2)..     log(imkgn(t+1))    =E= log(imkgss) + (log(ivn(t+1))-log(ivss));
eq14(t+2)..      log(imcg(t+1))     =E= log(imcgss) + (log(c(t+1))-log(css));
eq14n(t+2)..     log(imcgn(t+1))    =E= log(imcgss) + (log(cn(t+1))-log(css));
eq15(t+2)..      log(im(t+1))       =E= log(imss) + imrawss/imss*(log(imraw(t+1))-log(imrawss)) +
imkgss/imss*(log(imkg(t+1))-log(imkgss)) + imcgss/imss*(log(imcg(t+1))-log(imcgss));
eq15n(t+2)..     log(imn(t+1))      =E= log(imss) + imrawss/imss*(log(imrawn(t+1))-log(imrawss)) +
imkgss/imss*(log(imkgn(t+1))-log(imkgss)) + imcgss/imss*(log(imcgn(t+1))-log(imcgss));
eq16d(t+2)..     log(y(t+1))        =E= log(yss) + (1/yss)*(css*(log(c(t+1))-log(css)) +
gss*(log(g(t+1))-log(gss)) + ivss*(log(iv(t+1))-log(ivss)) + xss*(log(x(t+1))-log(xss)) -
imss*(log(im(t+1))-log(imss)));
eq16s(t+2)..     log(y(t+1))        =E= log(yss) + aL*(log(A(t+1))-log(Ass)) + aL*(log(Ld(t+1))-
log(Ldss)) + aK*(log(u(t+1))-log(uss)) + aK*(log(k(t))-log(kss)) + aM*(log(imraw(t+1))-log(imrawss))
+ eps_ys(t+1);
eq16n(t+2)..     log(yn(t+1))       =E= log(ynss) + (1/lambda)*((log(1-taun(t+1))-log(1-tauss)) -
sigma*(log(cn(t+1))-log(css))) + ((lambda+1)/lambda)*((log(A(t+1))-log(Ass)) - (aK/aL)*(log(zqn(t))-
log(zqss)) - (aM/aL)*(log(qn(t+1))-log(qss))) ;
eq17(t+2)..      piq(t+1)           =E= piqss + (1-simcg)*pidqss/piqss*((pidq(t+1)-
pidqss)+eps_adm(t+1)) + simcg*pimqss/piqss*(pimq(t+1)-pimqss) ;
eq17n(t+2)..     piqn(t+1)          =E= piqss + (1-simcg)*pidqss/piqss*(pidqn(t+1)-pidqss) +
simcg*pimqss/piqss*(pimqn(t+1)-pimqss) ;
eq18(t+2)..      log(p(t+1))        =E= log(pss(t+1)) + (log(p(t))-log(pss(t))) + (piq(t+1)-piqss);
eq18n(t+2)..     log(pn(t+1))       =E= log(pss(t+1)) + (log(pn(t))-log(pss(t))) + (piqn(t+1)-
piqss);
eq19(t+2)..      pidq(t+1)          =E= pidqss + gammab*(pidq(t)-pidqss) + gammaf*(pidq(t+2)-pidqss)
+ lambdakros*(log(mcd(t+1))-log(mcdss));
eq19n(t+2)..     pidqn(t+1)         =E= pidqss + (log(nmcdn(t+1)) - log(nmcdss(t+1))) -
(log(nmcdn(t)) - log(nmcdss(t)));
eq20(t+2)..      log(npd(t+1))      =E= log(npdss(t+1)) + (log(npd(t))-log(npdss(t))) +
(log(1+pidq(t+1))-log(1+pidqss)) ;
eq20n(t+2)..     log(npdn(t+1))     =E= log(npdss(t+1)) + (log(npdn(t))-log(npdss(t))) +
(log(1+pidqn(t+1))-log(1+pidqss));
eq21(t+2)..      log(pd(t+1))       =E= log(pdss) + (log(npd(t+1))-log(npdss(t+1))) - (log(p(t+1))-
log(pss(t+1))) ;
eq21n(t+2)..     log(pdn(t+1))      =E= log(pdss) + (log(npdn(t+1))-log(npdss(t+1))) -
(log(pn(t+1))-log(pss(t+1)));
eq22(t+2)..      log(mcd(t+1))      =E= log(mcdss) + aL*(log(w(t+1))-log(wss)) + aK*(log(zq(t))-
log(zqss)) + aM*(log(pm(t+1))-log(pmss)) - aL*(log(A(t+1))-log(Ass)) + eps_mc(t+1);
eq22n(t+2)..     log(mcdn(t+1))     =E= log(mcdss) + aL*(log(wn(t+1))-log(wss)) + aK*(log(zqn(t))-
log(zqss)) + aM*(log(pmn(t+1))-log(pmss)) - aL*(log(A(t+1))-log(Ass));
eq23(t+2)..      log(nmcd(t+1))     =E= log(nmcdss(t+1)) + (log(mcd(t+1))-log(mcdss)) +
(log(p(t+1))-log(pss(t+1)));
eq23n(t+2)..     log(nmcdn(t+1))    =E= log(nmcdss(t+1)) + (log(mcdn(t+1))-log(mcdss)) +
(log(pn(t+1))-log(pss(t+1)));
eq24(t+2)..      pimq(t+1)          =E= pimqss + gammaimb*(pimq(t)-pimqss) + gammaimf*(pimq(t+2)-
pimqss) + lambdakrosim*(log(q(t+1))-log(qss)) + eps_oil(t+1);
eq24n(t+2)..     pimqn(t+1)         =E= pimqss + (log(nmcmn(t+1)) - log(nmcmss(t+1))) -
(log(nmcmn(t)) - log(nmcmss(t)));
eq25(t+2)..      log(npm(t+1))      =E= log(npmss(t+1)) + (log(npm(t))-log(npmss(t))) +
(log(1+pimq(t+1))-log(1+pimqss));
eq25n(t+2)..     log(npmn(t+1))     =E= log(npmss(t+1)) + (log(npmn(t))-log(npmss(t))) +
(log(1+pimqn(t+1))-log(1+pimqss));
eq26(t+2)..      log(pm(t+1))       =E= log(pmss) + (log(npm(t+1))-log(npmss(t+1))) - (log(p(t+1))-
log(pss(t+1)));
eq26n(t+2)..     log(pmn(t+1))      =E= log(pmss) + (log(qn(t+1))-log(qss));
eq27(t+2)..      log(mcm(t+1))      =E= log(mcmss) + (log(q(t+1))-log(qss));
eq27n(t+2)..     log(mcmn(t+1))     =E= log(mcmss) + (log(qn(t+1))-log(qss));
eq28(t+2)..      log(nmcm(t+1))     =E= log(nmcmss(t+1)) + (log(mcm(t+1))-log(mcmss)) +
(log(p(t+1))-log(pss(t+1)));
eq28n(t+2)..     log(nmcmn(t+1))    =E= log(nmcmss(t+1)) + (log(mcmn(t+1))-log(mcmss)) +
(log(pn(t+1))-log(pss(t+1)));
eq29(t+2)..      piwq(t+1)          =E= piwqss + gammawb*(piwq(t)-piwqss) + gammawf*(piwq(t+2)-
piwqss) + lambdakrosw*1/(lambda+1)*(sigma*(log(c(t+1))-log(css)) - (log(1-tau(t+1)) - log(1-tauss)) +
lambda*(log(y(t+1))-log(yss)));
eq29n(t+2)..     piwqn(t+1)         =E= piwqss + (log(nmcwn(t+1)) - log(nmcwss(t+1))) -
(log(nmcwn(t)) - log(nmcwss(t)));
eq30(t+2)..      log(nw(t+1))       =E= log(nwss(t+1)) + (log(nw(t))-log(nwss(t))) +
(log(1+piwq(t+1))-log(1+piwqss));
```

```
eq31(t+2)..      log(w(t+1))         =E= log(wss) + (log(nw(t+1))-log(nwss(t+1))) - (log(p(t+1))-
log(pss(t+1)));
eq31n(t+2)..     log(wn(t+1))        =E= log(wss) + (1/(1+lambda))*(sigma*(log(cn(t+1))-log(css)) -
(log(1-taun(t+1))-log(1-tauss)) + lambda*(log(yn(t+1))-log(yss)));
eq32(t+2)..      log(mcw(t+1))       =E= log(mcwss) + (1/(1+lambda))*(sigma*(log(c(t+1))-log(css)) -
(log(1-tau(t+1))-log(1-tauss)) + lambda*(log(y(t+1))-log(yss)) );
eq32n(t+2)..     log(mcwn(t+1))      =E= log(mcwss) + (1/(1+lambda))*(sigma*(log(cn(t+1))-log(css)) -
(log(1-taun(t+1))-log(1-tauss)) + lambda*(log(yn(t+1))-log(yss)) );
eq33(t+2)..      log(nmcw(t+1))      =E= log(nmcwss(t+1)) + (log(mcw(t+1))-log(mcwss)) +
(log(p(t+1))-log(pss(t+1)));
eq33n(t+2)..     log(nmcwn(t+1))     =E= log(nmcwss(t+1)) + (log(mcwn(t+1))-log(mcwss)) +
(log(pn(t+1))-log(pss(t+1)));
eq34(t+2)..      log(tau(t+1))       =E= log(tauss) + 1/(1+uptheta)*((log(tau(t))-log(tauss)) +
uptheta*gss/(tauss*yss)*((log(g(t+1))-log(gss))-(log(y(t+1))-log(yss))));
eq34n(t+2)..     log(taun(t+1))      =E= log(tauss) + 1/(1+uptheta)*((log(taun(t))-log(tauss)) +
uptheta*gss/(tauss*yss)*((log(g(t+1))-log(gss))-(log(yn(t+1))-log(yss))));
eq35(t+2)..      iq(t+1)             =E= iqss + chi*(iq(t)-iqss) + ((1-
chi)/iqss)*(alphapi*(piqss*(piq(t+2)-piqss) - pitargetqss*(pitargetq(t+2)-pitargetqss))) ;
*eq35(t+2)..      iq(t+1)             =E= iqss + chi*(iq(t)-iqss) + ((1-
chi)/iqss)*(alphapi*(piqss*(piq(t+1)-piqss) - pitargetqss*(pitargetq(t+1)-pitargetqss)));
eq35n(t+2)..     iqn(t+1)            =E= iqss + chi*(iqn(t)-iqss) + ((1-
chi)/iqss)*(alphapi*(piqss*(piqn(t+2)-piqss) - pitargetqss*(pitargetqn(t+2)-pitargetqss)));
eq36(t+2)..      log(1+rq(t+1))      =E= log(1+rqss) + (log(1+iq(t+1))-log(1+iqss)) -
(log(1+piq(t+2))-log(1+piqss));
eq36n(t+2)..     log(1+rqn(t+1))     =E= log(1+rqss) + (log(1+iqn(t+1))-log(1+iqss)) -
(log(1+piqn(t+2))-log(1+piqss));
eq37(t+2)..      zq(t+1)             =E= zqss + (iqss/zqss)*(iq(t+1)-iqss);
eq37n(t+2)..     zqn(t+1)            =E= zqss + (iqss/zqss)*(iqn(t+1)-iqss);
eq38(t+2)..      log(1+irfq(t+1))    =E= log(1+irfqss) + sirf*(log(1+irfq(t))-log(1+irfqss)) +
eps_irf(t+1);
eq38n(t+2)..     log(1+irfqn(t+1))   =E= log(1+irfqss) + sirf*(log(1+irfqn(t))-log(1+irfqss)) +
eps_irf(t+1);
eq39(t+2)..      log(1+pifq(t+1))    =E= log(1+pifqss) + spif*(log(1+pifq(t))-log(1+pifqss)) +
eps_pif(t+1);
eq39n(t+2)..     log(1+pifqn(t+1))   =E= log(1+pifqss) + spif*(log(1+pifqn(t))-log(1+pifqss)) +
eps_pif(t+1);
eq40(t+2)..      log(pf(t+1))        =E= log(pfss(t+1)) + (log(pf(t))-log(pfss(t))) +
(log(1+pifq(t+1))-log(1+pifqss));
eq40n(t+2)..     log(pfn(t+1))       =E= log(pfss(t+1)) + (log(pfn(t))-log(pfss(t))) +
(log(1+pifqn(t+1))-log(1+pifqss));
eq41(t+2)..      log(yf(t+1))        =E= log(yfss) + syf*(log(yf(t))-log(yfss)) + eps_yf(t+1);
eq41n(t+2)..     log(yfn(t+1))       =E= log(yfss) + syf*(log(yfn(t))-log(yfss)) + eps_yf(t+1);
eq42(t+2)..      log(1+pitargetq(t+1)) =E= log(1+pitargetqss) + spitgt*(log(1+pitargetq(t))-
log(1+pitargetqss)) + eps_pitarget(t+1);
eq42n(t+2)..     log(1+pitargetqn(t+1)) =E= log(1+pitargetqss) + spitgt*(log(1+pitargetqn(t))-
log(1+pitargetqss));
eq43(t+2)..      1+pi(t+1)           =E= power((1+piq(t+1)),4);
eq44(t+2)..      1+pid(t+1)          =E= power((1+pidq(t+1)),4);
eq45(t+2)..      1+pim(t+1)          =E= power((1+pimq(t+1)),4);
eq46(t+2)..      1+pif(t+1)          =E= power((1+pifq(t+1)),4);
eq47(t+2)..      1+piw(t+1)          =E= power((1+piwq(t+1)),4);
eq48(t+2)..      1+i(t+1)            =E= power((1+iq(t+1)),4);
eq49(t+2)..      1+irf(t+1)          =E= power((1+irfq(t+1)),4);
eq50(t+2)..      1+z(t+1)            =E= power((1+zq(t+1)),4);
eq51(t+2)..      1+r(t+1)            =E= power((1+rq(t+1)),4);
eq52(t+2)..      1+pitarget(t+1)     =E= power((1+pitargetq(t+1)),4);
eq54(t+2)..      unem(t+1)           =E= Ls(t+1) - Ld(t+1);
eq55(t+2)..      profit(t+1)         =E= pd(t+1)*y(t+1) - (w(t+1)*Ld(t+1) + zq(t)*k(t) +
pm(t+1)*imraw(t+1));
eq56(t+2)..      wageinc(t+1)        =E= w(t+1)*Ld(t+1);
eq57(t+2)..      rentinc(t+1)        =E= zq(t)*k(t);
eq58(t+2)..      imporinc(t+1)       =E= pm(t+1)*imraw(t+1);
eqloss..         losstotal           =E= sum(tloss,
power(discfactor,ord(tloss))*(aa*(power((100*(pi.l(tloss)-pitarget(tloss))),2)) + (1-
aa)*(power((100*(log(y.l(tloss))-log(yn.l(tloss)))),2))));
```

B.2 Steady-State Model

```
********************************
* SECTION 1 : PARAMETER VALUES *
********************************
SCALARS
s_teta           household discount factor /0.98/
beta             producers's and importer's and wage setter's discount factor /1/
sigma            relative risk aversion (inverse of consumption intertemporal elasticity of
substitution) /125/
rho              inverse of interest rate elasticity of real money balance /25/
lambda           inverse of wage elasticity of labour supply     /50/
delta            depreciation rate                               /0.01/
aK               capital share                                   /0.5/
aL               labor share                                     /0.35/
aM               intermediate import share                       /0.15/
aMf              share of export in foreign economy total demand /0.01/
eta              price elasticity of export                      /0.1/
simkg            share of imports in investment                  /0.14/
```

```
simcg           share of finished goods imports in consumption  /0.14/
gpy             government expenditure-to-GDP ratio             /0.08/
xpy             exports-to-GDP ratio                            /0.30/
*---------------------------------------------------------------------------
* Policy parameter
*---------------------------------------------------------------------------
chi             degree of interest rate inertia                 /0.5/
alphapi         monetary policy response to inflation gap       /1.5/
uptheta         fiscal policy response parameter                /0.5/
psi             target of fiscal deficit ratio                  /0.02/
theta           degree of price stickiness                                  /0.5/
gamma           degree of price backward lookingness                        /0.6/
thetaim         degree of import price stickiness                           /0.3/
gammaim         degree of import price backward lookingness                 /0.25/
thetaw          degree of wage stickiness                                   /0.75/
gammaw          degree of wage indexation                                   /0.9/
theta_flex      degree of price stickiness when price is perfectly flexible /0.00000000000001/
gamma_flex      degree of backward looking when price is perfectly flexible /0/
si              constant for NKPC
gammab          parameter backward looking in NKPC
gammaf          parameter forward looking in NKPC
lambdakros      parameter of real marginal cost in NKPC
sim             constant for NKPC
gammaimb        parameter backward looking in NKPC import goods inflation
gammaimf        parameter forward looking in NKPC import goods inflation
lambdakrosim    parameter of real marginal cost in NKPC import goods inflation
siw             constant for NKPC
gammawb         parameter backward looking in NKPC wage inflation
gammawf         parameter forward looking in NKPC wage inflation
lambdakrosw     parameter of real marginal cost in NKPC wage inflation
si_flex         constant for flexible NKPC
gammab_flex     parameter backward looking in flexible NKPC
gammaf_flex     parameter forward looking in flexible NKPC
lambdakros_flex  parameter of flexible real marginal cost in flesible NKPC ;
si              = theta   + gamma  *(1-theta*(1-beta));
gammaf          = beta*theta*(1/si);
gammab          = gamma*(1/si);
lambdakros      = (1-gamma)*(1-theta)*(1-beta*theta)*(1/si);
sim             = thetaim + gammaim*(1-thetaim*(1-beta));
gammaimf        = beta*thetaim*(1/sim);
gammaimb        = gammaim*(1/sim);
lambdakrosim    = (1-gammaim)*(1-thetaim)*(1-beta*thetaim)*(1/sim);
siw             = thetaw  + gammaw *(1-thetaw*(1-beta));
gammawf         = beta*thetaw*(1/siw);
gammawb         = gammaw*(1/siw);
lambdakrosw     = (1-gammaw)*(1-thetaw)*(1-beta*thetaw)*(1/siw);
si_flex         = theta_flex + gamma_flex  *(1-theta_flex*(1-beta));
gammaf_flex     = beta*theta_flex*(1/si_flex);
gammab_flex     = gamma_flex*(1/si_flex);
lambdakros_flex  = (1-gamma_flex)*(1-theta_flex)*(1-beta*theta_flex)*(1/si_flex);
*******************************************
* SECTION 2 : TIME HORIZON FOR SIMULATION *
*******************************************
SETS
t        solution horizon           /1*50/
te(t)    effective solution horizon /1*50/
t1(t)    period one
tf(t)    final period;
t1(t)    = yes$(ord(t) eq 1);
tf(t)    = yes$(ord(t) eq (card(t)));
DISPLAY t1, tf;
***************************************
* SECTION 3 : COMPUTATION OF SOLUTION *
***************************************
JD..          J =E= 0;
eq1(t)..      log(erss(t))        =E= log(er0) + ord(t)*(log(1+iqss(t))-log(1+irfqss(t)));
eq2(t)..      log(qss(t))         =E= log(erss(t)) + log(pfss(t)) - log(pss(t));
eq3(t)..      log(mss(t))         =E= (sigma/rho)*log(css(t)) - (1/rho)*iqss(t);
eq4(t)..      log(Lsss(t))        =E= (-sigma/lambda)*log(css(t)) + (1/lambda)*log(wss(t)) +
(1/lambda)*log(1-tauss(t));
eq5(t)..      log(Ldss(t))        =E= log(aL) + log(pdss(t)) + log(yss(t)) - log(wss(t));
eq9(t)..      log(kss(t))         =E= log(beta) + log(aK) + log(pdss(t)) + log(yss(t)) -
log(zqss(t));
eq10(t)..     log(ivss(t))        =E= log(delta) + log(kss(t));
eq11(t)..     gss(t)              =E= gpy*yss(t);
eq12(t)..     log(xss(t))         =E= log(aMf) + eta*log(qss(t)) + log(yfss(t));
eq16(t)..     imss(t)             =E= imrawss(t) + imkgss(t) + imcgss(t);
eq13(t)..     log(imrawss(t))     =E= log(aM) + log(pdss(t)) + log(yss(t)) - log(pmss(t));
eq14(t)..     log(imkgss(t))      =E= log(simkg) + log(ivss(t));
eq15(t)..     log(imcgss(t))      =E= log(simcg) + log(css(t));
eq17(t)..     yss(t)              =E= css(t)+gss(t)+ivss(t)+xss(t)-imss(t);
eq18(t)..     log(yss(t))         =E= aL*log(Ass) + aL*log(Lsss(t)) + aK*log(uss(t)) + aK*log(kss(t))
+ aM*log(imrawss(t));
eq19(t)..     log(yss(t))         =E= (1/lambda)*(log(1-tauss(t)) - sigma*log(css(t)) + log(aL))
+ ((lambda+1)/lambda)*(log(Ass) - (aK/aL)*log(zqss(t)) - (aM/aL)*log(qss(t))+(1+lambda*(1-
aL))/(lambda*aL)*log(pdss(t)) + ((lambda+1)/(aL*lambda))*(aK*log(aK) + aM*log(aM));
eq21(t)..     log(pss(t))         =E= log(p0) + ord(t)*log(1+piqss(t));
eq30(t)..     piqss(t)            =E= pitargetqss;
```

```
eq31(t)..     piqss(t)            =E= (1-simcg)*pidqss(t) + simcg*pimqss(t);
eq32(t)..     log(npdss(t))       =E= log(p0) + ord(t)*log(1+pidqss(t));
eq33(t)..     log(pdss(t))        =E= log(npdss(t)) - log(pss(t));
eq7(t)..      log(mcdss(t))       =E= aL*log(wss(t))+aK*log(zqss(t))+aM*log(pmss(t))-aL*log(Ass)-
aL*log(aL)-aK*log(aK)-aM*log(aM);
eq8(t)..      log(nmcdss(t))      =E= log(mcdss(t)) + log(pss(t));
eq22(t)..     log(pmss(t))        =E= log(qss(t));
eq23(t)..     npmss(t)            =E= pmss(t)*pss(t);
eq24(t)..     log(1+pimqss(t))    =E= (1/ord(t))*(log(npmss(t))-log(p0));
eq24a(t)..    log(1+pimqss(t))    =E= (1/ord(t))*(log(nmcmss(t))-log(p0*mcmss('1')));
eq7m(t)..     log(mcmss(t))       =E= log(qss(t));
eq8m(t)..     log(nmcmss(t))      =E= log(mcmss(t)) + log(pss(t));
eq6(t)..      log(wss(t))         =E= (1/(1+lambda))*(sigma*log(css(t)) - log(1-tauss(t)) +
lambda*log(pdss(t)) + lambda*log(yss(t)) + lambda*log(aL));
eq37(t)..     nwss(t)             =E= wss(t)*pss(t);
eq38(t)..     log(1+piwqss(t))    =E= (1/ord(t))*(log(nwss(t))-log(p0*wss('1')));
eq38a(t)..    log(1+piwqss(t))    =E= (1/ord(t))*(log(nmcwss(t))-log(p0*mcwss('1')));
eq7w(t)..     log(mcwss(t))       =E= (1/(1+lambda))*(sigma*log(css(t)) - log(1-tauss(t)) +
lambda*log(pdss(t)) + lambda*log(yss(t)) + lambda*log(aL));
eq8w(t)..     log(nmcwss(t))      =E= log(mcwss(t)) + log(pss(t));
eq25(t)..     log(pfss(t))        =E= log(p0) + ord(t)*log(1+pifqss(t));
eq26(t)..     1+irfss(t)          =E= (1+rfss(t))*(1+pifss(t));
eq27(t)..     1+iss(t)            =E= (1+rss(t))*(1+piss(t));
eq28(t)..     zqss(t)             =E= iqss(t)+delta;
*eq28(t)..     zss(t)              =E= iss(t)+(power((1+delta),4)-1);
eq29(t)..     tauss(t)            =E= gss(t)/yss(t)-psi;
eq34(t)..     rss(t)              =E= 1/s_teta-1;
eq35(t)..     rfss(t)             =E= rss(t);
eq36(t)..     log(yfss(t))        =E= log(xpy)+log(yss(t))-log(aMf)-eta*log(qss(t));
eq39(t)..     uss(t)              =E= 1;
eq40(t)..     1+piss(t)           =E= power((1+piqss(t)),4);
eq41(t)..     1+pidss(t)          =E= power((1+pidqss(t)),4);
eq42(t)..     1+pimss(t)          =E= power((1+pimqss(t)),4);
eq43(t)..     1+pifqss(t)         =E= sqrt(sqrt(1+pifss(t)));
eq44(t)..     1+piwss(t)          =E= power((1+piwqss(t)),4);
eq45(t)..     1+iqss(t)           =E= sqrt(sqrt(1+iss(t)));
eq46(t)..     1+irfqss(t)         =E= sqrt(sqrt(1+irfss(t)));
*eq47(t)..     1+zqss(t)           =E= sqrt(sqrt(1+zss(t)));
eq47(t)..     1+zss(t)            =E= power((1+zqss(t)),4);
eq48(t)..     1+rqss(t)           =E= sqrt(sqrt(1+rss(t)));
eq49(t)..     1+rfqss(t)          =E= sqrt(sqrt(1+rfss(t)));
eq50..        1+pitargetqss       =E= sqrt(sqrt(1+pitargetss));
```

Chapter 3

Monetary transmission of persistent shock to the risk premium: the case of Indonesia

3.1 Introduction

Adverse exchange rate shocks frequently hit Indonesia. Such particular shocks might occur in terms of frequent one time shocks or in a more persistent way during a longer period. The currency crisis that badly hit the country in 1997-1998 can be considered as a severe persistent shock to the risk premium that devalued the exchange rate and altered the economy's dynamic equilibrium. Invaluable lesson should be continuously learned to pursue better monetary management in anticipating possible recurrence of such crises. Better understanding of monetary transmission mechanism and its consequence to monetary policy limitation is therefore necessary and worthwhile.

Cost channel of monetary policy has been increasingly explored for the case of developed economies. Barth and Ramey (2001) provide empirical evidence for cost channel of monetary policy based on industry level data. Ravenna and Walsh (2006) shows that, if nominal interest rate adjustment directly affect real marginal cost, then interest rate policy directly affects inflation. They also show that any shock to the economy with the presence of the channel will generate a trade-off between stabilizing inflation and stabilizing output gap. Chowdhury, et al. (2006) applied a structural approach to find that the estimated direct cost effects of short-run nominal interest rates significantly contribute to the inflation dynamics in the majority of G7 countries.

Existing empirical studies on Indonesia's monetary transmission compiled in Warjiyo and Juda Agung (2002) did not include cost channel of interest rate. However, the study, which employed VAR method, found "price puzzle" in response to monetary policy tightening. This phenomenon is usually linked to either VAR misspecification or the possible existence of a strong cost channel of monetary policy. As an emerging economy with relatively low labour productivity, it is likely that capital accumulation has been the main source of Indonesia's output growth. Hossain (2006) estimated a

Cobb-Douglas production function to find that capital accumulation accounts for 60 percent source of growth in Indonesia for the last forty years. It is in the spirit of the Young (1992) paper that claimed that growth in East Asian countries was mainly driven by high rates of capital formation. Combined with higher lending rate and lower wage than those in advanced economy, one can argue that capital share (capital owner's income as a fraction of GDP) is greater than the labour share. This argument enhances the importance of investigating cost channel of monetary policy.

This study uses a new Keynesian dynamic general equilibrium model of a small open economy involving four domestic economic players, namely the household, the firm-producer, the government, and the central bank, which interact with the foreign economy. The model characterizes the household's money-in-the-utility function and the firm's constant elasticity substitution production that employs labour, capital goods, and domestic and imported raw material. Interest rate policy is transmitted to the new Keynesian Phillips curve type of inflation through channels of aggregate demand, exchange rate pass-through, and cost of capital. I assume that the expectation channel of monetary policy is fully credible. It corresponds to agent's rational price expectation and perfectly credible monetary authority, which utilizes a simple interest rate policy rule contingent to the state of shock. Shock to interest rate risk premium is applied through a covered interest rate parity determination of exchange rate. The model is adapted and developed from optimizing models with staggered wage and prices-setting, which have been widely used in the literature on inflation and monetary policy[10].

The model is employed to observe the effect of short term persistent shock to the risk premium on the performance of an economy, which is intended to be close to the structure and behaviour of Indonesia's economy. The focus of this study are the relative

[10] See, for example, Ravenna and Walsh (2006), Christiano et al. (2005), Smets and Wouters (2003), Erceg and Levin (2003), Woodford (2003), and Murchison (2004). The first two incorporated interest cost channel for monetary policy.

importance of monetary transmission channel that pass the shock and interest rate response to inflation and how monetary policy should respond optimally to the particular type and state of the shocks, given the distinctive monetary transmission.

This paper shows that nominal exchange rate depreciation triggered by persistent shocks to interest risk premium worsens the state of the economy in the short- and long-run. The shocks are transmitted through the economy characterizing lack of response of consumer price disinflation to monetary policy contraction resulted from high real rigidity, strong cost channel of interest rate, strong cost channel of exchange rate pass-through, weak demand-side channel of exchange rate pass-through, and weak aggregate supply channel of interest rate.

The study suggests a proper monetary policy response, which is the smallest interest rate increases within the feasible set of monetary policy responses that the model recommends, to minimize the adverse effects of the shocks. Other economic policies might be necessarily complementary to the limited span of monetary policy that can in turn help strengthening aggregate demand channel of interest rate. The most important one is policies that help reducing capital share of economy's output and consecutively could weaken the cost channel of interest rate.

The organization of the rest of this paper is as follows. Section 3.2 presents a dynamic equilibrium model with prices and wage stickiness. Section 3.3 presents simulation scenarios, parameter calibration and model solution. Section 3.4 analyses simulation result. Section 3.5 concludes the study and infers some policy recommendations.

3.2 The model

This study extends the dynamic general equilibrium model used in chapter 2. I extend the model by incorporating interest-rate risk premium on foreign-denominated asset as a function of ratio of net foreign debt to GDP. Then, balance of payment block is developed that results in equations of current account, capital account, trade and service account, and net foreign asset. Moreover, I assume that the government also collects income tax on capital goods lessor's and the firm owner's dividend in addition to wage income tax in the previous model. I also change the Cobb-Douglas production technology with a constant elasticity of substitution technology to allow lower elasticities of factor inputs' demand with respect to input prices. The model's extension is described as follows.

3.2.1 The household

The dynamic budget constraint is expressed in domestic currency's nominal and real terms as follows.

$$\begin{aligned} &P_t c_t + \left(M_t^d - M_{t-1}^d\right) + \left(B_t^{HG} - B_{t-1}^{HG}\right) + \left(s_t B_t^{H*} - s_{t-1} B_{t-1}^{H*}\right) + P_t(k_t - (1-\delta)k_{t-1}) \\ &\leq i_{t-1} B_{t-1}^{HG} + \tilde{i}_{t-1}^{*} s_t B_{t-1}^{H*} + P_t^m im_t + (1-\tau_t)(W_t l_t + z_{t-1} P_t k_{t-1} + P_t \Pi_t) \end{aligned} \tag{1.1}$$

$$\begin{aligned} &c_t + (m_t^d - m_{t-1}^d) + (b_t^{HG} - b_{t-1}^{HG}) + (q_t b_t^{H*} - q_{t-1} b_{t-1}^{H*}) + (k_t - (1-\delta)k_{t-1}) \\ &\leq -\frac{\pi_t}{1+\pi_t} m_{t-1}^d + r_{t-1} b_{t-1}^{HG} + \tilde{r}_{t-1}^{*} q_{t-1} b_{t-1}^{H*} + p_t^m im_t + (1-\tau_t)\left(w_t l_t + z_{t-1} k_{t-1} + \Pi_t\right) \end{aligned} \tag{1.2}$$

Sources of household's revenues are income from supplying labour services (wages), selling imported goods, renting capital goods to the firm, owning firm (dividend) and selling the previous period's depreciated capital goods, as well as interest income on government bonds and foreign assets.

I assume that the household's net foreign asset position is negative $(B_t^{H*} < 0)$, meaning that the household is a net debtor of foreign asset. I further assume that foreign investors require a risk premium, κ_t, for the rate of interest, $\tilde{i}_t^{*}$, of foreign currency-denominated loans they extend to the domestic household, so that

$(1+\tilde{i}_t^*) = (1+i_t^*)(1+\kappa_t)$. Hence the principal and interest income from foreign asset is $(1+i_{t-1}^*)(1+\kappa_{t-1})s_t B_{t-1}^{H*} < 0$.

I follow Al-Eyd and Hall (2006), Murchison, et. al (2004), and Schmitt-Grohe and Uribe (2003) in defining the country-specific risk premium, κ_t, which depends on net foreign debt-to-GDP ratio. The risk premium is also subject to a shock process, ε_t^{κ}, representing unforecastable changes in foreign investor's preferences on domestic assets.

$$\kappa_t = \varsigma\left(e^{-\frac{s_t B_t^*}{P_t y_t}} - 1 \right) + \varepsilon_t^{\kappa}, \tag{1.3}$$

where ς is scaling parameter. The equation says that foreign asset interest-rate risk premium depends on net foreign debt, exchange rate, output, and exogenous shock to the risk premium. An increase in net foreign debt (or a decrease in net foreign asset) negatively affects the ability of domestic resident to repay the debt. Exchange rate depreciation increases the amount of domestic currency required to pay foreign debt and, in turn, worsens domestic resident's ability to repay their foreign debt. A declining real income worsens the economy's capability for foreign debt repayment. Risk premium on the foreign debt is absent when foreign asset equals foreign debt and negative if net foreign asset is positive. The later means that the domestic household can enjoy a lower-than-world interest rate for its foreign debt.

From the maximization of household utility function with respect to labour supply and consumption, we can find the real marginal cost of working of the form

$$mc_t^w = \left(\frac{A_t^{\lambda(\nu-1)} c_t^{\sigma} (\alpha_L y_t)^{\lambda}}{1-\tau_t} \right)^{\frac{1}{\nu\lambda+1}} \tag{1.4}$$

The household rents out capital goods to the firm with real rental rate of capital, z_t, which is obtained by combining the first order condition of utility maximization with respect to real capital stock and nominal domestic bonds as follow

$$z_t = \frac{r_t + \delta}{1 - E_t \tau_{t+1}} \tag{1.5}$$

Real rental price of capital that the household-lessor charges to the firm should cover real interest rate, depreciation rate of capital and the expected future income tax rate. Real marginal cost of imports equals real import price equation when prices are fully flexible, which is equal to real exchange rate.

$$mc_t^m = q_t \tag{1.6}$$

Nominal exchange rate is obtained by combining the first order condition of the household's utility maximization with respect to nominal domestic and foreign bonds, which implies covered interest rate parity.

$$s_t = E_t s_{t+1} \left(\frac{1 + i_t^*}{1 + i_t} \right) (1 + \kappa_t) \tag{1.7}$$

In order to obtain the household's financial assets and financial account, we can elaborate the equality of nominal budget constraint (1.2) by substituting the firm's real profit $(\Pi_t = y_t - w_t l_t - p_t^m im_t - z_{t-1} k_{t-1})$, capital accumulation equation, $[k_t = (1 - \delta) k_{t-1} + iv_t]$, and the decomposition of real investment as domestic and imported capital goods $(iv_t = iv_t^d + im_t^{kg})$. We can further substitute the decomposition of imported goods as finished goods, intermediate goods and capital goods $(im_t = im_t^{rm} + im_t^{cg} + im_t^{kg})$, and take into account that domestic output, y_t, is supplied to the domestic household as consumption goods (c_t^d), to the firm as additional capital goods (iv_t^d), to the government as consumption and investment goods (g_t), and to the foreign importers as exported goods (x_t). These substitutions result in the household's dynamic real budget constraint that can be rearranged to get the household's real financial assets of the form

$$b_t^H = (x_t - q_t im_t) + g_t + [(1+r_{t-1})b_{t-1}^{HG} + (1+r_{t-1}^*)(1+\kappa_{t-1})q_t b_{t-1}^{H*}] - \tau_t y_t - \left(m_t^d - \frac{m_{t-1}^d}{1+\pi_t} \right) \quad (1.8)$$

where b_t^H is the household's real financial investment on the government bonds and foreign bonds in period t. It is equal to their net real revenues as exporter and importer and as the supplier of goods to the government, plus the principal and interest real income from the previous period's financial investment, minus real income tax expenditure and changes in real money holding.

3.2.2 The firm-producer

The firm produces output using a Constant Elasticity of Substitution (CES) production technology that utilizes labour, capital, and foreign and domestically produced intermediate goods as production input. The aggregate real output of the economy follows Murchison et al. (2004) to take the form

$$y_t = \left(\alpha_L^{\frac{1}{\nu}} (A_t l_t^d)^{\frac{\nu-1}{\nu}} + \alpha_K^{\frac{1}{\nu}} (u_t k_{t-1})^{\frac{\nu-1}{\nu}} + \alpha_M^{\frac{1}{\nu}} (im_t^{rm})^{\frac{\nu-1}{\nu}} \right)^{\frac{\nu}{\nu-1}} \quad (2.1)$$

where $\alpha_L, \alpha_K, \alpha_M$ are labour, capital and import share, respectively, which are assumed to be constant and forms a constant return-to-scale technology of production, and ν is the elasticity of substitution between factor inputs. The objective of the firm is to choose the level of factor inputs that maximize its present discounted values of lifetime real profit, which is the deviation of total real revenues from total real cost.

$$\Pi_t = \left(\alpha_L^{\frac{1}{\nu}} (A_t l_t^d)^{\frac{\nu-1}{\nu}} + \alpha_K^{\frac{1}{\nu}} (u_t k_{t-1})^{\frac{\nu-1}{\nu}} + \alpha_M^{\frac{1}{\nu}} (im_t^{rm})^{\frac{\nu-1}{\nu}} \right)^{\frac{\nu}{\nu-1}} - w_t l_t^d - p_t^m im_t^{rm} - z_{t-1} k_{t-1} \quad (2.2)$$

Employment equation is given by the first order condition with respect to labour demand

$$l_t^d = \frac{\alpha_L A_t^{\nu-1} y_t}{w_t^{\nu}} \quad (2.3)$$

From the first order condition of the firm's profit maximization, we can obtain the demand for the imported intermediate goods of the form

$$im_t^{rm} = \frac{\alpha_M y_t}{p_t^{m\nu}} \quad (2.4)$$

The firm's stock of capital goods required for production is obtained from the first order condition of the firm's profit maximization with respect to capital:

$$k_t = \frac{\beta \alpha_K E_t u_{t+1}^{\nu-1} E_t y_{t+1}}{z_t^{\nu}} \quad (2.5)$$

Real marginal cost of producing goods is derived from the firm's real cost minimization problem in which the aggregate firm chooses the level of factors inputs that minimize total real cost, $tc_t = w_t l_t + p_t^m im_t^{rm} + z_{t-1} k_{t-1}$, subject to CES production function (2.1). The aggregate firm's real marginal cost, mc_t^d, is expressed as a function of real wage, real rental price of capital, real import price and the level of technology of the form:

$$mc_t^d = \frac{w_t}{A_t \alpha_L^{\frac{1}{\nu-1}}} \left(1 + \frac{1}{\alpha_L} \left(\frac{w_t}{A_t} \right)^{\nu-1} \left(\alpha_K \left(\frac{u_t}{z_{t-1}} \right)^{\nu-1} + \alpha_M \left(\frac{1}{p_t^m} \right)^{\nu-1} \right) \right)^{-\frac{1}{\nu-1}} \quad (2.6)$$

3.2.3 The fiscal authority

Government expenditure is financed through collecting income tax on the importer's, capital goods lessor's, and firm owner's dividend or issuing domestic- and foreign-denominated bonds. The government's nominal dynamic budget constraint is expressed as

$$B_t^{GH} + s_t B_t^{G*} + \tau_t P_t y_t + M_t^s - M_{t-1}^s = (1+i_{t-1})B_{t-1}^{GH} + (1+i_{t-1}^*)(1+\kappa_{t-1})s_t B_{t-1}^{G*} + P_t g_t \tag{3.1}$$

where $B_t^G = B_t^{GH} + s_t B_t^{G*}$ is government revenue from issuing domestic bonds (B_t^{GH}) and foreign bond (B_t^{G*}), $\tau_t P_t y_t$ is tax revenue, $(M_t^s - M_{t-1}^s)$ is seignorage revenue, g_t is real government spending, and s_t is nominal exchange rate. The government real debt, which comprises its debt to the household and to the foreign economy, $b_t^G = b_t^{GH} + q_t b_t^{G*}$, takes the form

$$b_t^G = g_t + \left((1+r_{t-1})b_{t-1}^{GH} + (1+r_{t-1}^*)(1+\kappa_{t-1})b_{t-1}^{G*}q_t\right) - \tau_t y_t - \left(m_t^s - \frac{m_{t-1}^s}{1+\pi_t}\right) \tag{3.2}$$

3.2.4 Real net foreign debt and financial account

Real net foreign debt, d_t^*, is obtained from the household's and the government's real budget constraints. It is used to finance trade deficit and repay the previous period's foreign debt.

$$d_t^* = (im_t - x_t / q_t) + (1+r_{t-1}^*)(1+\kappa_{t-1})d_{t-1}^* \tag{4.1}$$

Financial account (foreign debt flow), FA_t, is the total of changes in the government's net foreign debt and changes in the private sector's net foreign debt. We can get the national debt flow from the household and the government's nominal budget constraints by assuming that government's domestic debt equals the household's holding on government bonds $(B_t^{GH} = B_t^{HG})$, that foreign residents do not hold government domestic-denominated bond, and the equilibrium of money holds.

$$FA_t = \left(P_t^* im_t - P_t x_t / s_t\right) - [(1 + i_{t-1}^*)(1 + \kappa_{t-1}) - 1]B_{t-1}^* \tag{4.2}$$

3.2.5 The goods market equilibrium

The equilibrium of goods market is defined by resource constraint that equate the aggregate demand for output with the aggregate supply of output (2.1) of the form

$$c_t + g_t + iv_t + x_t - im_t = \left(\alpha_L^{\frac{1}{\nu}} (A_t l_t^d)^{\frac{\nu-1}{\nu}} + \alpha_K^{\frac{1}{\nu}} (u_t k_{t-1})^{\frac{\nu-1}{\nu}} + \alpha_M^{\frac{1}{\nu}} (im_t^{rm})^{\frac{\nu-1}{\nu}} \right)^{\frac{\nu}{\nu-1}} \tag{5}$$

3.3 Simulation Scenario and Parameter Setting

I conduct a simulation by applying an eight-quarter one percentage point positive exogenous shocks to the risk premium equation[11]. The type, magnitude and length of shock are meant to resemble a moderate currency crisis. The simulation objective is to evaluate the effect of such shocks on economic performance, in particular the exchange rate, balance of payment and monetary policy response. By applying one single type of shock, it is implicitly assumed that other kinds of shocks are not present and the economy is not pursuing disinflation. I also conduct a one-time exogenous shock to interest rate policy in order to confirm how the channel of monetary transmission works.

Table 3.1 exhibits parameter calibration. The firm's, importer's and wage setter's future profits are discounted at discount factor $\beta = 0.99$. From consumption Euler equation, we get the steady-state real interest rate that equals the household's rate of time preference. Setting real interest rate at 0.02 corresponds to the household discount

[11] Steady-state values and the simulation paths are solved by using GAMS software that employ the Generalized Reduced Gradient method of solution for non-linear programming problems (Rosenthal (2006), Drud (2006))

factor, ϑ, at 0.98. The economy's structure of output and demand for output are assumed to aproximately follow current figures. The share of capital goods, labour and imported intermediate goods in the aggregate output of the economy are set at α_K = 0. 5, α_L= 0.35, and α_M = 0.15.

Government spending-to-GDP ratio is set at α_g = 0.18 and export-to-GDP ratio at $\alpha_x = 0.28$. The share of imported consumption good in total consumption, α_{mcg}, and imported capital goods in total investment, α_{mkg}, are both 0.14. The share of government bond in household's assets, α_{HG}, is assumed equals 0.5, and the share of domestic debt in government liabilities, α_{GH}, is 0.6. The ratio of debt to GDP in steady-state is 20%.

Table 3.1
Model Calibration

Parameter	Description	Value
ϑ	the household's discount factor	0.98
β	the firm's, importer's and wage setters' discount factor	0.99
σ^{-1}	consumption intertemporal elasticity of substitution	0.004
ρ^{-1}	nominal interest rate elasticity of real money holding	0.008
λ^{-1}	real wage elasticity of labour supply	0.015
δ	depreciation rate of capital	0.01
v	elasticity of substitution between factor inputs	0.3
α_K	capital share	0. 5
α_L	labour share	0.35
α_M	imported intermediate goods share	0.15
α_M^*	share of domestic country's export in the rest of the world's total demand	0.00018
α_{mcg}	share of imported consumption good	0.14
α_{mkg}	share of imported capital goods investment	0.14
α_g	ratio of government expenditure-to-output	0.08
α_x	ratio of exports-to-output	0.28
η	real exchange rate elasticity of exports	0.2
θ	degree of price stickiness	0.35

θ^{m}	degree of import price stickiness	0.1
θ^{w}	degree of wage stickiness	0.75
γ^{w}	degree of wage indexation to lag inflation	0.9
ψ	target of fiscal deficit ratio	2%
χ	degree of interest rate inertia	0.5
α_{π}	monetary policy response parameter	very large
Θ	fiscal policy response paramater	0.5
ς	scaling parameter of risk premium	0.00000001
α_{HG}	share of government bond in household's assets	0.5
α_{GH}	share of domestic bond in government liabilities	0.6

I set the real consumption intertemporal elasticity of substitution at σ^{-1}= 0.004. This low substitution effect assumption is inline with the findings in Kusmiarso et al. (2002) that impliedly indicated the presence of strong income effect. Their study on interest rate channel of monetary transmission using VAR found that an increase in interest rate is initially responded by a negative growth of consumption. However, household consumption follows to decrease when interest rate starts to decrease. Nominal interest rate elasticity of real money holding is set at ρ^{-1}=0.008, reflecting a lower degree of cashless economy than in developed countries. Real exchange rate elasticity of exports is set at η= 0.2 in accordance with the associated coefficient in BI's macroeconometric model. I calibrate the real wage elasticity of labour supply at λ^{-1}= 0.002. This value is much lower than the elasticity in developed economies commonly used in related research. This reflects a labor market that is characterized by low real wage income, excess supply of labour and low appreciation for leisure time. The constant elasticity of substitution between factor input is set at ν = 0.3.

Degree of price rigidity of domestically-produced goods, θ, is set at 0.35 implying that the average time between domestic price adjustment is about one and a half quarters. Domestic price of imported goods is assumed less rigid than domestically-produced goods (θ^m = 0.1), implying that the average duration of import price is 3.3 months. In setting rigidity parameter, I refer to business price setting survey for Indonesia's economy in Darsono et al. (2002), which found that manufacturing goods prices stay an average of 4.6 months and that exchange rate changes is passed-through to import price in the same quarter. Wage rigidity is assumed at θ^w= 0.75, corresponding to yearly nominal wage changes. However, the refference for wage changes is heavily based on the previous wage inflation rather than on forward looking optimal price setting. This behaviour is reflected in parameter γ^w that is equal to 0.9.

Inflation feedback parameter in the simple interest rate rule is set at a value that minimizes present discounted value of dynamic welfare loss over a hundred quarters after the shock. The loss function is symmetric of the form $L = E_t \sum_{s=0}^{\infty} \beta_L{}^s \left((\pi_{t+s} - \bar{\pi})^2 + (y_{t+s} - \bar{y})^2 \right)$, where monetary policy makers have equal preferences on both inflation and output stabilization. Inflation feedback coefficient is contingent on the magnitude and extent of a shock to the risk premium. I search the optimal policy feedback coefficient by fixing interest rate smoothing coefficient at $\chi = 0.5$, reflecting equally backward- and forward-looking behaviour of monetary authority in formulating interest rate policy. Figure 3.1 shows the range of feasible inflation feedback parameters when interest rate responds to a future period's inflation gap. The figures show that the feasible set of the monetary authority response to the risk premium shock is a rising interest rate. However, the optimal response, which produces the lowest inflation effect and the smallest short-run output contraction, is the smallest interest rate increases within the feasible set. The highest interest rate increase in the set corresponds to the most nonoptimal response.

3.4 Simulation Results

3.4.1 Exchange rate and balance of payment

Figure 3.2 exhibit the responses economic variables to an eight-quarter one percentage point shock to the risk premium. Nominal exchange rate contemporaneously depreciates as a response to risk premium shock, but its extent is lowered by immediate interest rate response. The rate of nominal exchange finally achieves a new, weaker steady-state level when the nominal rate of interest returns to and stabilizes at the initial rate, leaving expectation channel works solely. The long run equilibrium of nominal exchange rate becomes weaker to compensate a lower relative price of foreign to domestic goods so that real exchange rate is unchanged in the long run.

Real export follows real exchange rate movement in the absence of changes to foreign demand. With a low elasticity of real export with respect to real exchange rate, real export only moves up by about 0.027%. It then falls below initial steady-state when real exchange rate strengthens several quarters after the shock. Exports returns to its initial steady-state level in the long run.

Following an increase in real import price, real import falls by about 1.6%, much larger than an increase in real exports in the early period of shocks. Foreign price value of imports declines sharply since foreign price quarterly inflation stays the same. On the other side, foreign price value of exported goods also declines accordingly as nominal exchange rate depreciates more than an increase in real export and consumer price. The net effect is a huge jump in trade surplus, exhibiting an inverted J-curve phenomenon. Indonesia's trade surplus and real exports and imports in the period of currency crisis justify the simulation result, to some extent, in terms of direction of related variables. Figure 3.3 shows that in the aftermath of currency crisis in 1998, when nominal exchange rate depreciated by 123%, real exports expanded 11.2% and real imports contracted 2.9%, resulted in 83% trade surplus increases.

This result is in line with an empirical study on J-curve effect. Using a VECM model on the quarterly data of Indonesia and its trading partners, Husman (2005) concluded that J-curve phenomenon is not found in aggregate level data. It is only found in the case of bilateral trade account with Japan, South Korea and Germany.

The movement of output, real import price and consumer inflation influence the following cyclical pattern of trade account. Real import rebounds as aggregate demand and output recovered and real import price lessens, resulting in a higher foreign price value of imports. Conversely, external demand for domestic goods decreases due to real exchange rate appreciation leading to a lower foreign price value of exports. Trade surplus is lower than its initial level in the medium run and finally stabilizes in the long-run at a slightly lower level than the initial steady-state value.

Some factors affect trade surplus dynamic. Exchange rate depreciation affects the volume of imports more than that of export since import price is less rigid than domestic price of exported goods. Moreover, imports plunge by significantly more than an upsurge of export in the short-run owing to quite high import content in production structure. In addition, real import price elasticity of imports is higher than real exchange rate elasticity of exports so that the sum of the elasticity is less than unity. The last factor explains why Marshall-Lerner condition does not hold. Hence the shock to the risk premium could worsen trade balance in the long term. Unlike this model simulation's result, Husman (2005) suggested that Marshall-Lerner condition is satisfied in the overall sample, implying the Rupiah's depreciation will increase the Indonesia exports in the long-run. She further found that although Marshal-Lerner condition is satisfied, exchange rate elasticity of bilateral trade account is quite small.

One percentage change of real exchange rate only increases export to import ratio by 0.37%. Different finding regarding Marshall-Lerner condition might imply an overestimated price elasticity of imports or underestimated price elasticity of exports assumed in this study.

Short-run improvement of trade account surplus enables the economy to reduce its net foreign debt. Afterwards, as trade account surplus worsens in the medium run and at last stabilises below its initial steady-state level, the economy has to increase net foreign debt continuously in the long-run. In line with net foreign debt's dynamics, service account deficit improves in the short-run then is getting worse in the long-run, diverging from the initial steady-state level. Overall, deficit current account lessens in the short-run because a better trade account surplus is enhanced by a smaller service account deficit. Ultimately, current account deficit becomes stable in the long-run at a worse level. Financial account surplus decreases in the short-run, then increases in the medium-run and finally reaches a higher steady-state surplus in the long-run.

3.4.2 Demand for and supply of input and output

Aggregate demand channel of interest rate policy works through exports, consumption and investment. Consumption drops off contemporaneously as the expected lower future consumption outweighs a small decrease in current real interest rate. It further decreases in several more periods as real interest rate increases in the following periods. When real interest rate stabilises in the long-run at a lower level than the initial steady-state, consumption stabilises at a higher new steady-state.

Demand for the stock of capital goods, to be utilized in the next period, falls when the shock to the risk premium hits the economy. Expected weakened aggregate demand in the following periods is behind the firm decision to ration its capital stock. This is often called as firm's balance sheet channel of interest rate to aggregate demand. A stronger external demand for domestic goods and domestic demand for domestic intermediate and final goods dampen investment demand contraction. The net effect is a fall in aggregate demand for domestic output in the wake of the shock. Thus, exchange rate depreciation triggered by a temporary shock to the risk premium is contractionary to output.

Demand for other factor inputs drops as well. As import price is less rigid, a depreciated real exchange rate leads to a more expensive real import price. Combined with a contemporaneous lowered aggregate demand, this strongly discourages demand for imported intermediate goods.

Employment falls because it is more affected by a much weakened aggregate demand than by a slightly more inexpensive real wage. This result is caused by unitary elasticity of labour demand with respect to real output and low elasticity of labour supply with respect to real wage.

3.4.3 Costs, Prices and Inflations

A squeezed labour demand brings downward pressure on real marginal cost of working. On the other side, leisure also decreases as demand for consumption goes down hence labour supply increases and puts a downward pressure on real marginal cost of working. Since nominal wage is quite rigid and highly indexed to its past inflation nominal wage is not responsive to changes in real marginal cost of working resulted from immediate adjustment in consumption and output.

Real wage declines because output price goes up and is more flexible than wage. Therefore, the immediate domestic inflation response to a lower aggregate demand is decreasing. In the following period of shock, investment starts to increase and consumption get stronger, causing upward pressure to the real marginal cost of working and wage inflation. Real wage is still below the initial steady-state level temporarily due to a more flexible output price than wage. Therefore, throughout the rest of shocks period the response of domestic inflation to a higher aggregate demand is decreasing.

Low real wage rigidity resulted from high nominal wage rigidity and low prices rigidity can be linked to a high real rigidity. Romer (2006) defines real rigidity as a low willingness of individual firm to change their relative price in response to changes in real output resulting from variations in real aggregate demand. A larger real rigidity corresponds to a greater consideration on competitor prices in price-setting behaviour. It means that when real rigidity is high each firm wants its price to move more closely with other prices. Bank Indonesia's business price setting survey (Darsono et al., 2002) revealed that cost-based approach is the most widely adopted price setting strategies among manufacturing and trading companies. The finding can justify the presence of price rigidities. It reflects the firm's reluctance to change prices when no cost changes occur. The survey also found that 'cost plus variable profit margin' and 'competitor prices' are the next most price setting methods used in manufacturing and retail firms, while 'market condition' is not the important factor in price setting policy. The survey results can be interpreted as low price rigidity in response to changes in cost and changes in competitor price. The latter means a high real rigidity[12].

Risk-premium-induced exchange rate depreciation is passed-through to domestically-produced goods inflation using three channels. First, direct pass-through via cost of imported intermediate goods, which has an increasing effect on domestic inflation. Second, indirect pass-through via demand for imported input, which has a decreasing effect on domestic inflation. Third, indirect pass-through via external

---

[12] Romer (2006) explains that, assuming the stylized aggregate demand curve, $\ln y = \ln M - \ln P$ (where M reflects factors that shift aggregate demand), real rigidity expression for the representative firm's profit-maximizing relative price, $\ln \boldsymbol{P}_i^* - \ln \boldsymbol{P} = \phi \ln \boldsymbol{y}$, implies $\ln P_i^* = \phi \ln M + (1-\phi) \ln P$, where high real rigidity is indicated by low ϕ.

demand for domestic output. The latter has a decreasing effect on domestic inflation as well since an increased exports put small upward pressure on the rigid wage. Thus, with less rigid output price, it causes a decline in real cost of employment.

A direct cost-push pass-through of exchange rate to domestic inflation strongly dominates its demand side pass-through because of several factors. Firstly, high import content in production structure. Secondly, low real exchange rate elasticity of exports. Thirdly, high nominal wage rigidity, meaning low aggregate demand elasticity of wage inflation. Fourthly, a real import price elasticity of demand for imported intermediate goods. Exchange rate pass-through to consumer inflation is even higher as it is a combination of net cost-push pass-through to domestic inflation and direct cost-push pass-through of imported consumption goods to consumer inflation.

Large weight on cost of capital reflects a strong cost channel of interest rate policy, which gives an upward pressure to domestic inflation. It amplifies the strong pass-through extent of risk-premium-induced exchange rate depreciation to a higher domestic price.

3.4.4 Tax and government debt

As a consequence of smaller aggregate demand and higher interest rate the government faces a reduced tax base and a higher interest payment on the existing debt. Thus, the fiscal authority needs to raise tax rate and increases debt financing to keep its consumption expenditure constant amid pressure from a rising primary deficit. Since tax rule responds to primary deficit, a higher debt interest payment has no strengthening effect on tax increase. Accordingly, government debt is sustainable but the economy needs a longer time to bring down government debt toward its initial path.

An increase in tax rate has a tiny effect in dampening down inelastic labour supply, causing a slight upward pressure on real marginal cost of working. However, its pass-through to wage is in a much smaller magnitude since wage is quite rigid but indexed to inflation. As output price is more flexible than wage, the immediate domestic inflation response to a higher interest rate through aggregate labour supply channel of interest rate policy is decreasing but exceedingly weak.

3.4.5 Interest rate

The model recommends the central bank to raise per annum interest rate up to the level that is 1.33 percentage points higher than the initial rate in one year after the initial shock. It then needs to be lowered but stays above the steady-state values for nine quarters, before finally stabilizes around the initial rate of 7%. This interest rate response results in 0.09 percentage point jump in year-on-year consumer inflation. As nominal interest rate increases by more than an increase in consumer inflation, ex ante real interest rate goes up temporarily up to a level that is 1.27 percentage points above the initial steady-state rate of 2%.

It is important to highlight the impact of implementing nonoptimal monetary policy response, which corresponds to the highest interest rate increase among the feasible response parameter. Figure 3.4 shows that such policy response results in a worse state of the economy in short-run: a higher nominal interest rate, more persistent consumer inflation, deeper output contraction, more unemployment, higher money balance and more expensive prices and wage. The economy also worse off in the long-run from more depreciated nominal exchange rate, more expensive prices and wage, higher net foreign debt, higher government debt, larger real money balance, smaller trade account surplus, larger current account deficit and larger financial account surplus.

This simulation reveals how strong the cost channel of monetary policy is. Interest rate increases results in an upward pressure on domestic inflation through an increased cost of capital. The main source of downward pressure to domestic and consumer inflation is a decreasing real cost of importing goods caused by appreciated exchange rate in the economy that features a more flexible import price than domestic price and high import content. Strong cost channel of interest rate policy, more rigid wage than output price and high wage indexation to its past inflation account for lack of response of consumer price disinflation to interest rate increases. This is in line with the properties of small macroeconometric model of Bank Indonesia that predicts a weak power of interest rate tightening in lowering consumer inflation. It suggests that one percentage point increase in interest rate can only reduce consumer inflation by around 0.06 percentage point.

3.4.6 Money balance

Real money demand, which is the opportunity cost of holding money by giving up both consuming goods and having return on money, falls off in the short-run and achieves a higher steady-state value in the long-run. The immediate response is not owing to the interest rate rise but rather simply follows the pattern of real consumption. This is due to a high real consumption elasticity of real money demand of $\sigma/\rho = 2.2$ despite small changes in consumption. On the other hand, low nominal interest rate elasticity of real money demand ($1/\rho = 0.0083$) dampens down the effect of relatively large interest rate increase. Therefore, a weakened demand for consumption goods strongly lowers demand for money holding.

Short-run fall in real money demand is less than consumer price increases. Therefore, when the central bank responds to the risk premium shock by raising interest rate nominal money supply has to be higher to clear money market. In this case, the direction of money and interest rate is contradictory, in the sense that monetary policy is tight in terms of interest rate but loose in terms of money supply.

Table 3.2
Correlation between currency growth and interest rate

Period	Coefficient of correlation	
	1-month SBI rate	3-month deposit rate
1990Q1-1997Q2	-0.33	-0.65
1997Q3-1998Q4	0.84	0.42
1999Q1-2007Q1	-0.13	-0.28

Table 3.2 shows that interest rate became positively correlated with currency growth during currency crisis. However, the relation was partly due to a massive increase in liquidity support combined with a large increase in interest rate. Moreover, Figure 3.5 shows that an increase (a decrease) in Bank Indonesia interest rate policy (SBI rate), which is positively highly correlated with changes in deposit rate, does not necessarily slow down (speed up) the growth of currency in circulation over the post-crisis period. The negative correlation between interest rate and currency growth weakened during the period as shown in Table 3.2. Since money growth and policy interest rate could move in the same direction, the tightening or easing stance of monetary policy should, therefore, only be represented and clearly communicated by interest rate policy.

3.5 Conclusion

This study found that, even with optimal monetary policy response, a nominal exchange rate depreciation, triggered by a two-years shock to the interest risk premium, causes the economy to suffer in the short-run from a higher inflation, lower output, higher nominal and real interest rate, higher cost of capital, lower investment, higher government deficit and debt, higher tax rate, and higher unemployment. The persistent shocks will also be worse for the economy in the long-run. It is characterised by a weaker long-run equilibrium of nominal exchange rate, more expensive domestic and imported prices and wage, and worse balance of payment (lower trade account surplus, higher current account deficit, higher capital inflow, larger net foreign debt, a higher but sustainable government debt). However, an appropriate monetary policy response, which is the smallest interest rate increases within the feasible set of interest rate responses, should manage to reduce such adverse effects.

Such property of shocks occurs because of lack of response of disinflation to increases in interest rate policy, which stems from the combination of high real rigidity, and strong cost channel of interest rates and exchange rate pass-through. Both aggregate demand channel of interest rates and demand-side channel of exchange rate pass-through have a weak effect on inflation.

Some policy implications might be appropriate. Such characteristics of monetary transmission complicate optimal monetary policy response. The central bank might be better pursuing a lower demand-induced inflation when adverse shock is nonexistent or in the presence of favourable supply shocks. When disinflation is successful, interest rate can, in turn, be lowered and finally helps reducing cost channel of interest rate and strengthen aggregate demand channel.

Since exchange rate shocks and cost-push shocks frequently harm the economy, other policies are necessary to complement monetary policy that can in turn help strengthen aggregate demand channel of monetary policy. The important thing is that the cost channel of interest rate needs to be weakened. It implies that the proportion of domestic income that goes to capital owner, investor or lender, should be reduced. Production structure switching, by increasing labour-intensive goods producers, could be a proper industrial policy to help reducing capital share of output.

Other possible policies are the ones that contribute to the reduction of cost of capital. This model and its simulation result are unable to suggest such policies that directly reduce cost of capital, as the absence of bank lending channel implies the equality of central bank policy rate and bank lending rate. However, when the channel exists, policy suggestions that encourage the reduction of financial intermediary's marginal cost and profit margin might be able to reduce physical capital cost. Other policies are the ones that help cutting nonmonetary-induced inflation that, in practice, will indirectly reduce cost of capital for a given real interest rate and spread between lending and deposit rate. In this study's modelling framework, the success of such policies will directly decrease both lending and policy rates. Given that price equals marginal cost plus profit margin, such policies are in the form of (i) reducing nonmonetary-induced marginal cost, (ii) decreasing profit margin, and (iv) enhancing profit margin flexibility to cost increases[13]. Nonmonetary-induced marginal cost, which is not modelled in this study, might take the form of marginal cost of 'external labour'[14] and other determinants of marginal cost that are not included in marginal cost equation (eq. 2.6).

Finally, it is important to address the model limitations that should be taken into account when interpreting the simulation result for policy purposes. This model is still deficient in its bank lending channel implying the absence of banks and that the central bank is part of the government. It would be interesting to find out how the economy reacts in the presence of bank as financial intermediary.

---

[13] The price of domestically produced goods can be set as nominal marginal cost multiplied by gross profit margin, $P = MC^d(1+\mu)$, in which $mc^d = mc^{dm} + mc^{dnm}$, where $\boldsymbol{mc^{dm}}$ is monetary-induced real marginal cost, as in (2.6), $\boldsymbol{mc^{dnm}}$ is nonmonetary-induced real marginal cost and μ is net profit margin.

[14] Cost of 'external labour' is the extra cost firms have to spend persistently, for any reasons, for persons who are not the firm's employees or do not supply their labour in the form of production input.

Appendix

A. Figures

Figure 3.1 Range of Feasible Response Parameter

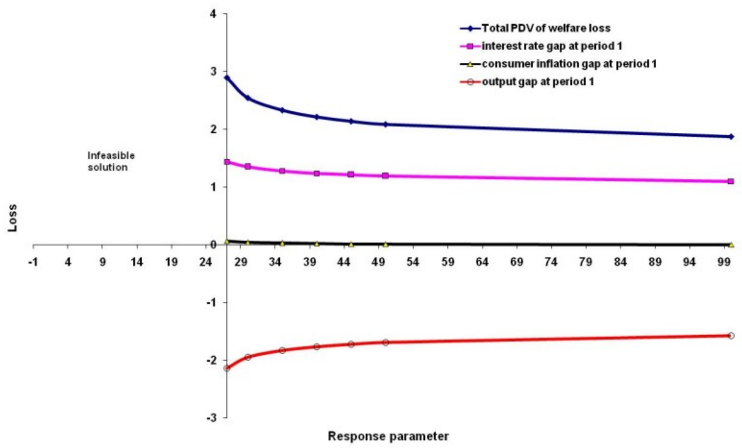
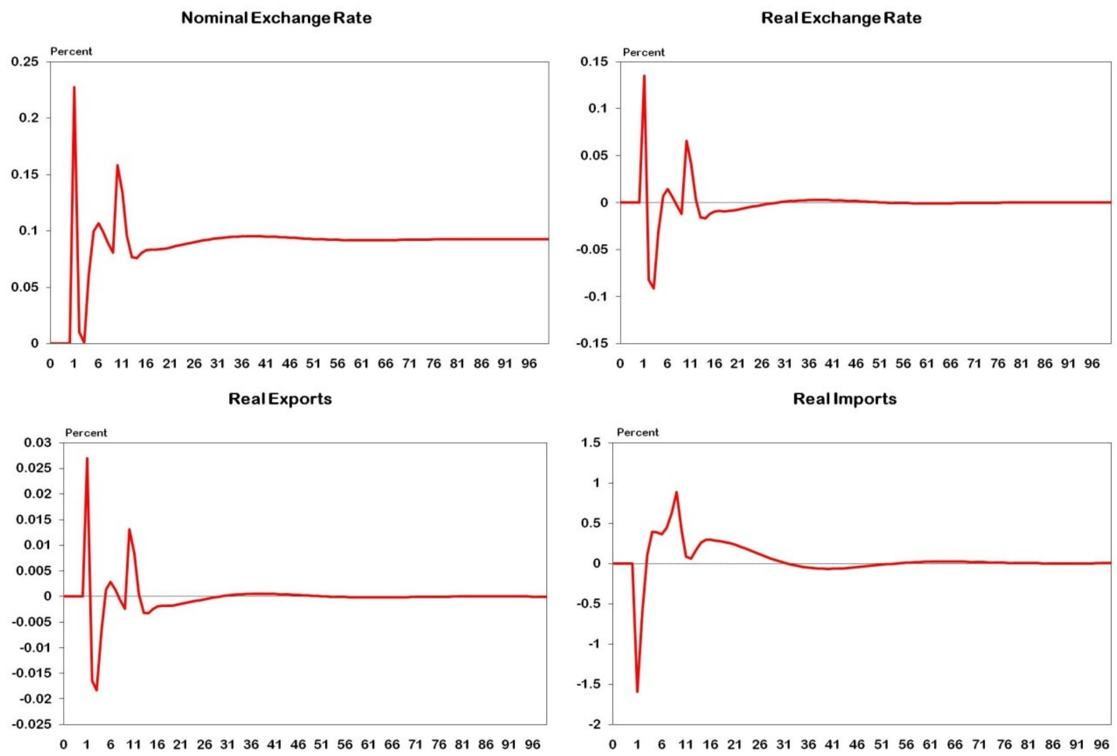
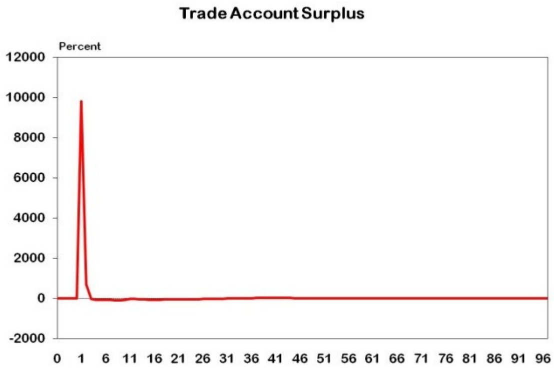
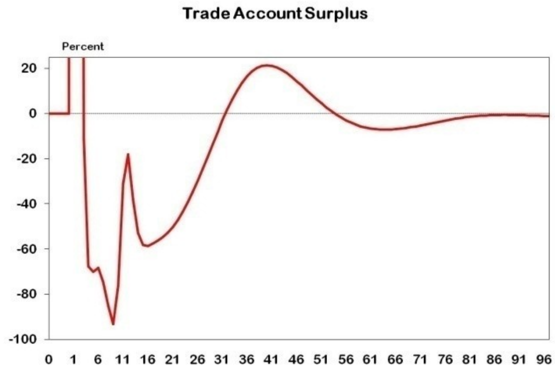
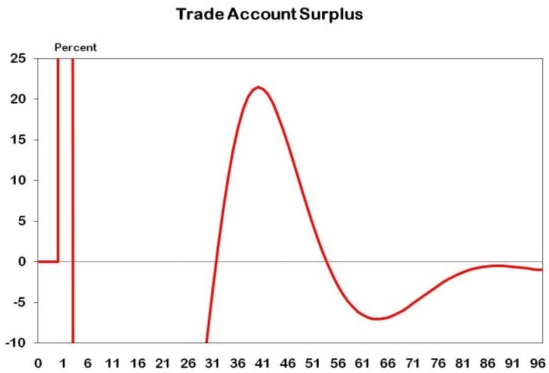


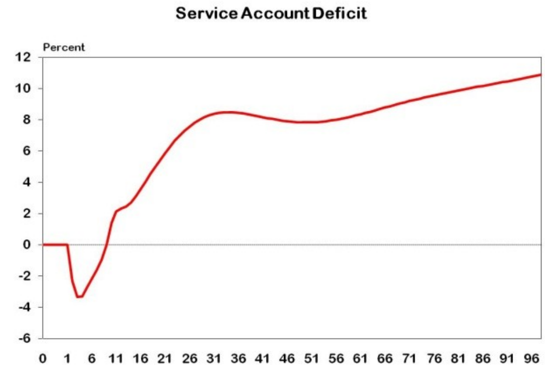
Figure 3.2 Responses to an eight-quarter one percentage point shock to the risk premium
(percent or percentage point deviation from baseline initial steady-state)

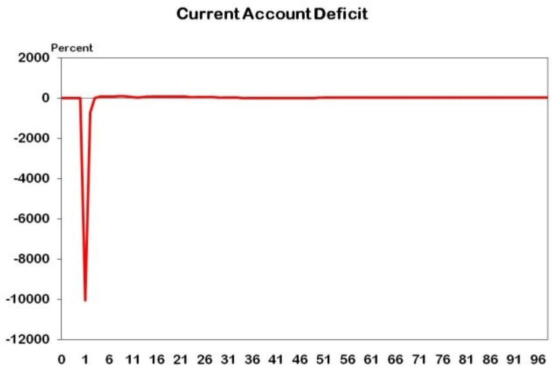


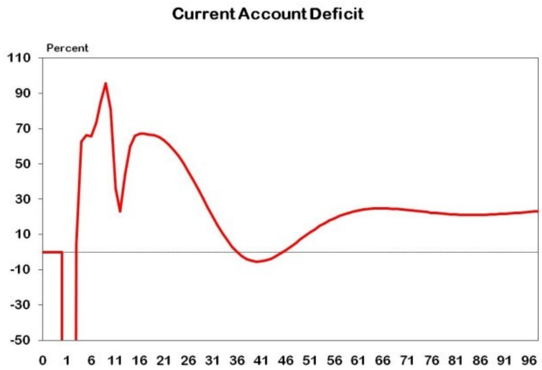

Trade Account Surplus
Percent
12000
10000
8000
6000
4000
2000
0
-2000
0 1 6 11 16 21 26 31 36 41 46 51 56 61 66 71 76 81 86 91 96

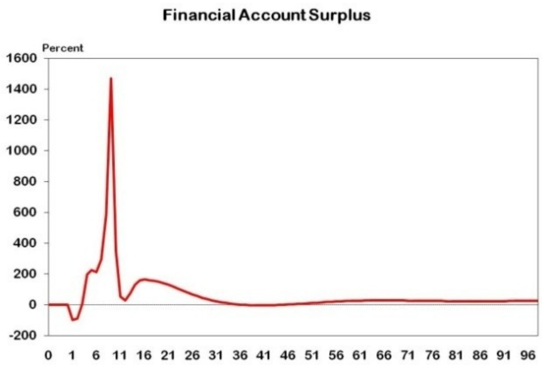

Trade Account Surplus
Percent
20
0
-20
-40
-60
-80
-100
0 1 6 11 16 21 26 31 36 41 46 51 56 61 66 71 76 81 86 91 96

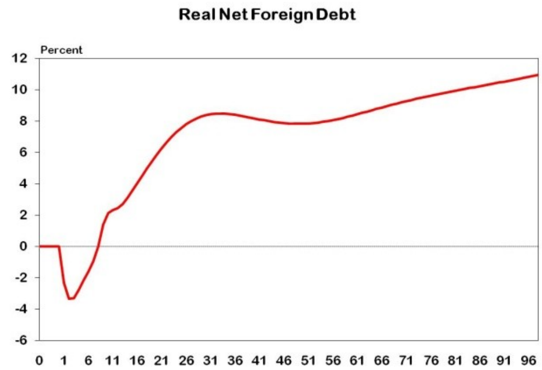

Trade Account Surplus
Percent
25
20
15
10
5
0
-5
-10
0 1 6 11 16 21 26 31 36 41 46 51 56 61 66 71 76 81 86 91 96

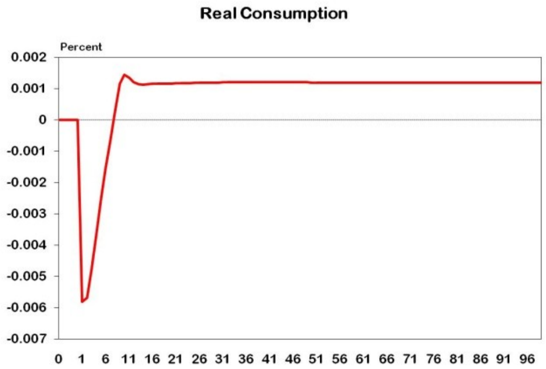

Service Account Deficit
Percent
12
10
8
6
4
2
0
-2
-4
-6
0 1 6 11 16 21 26 31 36 41 46 51 56 61 66 71 76 81 86 91 96

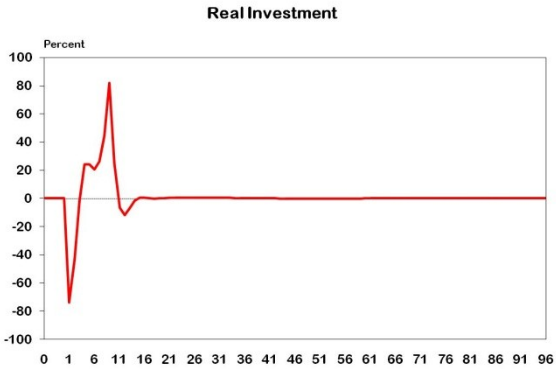

Current Account Deficit
Percent
2000
0
-2000
-4000
-6000
-8000
-10000
-12000
0 1 6 11 16 21 26 31 36 41 46 51 56 61 66 71 76 81 86 91 96

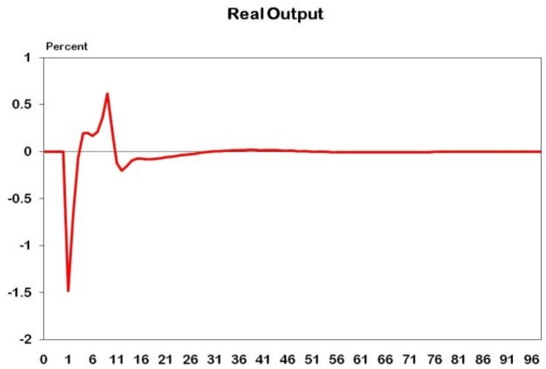

Current Account Deficit
Percent
110
90
70
50
30
10
-10
-30
-50
0 1 6 11 16 21 26 31 36 41 46 51 56 61 66 71 76 81 86 91 96

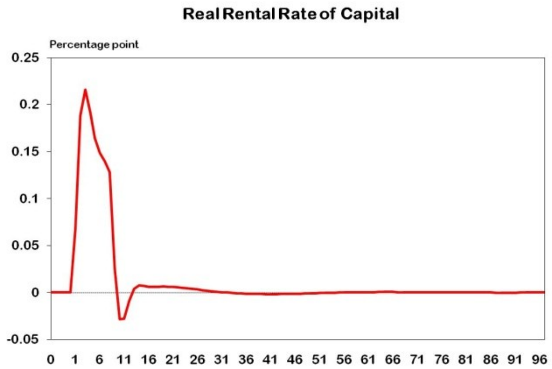

Financial Account Surplus
Percent
1600
1400
1200
1000
800
600
400
200
0
-200
0 1 6 11 16 21 26 31 36 41 46 51 56 61 66 71 76 81 86 91 96


Real Net Foreign Debt
Percent
12
10
8
6
4
2
0
-2
-4
-6
0 1 6 11 16 21 26 31 36 41 46 51 56 61 66 71 76 81 86 91 96


Real Consumption
Percent

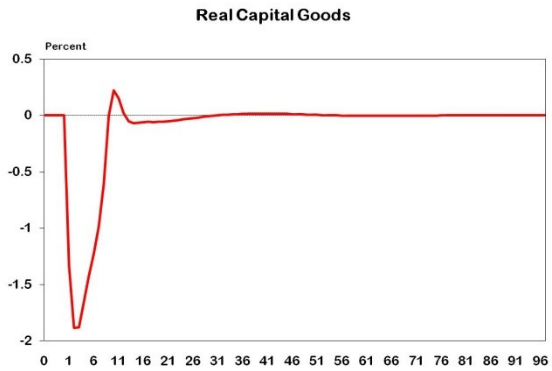

Real Investment
Percent

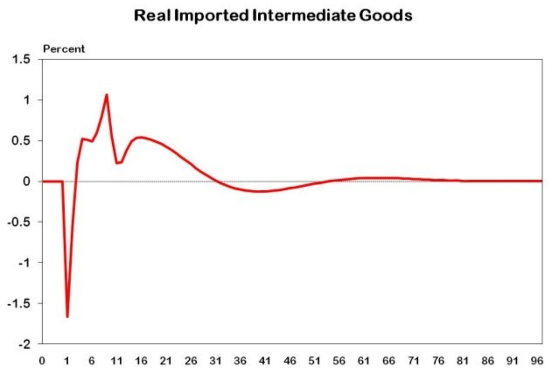

Real Output
Percent

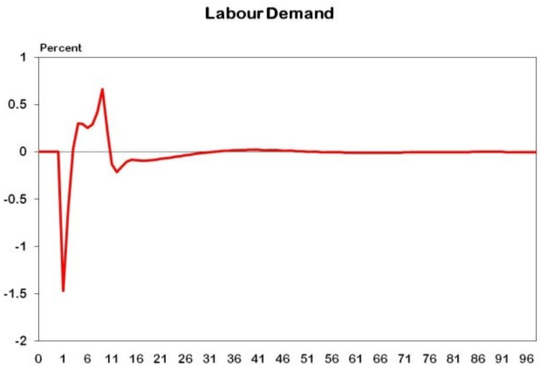

Real Rental Rate of Capital
Percentage point

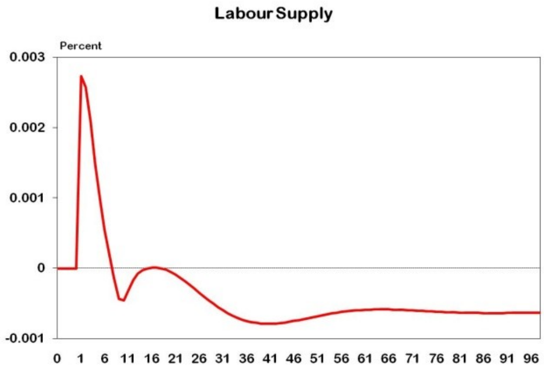

Real Import Price
Percent

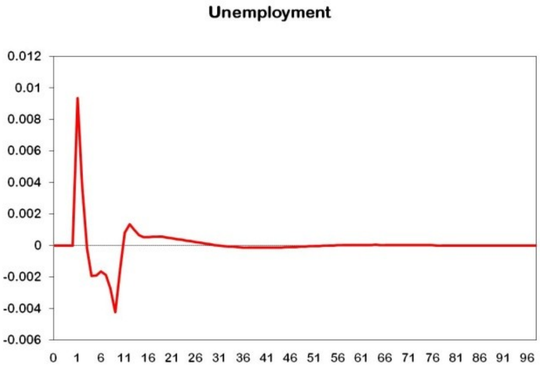

Real Wage
Percent


Real Capital Goods
Percent


Real Imported Intermediate Goods
Percent

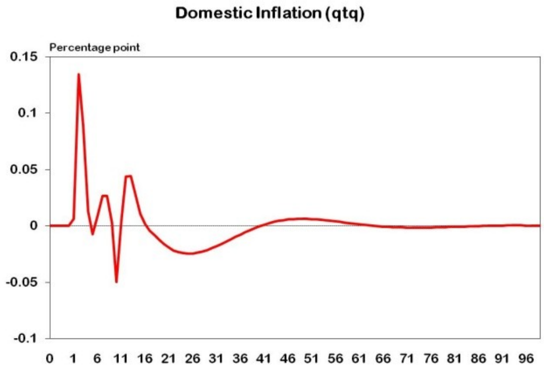

Labour Demand
Percent

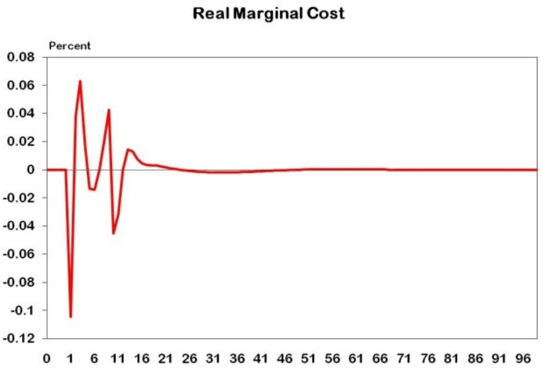

Labour Supply
Percent

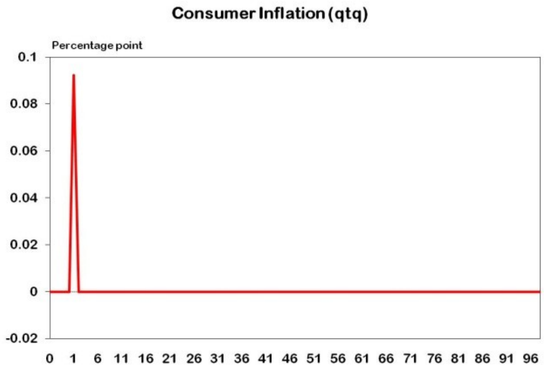

Unemployment

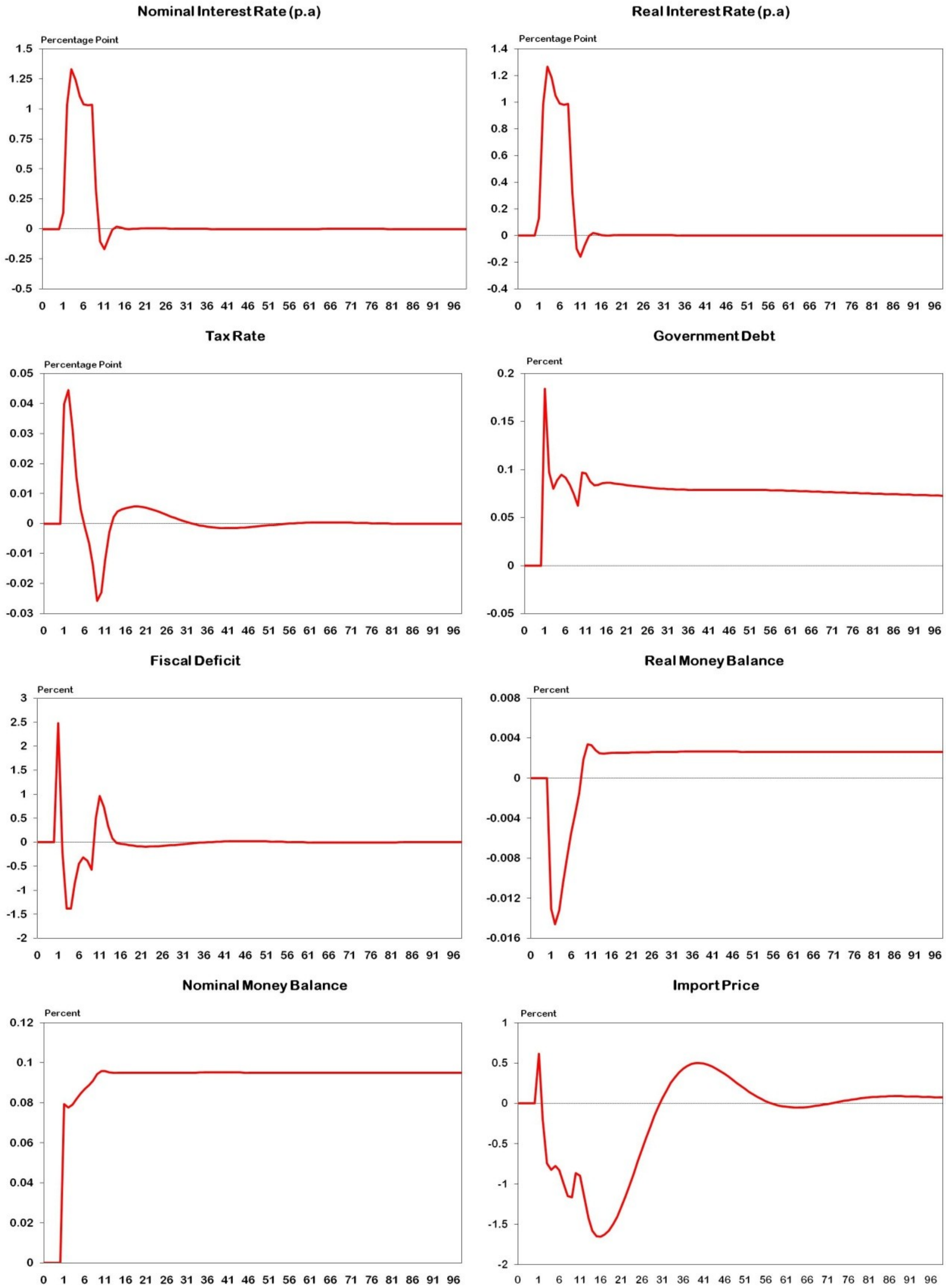

Wage Inflation (qtq)
Percentage Point


Imported Goods Inflation (qtq)
Percentage point


Domestic Inflation (qtq)
Percentage point


Real Marginal Cost
Percent


Consumer Inflation (qtq)
Percentage point


Nominal Interest Rate (p.a)
Percentage Point
Real Interest Rate (p.a)
Percentage Point
Tax Rate
Percentage Point
Government Debt
Percent
Fiscal Deficit
Percent
Real Money Balance
Percent
Nominal Money Balance
Percent
Import Price
Percent

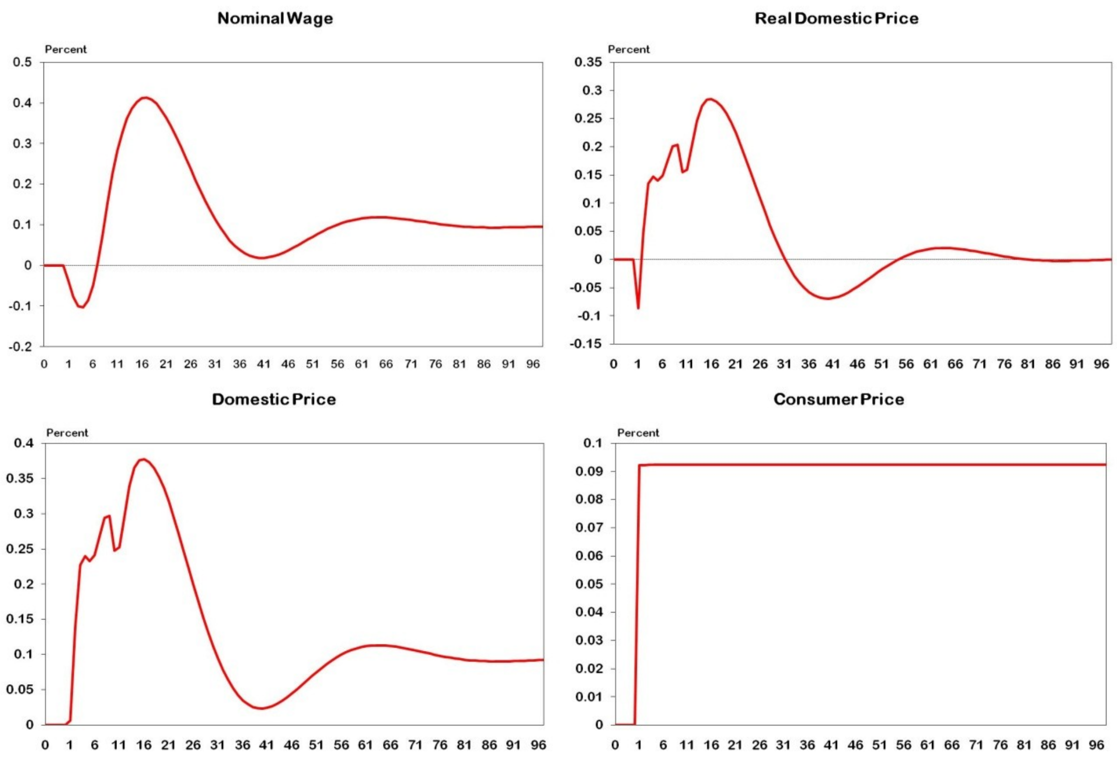


Figure 3.3 Real Exports, Real Imports and Trade Surplus of Indonesia

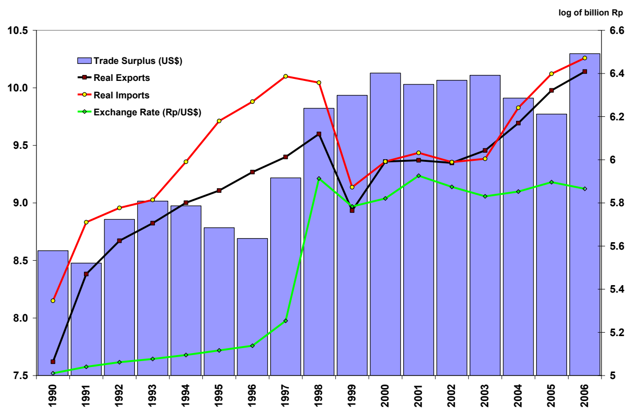
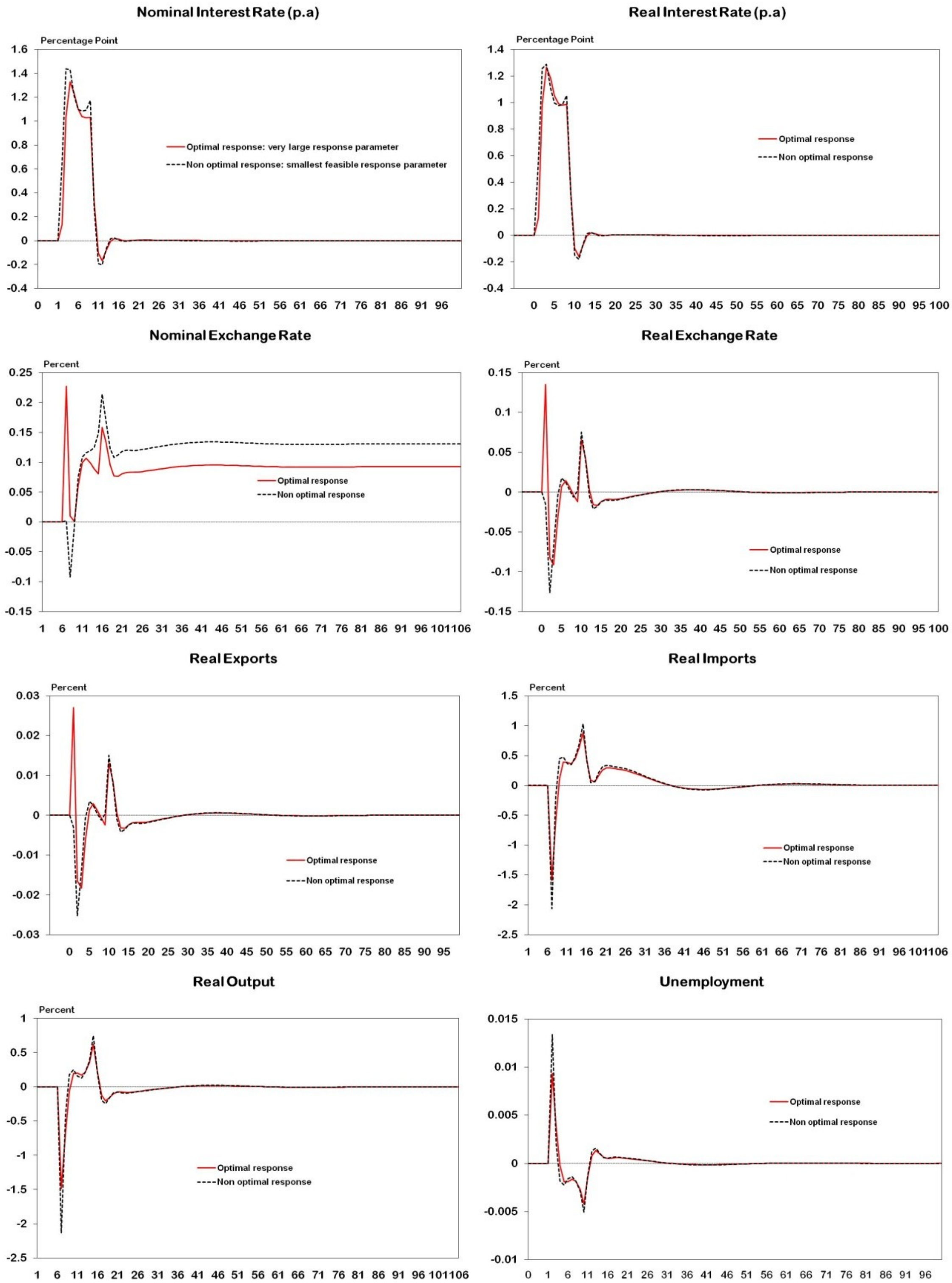


Figure 3.4 Effect of the optimality of monetary policy response to risk premium shock



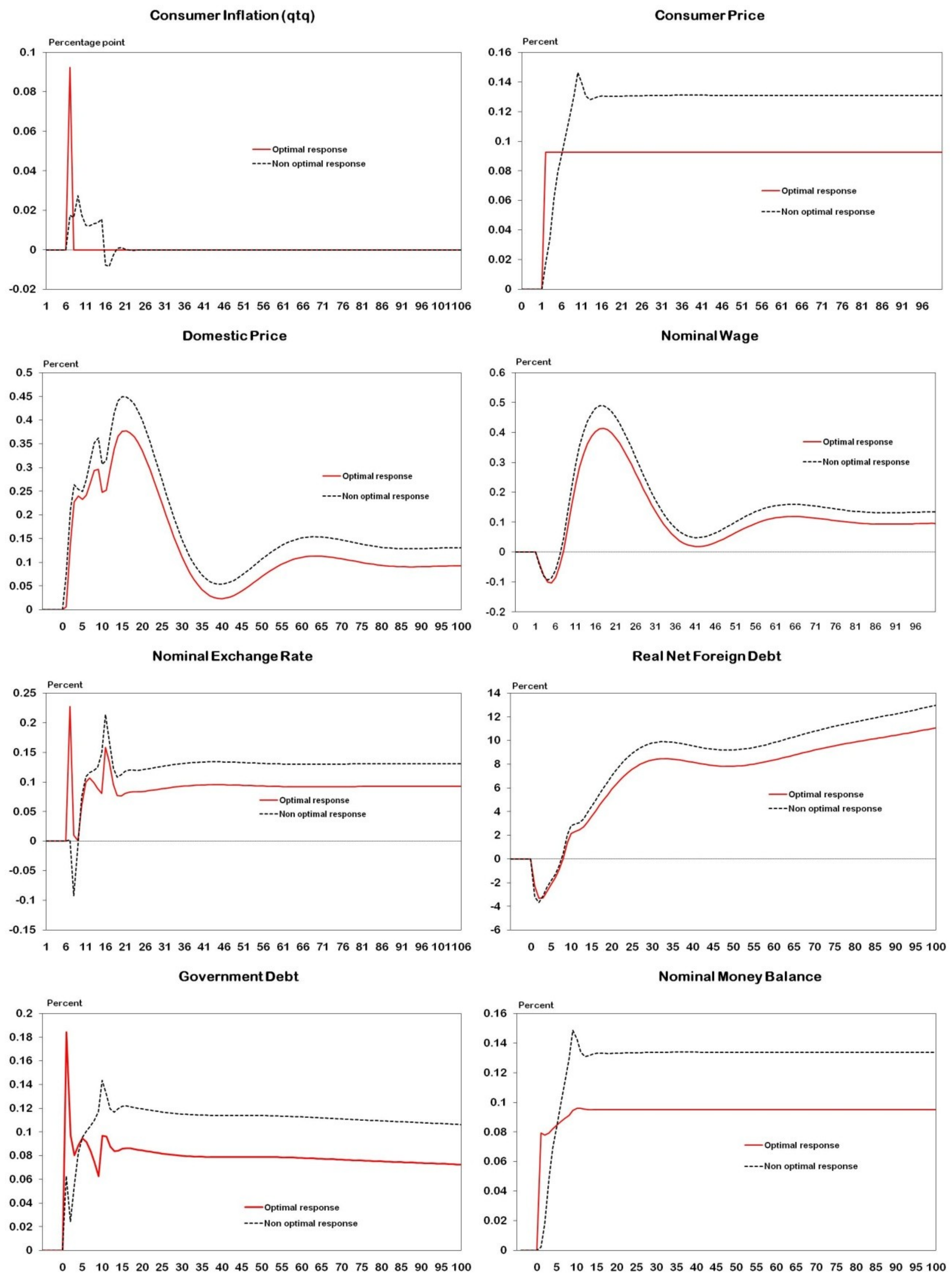
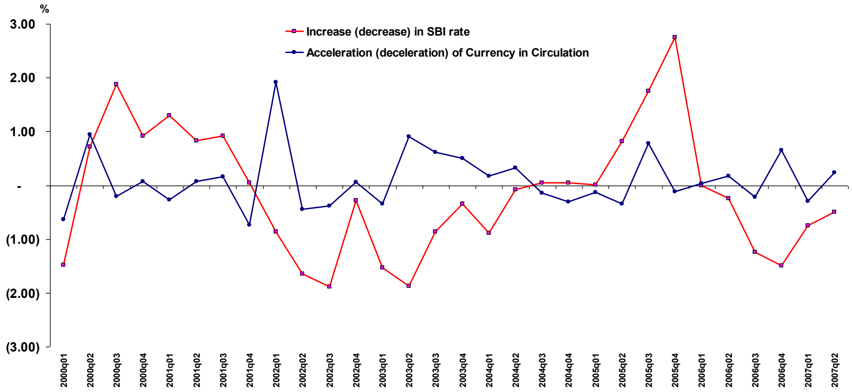

Consumer Inflation (qtq)
Percentage point
Optimal response
Non optimal response
Consumer Price
Percent
Optimal response
Non optimal response
Domestic Price
Percent
Optimal response
Non optimal response
Nominal Wage
Percent
Optimal response
Non optimal response
Nominal Exchange Rate
Percent
Optimal response
Non optimal response
Real Net Foreign Debt
Percent
Optimal response
Non optimal response
Government Debt
Percent
Optimal response
Non optimal response
Nominal Money Balance
Percent
Optimal response
Non optimal response

Figure 3.5 Direction of interest rate and growth of currency in Indonesia



B. The steady-state equations

Nominal exchange rate $\bar{s}_t = E_t \bar{s}_{t+1}\left(\frac{1+\bar{i}^*}{1+\bar{i}}\right)(1+\bar{\kappa})\,;\ \bar{r} = \bar{r}^*$

Real exchange rate $\bar{q} = \bar{s}_t \frac{\bar{P}_t^*}{\bar{P}_t}$

Real money demand $\bar{m}^d = \bar{c}^{\sigma/\rho}\left(\frac{\bar{i}}{1+\bar{i}}\right)^{-\frac{1}{\rho}}$

Labour supply $\bar{l}^s = \bar{c}^{-\frac{\sigma}{\lambda}}\,\bar{w}^{\frac{1}{\lambda}}(1-\bar{\tau})^{\frac{1}{\lambda}}$

Labour demand $\bar{l}^d = \alpha_L\left(\frac{\bar{p}^d}{\bar{w}}\right)^{\nu}\bar{A}^{\nu-1}\bar{y}$

Real marginal cost of domestic goods $\overline{mc}^d = \frac{\bar{w}}{\bar{A}\,\alpha_L^{\frac{1}{\nu-1}}}\left(1+\frac{1}{\alpha_L}\left(\frac{\bar{w}}{\bar{A}}\right)^{\nu-1}\left(\alpha_K\left(\frac{\bar{u}}{\bar{z}}\right)^{\nu-1}+\alpha_M\left(\frac{1}{\bar{p}^m}\right)^{\nu-1}\right)\right)^{-\frac{1}{\nu-1}}$

Real marginal cost of importing goods $\overline{mc}^m = \frac{\bar{q}}{1-\bar{\tau}}$

Real marginal cost of working $\overline{mc}^w = \left(\frac{\bar{A}^{\lambda(\nu-1)}\bar{c}^{\sigma}(\alpha_L\bar{y})^{\lambda}}{1-\bar{\tau}}\right)^{\frac{1}{\nu\lambda+1}}$

Technology $\bar{A} = 1$

Capital utilization rate $\bar{u} = 1$

Real capital stock $\bar{k} = \beta\alpha_K\left(\frac{\bar{p}^d}{\bar{z}}\right)^{\nu}\bar{u}^{\nu-1}\bar{y}$

Real investment $\overline{iv} = \delta\bar{k}$

Real consumption $\bar{r} = \vartheta^{-1} - 1$

Real consumption of imported

finished goods $\bar{c}^{mcg} = \alpha_{mcg}\bar{c}$

Real government consumption $\bar{g} = g_r\bar{y}$

Real exports $\bar{x} = \alpha_M^*\bar{q}^{\eta}\bar{y}^*$

Real imports $\overline{im} = \overline{im}^{rm} + \overline{im}^{cg} + \overline{im}^{kg}$

Real imports of raw material $\overline{im}^{rm} = \alpha_M\left(\frac{\bar{p}^d}{\bar{p}^m}\right)^{\nu}\bar{y}$

Real imports of consumption goods $\overline{im}^{cg} = \bar{c}^{mcg} = \alpha_{mcg}\bar{c}$

Real imports of capital goods $\overline{im}^{kg} = \alpha_{mkg}\overline{iv}$

Real demand for goods $\bar{y} = \bar{c} + \bar{g} + \overline{iv} + \bar{x} - \overline{im}$

Real output

$$\bar{y} = \left(\alpha_L^{\frac{1}{\nu}}(\bar{A}\bar{l}^d)^{\frac{\nu-1}{\nu}} + \alpha_K^{\frac{1}{\nu}}(\bar{u}\bar{k})^{\frac{\nu-1}{\nu}} + \alpha_M^{\frac{1}{\nu}}(\overline{im}_t^{rm})^{\frac{\nu-1}{\nu}}\right)^{\frac{\nu}{\nu-1}}$$

Consumer goods inflation $1+\bar{\pi} = (1+\bar{\pi}^d)^{(1-\alpha_{mcg})}(1+\bar{\pi}^m)^{\alpha_{mcg}}$

Domestic goods inflation $\bar{\pi}^d = \log\overline{MC}_t^d - \log\overline{MC}_{t-1}^d$

Imported goods inflation $\bar{\pi}^m = \log\overline{MC}_t^m - \log\overline{MC}_{t-1}^m$

Wage inflation $\bar{\pi}^w = \log\overline{MC}_t^w - \log\overline{MC}_{t-1}^w$

Domestic goods' marginal cost $\overline{MC}_t^d = \bar{P}_t\,\overline{mc}^d$

Imported goods' marginal cost $\overline{MC}_t^m = \bar{P}_t\,\overline{mc}^m$

Nominal marginal cost of working $M\bar{C}_t^w = \bar{P}_t\,\overline{mc}^w$

Consumer price $\bar{P}_t = \bar{P}_{t-1}(1+\bar{\pi})$

Domestic goods price $\bar{P}_t^d = \bar{P}_{t-1}^d(1+\bar{\pi}_t^d)$

Import price $\bar{P}_t^m = \bar{P}_{t-1}^m(1+\bar{\pi}^m)$

Nominal wage $\bar{W}_t = \bar{W}_{t-1}(1+\bar{\pi}^w)$

Real price of domestical good $\bar{p}^d = \frac{\bar{P}_t^d}{\bar{P}_t}$

Real import price $\bar{p}^m = \frac{\bar{q}}{1-\bar{\tau}}$

Flexible real import price $\bar{p}^{mn} = \frac{\bar{q}^n}{1-\bar{\tau}^n}$

Real wage $\bar{w} = \left(\frac{\bar{A}^{\lambda(\nu-1)}\bar{c}^{\sigma}(\alpha_L\bar{y})^{\lambda}}{1-\bar{\tau}}\right)^{\frac{1}{\nu\lambda+1}}$

Real Rental price of capital $\bar{z} = \frac{\bar{r}+\delta}{1-\bar{\tau}}$

Fiscal policy rule $\bar{\tau} = \frac{\bar{g}}{\bar{y}} - \psi$

Monetary policy rule	$\bar{\pi} = \bar{\pi}^T$
Real interest rate	$1+\bar{r} = \dfrac{1+\bar{i}}{1+\bar{\pi}}$; $\bar{r} = \bar{r}^*$
Households' real financial assets	$\bar{b}^H = \bar{b}^{HG} + \bar{q}\bar{b}^{H*}$
	$\bar{b}^H = \dfrac{1}{\bar{r}+(1+\bar{r})\bar{\kappa}(1-\alpha_{HG})}\left(\overline{\tau y} + \dfrac{\overline{\pi m}^d}{1+\bar{\pi}} - (\bar{x} - \bar{q}\overline{im}) - \bar{g}\right)$
Households' nominal financial assets	$\bar{B}_t^H = \bar{P}_t \bar{b}^H$
Households' real financial assets on government bond	$\bar{b}^{HG} = \alpha_{HG}\bar{b}^H$
Household's nominal financial assets on government bond	$\bar{B}_t^{HG} = \bar{P}_t\bar{b}^{HG}$
Household's real financial assets on foreign bond	$\bar{b}^{H*} = \dfrac{(1-\alpha_{HG})\bar{b}^H}{\bar{q}}$
Household's nominal financial assets on foreign bond	$\bar{B}_t^{H*} = \bar{P}_t^*\bar{b}^{H*}$

Household's real financial liabilities

$$\bar{d}^H = \frac{1}{\bar{r}+(1+\bar{r})\bar{\kappa}(1-\alpha_{HG})}\left((\bar{x} - \bar{q}\overline{im}) + \bar{g} - \overline{\tau y} - \frac{\overline{\pi m}^d}{1+\bar{\pi}}\right)$$

Government's real debt	$\bar{b}^G = \bar{b}^{GH} + \bar{q}\bar{b}^{G*}$
	$\bar{b}^G = \bar{g} + (1+\bar{r})\left(\bar{b}^{GH} + (1+\bar{\kappa})\bar{b}^{G*}\bar{q}\right) - \overline{\tau y} - \dfrac{\bar{m}^s\bar{\pi}}{(1+\bar{\pi})}$
Government's nominal debt	$\bar{B}_t^G = \bar{P}_t\bar{b}^G$
Government's real domestic debt	$\bar{b}^{GH} = \alpha_{GH}\bar{b}^G$
Government's nominal domestic debt	$\bar{B}_t^{GH} = \bar{P}_t\bar{b}^{GH}$
Government's real foreign debt	$\bar{b}^{G*} = \dfrac{(1-\alpha_{GH})\bar{b}^G}{\bar{q}}$
Government's nominal foreign debt	$\bar{B}_t^{G*} = \bar{P}_t^*\bar{b}^{G*}$
Real Net Foreign Liabilities	$\bar{d}^* = -\dfrac{(\overline{im} - \bar{x}/\bar{q})}{\bar{r}^* + \bar{\kappa} + \bar{r}^*\bar{\kappa}}$
Nominal Net Foreign Liabilities	$\bar{D}_t^* = \bar{P}_t^*\bar{d}^*$
Financial Account	$\overline{FA}_t = \bar{D}_t^* - \bar{D}_{t-1}^* = \bar{d}^*\bar{\pi}^*\bar{P}_{t-1}^*$
Current Account	$\overline{CA}_t = (\bar{P}_t\bar{x}/\bar{s}_t - \bar{P}_t^*\overline{im}) - [(1+\bar{i}^*)(1+\bar{\kappa}) - 1]\bar{D}_{t-1}^*$
Interest-rate risk premium	$\bar{\kappa} = \varsigma\left(e^{-\frac{\bar{q}\bar{b}^*}{y}} - 1\right)$

C. The log-linearised dynamic equations in deviation from steady-state

Nominal exchange rate $\hat{s}_t = E_t \hat{s}_{t+1} + (1+\hat{i}_t^*) - (1+\hat{i}_t) + (1+\hat{\kappa}_t)$

Real exchange rate $\hat{q}_t = \hat{s}_t + \hat{P}_t^* - \hat{P}_t$

Real money demand $\hat{m}_t^d = \dfrac{\sigma}{\rho}\hat{c}_t - \dfrac{1}{\rho}\hat{i}_t^{'}$ where $i_t^{'} = \dfrac{i_t}{1+i_t}$

Labour supply $\hat{l}_t^s = \dfrac{1}{\lambda}\left(\hat{w}_t + (1-\hat{\tau}_t) - \sigma\hat{c}_t\right),$

Labour demand $\hat{l}_t^d = \nu\left(\hat{p}_t^d - \hat{w}_t\right) + (\nu-1)\hat{A}_t + \hat{y}_t$

Real marginal cost of producing goods

$$m\hat{c}_t^d = \left[1 - m\bar{c}^{d(\nu-1)}\left[\alpha_K\left(\frac{\bar{u}}{\bar{z}}\right)^{\nu-1} + \alpha_M\left(\frac{1}{\bar{p}^m}\right)^{(\nu-1)}\right]\right](\hat{w}_t - \hat{A}_t)$$
$$+ m\bar{c}^{d\,\nu-1}\left(\alpha_K\left(\frac{\bar{u}}{\bar{z}}\right)^{\nu-1}(\hat{z}_{t-1} - \hat{u}_t) + \alpha_M\left(\frac{1}{\bar{p}^m}\right)^{\nu-1}\hat{p}_t^m\right)$$

Real marginal cost of importing goods $m\hat{c}_t^m = \hat{q}_t$

Real marginal cost of working $m\hat{c}_t^w = \dfrac{1}{\nu\lambda+1}\left(\lambda(\nu-1)\hat{A}_t + \sigma\hat{c}_t + \lambda\hat{y}_t - (1-\hat{\tau}_t)\right)$

Technology $\hat{A}_t = \varsigma\hat{A}_{t-1}$

Real capital stock $\hat{k}_t = \nu\left(E_t\hat{p}_{t+1}^d - \hat{z}_t\right) + (\nu-1)E_t\hat{u}_{t+1} + E_t\hat{y}_{t+1}$

Real investment $i\hat{v}_t = \dfrac{1}{\delta}\left(\hat{k}_t - (1-\delta)\hat{k}_{t-1}\right)$

Real consumption $\hat{c}_t = E_t\hat{c}_{t+1} - \dfrac{1}{\sigma}(1+\hat{r}_t)$

Real consumption of imported finished goods $\hat{c}_t^{mcg} = \hat{c}_t$

Real government consumption $\hat{g}_t = \hat{g}_{t-1}$

Real exports $\hat{x}_t = \eta\hat{q}_t + \hat{y}_t^*$

Real imports $i\hat{m}_t = \dfrac{\overline{im}^{rm}}{\overline{im}}i\hat{m}_t^{rm} + \dfrac{\overline{im}^{cg}}{\overline{im}}i\hat{m}_t^{cg} + \dfrac{\overline{im}^{kg}}{\overline{im}}i\hat{m}_t^{kg}$

Real imports of raw material $i\hat{m}_t^{rm} = \nu(\hat{p}_t^d - \hat{p}_t^m) + \hat{y}_t$

Real imports of consumption goods $i\hat{m}_t^{cg} = \hat{c}_t^{mcg} = \hat{c}_t$

Real imports of capital goods $i\hat{m}_t^{kg} = i\hat{v}_t$

Real demand for goods $\hat{y}_t = \dfrac{\bar{c}}{\bar{y}}\hat{c}_t + \dfrac{\bar{g}}{\bar{y}}\hat{g}_t + \dfrac{\overline{iv}}{\bar{y}}i\hat{v}_t + \dfrac{\bar{x}}{\bar{y}}\hat{x}_t - \dfrac{\overline{im}}{\bar{y}}i\hat{m}_t$

Real output	$\hat{y}_t = \bar{y}^{\frac{1-\nu}{\nu}} \begin{pmatrix} \alpha_L^{\frac{1}{\nu}} (\bar{A}\bar{l}^d)^{\frac{\nu-1}{\nu}} (\hat{A}_t + \hat{l}_t^d) + \alpha_K^{\frac{1}{\nu}} (\bar{u}\bar{k})^{\frac{\nu-1}{\nu}} (\hat{u}_t + \hat{k}_{t-1}) \\ + \alpha_M^{\frac{1}{\nu}} \overline{im}^{rm\frac{\nu-1}{\nu}} \hat{im}_t^{rm} \end{pmatrix}$
Consumer goods inflation	$\hat{\pi}_t = (1-\alpha_{mcg})(\hat{\pi}_t^d + e^{\hat{\varepsilon}_t^a}) + \alpha_{mcg}\hat{\pi}_t^m$
Domestic goods inflation	$\hat{\pi}_t^d = \beta E_t \hat{\pi}_{t+1}^d + \left(\frac{(1-\theta)(1-\beta\theta)}{\theta}\right) m\hat{c}_t^d$
Imported goods inflation	$\hat{\pi}_t^m = \beta E_t \hat{\pi}_{t+1}^m + \left(\frac{(1-\theta^m)(1-\beta\theta^m)}{\theta^m}\right)(\hat{q}_t - (1-\hat{\tau}_t))$

Wage inflation $\hat{\pi}_t^w = \frac{1}{\theta^w + \gamma^w[1-\theta^w(1-\beta)]} \left[\begin{array}{l} (\beta\theta^w \hat{\pi}_{t-1}^w + \gamma^w E_t \hat{\pi}_{t+1}^w) \\ + \frac{(1-\gamma^w)(1-\theta^w)(1-\beta\theta^w)}{\nu\lambda+1} \left(\lambda(\nu-1)\hat{A}_t + \sigma\hat{c}_t + \lambda\hat{y}_t - (1-\hat{\tau}_t)\right) \end{array} \right]$

Domestic goods' marginal cost	$M\hat{C}_t^d = \hat{P}_t + m\hat{c}_t^d$
Imported goods' marginal cost	$M\hat{C}_t^m = \hat{P}_t + m\hat{c}_t^m$
Nominal marginal cost of working	$M\hat{C}_t^w = \hat{P}_t + m\hat{c}_t^w$
Consumer price	$\hat{P}_t = \hat{P}_{t-1} + \hat{\pi}_t$
Domestically-produced goods price	$\hat{P}_t^d = \hat{P}_{t-1}^d + \hat{\pi}_t^d$
Import price	$\hat{P}_t^m = \hat{P}_{t-1}^m + \hat{\pi}_t^m$
Nominal wage	$\hat{W}_t = \hat{W}_{t-1} + \hat{\pi}_t^w$
Real domestic good price	$\hat{p}_t^d = \hat{P}_t^d - \hat{P}_t$
Real import price	$\hat{p}_t^m = \hat{P}_t^m - \hat{P}_t$
Flexible real import price	$\hat{p}_t^{mn} = \hat{q}_t^n - (1-\hat{\tau}_t^n)$
Real wage	$\hat{w}_t = \hat{W}_t - \hat{P}_t$
Rental rate of capital	$\hat{z}_t = \frac{\bar{r}}{\bar{z}(1-\bar{\tau})}\hat{r}_t + \left(\frac{\bar{\tau}}{1-\bar{\tau}}\right) E_t \hat{\tau}_{t+1}$
Fiscal policy rule	$\hat{\tau}_t = \frac{1}{1+\Theta}\left[\hat{\tau}_{t-1} + \frac{\Theta\bar{g}}{\bar{\tau}\bar{y}}(\hat{g}_t - \hat{y}_t)\right]$
Monetary policy rule	$\hat{i}_t = \chi\hat{i}_{t-1} + \frac{(1-\chi)\alpha_\pi\bar{\pi}}{\bar{i}}\left[\pi_t - \pi_t^T\right]$
Real interest rate	$1+\hat{r}_t = (1+\hat{i}_t) - (1+E_t\hat{\pi}_{t+1})$

Household's real financial asset

$$\hat{b}_t^H = \frac{1}{\overline{b}^H}\begin{pmatrix} \overline{x}\hat{x}_t - \overline{q}\,\overline{im}(i\hat{m}_t + \hat{q}_t) + \overline{g}\hat{g}_t \\ +(1+\overline{r})(\overline{b}^{HG} + (1+\overline{\kappa})\overline{q}\overline{b}^{H*})\hat{b}_{t-1}^H \\ +\overline{r}(\overline{b}^{HG}\hat{r}_{t-1} + (1+\overline{\kappa})\overline{q}\overline{b}^{H*}\hat{r}_{t-1}^*) \\ +(1+\overline{r})\overline{q}\overline{b}^{H*}[(1+\overline{\kappa})(\hat{q}_t - \hat{q}_{t-1}) + \overline{\kappa}\hat{\kappa}_{t-1}] \\ -\overline{\tau y}(\hat{y}_t + \hat{\tau}_t) - \overline{m}^d\hat{m}_t^d \\ +\dfrac{\overline{m}^d}{(1+\overline{\pi})}\left(\hat{m}_{t-1}^d - \dfrac{\overline{\pi}}{1+\overline{\pi}}\hat{\pi}_t\right) \end{pmatrix}$$

Household's nominal financial assets $\hat{B}_t^H = \hat{P}_t + \hat{b}_t^H$

Household's real financial assets on government bond $\hat{b}_t^{HG} = \hat{b}_t^H$

Household's nominal financial assets on government bond $\hat{B}_t^{HG} = \hat{P}_t + \hat{b}_t^{HG}$

Household's real financial assets on foreign bond $\hat{b}_t^{H*} = \hat{b}_t^H - \hat{q}_t$

Household's nominal financial assets on foreign bond $\hat{B}_t^{H*} = \hat{P}_t^* + \hat{b}_t^{H*}$

Household's nominal financial debt $\hat{D}_t^H = \hat{P}_t + \hat{d}_t^H$

Household's real financial debt on government bond $\hat{d}_t^{HG} = \hat{d}_t^H$

Household's real financial liabilities
$$\hat{d}_t^H = \frac{1}{\overline{d}^H}\begin{pmatrix} \overline{x}\hat{x}_t - \overline{q}\,\overline{im}(i\hat{m}_t + \hat{q}_t) + \overline{g}\hat{g}_t \\ +(1+\overline{r})(\overline{d}^{HG} + (1+\overline{\kappa})\overline{q}\overline{d}^{H*})\hat{d}_{t-1}^H \\ -\overline{r}(\overline{d}^{HG}\hat{r}_{t-1} + (1+\overline{\kappa})\overline{q}\overline{d}^{H*}\hat{r}_{t-1}^*) \\ -(1+\overline{r})\overline{q}\overline{d}^{H*}[(1+\overline{\kappa})(\hat{q}_t - \hat{q}_{t-1}) + \overline{\kappa}\hat{\kappa}_{t-1}] \\ -\overline{\tau y}(\hat{y}_t + \hat{\tau}_t) - \overline{m}^d\hat{m}_t^d \\ +\dfrac{\overline{m}^d}{(1+\overline{\pi})}\left(\hat{m}_{t-1}^d - \dfrac{\overline{\pi}}{1+\overline{\pi}}\hat{\pi}_t\right) \end{pmatrix}$$

Household's nominal financial liabilities on government bond $\hat{D}_t^{HG} = \hat{P}_t + \hat{d}_t^{HG}$

Household's real financial liabilities on foreign bond $\hat{d}_t^{H*} = \hat{d}_t^H - \hat{q}_t$

Household's nominal financial liabilities on foreign bond $\hat{B}_t^{H*} = \hat{P}_t^* + \hat{d}_t^{H*}$

Government's real debt

$$\hat{b}_t^G = \frac{1}{\bar{b}^G}\begin{pmatrix} \bar{g}\hat{g}_t + (1+\bar{r})(\bar{b}^{GH} + \bar{q}\bar{b}^{G*}(1+\bar{\kappa}))\hat{b}_{t-1}^G \\ +\bar{r}[\bar{b}^{GH}\hat{r}_{t-1} + (1+\bar{\kappa})\bar{q}\bar{b}^{G*}\hat{r}_{t-1}^*] \\ +(1+\bar{r}^*)\bar{q}\bar{b}^{G*}[(1+\bar{\kappa})(\hat{q}_t - \hat{q}_{t-1}) + \bar{\kappa}\hat{\kappa}_{t-1}] \\ -\bar{\tau}\bar{y}(\hat{y}_t + \hat{\tau}_t) - \bar{m}^s\hat{m}_t^s + \frac{\bar{m}^s}{1+\bar{\pi}}\left(\hat{m}_{t-1}^s - \frac{\bar{\pi}}{1+\bar{\pi}}\hat{\pi}_t\right) \end{pmatrix}$$

Government's nominal debt $\hat{B}_t^G = \hat{P}_t + \hat{b}_t^G$

Government's real domestic debt $\hat{b}_t^{GH} = \hat{b}_t^G$

Government's nominal domestic debt $\hat{B}_t^{GH} = \hat{P}_t + \hat{b}_t^{GH}$

Government's real foreign debt $\hat{b}_t^{G*} = \hat{b}_t^G - \hat{q}_t$

Government's nominal foreign debt $\hat{B}_t^{G*} = \hat{P}_t^* + \hat{b}_t^{G*}$

Real Net Foreign Liabilities
$$\hat{d}_t^* = \frac{\overline{im}}{\bar{d}^*}\hat{im}_t - \frac{\bar{x}}{\bar{q}\bar{d}^*}(\hat{x}_t - \hat{q}_t) + \hat{d}_{t-1}^* + \bar{r}^*(\hat{r}_{t-1}^* + \hat{d}_{t-1}^*)$$
$$+\bar{\kappa}(\hat{\kappa}_{t-1} + \hat{d}_{t-1}^*) + \bar{r}^*\bar{\kappa}(\hat{\kappa}_{t-1} + \hat{r}_{t-1}^* + \hat{d}_{t-1}^*)$$

Nominal Net Foreign Liabilities $\hat{D}_t^* = \hat{P}_t^* + \hat{d}_t^*$

Financial Account
$$\hat{FA}_t = \frac{\bar{D}_t^*}{\overline{FA}_t}\hat{D}_t^* - \frac{\bar{D}_{t-1}^*}{\overline{FA}_t}\hat{D}_{t-1}^*$$

Current Account
$$\hat{CA}_t = \frac{1}{\overline{CA}_t}\begin{pmatrix} \frac{\bar{P}_t\bar{x}}{\bar{s}_t}(\hat{P}_t + \hat{x}_t - \hat{s}_t) - \bar{P}_t^*\overline{im}(\hat{P}_t^* + \hat{im}_t) \\ -\bar{D}_{t-1}^*\bar{i}^*(\hat{i}_{t-1}^* + \hat{D}_{t-1}^*) \\ -\bar{\kappa}\bar{D}_{t-1}^*(\hat{D}_{t-1}^* + \hat{\kappa}_{t-1}) \\ -\bar{i}^*\bar{\kappa}\bar{D}_{t-1}^*(\hat{D}_{t-1}^* + \hat{\kappa}_{t-1} + \hat{i}_{t-1}^*) \end{pmatrix}$$

Interest-rate risk premium
$$\hat{\kappa}_t = \frac{\bar{q}\bar{d}^*(\bar{\kappa}+\varsigma)}{\bar{y}\bar{\kappa}}\left(\hat{q}_t + \hat{d}_t^* - \hat{y}_t\right) + \varepsilon_t^\kappa$$

D. Source code

D.1 Dynamic Model in deviation from steady-state

```
************************************************
* SECTION 1 : DEFINITION & VALUES OF PARAMETER *
************************************************
SCALARS
*------------------------------------------------------------
* Steady state values
*------------------------------------------------------------
mss            money demand                   /6.559754/
Ldss           labour demand                  /0.6381252/
Lsss           labour supply                  /0.6381252/
wss            real wage                      /3.264921/
Ass            technology                     /1/
kss            capital stock                  /3.754855/
ivss           investment                     /0.03754855/
css            consumption                    /2.343904/
gss            government expenditure         /0.208013/
xss            exports                        /0.725444/
imss           imports                        /0.714752/
imcgss         imports of consumption goods   /0.328147/
```

```
imrawss         imports of intermediate goods   /0.382851/
imkgss          imports of capital goods        /0.003755/
yss             aggregate demand = output       /2.600157/
ynss            natural output                  /2.600157/
piss            CPI inflation                   /0.05/
piqss           CPI inflation qtq               /0.012272/
pidss           domestic inflation              /0.05/
pidqss          domestic inflation qtq          /0.012272/
pimss           import price inflation          /0.05/
pimqss          import price inflation qtq      /0.012272/
piwss           wage inflation                  /0.05/
piwqss          wage inflation qtq              /0.012272/
pifss           foreign inflation               /0.02/
pifqss          foreign inflation qtq           /0.004963/
pitargetss      inflation target                /0.05/
pitargetqss     inflation target qtq            /0.012272/
tauss           tax rate                        /0.06/
rss             real interest rate              /0.020408/
rqss            real interest rate qtq          /0.005063/
rfss            foreign real int. rate          /0.020408/
rfqss           foreign real int. rate qtq      /0.005063/
iss             nominal interest rate           /0.071429/
iqss            nominal interest rate qtq       /0.017398/
irfss           foreign nominal int. rate       /0.040816/
irfqss          foreign nom int rate qtq        /0.010052/
qss             real exchange rate              /1/
mcdss           real marginal cost of domestically-produced goods /1/
mcmss           real marginal cost of imported goods /1.06383/
mcwss           real marginal cost of working   /3.264921/
pmss            real import price               /1.06383/
pdss            real domestic price             /1/
zss             capital rental rate             /0.121783/
zqss            capital rental rate qtq         /0.029147/
yfss            foreign output                  /4030.243849/
uss             capital utilization rate        /1/
unemss          unemployment                    /0/
kappass         risk premium yoy                   /2.2510E-9/
kappaqss        risk premium qtq                   /5.628E-10/
bfss            real net foreign debt              /2.111587/
bgss            real government debt               /5.435762/
bgfss           real foreign government debt       /2.174305/
bgdss           real domestic government debt      /3.26146/
dhss            real households liabilities             /3.324175/
dhfss           real foreign households liabilities     /1.66209/
dhdss           real domestic households liabilities    /1.66209/
*--------------------------------------------------------------------------
* Policy parameter
*--------------------------------------------------------------------------
chi             degree of interest rate inertia                         /0.5/
alphapi         monetary policy response to inflation gap               /30000/
uptheta         fiscal policy response parameter                        /0.5/
psi             target of fiscal deficit ratio                          /0.02/
s_teta          household discount factor /0.98/
beta            producers's and importer's and wage setter's discount factor /0.99/
sigma           relative risk aversion (inverse of consumption intertemporal elasticity of
substitution) /265/
rho             inverse of interest rate elasticity of real money balance /120/
lambda          inverse of wage elasticity of labour supply      /500/
delta           depreciation rate          /0.01/
aK              capital share              /0.5/
aL              labor share                /0.35/
aM              intermediate import share  /0.15/
aMf             share of export in foreign economy total demand /0.00018/
eta             real exchange rate elastity of export /0.2/
simcg           share of finished goods imports in consumption  /0.14/
stec            technology AR parameter /0/
syf             foreign output AR parameter /0/
spif            foreign inflation AR parameter /0/
sirf            foreign interest rate AR parameter /0/
smu             markup shock AR parameter /0/
sg              govt spending shock AR parameter /0/
ser             nominal exchange rate shock AR parameter /0/
sq              real exchange rate shock AR parameter /0/
sc              consumption shock AR parameter /0/
kap             parameter risk premium  /0.00000001/
ve              elasticity of substitution between factor inputs /0.3/
********************************************************
spitgt          inflation target shock AR parameter /0/
********************************************************
aa              preference weight for inflation stabilization in loss function /0.5/
discfactor      discount factor for loss function /0.98/
theta           degree of price stickiness                                  /0.35/
gamma           degree of price backward lookingness                        /0/
thetaim         degree of import price stickiness                           /0.1/
gammaim         degree of import price backward lookingness                 /0/
thetaw          degree of wage stickiness                                   /0.75/
gammaw          degree of wage indexation                                   /0.9/
```

```
theta_flex       degree of price stickiness when price is perfectly flexible
/0.000000000000000000000000000001/
gamma_flex       degree of backward looking when price is perfectly flexible /0/
si               constant for NKPC
gammab           parameter backward looking in NKPC
gammaf           parameter forward looking in NKPC
lambdakros       parameter of real marginal cost in NKPC
sim              constant for NKPC
gammaimb         parameter backward looking in NKPC import goods inflation
gammaimf         parameter forward looking in NKPC import goods inflation
lambdakrosim     parameter of real marginal cost in NKPC import goods inflation
siw              constant for NKPC
gammawb          parameter backward looking in NKPC wage inflation
gammawf          parameter forward looking in NKPC wage inflation
lambdakrosw      parameter of real marginal cost in NKPC wage inflation
si_flex          constant for flexible NKPC
gammab_flex      parameter backward looking in flexible NKPC
gammaf_flex      parameter forward looking in flexible NKPC
lambdakros_flex  parameter of flexible real marginal cost in flesible NKPC
po               substitution paremeter ;
si               = theta   + gamma  *(1-theta*(1-beta));
gammaf           = beta*theta*(1/si);
gammab           = gamma*(1/si);
lambdakros       = (1-gamma)*(1-theta)*(1-beta*theta)*(1/si);
sim              = thetaim + gammaim*(1-thetaim*(1-beta));
gammaimf         = beta*thetaim*(1/sim);
gammaimb         = gammaim*(1/sim);
lambdakrosim     = (1-gammaim)*(1-thetaim)*(1-beta*thetaim)*(1/sim);
siw              = thetaw  + gammaw *(1-thetaw*(1-beta));
gammawf          = beta*thetaw*(1/siw);
gammawb          = gammaw*(1/siw);
lambdakrosw      = (1-gammaw)*(1-thetaw)*(1-beta*thetaw)*(1/siw);
si_flex          = theta_flex + gamma_flex  *(1-theta_flex*(1-beta));
gammaf_flex      = beta*theta_flex*(1/si_flex);
gammab_flex      = gamma_flex*(1/si_flex);
lambdakros_flex  = (1-gamma_flex)*(1-theta_flex)*(1-beta*theta_flex)*(1/si_flex);
po               = (ve-1)/ve;
************************************
* SECTION 2 : SOLUTION TIME HORIZON *
************************************
SETS
t                extended solution horizon         /0*100/
te(t)            effective solution horizon        /1*99/
ttemporer(t)     period for temporary shocks       /1*1/
ttemporer1(t)    period for after one time shocks  /2*2/
tpermanen(t)     period for permanent shocks       /1*8/
tloss(t)         period for calculating total loss /1*99/
t0(t)            period zero
tf(t)            final period;
t0(t)            = yes$(ord(t) eq 1);
tf(t)            = yes$(ord(t) eq (card(t)));
DISPLAY t0, tf;
DISPLAY gammaf_flex, gammab_flex, si_flex, lambdakros_flex;

JD..               J                  =E= 0;
eq1(t+2)..         log(er(t+1))       =E= log(erss(t+1)) + (log(er(t+2))-log(erss(t+2))) +
(log(1+irfq(t+1))-log(1+irfqss)) - (log(1+iq(t+1))-log(1+iqss)) + (log(1+kappaq(t+1))-
log(1+kappaqss));
eq1k(t+1)..        kappa(t+1)         =E= exp(log(kappass) +
(qss*bfss/(4*yss*kappass))*(kappass+kap)*((log(q(t+1))-log(qss)) + (log(bf(t+1))-log(bfss)) -
(log(y(t+1))-log(yss)))) + eps_kappa(t+1);
eq1bf(t+1)..       log(bf(t+1))       =E= log(bfss) + (imss/bfss)*(log(im(t+1))-log(imss)) -
(xss/(qss*bfss))*((log(x(t+1))-log(xss))-(log(q(t+1))-log(qss))) + (log(bf(t))-log(bfss)) +
rfqss*((rfq(t)-rfqss) + (log(bf(t))-log(bfss))) + kappaqss*((log(kappaq(t))-log(kappaqss)) +
(log(bf(t))-log(bfss))) + rfqss*kappaqss*((log(kappaq(t))-log(kappaqss)) + (rfq(t)-rfqss) +
(log(bf(t))-log(bfss)));
eq1nombf(t+1)..    log(nbf(t+1))      =E= log(nbfss(t+1)) + (log(pf(t+1))-log(pfss(t+1))) +
(log(bf(t+1))-log(bfss));
eq1fa(t+1)..       log(fa(t+1))       =E= log(fass(t+1)) + (nbfss(t+1)/fass(t+1))*(log(nbf(t+1))-
log(nbfss(t+1))) - (nbfss(t)/fass(t+1))*(log(nbf(t))-log(nbfss(t)));
eq1ta(t+1)..       log(ta(t+1))       =E= log(tass(t+1)) + 1/tass(t+1) *
(pss(t+1)*xss/erss(t+1)*((log(p(t+1))-log(pss(t+1)))+(log(x(t+1))-log(xss))-(log(er(t+1))-
log(erss(t+1)))) - pfss(t+1)*imss*((log(im(t+1))-log(imss))+(log(pf(t+1))-log(pfss(t+1)))));
eq1sa(t+1)..       log(sa(t+1))       =E= log(sass(t+1)) + nbfss(t)/sass(t+1)*(irfqss*((irfq(t)-
irfqss) + (log(nbf(t))-log(nbfss(t)))) + kappaqss*((log(kappaq(t))-log(kappaqss)) + (log(nbf(t))-
log(nbfss(t))))                                          + kappaqss*irfqss*((log(kappaq(t))-
log(kappaqss)) + (irfq(t)-irfqss) + (log(nbf(t))-log(nbfss(t)))));
eq1ca(t+1)..       ca(t+1)            =E= ta(t+1) - sa(t+1);
eq1rgdebt(t+1)..   log(bg(t+1))       =E= log(bgss) + 1/bgss*(gss*(log(g(t+1))-log(gss)) +
(1+rqss)*(bgdss+(1+kappaqss)*qss*bgfss)*(log(bg(t))-log(bgss)) + rqss*(bgdss*(rq(t)-
rqss)+(1+kappaqss)*qss*bgfss*(rfq(t)-rfqss)) + (1+rfqss)*qss*bgfss*((1+kappaqss)*((log(q(t+1))-
log(qss)) - (log(q(t))-log(qss))) + kappaqss*(kappaq(t)-kappaqss)) - tauss*yss*((log(y(t+1))-
log(yss))+(log(tau(t+1))-log(tauss))) - mss*(log(m(t+1))-log(mss)) + mss/(1+piqss)*((log(m(t))-
log(mss))-piqss/(1+piqss)*(piq(t+1)-piqss)));
eq1rfgdebt(t+1)..  log(bgf(t+1))      =E= log(bgfss) + (log(bg(t+1))-log(bgss)) - (log(q(t+1))-
log(qss));
eq1rdgdebt(t+1)..  log(bgd(t+1))      =E= log(bgdss) + (log(bg(t+1))-log(bgss));
```

```
eq1ngdebt(t+1)..   log(nbg(t+1))       =E= log(nbgss(t+1)) + (log(p(t+1))-log(pss(t+1))) +
(log(bg(t+1))-log(bgss));
eq1nfgdebt(t+1)..  log(nbgf(t+1))      =E= log(nbgfss(t+1)) + (log(pf(t+1))-log(pfss(t+1))) +
(log(bgf(t+1))-log(bgfss));
eq1ndgdebt(t+1)..  log(nbgd(t+1))      =E= log(nbgdss(t+1)) + (log(p(t+1))-log(pss(t+1))) +
(log(bgd(t+1))-log(bgdss));
eq1rhdebt(t+1)..   log(dh(t+1))        =E= log(dhss) + 1/dhss*(xss*(log(x(t+1))-log(xss)) -
qss*imss*((log(im(t+1))-log(imss))+(log(q(t+1))-log(qss))) + gss*(log(g(t+1))-log(gss)) +
(1+rqss)*(dhdss+(1+kappaqss)*qss*dhfss)*(log(dh(t))-log(dhss)) - rqss*(dhdss*(rq(t)-rqss) +
(1+kappaqss)*qss*dhfss*(rfq(t)-rfqss)) - (1+rqss)*qss*dhfss*((1+kappaqss)*((log(q(t+1))-log(qss))-
(log(q(t))-log(qss))) + kappaqss*(log(kappaq(t)-log(kappaqss))) - tauss*yss*((log(y(t+1))-
log(yss))+(log(tau(t+1))-log(tauss))) - mss*(log(m(t+1))-log(mss))+ mss/(1+piqss)*((log(m(t))-
log(mss))-piqss/(1+piqss)*(piq(t+1)-piqss)));
eq1rfhdebt(t+1).. log(dhf(t+1))       =E= log(dhfss) + (log(dh(t+1))-log(dhss)) - (log(q(t+1))-
log(qss));
eq1rdhdebt(t+1).. log(dhd(t+1))       =E= log(dhdss) + (log(dh(t+1))-log(dhss));
eq1nhdebt(t+1)..  log(ndh(t+1))       =E= log(ndhss(t+1)) + (log(p(t+1))-log(pss(t+1))) +
(log(dh(t+1))-log(dhss));
eq1nfhdebt(t+1).. log(ndhf(t+1))      =E= log(ndhfss(t+1)) + (log(pf(t+1))-log(pfss(t+1))) +
(log(dhf(t+1))-log(dhfss));
eq1ndhdebt(t+1).. log(ndhd(t+1))      =E= log(ndhdss(t+1)) + (log(p(t+1))-log(pss(t+1))) +
(log(dhd(t+1))-log(dhdss));
eq1n(t+2)..       log(ern(t+1))       =E= log(erss(t+1)) + (log(ern(t+2))-log(erss(t+2))) +
(log(1+irfqn(t+1))-log(1+irfqss)) - (log(1+iqn(t+1))-log(1+iqss)) + eps_er(t+1);
eq2(t+1)..        log(q(t+1))         =E= log(qss) + (log(er(t+1))-log(erss(t+1))) + (log(pf(t+1))-
log(pfss(t+1))) - (log(p(t+1))-log(pss(t+1))) + eps_q(t+1);
eq2n(t+1)..       log(qn(t+1))        =E= log(qss) + (log(ern(t+1))-log(erss(t+1))) + (log(pf(t+1))-
log(pfss(t+1))) - (log(pn(t+1))-log(pss(t+1))) + eps_q(t+1);
eq3(t+1)..        log(m(t+1))         =E= log(mss) + (sigma/rho)*(log(c(t+1))-log(css)) -
(1/rho)*(iq(t+1)-iqss);
eq4(t+1)..        log(Ls(t+1))        =E= log(Lsss) - sigma/lambda*(log(c(t+1))-log(css)) +
(1/lambda)*(log(w(t+1))-log(wss)) + (1/lambda)*(log(1-tau(t+1))-log(1-tauss));
eq4n(t+1)..       log(Lsn(t+1))       =E= log(Lsss) - sigma/lambda*(log(cn(t+1))-log(css)) +
(1/lambda)*(log(wn(t+1))-log(wss)) + (1/lambda)*(log(1-taun(t+1))-log(1-tauss));
eq5(t+1)..        log(Ld(t+1))        =E= log(Ldss) + ve*((log(pd(t+1))-log(pdss))-(log(w(t+1))-
log(wss))) + (log(y(t+1))-log(yss)) + (ve-1)*(log(A(t+1))-log(Ass));
eq5n(t+1)..       log(Ldn(t+1))       =E= log(Ldss) + (log(yn(t+1))-log(yss)) - (log(wn(t+1))-
log(wss));
eq6(t+1)..        log(A(t+1))         =E= log(Ass) + stec*(log(A(t))-log(Ass)) + log(1+eps_A(t+1));
eq6n(t+1)..       log(An(t+1))        =E= log(Ass) + stec*(log(A(t))-log(Ass)) + log(1+eps_A(t+1));
eq7(t+2)..        log(k(t+1))         =E= log(kss) + ve*((log(pd(t+2))-log(pdss)) - (log(zq(t+1))-
log(zqss))) + (log(y(t+2))-log(yss));
eq7n(t+2)..       log(kn(t+1))        =E= log(kss) + (log(yn(t+2))-log(yss)) - (log(zqn(t+1))-
log(zqss));
eq8(t+1)..        log(iv(t+1))        =E= log(ivss) + (kss/ivss)*((log(k(t+1))-log(kss)) - (1-
delta)*(log(k(t))-log(kss)));
eq8n(t+1)..       log(ivn(t+1))       =E= log(ivss) + (kss/ivss)*((log(kn(t+1))-log(kss)) - (1-
delta)*(log(kn(t))-log(kss)));
eq9(t+2)..        log(c(t+1))         =E= log(c(t+2)) - (1/sigma)*(log(1+rq(t+1))-log(1+rqss)) +
eps_c(t+1);
eq9n(t+2)..       log(cn(t+1))        =E= log(cn(t+2)) - (1/sigma)*(log(1+rqn(t+1))-log(1+rqss)) +
eps_c(t+1);
eq10(t+1)..       log(g(t+1))         =E= log(gss) + sg*(log(g(t))-log(gss)) + eps_g(t+1);
eq10n(t+1)..      log(gn(t+1))        =E= log(gss) + sg*(log(gn(t))-log(gss)) + eps_g(t+1);
eq11(t+1)..       log(x(t+1))         =E= log(xss) + eta*(log(q(t+1))-log(qss)) + (log(yf(t+1))-
log(yfss));
eq11n(t+1)..      log(xn(t+1))        =E= log(xss) + eta*(log(qn(t+1))-log(qss)) + (log(yf(t+1))-
log(yfss));
eq12(t+1)..       log(imraw(t+1))     =E= log(imrawss) + ve*((log(pd(t+1))-log(pdss)) - (log(pm(t+1))-
log(pmss))) + (log(y(t+1))-log(yss));
eq12n(t+1)..      log(imrawn(t+1))    =E= log(imrawss) + (log(yn(t+1))-log(yss)) - (log(pmn(t+1))-
log(pmss));
eq13(t+1)..       log(imkg(t+1))      =E= log(imkgss) + (log(iv(t+1))-log(ivss));
eq13n(t+1)..      log(imkgn(t+1))     =E= log(imkgss) + (log(ivn(t+1))-log(ivss));
eq14(t+1)..       log(imcg(t+1))      =E= log(imcgss) + (log(c(t+1))-log(css));
eq14n(t+1)..      log(imcgn(t+1))     =E= log(imcgss) + (log(cn(t+1))-log(css));
eq15(t+1)..       log(im(t+1))        =E= log(imss) + imrawss/imss*(log(imraw(t+1))-log(imrawss)) +
imkgss/imss*(log(imkg(t+1))-log(imkgss)) + imcgss/imss*(log(imcg(t+1))-log(imcgss));
eq15n(t+1)..      log(imn(t+1))       =E= log(imss) + imrawss/imss*(log(imrawn(t+1))-log(imrawss)) +
imkgss/imss*(log(imkgn(t+1))-log(imkgss)) + imcgss/imss*(log(imcgn(t+1))-log(imcgss));
eq16d(t+1)..      log(y(t+1))         =E= log(yss) + (1/yss)*(css*(log(c(t+1))-log(css)) +
gss*(log(g(t+1))-log(gss)) + ivss*(log(iv(t+1))-log(ivss)) + xss*(log(x(t+1))-log(xss)) -
imss*(log(im(t+1))-log(imss)));
eq16s(t+1)..      log(y(t+1))         =E= log(yss) + yss2*(aL2*Ass2*Ldss2*((log(A(t+1))-log(Ass)) +
(log(Ld(t+1))-log(Ldss))) + aK2*uss2*kss2*((log(u(t+1))-log(uss)) + (log(k(t))-log(kss))) +
aM2*imrawss2*(log(imraw(t+1))-log(imrawss)));
eq16a..           log(Ass2)           =E= (ve-1)/ve*log(Ass);
eq16b..           log(Ldss2)          =E= (ve-1)/ve*log(Ldss);
eq16c..           log(uss2)           =E= (ve-1)/ve*log(uss);
eq16dd..          log(kss2)           =E= (ve-1)/ve*log(kss);
eq16e..           log(imrawss2)       =E= (ve-1)/ve*log(imrawss);
eq16f..           log(yss2)           =E= (1-ve)/ve*log(yss);
eq16g..           log(aL2)            =E= (1/ve)*log(aL);
eq16h..           log(aM2)            =E= (1/ve)*log(aM);
eq16i..           log(aK2)            =E= (1/ve)*log(aK);
eq16n(t+1)..      log(yn(t+1))        =E= log(ynss) + (1/lambda)*((lambda+1)*(log(A(t+1))-log(Ass)) +
(log(1-taun(t+1))-log(1-tauss)) - sigma*(log(cn(t+1))-log(css)))-
```

```
lambda+1)/(aL*lambda)*(aK*(log(zqn(t+1))-log(zqss)) + aM*(log(pmn(t+1))-log(pmss)) - (log(pdn(t+1))-
log(pdss)));
eq17(t+1)..      piq(t+1)            =E= piqss + (1-simcg)*pidqss/piqss*((pidq(t+1)-
pidqss)+eps_adm(t+1)) + simcg*pimqss/piqss*(pimq(t+1)-pimqss) ;
eq17n(t+1)..     piqn(t+1)           =E= piqss + (1-simcg)*pidqss/piqss*(pidqn(t+1)-pidqss) +
simcg*pimqss/piqss*(pimqn(t+1)-pimqss) ;
eq18(t+1)..      log(p(t+1))         =E= log(pss(t+1)) + (log(p(t))-log(pss(t))) + (piq(t+1)-piqss);
eq18n(t+1)..     log(pn(t+1))        =E= log(pss(t+1)) + (log(pn(t))-log(pss(t))) + (piqn(t+1)-
piqss);
eq19(t+2)..      pidq(t+1)           =E= pidqss + gammab*(pidq(t)-pidqss) + gammaf*(pidq(t+2)-pidqss)
+ lambdakros*(log(mcd(t+1))-log(mcdss));
eq19n(t+1)..     pidqn(t+1)          =E= pidqss + (log(nmcdn(t+1)) - log(nmcdss(t+1))) -
(log(nmcdn(t)) - log(nmcdss(t)));
eq20(t+1)..      log(npd(t+1))       =E= log(npdss(t+1)) + (log(npd(t))-log(npdss(t))) +
(log(1+pidq(t+1))-log(1+pidqss));
eq20n(t+1)..     log(npdn(t+1))      =E= log(npdss(t+1)) + (log(npdn(t))-log(npdss(t))) +
(log(1+pidqn(t+1))-log(1+pidqss));
eq21(t+1)..      log(pd(t+1))        =E= log(pdss) + (log(npd(t+1))-log(npdss(t+1))) - (log(p(t+1))-
log(pss(t+1)));
eq21n(t+1)..     log(pdn(t+1))       =E= log(pdss) + (log(npdn(t+1))-log(npdss(t+1))) -
(log(pn(t+1))-log(pss(t+1)));
eq22(t+1)..      log(mcd(t+1))       =E= log(mcdss) + (1-mcdss3*(aK*uss3/zqss3 +
aM/pmss3))*((log(w(t+1))-log(wss)) - (log(A(t+1))-log(Ass))) + mcdss3*uss3/zqss3*aK*((log(zq(t))-
log(zqss))) + mcdss3*1/pmss3*aM*(log(pm(t))-log(pmss)) + eps_mc(t+1);
eq22a..          log(mcdss3)         =E= (ve-1)*log(mcdss);
eq22b..          log(uss3)           =E= (ve-1)*log(uss);
eq22c..          log(zqss3)          =E= (ve-1)*log(zqss);
eq22d..          log(pmss3)          =E= (ve-1)*log(pmss);
eq22n(t+1)..     log(mcdn(t+1))      =E= log(mcdss) + aL*(log(wn(t+1))-log(wss)) + aK*(log(zqn(t))-
log(zqss)) + aM*(log(pmn(t+1))-log(pmss)) - aL*(log(A(t+1))-log(Ass));
eq23(t+1)..      log(nmcd(t+1))      =E= log(nmcdss(t+1)) + (log(mcd(t+1))-log(mcdss)) +
(log(p(t+1))-log(pss(t+1)));
eq23n(t+1)..     log(nmcdn(t+1))     =E= log(nmcdss(t+1)) + (log(mcdn(t+1))-log(mcdss)) +
(log(pn(t+1))-log(pss(t+1)));
eq24(t+2)..      pimq(t+1)           =E= pimqss + gammaimb*(pimq(t)-pimqss) + gammaimf*(pimq(t+2)-
pimqss) + lambdakrosim*((log(q(t+1))-log(qss)) - (log(1-tau(t+1))-log(1-tauss)));
eq24n(t+1)..     pimqn(t+1)          =E= pimqss + (log(nmcmn(t+1)) - log(nmcmss(t+1))) -
(log(nmcmn(t)) - log(nmcmss(t)));
eq25(t+1)..      log(npm(t+1))       =E= log(npmss(t+1)) + (log(npm(t))-log(npmss(t))) +
(log(1+pimq(t+1))-log(1+pimqss));
eq25n(t+1)..     log(npmn(t+1))      =E= log(npmss(t+1)) + (log(npmn(t))-log(npmss(t))) +
(log(1+pimqn(t+1))-log(1+pimqss));
eq26(t+1)..      log(pm(t+1))        =E= log(pmss) + (log(npm(t+1))-log(npmss(t+1))) - (log(p(t+1))-
log(pss(t+1)));
eq26n(t+1)..     log(pmn(t+1))       =E= log(pmss) + (log(qn(t+1))-log(qss)) - (log(1-taun(t+1))-
log(1-tauss));
eq27(t+1)..      log(mcm(t+1))       =E= log(mcmss) + (log(q(t+1))-log(qss)) - (log(1-tau(t+1))-
log(1-tauss));
eq27n(t+1)..     log(mcmn(t+1))      =E= log(mcmss) + (log(qn(t+1))-log(qss));
eq28(t+1)..      log(nmcm(t+1))      =E= log(nmcmss(t+1)) + (log(mcm(t+1))-log(mcmss)) +
(log(p(t+1))-log(pss(t+1)));
eq28n(t+1)..     log(nmcmn(t+1))     =E= log(nmcmss(t+1)) + (log(mcmn(t+1))-log(mcmss)) +
(log(pn(t+1))-log(pss(t+1)));
eq29(t+2)..      piwq(t+1)           =E= piwqss + gammawb*(piwq(t)-piwqss) + gammawf*(piwq(t+2)-
piwqss) + lambdakrosw*1/(ve*lambda+1)*(lambda*(log(y(t+1))-log(yss)) + lambda*(ve-1)*(log(A(t+1))-
log(Ass)) + sigma*(log(c(t+1))-log(css)) - (log(1-tau(t+1))-log(1-tauss)));
eq29n(t+1)..     piwqn(t+1)          =E= piwqss + (log(nmcwn(t+1)) - log(nmcwss(t+1))) -
(log(nmcwn(t)) - log(nmcwss(t)));
eq30(t+1)..      log(nw(t+1))        =E= log(nwss(t+1)) + (log(nw(t))-log(nwss(t))) +
(log(1+piwq(t+1))-log(1+piwqss));
eq31(t+1)..      log(w(t+1))         =E= log(wss) + (log(nw(t+1))-log(nwss(t+1))) - (log(p(t+1))-
log(pss(t+1)));
eq31n(t+1)..     log(wn(t+1))        =E= log(wss) + (1/(1+lambda))*(sigma*(log(cn(t+1))-log(css)) -
(log(1-taun(t+1))-log(1-tauss)) + lambda*(log(yn(t+1))-log(yss)));
eq32(t+1)..      log(mcw(t+1))       =E= log(mcwss) + 1/(ve*lambda+1)*(lambda*(log(y(t+1))-log(yss))
+ lambda*(ve-1)*(log(A(t+1))-log(Ass)) + sigma*(log(c(t+1))-log(css)) + ve*lambda*(log(pd(t+1))-
log(pdss)) - (log(1-tau(t+1))-log(1-tauss)));
eq32n(t+1)..     log(mcwn(t+1))      =E= log(mcwss) + (1/(1+lambda))*(sigma*(log(cn(t+1))-log(css)) -
(log(1-taun(t+1))-log(1-tauss)) + lambda*(log(yn(t+1))-log(yss)) );
eq33(t+1)..      log(nmcw(t+1))      =E= log(nmcwss(t+1)) + (log(mcw(t+1))-log(mcwss)) +
(log(p(t+1))-log(pss(t+1)));
eq33n(t+1)..     log(nmcwn(t+1))     =E= log(nmcwss(t+1)) + (log(mcwn(t+1))-log(mcwss)) +
(log(pn(t+1))-log(pss(t+1)));
eq34(t+1)..      log(tau(t+1))       =E= log(tauss) + 1/(1+uptheta)*((log(tau(t))-log(tauss)) +
uptheta*gss/(tauss*yss)*((log(g(t+1))-log(gss))-(log(y(t+1))-log(yss))));
eq34n(t+1)..     log(taun(t+1))      =E= log(tauss) + 1/(1+uptheta)*((log(taun(t))-log(tauss)) +
uptheta*gss/(tauss*yss)*((log(g(t+1))-log(gss))-(log(yn(t+1))-log(yss))));
eq35(t+2)..      iq(t+1)             =E= iqss + chi*(iq(t)-iqss) + ((1-
chi)/iqss)*alphapi*piqss*(piq(t+1)-pitargetq(t+1)) + eps_iq(t+1);
eq35n(t+2)..     log(iqn(t+1))       =E= log(iqss) + chi*(log(iqn(t))-log(iqss)) + ((1-
chi)/iqss)*(alphapi1*(piqss*(piqn(t+2)-piqss) - pitargetqss*(pitargetqn(t+2)-pitargetqss)));
eq36(t+2)..      log(1+rq(t+1))      =E= log(1+rqss) + (log(1+iq(t+1))-log(1+iqss)) -
(log(1+piq(t+2))-log(1+piqss));
eq36n(t+2)..     log(1+rqn(t+1))     =E= log(1+rqss) + (log(1+iqn(t+1))-log(1+iqss)) -
(log(1+piqn(t+2))-log(1+piqss));
eq36f(t+2)..     log(1+rfq(t+1))     =E= log(1+rfqss) + (log(1+irfq(t+1))-log(1+irfqss)) -
(log(1+pifq(t+2))-log(1+pifqss));
```

```
eq36fn(t+2)..    log(1+rfqn(t+1))    =E= log(1+rfqss) + (log(1+irfqn(t+1))-log(1+irfqss)) -
(log(1+pifqn(t+2))-log(1+pifqss));
eq37(t+2)..      zq(t+1)             =E= zqss + 1/(zqss*(1-tauss))*iqss*(iq(t+1)-iqss) + tauss/(1-
tauss)*(log(tau(t+2))-log(tauss));
eq37n(t+1)..     log(zqn(t+1))       =E= log(zqss) + 1/(zqss*(1-tauss))*(rqss*(log(rqn(t+1))-
log(rqss)) + (rqss+delta)/(1-tauss)*tauss*(log(taun(t+1))-log(tauss)));
eq38(t+1)..      log(1+irfq(t+1))    =E= log(1+irfqss) + sirf*(log(1+irfq(t))-log(1+irfqss)) +
eps_irf(t+1);
eq38n(t+1)..     log(1+irfqn(t+1))   =E= log(1+irfqss) + sirf*(log(1+irfqn(t))-log(1+irfqss)) +
eps_irf(t+1);
eq39(t+1)..      log(1+pifq(t+1))    =E= log(1+pifqss) + spif*(log(1+pifq(t))-log(1+pifqss)) +
eps_pif(t+1);
eq39n(t+1)..     log(1+pifqn(t+1))   =E= log(1+pifqss) + spif*(log(1+pifqn(t))-log(1+pifqss)) +
eps_pif(t+1);
eq40(t+1)..      log(pf(t+1))        =E= log(pfss(t+1)) + (log(pf(t))-log(pfss(t))) +
(log(1+pifq(t+1))-log(1+pifqss));
eq40n(t+1)..     log(pfn(t+1))       =E= log(pfss(t+1)) + (log(pfn(t))-log(pfss(t))) +
(log(1+pifqn(t+1))-log(1+pifqss));
eq41(t+1)..      log(yf(t+1))        =E= log(yfss) + syf*(log(yf(t))-log(yfss)) + eps_yf(t+1);
eq41n(t+1)..     log(yfn(t+1))       =E= log(yfss) + syf*(log(yfn(t))-log(yfss)) + eps_yf(t+1);
eq43(t+1)..      1+pi(t+1)           =E= power((1+piq(t+1)),4);
eq44(t+1)..      1+pid(t+1)          =E= power((1+pidq(t+1)),4);
eq45(t+1)..      1+pim(t+1)          =E= power((1+pimq(t+1)),4);
eq46(t+1)..      1+pif(t+1)          =E= power((1+pifq(t+1)),4);
eq47(t+1)..      1+piw(t+1)          =E= power((1+piwq(t+1)),4);
eq48(t+1)..      1+i(t+1)            =E= power((1+iq(t+1)),4);
eq49(t+1)..      1+irf(t+1)          =E= power((1+irfq(t+1)),4);
eq50(t+1)..      1+z(t+1)            =E= power((1+zq(t+1)),4);
eq51(t+1)..      1+r(t+1)            =E= power((1+rq(t+1)),4);
eq52(t+1)..      pitargetq(t+1)      =E= pitargetqss + eps_pitargetq(t+1);
eq53(t+1)..      1+kappaq(t+1)       =E= sqrt(sqrt(1+kappa(t+1)));
eq54(t+1)..      unem(t+1)           =E= Ls(t+1) - Ld(t+1);
eq55(t+1)..      bop(t+1)            =E= ca(t+1) + fa(t+1);
eqloss..         losstotal           =E= sum(tloss,
power(discfactor,ord(tloss))*(aa*(power((100*(piq.l(tloss)-pitargetq(tloss))),2)) + (1-
aa)*(power((100*(log(y.l(tloss))-log(yss))),2))));
```

D.2 Steady-State Model

```
********************************
* SECTION 1 : PARAMETER VALUES *
********************************
SCALARS
s_teta           household discount factor /0.98/
beta             producers's and importer's and wage setter's discount factor /1/
sigma            relative risk aversion (inverse of consumption intertemporal elasticity of
substitution) /125/
rho              inverse of interest rate elasticity of real money balance /25/
lambda           inverse of wage elasticity of labour supply     /50/
delta            depreciation rate                               /0.01/
aK               capital share                                   /0.35/
aL               labor share                                     /0.50/
aM               intermediate import share                       /0.15/
aMf              share of export in foreign economy total demand /0.01/
eta              price elasticity of export                      /0.5/
simkg            share of imports in investment                  /0.14/
simcg            share of finished goods imports in consumption  /0.14/
gpy              government expenditure-to-GDP ratio             /0.08/
xpy              exports-to-GDP ratio                            /0.30/
*----------------------------------------------------------------------------
* Policy parameter
*----------------------------------------------------------------------------
chi              degree of interest rate inertia                 /0.5/
alphapi          monetary policy response to inflation gap       /1.5/
uptheta          fiscal policy response parameter                /0.5/
psi              target of fiscal deficit ratio                  /0.02/
*----------------------------------------------------------------------------
theta            degree of price stickiness                                  /0.5/
gamma            degree of price backward lookingness                        /0.00/
thetaim          degree of import price stickiness                           /0.3/
gammaim          degree of import price backward lookingness                 /0.00/
thetaw           degree of wage stickiness                                   /0.75/
gammaw           degree of wage indexation                                   /0.00/
theta_flex       degree of price stickiness when price is perfectly flexible /0.00000000000001/
gamma_flex       degree of backward looking when price is perfectly flexible /0/
si               constant for NKPC
gammab           parameter backward looking in NKPC
gammaf           parameter forward looking in NKPC
lambdakros       parameter of real marginal cost in NKPC
sim              constant for NKPC
gammaimb         parameter backward looking in NKPC import goods inflation
gammaimf         parameter forward looking in NKPC import goods inflation
lambdakrosim     parameter of real marginal cost in NKPC import goods inflation
siw              constant for NKPC
gammawb          parameter backward looking in NKPC wage inflation
```

```
gammawf          parameter forward looking in NKPC wage inflation
lambdakrosw      parameter of real marginal cost in NKPC wage inflation
si_flex          constant for flexible NKPC
gammab_flex      parameter backward looking in flexible NKPC
gammaf_flex      parameter forward looking in flexible NKPC
lambdakros_flex  parameter of flexible real marginal cost in flesible NKPC ;
si               = theta   + gamma  *(1-theta*(1-beta));
gammaf           = beta*theta*(1/si);
gammab           = gamma*(1/si);
lambdakros       = (1-gamma)*(1-theta)*(1-beta*theta)*(1/si);
sim              = thetaim + gammaim*(1-thetaim*(1-beta));
gammaimf         = beta*thetaim*(1/sim);
gammaimb         = gammaim*(1/sim);
lambdakrosim     = (1-gammaim)*(1-thetaim)*(1-beta*thetaim)*(1/sim);
siw              = thetaw  + gammaw *(1-thetaw*(1-beta));
gammawf          = beta*thetaw*(1/siw);
gammawb          = gammaw*(1/siw);
lambdakrosw      = (1-gammaw)*(1-thetaw)*(1-beta*thetaw)*(1/siw);
si_flex          = theta_flex + gamma_flex  *(1-theta_flex*(1-beta));
gammaf_flex      = beta*theta_flex*(1/si_flex);
gammab_flex      = gamma_flex*(1/si_flex);
lambdakros_flex  = (1-gamma_flex)*(1-theta_flex)*(1-beta*theta_flex)*(1/si_flex);
***************************************
* SECTION 3 : COMPUTATION OF SOLUTION *
***************************************
JD..          J =E= 0;
eq1(t)..      log(erss(t))        =E= log(er0) + ord(t)*(log(1+iqss(t))-log(1+irfqss(t)));
eq2(t)..      log(qss(t))         =E= log(erss(t)) + log(pfss(t)) - log(pss(t));
eq3(t)..      log(mss(t))         =E= (sigma/rho)*log(css(t)) - (1/rho)*iqss(t);
eq4(t)..      log(Lsss(t))        =E= (-sigma/lambda)*log(css(t)) + (1/lambda)*log(wss(t)) +
(1/lambda)*log(1-tauss(t));
eq5(t)..      log(Ldss(t))        =E= log(aL) + log(pdss(t)) + log(yss(t)) - log(wss(t));
eq9(t)..      log(kss(t))         =E= log(beta) + log(aK) + log(pdss(t)) + log(yss(t)) -
log(zqss(t));
eq10(t)..     log(ivss(t))        =E= log(delta) + log(kss(t));
eq11(t)..     gss(t)              =E= gpy*yss(t);
eq12(t)..     log(xss(t))         =E= log(aMf) + eta*log(qss(t)) + log(yfss(t));
eq16(t)..     imss(t)             =E= imrawss(t) + imkgss(t) + imcgss(t);
eq13(t)..     log(imrawss(t))     =E= log(aM) + log(pdss(t)) + log(yss(t)) - log(pmss(t));
eq14(t)..     log(imkgss(t))      =E= log(simkg) + log(ivss(t));
eq15(t)..     log(imcgss(t))      =E= log(simcg) + log(css(t));
eq17(t)..     yss(t)              =E= css(t)+gss(t)+ivss(t)+xss(t)-imss(t);
eq18(t)..     log(yss(t))         =E= aL*log(Ass) + aL*log(Lsss(t)) + aK*log(uss(t)) + aK*log(kss(t))
+ aM*log(imrawss(t));
eq19(t)..     log(yss(t))         =E= (1/lambda)*(log(1-tauss(t)) - sigma*log(css(t)) + log(aL))
+ ((lambda+1)/lambda)*(log(Ass) - (aK/aL)*log(zqss(t)) - (aM/aL)*log(qss(t))) + (1+lambda*(1-
aL))/(lambda*aL)*log(pdss(t)) + ((lambda+1)/(aL*lambda))*(aK*log(aK) + aM*log(aM));
eq21(t)..     log(pss(t))         =E= log(p0) + ord(t)*log(1+piqss(t));
eq30(t)..     piqss(t)            =E= pitargetqss;
eq31(t)..     piqss(t)            =E= (1-simcg)*pidqss(t) + simcg*pimqss(t);
eq32(t)..     log(npdss(t))       =E= log(p0) + ord(t)*log(1+pidqss(t));
eq33(t)..     log(pdss(t))        =E= log(npdss(t)) - log(pss(t));
eq7(t)..      log(mcdss(t))       =E= aL*log(wss(t))+aK*log(zqss(t))+aM*log(pmss(t))-aL*log(Ass)-
aL*log(aL)-aK*log(aK)-aM*log(aM);
eq8(t)..      log(nmcdss(t))      =E= log(mcdss(t)) + log(pss(t));
eq22(t)..     log(pmss(t))        =E= log(qss(t));
eq23(t)..     npmss(t)            =E= pmss(t)*pss(t);
eq24(t)..     log(1+pimqss(t))    =E= (1/ord(t))*(log(npmss(t))-log(p0));
eq24a(t)..    log(1+pimqss(t))    =E= (1/ord(t))*(log(nmcmss(t))-log(p0*mcmss('1')));
eq7m(t)..     log(mcmss(t))       =E= log(qss(t));
eq8m(t)..     log(nmcmss(t))      =E= log(mcmss(t)) + log(pss(t));
eq6(t)..      log(wss(t))         =E= (1/(1+lambda))*(sigma*log(css(t)) - log(1-tauss(t)) +
lambda*log(pdss(t)) + lambda*log(yss(t)) + lambda*log(aL));
eq37(t)..     nwss(t)             =E= wss(t)*pss(t);
eq38(t)..     log(1+piwqss(t))    =E= (1/ord(t))*(log(nwss(t))-log(p0*wss('1')));
eq38a(t)..    log(1+piwqss(t))    =E= (1/ord(t))*(log(nmcwss(t))-log(p0*mcwss('1')));
eq7w(t)..     log(mcwss(t))       =E= (1/(1+lambda))*(sigma*log(css(t)) - log(1-tauss(t)) +
lambda*log(pdss(t)) + lambda*log(yss(t)) + lambda*log(aL));
eq8w(t)..     log(nmcwss(t))      =E= log(mcwss(t)) + log(pss(t));
eq25(t)..     log(pfss(t))        =E= log(p0) + ord(t)*log(1+pifqss(t));
eq26(t)..     1+irfss(t)          =E= (1+rfss(t))*(1+pifss(t));
eq27(t)..     1+iss(t)            =E= (1+rss(t))*(1+piss(t));
eq28(t)..     zss(t)              =E= rss(t)+(power((1+delta),4)-1);
eq29(t)..     tauss(t)            =E= gss(t)/yss(t)-psi;
eq34(t)..     rss(t)              =E= 1/s_teta-1;
eq35(t)..     rfss(t)             =E= rss(t);
eq36(t)..     log(yfss(t))        =E= log(xpy)+log(yss(t))-log(aMf)-eta*log(qss(t));
eq39(t)..     uss(t)              =E= 1;
eq40(t)..     1+piss(t)           =E= power((1+piqss(t)),4);
eq41(t)..     1+pidss(t)          =E= power((1+pidqss(t)),4);
eq42(t)..     1+pimss(t)          =E= power((1+pimqss(t)),4);
eq43(t)..     1+pifqss(t)         =E= sqrt(sqrt(1+pifss(t)));
eq44(t)..     1+piwss(t)          =E= power((1+piwqss(t)),4);
eq45(t)..     1+iqss(t)           =E= sqrt(sqrt(1+iss(t)));
eq46(t)..     1+irfqss(t)         =E= sqrt(sqrt(1+irfss(t)));
eq47(t)..     1+zqss(t)           =E= sqrt(sqrt(1+zss(t)));
eq48(t)..     1+rqss(t)           =E= sqrt(sqrt(1+rss(t)));
eq49(t)..     1+rfqss(t)          =E= sqrt(sqrt(1+rfss(t)));
```

Chapter 4

Indonesia’s inflation determinant: demand-pull vs. cost-push

4.1 Introduction

Previous study using a dynamic general equilibrium model in chapter 3 found the existence of strong cost channel and weak demand channel of monetary transmission in Indonesia's economy. Consequently, inflation is insensitive to monetary contraction, or in other words, a higher interest rate is less effective in reducing inflation. The finding is consistent with empirical study using macroeconometric model that estimated a low sensitivity of inflation to interest rate changes (Majardi, 2004). One can also imply the existence of strong cost channel of Bank Indonesia's interest rate policy to GDP deflator from a price puzzle finding in a previous study on monetary transmission of Indonesia (Agung, 2001). The aforementioned findings might bring about question whether interest rate policy has a quite powerful control on Indonesia's inflation.

There are several modelling features that might be able to provide insights about how monetary policy can have influential control on inflation. First, one needs to distinguish between interest policy rate, which is a signalling rate, and market interest rates that affect supply of and demand for goods and nonfinancial nonpublic services (henceforth called services). Second, interest rate cost channel to inflation needs to be separated into credit and equity interest cost channel. Third, interest rate cost channel should be linked to an interest rate-driven demand channel and interest rate-based measure of profit margin. Fourth, goods and services production needs to be linked with variety sources of capital stock financing by elaborating physical capital stock into real equity capital and real loan capital. Finally, it is essential to make a distinction in inflation determinant between cost and demand–supply interaction.

Macroeconometric models usually put less emphasis on modelling goods production cost as an inflation determinant. Current approaches mainly consider that sources of inflation pressure are output gap, which is a discrepancy between actual output and trend of output, inflation expectation and shocks to the supply of goods and services.

Modelling goods production cost empirically as an inflation determinant usually employs a partial equilibrium approach. In a mark-up model, which is applied for instance by deBrouwer & Ericson (1998) and Bailliu, et al. (2002), general domestic price level is a mark-up to total unit cost, which consist of unit labour cost, imported raw material price and energy price.

A newer approach for modelling cost as inflation determinant is a new Keynesian Phillips curve model, which is based on a study about staggered price setting behaviour (Taylor, 1980 and Calvo, 1983) and usually built-in in a dynamic general equilibrium model. In this model, firms' behaviour in setting their price optimally results in a relationship between inflation and expected inflation and real marginal cost.

This study analyses inflation determinant using a macroeconomic general equilibrium model with five representative agents (firm, bank, central bank, government and household), each agent has own budget and balance sheet constraints, and objective function. Model coefficients are calibrated with values that as closely as possible represent the structure of Indonesia's economy. The steady-state model provides sets of steady-state values of endogenous variables that describe economic structure, i.e. breakdown of output, consumption, currency holding, labour supply and demand, production structures and loans components.

This study aimed to gain an alternative analytical economic framework that can offer a conceptual support for policy analysis and judgement in policy decision making. It also serves as a preliminary research for further analysis involving dynamic simulations of shocks to the economy, particularly to financial services.

The analysis shows that the strongest effect of interest rate increases to demand-pull inflation works through investment demand and profit margin channel, which could have a restraining effect on supply hence causing likelihood to have a higher, instead of lower, inflation. Combined with a strong interest rate cost-push channel and market power, this study enhances the previous analysis on why an interest rate tightening has a weak control on reducing inflation in Indonesia.

The weak demand channel and strong cost channel of interest rates have some implications for the behaviour of and policy for banking related to the achievement of inflation target. First, the rate of interest on depositing funds at banks serves as a subset of rate of return on equity capital in all profit-maximising business units that subsequently affect firms' decision on price of goods and services. Thus, central bank's ability to drive interbank rate appropriately is crucial since interbank rate is a main determinant of deposit rate. Second, policy rate pass-through to lending rate also depends on capital adequacy ratio, meaning that the ratio is impliedly an inflation determinant. Therefore, banking policy is necessary to support the achievement of monetary authority's target through setting an inflation-oriented optimal range of capital adequacy ratio. Third, potential conflict between monetary and banking policy can be weak or even nonexistent in a certain period, in the economy with such properties of monetary transmission mechanism.

The rest of this paper is organized follows. Section 4.2 presents model development to provide the aforementioned features. Section 4.3 provides analysis about demand-pull and cost-push inflation. Section 4.4 explains the steady-state simulation results. Section 4.5 concludes the study and infers some policy recommendations.

4.2 The model

This study extends dynamic general equilibrium model developed in chapter 3 by adding the commercial bank and separating the central bank from the government. It allows the presence of different interest rates in financial system and pass-through of central bank signalling policy rate to market interest rates. This framework will enhance the cost channel analysis and provide bank lending channel of monetary policy. The model's extension is described as follows.

4.2.1 The firm

The monopolistically competitive firm maximizes its lifetime after-tax net return on equities (ROE), max $\sum_{t=0}^{\infty} \beta^t \widetilde{\Delta}_t^p$, subject to production function and balance sheet, where $\widetilde{\Delta}_t^p = (1-\tau_t^i) i_{t-1}^{\widetilde{\Delta}^p} K_{t-1}^{ep} > 0$ is defined as the difference between the firm's after-tax gross ROE, Δ_t^p, and after-tax cost of equity, $(1-\tau_t^i) i_{t-1}^{\widetilde{D}} K_{t-1}^{ep}$. The latter denotes the household-investor's opportunity cost of investing money on the business of producing goods and services, instead of putting money on financial product (financial investment). This principle makes sure that the firm's business profit will be greater than interest income earned from placing fund on financial assets, $\Delta_t^p = \widetilde{\Delta}_t^p + (1-\tau_t^i) i_{t-1}^{\widetilde{D}} K_{t-1}^{ep} > (1-\tau_t^i) i_{t-1}^{\widetilde{D}} K_{t-1}^{ep}$. In steady-state firms operate in a perfectly competitive market, where net rate of ROE is absent. In other words, ROE equals cost of equity capital in steady-state.

Similar with the idea in Christiano, et al. (2007), I assume that firms require the stock of working capital loans and equities to finance part of intermediate inputs due to production and sales throughput time as well as a need to keep a certain inventory level of raw material or merchandise. Flow of loans, equity shares and accumulated retained earning equities are required to procure new capital goods investment. I ignore the possibility of bond issuance to raise capital.

Firms use additional working capital loans and equities to raise the inventory level of working capital goods. At the end of the period, after taking into account part of sales income used to procure intermediate inputs, the stock of working capital loans and equities in real terms provide the inventory level of working capital goods.

Stock of fixed capital goods is separated into real fixed capital loans and real equity capital for fixed assets. The latter is further divided into real equity shares and real accumulated retained earnings. Investment of new fixed capital goods is financed by flow of fixed capital loan and equity, while part of income is spent to replace depreciated fixed capital goods.

The after-tax net real ROE of individual firm is defined as

$$
\begin{aligned}
\underbrace{\tilde{\Pi}_t^p = (1-\underbrace{\tau_t^i}_{\substack{\text{income}\\ \text{tax rate}}})r_{j,t-1}^{\tilde{\Pi}^p}k_{j,t-1}^{ep}}_{\substack{\text{after-tax net}\\ \text{real return on equity}}} = {} & \left(\begin{array}{l}
\underbrace{p_{j,t}^{dp}y_{j,t}^{p}}_{\substack{\text{real sales}\\ \text{income}}} + \underbrace{(\tilde{l}_{j,t}^{wc}-\tilde{l}_{j,t-1}^{wc})}_{\substack{\text{changes in}\\ \text{real working}\\ \text{capital loan}}} + \underbrace{(\tilde{l}_{j,t}^{fc}-\tilde{l}_{j,t-1}^{fc})}_{\substack{\text{changes in}\\ \text{real fixed}\\ \text{capital loan}}} + \underbrace{(k_{j,t}^{epsf}-k_{j,t-1}^{epsf})}_{\substack{\text{changes in real}\\ \text{equity stock for fixed}\\ \text{capital goods new}\\ \text{investment}}} + \underbrace{(k_{j,t}^{epsw}-k_{j,t-1}^{epsw})}_{\substack{\text{changes in real}\\ \text{equity stock for working}\\ \text{capital goods}}} \\
+ \underbrace{(k_{j,t}^{epref}-k_{j,t-1}^{epref})}_{\substack{\text{changes in accumulated}\\ \text{retained earnings}\\ \text{=retained earnings for fixed}\\ \text{capital goods new investment}}} + \underbrace{(k_{j,t}^{eprew}-k_{j,t-1}^{eprew})}_{\substack{\text{changes in accumulated}\\ \text{retained earnings}\\ \text{=retained earnings for working}\\ \text{capital goods new investment}}}
\end{array}\right) \\
& - \left(\begin{array}{l}
+ \underbrace{\varpi_L(k_{j,t}^{pf}-k_{j,t-1}^{pf})}_{\substack{\text{fixed capital goods}\\ \text{new investment}\\ \text{financed by loan}}} + \underbrace{\varpi_E(k_{j,t}^{pf}-k_{j,t-1}^{pf})}_{\substack{\text{fixed capital goods}\\ \text{new investment}\\ \text{financed by equity shares}}} + \underbrace{(1-\varpi_L-\varpi_E)(k_{j,t}^{pf}-k_{j,t-1}^{pf})}_{\substack{\text{fixed capital goods new investment}\\ \text{financed by retained earnings}}} + \underbrace{\delta k_{j,t-1}^{pf}}_{\substack{\text{fixed capital goods}\\ \text{replacement}\\ \text{investment}\\ \text{financed by income}}} \\
+ \underbrace{\psi_L(k_{j,t}^{pw}-k_{j,t-1}^{pw})}_{\substack{\text{working capital goods investment}\\ \text{financed by loan}}} + \underbrace{\psi_E(k_{j,t}^{pw}-k_{j,t-1}^{pw})}_{\substack{\text{working capital goods investment}\\ \text{financed by equity shares}}} + \underbrace{(1-\psi_L-\psi_E)(k_{j,t}^{pw}-k_{j,t-1}^{pw})}_{\substack{\text{working capital goods investment}\\ \text{financed by retained earnings}}} \\
+ \underbrace{w_{j,t}^{p}l_{j,t}^{dp}}_{\text{labour cost}} + \underbrace{p_t^m c_{j,t}^{igm}}_{\substack{\text{imported}\\ \text{intermediate}\\ \text{goods cost}}} + \underbrace{p_{k,t}^{dp}c_{k,t}^{igd}}_{\substack{\text{domestic}\\ \text{intermediate}\\ \text{goods cost}}} + \underbrace{r_{t-1}^{\tilde{L}}\tilde{l}_{j,t-1}^{wc}}_{\substack{\text{real working}\\ \text{capital loan}\\ \text{interest cost}}} + \underbrace{r_{t-1}^{\tilde{L}}\tilde{l}_{j,t-1}^{fc}}_{\substack{\text{real fixed}\\ \text{capital loan}\\ \text{interest cost}}} \\
+ \underbrace{(1-\tau_t^i)r_{j,t-1}^{\tilde{D}}k_{j,t-1}^{ep}}_{\substack{\text{after-tax}\\ \text{real cost of equity}}} + \underbrace{\tau_t^i(r_{j,t-1}^{\tilde{D}}+r_{j,t-1}^{\tilde{\Pi}^p})k_{j,t-1}^{ep}}_{\substack{\text{income tax on gross}\\ \text{real return on equity}}}
\end{array}\right)
\end{aligned}
\tag{1.1}
$$

Firms have a balance sheet constraint that equalises stock of capital goods with stock of real equities and loans.

$$
\underbrace{k_{j,t}^{pf}}_{\substack{\text{fixed}\\ \text{capital}\\ \text{goods}}} = \underbrace{\tilde{l}_{j,t}^{fc}}_{\substack{\text{real}\\ \text{fixed}\\ \text{capital}\\ \text{loan}}} + \underbrace{k_{j,t}^{epsf}}_{\substack{\text{real equity}\\ \text{shares for}\\ \text{fixed capital}\\ \text{goods}}} + \underbrace{k_{j,t}^{epref}}_{\substack{\text{real accumulated}\\ \text{retained earning}\\ \text{equities for}\\ \text{fixed capital}\\ \text{goods}}}
\tag{1.2}
$$

$$\underbrace{k_{j,t}^{pw}}_{\substack{working\\capital\\goods}} = \underbrace{\widetilde{l}_{j,t}^{fw}}_{\substack{real\\working\\capital\\loan}} + \underbrace{k_{j,t}^{epsw}}_{\substack{real\,equity\\shares\,for\\working\,capital\\goods}} + \underbrace{k_{j,t}^{eprew}}_{\substack{real\,accumulated\\retained\,earning\\equities\,for\\working\,capital\\goods}} \tag{1.3}$$

Firm retains a fraction of its after-tax profit to accumulate equities for internal financing of fixed capital goods investment or additional inventory level of working capital goods. The rest of after-tax profit goes to the household-owner as dividend. In steady-state, the firm pays profit fully to its owner, as real capital stock is unchanged.

$$\underbrace{k_{j,t}^{epref} - k_{j,t-1}^{epref}}_{\substack{retained\,earning\\equities\,for\\fixed\,capital\\goods\,investment}} + \underbrace{k_{j,t}^{eprew} - k_{j,t-1}^{eprew}}_{\substack{retained\,earning\\equities\,for\\additional\\working\,capital}} = \underbrace{\omega_{rep}}_{\substack{fraction\,of\\after-tax\\profit\\retained}} \underbrace{(1-\tau_t^i)(r_{j,t-1}^{\widetilde{\Pi}^p} + r_{j,t-1}^{\widetilde{D}})k_{j,t-1}^{ep}}_{after-tax\,gross\,real\,return\,on\,equity} \tag{1.4}$$

$$\underbrace{d_{j,t}^{vp}}_{\substack{real\\dividend}} = (1-\omega_{rep})\underbrace{(1-\tau_t^i)(r_{j,t-1}^{\widetilde{\Pi}^p} + r_{j,t-1}^{\widetilde{D}})k_{j,t-1}^{ep}}_{after-tax\,gross\,real\,return\,on\,equity} \tag{1.5}$$

The profit function of aggregate firm, after cancelling balance sheet constraint, takes the form of after-tax net real return on total equity capital of the form

$$\widetilde{\Pi}_t^p = (1-\tau_t^i)r_{t-1}^{\widetilde{\Pi}^p}k_{t-1}^{ep} = p_t^d y_t^p - \begin{pmatrix} w_t^p l_t^{dp} + p_t^m c_t^{igm} + r_{t-1}^{\widetilde{L}}\widetilde{l}_{t-1}^{wc} + (r_{t-1}^{\widetilde{L}} + \delta)\widetilde{l}_{t-1}^{fc} \\ +(r_{t-1}^{\widetilde{D}} + \tau_t^i r_{t-1}^{\widetilde{\Pi}^p} + \delta)k_{t-1}^{epfc} + (r_{t-1}^{\widetilde{D}} + \tau_t^i r_{t-1}^{\widetilde{\Pi}^p} + \delta)k_{t-1}^{epref} \\ +(r_{t-1}^{\widetilde{D}} + \tau_t^i r_{t-1}^{\widetilde{\Pi}^p})k_{t-1}^{epwc} + (r_{t-1}^{\widetilde{D}} + \tau_t^i r_{t-1}^{\widetilde{\Pi}^p})k_{t-1}^{eprew} \end{pmatrix} \tag{1.6}$$

The aggregate firm earns revenue from selling goods and services to the household, the government, the central bank, the foreign, and itself.

$$y_t^p = c_t^h + c_t^b + c_t^{cb} + c_t^g + iv_t^{pf} + iv_t^{bf} + iv_t^{gf} + iv_t^{cbf} + iv_t^{pw} + c_t^{igm} + x_t - im_t \tag{1.7}$$

It produces goods and services using a Cobb-Douglas production technology that utilizes labour, foreign intermediate goods and services and capital goods, which are separated into types of real loan capital and real equity capital, as factors of production. The production function takes the form

$$\begin{aligned} y_t^p = {} & (A_t l_t^{dp})^{\alpha_L}(c_t^{igm})^{\alpha_{MIG}}(\widetilde{l}_t^{wc})^{\alpha_{LWC}}(k_t^{epsw})^{\alpha_{KESW}} \\ & (k_t^{eprew})^{\alpha_{KEREW}}(u_t\widetilde{l}_t^{fc})^{\alpha_{LFC}}(u_t k_t^{epsf})^{\alpha_{KESF}}(u_t k_t^{epref})^{\alpha_{KEREF}} \end{aligned} \tag{1.8}$$

The utilised stock of real fixed capital loans, $u_t\tilde{l}_{t-1}^{fc}$, real equity shares for fixed capital goods, $u_t k_{t-1}^{epsf}$, and real accumulated retained earning equity capital for fixed capital goods, $u_t k_{t-1}^{epref}$ can be interpreted as utilised stock of fixed capital goods that the firm "lease" from the bank and the household-firm's owners. The stock of real working capital loans, $\tilde{l}_{t-1}^{wc}$, real equity shares for working capital goods, k_{t-1}^{epsw}, and real accumulated retained earning equities for working capital goods, k_{t-1}^{eprew}, are considered as working capital goods, i.e. raw materials, that the bank and the firm's owner "rent out" to the firm.

The first-order conditions with respect to labour, imported intermediate goods, real loans, and real equities at t=s+1 for s = 1, 2, …, T-1, give optimality conditions that lead to inputs share equations.

- Share of labour cost

$$w_t^p l_t^{dp} = \alpha_L p_t^{dp} y_t^p \tag{1.9}$$

- Share of imported intermediate goods cost

$$p_t^m c_t^{igm} = \alpha_{MIG} p_t^{dp} y_t^p \tag{1.10}$$

- Share of working capital loan interest cost

$$r_t^{\tilde{L}} \tilde{l}_t^{wc} = \alpha_{LWC} E_t p_{t+1}^{dp} E_t y_{t+1}^p \tag{1.11}$$

- Share of interest cost of fixed capital loan and investment of depreciated real fixed capital loan

$$(r_t^{\tilde{L}} + \delta)\tilde{l}_t^{fc} = \alpha_{LFC} E_t p_{t+1}^{dp} E_t y_{t+1}^p \tag{1.12}$$

- Share of interest cost of equity shares for fixed capital goods, income tax on net return on equity shares used for fixed capital goods, and investment of depreciated real equity shares for fixed capital goods

$$(r_t^{\tilde{D}} + E_t\tau_{t+1}^i r_t^{\tilde{\Pi}^p} + \delta)k_t^{epsf} = \alpha_{KESF}E_t p_{t+1}^{dp} E_t y_{t+1}^p \tag{1.13}$$

- Share of interest cost of equity shares for working capital goods and income tax on net return on equity shares used for working capital goods

$$(r_t^{\tilde{D}} + E_t\tau_{t+1}^i r_t^{\tilde{\Pi}^p})E_t k_{t+1}^{epwc} = \alpha_{KESW}E_t p_{t+1}^{dp} E_t y_{t+1}^p \tag{1.14}$$

- Share of interest cost of accumulated retained earning equities for fixed capital goods, income tax on net return on accumulated retained earning equities used for fixed capital goods, and investment of depreciated real accumulated retained earning equities for fixed capital goods

$$(r_t^{\tilde{D}} + E_t\tau_{t+1}^i r_t^{\tilde{\Pi}^p} + \delta)E_t k_{t+1}^{epref} = \alpha_{KEREF}E_t p_{t+1}^{dp} E_t y_{t+1}^p \tag{1.15}$$

- Share of interest cost of accumulated retained earning equities for working capital goods and income tax on net return on accumulated retained earning equities used for working capital goods

$$(r_t^{\tilde{D}} + E_t\tau_{t+1}^i r_t^{\tilde{\Pi}^p})E_t k_{t+1}^{eprew} = \alpha_{KEREW}E_t p_{t+1}^{dp} E_t y_{t+1}^p \tag{1.16}$$

Real marginal cost of producing firm's goods and services is derived from the firm's real cost minimization problem, in which the aggregate firm chooses the level of production inputs that minimize total real cost subject to production function. The aggregate firm's real marginal cost of production, mc_t^p, is a function of real wage, real deposit rate, real lending rate, real imported price, income tax rate, real net rate of ROE, and level of technology of the form:

$$\begin{aligned} mc_t^p = &\left(\frac{w_t^p}{\alpha_L A_t}\right)^{\alpha_L}\left(\frac{p_t^m}{\alpha_{MIG}}\right)^{\alpha_{MIG}}\left(\frac{r_{t-1}^{\tilde{L}}}{\alpha_{LWC}}\right)^{\alpha_{LWC}}\left(\frac{r_{t-1}^{\tilde{L}}+\delta}{\alpha_{LFC}}\right)^{\alpha_{LFC}} \\ &\left(\frac{r_{t-1}^{\tilde{D}} + \tau_t^i r_{t-1}^{\tilde{\Pi}^p} + \delta}{\alpha_{KESF}}\right)^{\alpha_{KESF}}\left(\frac{r_{t-1}^{\tilde{D}} + \tau_t^i r_{t-1}^{\tilde{\Pi}^p}}{\alpha_{KESW}}\right)^{\alpha_{KESW}} \\ &\left(\frac{r_{t-1}^{\tilde{D}} + \tau_t^i r_{t-1}^{\tilde{\Pi}^p} + \delta}{\alpha_{KEREF}}\right)^{\alpha_{KEREF}}\left(\frac{r_{t-1}^{\tilde{D}} + \tau_t^i r_{t-1}^{\tilde{\Pi}^p}}{\alpha_{KEREW}}\right)^{\alpha_{KEREW}} \end{aligned} \tag{1.17}$$

4.2.2 The bank

The bank operates in a monopolistically competitive market as a financial intermediary, through taking deposits from the household, extending consumer loans to the household, providing working and fixed capital loans to the firm, and lending and borrowing money in short-term interbank money market. It also invests its fund in government bonds, central bank certificates and foreign securities. Industrial Organization approach is used to model typical banking activity as production of financial services (Freixas and Rochet, 2008), with the exclusion of asymmetrical information and formal risk aspect of banking operation. I assume that the issuance of bank's corporate bonds and purchase of firm's bonds are inapplicable.

Banks hold equity capital for buying fixed capital goods and holding reserve equity capital required by banking authority. The bank maximizes its lifetime after-tax net ROE, max $\sum_{t=0}^{\infty}\beta^t\widetilde{\Delta}_t^b$, where $\widetilde{\Delta}_t^b > 0$ is defined as the difference between bank's after-tax gross ROE, Δ_t^b, and after-tax cost of equity, $(1-\tau_t^i)i_{t-1}^{\widetilde{D}}K_{t-1}^{eb}$, subject to several constraints. The after-tax net ROE of an individual bank is expressed in eq. 2.4.

The constraints that banks face are:

- Bank's required reserved account at central bank as a fraction of deposits.

  $\widehat{\widetilde{R}}_t = rr\ \widetilde{D}_t$, where rr is compulsory reserve ratio

- Bank's currency holding (cash in vault), as a fraction of deposits.

  $\widetilde{C}_t^b = cbr\ \widetilde{D}_t$, cbr is currency-to-deposit ratio

- Minimum capital adequacy ratio (CAR) imposed by banking authority that sets the lower bound ratio of equities to risk-weighted assets.

  $\Gamma_{j,t-1} \geq \widetilde{\Gamma}$, where

$$K^{eb}_{j,t-1} = \Gamma_{j,t-1}\left(\begin{array}{l} \rho_1 \widetilde{L}^{s}_{j,t-1} + \rho_{20}\widetilde{C}^{b}_{j,t-1} + \rho_{21}\widehat{\widehat{R}}_{j,t-1} + \rho_{22}\widehat{\widehat{R}}^{xd}_{j,t-1} + \rho_3 \widetilde{L}^{ib}_{j,t-1} \\ + \rho_4 B^{BCB}_{j,t-1} + \rho_5 B^{BG}_{j,t-1} + \rho_6 s_t B^{BF}_{j,t-1} + \rho_7 K^{bfc}_{j,t-1} \end{array}\right) \tag{2.1}$$

- Balance sheet: liabilities and reserve equities equals financial asset

$$\widetilde{D}_{j,t} + \widetilde{L}^{ib}_{k,t} + K^{ebsr}_{j,t} + K^{ebrer}_{j,t} = \widetilde{C}^{b}_{j,t} + \widehat{\widehat{R}}_{j,t} + \widehat{\widehat{R}}^{xd}_{j,t} + \widetilde{L}_{j,t} + \widetilde{L}^{ib}_{j,t} + B^{BG}_{j,t} + B^{BCB}_{j,t} + s_t B^{BF}_{j,t} \tag{2.2}$$

- Balance sheet: fixed capital goods equals real equity shares for fixed capital goods plus real accumulated retained earnings for fixed capital goods

$$k^{bfc}_{j,t} = k^{ebsf}_{j,t} + k^{ebref}_{j,t} \tag{2.3}$$

where ρ represent the associated asset's risk weight.

$$\begin{aligned}
\widetilde{\Delta}^{b}_{j,t} = \underbrace{(1-\tau_t)\, i^{\widetilde{\Pi}^p}_{t-1} K^{eb}_{t-1}}_{\text{after-tax net ROE}} = \underbrace{\left\{\begin{array}{l}
-\underbrace{\frac{\pi_t}{1+\pi_t}\widetilde{C}^{b}_{j,t-1}}_{\text{currency holding income}} + \underbrace{i^{\widehat{\widehat{R}}}_{t-1}(\widehat{\widehat{R}}_{j,t-1} + \widehat{\widehat{R}}^{xd}_{j,t-1})}_{\text{reserve deposits interest income}} + \underbrace{i^{\widetilde{L}}_{j,t-1}\widetilde{L}^{s}_{j,t-1}}_{\text{loan interest income}} + \underbrace{i^{g}_{j,t-1}B^{BG}_{j,t-1}}_{\text{gov bond interest income}} + \underbrace{i^{cb}_{j,t-1}B^{BCB}_{j,t-1}}_{\text{CB certificates interest income}} \\
+ \underbrace{i^{ib}_{j,t-1}\widetilde{L}^{ib}_{j,t-1}}_{\text{interbank short-term loan interest income}} + \underbrace{(i^{*}_{t-1} + \kappa^{*}_{t-1} + i^{*}_{t-1}\kappa^{*}_{t-1}) s_t B^{BF}_{j,t-1}}_{\text{net foreign assets interest income}} \\
+ \underbrace{(\widetilde{D}_{j,t} - \widetilde{D}_{j,t-1})}_{\text{changes in households' deposit}} + \underbrace{(K^{ebsf}_{j,t} - K^{ebsf}_{j,t-1})}_{\text{changes in equity shares for fixed capital goods}} + \underbrace{(K^{ebsr}_{j,t} - K^{ebsr}_{j,t-1})}_{\text{changes in equity shares for reserved capital}} \\
+ \underbrace{(K^{ebref}_{t} - K^{ebref}_{t-1})}_{\substack{\text{changes in accumulated retained earning equities} \\ \text{= retained earnings for fixed capital goods new investment}}} + \underbrace{(K^{ebrer}_{t} - K^{ebrer}_{t-1})}_{\substack{\text{changes in accumulated retained earning equities} \\ \text{= retained earnings for reserve equity capital}}} + \underbrace{(\widetilde{L}^{ib}_{k,t} - \widetilde{L}^{ib}_{k,t-1})}_{\text{additional short-term interbank borrowing}}
\end{array}\right\}}_{\text{Revenues and changes in liabilities and net worth}} \\
- \underbrace{\left\{\begin{array}{l}
+ \underbrace{(\widetilde{C}^{b}_{j,t} - \widetilde{C}^{b}_{j,t-1})}_{\text{changes in cash in vault}} + \underbrace{(\widehat{\widehat{R}}_{j,t} - \widehat{\widehat{R}}_{j,t-1})}_{\text{changes in required reserves}} + \underbrace{(\widehat{\widehat{R}}^{xd}_{j,t} - \widehat{\widehat{R}}^{xd}_{j,t-1})}_{\text{changes in excess reserves deposits}} + \underbrace{(\widetilde{L}_{j,t} - \widetilde{L}_{j,t-1})}_{\text{changes in loan to household \& firm}} \\
+ \underbrace{(B^{BG}_{j,t} - B^{BG}_{j,t-1})}_{\text{bank buys gov bond from govt (primary market)}} + \underbrace{(B^{BCB}_{j,t} - B^{BCB}_{j,t-1})}_{\text{bank buys CB securities (positive = monetary contraction)}} + \underbrace{(s_t B^{BF}_{j,t} - s_{t-1}B^{BF}_{j,t-1})}_{\text{changes in net foreign assets}} \\
+ \underbrace{(\widetilde{L}^{ib}_{j,t} - \widetilde{L}^{ib}_{j,t-1})}_{\text{changes in short-term interbank loan}} + \underbrace{i^{\widetilde{D}}_{j,t-1}\widetilde{D}_{j,t-1}}_{\text{deposit interest cost}} + \underbrace{i^{ib}_{k,t-1}\widetilde{L}^{ib}_{k,t-1}}_{\text{interbank loan interest cost}} + \underbrace{W_{j,t} l^{b}_{j,t}}_{\text{labour cost}} \\
+ \underbrace{P^{d}_{j,t} c^{bpd}_{j,t}}_{\text{domestic consumption goods}} + \underbrace{P^{m}_{j,t} c^{bpm}_{j,t}}_{\text{imported consumption goods}} + \underbrace{P_t \delta^{d} k^{bfcd}_{j,t-1}}_{\substack{\text{domestic fixed capital goods replacement investment} \\ \text{(financed by income)}}} + \underbrace{P_t \delta^{m} k^{bfcm}_{j,t-1}}_{\substack{\text{imported fixed capital goods replacement investment} \\ \text{(financed by income)}}} \\
+ \underbrace{\varpi_E P_t (k^{bfc}_{j,t} - k^{bfc}_{j,t-1})}_{\substack{\text{fixed capital goods new investment} \\ \text{(financed by equity shares)}}} + \underbrace{(1-\varpi_E) P_t (k^{bfc}_{j,t} - k^{bfc}_{j,t-1})}_{\substack{\text{fixed capital goods new investment} \\ \text{(financed by retained earning equities)}}} + \underbrace{i^{\widetilde{D}}_{t-1} P_t k^{eb}_{j,t-1}}_{\text{cost of equity}} + \underbrace{\tau^{i}_{t} i^{\widetilde{\Pi}^b}_{j,t-1} P_t k^{eb}_{j,t-1}}_{\text{income tax on net return on equity}}
\end{array}\right\}}_{\text{Expenditures and changes in assets}}
\end{aligned} \tag{2.4}$$

After substituting for all constraints, and aggregating all banks, one can express the aggregate bank's net ROE as of the form

$$\widetilde{\Delta}_t^b = \begin{pmatrix} +\left(i_{t-1}^{\widetilde{L}} - i_{t-1}^{ib} - (\rho_1 - \rho_3)\Gamma_{t-1} i_{t-1}^{\widetilde{D}}\right)\widetilde{L}_{t-1} \\ +\left(i_{t-1}^{g} - i_{t-1}^{ib} - (\rho_5 - \rho_3)\Gamma_{t-1} i_{t-1}^{\widetilde{D}}\right)B_{t-1}^{BG} \\ +\left(i_{t-1}^{cb} - i_{t-1}^{ib} - (\rho_4 - \rho_3)\Gamma_{t-1} i_{t-1}^{\widetilde{D}}\right)B_{t-1}^{BCB} \\ +\left((i_{t-1}^{*} + \kappa_{t-1}^{*} + i_{t-1}^{*}\kappa_{t-1}^{*}) - i_{t-1}^{ib} - (\rho_6 - \rho_3)\Gamma_{t-1} i_{t-1}^{\widetilde{D}}\right)s_{t-1}B_{t-1}^{BF} \end{pmatrix}$$

$$- \begin{pmatrix} \begin{pmatrix} \left[1 + \left(\rho_3 + \left(cbr(\rho_{20} - \rho_3) + rr\,(\rho_{21} - \rho_3) + er\,(\rho_{22} - \rho_3)\right)\right)\Gamma_{t-1}\right] i_{t-1}^{\widetilde{D}} \\ -(1 - (cbr + rr + er\,))i_{t-1}^{ib} \\ -(rr + er)\, i_{t-1}^{\hat{\bar{R}}} + cbr\dfrac{\pi_t}{1+\pi_t} \end{pmatrix} \widetilde{D}_{t-1} \\ +\dfrac{\partial \mathcal{C}_{t-1}^b}{\partial \widetilde{D}_{t-1}}\widetilde{D}_{t-1} + \dfrac{\partial \mathcal{C}_{t-1}^b}{\partial K_{t-1}^{ebsr}}K_{t-1}^{ebsr} + \dfrac{\partial \mathcal{C}_{t-1}^b}{\partial K_{t-1}^{ebrer}}K_{t-1}^{ebrer} \\ +\dfrac{\partial \mathcal{C}_{t-1}^b}{\partial \widetilde{L}_{t-1}}\widetilde{L}_{t-1} + \dfrac{\partial \mathcal{C}_{t-1}^b}{\partial B_{t-1}^{BG}}B_{t-1}^{BG} + \dfrac{\partial \mathcal{C}_{t-1}^b}{\partial B_{t-1}^{CB}}B_{t-1}^{CB} + \dfrac{\partial \mathcal{C}_{t-1}^b}{\partial B_{t-1}^{BF}}B_{t-1}^{BF} \end{pmatrix} \tag{2.5}$$

Maximizing after-tax net ROE with respect to demand for deposits and supply of loans result in prices of deposits and loans, accordingly, of the form

$$i_t^{\widetilde{D}} = \frac{(1-(cbr + rr + er_t\,))i_t^{ib} + (rr + er_t)\, i_t^{\hat{\bar{R}}} - cbr\dfrac{E_t\pi_{t+1}}{1+E_t\pi_{t+1}} - E_t mc_{t+1}^{\widetilde{D}}}{1 + (1-(cbr + rr + er_t))\Gamma_t \rho_3} \tag{2.6}$$

$$i_t^{\widetilde{L}} = i_t^{ib} + (\rho_1 - \rho_3)\Gamma_t i_t^{\widetilde{D}} + \frac{1}{\beta}E_t mc_{t+1}^{\widetilde{L}} \tag{2.7}$$

$E_t mc_{t+1}^{\widetilde{D}}$ and $E_t mc_{t+1}^{\widetilde{L}}$ are real marginal cost of managing deposits and loans, respectively, that take the form

$$E_t mc_{t+1}^{\widetilde{D}} = \frac{\partial E_t \mathcal{C}_{t+1}}{\partial \widetilde{D}_t} = \frac{m\phi_t^b \gamma_D y_t^b}{\widetilde{d}_{t-1}} \tag{2.8}$$

$$E_t mc_{t+1}^{\widetilde{L}} = \frac{\partial E_t \mathcal{C}_{t+1}}{\partial \widetilde{L}_t} = \frac{E_t \partial \mathcal{C}_{t+1}}{\partial \widetilde{D}_t}\frac{1}{(1-(cbr + rr + er_t\,))} \tag{2.9}$$

where $m¢_t^b$ is real marginal operational cost of producing bank's financial services, which is defined as

$$m¢_t^b = \left(\frac{w_t}{\gamma_L A_t^b}\right)^{\gamma_L} \left(\frac{p_t^{dp}}{\gamma_{Cd}}\right)^{\gamma_{Cd}} \left(\frac{p_t^m}{\gamma_{Cm}}\right)^{\gamma_{Cm}} \left(\frac{r_{t-1}^{\tilde{D}} + \delta + \tau_t^i r_{t-1}^{\tilde{\Pi}^p}}{\gamma_{KEBSF} + \gamma_{KEBREF}}\right)^{\gamma_{KEBSF} + \gamma_{KEBREF}} \tag{2.10}$$

I assume that cost of acquiring and providing information is embedded in the cost of labour, capital goods, and consumption goods and services.

The higher the nominal marginal costs the lower the bank's price-to-cost margin (inverse of real marginal cost). This condition will ignite pressure for those banks that are re-setting lending rates to raise their price of financial intermediary services in order to keep the mark-up over marginal cost fixed.

When the bank that operates in a monopolistically competitive market faces cost of changing interest rates, its price setting behaviour will result in nominal interest rate rigidity. As a result, policy rate is imperfectly passed-through to market interest rates in the short-run. Modelling rigidity of loan and deposit interest rates follows Calvo's staggered price setting mechanism (Calvo, 1983). In the case of lending rate, for instance, it is assumed that a θ^{bL} fraction of banks keeps their lending rate fixed in a given period. Thus, θ^{bL} represents degree of lending rate stickiness implying that the average time between interest rate changes is equal to $1/(1-\theta^{bL})$. The $1-\theta^{bL}$ fraction of banks re-sets their interest rate optimally, $\hat{i}_{t-1}^{\tilde{L}}$, to the level that maximizes the present discounted value of expected future profits.

To derive rigid deposit and lending rates, we can start with the problem of an individual re-optimizing bank that maximizes expected net ROE with respect to re-optimized interest rate of loans or deposits, i.e., $\max_{\hat{i}_{t-1}^{\tilde{L}}} L = E_t \sum_{s=0}^{\infty} \beta^s \theta^s \widetilde{\Delta}_{t+s}^b (\hat{i}_{t-1}^{\tilde{L}})$, where

$E_t\widetilde{\Delta}^b_{t+s}(\hat{i}^{\widetilde{L}}_{t-1})$ is the bank's net ROE at *t+1+s*, given that it re-optimizes its interest rate to be equal to $\hat{i}^{\widetilde{L}}_{t-1}$ at the end of *t-1* and keep it fixed to *t-1+s*. After some algebra, we can find rigid interest rate of deposits and loans in deviation from their corresponding steady-state values of the form:

$$\hat{i}_t^{\widetilde{D}} = \frac{1}{1+\beta {\theta^D}^2}\begin{pmatrix} \theta^D \hat{i}^{\widetilde{D}}_{t-1} + \beta\theta^D E_t \hat{i}^{\widetilde{D}}_{t+1} + (1-\theta^D)(1-\beta\theta^D)E_t M\hat{C}^{b\widetilde{D}}_{t+1} \\ +(1-\theta^D)\beta\theta E_t\hat{\Lambda}_{t+1} - (1-\theta^D)\hat{\Lambda}_t \end{pmatrix} \tag{2.11}$$

where:

$$\hat{\Lambda}_t = \ln\left(1+\left(1-(cr+rr+er_t)\right)\rho_3\Gamma_t\right) - \ln\left(1+\left(1-(cr+rr)\right)\rho_3\overline{\Gamma}\right)$$

$$\hat{i}_t^{\widetilde{L}} = \frac{1}{1+\beta {\theta^L}^2}\left(\theta^L \hat{i}^{\widetilde{L}}_{t-1} + \beta\theta^L E_t \hat{i}^{\widetilde{L}}_{t+1} + (1-\theta^L)(1-\beta\theta^L)E_t M\hat{C}^{b\widetilde{L}}_{t+1}\right) \tag{2.12}$$

$M\hat{C}^{b\widetilde{L}}_t$ and $M\hat{C}^{b\widetilde{D}}_t$ are marginal cost of loans and deposits in deviation from steady-state, respectively, where

$$\begin{aligned} M\hat{C}^{b\widetilde{D}}_t = &\ln\left((1-(cr+rr+er_t))i^{ib}_t - cbr\frac{E_t\pi_{t+1}}{1+E_t\pi_{t+1}} - E_t mc^{\widetilde{D}}_{t+1} \right) \\ &-\ln\left((1-(cr+rr))\bar{i}^{ib} - cbr\frac{\overline{\pi}}{1+\overline{\pi}} - \overline{mc}^{\widetilde{D}} \right) \end{aligned} \tag{2.13}$$

$$M\hat{C}^{b\widetilde{L}}_t = \ln\left(i^{ib}_t + (\rho_1-\rho_3)\Gamma_t i^{\widetilde{D}}_t + E_t mc^{\widetilde{L}}_{t+1}\right) - \ln\left(\bar{i}^{ib} + (\rho_1-\rho_3)\overline{\Gamma}\bar{i}^{\widetilde{D}} + \overline{mc}^{\widetilde{L}}\right) \tag{2.14}$$

We further need to find after-tax net real ROE and maximise its lifetime values subject to the bank's services output **(** y^b_t **)**. It solves for the demand for deposits, labour, capital goods and consumption goods and services that the bank utilise in intermediating fund.

Recent researches on banking in DGE models use loan supply functions instead of bank's production function of loan services. One of them is Goodfriend & McCallum (2007) that applies a real loan 'production' function relating to management of loans, by a combination of collateral, k_t, and loan monitoring l_t^{db}. Loan supply function is of the form $\widetilde{l}_t^{\,s} = F(b_{t+1} + A_{3t}\varpi p_t^k k_{t+1})^{\alpha}(A_{2t} l_t^{db})^{1-\alpha}$, where $b_{t+1} + A_{3t}\varpi p_t^k k_{t+1}$ is collateral, with $b_{t+1} = \frac{B_{t+1}}{P_t}(1 + R_t^B)$ is real bonds, and p_t^k is the real price of capital goods.

Leao & Leao (2006) defines real loan 'production' function as a measure of how much credit, in real terms, that the banks can produce for each combination of work hours hired (l_t^{db}) and capital stock available (k_t^b). This 'production' function can be summarized by a Cobb-Douglas type of technology of the form $\widetilde{l}_t^{\,s} = A_t k_t^{b^{1-\gamma}} l_t^{db^{\gamma}}$. Another type of loan supply function assumes a linear loan technology, in which deposits are assumed to be convertible into loans with a linear technology (Gerali, et.al, 2008). In this setting, banks deposits are essentially an input to the loan supply process. Nominal supply of loans, $(\widetilde{L}_t)$, is a function of household deposits fund, $(\widetilde{D}_t)$, central bank loans to the bank (M_t) and bank's equities (K_t^{fb}); the function takes the form of $\widetilde{L}_t = f(\widetilde{D}_t + M_t, K_t^{fb})$. Similar with this approach is the intermediation technology for loan production, $\widetilde{L}_t \leq \zeta_t(\widetilde{D}_t + X_t)$, where X_t is a lump-sum nominal transfer from the monetary authority, and $\zeta_t \in [0,1]$ represents the fraction of total deposits lent out to the firm (Atta-Mensah & Dib, 2008).

In this study, I interpret the stock of real loans as "good's production power of loans", which are transferred from the surplus unit households, through its supply of real deposits, to the deficit unit's households and firms. Real loans can stand for the number of goods and services that households can purchase by borrowing consumption loans. In the form of working and fixed capital loans extended to the firm, their real value means the quantity of working and fixed capital goods that the firm can buy to produce goods and services.

Real deposit is “goods’ and services’ consumption power of deposit money” that the household, as the surplus unit agent, gives up by putting some amount of fund in their bank account. The bank transfers the purchasing power of deposit fund to other households and the firm through the bank’s placement of fund on loans. It can also transfer it to the government through bank’s purchase of government bonds that enable the government to finance fixed capital goods investment. When the bank uses part of deposit funds to buy central bank certificates or to fulfill required reserve ratio, monetary authority shrinks some amount of money. In real terms, it implies that the central bank eliminates goods purchasing or producing power of some loanable funds. It is the lost of opportunity to produce consumption, intermediate and capital goods through lending and financing government deficit.

The bank’s output is financial intermediation services. Given the interpretation of real loans and real deposits, we can construe the bank’s output in real term as “intermediation services of leased goods”. It is as if banks lease goods from the household and rent them out to other households as consumption goods, to the firm as working and fixed capital goods, to the government as fixed capital goods, and to the central bank as all type of goods. This framework links banking sector, which deals with stock and nominal variables, with real sector that is in flow and real variables.

Demand for the bank’s real output of financial intermediary services is the sum of interest payment to the bank. Interest payment consists of households’ and firms’ real interest payment for outstanding loans (household’s and firm’s consumption of bank services), and the government and the central bank consumption of bank services in terms of real interest payment of government bonds and central bank certificates.

$$p_t^{db} y_t^b = r_{t-1}^{\widetilde{L}} \widetilde{l}_{t-1} + r_{t-1}^{g} b_{t-1}^{BG} + r_{t-1}^{cb} b_{t-1}^{BCB} + (r_{t-1}^{*} + \kappa_{t-1}^{*} + r_{t-1}^{*} \kappa_{t-1}^{*}) q_t b_{t-1}^{BF} \\ + r_{t-1}^{\hat{\hat{R}}} (\hat{\hat{r}}_{t-1} + \hat{\hat{r}}_{t-1}^{xd}) - \frac{\pi_t}{1+\pi_t} \widetilde{c}_{t-1}^{b} \tag{2.15}$$

I assume that the bank's real financial services is produced using a Cobb-Douglas type production technology of the form

$$y_t^b = \left(A_t^b l_t^b\right)^{\gamma_L} \left(c_t^{bd}\right)^{\gamma_{Cd}} \left(c_t^{bm}\right)^{\gamma_{Cm}} \left(\widetilde{d}_{t-1}\right)^{\gamma_D} \left(k_{t-1}^{ebsr}\right)^{\gamma_{KEBSR}} \left(k_{t-1}^{ebrer}\right)^{\gamma_{KEBRER}} \left(k_{t-1}^{ebsf}\right)^{\gamma_{KEBSF}} \left(k_{t-1}^{ebref}\right)^{\gamma_{KEBREF}} \tag{2.16}$$

Input for producing financial intermediary services consists of real deposits ($\widetilde{d}_{t-1}$), effective labour working time ($A_t^b l_t^{db}$), domestic consumption goods and services (c_t^{bd}), imported consumption goods and services (c_t^{bm}), real accumulated retained earning equities for fixed capital goods (k_{t-1}^{ebref}), real equity shares for fixed capital goods (k_{t-1}^{ebsf}), real equity shares for reserve capital (k_{t-1}^{ebsr}) and real accumulated retained earning equities for reserve capital (k_{t-1}^{ebrer}). The first input resembles the "goods" that the bank leases from the household. The last two inputs are analogous to the "goods' inventory" that is required to safeguard the continuity of financial services production. The other inputs offer the same services as in the firm's production function. The bank chooses the level of factor inputs that maximize its present discounted values of lifetime after-tax net real ROE, $\Pi = E_t \sum_{t=0}^{\infty} \beta^t \widetilde{\Pi}_t^b$

$$\widetilde{\Pi}_t^b = \left\{ \underbrace{\begin{array}{l} r_{t-1}^{\widetilde{L}} \widetilde{l}_{t-1}^{s} + r_{t-1}^{g} b_{t-1}^{BG} + r_{t-1}^{cb} b_{t-1}^{BCB} + (r_{t-1}^{*} + \kappa_{t-1}^{*} + r_{t-1}^{*} \kappa_{t-1}^{*}) q_t b_{t-1}^{BF} \\ - \frac{\pi_t}{1+\pi_t} \widetilde{c}_{t-1}^{b} + r_{t-1}^{\hat{\hat{R}}} (\hat{\hat{r}}_{t-1} + \hat{\hat{r}}_{t-1}^{xd}) + \end{array}}_{p_t^{db} y_t^b} \right\} \\ - \left\{ \begin{array}{l} r_{t-1}^{\widetilde{D}} \widetilde{d}_{t-1} + (r_{t-1}^{\widetilde{D}} + \tau_t^i r_{t-1}^{\widetilde{\Pi}^b})(k_{t-1}^{ebsr} + k_{t-1}^{ebrer}) + \\ \left(\underbrace{w_t l_t^b + p_t^{dp} c_t^{bpd} + p_t^m c_t^{bpm} + (r_{t-1}^{\widetilde{D}} + \delta^b + \tau_t^i r_{t-1}^{\widetilde{\Pi}^b})(k_{t-1}^{ebsf} + k_{t-1}^{ebref})}_{\substack{\cent_t(\widetilde{d}_{t-1}^{d}, k_{t-1}^{ebsr}, k_{t-1}^{ebrer}, \widetilde{l}_{t-1}^{s}, b_{t-1}^{BG}, b_{t-1}^{BCB}, b_{t-1}^{BF}, \widetilde{c}_{t-1}^{b}, \hat{\hat{r}}_{t-1}, \hat{\hat{r}}_{t-1}^{xd}) \\ \text{cost of managing financial assets, liabilities \& equities}}} \right) \end{array} \right\} \tag{2.17}$$

The bank retains a fraction of its after-tax profit to accumulate equities for financing fixed capital goods investment and additional reserve equity capital. The rest of after-tax profit goes to the household-owner as dividend. The bank pays real profit fully as dividend in steady-state.

$$\underbrace{(k_{j,t}^{ebref} - k_{j,t-1}^{ebref})}_{\substack{retained\,earning \\ equities\,for\,fixed \\ capital\,goods\,investment}} + \underbrace{(k_{j,t}^{ebrer} - k_{j,t-1}^{ebrer})}_{\substack{retained\,earning \\ equities\,for\,fixed \\ capital\,goods\,investment}} = \underbrace{\omega_{reb}}_{\substack{fraction\,of \\ after-tax \\ profit \\ retained}} \underbrace{(1-\tau_t^i)(r_{j,t-1}^{\widetilde{\Pi}^b} + r_{j,t-1}^{\widetilde{D}})k_{j,t-1}^{eb}}_{after-tax\,gross\,real\,return\,on\,equity} \tag{2.18}$$

$$\underbrace{d_{j,t}^{vb}}_{\substack{real \\ dividend}} = (1-\omega_{reb})\underbrace{(1-\tau_t^i)(r_{j,t-1}^{\widetilde{\Pi}^b} + r_{j,t-1}^{\widetilde{D}})k_{j,t-1}^{eb}}_{after-tax\,gross\,real\,return\,on\,equity} \tag{2.19}$$

Substituting production function (2.16) into profit function (2.17) and maximizing the profit results in inputs share as follows:

- Share of deposit fund interest cost

$$r_t^{\widetilde{D}} \widetilde{d}_t = \gamma_{\widetilde{D}} E_t p_{t+1}^{db} E_t y_{t+1}^{b} \qquad 2.20)$$

- Share of labour cost

$$w_t^b l_t^{db} = \gamma_L p_t^{db} y_t^b \qquad (2.21$$

- Share of domestic consumption goods and services cost

$$p_t^{dp} c_t^{bd} = \gamma_{Cd} p_t^{db} y_t^b \tag{2.22}$$

- Share of imported consumption goods and services cost

$$p_t^{m} c_t^{bm} = \gamma_{Cm} p_t^{db} y_t^b \tag{2.23}$$

- Share of interest cost of equity for fixed capital goods, income tax on net return on equity capital used for fixed capital goods, and investment cost of depreciated real equity capital for fixed assets

$$(r_t^{\widetilde{D}} + E_t \tau_{t+1}^i r_t^{\widetilde{\Pi}^b} + \delta)(k_t^{ebsf} + k_t^{ebref}) = (\gamma_{KEBSF} + \gamma_{KEBREF}) E_t p_{t+1}^{db} E_t y_{t+1}^b \tag{2.24}$$

- Share of interest cost of equity for reserve capital and income tax on net return on equity used for reserve capital

$$(r_t^{\widetilde{D}} + E_t \tau_{t+1}^i r_t^{\widetilde{\Pi}^p})(k_t^{ebsr} + k_t^{ebrer}) = (\gamma_{KEBSR} + \gamma_{KEBRER}) E_t p_{t+1}^{db} E_t y_{t+1}^b \qquad (2.25)$$

4.2.3 The central bank

The central bank sets the signalling policy rate, which is the target of interbank rate that needs to occur in interbank loan market in order to ensure that consumer inflation equals its target, which is a zero steady-state inflation, or a constant consumer price level. Policy rate enters deposit and lending rate equations (eq 2.6 & 2.7). Real deposit and lending rate enter the equation of real marginal cost of producing domestic goods (eq 1.17), which affects real domestic price of goods. Given that consumer price is the weighted sum of the price of domestically-produced and imported goods, $P_t = \overline{P} = \alpha_d P_t^d + \alpha_m P_t^m$, then nominal policy rate is set at the level such that real policy rate holds the following equation.

$$\alpha_d mc_t^d (r_{t-1}^{\widetilde{D}}(r_{t-1}^{ib}), r_{t-1}^{\widetilde{L}}(r_{t-1}^{ib}), p_t^m, w_t^p, \tau_t^i)(1+\mu) + \alpha_m p_t^m = 1 \qquad (3.1)$$

When, for instance, firms face changes in real import price or determinant of real marginal cost other than lending and deposit rate, then the bank rates need to adjust to satisfy equation 3.1. We will subsequently know the required interbank money market rate, which is a free endogenous variable in the dynamic model or an exogenous variable in steady-state model. Thus, this model requires no ad hoc interest rate policy rule.

As a response, the CB adjusts its signalling policy rate to be equal to the new interbank rate that the model solve and achieve the target by adjusting bank's liquidity through open market operation. In this model, central bank uses only CB certificates as its open market operation instrument, which is a contraction instrument. The CB also holds government bonds but is of no use as monetary instrument. The other monetary expansionary securities instruments are not applicable.

The objective function is not profit maximisation but inflation stabilisation. The CB sets interest rate of its monetary instrument in accordance with the target of bank's liquidity associated with an interbank rate that is consistent with the inflation target. In dynamic model it needs a behavioural equation that serve as a rule for interest rate of monetary instrument. Such interest rate rule is required to clear the demand for and supply of central bank certificates and achieve the required interbank interest rate induced by inflation-stabilisation mechanism. Interest rate of CB certificates is set in steady-state at the level that results in a certain ratio of the liabilities to GDP. The budget constraint takes the form

$$
\left(\begin{array}{l}
+\underbrace{\underbrace{(r_{t-1}^{*}+\kappa_{t-1}^{*}+r_{t-1}^{*}\kappa_{t-1}^{*})b_{t-1}^{CBF}q_t}_{\text{foreign assets interest income}}+\underbrace{r_{t-1}^{g}b_{t-1}^{CBG}}_{\substack{\text{gov bond}\\ \text{interest income}}}+\underbrace{(m0_t-m0_{t-1})}_{\text{seignorage income}}}_{=y_t^{cb}\ (CB's\ income)}+\underbrace{\underbrace{(b_t^{CB}-b_{t-1}^{CB})}_{\substack{\text{changes in CB}\\ \text{certificates sold}\\ \text{to banks}}}}_{\text{positive = monetary contraction}} \\
+\underbrace{(\widetilde{d}_t^{g}-\widetilde{d}_{t-1}^{g})}_{\substack{\text{changes in govt}\\ \text{account at CB}}}+\underbrace{(k_t^{ecbs}-k_{t-1}^{ecbs})}_{\substack{\text{changes in govt equity}\\ \text{capital at CB}}}+\underbrace{(k_t^{ecbrer}-k_{t-1}^{ecbrer})}_{\substack{\text{changes in accumulated}\\ \text{retained earnings for}\\ \text{general reserve}}}+\underbrace{(k_t^{ecbref}-k_{t-1}^{ecbref})}_{\substack{\text{changes in accumulated}\\ \text{retained earnings for}\\ \text{specific-purposed reserve}\\ \text{(for fixed assets)}}}
\end{array}\right)
$$

$$
-\left(\begin{array}{l}
+\underbrace{r_{t-1}^{\hat{\hat{R}}}(\hat{\hat{r}}_{t-1}+\hat{\hat{r}}_{t-1}^{xd})}_{\substack{\text{consumption of}\\ \text{bank's reserve deposit}\\ \text{services}}}\underbrace{-\frac{\pi_t}{1+\pi_t}(\widetilde{c}_{t-1}^{h}+\widetilde{c}_{t-1}^{b})}_{\substack{\text{seignorage income when}\\ \text{inflation is positive}}}+\underbrace{\underbrace{r_{t-1}^{cb}b_{t-1}^{CB}}_{\substack{\text{CB certificates}\\ \text{interest payment}\\ \text{to banks}}}}_{\substack{\text{consumption of CB}\\ \text{certificates}\\ \text{investment services}}}+\underbrace{r_{t-1}^{cbg}\widetilde{d}_{t-1}^{g}}_{\substack{\text{consumption}\\ \text{of government}\\ \text{deposit services}}} \\
+\underbrace{w_t^{cb}l_t^{dcb}}_{\substack{\text{consumption}\\ \text{of households}\\ \text{labour services}}}+\underbrace{p_t^{d}c_t^{cbpd}+p_t^{m}c_t^{cbpm}}_{\text{goods consumption}}+\underbrace{\delta k_{t-1}^{cbf}}_{\substack{\text{fixed capital}\\ \text{goods}\\ \text{replacement}\\ \text{investment}}}+\underbrace{r_{t-1}^{\Pi^{cb}}k_{t-1}^{ecb}}_{\text{return on equity}} \\
+\underbrace{(q_tb_t^{CBF}-q_{t-1}b_{t-1}^{CBF})}_{\substack{\text{changes in foreign}\\ \text{securities holding}}}+\underbrace{(b_t^{CBG}-b_{t-1}^{CBG})}_{\substack{\text{changes in gov bond}\\ \text{held by CB}}}+\underbrace{(k_t^{cbf}-k_{t-1}^{cbf})}_{\substack{\text{fixed capital goods new investment}\\ \text{financed by retained earnings}}}
\end{array}\right)
$$

(3.2)

The CB faces some constraints:

- Balance sheet: fixed capital goods equals real accumulated retained earning equities

$$\underbrace{k_t^{cbf}}_{\substack{fixed\\capital\\goods}} = \underbrace{k_t^{ecbref}}_{\substack{accumulated\\retained\,earning\\equities\\for\,fixed\,assets}} \tag{3.3}$$

- Balance sheet: real net foreign asset plus government bond equals real monetary liabilities plus real equity shares and real general reserve capital.

$$\underbrace{b_t^{CBF} q_t}_{NFA} + \underbrace{b_t^{CBG}}_{gov\,bond} = \underbrace{m0_t}_{\substack{base\\money}} + \underbrace{b_t^{CB}}_{\substack{CB\\certifi-\\cates}} + \underbrace{\tilde{d}_t^{\,g}}_{\substack{govt\\account\\at\,CB}} + \underbrace{k_t^{ecbs}}_{\substack{gov\,equity\\shares\,at\,CB}} + \underbrace{k_t^{ecbrer}}_{\substack{accumulated\\retained\\earnings\\for\,general\\reserve}} \tag{3.4}$$

- Accumulated retained earning equities for specific-purposed reserve (for fixed asset investment)

$$k_t^{ecbref} = k_{t-1}^{ecbref} + \underbrace{\omega^{recbf}}_{\substack{fraction\,of\\profit\,retained\\for\,specific-\\purposed\,reserve}} \underbrace{r_{t-1}^{\Pi^{cb}} k_{t-1}^{ecb}}_{return\,on\,equity} \tag{3.5}$$

- Accumulated retained earning equities for general reserve

$$k_t^{ecbrer} = k_{t-1}^{ecbrer} + \underbrace{\omega_t^{recbr}}_{\substack{fraction\,of\\profit\\retained\\for\,general\\reserve}} \underbrace{r_{t-1}^{\Pi^{cb}} k_{t-1}^{ecb}}_{return\,on\,equity} \tag{3.6}$$

- Ratio to monetary liabilities of equity shares plus accumulated retained earning equities for general reserve ($\hbar$)

$$k_t^{ecbs} + k_t^{ecbrer} = \hbar(m0_t + b_t^{CB} + \tilde{d}_t^{\,g}) \tag{3.7}$$

- Dividend paid to the government

$$\underbrace{d_t^{vcb}}_{dividend} = (1 - \omega^{recbf} - \omega_t^{recbr}) \underbrace{r_{t-1}^{\Pi^{cb}} k_{t-1}^{ecb}}_{return\,on\,equity} \tag{3.8}$$

where steady-state dividend is $\bar{d}^{vcb} = \bar{r}^{\Pi^{cb}} \bar{k}^{ecb}$.

Central bank's income is interest revenue on holding foreign securities and government bond. In addition, it creates seignorage income when inflation is positive. I assume that the CB does not have other domestic financial assets.

$$y_t^{cb} = q_t(r_{t-1}^* + \kappa_{t-1}^* + r_{t-1}^*\kappa_{t-1}^*)b_{t-1}^{CBF} + r_{t-1}^g b_{t-1}^{CBG} \tag{3.9}$$

The CB earns foreign asset interest income for foreign assets investment services it provides. When the CB generates seignorage income, it can be interpreted as its revenue as monetary authority in servicing money supply expansion. The cost share equations are listed as follows.

- Share of labour cost

$$w_t^{cb} l_t^{cb} = \alpha_{LCB} y_t^{cb} \tag{3.10}$$

- Share of domestic consumption goods and services cost

$$p_t^{dp} c_t^{cbpd} = \alpha_{CCBD} y_t^{cb} \tag{3.11}$$

- Share of imported consumption goods and services cost

$$p_t^m c_t^{cbpm} = \alpha_{CCBM} y_t^{cb} \tag{3.12}$$

- Share of government account interest cost

$$r_t^{cbg} \tilde{d}_t^g = \alpha_{DEPG} E_t y_{t+1}^{cb} \tag{3.13}$$

- Share of interest cost of CB certificates

$$r_t^{cb} b_t^{CB} = \alpha_{CB} E_t y_{t+1}^{cb} \tag{3.14}$$

- Share of return on equity share and general reserve equities

$$r_t^{\Pi^{cb}}(k_t^{ecbs} + k_t^{ecbrer}) = (\alpha_{KECBS} + \alpha_{KECBRER}) E_t y_{t+1}^{cb} \tag{3.15}$$

- Share of return on equity for specific-purposed reserve and for investment of depreciated real equity capital for fixed capital goods

$$(r_t^{\Pi^{cb}} + \delta) k_t^{ecbref} = \alpha_{KECBREF} E_t y_{t+1}^{cb} \tag{3.16}$$

- Share of interest cost of bank's reserve account at CB (if $r_t^{\hat{\hat{R}}} > 0$)

$$r_t^{\hat{\hat{R}}}(\hat{\hat{r}}_t + \hat{\hat{r}}_t^{xd}) = (\alpha_{RR} + \alpha_{ER})E_t y_{t+1}^{cb} \tag{3.17}$$

- Share of cost of currency liabilities to the household and the bank (when deflation)

$$-\frac{E_t \pi_t}{1 + E_t \pi_t}(\tilde{c}_t^h + \tilde{c}_t^b) = (\alpha_{CH} + \alpha_{CB})E_t y_t^{cb} \tag{3.18}$$

4.2.4 The government

The government's balance budget constraint can be interpreted as a zero profit function or zero real return on net worth of the form

$$\Pi_t^G = r_{t-1}^{\Pi^G} k_{t-1}^{eg} = \left(\begin{array}{l} \underbrace{\underbrace{+\tau_t^i \begin{pmatrix} y_t^h + (p_t^m - q_t(1+\mu_t^m))im_t \\ +(p_t^x - p_t^d(1+\mu_t^x))x_t \\ +(r_{t-1}^{\tilde{D}} + r_{t-1}^{\tilde{\Pi}^p})k_{t-1}^{ep} + (r_{t-1}^{\tilde{D}} + r_{t-1}^{\tilde{\Pi}^b})k_{t-1}^{eb} \end{pmatrix}}_{\text{tax income}} + \underbrace{(r_{t-1}^{\tilde{D}} + r_{t-1}^{\Pi^{cb}})k_{t-1}^{ecb}}_{\text{dividend income}} + \underbrace{r_{t-1}^{cbg}\tilde{d}_{t-1}^{g}}_{\substack{\text{interest income} \\ \text{on gov account} \\ \text{at CB}}}}_{y_t^g\ (\text{government income})} \\ + \underbrace{(b_t^G - b_{t-1}^G)}_{\substack{\text{changes in government debt} \\ = \text{fiscal deficit financing}}} + \underbrace{(k_t^{egref} - k_{t-1}^{egref})}_{\substack{\text{changes in equities} \\ \text{for fixed asset investment}}} + \underbrace{(k_t^{egrefn} - k_{t-1}^{egrefn})}_{\substack{\text{changes in equities} \\ \text{for financial asset investment}}} \end{array} \right) \tag{4.1}$$

$$- \left(\begin{array}{l} \underbrace{p_t^{dp}c_t^{gd}}_{\substack{\text{consumption of} \\ \text{domestic goods}}} + \underbrace{p_t^m c_t^{gm}}_{\substack{\text{consumption of} \\ \text{imported goods}}} + \underbrace{w_t^g l_t^g}_{\substack{\text{consumption of} \\ \text{household's} \\ \text{labour services}}} + \underbrace{\tilde{t}_t}_{\substack{\text{consumption} \\ \text{of household} \\ \text{other services} \\ (\text{subsidy})}} + \underbrace{r_{t-1}^g b_{t-1}^G}_{\substack{\text{consumption of} \\ \text{government bond} \\ \text{investment services}}} + \underbrace{\delta^d k_{t-1}^{gfcd}}_{\substack{\text{domestic fixed} \\ \text{capital goods} \\ \text{replacement} \\ \text{investment} \\ \text{financed} \\ \text{by income}}} + \underbrace{\delta^m k_{t-1}^{gfcm}}_{\substack{\text{imported fixed} \\ \text{capital goods} \\ \text{replacement} \\ \text{investment} \\ \text{financed} \\ \text{by income}}} \\ + \underbrace{\lambda_L(k_t^{gfc} - k_{t-1}^{gfc})}_{\substack{\text{fixed capital goods} \\ \text{new investment} \\ \text{financed by loan}}} + \underbrace{(1-\lambda_L)(k_t^{gfc} - k_{t-1}^{gfc})}_{\substack{\text{fixed capital goods new investment} \\ \text{financed by equities}}} + \underbrace{(k_t^{ecbs} - k_{t-1}^{ecbs})}_{\substack{\text{changes in real} \\ \text{equity shares at CB}}} + \underbrace{(\tilde{d}_t^g - \tilde{d}_{t-1}^g)}_{\substack{\text{changes in real} \\ \text{deposits at CB}}} \end{array} \right) = 0$$

The government faces two balance sheet constraints. First, fixed asset must be equal to debt plus equities (net worth) for fixed capital, k_{t-1}^{egref}. Second, the sum of equity shares placed at CB and current account at CB equals government accumulated retained earning equities for financial assets, k_{t-1}^{egrefn}.

$$\underbrace{k_t^{gfc}}_{\substack{\text{fixed} \\ \text{assets}}} = \underbrace{b_t^G}_{\text{liabilities}} + \underbrace{k_t^{egref}}_{\substack{\text{net worth} \\ \text{corresponds} \\ \text{to fixed assets}}} \tag{4.2}$$

$$\underbrace{\underbrace{k_t^{ecbs}}_{\substack{equity\\shares\\at\,CB}} + \underbrace{\tilde{d}_t^g}_{\substack{account\\at\,CB}}}_{financial\,assets} = \underbrace{k_t^{egrefn}}_{\substack{net\,worth\\correspond\\to\,financial\\assets}} \tag{4.3}$$

The government uses debt to cover lack of fixed capital investment financing so that it can still use its income to pay employees' salary and subsidy, purchase consumption goods and services, maintain stock of account at CB, and provide additional capital to the CB.

Government income consists of income tax revenue, interest on government account at CB, and return on CB's equities. The first income is the household's, the firm's and the bank's consumption of government public services while the rest are the CB's purchase of government lending and equity services.

$$\Pi_t^G = y_t^g - \left(p_t^{dp} c_t^{gd} + p_t^m c_t^{gm} + w_t^g l_t^g + \tilde{t}_t + \delta^d k_{t-1}^{gfcd} + \delta^m k_{t-1}^{gfcm} + r_{t-1}^g b_{t-1}^G\right) = 0 \tag{4.4}$$

The objective function is to keep profit function zero. When, for instance, the government spends more but wants to keep its debt constant, tax rate needs to be adjusted to ensure that all expenditures can be financed by income (tax, interest and profit) and debt. The model treats tax rate as a free endogenous variable so that tax policy rule is not required. The cost share equations are described as follows.

- Share of labour cost

$$w_t^g l_t^g = \alpha_{GL} y_t^g \tag{4.5}$$

- Share of domestic consumption goods and services cost

$$p_t^{dp} c_t^{gd} = \alpha_{GCD} y_t^g \tag{4.6}$$

- Share of imported consumption goods and services cost

$$p_t^m c_t^{gm} = \alpha_{GCM} y_t^g \tag{4.7}$$

- Share of subsidy cost

$$\widetilde{t}_t = \alpha_{GT} y_t^g \tag{4.8}$$

- Share of domestic fixed capital goods replacement investment

$$\delta^d k_t^{gfcd} = \alpha_{GKD} E_t y_{t+1}^g \tag{4.9}$$

- Share of imported fixed capital goods replacement investment

$$\delta^m k_t^{gfcm} = \alpha_{GKM} E_t y_{t+1}^g \tag{4.10}$$

- Share of interest cost of government bond

$$r_t^g b_t^G = \alpha_{GB} E_t y_t^g \tag{4.11}$$

The government in this chapter is quite different with the one in the previous chapters. In the previous models government spending only comprises consumption of goods and services and interest payment for government bond. Its sources of income are tax and seignorage revenue in which the government plays the role as central bank to print and supply money to the household when purchasing goods.

4.2.5 The household

The household supplies its labour services to the firm, the bank, the government and the CB. It consumes domestically-produced and imported goods and services using income or loans. The household owns the firm and the bank. Its financial investment portfolio consists of bank deposits, government bonds, central bank certificates and foreign assets. Sources of household's revenues are wage, subsidy, dividend and interest income on financial assets. The household also acts as an importer and exporter of goods and services.

The household increases its utility by consuming goods and services and holding currency, and increase disutility by supplying labour services. I categorise households as five representative households based on source of income: firms', banks', government's and central bank's wage earners, and nonwage earner households, with the assumption that each household has a unique source of income. Each representative household has a utility function in the form of a constant elasticity of substitution function. The period utility function of the household-firms' worker takes the form

$$u_t^{hf}(c_t^{hf},\tilde{c}_t^{hf},l_t^{f})=\frac{\eta_{cf}c_t^{hf^{1-\sigma}}}{1-\sigma}+\frac{\eta_{\tilde{c}f}\tilde{c}_t^{hf^{1-\rho}}}{1-\rho}-\frac{\eta_{lf}l_t^{f^{1+\lambda_f}}}{1+\lambda_f} \tag{5.1}$$

Parameter σ, which is the intertemporal elasticity of consumption or real interest rate elasticity of consumption, can be unique if each household is assumed to have identical preference on consuming goods and services in an aggregate goods market. We can apply the same assumption to ρ, which is nominal interest rate elasticity of currency demand, because each household is assumed behaving uniformly in holding currency supplied by central bank. However, it is not the case with λ, which is real wage elasticity of labour supply. While each household, regardless where they work at, has the same leisure preference (η_l) they supply their labour services to four labour markets that have different labour demand characteristics depending on their corresponding income and labour share parameter (wage budget). Consequently, we can no longer have the assumption of single aggregate wage and sole elasticity of labour supply with respect to real wage. Firms, banks, government and central bank have different income and share of income that goes to labour cost. That justifies the need for having heterogenous households in this model.

The household faces balance sheet constraint that equalise real wealth and real loan with physical and financial assets.

$$\tilde{w}_t+\tilde{l}_t^{c}+q_tb_t^{FH}=b_t^{HG}+b_t^{HCB}+q_tb_t^{HF}+k_t^{ep}+k_t^{eb}+\tilde{c}_t^{h}+\tilde{d}_t^{h}+a_t^{pw}+a_t^{pl} \tag{5.2}$$

It maximises its utility subject to budget constraint (5.3) that ensures that its consumption and investment can be financed by income, borrowing and saving. The first order conditions with respect to (1) real current and future consumption, (2) demand for real currency, (3) supply of labour, (4) real imported goods, (5) real deposits, (6) real government bonds, (7) real central bank certificates, (8) real foreign bonds, (9) nominal foreign bonds, (10) real domestic consumption loans, at *t=s+1*, for *s=1,2,...,T-1*, give the optimality conditions that are required to get household's behavioural equations.

$$
\begin{aligned}
&\left(\begin{aligned}
&\underbrace{\left(\begin{aligned}
&\underbrace{w_t^f l_t^f + w_t^b l_t^b + w_t^g l_t^g + w_t^{cb} l_t^{cb}}_{\text{wage income}} + \underbrace{\tilde{t}_t}_{\substack{\text{subsidy}\\ \text{income}}}\\
&\underbrace{+ r_{t-1}^{\tilde{D}}\tilde{d}_{t-1} + r_{t-1}^{g} b_{t-1}^{HG} + r_{t-1}^{cb} b_{t-1}^{HCB} + (r_{t-1}^{*} + \kappa_{t-1}^{*} + r_{t-1}^{*}\kappa_{t-1}^{*}) q_t b_{t-1}^{HF} - \frac{\pi_t}{1+\pi_t}\tilde{c}_{t-1}^{h}}_{\text{financial asset's interest income}}\\
&+ \underbrace{d_t^{vp} + d_t^{vb}}_{\substack{\text{firm's and bank's}\\ \text{owner's dividend}\\ \text{income}}} + \underbrace{(p_t^m - q_t(1+\mu_t^m)) im_t}_{\text{importer's profit income}} + \underbrace{(p_t^x - p_t^d(1+\mu_t^x)) x_t}_{\text{exporter's profit income}}
\end{aligned}\right)}_{\text{income}=y_t^h}\\
&+ \underbrace{(\tilde{w}_t - \tilde{w}_{t-1})}_{\substack{\text{changes in wealth}\\ (\text{saving})}} + \underbrace{(\tilde{l}_t^c - \tilde{l}_{t-1}^c) + (q_t b_t^{FH} - q_{t-1} b_{t-1}^{FH})}_{\text{changes in consumption loan}}
\end{aligned}\right)\\
&= \left(\begin{aligned}
&\underbrace{\underbrace{p_t^{dp} c_t^{hpd}}_{\substack{\text{consumption}\\ \text{of domestic}\\ \text{goods financed}\\ \text{by income}}} + \underbrace{p_t^m c_t^{hpm}}_{\substack{\text{consumption}\\ \text{of imported}\\ \text{goods financed}\\ \text{by income}}} + \underbrace{r_{t-1}^{\tilde{L}} \tilde{l}_{t-1}^c}_{\substack{\text{consumption}\\ \text{of domestic}\\ \text{consumption}\\ \text{loan services}}} + \underbrace{(r_{t-1}^{*} + \kappa_{t-1} + r_{t-1}^{*}\kappa_{t-1}) q_t b_{t-1}^{FH}}_{\substack{\text{consumption of}\\ \text{foreign loan services}}} + \underbrace{\tau_t^i y_t^h}_{\substack{\text{consumption}\\ \text{of government}\\ \text{public services}\\ (\text{income tax}\\ \text{payment, } y_t^{taxh})}}}_{\text{cost}}\\
&+ \underbrace{\begin{pmatrix}(b_t^{HG} - b_{t-1}^{HG}) + (b_t^{HCB} - b_{t-1}^{HCB}) + (q_t b_t^{HF} - q_{t-1} b_{t-1}^{HF})\\ + (k_t^{eps} - k_{t-1}^{eps}) + (k_t^{ebs} - k_{t-1}^{ebs}) + (\tilde{c}_t^h - \tilde{c}_{t-1}^h) + (\tilde{d}_t^h - \tilde{d}_{t-1}^h)\end{pmatrix}}_{\text{changes in financial assets (financial asset investment)}}\\
&+ \underbrace{(a_t^{pw} - a_{t-1}^{pw})}_{\substack{\text{changes in}\\ \text{physical assets}\\ \text{financed by saving}\\ (\text{goods consumption}\\ \text{financed by saving})}} + \underbrace{(a_t^{pl} - a_{t-1}^{pl})}_{\substack{\text{changes in}\\ \text{physical assets}\\ \text{financed by debt}\\ (\text{goods consumption}\\ \text{financed by loan})}}
\end{aligned}\right)
\end{aligned}
\tag{5.3}
$$

Labour supply

The household's supply of working hours to the firm, bank, central bank and government is derived by combining the optimality condition with respect to the consumption of each corresponding worker's group and to the supply of labour to the corresponding employer. Labour supply of nonemployee's households is set as a certain percentage of total employment. The example of household's labour supply to the firm takes the form

$$l_t^f = \left(\frac{\eta_{cf}(1-\tau_t^i)w_t^f}{\eta_{lf} c_t^{hf\,\sigma}} \right)^{\frac{1}{\lambda_f}} \tag{5.4}$$

Consumption

The first-order condition of utility maximization with respect to the current and future consumption, and the first order condition with respect to real deposits, provides the Euler condition for the intertemporal consumption allocation of five groups of households, both for consumption of domestic and imported goods and services. For the household-firm's worker, for example, the consumption equations take the form of

$$c_t^{hpdf} = E_t c_{t+1}^{hpdf} \left(\frac{\vartheta(1+(1-E_t\tau_{t+1}^i)r_t^{\tilde{D}})p_t^d}{E_t p_{t+1}^d} \right)^{-\frac{1}{\sigma}} \tag{5.5}$$

$$c_t^{hpmf} = E_t c_{t+1}^{hpmf} \left(\frac{\vartheta(1+(1-E_t\tau_{t+1}^i)r_t^{\tilde{D}})p_t^m}{E_t p_{t+1}^m} \right)^{-\frac{1}{\sigma}} \tag{5.6}$$

Currency demand

Demand for currency for five household's group are derived by combining the first-order condition of the household's utility maximization with respect to real consumption, real currency demand, and real domestic bonds, and the definition of real interest rate, $1+(1-E_t\tau_{t+1}^i)r_t^{\tilde{D}} = \dfrac{1+(1-E_t\tau_{t+1}^i)i_t^{\tilde{D}}}{1+E_t\pi_{t+1}}$. The household-firms worker's demand for currency takes the form:

$$\tilde{c}_t^{hf} = c_t^{hf\,\sigma/\rho} \left(\frac{\eta_{cf}(1-E_t\tau_{t+1}^i)i_t^{\tilde{D}} - E_t\tau_{t+1}^i E_t\pi_{t+1}}{\eta_{\tilde{c}f}(1+(1-E_t\tau_{t+1}^i)i_t^{\tilde{D}})} \right)^{-\frac{1}{\rho}} \tag{5.7}$$

Cost structure

We can reconcile household income and cost with utility maximisation to result in time-varying coefficients of cost share as follows.

- Coefficient of share of domestic consumption goods and services cost

$$\alpha_{HDt} = \frac{p_t^{dp} c_t^{hpd}}{y_t^h} \tag{5.8}$$

- Coefficient of share of imported consumption goods and services cost

$$\alpha_{HMt} = \frac{p_t^{m} c_t^{hpm}}{y_t^h} \tag{5.9}$$

The time-varying coefficients of shares of domestic and imported consumption goods and services (α_{HDt} and α_{HMt}) depend on the sum of demand for consumption goods provided by consumption Euler equation, household's income, and the price of domestic and imported goods.

- Coefficient of share of income tax payment. It is equal to income tax rate.

$$\alpha_{HTt} = \frac{y_t^{taxh}}{y_t^h} = \tau_t^i \tag{5.10}$$

- Coefficient of share of interest cost of foreign loans

$$\alpha_{HFt} = \kappa_{HF}(1 - \alpha_{HDt} - \alpha_{HMt} - \alpha_{HTt}) \tag{5.11}$$

where κ_{HF} is a fixed ratio of foreign consumption loan to total consumption loan

- Coefficient of share of interest cost of domestic consumption loans

$$\alpha_{HLt} = (1 - \kappa_{HF})(1 - \alpha_{HDt} - \alpha_{HMt} - \alpha_{HTt}) \tag{5.12}$$

The household's demand for real consumption loan is given by $\tilde{l}_t^c = \frac{\alpha_{HLt} E_t y_t^h}{r_t^{\tilde{L}}}$. While demand for and supply of real loan clear in steady-state, they do not necessarily the case in a dynamic state. The bank's loan interest income for loan services to the firm and household is determined by loan supply.

4.3 Cost push vs. demand pull inflation

Inflation is a rise in the general level of prices of goods and services over a period of time. In a simpler definition, inflation is an identity equation of an increase in the general price level. Sellers set and ask price. Buyers bid and pay the price. Thus, I analyse inflation determinants through price determinants analysis using basic price equation: $P_t^d = MC_t^p(1+\mu_t^p)$. It is the price of domestically-produced goods and services, which has only two main determinants: marginal cost and marginal profit.

I use old macroeconomic concept: cost-push and demand-pull inflation. Cost-push inflation occurs when sellers respond to a rising cost by increasing their prices to protect profit margin. Demand-pull inflation occurs through upward adjustment of profit margin as the seller's respond to a rising demand. Profit margin is measured by net rate of return on equity.

One might ask where other measures of inflation determinants such as administered price shocks and people's expectation of inflation, which is the one that central banks have placed considerable emphasise, have places in this classic concept. Shocks to the administered price of domestically produced consumer goods and services can be partly categorised as demand-pull and cost-push inflation. For instance, in the case of shock to the administered transportation fuel price, price increases can affect both demand for and cost of transportation services. However, the new nonequilibrium price is fully transmitted to consumer price basket without entering agent's consumption decision and production cost calculation process. This controlled price does not exist in this model as all goods price is the equilibrium price of supply of and demand for goods and services.

Price expectation is already inherent in demand-pull and cost-push inflation framework. Sellers' calculation of marginal cost must take the expectation (forecast) of input prices into consideration. When they set prices of their products to be kept fixed for t periods ahead, they need to consider the expectation of input prices that will occur during the corresponding horizon. Consumers also consider their expectation of future price of consumption goods and services in their consumption decision as it depends on expected future consumption (see equation 5.5-5.6).

4.3.1 Cost-push inflation

Analysis of cost-push inflation uses marginal cost in real term with marginal profit is expressed as the ratio of after-tax net ROE to total cost. Real marginal cost depends on real prices of inputs: real wage, real import price, income tax rate, real lending rate, real deposit rate. It also depends on fixed capital depreciation rate, productivity and input share coefficients.

$$p_t^d = \underbrace{\left(\frac{\left(\frac{w_t^p}{\alpha_L A_t}\right)^{\alpha_L} \left(\frac{p_t^m}{\alpha_{MIG}}\right)^{\alpha_{MIG}} \left(\frac{r_{t-1}^{\tilde{L}}}{\alpha_{LWC}}\right)^{\alpha_{LWC}} \left(\frac{r_{t-1}^{\tilde{L}}+\delta}{\alpha_{LFC}}\right)^{\alpha_{LFC}}}{\left(\frac{r_{t-1}^{\tilde{D}}+\tau_t^i r_{t-1}^{\tilde{\Pi}^p}+\delta}{\alpha_{KESF}+\alpha_{KEREF}}\right)^{\alpha_{KESF}+\alpha_{KEREF}} \left(\frac{r_{t-1}^{\tilde{D}}+\tau_t^i r_{t-1}^{\tilde{\Pi}^p}}{\alpha_{KESW}+\alpha_{KEREW}}\right)^{\alpha_{KESW}+\alpha_{KEREW}}} \right)}_{real\,marginal cost} \left(1 + \underbrace{\frac{(1-\tau_t^i) r_{t-1}^{\tilde{\Pi}^p} k_{t-1}^{ep}}{tc_t^p}}_{real\,marginal\,profit} \right) \tag{6.1}$$

Wage

I follow the assumption in the previous chapters that wage is stickier than goods price. Its setting is mainly based on previous period inflation, while real marginal cost of working, $mc_t^{wf} = \left(\alpha_{FL} p_t^d y_t^p \left(\eta_l c_t^{hpf\sigma} / (\eta_c (1-\tau_t^i)) \right)^{\tilde{\lambda}_f} \right)^{\frac{1}{1+\tilde{\lambda}_f}}$, is a minor wage determinant.

While studies in earlier chapters assumes a positive, small real wage elasticity of labour supply $(\tilde{\lambda})$, the steady-state simulation in this study solved for a negative elasticity. However, negative elasticity does make some sense for a developing country where a large part of the population is poor. When workers want to buy more consumption goods and services, which are predominantly primary goods, they need to work more in order to afford it. As labour supply increases, firms need to decrease real wage so that labour supply and demand clears. When the government raises household income tax, workers have to work more to keep up their income levels. Firms respond to this rising labour supply by lowering real wage[15]. Finally, an increase in output demand followed by an increase in labour demand requires an increase in real wage so that labour supply can satisfy its demand.

Corporate income tax

Firms' owners need to maximise their dividend, which is the after-tax gross ROE, $(1-\tau_t^i)(r_{t-1}^{\tilde{D}} + r_{t-1}^{\tilde{\Pi}^p})k_{t-1}^{ep}$. When firms face higher corporate income tax rate, they might raise net ROE so that the dividend is not eroded. Afterwards, raising net ROE leads to a higher marginal cost because firms pay higher income tax. This indirect channel of profit margin to prices via marginal cost magnifies the effect of an increase in income tax rate to domestic price.

Interest rate

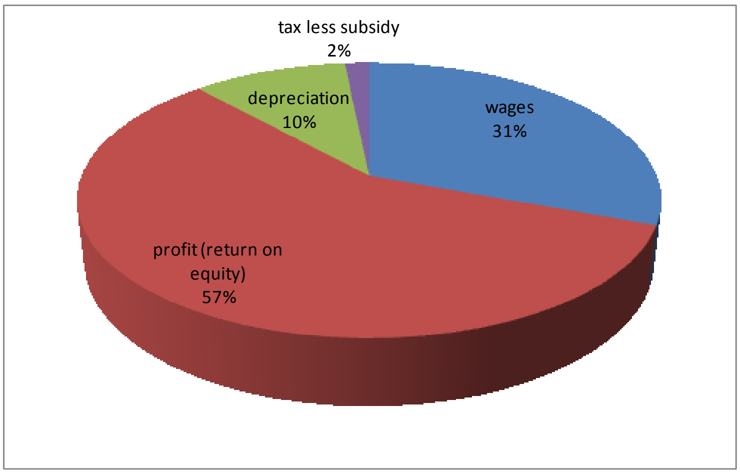
As explained in section 4.2.1, firms use fixed capital loans, equity share and retained earning equities to finance fixed capital goods new investment and procure additional stock of working capital goods. Therefore, firms have to allocate part of their income for interest cost of fixed and working capital. In order to keep dividend constant, firms facing higher deposit and loan interest need to pass the rising cost of capital to their goods prices.

The share of ROE of all agents in Gross Domestic Income is 57%, according to Input-Output Table 2005 (data processed). That indicates how large the interest cost of real equity and real loan in the firm's cost structure. In the steady-state model, I set the

[15] We usually assume a positive real wage elasticity of labour supply for rich countries. It implies that a lowering real wage or raising income tax may encourage workers to give up their working time and spend their time instead for buying (secondary and tertiary) consumption goods and services, i.e. drinking at pub, going skiing and travelling for holiday.

firm's share of those interest cost at about 20% after taking into account the absence of net ROE and for the sake of modelling solution feasibility.

Figure 4.1 Gross Domestic Income



Source: Input-Output Table 2005, BPS (Statistic Office), data processed

Import price

Import price setting is determined by real exchange rate and importer's profit margin. Import price share in the model is assumed 30% reflecting import content of goods and services production. Interest rate has an indirect effect on import price cost-push inflation through exchange rate but in a different direction than its direct effect via cost of capital.

4.3.2 Demand-pull inflation

As a response to excess demand, firms adjust profit margin thus prices so that in the end, the quantity of goods and services supplied equals those demanded.

$$P_t^d = \frac{P_t c_t + P_t^d iv_t + P_t^m im_t^{ig} + P_t^x x_t - P_t^m im_t}{y_t^p} = MC_t^p (1 + \mu_t^p) \tag{6.2}$$

where

$$y_t^p = c_t + iv_t + im_t^{ig} + x_t - im_t = \begin{pmatrix} (A_t l_t^{dp})^{\alpha_L} (c_t^{igm})^{\alpha_{MIG}} (k_t^{epsw})^{\alpha_{KESW}} (k_t^{eprew})^{\alpha_{KEREW}} \\ (u_t \tilde{l}_t^{fc})^{\alpha_{LFC}} (u_t k_t^{epsf})^{\alpha_{KESF}} (u_t k_t^{epref})^{\alpha_{KEREF}} \end{pmatrix} \tag{6.3}$$

The extent of price increases depends on the ability to satisfy part of demand increases by using more inputs including utilising the existing capital goods. The adjustment of fixed capital utilisation and requirement of additional working capital depend on loan and equity shares financing of working capital. The external financing requires low interest rates and relies on the efficacy of bank lending channel of monetary transmission.

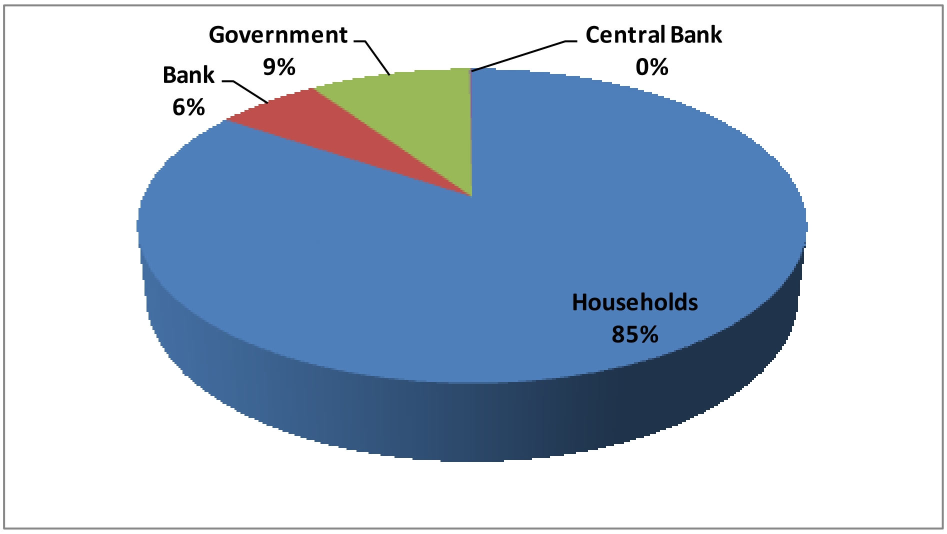
Other important factor that determines the strength of demand-pull inflation is price rigidity or profit margin downward flexibility, which depends on market power, cost of changing prices, real rigidity (the responsiveness of profit-maximizing real prices to aggregate demand) and insensitivity of the profit function to price changes (Romer, 2006).

Previous study on price setting and profit margin indicates that Indonesia's goods prices are less rigid than in the US and UK, and profit margin is upwardly flexible. A price setting survey conducted by Darsono et.al. (2001) found an implied degree of prices stickiness of 0.35. It also revealed some profit taking behaviour in response to cost increase. Majority firms said that they passed cost increases to output price proportionately. However, among the rest, more firms admitted that they pass cost changes to output price in a larger proportion than those willing to give up some profit.

Astiyah et al. (2004), in their study on the effect of financial liberalisation on manufacturing firm's profit, found that manufacturing firm's market structure is considered tightly oligopolistic. They also found that financial liberalisation had been successful to reduce imported input prices but surprisingly reveal an increasing price-to-cost margin.

Immediate source of demand-pull inflation is demand for goods and services (consumption, exports, investment). From income and cost function, we can see that the household, the bank, the government and the CB consumption of finished goods and services depend on their corresponding total income, budget allocation on consumption goods and services, and price of consumption goods and services. From household utility function and budget constraint, it is derived that each group of household makes consumption decision based on its expected future consumption, real deposits interest rates, income tax rate and price of goods and services. Each group's consumption equals the ratio of the corresponding group's wage income share multiplied by total household consumption.

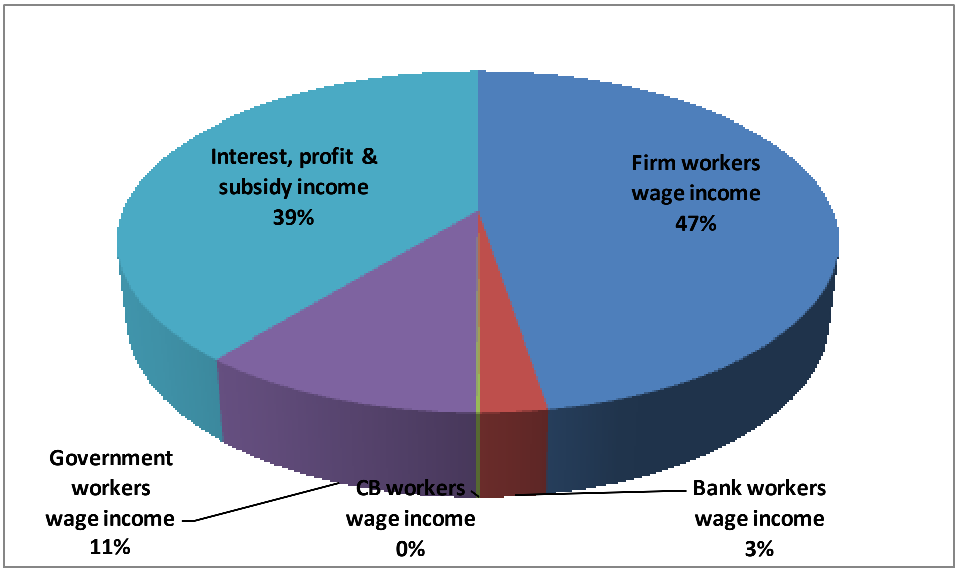
Figure 4.2 Consumption of goods and services
(steady-state solution)



Previous study in chapter 3 calibrated elasticity parameter that reflects lack of response of exports to real exchange rate depreciation. It also assumed low consumption intertemporal elasticity of substitution implying a weak substitution effect of real interest rate on consumption. It means that demand-pull channel of interest rates has a weak effect on consumption thus inflation.

Demand-pull inflation channel of income tax rate works to consumption in two ways. The first channel is through the after-tax substitution effect of interest rate on consumption (see equation 5.5-5.6). An increase in income tax rate reduces after-tax real interest rate and causes consumption to go up (increasing effect on consumption and inflation). Therefore, jointly raising income tax rate and interest rate can weaken demand-pull effect of interest rates tightening on consumption and prices. The second channel is income effect of income tax rate that has a decreasing effect on disposable income, consumption and prices. Section 4.4.4 describes the effect of higher tax rate in lowering households' goods and services consumption and firm's output.

Figure 4.3 Households Non Loan Goods Consumption Financing
(steady-state solution)

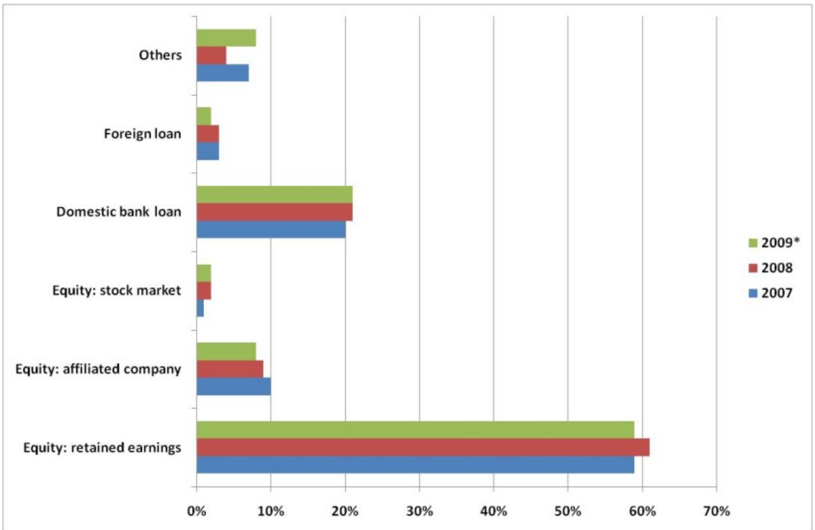


The model setting assumes a strong effect of changes in interest rate on the firm's demand for investment. An increase in lending rate means a rise in loan capital cost. Kusmiarso et al. (2002), in their study on interest rate channel of monetary transmission in Indonesia, found that investment growth was weakly influenced by the change in real investment loan rate in pre currency crisis period because investors had high access to offshore borrowing. However, investment growth responds stronger to lending rate after currency crisis because of a more limited access to source of external financing due to higher credit risk.

An increase in deposit interest rate also discourages investment through a rise in equity capital cost. The effect of an increase in deposit rate on equity capital cost is larger than the effect of a higher lending rate on loan capital cost. If firms maintain a constant rate of net return on equity, the effect on price increases of a higher interest cost of equity capital is therefore larger than of a higher interest cost of loan capital. The discrepancy is getting larger when the spread between lending and deposit rate becomes wider.

As firms have to allocate more income for interest cost, they have to retain less earning for internal investment financing in order to keep prices and gross ROE stable. Alternatively, an increase in deposit interest cost can cause a one-for-one increase in gross ROE, thus price, if firms want to retain the same earnings and keep its net ROE unaffected. Other option is that the shareholders have to give up receiving the same net ROE in order to prevent higher output price and lower demand. All scenarios could discourage shareholders to supply additional equity shares. As a result, growth of both accumulated retained earning equities and equity shares slow down. This condition can significantly decelerate the growth of fixed asset and GDP because the main source of corporate's investment fund is equity (Figure 4.4).

Figure 4.4 Corporate's Source of Investment Fund



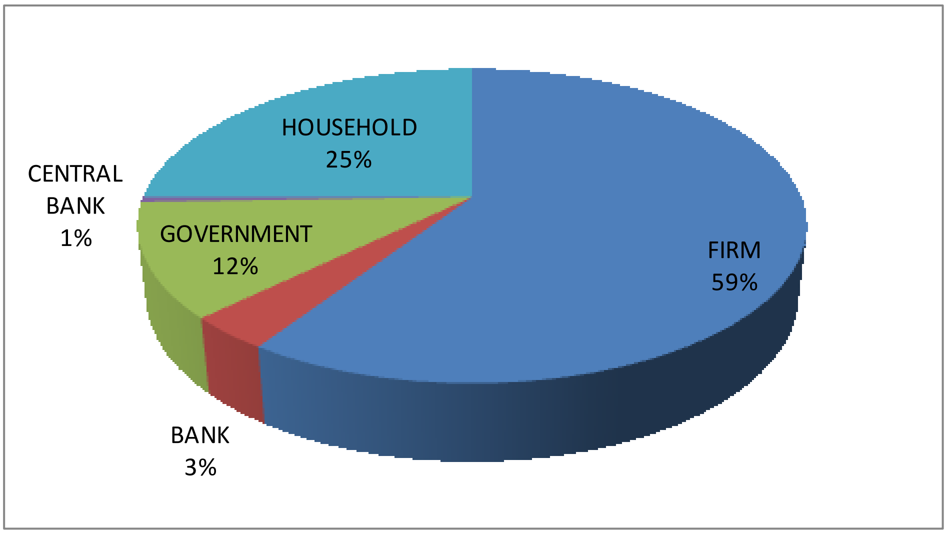
*) firms' estimate
Source: Bank Indonesia, Survay of Source of Fund

In addition, a worsened firms' net worth increases firm's bankruptcy risk and could discourage banks to supply fixed capital loans to firms (financial accelerator model)[16]. In the context of inflation determinant, it is worth noting how the effect of interest rate changes on future inflation through investment demand can have synergy with interest rate cost-push inflation in the same interest rate direction.

4.3.3 Demand-pull inflation, GDP, money and output gap

In many inflation models, demand-pull inflation is usually linked to several variables, such as GDP, money supply and output gap. This section explains whether the modelling practices can be theoretically justified by the equilibrium-approach model applied in this study.

Figure 4.5 Gross Domestic Product
(steady-state solution)



Using a total demand for GDP (y_t) as a source of demand-pull consumer inflation can be overestimated. Consumer price is a weighted average of domestic and imported prices of goods and services. This price level is formed by the equilibrium of supply of and demand for domestic goods and services and the equilibrium of supply of and

[16] Agung et al. (2001) investigated the firm's balance sheet channel of monetary transmission in Indonesia using panel data. The empirical evidence suggested that the firm balance sheet variables is a very important determinant in the firm investment and the sensitivity of investment with respect to a change in balance sheet variables increases during the period of monetary contraction.

demand for imported consumption goods and services. The steady-state model solution predicts that the output of firm's goods and services is 59% of total GDP.

Considering total monetary aggregate as a determinant of demand-pull inflation is less appropriate as well. Money supply is currency plus deposits, where deposits are loans divided by the rate of loanable fund. However, only consumption loans are used to finance consumption of goods and services. Real fixed and working capital loans, which are inputs for producing goods and services, have a downward effect on prices.

Real currency depends on goods consumption, after-tax deposit interest rate, and tax on inflation[17] (see equation 5.7). Thus, currency is dependent of demand for goods and services. An increase in household currency holding does not intensify pressure on aggregate demand for goods and services. Section 4.4.5 describes how an increase in household currency holding does decrease consumption of majority of households through a lower loanable fund and firm's income. Therefore, only part of money supply that goes to consumption loans is considered as source of demand-pull inflation. However, figures 4.6 shows that only about 12.5% of consumption is financed by loan. Total base money is not the main and direct cause of inflation either. Excess reserve is the only base money component that can trigger demand-pull inflation through consumption loan extension, besides its effect on inflation through currency substitution.

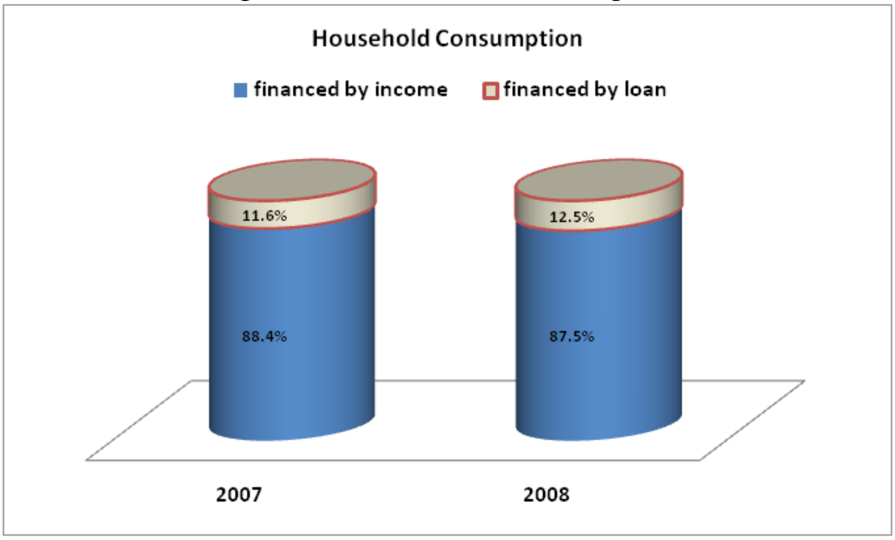
One might question whether the firm's output gap is a proper demand-pull inflation determinant. To answer this question, we need to recall that goods price is the one that clears the supply of and demand for goods and services, where the supply of goods and services is the actual output produced plus changes in finished goods inventory. Trend

[17] Real currency holding is the opportunity cost of holding currency by giving up consuming goods and services and/or earning after-tax return on deposit. It is less the opportunity benefit of avoiding tax on part of currency values eroded by inflation, if the currency is put into deposit or used to buy goods and services.

of output or potential output does not clear goods' demand. The actual output does. However, the current potential output can be an indicator for future demand-pull inflation because it can turn to be the future actual output. A further inappropriate inflation determinant is GDP gap, which includes output of agents other than the firm.

Another definition of output gap, which is discrepancy between actual output produced in presumably monopolistically competitive market and output produced in steady-state where goods market is perfectly competitive, is not applicable to stand for demand-pull inflation determinant because price clears output supply and demand in monopolistically competitive market.

Figure 4.6 Household Consumption



Source: Bank Indonesia

4.3.4 Bank's interest rate and monetary and banking policy

As previously mentioned, the study in chapter 3 found that Indonesia's economy characterizes lack of response of consumer price disinflation to increases in interest rate policy, which is caused by weak demand channel and strong cost channel of interest rate and strong cost channel and weak demand channel of exchange rate pass-through. The finding does not mean that the central bank policy rate has a weak power on reducing inflation. It is monetary contraction that has a weak control on combating inflation. The important implication from the previous finding combined with this study is a requirement to have a proper bank's deposit and lending rates to affect domestic inflation through both demand-pull and cost-push inflation, before finally hit consumer inflation target.

Deposit and credit rates are not only determined by the supply of and demand for deposits and loans, but also affected by monetary and banking policy. Equation (2.6) and (2.7) show the determinants of deposit and lending rate, which are interbank rate targeted by CB's signalling policy rate, interest rate on bank reserves, inflation as a rate of return given up for holding currency, reserve requirement policy, excess reserve ratio, capital adequacy ratio, risk-weight of asset, operational cost and marginal profit. Equation (2.6) highlights deposit rate setting by assuming that the bank puts all loanable fund into interbank loans. An individual bank sets the deposit rate at a level where its marginal revenue of holding net interbank loan and reserve account at CB equals the sum of marginal cost of deposit, marginal cost of reserved equity capital, marginal cost of managing deposits and marginal cost of holding currency multiplied by gross marginal profit.

$$\underbrace{(1-(cbr+rr+er_{j,t}))i_t^{ib}}_{\substack{marginal\,revenue\,of\\ net\,interbank\,loan}}+\underbrace{(rr+er_{j,t})\,i_t^{\hat{\tilde{R}}}}_{\substack{marginal\,revenue\\ of\,reserve\,account\\ at\,CB}}=\left(\underbrace{i_{j,t}^{\tilde{D}}}_{\substack{marginal\\ cost\,of\\ deposits}}+\underbrace{\big(1-(cbr+rr+er_t)\big)\rho_3\Gamma_{j,t}i_{j,t}^{\tilde{D}}}_{marginal\,cost\,of\,reserve\,equity}+\underbrace{\frac{cbr\;E_t\pi_{t+1}}{1+E_t\pi_{t+1}}}_{\substack{marginal\,cost\\ of\,holding\\ currency}}+\underbrace{\frac{\partial E_t\mathbb{C}_{j,t+1}}{\partial\tilde{D}_{j,t}}}_{\substack{marginal\\ cost\,of\\ managing\\ deposits}}\right)\left(1+\underbrace{\frac{(1-\tau_t^i)r_{j,t-1}^{\tilde{\Pi}^b}k_{j,t-1}^{eb}}{tc_{j,t}^b}}_{marginal\,profit}\right)$$

(6.4)

Meanwhile, equation (2.7) shows how lending rate is set such that the net marginal revenue of loan to the firm and household is greater or equal than that of loan to other banks in inter bank money market.

$$\underbrace{\underbrace{i_t^{\tilde{L}}}_{\substack{\text{marginal revenue of}\\ \text{extending loan to firm}\\ \text{and households}}} - \underbrace{\rho_1 \Gamma_t i_t^{\tilde{D}}}_{\substack{\text{marginal cost}\\ \text{of reserved}\\ \text{equity capital}\\ \text{for loan to}\\ \text{firms and}\\ \text{households}}} - \underbrace{\frac{1}{\beta} E_t mc_{t+1}^{\tilde{L}}}_{\substack{\text{marginal cost}\\ \text{of managing}\\ \text{loan}}}}_{\text{net marginal revenue of extending loan to firm and households}} \geq \underbrace{\underbrace{i_t^{ib}}_{\substack{\text{marginal}\\ \text{revenue of}\\ \text{extending}\\ \text{loan to}\\ \text{other firms}}} - \underbrace{\rho_3 \Gamma_t i_t^{\tilde{D}}}_{\substack{\text{marginal cost}\\ \text{of reserved}\\ \text{equity capital}\\ \text{for interbank}\\ \text{loan}}}}_{\substack{\text{net marginal revenue of}\\ \text{extending loan to other banks}}} \tag{6.5}$$

Some of bank's interest rate determinants can be controlled by monetary authority and banking regulatory and supervisory authority. Monetary authority can affect marginal revenue of placing loanable fund by setting interbank rate target, conducting open-market operation to achieve the target by controlling excess reserve, and setting the ratio to deposits of bank's currency and required-reserve. Marginal revenue of reserve account at CB can be influenced through its setting of interest rate on bank reserve account, setting of required reserve account to deposits ratio and controlling excess reserve.

Monetary authority can also have some control on marginal cost of equity by setting the ratio of currency and required reserve account to deposits, and controlling excess reserve. In addition, the latter marginal cost can also be affected by banking authority through its policy setting of capital adequacy ratio and risk-weight of assets, as well as by supervising the bank to ensure its compliance with the policy.

A higher required reserve ratio reduces loanable funds. Banks might then need to defend their liquidity level by increasing deposit rate. However, a higher required reserve ratio with constant capital adequacy ratio lowers the rate of marginal revenue of net interbank loan and the rate of marginal cost of reserved equity capital for associated net interbank loan. Assuming the CB manages to control the stability of interbank rate and the bank keeps its marginal cost of managing deposits and marginal profit unchanged, then the bank can lower deposit rate.

It is interesting to see from (2.6) that positive inflation enters deposit rate determination directly through negative marginal revenue of holding currency. In other words, inflation has a negative direct effect on deposit rate. Inflation also feeds to deposit rate indirectly through interbank rate targeted by central bank (policy rate) to be consistent with the achievement of inflation target. However, direction and magnitude of indirect effect of inflation to deposit rate depends on the net effect of monetary policy channels that drives the policy rate.

With respect to interest rate policy response to achieve consumer inflation target, section 4.2.3 mentioned model property that does not require an ad hoc interest rate policy rule. The free endogenous interbank rate ensures the achievement of consumer inflation target through interaction of different monetary policy channels in several equations such as bank's interest rates, consumption, investment, exchange rate, firm's real marginal cost and domestic and consumer price.

As an instance, it is interesting to consider direction choice of interest rate policy response to a more expensive import price caused by a depreciated exchange rate. With regard to strong-direct pass-through of bank's interest rate to firms' marginal cost, we need to lower policy rate in order to decrease domestic price. Such response could further weaken exchange rate and increase import price, but a lesser pressure on domestic price through interest cost channel could dampen down the effect of a higher import price to the consumer price. It is in contrast with policy implication of exchange rate channel by raising interest rate in response to an import price increases. In this channel, while interest rate tightening might be able to bring exchange rate, thus import price, back to their initial levels, interest cost channel causes domestic price to go up hence consumer price.

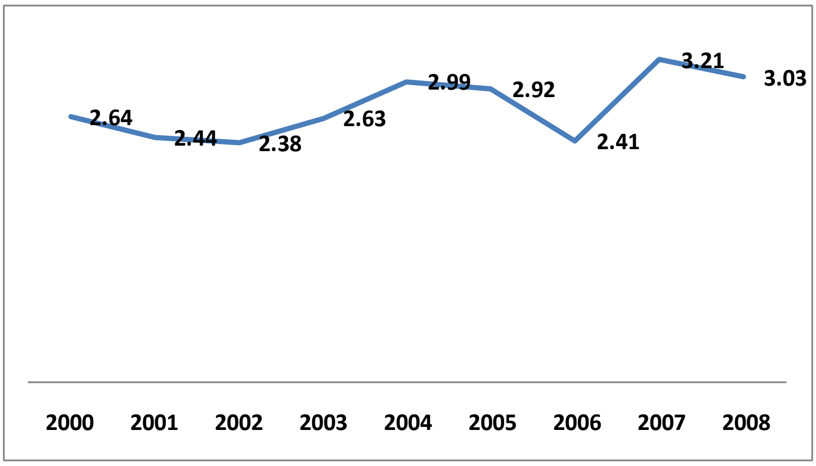
One can infer the importance of having appropriate capital adequacy ratio (CAR) from equation 6.4 and 6.5. The ratio provides a cushion that should be adequate to absorb a reasonable amount of unexpected losses due to risks involved. Having more reserved equity enables the bank to provide better protection to its depositors or other lenders.

However, retaining more reserved equity capital corresponds to a higher marginal cost of equity. Bank needs to place its reserved equity capital in more-liquid and less-risky assets, which have lower return. Keeping too much reserved capital means that the shareholders have to give up opportunity to earn more income from higher-return assets. Alternatively, banks need to raise loan interest rate in order to protect their profit margin. In the latter case, it implies that bank debtors pay part of excess reserve equity capital. In the end, the cost of excess CAR is shared to the consumer of goods and services. Thus, it would be better for banking authority to set the ceiling for capital adequacy ratio that provides a range of optimal reserve equity capital. Section 4.4.1 shows how the bank's policy to have a higher capital adequacy ratio from 18% to 20% affects the steady-state of the economy, including increasing effect on lending rates.

Having a low rate of nonperforming loans is also indirectly supportive to the achievement of inflation target through cost channel of monetary transmission. In the case of unrecovered bad loans, bank has to convert part of its reserved equity capital into new assets to substitute assets loss. The bank then needs to retain more earnings to replace the reserved equities thus keeping its capital adequacy ratio relatively stable. This could imply a higher price of bank services when other nonfund cost and dividend are preferably not (much) sacrificed.

Effectiveness of open market operation in achieving interbank rate target is undoubtedly crucial in ensuring that the CB's policy rate is entirely passed-through to market interbank rate, so that policy rate can play its role as a determinant of inflation. However, further policy rate pass-through to deposit and lending rate depends on bank's efficiency and profit margin flexibility, which are under limited influence of monetary and banking authority. Increasing trend of Indonesian bank's return on asset, as shown in Figure 4.7 indicates a strong market power that causes downward rigidity of lending rate in response to a decrease in monetary policy rate.

Figure 4.7 Bank's Return on Assets



Source: Bank Indonesia

4.4 Steady-state Simulation

All markets are perfectly competitive in steady-state, in which net real return on equity is not present. Real variables are constant. Inflation is exogenously equal to zero. Thus, nominal variables are also constant.

Table 4.1
Model Calibration (baseline)

Parameter	Description	Value
	FIRM	
β	the firm's, importer's and wage setters' discount factor	1
α_L	share of labour cost	0.20
α_M	share of imported intermediate goods cost	0.30
α_{LWC}	share of working capital loan interest cost	0.024
α_{LFC}	share of fixed capital loan interest and fixed capital goods investment financed by loan	0.018
α_{KEPFC}	share of interest cost of equity shares for fixed capital goods and fixed capital goods investment financed by equity shares	0.206
α_{KEPREF}	share of interest cost of accumulated retained earnings for fixed capital goods and fixed capital goods investment financed by retained earnings	0.206
α_{KEPWC}	share of interest cost of equities for working capital goods	0.023

α_{KEPREW}	share of interest cost of accumulated retained earnings for working capital goods	0.023
α_{MFCGP}	share of imports in fixed capital goods investment	0.3
BANK		
Γ	capital adequacy ratio	0.18
ρ_1	risk weight of loan	0
ρ_{20}	risk weight of currency	0
ρ_{21}	risk weight of required reserve	0
ρ_{22}	risk weight of excess reserve	0
ρ_3	risk weight of interbank loan	0.2
ρ_4	risk weight of government bond	0
ρ_5	risk weight of central bank certificates	0
ρ_6	risk weight of foreign assets	1
ρ_7	risk weight of fixed assets	1
$cbdr$	ratio of bank currency to deposits	0.005
rr	ratio of required reserve to deposits	0.05
er	ratio of excess reserve to deposits	0
ω_{RNFAE}	ratio of net foreign asset to equities	0.2
$\gamma_{\tilde{D}}$	share of interest cost of deposits	0.196
γ_{KEBSF}	share of cost of equity shares for fixed capital goods	0.15
γ_{KEBREF}	share of cost of accumulated retained earnings equities	0.15
γ_{KEBSR}	share of interest cost of accumulated retained earnings equities	0.008
γ_{KEBRES}	share of interest cost of equity shares for reserve capital	0.008
γ_{Cd}	share of domestic consumption goods cost	0.215
γ_{Cm}	share of imported consumption goods cost	0.092
γ_L	share of labour cost	0.18
α_{MFCGB}	share of imports in fixed capital goods investment	0.2
CENTRAL BANK		
i^{ib}	target of interbank interest rate (policy rate)	0.061
α_{CBYR}	ratio of CB certificates to GDP	0.06
γ_{idgiib}	ratio of interest rate of government deposit at CB to policy rate	0.65
γ_{icbiib}	ratio of interest rate of CB certificates to policy rate	0.63
α_{LCB}	share of labor cost	0.07
α_{CCBD}	share of domestic consumption goods and services cost	0.038
α_{CCBM}	share of imported consumption goods and services cost	0.016
α_{KECBS}	share of cost of equity share for reserve capital	0.042
$\alpha_{KECBRER}$	share of cost of accumulated retained earnings for general reserve	0.286

$\alpha_{KECBREF}$	share of cost of accumulated retained earnings for specific-purposed reserve	0.041
α_{DEPG}	share of government account interest cost	0.077
α_{CB}	share of interest cost of CB certificates' held by the bank	0.259
α_{RR}	share of interest cost of bank's required reserve	0
α_{ER}	share of interest cost of bank's excess reserve	0
α_{CH}	share of cost of currency liabilities to the household	0
α_{CB}	share of cost of currency liabilities to the bank	0
α_{MFCGCB}	share of imports in fixed capital goods investment	0.2
ω^{recbf}	fraction of profit retained for specific purposed reserve	0.1
$\hbar$	ratio of equity shares plus general reserve to monetary liabilities	0.1
$\hbar_s$	ratio of equity shares to monetary liabilities	0.01
ω_{BBCB}	share of CB certificates held by banks	0.80
ω_{BHCB}	share of CB certificates held by household	0.07
ω_{BFCB}	share of CB certificates held by foreign	0.13
GOVERNMENT		
τ	income tax rate	0.356
α_{TBR}	tax base ratio	0.115
α_{DYR}	ratio of debt to GDP	0.25
γ_{igiib}	ratio of interest rate of government bond to policy rate	1.33
α_{GL}	share of labour cost	0.23
α_{GD}	share of domestic consumption goods and services cost	0.11
α_{GM}	share of imported consumption goods and services cost	0.03
α_{GT}	share of subsidy cost	0.35
α_{KGFCD}	share of domestic goods investment	0.077
α_{KGFCM}	share of imported goods investment	0.033
α_{GB}	share of interest cost of government bond	0.17
α_{MFCGCB}	share of imports in fixed capital goods investment	0.2
ω_{BCBG}	share of government bond held by CB	0.17
ω_{BBG}	share of government bond held by banks	0.16
ω_{BHG}	share of government bond held by households	0.13
ω_{BFG}	share of government bond held by foreigns	0.54
HOUSEHOLD		
ϑ	the household's discount factor	0.988
σ^{-1}	consumption intertemporal elasticity of substitution	0.004
η_c	weight of demand for consumption in household utility function	1
$\eta_{\tilde{c}}$	weight of demand for currency in household utility function	1

η_{cf}	weight of supply of labour in household utility function	1
ρ^{-1}	interest rate elasticity of real money balance	0.003
α_{CHDR}	ratio of household's currency to deposits	0.115
λ_p^{-1}	real wage elasticity of labour supply to firms	-0.0049
λ_b^{-1}	real wage elasticity of labour supply to banks	-0.0065
λ_g^{-1}	real wage elasticity of labour supply to government	-0.0061
λ_{cb}^{-1}	real wage elasticity of labour supply to CB	-0.0056
λ_n^{-1}	real wage elasticity of nonwage earners labour supply	-0.0115
α_{LFL}	ratio of firm's worker to total labour	0.95
α_{LBL}	ratio of bank's worker to total labour	0.002
α_{LGL}	ratio of government's worker to total labour	0.04
α_{LCBL}	ratio of central bank's worker to total labour	0.0001
α_{LNL}	ratio of nonwage earner labour supply to total labour	0.0079
η	real exchange rate elasticity of exports	0.015
α_M^*	share of domestic country's export in the rest of the world's total demand	0.00018
α_{mkg}	share of imported capital goods investment	0.2
α_{HD}	share of domestic consumption goods and services cost	0.418
α_{HM}	share of imported consumption goods and services cost	0.179
α_{HL}	share of interest cost of domestic consumption loan	0.037
α_{HF}	share of interest cost of foreign loan	0.01
α_{HT}	share of income tax	0.356

There are four simulations conducted that represents changes in monetary, banking and fiscal policy as well as the effect of changes in household's currency holding behaviour or noncash payment system. Changes in monetary is represented by changes in required reserve ratio. I do not discuss the effect of changes in interbank rate target because the model still lacks a policy rule that links interest rate of monetary instrument with the signalling policy rate of interbank rate target.

4.4.1 An increase in capital adequacy ratio (from 18% to 20%)

This simulation represents a more cautious banking policy than in the baseline state. Bank has a larger reserved equity capital. Consequently, the bank set a higher lending rate in order to maintain a zero net real return on equities. The bank supplies fewer loans as it faces lower demand from the firm and the household.

The government obtains lower income tax revenue due to a lower firm's equities and lower profit income from the central bank. With a lower goods consumptions and investment, the government can have a lower level of debt. Thus, the bank earns lower interest income from its government bond assets.

The CB has less income than in baseline steady-state because it has fewer net foreign assets, which is partly due to a less currency in circulation and less bank reserves caused by a fewer deposits. Having less income leads to a smaller liabilities position. A lesser amount of CB balance sheet causes the bank to have a lower level of assets in the form of CB certificates. However, the bank has a higher income because of a higher lending rate and wider spread between lending and deposit rate.

The household has less income because of a smaller profit income from the firm's return on equity and lower subsidy income. A smaller household income causes less goods consumption. The bank also spends less on goods consumption because its goods consumption share gets smaller as share of deposits and equities becomes larger. Therefore, the firm faces less demand for goods output. On the supply side, although the firm faces a less fixed capital loans, the household supply more equity capital. The overall economy suffers from a lower level of GDP.

4.4.2 A higher required reserve ratio (from 5% to 7%)

A higher required reserve ratio is intended to represent a tighter monetary policy. As loanable funds get smaller, banks might want to defend their liquidity level by increasing deposit rate. However, a higher required reserve ratio reduces both marginal revenue of net interbank loan and the rate of marginal cost of reserve equity capital. Given a constant interbank rate controlled by monetary policy, the net effect of this price channel is a lower deposit rate. This encourages households to invest more equity on firms and banks that result in a larger production of firms' output and bank's financial services. As firms output increases, demand for loans also goes up albeit small increase in lending rate due to a higher marginal cost of managing loan. A higher bank supply of financial services leads to a larger demand for deposits.

The CB has a higher interest income because its net foreign asset increases due to expanded base money. The CB can sustain a higher steady-state financial liabilities and net worth. Therefore, the bank gets a higher interest income from holding higher CB certificates.

The government can obtain higher tax revenue due to a higher firm's and bank's equity and higher CB dividend. Therefore, it can provide more subsidies, spend more on goods consumption and investment and maintain a higher level of steady-state debt. Thus, banks can have higher government bond's interest income. Overall, the economy betters off with a higher GDP.

4.4.3 A higher tax base ratio (from 11.5% to 12%)

This simulation implies a higher income tax rate that the government has to impose. The government has a higher income that allows it to use more consumption and investment goods and provide more subsidies. A higher steady-state tax income also allows the government to have a higher debt. Given the same proportion of government bonds held by the bank, the household and the foreign, the bank earns more interest income from its government bond assets.

Households get fewer dividends but receive much more subsidies so that the aggregate household can earn more income. However, it has less disposable income to spend on consumption goods. That causes a decline in the firms' goods and services output.

A larger government income has a positive effect on the bank's and the CB's income through their holding of government bond and fixed share of government debt held by the bank and the CB. A higher bank income corresponds to a larger deposit fund and further ability to extend loan. The CB can maintain a higher level of liabilities and net worth. Although firms output declines, the other agents contribute to a large total GDP.

4.4.4 A higher household's currency-to-deposit ratio (from 11.5% to 13%)

This simulation represents a narrower use of noncash payment system that increases households' currency holding thus reduces banks' loanable funds. The bank extends fewer loans causing the firm produces fewer goods and the household has less financial investment thus gets less revenue. Majority of households consume fewer goods and have fewer deposits and equity assets.

The CB has larger monetary base liabilities as a resultant of a larger household currency but smaller bank's currency and required reserve resulted from smaller deposits. Thus, the CB holds more net foreign assets and has a greater income. Subsequently, it requires a smaller CB certificates and larger net worth. Therefore, the bank gets a fewer interest income from loans, government bonds and CB certificates.

Consequently, the government can still obtain a higher income because an increase in central bank dividend outweighs lowered income tax revenue. This allows the government to spend more on consumption goods and disburse more subsidies. Accordingly, the government can have smaller debt. Thus, the household and the bank hold fewer government bonds.

Overall, the bank produces less financial services. The smaller amount of firms and households income outweighs the larger amount of governments and CB income, causing the economy to produce a smaller GDP.

Table 4.2
Steady-State Simulation Results (higher ratio or policy rate)
(percent or percentage point deviation from baseline)

Variables (in real terms; except stated)	**Simulations**			
	1 higher capital adequacy ratio	2 higher required reserve ratio	3 higher tax rate	4 higher household currency-to-deposit ratio
Total goods and all services (GDP)	-0.08%	1.32%	0.34%	-0.01%
Goods and services	-0.12%	1.46%	-0.64%	-0.04%
Bank's financial services	9.37%	1.44%	0.25%	-0.02%
Government income	-0.01%	0.95%	4.68%	0.04%
Central bank income	-0.08%	5.43%	0.79%	1.89%
Household income	-0.05%	1.08%	0.49%	-0.01%
Household consumption of goods and services	-0.05%	1.08%	-2.16%	-0.01%
Household firm-worker's consumption of goods and services	-0.12%	1.46%	-3.26%	-0.05%
Household bank-worker's consumption of goods and services	0.00%	1.42%	-1.79%	0.12%
Household government-worker's consumption of goods and services	-0.01%	0.95%	1.91%	0.04%
Household CB-worker's consumption of goods and services	0.00%	4.04%	0.68%	2.38%
Household nonwage earner consumption of goods and services	0.01%	0.63%	-1.99%	0.01%
Fixed capital loan	-0.22%	1.46%	0.34%	-0.01%
Working capital loan	-0.30%	1.46%	0.34%	-0.01%
Consumption loan	-0.24%	1.08%	0.34%	-0.01%
Total loan	-0.27%	1.34%	0.34%	-0.01%
Deposits	-0.85%	3.84%	0.34%	-0.01%
Nominal loan interest rate (percentage point changes)	0.005%	0.000%	-0.001%	0.000%
Nominal deposits interest rate (percentage point changes)	0.001%	-0.011%	0.001%	0.000%
Nominal central bank certificates interest rate (percentage point changes)	0.000%	0.000%	0.028%	0.022%
Nominal government bond coupon rate (percentage point changes)	0.000%	0.000%	0.086%	0.001%
Nominal interbank interest rate (percentage point changes)	0.000%	0.000%	0.000%	0.000%
Nominal loan interest rate (percentage point changes)	0.021%	0.0004%	-0.004%	-0.001%
Nominal deposits interest rate (percentage point changes)	0.002%	-0.043%	0.004%	0.001%
Nominal central bank certificates interest rate (percentage point changes)	0.000%	0.000%	0.116%	0.089%
Nominal government bond coupon rate (percentage point changes)	0.000%	0.000%	0.366%	0.004%
Nominal interbank interest rate (percentage point changes)	0.000%	0.000%	0.000%	0.000%
Price of goods and services output	0.00%	0.00%	0.00%	0.00%
Price of bank's financial services output	-8.56%	-0.01%	0.62%	0.12%
Marginal cost of producing goods and services	0.00%	0.00%	0.00%	0.00%
Marginal cost of producing bank financial services	-8.56%	-0.01%	0.62%	0.12%
Marginal cost of managing bank assets, liabilities and reserve equities	-8.91%	0.40%	0.28%	0.05%
Marginal cost of managing deposits	-0.25%	-1.96%	-0.12%	-0.03%
Marginal cost of managing loans	-0.25%	0.16%	-0.10%	-0.02%

Marginal cost of importing goods and services	0.00%	0.00%	0.00%	0.00%
Income tax rate	0.00%	0.00%	1.58%	0.00%
Income tax: total	-0.01%	0.89%	4.70%	-0.01%
Income tax: firms and banks	0.14%	0.21%	3.82%	-0.02%
Income tax: households	-0.05%	1.08%	4.96%	-0.01%
Consumption of goods and services: households	-0.05%	1.08%	-2.16%	-0.01%
Consumption of goods and services: banks	-12.51%	1.78%	1.11%	0.16%
Consumption of goods and services: central bank	0.00%	3.91%	3.15%	2.10%
Consumption of goods and services: government	-0.01%	0.95%	4.68%	0.04%
Fixed capital goods investment: firms	-0.14%	1.89%	-0.74%	-0.06%
Fixed capital goods investment: bank	12.62%	1.34%	0.34%	-0.02%
Fixed capital goods investment: central bank	0.00%	11.11%	0.00%	0.00%
Fixed capital goods investment: government	-0.01%	0.95%	4.68%	0.04%
Exports	-0.16%	1.42%	-0.53%	-0.07%
Imports	-0.16%	1.48%	-0.72%	-0.04%
Imports: firms raw material (intermadiate goods)	-0.12%	1.46%	-0.64%	-0.04%
Imports: households consumption goods	-0.05%	1.08%	-2.16%	-0.01%
Imports: banks consumption goods	-12.51%	1.79%	1.11%	0.16%
Imports: central banks consumption goods	0.00%	3.51%	2.65%	1.77%
Imports: government consumption goods	-0.02%	0.95%	4.66%	0.02%
Imports: firms fixed capital goods	-0.14%	1.89%	-0.74%	-0.06%
Imports: bank fixed capital goods	12.62%	1.31%	0.32%	0.00%
Imports: central bank fixed capital goods	0.00%	0.00%	0.00%	0.00%
Imports: government fixed capital goods	-0.02%	0.94%	4.68%	0.04%
Central bank certificates	-0.04%	3.96%	0.34%	-0.01%
Central bank certificates: held by banks	-0.04%	3.96%	0.34%	-0.01%
Central bank certificates: held by households	-0.04%	3.96%	0.34%	0.00%
Central bank certificates: held by foreigns	-0.04%	3.96%	0.34%	-0.01%
Government bonds	-0.01%	0.95%	0.34%	-0.01%
Government bonds: held by banks	-0.01%	0.95%	0.34%	-0.01%
Government bonds: held by households	-0.01%	0.95%	0.34%	-0.01%
Government bonds: held by foreigns	-0.01%	0.95%	0.34%	-0.01%
Government bonds: held by CB	-0.01%	0.95%	0.34%	-0.01%
Firms equity	-0.19%	2.66%	-0.83%	-0.07%
Firms equity share: for fixed capital goods	-0.14%	1.90%	-0.77%	-0.06%
Firms equity share: for working capital goods	-0.26%	3.92%	-0.95%	-0.10%
Firms accumulated retained earnings equity: for fixed capital goods	-0.14%	1.90%	-0.77%	-0.06%
Firms accumulated retained earnings equity: for working capital goods	-0.26%	3.92%	-0.95%	-0.10%
Banks equity	12.62%	1.34%	0.34%	-0.01%
Banks equity share: for fixed capital goods	12.62%	1.34%	0.34%	-0.01%
Banks accumulated retained earnings equities: for fixed capital goods	12.62%	1.34%	0.34%	-0.01%
Banks equity share: for reserved capital	12.62%	1.34%	0.34%	-0.01%
Banks accumulated retained earnings equities: for reserved capital	12.62%	1.34%	0.34%	-0.01%

Central bank equity	-0.17%	8.80%	0.58%	4.38%
Central bank equity: government share	-0.16%	8.81%	0.57%	4.39%
Central bank equity: reserve	-0.16%	8.81%	0.57%	4.38%
Central bank accumulated retained earnings equity for fixed assets	-0.17%	8.66%	0.66%	4.32%
Government equity for fixed capital goods	-0.01%	0.95%	11.74%	0.11%
Government equity for nonfinancial assets	-0.05%	4.65%	2.92%	2.56%
Government deposits at central bank	-0.04%	3.96%	3.31%	2.26%
Firms working capital goods	-0.26%	3.71%	-0.84%	-0.09%
Firms fixed capital goods	-0.14%	1.89%	-0.74%	-0.06%
Bank fixed capital goods	12.62%	1.34%	0.34%	-0.01%
Central bank fixed capital goods	-0.17%	8.66%	0.66%	4.32%
Government fixed capital goods	-0.01%	0.95%	4.68%	0.04%
Government subsidy	-0.01%	0.95%	4.68%	0.04%
Households currency holding	-0.05%	1.04%	0.34%	13.03%
Bank's currency in vault	-0.85%	3.84%	0.34%	-0.01%
Required reserve	-0.85%	45.38%	0.34%	-0.01%
Monetary base	-0.30%	14.12%	0.34%	8.81%
Households net foreign debt	-0.19%	3.53%	0.27%	-0.06%
Banks foreign assets	12.62%	1.34%	0.34%	-0.01%
National net foreign assets	-0.93%	-3.87%	0.07%	-4.03%

Table 4.3
Steady-State Simulation Results (lower ratio or policy rate)
(percent or percentage point deviation from baseline)

Variables (in real terms; except stated)	**Simulations**			
	1 lower capital adequacy ratio	2 lower required reserve ratio	3 lower tax rate	4 lower household currency-to-deposit ratio
Total goods and all services (GDP)	0.13%	-1.29%	-0.34%	0.01%
Goods and services	0.18%	-1.43%	0.63%	0.04%
Bank's financial services	-10.62%	-1.41%	-0.24%	0.01%
Government public and financial services	0.02%	-0.93%	-4.64%	-0.04%
Central bank financial services	0.12%	-5.29%	-0.79%	-1.93%
Household labour and financial services	0.08%	-1.06%	-0.48%	0.01%
Household consumption of goods and services	0.08%	-1.06%	2.15%	0.01%
Household firm-worker's consumption of goods and services	0.18%	-1.43%	3.29%	0.05%
Household bank-worker's consumption of goods and services	0.00%	-1.40%	1.77%	-0.10%
Household government-worker's consumption of goods and services	0.02%	-0.94%	-2.12%	-0.04%
Household CB-worker's consumption of goods and services	0.34%	-3.70%	-0.68%	-2.04%
Household nonwage earner consumption of goods and services	-0.02%	-0.63%	1.98%	-0.01%
Fixed capital loan	0.34%	-1.42%	-0.34%	0.01%
Working capital loan	0.46%	-1.42%	-0.34%	0.01%
Consumption loan	0.36%	-1.06%	-0.34%	0.01%

Total loan	0.40%	-1.31%	-0.34%	0.01%
Deposits	1.24%	-3.66%	-0.34%	0.01%
Nominal loan interest rate (percentage point changes)	-0.007%	0.000%	0.001%	0.000%
Nominal deposits interest rate (percentage point changes)	-0.001%	0.011%	-0.001%	0.000%
Nominal central bank certificates interest rate (percentage point changes)	0.000%	0.000%	-0.028%	-0.021%
Nominal government bond coupon rate (percentage point changes)	0.000%	0.000%	-0.086%	-0.001%
Nominal interbank interest rate (percentage point changes)	0.000%	0.000%	0.000%	0.000%
Nominal loan interest rate (percentage point changes)	-0.031%	0.000%	0.004%	0.001%
Nominal deposits interest rate (percentage point changes)	-0.004%	0.043%	-0.004%	-0.001%
Nominal central bank certificates interest rate (percentage point changes)	0.000%	0.000%	-0.116%	-0.088%
Nominal government bond coupon rate (percentage point changes)	0.000%	0.000%	-0.365%	-0.004%
Nominal interbank interest rate (percentage point changes)	0.000%	0.000%	0.000%	0.000%
Price of goods and services output	0.00%	0.00%	0.00%	0.00%
Price of bank's financial services output	11.88%	0.01%	-0.62%	-0.12%
Price of central bank financial services output	-0.07%	1.46%	-2.51%	-0.33%
Marginal cost of producing goods and services	0.00%	0.00%	0.00%	0.00%
Marginal cost of producing bank financial services	11.88%	0.01%	-0.62%	-0.12%
Marginal cost of managing bank assets, liabilities and equities	12.55%	-0.40%	-0.29%	-0.05%
Marginal cost of managing deposits	0.38%	1.95%	0.11%	0.02%
Marginal cost of managing loans	0.38%	-0.16%	0.11%	0.03%
Marginal cost of producing central bank financial services	-0.07%	1.46%	-2.51%	-0.33%
Marginal cost of importing goods and services	0.00%	0.00%	0.00%	0.00%
Income tax rate	0.00%	0.00%	-1.58%	0.00%
Income tax: total	0.02%	-0.87%	-4.67%	0.01%
Income tax: firms and banks	-0.20%	-0.23%	-3.88%	0.02%
Income tax: households	0.08%	-1.06%	-4.90%	0.01%
Consumption of goods and services: households	0.08%	-1.06%	2.15%	0.01%
Consumption of goods and services: banks	18.17%	-1.74%	-1.10%	-0.16%
Consumption of goods and services: central bank	0.00%	-3.91%	-3.41%	-2.36%
Consumption of goods and services: government	0.02%	-0.93%	-4.64%	-0.04%
Fixed capital goods investment: firms	0.23%	-1.84%	0.74%	0.06%
Fixed capital goods investment: bank	-18.29%	-1.31%	-0.34%	0.00%
Fixed capital goods investment: central bank	0.00%	-11.11%	0.00%	-11.11%
Fixed capital goods investment: government	0.02%	-0.93%	-4.64%	-0.03%
Exports	0.25%	-1.38%	0.53%	0.07%
Imports	0.24%	-1.45%	0.72%	0.03%
Imports: firms raw material (intermadiate goods)	0.18%	-1.43%	0.63%	0.05%
Imports: households consumption goods	0.08%	-1.06%	2.15%	0.01%
Imports: banks consumption goods	18.19%	-1.74%	-1.10%	-0.16%
Imports: central banks consumption goods	0.00%	-4.39%	-3.54%	-2.65%
Imports: government consumption goods	0.02%	-0.93%	-4.66%	-0.04%
Imports: firms fixed capital goods	0.23%	-1.84%	0.74%	0.06%
Imports: bank fixed capital goods	-18.29%	-1.31%	-0.32%	0.00%

Imports: central bank fixed capital goods	0.00%	0.00%	0.00%	0.00%
Imports: government fixed capital goods	0.02%	-0.94%	-4.62%	-0.02%
Central bank certificates	0.05%	-3.91%	-0.34%	0.01%
Central bank certificates: held by banks	0.05%	-3.91%	-0.34%	0.01%
Central bank certificates: held by households	0.05%	-3.91%	-0.34%	0.01%
Central bank certificates: held by foreign	0.05%	-3.91%	-0.34%	0.01%
Government bonds	0.02%	-0.93%	-0.34%	0.01%
Government bonds: held by banks	0.02%	-0.93%	-0.34%	0.01%
Government bonds: held by households	0.02%	-0.93%	-0.34%	0.01%
Government bonds: held by foreigns	0.02%	-0.93%	-0.34%	0.01%
Government bonds: held by CB	0.02%	-0.93%	-0.34%	0.01%
Firms equity	0.29%	-2.56%	0.83%	0.07%
Firms equity share: for fixed capital goods	0.22%	-1.85%	0.76%	0.06%
Firms equity share: for working capital goods	0.40%	-3.71%	0.95%	0.10%
Firms accumulated retained earnings equity: for fixed capital goods	0.22%	-1.86%	0.76%	0.06%
Firms accumulated retained earnings equity: for working capital goods	0.40%	-3.71%	0.95%	0.10%
Banks equity	-18.29%	-1.31%	-0.34%	0.01%
Banks equity share: for fixed capital goods	-18.29%	-1.31%	-0.34%	0.01%
Banks accumulated retained earnings equities: for fixed capital goods	-18.29%	-1.31%	-0.34%	0.01%
Banks equity share: for reserved capital	-18.29%	-1.31%	-0.34%	0.01%
Banks accumulated retained earnings equities: for reserved capital	-18.29%	-1.31%	-0.34%	0.01%
Central bank equity	0.24%	-8.31%	-0.58%	-4.38%
Central bank equity: government share	0.24%	-8.32%	-0.57%	-4.39%
Central bank equity: reserve	0.24%	-8.33%	-0.57%	-4.38%
Central bank accumulated retained earnings equity for fixed assets	0.23%	-8.21%	-0.64%	-4.32%
Government equity for fixed capital goods	0.02%	-0.93%	-11.66%	-0.11%
Government equity for nonfinancial assets	0.08%	-4.53%	-2.90%	-2.56%
Government deposits at central bank	0.05%	-3.90%	-3.29%	-2.26%
Firms working capital goods	0.41%	-3.52%	0.84%	0.09%
Firms fixed capital goods	0.23%	-1.84%	0.74%	0.06%
Bank fixed capital goods	-18.29%	-1.31%	-0.34%	0.01%
Central bank fixed capital goods	0.23%	-8.21%	-0.64%	-4.32%
Government fixed capital goods	0.02%	-0.93%	-4.64%	-0.04%
Government subsidy	0.02%	-0.93%	-4.64%	-0.04%
Households currency holding	0.08%	-1.02%	-0.34%	-13.04%
Bank's currency in vault	1.23%	-3.66%	-0.34%	0.01%
Required reserve	1.24%	-42.19%	-0.34%	0.01%
Monetary base	0.45%	-13.17%	-0.34%	-8.82%
Households net foreign debt	0.30%	-3.36%	-0.26%	0.06%
Banks foreign assets	-18.29%	-1.31%	-0.34%	0.01%
National net foreign assets	1.38%	3.59%	-0.06%	4.04%

4.5 Conclusion

The model setting and analysis presented in this paper show that the dominant, strong effect of interest rate increases to demand-pull inflation works through investment demand and profit margin channel. However, both channels affect inflation through restraining supply rather than demand, causing likelihood to have a higher instead of lower inflation. An increase in interest rate reduces demand for fixed capital investment hence the supply of future output. It also lessens demand for and supply of working capital through equity and loan financing that affect supply of current and future output. Combined with robust interest rate cost-push channel and market power, this study framework enhances the previous findings that interest rate tightening has a weak control on reducing inflation. Monetary policy maker should bear in mind that interest rate policy should not only be treated as a demand stabilisation but also as a cost and supply stabilisation instrument.

It is worth noting to see that the rate of interest on depositing funds at banks serves as a subset of rate of return on equity in all profit-maximising business units (firms and banks). Thus, central bank's ability to set a proper direction and magnitude of policy rate to achieve interbank rate target is crucial since interbank rate is the main determinant of deposit rate. Such capability is necessary for monetary policy rate to play its role as inflation determinant. However, we need sufficient condition to ensure that policy rate is passed-through effectively to lending rate. Monetary and banking authority need to promote concerted efforts to improve banks' operational efficiency and dilute the viscosity of bank's market concentration. It is advisable that regulating and supervising banking business competition is inherent in the task of banking authority.

Furthermore, it is indispensable to realise that capital adequacy ratio is indeed an inflation determinant as well. Thus, banking policy is necessary to support the achievement of monetary authority's inflation target through setting an inflation-oriented optimal range of capital adequacy ratio and supervising the bank's policy compliance.

There is a common argument that monetary and banking policy can be conflicting in response to banking crises. In that circumstances, monetary authority is likely to relax its policy while banking authority is inclined to pursue a more prudent policy that may discourage banking intermediation. This potential conflict should be able to minimise by treating inflation as a joint overriding goal of both monetary and banking policy.

Another potential conflict of interest between the two authorities can occur when monetary authority desires higher interest rates to fight inflation while banking authority is concerned about the adverse effect of higher interest rate on the solvency and profitability of banking sector (Ioannidou, 2003). However, this conflict can be weak or even nonexistent in a certain period in the economy with weak demand channel and strong cost channel of interest rates. The clear policy implication for such economic environment is that the monetary authority has an opportunity to pursue disinflation by lowering cost of capital when the state of the economy is characterized by weak demand condition, overvalued exchange rate and favourable supply shocks. It is, therefore, essential to enhance the linkage between monetary and banking policies making and control.

Finally, we can further explore the findings in this study as challenging field of research. It would be intriguing to observe the relative strength of demand-pull vs. cost-push inflation through dynamic simulation of interest rate policy and of demand, supply and profit margin shocks. Dynamic model can also be utilised to investigate issues related to bank lending channel of monetary policy, i.e. real sector effect of changes in bank's financial assets portfolio, lending and deposit rate rigidity and policy rate pass-through to market interest rates. Empirically testing interest equity and credit cost channel of monetary policy could also be worth justifying.

Appendix

Source code

```
$TITLE AK_PROJECT3.gms: BANKING DGE MODEL
OPTION SYSOUT=OFF;
OPTION LIMROW=50;
OPTION LIMCOL=0;
********************************
* SECTION 1 : PARAMETER VALUES *
********************************
SCALARS
*-------------------------------------------------------------------------------
* Banking parameters
*-------------------------------------------------------------------------------
CAR              capital adequacy ratio                                /0.18/
RHO1             risk weight of placement in loan                      /1/
RHO20            risk weight of placement in currency                  /0/
RHO21            risk weight of placement in required reserve          /0/
RHO22            risk weight of placement in excess reserve            /0/
RHO3             risk weight of placement in interbank money market    /0.20/
RHO4             risk weight of placement in government bond           /0/
RHO5             risk weight of placement in central bank certificates /0/
RHO6             risk weight of placement in foreign assets            /1/
RHO7             risk weight of placement in fixed assets              /1/
CBDR             ratio of bank currency to deposits                    /0.005/
RR               ratio of required reserve to deposits                 /0.05/
ERR              ratio of excess reserve to deposits                   /0/
LDR              loan-to-deposit ratio                                 /0.76/
LFC              fixed capital loan to loan ratio                      /0.21/
LWC              working capital loan to loan ratio                    /0.48/
LC               consumption loan to loan ratio                        /0.31/
RKEBF            share of equity for fixed asset                       /0.5/
BBFEQ            ratio of bank's net foreign asset to equity           /0.2/
CHG              ratio of charge income to total income                /0.18/
DELTAB           depreciation rate of bank's fixed capital goods       /0.03/
Ab               technology                                            /1/
ub               capacity utilization                                  /1/
* Cost structure
aBL              share of labor cost                                   /0.18/
*-------------------------------------------------------------------------------
* Firm parameters
*-------------------------------------------------------------------------------
A                technology                                            /1/
u                capacity utilization                                  /1/
aMf              share of export in foreign economy total demand       /0.000018/
ETA              real exchange rate price elasticity of real export    /0.015/
BETHA            producers's and importer's and wage setter's discount factor /1/
DELTA            depreciation rate of firm's fixed capital goods       /0.02/
* Cost structure
aFL              share of labour                                       /0.20/
aFRM             share of imported raw material goods cost             /0.30/
*-------------------------------------------------------------------------------
* Government parameters
*-------------------------------------------------------------------------------
DYR              ratio of debt to GDP                                  /0.25/
TBR              tax base ratio                                        /0.115/
DELTAG           depreciation rate of govt's fixed capital goods       /0.008/
RBCBG            share of government bond held by CB                   /0.17/
RBBG             share of government bond held by banks                /0.16/
RBHG             share of government bond held by households           /0.13/
RBFG             share of government bond held by foreigns             /0.54/
* Cost structure
GCDYGOV          share of cost of domestic consumption goods           /0.11/
GCMYGOV          share of cost of imported consumption goods           /0.03/
WLYGOV           share of employee cost                                /0.23/
SOYGOV           share of subsidy                                      /0.35/
aKGFCD           share of cost of replacement investment: domestic     /0.077/
aKGFCM           share of cost of replacement investment: imported     /0.033/
BGYGOV           share of debt cost (solved given bg & ygov)           /0.17/
*-------------------------------------------------------------------------------
* Central bank parameters
*-------------------------------------------------------------------------------
iibq             interbank rate qtq                                     /0.015/
CBYR             ratio of CB certificates to GDP                        /0.06/
RTML             ratio of CB reserve equity to monetary liabilities     /0.1/
RBBCB            share of CB certificates held by banks                 /0.80/
RBHCB            share of CB certificates held by banks                 /0.07/
RBFCB            share of CB certificates held by banks                 /0.13/
DELTACB          depreciation rate of CB's fixed capital goods          /0.001/
* Cost structure
WLYCB            share of labor cost                                    /0.07/
aDEPG            share of cost of gov deposit interest                  /0.077/
```

```
BCBYCB          share of interest cost of CB certificates              /0.43/
CCBd            share of domestic consumption goods cost               /0.038/
CCBm            share of imported consumption goods cost               /0.016/
aKECBS          share of cost of equity share for reserve capital      /0.042/
aKECBRER        share of cost of accumulated retained earnings for general reserve /0.286/
aKECBREF        share of cost of accumulated retained earnings for specific-purposed reserve /0.041/
*-------------------------------------------------------------------------------
* Household parameters
*-------------------------------------------------------------------------------
SCALARS
SIGMA           relative risk aversion (inverse of consumption intertemporal elasticity of
substitution) /265/
ETA_CONS        weight of demand for consumption in household utility function /1/
ETA_CUR         weight of demand for currency in household utility function    /1/
ETA_L           weight of supply of labour in household utility function       /1/
CHDR            ratio of household's currency to deposits                      /0.115/
RHBFH           share of foreign loan interest payment in household's expenditure  /0.01/
* Labour supply
RLFL            ratio of firm worker to total labour                    /0.95/
RLBL            ratio of bank worker to total labour                    /0.002/
RLGL            ratio of government worker to total labour              /0.04/
RLCBL           ratio of central bank worker to total labour            /0.0001/
RLNL            ratio of government worker to total labour              /0.0079/
* Imports share
SIMKG           share of imports in firm's fixed capital goods investment /0.3/
SIMKGB          share of imports in bank's fixed capital goods investment /0.2/
SIMKGG          share of imports in government's fixed capital goods investment /0.2/
SIMKGCB         share of imports in CB's fixed capital goods investment   /0.2/
*************************************************************************************
EQUATIONS
************************************************************************************
JD..              J             =E= 0;
eqG_y..           y             =E= pdp*yp + pdb*yb + pdcb*ycb + ygov + yh;
*************************************************************************************
FIRM
*************************************************************************************
Output and income
eqGDPFIRM..       log(yp)       =E= aFL*(log(A)+log(Lf)) + aFRM*log(cpprmm) + aFLWC*log(loanwc) +
aFLFC*log(loanfc) + aFKEPFC*log(kepfc) + aFKEPREF*log(kepref) + aFKEPREW*log(keprew) +
aFKEPWC*log(kepwc);
eqGADFIRM..       yp            =E= chpd + cbpd + ccbpd + cgpd + ivpfd + ivbfd + ivgfd + ivcbfd +
x;
* Expenditure
eqL_fd..          Lf            =E= aFL*pdp*yp/wf;
eqG_cpprmm..      cpprmm        =E= aFRM*pdp*yp/pm;
eqG_loanwcdem..   loanwc        =E= aFLWC*pdp*yp/rloanq;
eqG_loanfcdem..   loanfc        =E= aFLFC*pdp*yp/(rloanq+DELTA);
eqG_aFKEP..       aFKEP         =E= 1-aFL-aFRM-aFLWC-aFLFC;
eqG_aFKEPF..      aFKEPF        =E= 0.9*aFKEP;
eqG_aFKEPW..      aFKEPW        =E= 0.1*aFKEP;
eqG_aFKEPFC..     aFKEPFC       =E= 0.5*aFKEPF;
eqG_kepfcdem..    kepfc         =E= aFKEPFC*pdp*yp/(rdepq+DELTA);
eqG_aFKEPREF..    aFKEPREF      =E= 0.5*aFKEPF;
eqG_keprefdem..   kepref        =E= aFKEPREF*pdp*yp/(rdepq+DELTA);
eqG_aFKEPWC..     aFKEPWC       =E= 0.5*aFKEPW;
eqG_kepwcdem..    kepwc         =E= aFKEPWC*pdp*yp/rdepq;
eqG_aFKEPREW..    aFKEPREW      =E= 0.5*aFKEPW;
eqG_keprewdem..   keprew        =E= aFKEPREW*pdp*yp/rdepq;
eqG_kpfc..        kpfc          =E= loanfc + kepfc + kepref;
eqG_kpwc..        kpwc          =E= loanwc + kepwc + keprew;
eqG_keptot..      kep           =E= kepfc + kepwc + kepref + keprew;
eqG_FDEBTOEQ..    FDEBTOEQ      =E= (loanwc+loanfc)/kep;
* Equity, capital goods, investment
eqG_ivpf..        ivpf          =E= DELTA*kpfc;
eqG_ivpfm..       ivpfm         =E= SIMKG*ivpf;
eqG_ivpfd..       ivpfd         =E= (1-SIMKG)*ivpf;
* Cost, prices, profit
eqG_pidq..        pidq          =E= pitargetq;
eqG_pid..         pid           =E= power((1+pidq),4)-1;
eqG_npdp..        npdp          =E= p0;
eqG_pdp1..        pdp           =E= npdp/p;
eqG_pdp..         pdp           =E= mcp;
eqG_mcp..         log(mcp)      =E= aFL*(log(wf)-log(A)-log(aFL)) + aFRM*(log(pm)-log(aFRM)) +
aFLWC*(log(rloanq)-log(aFLWC)) + aFLFC*(log(rloanq+DELTA)-log(aFLFC)) + aFKEPFC*(log(rdepq+DELTA)-
log(aFKEPFC)) + aFKEPREF*(log(rdepq+DELTA)-log(aFKEPREF)) + aFKEPWC*(log(rdepq)-log(aFKEPWC)) +
aFKEPREW*(log(rdepq)-log(aFKEPREW));
eqG_divp..        dividendfirm  =E= (1-tax)*rdepq*kep;
*************************************************************************************
BANK
*************************************************************************************
Output and income
eqGDPBANK..       log(yb)       =E= aBD*log(dep) + aBL*log(Lb) + aBKEBSF*log(kebsf) +
aBKEBREF*log(kebref)  + aBKEBSR*log(kebsr) + aBKEBRER*log(kebrer) + aBCd*log(cbpd) + aBCm*log(cbpm);
eqGADBANK..       yb            =E= (rloanq*loan + rgovq*bbg + rcbq*bbcb + rfq*q*bbf)/pdb;
eqB_ybcharge..    ybcharge      =E= CHG*pdb*yb;
* Expenditure
eqEM_curb..       curb          =E= CBDR*dep;
eqEM_reqres..     reqres        =E= RR*dep;
```

```
eqEM_exres..       excesres       =E= ERR*dep;
eqFIN_LDR..        dep            =E= loan/LDR;
eqFIN_depcons..    dep            =E= curb + reqres + excesres + loan + bbg + bbcb + bbf*q - kebrer -
kebsr;
eqFIN_depdem..     dep            =E= aBD*pdb*yb/rdepq;
eqB_loanfc..       loanfc         =E= LFC*loan;
eqB_loanwc..       loanwc         =E= LWC*loan;
eqB_loancon..      loancon        =E= LC*loan;
eqFIN_loandem..    loan           =E= loancon + loanfc + loanwc;
eqEQ_kebcarrho..   keb            =E= CAR*(RHO1*loan + RHO6*bbf*q + RHO7*kbfc);
eqEQ_bbf..         bbf            =E= BBFEQ*keb/q;
eqB_rkbfc..        kbfc           =E= RKEBF*keb;
eqB_rkebsf..       kebsf          =E= 0.5*kbfc;
eqB_rkebref..      kebref         =E= 0.5*kbfc;
eqG_kebsf..        kebsf          =E= aBKEBSF*pdb*yb/(rdepq+DELTAB);
eqG_kebref..       kebref         =E= aBKEBREF*pdb*yb/(rdepq+DELTAB);
eqG_kbfctot..      kbfc           =E= kebsf+kebref;
eqB_rkebsr..       kebsr          =E= 0.5*(1-RKEBF)*keb;
eqB_rkebrer..      kebrer         =E= 0.5*(1-RKEBF)*keb;
eqEQ_kebsr..       kebsr          =E= aBKEBSR*pdb*yb/rdepq;
eqEQ_kebrer..      kebrer         =E= aBKEBRER*pdb*yb/rdepq;
eqEQ_kebdem..      keb            =E= kebsr + kebrer + kbfc;
eqL_bd..           Lb             =E= aBL*pdb*yb/wb;
eqG_cbpddem..      cbpd           =E= aBCd*pdb*yb/pdp;
eqG_cbpmdem..      cbpm           =E= aBCm*pdb*yb/pm;
eqG_cbp..          cbp            =E= cbpd+cbpm;
eqB_aBCd..         aBCd           =E= 0.7*(1-aBL-aBD-aBKEBSR-aBKEBRER-aBKEBSF-aBKEBREF);
eqB_aBCm..         aBCm           =E= 0.3*(1-aBL-aBD-aBKEBSR-aBKEBRER-aBKEBSF-aBKEBREF);
* Equity, reserve capital, fixed capital goods, investment
eqG_ivbf..         ivbf           =E= DELTAB*kbfc;
eqG_ivbfm..        ivbfm          =E= SIMKGB*ivbf;
eqG_ivbfd..        ivbfd          =E= (1-SIMKGB)*ivbf;
* Costs, prices, profit
eqG_pdb..          pdb            =E= mcb;
eqFIN_mcb..        log(mcb)       =E= aBL*(log(wb)-log(Ab)-log(aBL)) + aBCd*(log(pdp)-log(aBCd)) +
aBCm*(log(pm)-log(aBCm)) + aBKEBSF*(log(rdepq+DELTAB) - log(aBKEBSF)) + aBKEBREF*(log(rdepq+DELTAB) -
log(aBKEBREF)) + aBKEBSR*(log(rdepq)-log(aBKEBSR)) + aBKEBRER*(log(rdepq)-log(aBKEBRER)) +
aBD*(log(rdepq)-log(aBD));
eqFIN_mcbmgt..     log(mcbmgt)    =E= aBL*(log(wb)-log(Ab)-log(aBL)) + aBCd*(log(pdp)-log(aBCd)) +
aBCm*(log(pm)-log(aBCm)) + aBKEBSF*(log(rdepq+DELTAB) - log(aBKEBSF)) + aBKEBREF*(log(rdepq+DELTAB) -
log(aBKEBREF));
eqFIN_mcdepm..     mcdepmgt       =E= mcbmgt*aBD*yb/dep;
eqFIN_mcloanm..    mcloanmgt      =E= mcdepmgt*(1/(1-(CBDR+RR+ERR)));
eqBANK_divb..      dividendbank   =E= (1-tax)*rdepq*keb;
* Interest rates
eqFIN_rdep..       rdep           =E= (1-S_TETA)/(S_TETA*(1-tax));
eqFIN_rdepq..      rdepq          =E= sqrt(sqrt(1+rdep))-1;
eqFIN_idepq..      idepq          =E= (1+rdepq)*(1+piq)-1;
eqFIN_idepqb..     idepq          =E= 1/(1+(1-(CBDR+RR+ERR))*CAR*RHO3)*((1-(CBDR+RR+ERR))*iibq-
mcdepmgt);
eqFIN_iloanq..     iloanq         =E= iibq+(RHO1-RHO3)*CAR*idepq+mcloanmgt;
eqFIN_rloanq..     rloanq         =E= (1+iloanq)/(1+piq)-1;
************************************************************************************
CENTRAL BANK
************************************************************************************
Output and income
eqCB_GDP..         log(ycb)       =E= WLYCB*log(Lcb) + CCBd*log(ccbpd) + CCBm*log(ccbpm) +
aKECBS*log(kecbs) + aKECBRER*log(kecbrer) + aKECBREF*log(kecbref) + BCBYCB*log(bcb) +
aDEPG*log(depg);
eqGADCB..          ycb            =E= (rfq*q*bcbf + rgovq*bcbg)/pdcb;
* Expenditure
eqCB_kecbs..       kecbs          =E= aKECBS*pdcb*ycb/rkecbq;
eqCB_kecbrer..     kecbrer        =E= aKECBRER*pdcb*ycb/rkecbq;
eqCB_kecbref..     kecbref        =E= aKECBREF*pdcb*ycb/(rkecbq+DELTACB);
eqCB_bcb..         bcb            =E= BCBYCB*pdcb*ycb/rcbq;
eqCB_depg..        depg           =E= aDEPG*pdcb*ycb/rdepgq;
eqL_cbd..          Lcb            =E= WLYCB*pdcb*ycb/wcb;
eqCB_ccbpm..       ccbpm          =E= CCBm*pdcb*ycb/pm;
eqCB_ccbpd..       ccbpd          =E= CCBd*pdcb*ycb/pdp;
eqCB_ccbp..        ccbp           =E= ccbpd+ccbpm;
* Equity, fixed capital goods, investment
eqCB_kecbr..       kecbr          =E= RTML*(m0 + bcb + depg);
eqCB_kecbs_ras..   kecbs          =E= aKECBS/(aKECBS+aKECBRER)*kecbr;
eqCB_kecbrer_ras.. kecbrer        =E= aKECBRER/(aKECBS+aKECBRER)*kecbr;
eqCB_kecb..        kecb           =E= kecbs + kecbrer + kecbref;
eqCB_DEPGNFA..     DEPGNFA        =E= depg/(bcbf*q);
eqCB_EQNFA..       EQNFA          =E= kecb/(bcbf*q);
eqCB_BCBGNFA..     BCBGNFA        =E= bcbg/(bcbf*q);
eqCB_kcbfc..       kcbfc          =E= kecbref;
eqCB_ivcbf..       ivcbf          =E= DELTACB*kcbfc;
eqCB_ivcbfm..      ivcbfm         =E= SIMKGCB*ivcbf;
eqCB_ivcbfd..      ivcbfd         =E= (1-SIMKGCB)*ivcbf;
* Debt (CB certificates)
eqCB_CBYR..        bcb            =E= CBYR*4*y;
eqCB_bbcbr..       bbcb           =E= RBBCB*bcb;
eqCB_bhcbr..       bhcb           =E= RBHCB*bcb;
eqCB_bfcbr..       bfcb           =E= RBFCB*bcb/q;
* Net foreign assets
```

```
eqCB_bcbf..         bcbf            =E= (m0 + bcb + depg + kecbs + kecbrer - bcbg)/q;
eqCB_bcbftoim..     CAD             =E= bcbf*q/im;
* Monetary Base
eqEM_M0..           m0              =E= curh + curb + reqres + excesres;
* Costs, price, profit
eqG_pdcb..          pdcb            =E= mccb;
eqCB_mccb..         log(mccb)       =E= WLYCB*(log(wcb)-log(WLYCB)) + CCBd*(log(pdp)-log(CCBd)) +
CCBm*(log(pm)-log(CCBm)) + aKECBREF*(log(rkecbq+DELTACB)-log(aKECBREF)) + aKECBS*(log(rkecbq)-
log(aKECBS)) + aKECBRER*(log(rkecbq)-log(aKECBRER)) + BCBYCB*(log(rcbq) - log(BCBYCB)) +
aDEPG*(log(rdepgq) - log(aDEPG));
eqCB_mccbmgt..      log(mccbmgt)    =E= WLYCB*(log(wcb)-log(WLYCB)) + CCBd*(log(pdp)-
log(CCBd))+CCBm*(log(pm)-log(CCBm))+aKECBREF*(log(rkecbq+DELTACB)-log(aKECBREF)) ;
eqCB_mcsbim..       mcsbimgt        =E= mccbmgt*BCBYCB*ycb/bcb;
eqCB_divcb..        dividendcb      =E= rkecbq*kecb;
* Interest rates
eqFIN_rresq..       rresq           =E= 0;
eqFIN_isbiq..       icbq            =E= SICBQ*iibq;
eqFIN_rsbiq..       rcbq            =E= (1+icbq)/(1+piq)-1;
eqFIN_idepgq..      idepgq          =E= 0.65*iibq;
eqFIN_rdepgq..      rdepgq          =E= (1+idepgq)/(1+piq)-1;
eqFIN_ikecbq..      ikecbq          =E= SIKECBQ*iibq;
eqFIN_rkecbq..      rkecbq          =E= (1+ikecbq)/(1+piq)-1;
***************************************************************************************
GOVERNMENT
***************************************************************************************
Income
eqGADGOV..          ygov            =E= ytax + dividendcb + rdepgq*depg;
* Tax income
eqG_tbr..           ytax            =E= TBR*y;
eqG_ytax..          ytax            =E= ytaxc+ytaxh;
eqG_ytaxc..         ytaxc           =E= tax*rdepq*(kep + keb);
* Expenditure
eqGOV_bg..          bg              =E= BGYGOV*ygov/rgovq;
eqG_kgfcd..         kgfcd           =E= aKGFCD*ygov/(pdp*DELTAG);
eqG_kgfcm..         kgfcm           =E= aKGFCM*ygov/(pm*DELTAG);
eqG_kgfc..          kgfc            =E= kgfcd+kgfcm;
eqL_gd..            Lg              =E= WLYGOV*ygov/wg;
eqG_suboil..        to              =E= SOYGOV*ygov;
eqG_gmcons..        cgpm            =E= GCMYGOV*ygov/pm;
eqG_gdcons..        cgpd            =E= GCDYGOV*ygov/pdp;
eqG_gcons..         cgp             =E= cgpd+cgpm;
* Equity, fixed capital goods, investment
eqGOV_kegrefn..     kegrefn         =E= kecbs+depg;
eqG_kegref..        kegref          =E= kgfc-bg;
eqGOV_ivgfd..       ivgfd           =E= DELTAG*kgfcd;
eqGOV_ivgfm..       ivgfm           =E= DELTAG*kgfcm;
eqGOV_ivgf..        ivgf            =E= ivgfd+ivgfm;
* Debt
eqGOV_DYR..         bg              =E= DYR*4*y;
eqGOV_bcbgr..       bcbg            =E= RBCBG*bg;
eqGOV_bbgr..        bbg             =E= RBBG*bg;
eqGOV_bhgr..        bhg             =E= RBHG*bg;
eqGOV_bfgr..        bfg             =E= RBFG*bg/q;
* Interest rate
eqFIN_igovq..       igovq           =E= SIGOVQ*iibq;
eqFIN_rgovq..       rgovq           =E= (1+igovq)/(1+piq)-1;
***************************************************************************************
HOUSEHOLD
***************************************************************************************
Income
eqGDIHOUSE..        yh              =E= yhw + yhid + yhs + yhim;
* Expenditure
eqHOU_yhw..         yhw             =E= wf*Lf + wb*Lb + wg*Lg + wcb*Lcb;
eqHOU_yhid..        yhid            =E= dividendfirm + dividendbank - piq/(1+piq)*curh + rdepq*dep +
rgovq*bhg + rcbq*bhcb;
eqHOU_yhs..         yhs             =E= to;
eqHOU_yhim..        yhim            =E= (pm-q)*im;
eqHOU_ytaxh..       ytaxh           =E= tax*yh;
eqHOU_loancon..     loancon         =E= RHLC*yh/rloanq;
eqHOU_bfh..         bfh             =E= RHBFH*yh/(rfq*q);
eqHOU_chpm..        chpm            =E= RHCPM*yh/pm;
eqHOU_chpd..        chpd            =E= RHCPD*yh/pdp;
eqG_chp..           chp             =E= chpd+chpm;
eqHOU_RHCPD..       RHCPD           =E= 0.7*(1-tax-RHLC-RHBFH);
eqHOU_RHCPM..       RHCPM           =E= 0.3*(1-tax-RHLC-RHBFH);
* Labour supply
eqL_RLFL..          Lf              =E= RLFL*L;
eqL_RLBL..          Lb              =E= RLBL*L;
eqL_RLCBL..         Lcb             =E= RLCBL*L;
eqL_RLGL..          Lg              =E= RLGL*L;
eqL_RLNL..          Ln              =E= RLNL*L;
eqL_L..             L               =E= Lf+Lb+Lcb+Lg+Ln;
eqL_fs..            log(Lf)         =E= LAMBDAF*(log(wf) + log(1-tax) - SIGMA*log(chpf) + log(ETA_CONS)
- log(ETA_L));
eqL_bs..            log(Lb)         =E= LAMBDAB*(log(wb) + log(1-tax) - SIGMA*log(chpb) + log(ETA_CONS)
- log(ETA_L));
eqL_cbs..           log(Lcb)        =E= LAMBDACB*(log(wcb) + log(1-tax) - SIGMA*log(chpcb) +
log(ETA_CONS) - log(ETA_L));
```

```
eqL_gs..            log(Lg)         =E= LAMBDAG*(log(wg) + log(1-tax) - SIGMA*log(chpg) + log(ETA_CONS)
- log(ETA_L));
eqL_ns..            log(Ln)         =E= LAMBDAN*(log(wn) + log(1-tax) - SIGMA*log(chpn) + log(ETA_CONS)
- log(ETA_L));
* Currency holding
eqEM_curhf..        log(curhf)      =E= (SIGMA*RHO)*log(chpf) - RHO*(log(ETA_CONS)-log(ETA_CUR)+log((1-
tax)*idepq-tax*piq)-log(1+(1-tax)*idepq));
eqEM_curhb..        log(curhb)      =E= (SIGMA*RHO)*log(chpb) - RHO*(log(ETA_CONS)-log(ETA_CUR)+log((1-
tax)*idepq-tax*piq)-log(1+(1-tax)*idepq));
eqEM_curhg..        log(curhg)      =E= (SIGMA*RHO)*log(chpg) - RHO*(log(ETA_CONS)-log(ETA_CUR)+log((1-
tax)*idepq-tax*piq)-log(1+(1-tax)*idepq));
eqEM_curhcb..       log(curhcb)     =E= (SIGMA*RHO)*log(chpcb) - RHO*(log(ETA_CONS)-
log(ETA_CUR)+log((1-tax)*idepq-tax*piq)-log(1+(1-tax)*idepq));
eqEM_curhn..        log(curhn)      =E= (SIGMA*RHO)*log(chpn) - RHO*(log(ETA_CONS)-log(ETA_CUR)+log((1-
tax)*idepq-tax*piq)-log(1+(1-tax)*idepq));
eqEM_curh..         curh            =E= curhf+curhb+curhcb+curhg+curhn;
eqEM_curhr..        curh            =E= CHDR*dep;
* Consumptions
eqHOU_chpf..        chpf            =E= wf*Lf/(yh)*chp;
eqHOU_chpb..        chpb            =E= wb*Lb/(yh)*chp;
eqHOU_chpcb..       chpcb           =E= wcb*Lcb/(yh)*chp;
eqHOU_chpg..        chpg            =E= wg*Lg/(yh)*chp;
eqHOU_chpn..        chpn            =E= wn*Ln/(yh)*chp;
eqHOU_chpt..        chp             =E= chpf+chpb+chpcb+chpg+chpn;
* Imports
eqG_impfcg..        impfcg          =E= ivpfm;
eqG_imbfcg..        imbfcg          =E= ivbfm;
eqG_imgfcg..        imgfcg          =E= ivgfm;
eqG_imcbfcg..       imcbfcg         =E= ivcbfm;
eqG_impig..         impig           =E= cpprmm;
eqG_imbcg..         imbcg           =E= cbpm;
eqG_imcbcg..        imcbcg          =E= ccbpm;
eqG_imgcg..         imgcg           =E= cgpm;
eqG_imhcg..         imhcg           =E= chpm;
eqG_im..            im              =E= impfcg + imbfcg + imgfcg + imcbfcg + impig + imbcg + imcbcg +
imgcg + imhcg;
* Export, foreign demand
eqNFA_net..         x               =E= q*im + rfq*q*bfh + rgovq*q*bfg + rcbq*q*bfcb - rfq*q*bbf -
rfq*q*bcbf;
eqG_xpor..          log(x)          =E= log(aMf)+ETA*log(q)+log(yf);
* Prices, cost, inflations, exchange rates
eqF_pimq..          pimq            =E= 0;
eqF_pim..           pim             =E= 0;
eqF_pm..            pm              =E= q;
eqF_npm..           npm             =E= pm*p;
eqF_mcm..           mcm             =E= q;
eqF_nmcm..          nmcm            =E= mcm*p;
eqEM_er..           er              =E= q;
eqEM_q..            q               =E= 1;
eqG_piq..           piq             =E= RHCPD/(RHCPD+RHCPM)*pidq + RHCPM/(RHCPD+RHCPM)*pimq;
eqG_pi..            pi              =E= power((1+piq),4)-1;
eqG_p..             p               =E= p0;
***************************************************************************************
Foreign
**************************************************************************************
eqF_rfq..           rfq             =E= rdepq;
eqF_irfq..          irfq            =E= (1+rfq)*(1+pifq)-1;
eqF_pifq..          pifq            =E= sqrt(sqrt(1+pif))-1;
eqF_pf..            pf              =E= p0;
***************************************************************************************
BOP & National NFA
**************************************************************************************
eqBOP_fa..          fa              =E= bf*pifq*pf;
eqBOP_ca..          ca              =E= ta+sa;
eqBOP_ta..          ta              =E= p*x/er-pf*im;
eqBOP_sa..          sa              =E= + irfq*bbf*pf + irfq*bcbf*pf - irfq*bfh*pf - igovq*bfg*pf -
icbq*bfcb*pf;
eqBOP_ob..          bop             =E= ca + fa;
eqNFA_sum..         bf              =E= bbf + bcbf - bfh - bfcb - bfg;
eqNFA_nom..         nbf             =E= pf*bf;
eqNFA_ratio..       nfdtogdp        =E= -nbf*er/(p*4*y);
```

Chapter 5

Concluding remarks

This thesis has attempted to produce contribution to some macroeconomic issues related to monetary policy, monetary transmission and inflation, using dynamic and steady-state general equilibrium models. Issues covered in this framework of central bank core function are:

1. Optimal monetary policy response and policy interest rate pass-through to market interest rates
2. Relations between interest rate policy and monetary aggregate
3. Exchange rate pass-through, transient exchange rate depreciation and moderate currency crises
4. Relative strength of monetary transmission to inflation through demand, supply and cost channel
5. Cost-push vs. demand-pull inflation
6. Role of banking in monetary transmission to inflation through financial intermediary and the setting of deposit and lending rate
7. Nexus between monetary and banking policy

The interest cost of equity and borrowing is central to the framework of this study. It is instigated by the central bank’s policy rate and transmitted through banking intermediary function to the interest rate cost-push inflation. Assuming that deposit rate is the lower bound of goods-producers’ rate of return on equity, then we can say that the interest rate is a large contributor to price determination. It is in line with the estimated low positive intertemporal elasticity of consumption and the role of return on equity as the largest contributor for Indonesia’s gross domestic income. Moreover, it is consistent with the model estimate of low firm’s wage and negative real wage elasticity of labour supply, which both indicated a wide income gap.

This role of interest rate cost on inflation has significant implication on the magnitude of policy response. In the case of moderate currency crisis in the second essay, the finding shows that the proper monetary policy response is the smallest interest rate increases within the feasible set of monetary policy responses provided by the model. As the implication of strong interest rate cost channel of monetary transmission, the second essay also discusses the requirement of long-term policies complement such as improvement in economic structure. They are expected to strengthen monetary policy in its role as demand stabilisation instrument through lessening the power of interest rate cost channel.

The third essay focuses on how monetary policy should play its function as the short-run demand, supply and cost stabilisation instrument. However, policy focus in those two essays shares the same required policy supplement. It is a longer-term and less-immediate complementary policy solution to monetary policy: boosting competition in goods and financial market.

The third essay also underlined a key concept that the main positive determinant of deposit rate is the central bank's policy rate, not inflation. Inflation feeds to deposit rate indirectly through policy rate that is set consistent with the achievement of the inflation target. The direction and magnitude of the indirect effect of inflation to deposit rate depend on the net effect of monetary policy channels that drive the policy rate response.

In finding answers to the main issues related to monetary policy, monetary transmission and inflation, this study built a modelling framework that features Indonesia's distinctive agent's behaviour and the structure and market imperfection of Indonesia's economy. The features distinguish them with those of advanced economies. In terms of their comparison to those in an advanced economy, the features comprise (a) a less rigid domestic and import prices, (b) much lower intertemporal elasticity of consumption and (c) much smaller interest rate elasticity of real money balance, which is associated with higher household currency-to-deposit ratio. Other distinct economic features include the structure of agent's expenditure and income.

With respect to price rigidity, the assumption of a more flexible domestic price than that in advanced economies resulted in a coefficient of contemporaneous real marginal cost in the new Keynesian Phillip curve that is higher than that of expected inflation. It means that inflation depends more on the current pressure on the price-to-cost margin than on the expected future profit margin. It implies that the weight for the expectation of changes in the contemporaneous inflation determinant is larger than that for the expectation of future inflation determinant. That makes a distinction with the researches on advanced economies that assumed that prices are quite rigid, which is more rigid than what I assumed for Indonesia's economy. In this case, inflation depends more on the expected future profit margin than on the current pressure on the price-to-cost margin.

However, the assumption of less rigid price in Indonesia than in advanced economies might be inappropriate for downward price rigidity if the model accommodates asymmetric rigidity feature. We could have a hypothesis that prices are stickier downward in Indonesia than in advanced economies because firms in the former economy has a lower degree of competition than those in the later.

With regard to the behaviour of household, the third part of this study managed to introduce heterogeneous households, in which the household is separated into wage- and nonwage-earners. I classified the former into four groups according to the agents where they supply their labour services. I also found and discussed negative labour supply elasticity with respect to changes in real wage. The third model also produces four groups of individual real wages, with the real wage of firm's workers is much smaller than those of other workers and the individual real income of nonwage-earners. That implies a high degree of income inequality, which is a common macroeconomic feature in developing economies.

With respect to interest rate cost channel, I applied the essential assumption mentioned earlier that the deposit rate serves as the lower bound of the rate of return on equity for all profit-seeking agents. Therefore, the interest cost channel of monetary policy consist not only cost of real loan but also cost of real equity.

Meanwhile, the assumption in this study makes a distinction with several studies (see, for instance, Christiano and Eichenbaum 1992), in which the justification for interest rate cost channel is through interest cost of working capital loans because firms need financing for purchasing raw material and paying the employee's salary prior to the sale of the product. The inclusion of cost of equity in the interest cost channel for this study relies on two implied assumptions. First, that the firm's loan-to-equity ratio in Indonesia's nonfinancial business units is lower than that in developed economies. Second, that the firm's market power in the former economy is stronger than in the later, causing likelihood to have the rate of return on equity greater than deposit rate in most of the time. It is in line with the view of Chowdhury et al. (2006) that the logic of interest rate effects on firms' costs also applies when firms are primarily financed by internal funds.

With respect to linking financial intermediary to the real sector, central bank and government, this study has introduced the interpretation of real equity, real loan, real deposits, real government bonds and real CB certificates as a key idea for linking those sectors. The model features the demand for and supply of financial intermediation services, which, combined with other agent's output or income, form the total of GDP. This approach makes dissimilarity with common macroeconomic modelling methods, which assume that GDP is represented by the firm's output. Since GDP is aggregated into agents' output or income and there are five groups of household-labour suppliers, then we can have five groups of household-consumers. This feature enriches the monetary transmission mechanism to total consumption, GDP and inflation.

Furthermore, the third essay has a feature that all agents have own budget and balance-sheet constraints and objective function, where all balance-sheet and budget equation are linked and consolidated. These modelling characteristics bring consequence that the government does not need a common ad-hoc tax rule i.e the one that maintains a fixed ratio of primary fiscal deficit-to-GDP, because tax variable works as an automatic adjustment in ensuring the government budget balanced. With regard to tax, this study could be able to provide a better representation of Indonesia's economic environment as a developing economy if the model also incorporates tax on consumption and relaxes the implicit assumption of zero tax avoidance.

In addition to the aforementioned properties of balance sheet, budget constraint and objective function, the modelling of deposit and lending rates determination rules out the need to have an ad-hoc interest rate policy rule of targeting interbank rate to achieve consumer inflation target. It also allows the model to present the banking institution that has two market interest rates that can move in disharmony with policy rate. Yet the third model still lacks a behavioural equation that serves as a rule for the interest rate of monetary instrument. Moreover, it is also deficient in the behavioural equation of government bond interest rate. However, the overall modelling approach managed to minimise the involvement of non micro-founded behavioural equation in general equilibrium model.

References

Agénor, Pierre-Richard and Peter J. Montiel (2008). Development Macroeconomics, Third Edition. Princeton University Press.

Agung, J., Rita Morena, Bambang Pramono, Nugroho J. Prastowo (2001). "Bank Lending Channel of Monetary Transmission in Indonesia", Bank Indonesia Working Paper.

Agung, J., Rita Morena, Bambang Pramono, Nugroho J. Prastowo (2001). "Monetary Policy and Firm Investment: Evidence for Balance Sheet Channel in Indonesia", Bank Indonesia Working Paper.

Al-Eyd, Ali and Stephen G. Hall (2006). "Financial Crisis, Effective Policy Rules and Bounded Rationality in a New keynesian Framework". NIESR Discussion Paper No. 272.

Altissimo, Filippo, Michael Ehrmann, Frank Smets (2006). "Inflation Persistence and Price-setting Behaviour in The Euro Area: A Summary of The IPN Evidence". National Bank of Belgium Working Paper.

Ambler, Steve, Ali Dib, and Nooman Rebei (2003). "Nominal Rigidities and Exchange Rate Pass-Through in a Structural Model of a Small Open Economy". Bank of Canada Working Paper 2003-29.

Ascari, Guido (2003). "Staggered prices and trend inflation: some nuisances". Bank of Finland Discussion Papers 27.

Aoki, Kosuke (2001). "Optimal monetary policy responses to relative-price changes", *Journal of Monetary Economics* 48 (2001), pp. 55-80.

Atta-Mensah, Joseph and Ali Dib (2008). Bank lending, credit shocks, and the transmission of Canadian monetary policy, *International Review of Economics and Finance*, Volume 17, Issue 1, 2008, Pages 159-176.

Azis, Iwan J. (2008). "Indonesia's Slow Recovery After Meltdown", Asian Economic Papers 7:1, The Earth Institute at Columbia University and the Massachusetts Institute of Technology.

Bagliano, Fabio-Cesare & Giuseppe Bertola (2007). Models for Dynamic Macroeconomics. Oxford University Press.

Bailliu, Jeannine, Daniel Garces, Mark Kruger and Miguel Messmacher (2002). "Explaining and Forecasting Inflation in Emerging Markets: the Case of Mexico", Bank of Canada Working Paper 2003-17.

Bank Indonesia (2010). Indonesia's Economic Report, April.

Bank Indonesia (2009). Financial Report 2008, May.

Barth, M.J., Ramey, V. (2001). "The Cost Channel of Monetary Transmission". NBER Macroeconomic Annual, pp. 199–239.

Besar, Dwityapoetra S. and Alistair Milne (2009). "Competition in Indonesian Provincial Banking Markets: A Comparison of Structural and New Empirical Industrial Organization Models". Working Paper, Cass Business School, City University London.

Blanchard, Olivier J. & Nobuhiro Kiyotaki (1999). “Monopolistic Competition and the Effects of Aggregate Demand”. *American Economic Review*, Vol. 77, No. 4, 647-666.

Blanchard, Olivier J. & Stanley Fisher (1989). “Lectures on Macroeconomics”. The MIT Press.

Blinder, Alan S. (1991). “Why are prices Sticky? Preliminary Results from an Interview Study”*, American Economic Review* Vol. 81(2), pp. 89-100.

Blinder, Alan S. (2010). “How Central Should the Central Bank Be?”*,* CEPS Working Paper, No. 198.

Calvo, Guillermo (1983). “Staggered Proces in A Utility-Maximizing Framework”, *Journal of Monetary Economics* 12 (1983), pp. 383-398.

Calvo, Guillermo and Reinhart C.M. (2002). “Fear of Floating”, *Quarterly Journal of Economics,* Vol.117(2), pp. 379-408.

Camilo E. Tovar (2008). “DSGE models and central banks”. Bank for International Settlements Working Papers No 258.

Campa, J. and L. Goldberg (2001). “Exchange Rate Pass-Through into Import Prices: A Macro and Micro Phenomenon." Federal Reserve Bank of New York.

Castelnuovo, Efrem and Paolo Surico (2006). “The price puzzle: fact or artifact?” Bank of England Working Paper No. 288.

Cecchetti, Stephen (2001). “Making Monetary Policy: Objectives and Rules”. Misconceptions Regarding Rules vs. Discretion for Monetary Policy”. *Oxford Review of Economic Policy* Vol.16.

Cecchetti, Stephen G., Piti Disyatat and Marion Kohler (2009). “Integrating financial stability: new models for a new challenge”. An essay for the joint BIS-ECB Workshop on "Monetary policy and financial stability", Basel, Switzerland, 10-11 September 2009.

Chowdhury, A., Roger Ham (2009). “Inflation Targeting in Indonesia: Searching for a Threshold”. *The Singapore Economic Review* Vol.54, Issue 04, pp. 645-655.

Chowdhury, A., Hermanto Siregar (2004). “Indonesia’s Monetary Policy Dilemma – Constraints of Inflation Targeting”. *The Journal of Developing Areas*, Volume 37, Number 2, Spring 2004, pp.137-153.

Chowdhury, Ibrahim, Mathias Hoffmanna, and Andreas Schabert (2006). “Inflation dynamics and the cost channel of monetary transmission”. *European Economic Review* 50, pp. 995–1016.

Christiano, Lawrence J. and Martin Eichenbaum (1992). “Liquidity Effects and the Monetary Transmission Mechanism”. *American Economic Review*, Vol.82, 346-53.

Christiano, Lawrence J., Christopher Gust and Jorge Roldos (2004). “Monetary policy in a financial crisis” *Journal of Economic Theory,* Vol. 119, pp. 64-103.

Christiano, Lawrence J., Martin Eichenbaum, and Charles L. Evans (2005). “Nominal Rigidities and the Effects of a Shock to Monetary Policy,” *Journal of Political Economy*, Vol. 113(1), 1−45.

Clarida, R., J. Gali, M. Gertler (1999). "The Science of Monetary Policy: A New Keynesian Perspective". *Journal of Economic Literature*, Vol. 37, Issue 4, 1661-1707.

Copeland, Laurence (2005). "Exchange Rates and International Finance". Prentice Hall.

Cúrdia, Vasco and Michael Woodford (2008). "Credit Frictions and Optimal Monetary Policy". Department of Economics, Columbia University, Discussion Paper No. 0809-02.

D'Adda, C. and Antonello E. Scorcu (2003). "On the stability of the output-capital ratio". *Economic Modelling*, vol. 20(6), pages 1175-1189.

Darsono, Akhis R. Hutabarat, Diah Esti Handayani, Hery Indratno, Retno Muhardini (2002). "Survey of Bussiness Price Setting Behavior". Paper presented at The 26th CIRET Conference, Taipei, October 2002.

deBrouwer, Gordon and Neil R. Ericsson (1998). Modeling Inflation in Australia. *Journal of Business & Economic Statistics*, Vol. 16, No. 4, 433-449.

Devereux, Michael B., Philip R. Lane and Juanyi Xu (2006). "Exchange Rates and Monetary Policy in Emerging Market Economies". *The Economic Journal*, 116 (April), 478–506. Royal Economic Society 2006.

Devereux, Michael B. and Yetman, James (2005). "Price Adjustment and Exchange Rate Pass-through". Available at SSRN: http://ssrn.com/abstract=779846

Devereux, M. and J. Yetman. 2003. "Price Setting and Exchange Rate Pass-Through: Theory and Evidence." In Price Adjustment and Monetary Policy. Proceedings of a conference held by the Bank of Canada, November 2002.

Devereux, M. 2001. "Monetary Policy, Exchange Rate Flexibility and Exchange Rate Pass-Through." In Revisiting the Case for Flexible Exchange Rates, 47-82. Proceedings of a conference held by the Bank of Canada, November 2000. Ottawa: Bank of Canada.

DiCecio, Riccardo and Edward Nelson (2007). "An Estimated DSGE Model for the United Kingdom". Federal Reserve Bank of St.Louis, Working Paper 2007-006A

Dossche, Maarten (2009). "Understanding inflation dynamics: Where do we stand?" National Bank of Belgium Working Paper Research No.165.

Driskill, Robert A. and Steven M. Sheffrin (1985). "The "Patman Effect" and Stabilization Policy". *The Quarterly Journal of Economics*, Vol. 100, No. 1 (Feb., 1985), pp. 149-163. The MIT Press.

Drud, Arne (2006). "CONOPT", GAMS – The Solver Manuals, ARKI Consulting and Development A/S, Bagsvaerd, Denmark.

Edward, Sebastian (1986). "Are Devaluations Contractionary?", *The Review of Economics and Statistics, Vol.* 68, No.3 (Aug., 1986), pp. 501-508.

Ehrenberg, Ronald G. & Robert S. Smith (2009). Modern Labor Economics – Theory and Public Policy, Tenth Edition. Pearson Education, Inc.

Eichenbaum, M. (1992). "Comment on 'Interpreting the macroeconomic time series facts: the effects of monetary policy' by C.A. Sims". *European Economic Review*, 36, pp. 1001–1011.

Erceg, Christopher J., Andrew T. Levin (1983). "Imperfect credibility and inflation persistence", *Journal of Monetary Economics* 50 (2003), pp. 915-955.

Freixas, Xavier and Jean-Charles Rochet (2008). Microeconomics of Banking. The MIT Press.

Fuhrer, Jeffrey C. (2006). "Intrinsic and Inherited Inflation Persistence". *International Journal of Central Banking.*

Gali, Jordi, Mark Gertler (1999). "Inflation dynamics: A Structural econometric analysis". *Journal of Monetary Economics*, Vol. 44, 195-222.

Gali, Jordi, Tommaso Monacelli (1999). "Monetary Policy and Exchange Rate Volatility In Small Open Economy". NBER Working Paper 8905.

Garratt, Anthony, Kevin Lee, M. Hashem Pesaran, Yongcheol Shin (2006). "Global and National Macroeconometric Modelling – A Long-Run Structural Approach, Draft Chapter 1-3.

Gerali, Andrea, Stefano Neri, Luca Sessa, and Federico M. Signoretti (2010). "Credit and Banking in a DSGE Model of the euro area". Banca d'Italia Working Paper

Gibson, Alfred Herbert (1923). "The future course of high class investment values". Banker's Magazine, January, pp. 15–34.

Goodfriend, Marvin & Bennett T. McCallum (2007). "Banking and Interest Rates in Monetary Policy Analysis: A Quantitative Exploration," NBER Working Papers 13207, National Bureau of Economic Research, Inc.

Hamann, Franz (2004). "On the Use of Models for Monetary Policy in Colombia: a Technocrat's Perspective". Webpondo.org edition No.13, July-Sep 2004.

Hall, Simon, Mark Walsh, Anthony Yates (1997). "How do UK companies set prices?". Bank of England Working Paper 8905.

Harrison, Richard, Kalin Nikolov, Meghan Quinn, Gareth Ramsay, Alasdair Scott and Ryland Thomas (2005). "The Bank of England Quarterly Model". Bank of England.

Henzel, Steffen, Oliver Hülsewig, Eric Mayer, Timo Wollmershäuser (2008). "The price puzzle revisited: Can the cost channel explain a rise in inflation after a monetary policy shock?"

Hossain, A (2006). "Sources of Economic Growth in Indonesia, 1966-2003" *Journal of Applied Econometrics and International Development*, Vol.6 Issue 2.

Husman, Jardine A. (2005). "Pengaruh Nilai Tukar Riil Terhadap Neraca Perdagangan Bilateral Indonesia: Kondisi Marshall-Lerner dan Fenomena J-Curve (The Effect of Real Exchange Rate on Indonesia's Bilateral Trade Balance: Marshall-Lerner Condition and J-Curve Phenomenon)". Buletin Ekonomi Moneter dan Perbankan Bank Indonesia (Volume 8 No.3).

Ioannidou, Vasso P. (2005). "Does monetary policy affect the central bank's role in banking supervision?", *Journal of Financial Intermediation* 14 (2005) 58–85.

Kamihigashi, Takashi (2008). "Transversality conditions and dynamic economic behaviour." The New Palgrave Dictionary of Economics. Second Edition. Eds. Stephen N. Durlauf and Lawrence E. Blume. Palgrave Macmillan, 2008. The

New Palgrave Dictionary of Economics Online. Palgrave Macmillan. 21 June 2010 <http://www.dictionaryofeconomics.com/article?id=pde2008_T000217>

Kendrick, David A., P. Ruben Mercado, and Hans M. Amman (2005). "*Computational Economics*". Princeton University Press.

Knoop, Todd A. (2008). Modern Financial Macroeconomics - Panics, Crashes, and Crises. Blackwell Publishing.

Kremer, Jana, Giovanni Lombardo, Leopold von Thadden, and Tomas Werner (2006). "Dynamic Stochastic General Equilibrium Models as a Tool for Policy Analysis", CESifo Economic Studies, Vol. 52, 4/2006, 640-665.

Kusmiarso, B., Elisabeth Sukawati, Sudiro Pambudi, Dadal Angkoro, Andry Prasmuko, Iss Savitri Hafids (2002). "Interest Rate Channel of Monetary Transmission in Indonesia", Bank Indonesia Working Paper.

Lane, Phillip R. (2001). "The new open economy macroeconomics: a survey", *Journal of International Economics*, Vol. 54 (2001) 235-266.

Leao, Emanuel R. and Pedro R. Leao (2006). "Technological Innovations and the Interest Rate", *Journal of Economics* Vol. 89 (2006), No.2, pp. 129-163.

Lima, Gilberto T. & Mark Setterfield (2010). "Pricing Behaviour and the Cost-Push Channel of Monetary Policy", *Review of Political Economy*, Vol 22, No. 1, 19-40.

Linnemann, Ludger (2005). "Can raising interest rates increase inflation?", *Economics Letters* 87 (2005) 307–311.

Mahajan, Sanjiv (2006). "United Kingdom Input-Output Analyses". Office for National Statistics.

Maih, Junior (2006). "Wage-Price Dynamics in a DSGE Model with Imperfect Exchange Rate Pass-Throurh". Norges Bank.

Majardi, F. (2004). "Small-Scale Macro Model - Extended". Bank Indonesia Working Paper.

Matthews, D. & John Thomposon (2005). The Economics of Banking. John Wiley & Sons Ltd.

McCallum, Bennett T. "Misconceptions Regarding Rules vs. Discretion for Monetary Policy". Shadow Open Market Committee, November 4, 2003.

Metz, Robert, Rebecca Riley and Martin Weale (2004). "Economic Performance in France, Germany and the United Kingdom: 1997–2002". National Institute Economic Review 2004; 188; 83.

Ministry of Finance Republic of Indonesia (2010). State Debt Report, Directorate General of Debt Management, February.

Murchison, Stephen, Andrew Rennison, and Zhenhua Zhu (2004). "A Structural Small Open-Economy Model for Canada". Bank of Canada Working Paper 2004-4.

Neiss, Katharine S. & Edward Nelson (2005). "Inflation Dynamics, Marginal Cost, and the Output Gap: Evidence from Three Countries", *Journal of Money, Credit, and Banking,* Vol. 37, Number 6, December 2005, pp. 1019-1045

Raillavo, Jukka (2005). "Effects of the supply-side channel on stabilisation policies", in "Essays on macro-economic effects of fiscal policy rules", Bank of Finland Studies E:33-2005

Ravenna, Federico, Carl E. Walsh (2006). "Optimal monetary policy with the cost channel". *Journal of Monetary Economics* Vol. 53, pp. 199-216.

Romer, D. (2006). Advanced Macroeconomics, 3rd edn. New York: McGraw-Hill.

Rosenthal, Richard E. (2006). "GAMS — A User's Guide". GAMS Development Corporation, Washington, DC, USA

Ross, Stephen A., Randolph W. Westerfield, Jeffrey Jaffe and Bradford D. Jordan (2008). Modern Financial Management, Eighth Edition. McGraw-Hill International Edition.

Rumler, Fabio (2005). "Estimates of The Open Economy New Keynesian Phillips Curve For Euro Area Countries". ECB Working Paper No.496.

Seelig, Steven A. (1974). "Rising Interest Rates and Cosh Push Inflation", *The Journal of Finance,* Vol.29, No.4 (Sep., 1974), pp.1049-1061.

Sidrausky, Miguel (1967). "Rational Choice and Patterns of Growth in a Monetary Economy". *American Economic Review* Vol. 57 No. 2, pp. 534-544.

Sims, Christopher A. (1992). "Interpreting the macroeconomic time series facts: the effects of monetary policy". *European Economic Review*, 36, pp. 975–1000.

Smith, Matthew (2002). "Tooke's approach to explaining prices". *The European Journal of the History of Economic Thought*, 9:2, 333-358.

Smith, Matthew (2006). "On Interest and Profit: Thomas Tooke's Major Legacy to Economics", *Contribution to Political Economy* Vol. 25, pp 1-34.

Smets, Frank, and Raf Wouters (2002). "An estimated stochastic dynamic general equilibrium model of the Euro area", ECB Working Paper No.171.

Sodertstom, Ulf (2003). "An introduction to log-linearization". Lecture Notes, Universita Bocconi.

Sodertstom, Ulf (2003). "The Basic Sticky-Price Framework". Lecture Notes. Sveriges Riskbank.

Sorensen, Peter Birch, Hans Jorgen Whitta-Jacobsen (2005). "Introducing Advanced Macroeconomics – Growth and Business Cycles". The McGraw-Hill Companies.

Tamborini, Roberto (2008). "The 'Credit–Cost Channel' of Monetary Policy. A Theoretical Assessment". University of Trento Discussion Paper Nr. 2008-33|

Tanuwidjaja, E. and Keen Meng Choy (2006). "Central bank credibility and monetary policy in Indonesia". *Journal of Policy Modeling* Vol.28, Issue 9, December 2006, Pages 1011-1022.

Taylor, John B. (1980). "Aggregate Dynamics and Staggered Contracts". *The Journal of Political Economy* Vol. 88 No. 1, pp. 1-23.

Taylor, Lance (2004). Reconstructing Macroeconomics - Structuralist Proposals and Critiques of the Mainstream. Harvard University Press.

Tooke, T. (1838). A History of Prices, and the State of Circulation, from 1793 to 1837. London: Longman.

Uhlig, Harald (1999). "A Toolkit for Analyzing Nonlinear Dynamic Stochastic Models Easily".

van der Eng, Pierre (2005). "Capital Formation and Economic Growth in Indonesia, 1951-2004". N.W. Posthumus Institute of Economic and Social History, Groningen and Hitotsubashi University 21st Century Program, Hitotsubashi University.

van Wijnbergen, S. (1981). "Stagflationary Effect of Monetary Stabilization Policies – A Quantitative Analysis of South Korea". *Journal of Development Economics*, Vol.10 (1982), pp.133-169.

Warjiyo, Perry and Juda Agung (2002). "Transmission Mechanisms of Monetary Policy in Indonesia", Bank Indonesia: Directorate of Economic Research and Monetary Policy.

Whelan, Karl (2010). "The Calvo Model of Price Rigidity". Technical Derivations for the NKPC, http://www.karlwhelan.com/Teaching/MA10/nkpc-details.pdf

Wickens, Michael (2008). Macroeconomic Theory. A Dynamic General Equilibrium Approach. Princeton University Press.

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

Wren-Lewis, Simon (2006). "Are There Dangers in the Microfoundations Consensus?" University of Exeter, June 2006.

Yanuarti, Tri (2007). "Has Inflation Persistence in Indonesia Changed?". Bank Indonesia Working Paper.

Young, Alwyn (1995). "The Tyranny of Numbers: Confronting the Statistical Realities of the East Asian Growth Experience". *The Quarterly Journal of Economics*, Vol. 110, No. 3, pp. 641-680.

Zulverdi, Doddy, Iman Gunadi, Bambang Pramono, and Wahyu Ari Wibowo (2004). "A Model of Bank Portfolio Management for Indonesia." Bank Indonesia Occasional Paper.