

The Evolving Role and Limits of Monetary Policy: New Perspectives for Emerging Market Economies 2014 BSP International Research Conference

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In this research a DSGE model is developed for the small open economy of Indonesia, complemented with the inclusion of financial frictions in the form of collateral constraints amongst households and a financial accelerator amongst entrepreneurs. The model demonstrates that shocks in the banking sector, for instance raising the CAR requirement, impacts the real sector through the credit channel, which undermines GDP and lowers the rate of inflation. The financial accelerator mechanism in the model evidences procyclicality in the financial system to economic conditions.

The simulations also show that a policy mix of monetary and macroprudential policy not only achieves sustainable GDP and stable inflation but also helps to control consumption, thereby reducing demand for imported goods. Coupled with stable exports, a slowdown in imports will have a favourable effect on the current account.

JEL Codes: E32, E44, E52, E58 Keywords: Monetary policy, DSGE with banking sector, macroprudential policy

# 1 INTRODUCTION

The array of economic and financial crises that have plagued economies around the world over the past few decades has shown that macroeconomic instability stems primarily from shocks in the financial/banking sector, which is highly procyclical. Agung (2010) stated that the level of procyclicality in the financial sector of Indonesia is categorised as high. This is evidenced by the pace of real credit growth that exceeds GDP during a period of expansion and a decline that far surpasses that of GDP during a contractionary phase. The high level of procyclicality in the banking sector of Indonesia demands synergy between monetary policy and macroprudential policy in order to mitigate excessive economic fluctuations (the business cycle) and the financial cycle.

Monetary policy has the potential to support financial system stability through its ability to influence financial conditions and behaviour on financial markets through its transmission to the balance sheets of companies and banks as well as their appetite for risk. Similarly, conditions in the financial system also have the potential to affect monetary stability. Bernanke and Gertler (2001) stated that aggressive monetary policy

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does not provide any significant benefits in terms of controlling asset prices because financial variables have inherently large volatility, which requires a set of policy instruments to achieve price stability and financial market stability. An economic model is used to assist Bank Indonesia in terms of formulating policy to stabilise prices and financial markets, which is able to simulate the effects of monetary policy and macroprudential policy on the financial/banking sector and economy as a whole that provides the best coordination and combination of monetary policy and macroprudential policy.

The goal of this research is to develop a DSGE model, complemented by the inclusion of the banking sector, to accurately simulate monetary and macroprudential policy. Furthermore, the benefits of the research are as follows:

- As a tool to assist monetary and macroprudential policymaking at Bank Indonesia.
- As a step towards competence building in the development of a DSGE model to simulate diverse monetary and macroprudential policy in the development of a core model in the Forecasting and Policy Analysis System (FPAS) of Bank Indonesia looking ahead (pursuant to best practices from advanced countries that have adopted a core model based on DSGE)

One component rarely found in models used by a central bank, primarily for the period before the global financial crisis in 2007-2008, is a financial sector with the inclusion of financial frictions. This is particularly unfortunate because the macroprudential policy transmission mechanism depends heavily on the characteristics of the financial sector. As cited by Roger and Vicek (2011), the inclusion of the credit channel and the presence of financial intermediation in the macroeconomic model used by a central bank help explain the dynamics of the business cycle that is influenced by financial sector procyclicality. In addition, they also emphasized the importance of modelling household balance sheets as well as the effect of durable assets, like housing, on the transmission of macroeconomic policy. Recently, after the global financial crisis, financial frictions feature is used by most DSGE models as well as macroprudential policy transmission.

# 2 MODELLING FINANCIAL FRICTIONS IN THE DSGE MODEL

Based on existing literature, there are two main approaches to include financial frictions in the DSGE model: the financial accelerator approach and the collateral constraints approach. Each approach has its own set of strengths and weaknesses that continue to evoke debate among economists, in academia and central bankers alike. Introducing the banking sector into the DSGE model provides an additional method to model financial frictions, particularly those related to the cost of intermediation.

The basic assumption of the financial accelerator approach is the presence of asymmetric information between lenders and borrowers that results in an external finance premium, which illustrates the difference between the cost of borrowing and the cost of using internal funds. The external finance premium is determined by the net worth of the borrower and determines the size of the loan that can be approved. Net worth is defined as the value of assets owned by the borrower subtracted by the amount of outstanding debt. When an economy is experiencing an expansionary phase, the net worth of borrowers also increases due to greater credit worthiness and a lower external finance premium. In contrast, when an economy contracts, lower net worth decreases credit worthiness and exacerbates the cost of borrowing. The countercyclical dynamics of the external finance premium is a mechanism that amplifies the response of GDP and investment to a shock. For example, the initial response of GDP to a

technological shock will be amplified by rising asset prices that emerge due to that shock. Soaring assets prices will raise the net worth of borrowers and lower the external finance premium, which will ultimately boost investment. The financial accelerator approach helps explain the magnitude of change in investment and a hump-shaped output response to moderate changes in interest rates. In this model, the financial accelerator is modelled on entrepreneurs who loan the product of their capital investment to intermediate goods producers in order to produce intermediate goods.

Similar to the financial accelerator approach, the basic mechanism of the collateral constraint approach is a shift in asset prices that interact with imperfections in the credit market and amplify the response to a shock. Notwithstanding, departing from the financial accelerator approach, the net worth of borrowers will directly influence the size of loan approved but not through its effect on the external finance premium. Lenders require collateral when extending a loan in order to provide incentives to borrowers to repay their outstanding loans. Durable assets like land, housing and capital goods are typically used as collateral. In this case, collateral constraints are applied to impatient households that borrow from a bank with collateral in the form of housing to offset their consumption, housing investment, tax payments as well as repaying debt from the previous period. When an economy is experiencing an episode of expansion, housing prices of impatient households tend to increase, thereby increasing the size of loans received, boosting household consumption and catalysing economic growth. In contrast, when an economy contracts, asset prices of impatient households decline, thereby reducing the amount of bank loans and tempering household consumption, thereby triggering a deeper contraction in the economy. Such conditions explain the phenomenon of procyclical financial frictions on the economy of Indonesia.

Financial system procyclicality is the propensity of the financial system to stimulate faster economic growth during an expansionary episode and suppress the economy during a contractionary phase. Procyclical behaviour causes the financial system to exacerbate macroeconomic instability through the creation of fluctuations in output. Borio et al. (2001) stated that although financial friction is the primary mechanism stemming from procyclicality, the response elicited from market participants is not proportional in terms of evaluating risk, which in turn amplifies procyclicality. Consequently, in general, procyclicality is compounded by interaction between the business cycle, financial cycle and the behaviour of economic agents to risk. Interaction between the three cycles, which move in the same direction and mutually reinforce one another, is what creates financial sector procyclicality. In the majority of emerging market countries, like Indonesia, managing financial system procyclicality fundamentally involves managing banking sector procyclicality because the domestic economy depends heavily on the banking sector as the main source of investment financing. Therefore, controlling banking sector procyclicality has important implications in terms of creating and maintaining macroeconomic stability.

Macroprudential policy instruments aim to prevent or alleviate the effects of financial system procyclicality. Instruments like the loan-to-value ratio, countercyclical capital requirement and time-varying reserve requirement function through the balance sheet of the banking sector or the borrower. Consequently, this means that explicitly modelling financial friction and the balance sheet of the banking sector is imperative in order to simulate the transmission mechanism of macroprudential policy instruments.

Gerali *et al.* (2010) developed a DSGE model that included the banking sector, which was subsequently used as the basis of model development to simulate macroprudential policy at a number of central banks. The resultant model was a DSGE model for a closed economy with credit market friction in the form of borrowing

constraints and a banking sector that operated under monopolistic competitive conditions. The model is populated with agents that function as lenders (patient households) and borrowers (impatient households and entrepreneurs). Both borrower agents face borrowing constraints in the form of collateral constraints à la lacoviello (2005), linked to the assets held (housing in the case of impatient households and capital goods for entrepreneurs). The bank balance sheet is modelled on term deposits and capital on the liabilities side and loans receivable on the assets side. Banks accumulate capital through retained earnings and are required to meet the Capital Adequacy Ratio (CAR) determined by the central bank. It is assumed that banks have market power in terms of accruing and allocating funds, and banks set differing interest rates for loans extended to impatient households and entrepreneurs. Stickiness is also assumed to occur between bank retail interest rates and the dynamics of the policy rate.



Figure 1. Model Scheme of Gerali et al. (2010)

The model of Gerali *et al.* (2010) was estimated using the Bayesian approach with data from the euro area. That model is applied to understand the distinction between financial friction and financial intermediation in determining the dynamics of the business cycle, in particular relating to how monetary policy transmission to the real sector is influenced by financial friction and financial intermediation. Furthermore, Angelini *et al.* (2010) also applied that model to investigate the additional procyclicality caused by the implementation of Basel II compared to Basel I. In 2011, Angelini *et al.* reapplied the Gerali model to study interaction between monetary policy and macroprudential policy.

# **3** CHARACTERISTICS OF THE INDONESIAN ECONOMY AND BANKING SECTOR

The economy of Indonesia has demonstrated constant growth over the past decade, with average GDP for the period 2001-2012 achieving 5.42 percent. The economy has continued to expand, peaking in 2011 when growth of 6.49 percent (yoy) was realised. This is an impressive achievement when compared to neighbouring countries that were blighted by the global crisis in 2007-2008.

On the demand side, the economy of Indonesia is buoyed by private consumption with a 55.42 percent share of total GDP, followed by investment accounting for 27.44 percent (Table 1). Tenacious domestic consumption and a growing share of exports due to strong demand from leading trade partners like China and India, especially for commodities and mined products, provide an important contribution to economic growth. The expanding share of investment from year to year spurs economic

development and advancement by creating employment opportunities and income, thereby maintaining the level of public consumption.

On the production side, the economy of Indonesia is underpinned by the manufacturing industry that accounts for the largest share of GDP, followed by the trade, hotels and restaurants sector. Greater domestic consumption and stronger export demand from export partners has catalysed growth in a variety of economic sectors.

Rising incomes coupled with low inflation and interest rates have also stimulated growth in production sectors, like construction and transportation. Other sectors experiencing rapid growth include the financial sector, leasing and services as well as the services sector. Growth in those sectors helped raise total GDP to 6.23 percent in 2012.

An assumption made when modelling the banking sector in the DSGE model by a number of central banks is that banks have market power in terms of accumulating and disbursing funds, thus banks also have the power to determine lending rates and deposit rates. Moreover, a body of empirical research in Indonesia has corroborated the same conclusion. One such piece of research was conducted by Purwanto (2009), who concluded that the dynamics of bank interest rate spread (defined as the difference between the interest rate charged on loans minus the interest paid on deposits) is predominantly influenced by the level of concentration in the banking industry in Indonesia. In that research, the Herfindahl-Hirschman Index is used to measure the level of concentration in the banking industry. Based on the empirical model using monthly (panel) data for individual banks from January 2002 to April 2009, it was concluded that during the aforementioned period a narrower spread was the result of increased competition in the banking sector due to increased market share of the majority of banks accompanied by a diminishing market share of the largest banks. Those results are congruous with other research using the Structure-Conduct-Performance approach that links market concentration and market power to the setting of interest rates (Berger et al. (2004)).

Additionally, in the DSGE models developed by a number of central banks, stickiness is also assumed to occur between the bank retail interest rate and the policy rate. From a theoretical perspective, banks prefer not to frequently adjust interest rates when consumer demand is inelastic in the near run due to the high switching costs involved (Calem *et al.* (2006)) or because of the fixed cost (menu cost) associated with adjusting interest rates (Berger and Hannan, 1991). Another theoretical argument proposed by economists is the importance banks placed on maintaining loyal relationships with their customers through interest rate smoothing to protect the consumer from fluctuations in the market (policy) rate. This enables banks to set high interest rates even when the policy rate is low (Berger and Udell (1992)).

In simple terms, a rigid near-term bank retail rate response to the dynamics of the policy rate has been discussed in previous research conducted by Harmanta *et al.* (2012). An impulse response analysis of the bivariate VAR system<sup>6</sup> showed that the short-term response of the bank retail rate to changes in the BI (policy) rate is limited, especially for rates on consumer loans. The response of the deposit rates and lending rates offered to the corporate sector are more or less the same. Although the magnitude is not as small as the response of the rate on consumer loans, the level of stickiness is similarly high.

<sup>&</sup>lt;sup>6</sup> Each respective VAR system is established based on exogenous variables, namely the size of the reserve ratio for VAR of the deposit rate; and the magnitude of capital, risk-weighted assets (risk-based balanced sheet by total credit), and the size of loans disbursed for VAR of the lending rate.

Item	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
GDP According to Sector												
- Agriculture	3.26	3.45	3.79	2.82	2.72	3.36	3.47	4.83	3.96	3.01	3.37	3.97
- Mining and Quarrying	0.33	1.00	-1.37	-4.48	3.20	1.70	1.93	0.71	4.47	3.86	1.39	1.49
- Industry	3.30	5.29	5.33	6.38	4.60	4.59	4.67	3.66	2.21	4.74	6.14	5.73
- Energy	7.92	8.94	4.87	5.30	6.30	5.76	10.33	10.93	14.29	5.33	4.82	6.40
- Construction	4.58	5.48	6.10	7.49	7.54	8.34	8.53	7.55	7.07	6.95	6.65	7.50
- Trade, Hotel and Restaurant	3.95	4.27	5.45	5.70	8.30	6.42	8.93	6.87	1.28	8.69	9.17	8.11
- Transportation and Communication	8.10	8.39	12.19	13.38	12.76	14.23	14.04	16.57	15.85	13.41	10.70	9.98
- Finance, Rental and Merit	6.76	6.70	6.73	7.66	6.70	5.47	7.99	8.24	5.21	5.67	6.84	7.15
- Services	3.24	3.75	4.41	5.38	5.16	6.16	6.44	6.24	6.42	6.04	6.75	5.24
GDP According to Demand												
- Private Consumption	3.49	3.84	3.89	4.97	3.95	3.17	5.01	5.34	4.86	4.74	4.71	5.28
- Investation	8.56	-4.46	10.84	6.90	12.38	1.34	1.93	12.44	2.43	8.80	10.53	16.90
- Government Expenditure	7.56	12.99	10.03	3.99	6.64	9.61	3.89	10.43	15.67	0.32	3.20	1.25
- Export	0.64	-1.22	5.89	13.53	16.60	9.41	8.54	9.53	-9.69	15.27	13.65	2.01
- Import	4.18	-4.25	1.56	26.65	17.77	8.58	9.06	10.00	-14.98	17.34	13.34	6.65
GDP Total	3.64	4.50	4.78	5.03	5.69	5.50	6.35	6.01	4.63	6.22	6.49	6.23

Table 1. Growth of GDP Component of Indonesia (percent)

Source: Indonesia Statistics Bureau

# Table 2. Share of GDP Component of Indonesia (percent)

ltem	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
GDP According to Sector													
- Agriculture	15.60	15.54	15.39	15.24	14.92	14.50	14.21	13.82	13.67	13.58	13.17	12.78	12.51
- Mining and Quarrying	12.07	11.68	11.29	10.63	9.66	9.44	9.10	8.72	8.28	8.27	8.09	7.70	7.36
- Industry	27.75	27.65	27.86	28.01	28.37	28.08	27.83	27.39	26.78	26.17	25.80	25.71	25.59
- Energy	0.60	0.63	0.66	0.66	0.66	0.66	0.66	0.69	0.72	0.79	0.78	0.77	0.77
- Construction	5.51	5.56	5.61	5.68	5.82	5.92	6.08	6.20	6.29	6.44	6.48	6.49	6.57
- Trade, Hotel and Restaurant	16.15	16.20	16.16	16.26	16.37	16.77	16.92	17.33	17.47	16.91	17.30	17.74	18.05
- Transportation and Communication	4.68	4.88	5.06	5.42	5.85	6.24	6.76	7.25	7.97	8.82	9.42	9.79	10.14
- Finance, Rental and Merit	8.31	8.56	8.74	8.90	9.12	9.21	9.21	9.35	9.55	9.60	9.55	9.58	9.66
- Services	9.34	9.30	9.23	9.20	9.23	9.18	9.24	9.25	9.27	9.43	9.41	9.43	9.35
GDP According to Demand													
- Private Consumption	61.07	61.06	61.56	59.64	60.94	59.33	58.82	59.20	57.95	57.39	56.87	55.63	55.42
- Investation	22.04	23.11	21.44	22.16	23.06	24.27	23.64	23.09	24.13	23.34	24.03	24.81	27.44
- Government Expenditure	6.47	6.72	7.38	7.57	7.66	7.65	8.06	8.03	8.24	9.00	8.54	8.23	7.89
- Export	40.59	39.47	37.86	37.37	41.31	45.11	47.42	49.34	50.22	42.83	46.71	49.59	47.87
- Import	30.17	30.37	28.23	26.74	32.96	36.36	37.94	39.66	40.54	32.55	36.14	38.27	38.62

Source: Indonesia Statistics Bureau

# 4 THE BANKING SECTOR DSGE MODEL

The model developed in this research is based on the banking sector DSGE model refined by Harmanta et al. (2012), which itself was expanded based on the model of Gerali et al. (2010) that includes a banking sector under a New Keynesian DSGE Model framework à la Christiano et al. (2005). In this context, a financial accelerator is added to the 2012 DSGE model à la Bernanke et al. (1999), which was subsequently modified by Zhang (2010). The main modification to this model compared to the previous research of Harmanta et al. (2012), is the inclusion of financial frictions, namely collateral constraints on households and a financial accelerator on entrepreneurs. Additionally, the model also simulates default by entrepreneurs that prevents them repaying the loan to the bank. Banks also bear risk due to the presence of asymmetric information concerning the repayment capacity of the entrepreneur, which in this model will affect the level of bank profit generated and, ultimately, bank capital. Bank capital in this model also functions as a buffer stock against the unexpected realization risk of aggregate returns on capital from the entrepreneur, which subsequently influences the capital adequacy ratio and forces the bank to manage its asset portfolio. The model assumes a small open economy and includes the government to enrich the simulations of macroprudential policy. The standard features of the DSGE model, for instance habit persistence in terms of consumption, the adjustment cost related to adjusting investment, the modelling of sticky prices and sticky wages are also included in the model developed in this research. The complete model schematic is presented in Figure 2.

In the model there are two groups of households, namely patient and impatient households. The difference between the two agents lies in the discount factor, where the value of the discount factor of patient households is higher than that of impatient households. Due to the higher discount factor, patient households consider future consumption important, thereby avoiding spending their income in the current period and tending to save at a bank in the form of term deposits. These agents also consist of bank owners and retailers, thereby receiving revenue from the profits of banks, domestic retailers, importer retailers and exporter retailers. Conversely, impatient households tend to consume in the current period and consequently have to borrow from banks. In addition to spending in the form of consumption, both types of households also invest in housing and pay taxes to the government.

Another agent, entrepreneur, leases capital to intermediate goods producers after purchasing from capital goods producers. Intermediate goods producers produce homogeneous intermediate goods using capital goods (capital) leased from entrepreneurs and employ workers from patient households and impatient households. Homogeneous intermediate goods produced by intermediate goods producers are subsequently sold to domestic retailers for the domestic market and exporting retailers for the international market, which are transformed into differentiated goods. Final goods producers act as aggregators, amalgamating intermediate differentiated goods from the domestic market purchased from domestic retailers with international intermediate differentiated goods purchased from importing retailers.

In the model, there are capital goods producers and housing producers who utilise goods produced by final goods producers in order to produce capital goods (capital) and housing, consecutively, applying technology and incurring an investment adjustment cost. The adjustment cost enables the prices of capital goods and housing to differ from the prices of consumer goods.



Figure 2. Model Scheme

There are two types of financial instrument offered by banks to economic agents in the model: savings accounts (term deposits) and loans/credit. Households face borrowing constraints when borrowing funds from a bank. Borrowing constraints correlate to the value of collateral held, namely the stock of housing. Meanwhile, extending credit to entrepreneurs is determined by the bank's expectations concerning the return on capital of the entrepreneur that affects the expected net worth of the entrepreneur.

The banking sector operates under monopolistic competitive conditions, where a bank sets its deposit rates and lending rates to maximise profit. Total loans extended by a bank are offset by the term deposits accumulated and the bank's capital. Capital in this research is a risk-free asset and part of the bank's assets, as modified from Gerali *et al.* (2010).

# 4.1 Households and Entrepreneurs

Patient households maximise their utility function based on their desired level of consumption  $c_t^P$ , their rest time (outside working time  $n_t^P$ ) and housing assets  $\chi_t^P$  with a discount factor  $\beta_p$ .

$$\max_{\substack{c_{t}^{P}(i), \chi_{t}^{P}(i), n_{t}^{P}(i) \\ = 0}} \sum_{t=0}^{\infty} (\beta_{P})^{t} \varepsilon_{u,t} \left[ \frac{\left( c_{t}^{P}(i) - \xi c_{t-1}^{P} \right)^{1-\sigma_{c}}}{1 - \sigma_{c}} + \varepsilon_{\chi,t} \frac{\chi_{t}^{P}(i)^{1-\sigma_{\chi}}}{1 - \sigma_{\chi}} - \varepsilon_{n,t} \frac{n_{t}^{P}(i)^{1+\sigma_{n}}}{1 + \sigma_{n}} \right].$$
(1)

The parameter,  $\xi$ , is the level of external habit formation and  $\varepsilon_{u,t}$ ,  $\varepsilon_{\chi,t}$ ,  $\varepsilon_{n,t}$  is the intertemporal shock, housing preference and labour preference with dynamics, AR(1), and an error term, i.i.d.

Patient households receive income from the provision of labour to entrepreneurs  $W_t n_t^P$ , income from term deposits  $(1 + r_{t-1}^D)d_{t-1}$  and dividends from their company  $\Pi_t^P$ . Income is subsequently used to pay taxes  $T_t^P$ , fund consumption, purchase housing assets and save the remainder in the form of term deposits  $d_t$ . Therefore, the budget constraints faced by patient households are as follows:

$$P_{t}c_{t}^{P}(i) + P_{\chi,t}\left(\chi_{t}^{P}(i) - (1 - \delta_{\chi})\chi_{t-1}^{P}(i)\right) + d_{t}(i) \\ = W_{t}n_{t}^{P}(i) + (1 + r_{t-1}^{D})d_{t-1}(i) - T_{t}^{P}(i) + \Pi_{t}^{P}(i).$$
(2)

In terms of budget constraints, the variables, consumer spending and housing assets, are respectively multiplied by the price to obtain their nominal value. Parameter  $\delta_{\gamma}$  is the level of depreciation of housing assets owned by the households.

From the objective function and budget constraints of patient households mentioned previously is obtained a solution to the equation that can explain the level of consumption of patient households, which is determined by the lending rate, tax payable on the deposit rate as well as the rate of inflation, and can be expressed as follows:

$$-\left(-\frac{\sigma_{c}}{(1-\xi)}(\hat{c}_{t+1}^{P}-\xi\hat{c}_{t}^{P})+\hat{\varepsilon}_{u,t+1}\right)-\frac{\sigma_{c}}{(1-\xi)}(\hat{c}_{t}^{P}-\xi\hat{c}_{t-1}^{P})+\hat{\varepsilon}_{u,t}$$

$$=\frac{\beta_{P}r^{D}}{\pi}(1-\alpha_{TD})\hat{r}_{t}^{D}-\hat{\pi}_{t+1}.$$
(3)

Meanwhile, the accumulation of housing by patient households is calculated by solving the objective function and budget constraints, which are determined by the deposit rate, tax payable on the deposit rate, the rate of inflation, housing prices as well as expected houses prices looking forward, and can be written as follows:

$$\frac{\beta_P (1 - \delta_{\chi})}{\left(1 - \beta_P (1 - \delta_{\chi})\right)} \Big[ -(1 - \alpha_{TD} \beta_P) \hat{r}_t^D + E_t (\hat{\pi}_{t+1}) + E_t (\hat{\pi}_{\chi,t+1}) \Big] + \hat{\varepsilon}_{u,t} + \hat{\varepsilon}_{\chi,t} - \sigma_{\chi} \hat{\chi}_t^P = \hat{Y}_t + \hat{p}_{\chi,t}.$$
(4)

The size of the term deposits saved by patient households at a bank is determined by the level of profit received, the return on term deposits in the previous period, wages earned from working, the level of consumption as well as level of housing investment, and can be expressed as follows:

$$\frac{\tilde{d}}{\tilde{y}}\hat{d}_{t} = \frac{(1-\alpha_{TD})(1+r^{D})}{\pi}\frac{\tilde{d}}{\tilde{y}}\left(\hat{d}_{t-1}-\hat{\pi}_{t}+\hat{r}_{t-1}^{D}\right) + (1-\alpha_{T\Pi})\frac{\widetilde{\Pi}^{P}}{\tilde{y}}\left(\widehat{\Pi}_{t}^{P}\right) \\
-\frac{\chi^{P}\gamma^{P}}{\tilde{y}}\left(\hat{p}_{\chi,t}+\hat{\chi}_{t}^{P}\right) + (1-\delta_{\chi})\frac{\chi^{P}\gamma^{P}}{\tilde{y}}\left(\hat{p}_{\chi,t}+\hat{\chi}_{t-1}^{P}\right) \\
-\frac{c^{P}\gamma^{P}}{\tilde{y}}\left(\hat{c}_{t}^{P}\right) + (1-\alpha_{TW})\frac{\widetilde{W}_{P}n^{P}}{\tilde{y}}\left(\widehat{W}_{P,t}+\hat{n}_{t}^{P}\right).$$
(5)

Meanwhile, impatient households also have a utility function consisting of the same variables as patient households as follows:

$$\max_{\substack{c_{t}^{l}(i), \chi_{t}^{l}(i), n_{t}^{l}(i), b_{t}^{l}(i) \\ -\varepsilon_{n,t}} \sum_{t=0}^{\infty} (\beta_{I})^{t} \varepsilon_{u,t} \left[ \frac{(c_{t}^{I}(i) - \xi c_{t-1}^{I})^{1-\sigma_{c}}}{1-\sigma_{c}} + \varepsilon_{\chi,t} \frac{\chi_{t}^{I}(i)^{1-\sigma_{\chi}}}{1-\sigma_{\chi}} - \varepsilon_{n,t} \frac{n_{t}^{I}(i)^{1+\sigma_{n}}}{1+\sigma_{n}} \right].$$
(6)

To fund their spending, in addition to income earned from providing labour  $W_t n_t^I$ , impatient households also borrow from banks  $b_t^I(i)$ . Consequently, impatient households are also liable to repay their loans from the previous period  $(1 + r_{t-1}^{BI})b_{t-1}^I$  to the lender. The budget constraint of impatient households is as follows:

$$P_{t}c_{t}^{I}(i) + P_{\chi,t}\left(\chi_{t}^{I}(i) - (1 - \delta_{\chi})\chi_{t-1}^{I}(i)\right) + (1 + r_{t-1}^{BI})b_{t-1}^{I}(i) \\ = W_{t}n_{t}^{I}(i) + b_{t}^{I}(i) - T_{t}^{I}(i).$$
(7)

Through borrowing to fund their consumption, total loans that can be obtained by impatient households are limited by the value of housing assets owned multiplied by the current loan-to-value ratio,  $m_t^I$  in effect.

$$(1 + r_t^{BI})b_t^I(i) \le m_t^I E_t [P_{\chi, t+1}(1 - \delta_\chi)\chi_t^I(i)].$$
(8)

From a microeconomic perspective, the value of  $(1 - m_t^I)$  can be interpreted as the proportional cost of collateral repossession for the bank in the event of default. From a macroeconomic standpoint, the value  $m_t^I$  determines the total loans offered by a bank to households for a specific value of housing asset owned. It is assumed that variation in the LTV ratio is independent of the decision of each respective bank and is a stochastic exogenous process, the dynamics of which enable us to study credit-supply restrictions on the real sector from the economy.

From the aforementioned objective function and budget constraints of impatient households is obtained a solution to the equation that can explain the level of consumption of impatient households, which is determined by the wages earned from providing labour, loans from a bank, the interest rate on consumer loans, rate of inflation, housing prices as well as housing stock, and can be written as follows:

$$\frac{c^{I}\gamma^{I}}{\tilde{y}}\hat{c}_{t}^{I} = (1 - \alpha_{TW})\frac{\widetilde{w}_{I}n^{I}}{\tilde{y}}\left(\widehat{\tilde{w}}_{I,t} + \hat{n}_{t}^{I}\right) \\
+ \frac{\tilde{b}^{I}}{\tilde{y}}\left(\widehat{\tilde{b}}_{t}^{I} - \frac{(1 + r^{BI})}{\pi}\left(\widehat{\tilde{b}}_{t-1}^{I} - \hat{\pi}_{t} + \hat{r}_{t-1}^{BI}\right)\right) \\
- \frac{\chi^{I}\gamma^{I}}{\tilde{y}}\left(\hat{\chi}_{t}^{I} + \hat{\tilde{p}}_{\chi,t} - (1 - \delta_{\chi})\left(\hat{\chi}_{t-1}^{I} + \hat{\tilde{p}}_{\chi,t}\right)\right).$$
(9)

Meanwhile, the accumulation of housing by impatient households is calculated by solving the objective function and budget constraints, which are determined by the LTV ratio, housing prices, the interest rate on consumer loans as well as the rate of inflation, and can be expressed as follows:

$$\left(\frac{m^{I}\pi(1-\delta_{\chi})}{(1+r^{BI})}\right)\left[\widehat{Y}_{I,t}+\widehat{m}_{t}^{I}+\widehat{p}_{\chi,t+1}-\widehat{r}_{t}^{BI}+\widehat{\pi}_{t+1}\right]-\widehat{p}_{\chi,t} \\
+\beta_{I}(1-\delta_{\chi})(1-m^{I})\left[E_{t}(\widehat{Y}_{I,t+1})+\widehat{p}_{\chi,t+1}-\frac{m^{I}}{(1-m^{I})}\widehat{m}_{t}^{I}\right] \\
=\left(\frac{m^{I}(1-\delta_{\chi})}{(1+r^{BI})}-1+\beta_{I}(1-\delta_{\chi})(1-m^{I})\right)(\widehat{\varepsilon}_{u,t}+\widehat{\varepsilon}_{\chi,t} \\
-\sigma_{\chi}\widehat{\chi}_{t}^{I})+\widehat{Y}_{I,t}.$$
(10)

The size of loan borrowed by impatient households from a bank is determined by the LTV ratio, expected housing prices, expected inflation, housing stock as well as the interest rate on consumer loans, and can be written as follows:

$$\hat{\hat{b}}_{t}^{I} = \hat{m}_{t}^{I} + \hat{\hat{P}}_{\chi,t+1} + \hat{\pi}_{t+1} + \hat{\chi}_{t}^{I} - \hat{\hat{r}}_{t}^{BI}$$

$$\hat{\hat{b}}_{t}^{I} = \hat{m}_{t}^{I} + \hat{\hat{P}}_{\chi,t+1} + \hat{\pi}_{t+1} + \hat{\chi}_{t}^{I} - \hat{\hat{r}}_{t}^{BI}.$$
(11)

The utility function of entrepreneurs is based on the return on capital that determines the level of income and loan repayment capacity to a bank or international lender. Consequently, the profit realisation of entrepreneurs can be expressed as follows:

$$V_{t+1} = \int_{\overline{\omega}_t^{i,b}}^{\infty} \omega R_{t+1}^K P_{k,t} K_t^i f(\omega) d\omega - \left(1 - F(\overline{\omega}_t^{i,b})\right) \left(1 + r_t^{bE}\right) b_t^E.$$
(12)

The variable,  $\omega$ , is the idiosyncratic shock faced by an entrepreneur and  $\overline{\omega}_{t}^{i,b}$  is the threshold that determines whether the entrepreneur will default  $(if \ \omega < \overline{\omega}_{t}^{i,b})$  or repay the loan  $(if \ \omega > \overline{\omega}_{t}^{i,b})$  with a log-normal probability of default  $F(\overline{\omega}_{t}^{i,b})$ .

A financial contract between a bank and entrepreneur will occur if the bank, at a minimum, can receive an expected return equal to the opportunity cost. In this model, a loan to an entrepreneur is a loan unit, which already incorporates a minimum target loan rate of the wholesale unit, therefore the size of the opportunity cost incurred by the bank is equal to the funding rate determined by the wholesale unit, more specifically  $R_t^b$ . The prime lending rate determined by the wholesale unit already includes a mark up that takes into consideration stickiness, as well as the probability of default of the entrepreneur,  $F(\overline{\omega}_t^{i,a})$ , based on bank expectations concerning the return on capital of the entrepreneur. If the entrepreneur is unable to repay its liabilities pursuant to the financial contract and therefore experiences default, the bank will incur a monitoring cost and foreclose on the assets of the entrepreneur, which can be expressed as  $(1 - \mu^m)\omega R_{t+1}^K P_{k,t} K_t^i$ , while an entrepreneur that has defaulted receives nothing. A financial contract between a bank and entrepreneur must satisfy the following requirements:

$$V_{t+1} = \int_{\overline{\omega}_t^{i,b}}^{\infty} \omega R_{t+1}^K P_{k,t} K_t^i f(\omega) d\omega - \left(1 - F(\overline{\omega}_t^{i,b})\right) \left(1 + r_t^{bE}\right) b_t^E$$
(13)

Subject to:

$$\left(1 - F\left(\overline{\omega}_t^{i,a}\right)\right) \left(1 + r_t^{bE}\right) b_t^E + (1 - \mu^m) \int_0^{\overline{\omega}_t^{i,a}} \omega E_t R_{t+1}^k P_{k,t} K_t^i f(\omega) d\omega$$

$$= \left(1 + R_t^b\right) b_t^E.$$
(14)

The left-hand side of the equation shows the expected gross rate of return of the loan lent to the entrepreneur and the right-hand side indicates the opportunity cost of the bank. Parameter,  $\mu^m$ , is the monitoring cost of the bank in the event of default, the value of which increases as the bank verifies and monitors the remaining project after default. The probability of default  $F(\overline{\omega}_t^{i,a})$  of an entrepreneur is the cumulative distribution function, while  $f(\omega)$  is the probability distribution function. Where  $\overline{\omega}_t^{i,a}$  is the expected threshold (ex–ante). Adhering to the concept proposed by Zhang (2010), the difference between the expected threshold ( $\overline{\omega}_t^{i,a}$ ) and realised threshold ( $\overline{\omega}_t^{i,b}$ ) (which can be interpreted as the prediction error of the bank) will indicate the difference between expected income and realised income, which represents the portion of the cost borne by the bank.

The solution to the equation above is the relationship between corporate leverage  $k_t = \frac{P_{k,t}K_t}{N_t}$  and the external finance premium  $s_t^{Ei} = \frac{E_t(1+R_{t+1}^K)}{(1+R_t^b)}$ .

$$s_t^{Ei} = \frac{E_t (1 + R_{t+1}^K)}{\left(1 + R_t^b\right)} = f(k_t) = f\left(\frac{P_{k,t}K_t}{N_t}\right), \quad f'(.) > 0.$$
(15)

An increase in the expected discounted return to capital will reduce the expected probability of default, thus the entrepreneur could take on more debt and expand his/her business. That mechanism is known as the financial accelerator because in the event of a positive shock that raises the net worth of the business, then the resultant healthier balance sheet will bolster investment to expand the business and reduce the external finance premium.

The evolution of ex-ante threshold to ex-post threshold is a function of expected return to capital and the realised return to capital and can be expressed as follows:

$$\overline{\omega}_t^{i,b} = \frac{E_t (1 + R_{t+1}^K)}{(1 + R_{t+1}^K)} \overline{\omega}_t^{i,a}.$$
(16)

#### 4.2 Producers

Intermediate good producers operate in a perfectly competitive market and have an objective function to maximise profit, which is the difference between the products sold and the cost of capital and labour as follows:

$$\max_{p_{t}(j)} E_{t} \sum_{s=0}^{\infty} (\beta_{P} \theta_{F})^{s} \left\{ P_{w,t+s}(j) y_{w,t+s}(j) - \left( w_{p,t+s}(j) n_{p,t+s}(j) + w_{I,t+s}(j) n_{I,t+s}(j) + z_{t+s}(j) K_{t+s}(j) \right) \right\}$$
(17)

where  $P_{w,t}$  is the price of the product made and  $y_{w,t}$  is the homogenous intermediate product made using the following production function:

$$y_{W,t}(i) = A_t [u_t(i)k_t(i)]^{\alpha} \left( \left( n_{P,t}(i) \right)^{\mu_l} \left( n_{I,t}(i) \right)^{1-\mu_l} \right)^{1-\alpha}$$
(18)

where  $A_t$  is total factor productivity,  $u_t \epsilon[0, \infty)$  is the level of capital utilisation,  $k_t$  is capital stock,  $n_{P,t}$  is the labour input of patient households and  $n_{I,t}$  is the labour input of impatient households.

There are three other types of producers in the model, namely capital goods producers, housing producers and final (consumption) goods producers. Capital goods producers operate in a perfectly competitive market and utilise consumer goods to produce capital goods. In addition, capital goods producers also use old capital goods that do not depreciate,  $(1 - \delta_k)k_{t-1}$ , to sell to entrepreneurs, which can be expressed as follows:

$$k_{t} = (1 - \delta)k_{t-1} + \varepsilon_{i,t} \left(1 - \frac{1}{2}\kappa_{k} \left(\frac{i_{k,t}}{i_{k,t-1}} - 1\right)^{2}\right)i_{k,t}$$
(19)

where  $\varepsilon_{i,t}$  is the variable shock that has the dynamics, AR(1), with an error i.i.d. Old capital goods of the entrepreneur are directly transformed into new capital goods, while the transformation of consumer goods into capital goods is subject to a function of the adjustment cost  $S_k = \begin{pmatrix} i_{k,t} \\ i_{k,t-1} \end{pmatrix}$  that has the following characteristics:

$$S_k(1) = S'_k(1) = 0; \ S''_k(1) = \kappa_K > 0.$$
 (20)

In a steady state, there is no adjustment cost and as the level of utilisation of consumer goods moves farther away from the steady state, the adjustment cost increases.

The objective function of capital goods producers is to maximize

$$\max_{k_t} \sum_{s=0}^{\infty} (\beta_p)^s \left( P_{k,t+s} k_{t+s} - \left( P_{k,t+s} (1-\delta) k_{t+s-1} + P_{t+s} i_{k,t+s} \right) \right).$$
(21)

Housing producers act in a similar way to capital goods producers, namely:

$$\chi_t = (1 - \delta_{\chi})\chi_{t-1} + \varepsilon_{i\chi,t} \left(1 - \frac{1}{2}\kappa_{\chi}\left(\frac{i_{\chi,t}}{i_{\chi,t-1}} - 1\right)^2\right)i_{\chi,t}.$$
(22)

The function of the adjustment cost also has similar characteristics as capital goods producers:

$$S_{\chi}(1) = S'_{\chi}(1) = 0; \ S''_{\chi}(1) = \kappa_{\chi} > 0.$$
 (23)

The objective function is to maximize

$$\max_{\chi_{t}} \sum_{s=0}^{\infty} (\beta_{p})^{s} \left( P_{\chi,t} \chi_{t} - (P_{\chi,t} (1 - \delta_{\chi}) \chi_{t-1} + P_{t} i_{\chi,t}) \right).$$
(24)

Final goods producers are agents that combine goods from domestic retailers  $y_{H,t}(j_H)$  and retailers of imported goods  $y_{F,t}(j_F)$  to make a final product that is subsequently sold on a perfectly competitive market. The production function of final goods producers is as follows:

$$y_t = \left[\eta^{\frac{\mu}{1+\mu}} y_{H,t}^{\frac{1}{1+\mu}} + (1-\eta)^{\frac{\mu}{1+\mu}} y_{F,t}^{\frac{1}{1+\mu}}\right]^{1+\mu}$$
(25)

where  $\eta$  is the home bias parameter and  $\mu$  determines the elasticity of substitution between domestic and foreign goods. Optimisation of the objective function of final good producers will produce an equation of demand for domestic goods  $(y_{H,t})$ , demand for imported goods  $(y_{F,t})$  and the price (final) of consumer goods  $(P_t)$ ) as follows:

$$y_{H,t} = \eta \left(\frac{P_{H,t}}{P_t}\right)^{-\frac{1+\mu}{\mu}} y_t \tag{26}$$

$$y_{F,t} = (1 - \eta) \left(\frac{P_{F,t}}{P_t}\right)^{-\frac{1+\mu}{\mu}} y_t$$
(27)

$$P_t^{-\frac{1}{\mu}} = \eta \left( P_{H,t} \right)^{-\frac{1}{\mu}} + (1 - \eta) \left( P_{F,t} \right)^{-\frac{1}{\mu}}.$$
(28)

Demand for imported (foreign) goods  $(y_{F,t})$  is determined by the import price relative to the price of the final goods. Similarly, demand for domestic goods  $(y_{F,t})$  is determined by the domestic price relative to the price of the final goods. Meanwhile, the price of final goods  $(P_t)$  is determined by the domestic price and import price.

# 4.3 Retailers

Retailers in the model include domestic retailers, exporting retailers and importing retailers. Domestic retailers purchase undifferentiated intermediate goods from entrepreneurs, convert them into differentiated goods and sell them to final good producers. Exporting retailers purchase undifferentiated intermediate goods from entrepreneurs, convert them into differentiated goods and sell them to the international market. Importing retailers purchase undifferentiated goods from the international market, convert them into differentiated goods and sell them to the international market, convert them into differentiated goods and sell them to final goods producers. Prices are determined at the three agents according to the sticky price model à la Calvo, where in each period, only a portion of retailers re-optimise their prices, while the remainder adjust price based on the level of inflation in the previous period (backward looking).

For domestic retailers that re-optimise prices, prices are determined by  $P_{H,t} = P_{H,t-1}\pi_{t-1}$ . Therefore, aggregate prices at period t can be calculated using the following function:

$$P_{H,t} = \left(\theta_H (P_{H,t-1}\pi_{H,t-1})^{1-\varepsilon_H} + (1-\theta_H) (P_{H,t}(i))^{1-\varepsilon_H}\right)^{\frac{1}{1-\varepsilon_H}}.$$
(29)

The final log-linearization of the first-order condition (FOC) of the objective function of domestic retailers indicates the NKPC equation of inflation where domestic prices are determined by self-expectations, both backward and forward, in addition to being determined by the price of intermediate goods, which can be written as follows:

$$\hat{\pi}_{H,t} = \frac{1}{(1+\beta_P)}\hat{\pi}_{H,t-1} + \frac{\beta_P}{(1+\beta_P)}(\hat{\pi}_{H,t+1}) + \frac{(1-\beta_P\theta_H)(1-\theta_H)}{(1+\beta_P)\theta_H}(\hat{P}_{W,t}).$$
(30)

For importing retailers that do not re-optimise, prices are determined by  $P_{F,t} = P_{F,t-1}\pi_{t-1}$ . Similarly, aggregate prices at period t can be calculated using the following function:

$$P_{F,t} = \left(\theta_F (P_{F,t-1} \pi_{F,t-1})^{1-\epsilon_F} + (1-\theta_F) (P_{F,t}(i))^{1-\epsilon_F} \right)^{\frac{1}{1-\epsilon_F}}.$$
(31)

The final log-linearization of the first-order condition (FOC) of the objective function of importing retailers is NKPC as follows:

$$\widehat{\pi}_{F,t} = \frac{1}{(1+\beta_{P})} \widehat{\pi}_{F,t-1} + \frac{\beta_{P}}{(1+\beta_{P})} (\widehat{\pi}_{F,t+1}) + \frac{(1-\beta_{P}\theta_{F})(1-\theta_{F})}{(1+\beta_{P})\theta_{F}} (\widehat{s}_{t} + \widehat{P}_{F,t}^{*}).$$
(32)

From the equation above, it can be seen that import price inflation is determined by self-expectations, both backward expectations and forward, in addition to being determined by international prices.

Exporting retailers purchase domestic undifferentiated goods, provide branding and sell to the international market at a price  $P_{H,t}^*$ , expressed in a foreign currency. It is assumed that prices denominated in a foreign currency are sticky. The demand equation for export goods is as follows:

$$y_{H,t}^* = \left(\frac{P_{H,t}^*}{P_{H,t}^*}\right)^{\frac{-(1+\mu_{H^*})}{\mu_{H^*}}} y_{H,t}^*$$
(33)

where  $y_{H}^{*}$  indicates the output of the retailer that is defined as follows:

$$y_{H,t}^* = \left(\frac{P_{H,t}^*}{P_{H,t}^*}\right)^{\frac{-(1+\mu_{H^*})}{\mu_{H^*}}} y_{H,t}^*$$
(34)

and  $P_{H,t}^*$  as

$$P_{H,t}^* = \left(\int_0^1 P_{H,t}^* \left(j_H^*\right)^{\frac{-1}{\mu_{H^*}}} dj_H^*\right)^{-\mu_{H^*}}.$$
(35)

Furthermore, it is assumed that international demand is given by:

$$y_{H,t}^* = (1 - \eta^*) \left(\frac{P_{H,t}^*}{P_t^*}\right)^{\frac{-(1 + \mu_H^*)}{\mu_{H^*}}} y_t^*.$$
(36)

Similar to other retailers in the model, prices are determined by exporting retailers referring to the standard scheme of Calvo, where the probability of adjusting the price is  $(1 - \theta)$  and the probability of not re-optimising prices is  $\theta$ . For exporting retailers that do not re-optimise, prices are determined by the function  $P_{H,t}^* = P_{H,t-1}^* \pi_{t-1}^*$ . Therefore, the aggregate price at time *t* is calculated using the following function:

$$P_{H,t}^{*} = \left(\theta_{H}^{*} \left(P_{H,t-1}^{*} \pi_{H,t-1}^{*}\right)^{1-\varepsilon_{H}^{*}} + (1-\theta_{H}^{*}) \left(P_{H,t}^{*}(i)\right)^{1-\varepsilon_{H}^{*}}\right)^{\frac{1}{1-\varepsilon_{H}^{*}}}$$
(37)

The final log-linearization of the first-order condition (FOC) of the objective function of exporting retailers indicates that export price inflation is determined by self-expectations, both forward and backward, as well as determined by the price of intermediate goods and the exchange rate, which can be expressed as follows:

$$\widehat{\pi}_{H,t}^{*} = \frac{1}{(1+\beta_{P})} \widehat{\pi}_{H,t-1}^{*} + \frac{\beta_{P}}{(1+\beta_{P})} \left( \widehat{\pi}_{H,t+1}^{*} \right) + \frac{(1-\beta_{P}\theta_{H}^{*})(1-\theta_{H}^{*})}{(1+\beta_{P})\theta_{H}^{*}} \left( \widehat{P}_{W,t} - \widehat{s}_{t} \right).$$
(38)

#### 4.4 Bank

Banks play an important role in the financial intermediation process in the model. The only financial instruments available to patient households are bank term deposits and the only financial instrument available to impatient households and entrepreneurs is to borrow through a bank loan. We slightly modified the preliminary model developed by Gerali *et al.* (2010) in terms of the financial intermediation process, namely that agents in the new model have access to international sources of financing. Only the government, however, has access to external sources of finance in order to simplify the model.

The model developed in this research has the capacity to simulate default that could occur when an entrepreneur fails to repay his/her debt to the bank, which involves the bank bearing the risk of asymmetric information regarding the repayment capacity of the entrepreneur. Such conditions affect the size of bank profit that will subsequently determine bank capital. Risk sharing by a bank is possible because the model has two threshold values, namely  $\overline{w}_t^{i,a}$  that is the ex-ante threshold based on bank expectations regarding the return on capital of the entrepreneur. The difference between the expected and realised return on capital of the entrepreneur will determine bank capital that functions as a buffer stock against the unexpected realisation of aggregate return on capital of the entrepreneur, which will subsequently affect the capital adequacy ratio of the bank and compel the bank to manage its asset portfolio.

Pursuant to the approach taken by Gerali, we also assume that banks have market power in terms of accumulating and allocating funds, thus giving the bank the power to set the lending rate and deposit rate. In addition, stickiness is also assumed to affect the retail lending rate when linked to the dynamics of the policy rate. In this model the bank balance sheet is more detailed compared to the model developed by Gerali with the inclusion of risk free assets and reserves on the assets side of the bank balance sheet. This is in accordance with the (aggregate) balance sheets of the banking industry in Indonesia that continue to enjoy an abundance of excess liquidity in the form of Bank Indonesia Certificates (SBI) and tradeable government securities (SBN). This is an important inclusion to the model considering that the condition of excess liquidity can determine the transmission of monetary and macroprudential policy.

Assets	Liabilities
Total Loan	Deposit
Risk Free Asset (SBI and SBN)	Capital
Reserve	

Table 3. Bank Balance Sheet

Each bank in the model contains three units, namely two retail units and one wholesale unit. The first retail unit is responsible for disbursing different loans to impatient households and to entrepreneurs, while the second retail unit is responsible for accumulating term deposits from patient households.

Each wholesale unit operates under a perfectly competitive market and functions to manage the balance sheet of the bank as follows:

$$RF_t + B_t = (1 - \Gamma_t)D_t + K_t^b \tag{39}$$

where  $RF_t$  is risk-free assets,  $B_t$  is total loans extended by the bank,  $D_t$  is total deposits accrued,  $\Gamma_t$  is the reserve ratio set by the bank and determined by the reserve ratio requirement set by the central bank and  $K_t^b$  is bank capital.



Figure 3. Bank's Financial Intermediation Process

It is assumed that banks do not have access to external financing, hence the only way a bank can augment its capital is through retained earnings:

$$K_t^b = (1 - \delta^b) K_{t-1}^b + w^b j_{t-1}^b \tag{40}$$

where  $j_t^b$  is total profit generated by the three bank units,  $(1 - w^b)$  is the portion of bank dividend allocation and  $\delta^b$  is the resources invested to manage bank capital. Dividends are assumed to be exogenous and fixed, therefore bank capital is not variable option for the bank. Comprehensively, the utility function of the wholesale unit is as follows:

$$\max_{\{Risk\_free_{t},B_{t},D_{t}\}} E_{0} \sum_{s=0}^{\infty} (\beta_{P})^{s} \frac{\lambda_{t+s}^{P}}{\lambda_{t}^{P}} \left[ \Gamma_{t+s} D_{t+s} - \Gamma_{t+s+1} D_{t+s+1} + (1+r_{t+s}) RF_{t+s} - RF_{t+s+1} + (1+R_{t+s}^{b}) B_{t+s} - B_{t+s+1} + D_{t+s+1} - (1+R_{t+s}^{d}) D_{t+s} + \Delta K_{t+s+1}^{b} - (1+R_{t+s}^{d}) D_{t+s} + \Delta K_{t+s+1}^{b} - \frac{\kappa_{Kb}}{2} \left( \frac{K_{t+s}^{b}}{\omega_{t+s}^{b} B_{t+s}} - v_{b,t+s} \right)^{2} K_{t+s}^{b} \right]$$
(41)

subject to

$$RF_t + B_t = (1 - \Gamma_t)D_t + K_t^b \tag{42}$$

where  $\frac{\lambda_{t+s}^p}{\lambda_t^p}$  is the stochastic discount factor,  $R_t^b$  is the wholesale lending rate,  $R_t^d$  is the wholesale deposit rate and  $r_t$  is the policy rate of the central bank. The first-order condition (FOC) of the objective function of the wholesale unit illustrates the equation that determines the lending and deposit rates offered by the loan unit and deposit unit:

$$R_t^b - r_t = -(\omega_t^b)\kappa_{Kb} \left(\frac{K_t^b}{\omega_t^b B_t} - \nu_{b,t}\right) \left(\frac{K_t^b}{\omega_t^b B_t}\right)^2$$
(43)

$$r_t(1-\Gamma_t) = R_t^d.$$
(44)

Under conditions where  $CAR = \frac{K_t^b}{\omega_t^b B_t} = v_{b,t}$  then  $R_t^b = r_t$ . Meanwhile, under conditions where  $CAR > v_{b,t}$ , then a bank will react to lower CAR by increasing the

allocation of loans  $B_t$  (decreasing  $R_t^b$ ), thus the level of CAR will approach the statutory minimum,  $CAR \approx v_{b,t}$ .

Under conditions where reserve requirement,  $RR = \Gamma_t = 0$ , then  $\frac{R_t^4}{r_t} = 1$ , while under conditions where RR > 0 then a bank will endure an increase in opportunity cost when extending funds, hence the bank will react to lower that cost by reducing total deposits, equivalent to decreasing  $R_t^4$ .

In addition, we added an ad hoc equation to explain the dynamics of the reserve ratio selected by a bank. Previously we set the dynamics of the reserve requirement ratio  $(\hat{I}_t^r)$  determined by the central bank as follows (in the form of log linearization):

$$\widehat{\Gamma}_t^r = \rho_{\Gamma} \widehat{\Gamma}_{t-1}^r + \widehat{e}_{\Gamma^r, t} \,. \tag{45}$$

The reserve requirement ratio subsequently determines the magnitude of excess reserves ( $\hat{\varepsilon}_t^{\Gamma}$ ), which is set by a bank as follows:

$$\hat{\varepsilon}_t^{\Gamma} = \rho_{\varepsilon} \hat{\varepsilon}_{t-1}^{\Gamma} + (1 - \rho_{\varepsilon}) \hat{\Gamma}_t^r + \hat{e}_{\Gamma,t} .$$

$$\tag{46}$$

And the dynamics of reserves are as follows:

$$\hat{\varepsilon}_t^{\Gamma} = \rho_{\varepsilon} \hat{\varepsilon}_{t-1}^{\Gamma} + (1 - \rho_{\varepsilon}) \hat{\Gamma}_t^r.$$
(47)

In this model, the level of market power ascribed to a bank is determined by the magnitude (steady state value) of demand elasticity for deposits and loans alike. A lower absolute value of elasticity indicates the more monopolistic power of a bank. It is assumed that credit (savings) extended to (acquired from) households and entrepreneurs is in the form a composite Constant Elasticity of Substitution (CES) of several slightly differentiated products offered by a bank branch, *j*, with an elasticity of substitution equal to  $\varepsilon_t^{bH}$ ,  $\varepsilon_t^{bE}$  and  $\varepsilon_t^d$ . The three values of elasticity will determine markup (for credit) and mark-down (for savings/deposits) set by a bank when determining interest rates. In other words, the value of elasticity determines spread between the policy rate and lending rate (and deposit rate). It is assumed that the three values of elasticity are stochastic and changes that occur in the three values can be interpreted as changes in the spread of bank retail interest rates that occur outside the sphere of monetary policy. The demand for credit from entrepreneurs ( $b_t^E$ ) and impatient households ( $b_t^I$ ) can be expressed as follows:

$$b_t^I(j) = \left(\frac{r_t^{bH}(j)}{r_t^{bH}}\right)^{-\varepsilon_t^{bH}} b_t^I$$
(48)

$$b_t^E(j) = \left(\frac{r_t^{bE}(j)}{r_t^{bE}}\right)^{-\varepsilon_t^{bE}} b_t^E .$$
(49)

While the demand for deposits  $(d_t)$  from patient households can be written as follows:

$$d_t(j) = \left(\frac{r_t^d(j)}{r_t^d}\right)^{-\varepsilon_t^d} d_t .$$
(50)

The loan unit receives wholesale loans,  $B_t$ , from the wholesale unit at a rate of interest,  $R_t^b$ , and then extends the loan to households and entrepreneurs applying two different levels of mark-up. In order to apply stickiness and investigate the implications of imperfect bank pass-through, it is assumed that each respective bank faces a quadratic adjustment cost when adjusting its lending rate. The size of that cost is

determined by the parameters  $\kappa_{bE}$  and  $\kappa_{bH}$ . The utility function of the loan unit is as follows:

$$\max_{\{r_{t}^{bH}(j), r_{t}^{bE}(j)\}} E_{0} \sum_{s=0}^{\infty} (\beta_{P})^{s} \frac{\lambda_{t+s}^{P}}{\lambda_{t}^{P}} \left[ r_{t+s}^{bH}(j) b_{t+s}^{I}(j) + r_{t+s}^{bE}(j) b_{t+s}^{E}(j) - R_{t+s}^{b} B_{t+s}(j) - \frac{\kappa_{bH}}{2} \left( \frac{r_{t+s}^{bH}(j)}{r_{t+s-1}^{bH}(j)} - 1 \right)^{2} r_{t+s}^{bH} b_{t+s}^{I} - \frac{\kappa_{bE}}{2} \left( \frac{r_{t+s}^{bE}(j)}{r_{t+s-1}^{bE}(j)} - 1 \right)^{2} r_{t+s}^{bE} b_{t+s}^{E} \right]$$

$$(51)$$

subject to

$$b_t^I(j) = \left(\frac{r_t^{bH}(j)}{r_t^{bH}}\right)^{-\varepsilon_t^{bH}} b_t^I$$
(52)

$$b_t^E(j) = \left(\frac{r_t^{bE}(j)}{r_t^{bE}}\right)^{-\varepsilon_t^{bE}} b_t^E$$
(53)

$$B_t(j) = b_t(j) = b_t^I(j) + b_t^E(j).$$
(54)

In linear form, the lending rate for households is as follows:

$$\hat{r}_{t}^{bI} = \varepsilon^{bI} \frac{(1+R^{B})}{(1+r^{BI})(\varepsilon^{bI}-1+\beta_{P}\kappa_{bI}+\kappa_{bI})} \hat{R}_{t}^{b} + \frac{\beta_{P}\kappa_{bI}}{(\varepsilon^{bI}-1+\beta_{P}\kappa_{bI}+\kappa_{bI})} \hat{r}_{t+1}^{bI} + \frac{\kappa_{bI}}{(\varepsilon^{bI}-1+\beta_{P}\kappa_{bI}+\kappa_{bI})} \hat{r}_{t-1}^{bI}.$$
(55)

where the lending rate for households is determined by forward and backward-looking expectations of their own lending rates as well as the wholesale prime lending rate  $\hat{R}_t^b$ . The adjustment cost ( $\kappa_{bI}$ ) of the wholesale lending rate is inversely proportional to the interest rate adjustment process. If the value of  $\kappa_{bI}$  is large, then the adjustment cost of the deposit rate to increases in the wholesale interest rate is small.

Similar to the loan unit, the deposit unit accumulates term deposits  $d_t$  from households and forwards them to the wholesale unit applying an interest rate  $r_t^d$ . The utility function of the deposit unit is as follows:

$$\max_{\{r_t^d(j)\}} E_0 \sum_{s=0}^{\infty} (\beta_P)^s \frac{\lambda_{t+s}^P}{\lambda_t^P} \left[ R_{t+s}^D D_{t+s}(j) - r_{t+s}^d(j) d_{t+s}(j) - \frac{\kappa_d}{2} \left( \frac{r_{t+s}^d(j)}{r_{t+s-1}^d(j)} - 1 \right)^2 r_{t+s}^d d_{t+s} \right]$$
(56)

subject to

$$d_t(j) = \left(\frac{r_t^d(j)}{r_t^d}\right)^{-\varepsilon_t^d} d_t$$
(57)

$$D_t(j) = d_t(j). \tag{58}$$

In linear form, the deposit rate set by the deposit unit can be calculated as follows:

$$\hat{r}_{t}^{d} = -\frac{\varepsilon^{d}}{\left(1 - \varepsilon^{d} + \kappa_{d} + \beta_{P}\kappa_{d}\right)} \frac{\left(1 + R^{D}\right)}{\left(1 + r^{d}\right)} \hat{R}_{t}^{D} + \frac{\kappa_{d}}{\left(1 - \varepsilon^{d} + \kappa_{d} + \beta_{P}\kappa_{d}\right)} \hat{r}_{t-1}^{d} + \frac{\beta_{P}\kappa_{d}}{\left(1 - \varepsilon^{d} + \kappa_{d} + \beta_{P}\kappa_{d}\right)} E_{t}\hat{r}_{t+1}^{d}.$$
(59)

The wholesale deposit rate is inversely proportional to the deposit rate set by the deposit unit. The response of the deposit rate to the wholesale rate is faster if the wholesale unit lowers its interest rates. In contrast, the response of the deposit rate is not as high if the wholesale deposit rate is increased.

#### 4.5 The Government and Central Bank



The government collects taxes and lends on the domestic market (through banks) and on the international market to offset spending. Government budget constraints in the economy are as follows:

$$P_t g_t + (1 + r_{B,t-1}^*) e_t b_{G,t-1}^* + (1 + r_{t-1}) b_{G,t-1} = (T_t^P + T_t^I) + e_t b_{G,t}^* + b_{G,t}$$
(60)

where  $g_t$  is government spending modelled with the dynamics, AR(1),  $b_{G,t}^*$  is external government loans that are also modelled as AR(1), and  $T_t^P$  as well as  $T_t^I$  are taxes collected from patient and impatient households.

Determining the policy rate  $(r_t)$  set by the central bank is modelled using the Taylor Rule as follows:

$$(1+r_t) = \left(\frac{1+r_{t-1}}{1+\bar{r}}\right)^{\phi_R} \left( \left(\frac{\pi_t}{\bar{\pi}_t}\right)^{\phi_\pi} \left(\frac{\tilde{y}_t}{\bar{y}}\right)^{\phi_y} \right)^{1-\phi_R} \varepsilon_{r,t}$$
(61)

where  $\phi_{\pi}$  and  $\phi_{y}$  are the respective weights of inflation and output stabilisation,  $\bar{r}$  is the steady state nominal interest rate and  $\varepsilon_{t}^{r}$  is the i.i.d shock on monetary policy with a normal distribution and standard deviation  $\sigma_{r}$ .

#### 4.6 Market Clearing Conditions

To finalise the model, market clearing condition equations are required for goods produced by final goods producers, goods produced by intermediate goods producers (intermediate homogeneous goods), the housing market, the balance of payments and the definition of GDP in the model. Furthermore, as the economy being modelled is a small open economy, the risk premium must be specified, which is a

function of the ratio of total external debt to GDP (pursuant to Schmitt-Grohe and Uribe, 2003).

Final Goods Producers Output

$$\hat{\pi}_{t} = \eta(p_{H})^{-\frac{1}{\mu}} (\hat{\pi}_{H,t} + \hat{p}_{H,t-1}) + (1 - \eta)(p_{F})^{-\frac{1}{\mu}} (\hat{\pi}_{F,t} + \hat{p}_{F,t-1})$$
(62)

$$\frac{c}{\tilde{y}}\hat{c}_t = \frac{\gamma^I c^I}{\tilde{y}}\hat{c}_t^I + \frac{\gamma^P c^P}{\tilde{y}}\hat{c}_t^P + RnY * N$$
(63)

Intermediate Homogenous Goods Market

$$\int_{0}^{1} y_{H,t}(j)dj + \int_{0}^{1} y_{H,t}^{*}(j)dj = y_{W,t}$$
(64)

Housing Market

$$\gamma^P \chi_t^P + \gamma^I \chi_t^I = \chi_t \tag{65}$$

**Balance of Payment** 

$$P_{F,t}y_{F,t} + e_t(1 + r_{t-1}^*)\rho_{t-1}b_{tot,t-1}^* = e_t P_{H,t}^* y_{H,t}^* + e_t b_{tot,t}^*$$
(66)

where

$$b_{tot,t}^* = b_{G,t}^*$$
 (67)

<u>GDP</u>

$$P_t \tilde{y}_t = P_t y_t + e_t P_{H,t}^* y_{H,t}^* - P_{F,t} y_{F,t}$$
(68)

**Risk Premium** 

$$(1+\rho_t) = exp\left(-\varrho \frac{e_t b_{tot,t}^*}{P_t \tilde{y}_t}\right) \varepsilon_{\rho,t}$$
(69)

# 5 ESTIMATION

Quarterly data from quarter I 2001 until quarter IV 2012 is used for the purposes of estimation. In addition, the following real sector data is also used: private consumption, government spending, exports, imports, headline inflation, import deflator, export deflator and the exchange rate. GDP data published by Statistics Bureau of Indonesia is used for disaggregated GDP data, the export deflator and import deflator. Exchange rate data along with headline inflation are acquired from the ARIMBI/SOFIE<sup>7</sup> database models. Concerning external sector variables, data is again taken from the ARIMBI and SOFIE models, namely global inflation, US inflation and LIBOR.

In terms of the banking sector, the following data is used: the policy rate (BI rate); the deposit rate and total deposits accumulated; bank capital; the interest rate and total outstanding household credit (consumer loans); the interest rate and total

<sup>&</sup>lt;sup>7</sup> ARIMBI is Bank Indonesia core model, based on semi DSGE model. SOFIE is satellite model of ARIMBI that disaggregate the projection result from ARIMBI into its component.

outstanding corporate loans (investment credit and working capital); total Bank Indonesia Certificates (SBI) (and other monetary operations) held by banks; total bank debt owed to the central government (SBN), total bank reserves (including cash in vault); and non-performing loans (NPL).

Actual data for the estimation period (quarter 1 2001 – quarter 4 2011) is used as the primary reference when determining the steady state values of real sector variables. Nonetheless, steady state values are also calculated using the DSGE models of advanced countries and developing countries alike for comparison. Disaggregated GDP data is based on that processed using the HP Filter as illustrated in Figure 5.





Departing from the disaggregation conducted by BPS-Statistics Indonesia for the variable, investment (business investment and construction investment), is split into two in this model, namely: housing investment and investment in capital goods. To calculate the steady state value of housing investment to total GDP, we multiply the ratio of completed construction for that category of building (0.4) with the average ratio of construction investment to total investment (0.83), and then multiply that with the ratio of investment to GDP (0.22). Using that approach (and rounding off), we determine that the steady state value of housing investment to total GDP is 0.08.



Figure 6. Ratio of Value of Building Completed Construction for each Category and Ratio of Construction Investment

Using a similar approach, we also calculate the steady state values for components of the balance sheet. As can be seen in Figure 7, however, the results of the HP filter for the ratio of the balance sheet to total assets is not stable around a specific value. In addition to using the results of the HP filter presented in Figure 7, the research of Gunadi and Budiman (2011) concerning the optimisation of bank portfolio

composition in Indonesia is used to determine the steady state values of bank balance sheets, which are presented in full in Table 4.



Figure 7. Result of HP Filter from Ratio of Bank Balance Sheet Variable to Total Asset

Tabla 1	Ctood	Ctata	Value	of Dould	Delence	Charty	Variables
i abie 4.	Sleauy	Slale	value	UI Dalik	Dalatice	Sheet	variables

Assets	Liabilities		
Total Loan	0.7	Deposit	0.9
SBI	0.12	Capital	0.1
Loan to Government (SBN)	0.08		
Reserve	0.1		

Referring to Figure 8 that presents the results of the HP filter of different interest rate variables in the model, we can observe that the spread between the BI rate and deposits rate is not stable. When the BI rate is high, for example, the spread with the deposit rate is also high. When the BI rate is low, however, the spread with the deposit rate is also low. As we use a steady state value of the BI rate that is categorised as low for data consistency, a low value of spread is also used to calculate the steady state value of the deposit rate to be 4.5 percent. Additionally, to calculate the steady state value of interest rates on consumer loans and investment credit, we include the average difference between both aforementioned rates and the BI rate during the sample period, which produces a steady state value for the interest rate on consumer loans of 13.65 percent and a steady state value for the interest rate on corporate loans (working capital and investment) of 11.4 percent. For the LIBOR rate, which is a proxy of international interest rates, we use the same value as that found in the ARIMBI model, namely 3 percent.



In full, the steady state values of all variables used in the model are presented in Table 5 as follows:

Variables	Values
Consumption to GDP ratio	0.59
Capital investment to GDP ratio	0.19
Housing investment to GDP ratio	0.08
Government expenditure to GDP ratio	0.09
Import to absorption ratio	0.38
Export to output ratio	0.44
Loan to HH to GDP ratio	0.31
Loan to entrepreneur to GDP ratio	0.71
Deposit to GDP ratio	1.28
Importer's profit margin	0.03
Exporter's profit margin	0.026
Domestic retailer's profit margin	0.18
Rate on loan to HH*	14.98 percent
Rate on loan to entrepreneur*	12.9 percent
Rate on deposit*	4.5 percent
Foreign interest rate*	3 percent
CAR	0.14
Bank's profit to total asset ratio	0.025
Deposit to bank's total asset ratio	0.9
Bank's capital to total asset ratio	0.1
Loan to bank's total asset ratio	0.7
Risk free asset to bank's total asset ratio**	0.2
Reserve to total asset ratio	0.1

Table J. Sleady State value of All valiables	Table 5. Steady	/ State	Value of All	Variables
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A number of parameters used in the model are calibrated using the values found in other models developed by Bank Indonesia and related empirical research. Capital share in the production function is set at 0.54 in line with the 2012 MODBI<sup>8</sup> model. The value of home bias of the parameters is calculated based on the HP filter value of the import to absorption ratio of Indonesia during the estimation period. The parameters that determine the elasticity of substitution between domestic and foreign goods as well as the elasticity of substitution for export goods are based on the research

<sup>&</sup>lt;sup>8</sup> MODBI is Bank Indonesia long-term projection model, based on simultaneous econometric method.

of Zhang and Verikios (2006)<sup>9</sup>. The values of the risk premium and that which controls the cost of managing bank capital are calculated through the steady state correlation between several variables included in the model. The Calvo parameter for labour follows the estimation results of the BISMA model (2009). The parameters of the ad hoc equations, which determine the dynamics of risk-weighted assets (Equation 44) and bank reserves (Equations 45 - 47) utilise the results of the partial equation based on data for the estimation period.

Parameters						
Mark-up parameter in labor market	$\mathcal{E}_W$	11				
Depreciation rate of capital	$\delta_k$	0.025				
Depreciation rate of housing asset	$\delta_{\chi}$	0.0125				
Cost to managing bank's capital	$\delta_b$	0.1				
Risk premium parameter	$ ho^b$	0.11				
Capital share in production function	α	0.54				
Home bias parameter	η	0.62				
Elasticity of subtitution between domestic and foreign goods	μ	0.63				
Elasticity of subtitution for export goods	$\mu_{H*}$	0.45				
Labour income share of unconstrained household	$\mu_L$	0.67				
The probability of given labor (from patient and impatient HH) is selected not to reoptimize its wage	$ heta_{wp}  dan   heta_{wi}$	0.65				
Reserve equation's parameter	$ ho_{\Gamma}$	0.197				
Excess reserve equation's parameter	$\rho_{\epsilon}$	0.632				

The prior distributions of parameters are determined through the same approach as that used to calculate the calibrated parameters, namely by utilising the values of models previously developed and related empirical research. For the parameters  $\kappa_d$ ,  $\kappa_{be}$  and  $\kappa_{bi}$ , the prior distributions are determined by setting the bank retail interest rate response to policy rate shocks in accordance with the estimations of immediate pass-through conducted by Harmanta and Purwanto (2012). For the Taylor rule parameters ( $\varphi_r$ ,  $\varphi_\pi$  and  $\varphi_y$ ), the values of priors are set according to the value contained in the ARIMBI core model. The prior distribution of the parameter that measures habit persistence in household consumer activity is the same as that in the BISMA<sup>10</sup> model (2009). The prior distributions, types of distribution and posterior distributions of the parameters are presented in full in Table 7.

<sup>&</sup>lt;sup>9</sup> Utilising a CES-based estimation congruent with the assumptions used when developing the model used in this research.

<sup>&</sup>lt;sup>10</sup> BISMA is structural DSGE model that give a focus on complete households balance sheet, with no discussion about complete banking sector

Parameters		Distributions	F Dist	Prior ribution	Posterior Distribution
Falameters		Distributions	Mean	Std. Dev.	Mean
Inverse of intertemporal elasticity of substitution for housing	$\sigma_{\chi}$	normal	4	0.2	4.1670
Inverse of intertemporal elasticity of substitution for consumption	$\sigma_c$	normal	2	0.2	2.1274
Inverse of Frisch elasticity of labour supply	$\sigma_n$	normal	2	0.2	4.1417
Adjustment cost paremeter for deposit rate	κ <sub>d</sub>	gamma	3.25	0.2	3.2675
Adjustment cost paremeter for entrepreneur loan rate	ĸ <sub>be</sub>	normal	3.5	0.2	3.7420
Adjustment cost paremeter for household loan rate	κ <sub>bi</sub>	normal	8	0.2	8.1676
Adjustment cost paremeter for capital investment	$\kappa_k$	gamma	5	0.5	5.1631
Adjustment cost paremeter for housing investment	κχ	normal	50	0.5	49.3372
Adjustment cost paremeter for bank's CAR	$\kappa_{kb}$	beta	1	0.05	0.9684
Calvo paremeter for import goods	$\boldsymbol{\theta}_{f}$	beta	0.7	0.05	0.6254
Calvo paremeter for domestic goods	$\boldsymbol{\theta}_{\mathbf{h}}$	beta	0.4	0.05	0.3948
Calvo parameter for export goods	$\boldsymbol{ heta}_{\mathbf{h}*}$	beta	0.6	0.05	0.7898

# Table 7. Parameter Values from Estimation

# 6 SIMULATIONS

We will study the dynamics of the impulse function produced by the model in this section. Discussion focuses on the simulation of monetary policy in the form of shocks in the BI rate, total factor productivity and the exchange rate as well as simulations of macroprudential policy. In accordance with model design, macroprudential policy includes the capital adequacy requirement, the LTV ratio and reserve requirement (RR). Furthermore, the dynamics of the impulse function relating to shocks stemming from the banking sector, namely a decrease in bank capital, will also be investigated. This is done in order to understand the transmission of such shocks to the real sector and comprehend the role played by monetary policy in terms of mitigating such shocks. The model developed in this research assumes a small open economy; therefore a shock in the form of increased world GDP will also be studied.



#### 6.1 **BI Rate Shock**



#### Figure 9. Impulse Response BI Rate Shock

A 1 percent hike in the BI rate (blue line in the figure) would be transmitted to the various interest rates in the banking sector. The magnitude of those interest rates is determined by the mark-up applied at the respective bank as well as the level of stickiness of each corresponding interest rate. The fastest response to an increase in the BI rate is transmitted to the deposit rate, which is raised directly in the same period as the BI rate hike. This is because the deposit rate has a lower level of stickiness than the lending rate. Furthermore, raising the lending rate would also exacerbate the risk of default, which is demonstrated by an increase in non-performing loans and ultimately erodes a bank's capital adequacy ratio due to the high risk-weighted assets. A decline in the extension of total credit would lower bank LDR and eventually also dissuade investment and undermine capital.

The effect of the financial accelerator mechanism can be observed in the variable, idiosyncratic shock, which is higher ex-post than ex-ante, which forces banks to bear risk and reduce their capital. The higher idiosyncratic shock ex-post compared to ex-ante is the result of banks overvaluing their assessment of the return on capital from the entrepreneur due to an ongoing economic contraction that means the actual return on capital is not as large as that predicted by the bank.

The increase that occurs in the lending rates offered to households would impinge upon the households' ability to consume. Moderating domestic demand compels producers to reduce production, which is evidenced by a decline in final goods output. A lower level of production of final goods would also manifest due to rupiah appreciation stemming from a hike in the BI rate, which compromises product competitiveness and ultimately supresses exports. Imports would also slump as a consequence of weaker demand for consumption and investment. Against this backdrop, the rate of inflation would decrease.

It is assumed that the policy implemented does not merely rely on the BI rate but also a combination of countercyclical macroprudential policy to supress credit growth that involves lowering the LTV ratio (red line). The simulations prove that a shock in the form of a policy mix would stifle credit growth more deeply than conditions without an LTV shock. GDP and the rate of inflation decline but only moderately compared to conditions when only BI rate policy is used. Instituting a policy mix enables the slump in consumption to be offset by the slowdown in imports, hence GDP tends to remain more stable. The simulations also show that in addition to a policy mix helping to stabilise GDP and inflation, it also controls consumption thus alleviating the demand for imported goods. Coupled with stable exports, the decline in imports would favourably impact the current account.

#### 6.2 Households' LTV Ratio Requirement Shock



Figure 10. Impulse Response Household LTV Ratio Shock

Raising the LTV ratio requirement on household credit (consumer loans) triggers an increase in the volume of household credit due to an incentive stemming from the larger volume of loan that can be allocated by the banks and backed by the collateral of the household. By raising the LTV ratio, but with the same asset value, households could borrow more from a bank. The increase in loan volume encourages banks to manage their asset portfolio by lowering the volume of credit extended to entrepreneurs. Increasing total bank loans would raise bank LDR and reduce bank CAR due to credit expansion implemented by the bank. A high level of credit allocation also increases bank profit and would ultimately bolster bank capital in subsequent periods. The increase in total loans extended to households would cause impatient households to increase their level of consumption, which would prompt producers to ramp up production of final goods output. Such conditions would eventually stimulate GDP growth.

Economic expansion due to greater GDP growth would increasingly expedite credit allocation due to the financial accelerator mechanism. The effect of the financial accelerator mechanism can be observed in the variable, idiosyncratic shock, which is

lower ex-post than ex-ante, which shows that the actual return on capital from entrepreneurs is higher than the banks' expectations. This helps to lower the level of non-performing loans (NPL).

#### 6.3 CAR Requirement Shock

#### Figure 11. Impulse Response CAR Requirement Shock



When the CAR requirement experiences an increase, banks tend to transfer their assets by reducing credit extension, both to households and entrepreneurs, and increasing risk-free assets. Such conditions would lower the LDR ratio as the disbursement of credit slows. On the other hand, however, banks would enjoy an increase of capital as a result of the reduction in credit allocation, thus raising the level of CAR. Figure 11 illustrates that an increase in bank CAR would not be as pronounced as the increase in the CAR requirement, which is possible due to the small adjustment cost of the difference in the CAR requirement estimated in the model because of how far apart the steady state value of CAR is compared to the CAR requirement.

This kind of shock in the banking sector also impacts the real sector, which is represented by a reduction in the disbursement of credit that erodes investment and the production of final goods by producers. Accordingly, the GDP of Indonesia would decline.

#### 6.4 Bank Capital Shock



Figure 12. Impulse Response Bank Capital Shock

When a shock appears in the form of less bank capital, banks react by reducing their disbursement of loans, both to households and to entrepreneurs, thus the amount of total loans would decrease. Less capital at a bank would also precipitate a decline in risk-free assets and, thus, a lower LDR ratio. Less bank capital also forces the bank to increase profit, hence the accumulation of profit can boost capital in the subsequent period.

Greater bank profit would increase the income of patient households as the owners of the bank, which subsequently results in more consumption. Greater consumption would drive up production of final goods as well as investment. Consequently, total GDP will follow an upward trend and the rupiah appreciation that occurs will lower the price of imported goods and supress the rate of inflation, which will elicit a central bank response in the form of lowering its policy rate.



#### 6.5 World GDP Shock

Figure 13. Impulse Response World GDP Shock

An increase in world GDP would trigger a surge in exports followed by growth in final goods output. The increase in final goods output would lead to an increase in investment and imports of raw materials required for production. Such circumstances would raise GDP as well as income and ultimately boost public purchasing power. Greater public purchasing power would bolster consumption and spark inflationary pressures in the economy. Consumer loans would also expand in line with solid public consumption. Greater public purchasing power would also occasion an increase in deposits held at banks, which are subsequently allocated by the banks in the form of loans to the household sector. An increase in loan disbursements would also improve bank profits and subsequently buoy bank capital, thereby eventually raising bank CAR.

Under expansive economic conditions, when the production of goods increases due to the positive shock of stronger international demand, the financial accelerator also encourages the banking sector to expand credit allocation. Such behaviour is observed in the variable, idiosyncratic shock, for which the ex-post value is smaller than the ex-ante value; therefore, non-preforming loans are lower and the external finance premium becomes increasingly small. Such conditions make it easier to access credit from the banking sector.

#### 6.6 Exchange Rate Shock



Figure 14. Impulse Response Exchange Rate Shock

Depreciation in the rupiah exchange rate would boost the competitiveness of export products, hence creating a surge in exports accompanied by an increase in final goods output. The increase in production of final goods would be followed by a greater requirement for investment, thereby raising GDP and income. Greater income would strengthen public purchasing power and drive consumption. The gains in consumption, however, would exacerbate inflationary pressures in the economy.

The requirement for greater production of goods by producers would cause entrepreneurs to borrow more from the banks. During an expansive economic phase, when the production of goods increases to meet the surge in exports, the financial accelerator compels banks to lend more. The effect of the financial accelerator mechanism can be observed in the idiosyncratic shock variable, which is lower ex-post than ex-ante; thus, non-performing loans are low and the external finance premium also becomes increasingly small. Such conditions make it easier to access credit from the banking sector.

# 7 CONCLUSION

A DSGE model was developed in this research for the small open economy of Indonesia, complemented with financial frictions in the form of collateral constraints and the financial accelerator mechanism as well as a banking sector designed according to the conditions found in Indonesia. Analysis of the impulse response function of the model showed that the transmission of monetary and macroprudential policy is as follows:

a) Raising the BI rate would compel banks to hike their retail rate and reduce loan disbursements, which would ultimately erode final goods output. Such conditions would subsequently lower GDP and the rate of inflation. The proceeding economic contraction would trigger a larger idiosyncratic shock ex-post than ex-ante, where the expected return on capital of the entrepreneur would exceed the actual realisation and, therefore, non-performing loans (NPL) would increase. This situation

forces the banks to bear the risks that emerge and erode bank capital. Such conditions would also raise the external finance premium, thereby making it increasingly difficult for entrepreneurs to borrow from banks.

- b) Raising the LTV ratio requirement for household credit (consumer loans) triggers a surge in consumption and purchases of housing assets by households. Strong demand from households would force producers to increase final goods output, thus causing an increase in output and eventually pushing up the rate of inflation. Consequently, in order to expand credit allocation to the household sector, banks would reduce their risk-free assets.
- c) A shock in the banking sector in the form of a more stringent CAR requirement would force the banks to reduce credit allocation to the household sector and entrepreneurs, precipitating a decline in bank LDR. Such a shock would also impact the real sector through a decline in loan disbursements that would undermine investment and reduce the production of final goods by producers. Consequently, GDP and the rate of inflation would both decelerate.
- d) Simulations show that a policy mix combining monetary policy and macroprudential policy would not only spur stable GDP growth and inflation but also control consumption and alleviate demand for imports. Coupled with stable exports, weaker imports would favourably impact the current account.

By including the banking sector in the model, analysis was possible of the policies required to overcome shocks originating from the banking sector. When bank capital suddenly plummeted (due to large-scale write-offs of their assets), the central bank would be required to provide a stimulus in the form of lowering its policy rate (BI rate) in the same period as the shock. Postponing the reduction in the policy rate by the central bank would lead to a more pronounced decline in output and require a much larger monetary stimulus. The simulations conducted in this research highlight the importance of timely monetary policy when confronting a shock stemming from the banking sector. The origins of shock need to be identified before central bank decides the policy response needed. For example, if there is an increase in technological shock that increases the GDP as well as credit volume, it is not necessary to increase the policy rate since there will be no hike price due to high supply of goods.

The model developed in this research met all of its development objectives, namely, to simulate monetary policy (BI rate) and macroprudential policy (CAR and LTV requirement). There remains one caveat, however, which should be remembered when interpreting the simulation of an LTV shock produced by the model. The definition and assumption of the LTV ratio requirement in the model is not fully aligned with the concept of the LTV ratio requirement applied in Indonesia since 2012. Consequently, the results of the simulations performed using this model must be more carefully interpreted.

# **Further Model Development**

Based on the impulse response function and the potential for this model to be used under the Bank Indonesia FPAS (forecasting and policy analysis) framework, there are several refinements that could be made as follows:

a) Develop a model that supports a broader application relating to interaction between a range of monetary and macroprudential policies. This could be achieved, among others, by endogenously modelling macroprudential policy, for instance with a CAR requirement rule, LTV requirement rule and their interaction with the Taylor rule.

b) Develop a model that could not only be used as a simulation model but also to project macro variables as well as variables linked to balance sheets and conditions in the banking sector.

# References

- Adolfson, Malin and Stefan Laséen and Jesper Lindé and Mattias Villani (2005) "Bayesian Estimation of an Open Economy DSGE Model with Incomplete Pass-Through," Working Paper Series 179, Sveriges Riksbank (Central Bank of Sweden).
- Agung, Juda (2010)"Integration of Monetary and Macroprudential Policy: To the New Monetary Policy Paradigm after Global Crisis," Bank Indonesia Working Paper No.WP/07/2010.
- Angelini, Paolo and Andrea Enria and Stefano Neri and Fabio Panetta and Mario Quagliariello (2010) "Pro-cyclicality of capital regulation: is it a problem? How to fix it?", Questioni di Economia e Finanza (Occasional Papers) 74, Bank of Italy, Economic Research and International Relations Area.
- Angelini, Paolo and Stefano Neri and Fabio Panetta (2011)"Monetary and macroprudential policies", Temi di discussione (Economic working papers) 801, Bank of Italy, Economic Research and International Relations Area.
- Bank Indonesia (2006) "General Equilibrium Model Bank Indonesia 2006," Bank Indonesia Working Paper.
- Bank Indonesia (2009) "Bank Indonesia Structural Macromodel" Bank Indonesia Working Paper.
- Berger, A.N. and A. Demirguc-Kunt and R. Levine and J.G. Haubrich (2004) "Bank Concentration and Competition: An Evolution in the Making", *Journal of Money*, *Credit and Banking*, Vol 36(3).
- Berger, A.N. and T.H. Hannan (1991) "The Rigidity of Prices: Evidence from the Banking Industry", *American Economic Review*, Vol 81(4), pp. 938-45.
- Berger, A.N. and G. Udell (1992) "Some Evidence on the Empirical Significance of Credit Rationing", *Journal of Political Economy*, Vol 100(5), pp. 1047-77.
- Bernanke, Ben and Gertler, Mark and Simon Gilchrist (1999) "The Financial Accelerator in a Quantitative Business Cycle Framework", *Handbook of Macroeconomics*, Elsevier, Edition 1, Volume 1, Number 1.
- Bernanke, Ben and Mark Gertler (2001) "Should Central Banks Respond to Movements in Asset Prices?," *American Economic Review*, 91(2), 253-257.
- Borio, C. and C. Furfine and P. Lowe (2001) "Pro-cyclicality of the Financial System and Financial Stability: Issues and Policy Options," BIS Papers, No.1.
- BIS (2010) "Macroprudential instruments and frameworks: A stocktaking of issues and experiences. Committee on The Global Financial System.
- Brzoza-Brzezina, MichaÅ, and Krzysztof Makarski (2011) "Credit crunch in a small open economy," *Journal of International Money and Finance*, Elsevier, vol. 30(7), pages 1406-1428.
- Calem, Paul and Michael Gordy and Loretta Master (2006) "Switching Costs and Adverse Selection in the Market for Credit Cards: New Evidence," *Journal of Banking and Finance*, Elsevier, vol. 30(6), pages 1653-1685.

- Camilo E. Tovar (2008) "DSGE models and central banks," BIS Working Papers 258, Bank for International Settlements.
- Christiano, Lawrence J. and Martin Eichenbaum and Charles L. Evans (2005) "Nominal Rigidities and the Dynamic Effects of a Shock to Monetary Policy," *Journal of Political Economy*, University of Chicago Press, vol. 113(1), pages 1-45, February.
- Gerali, Andrea and Stefano Neri and Luca Sessa and Federico M. Signoretti (2010) "Credit and banking in a DSGE model of the euro area,"Temi di discussione (Economic working papers) 740, Bank of Italy, Economic Research and International Relations Area.
- Gunadi, Iman and Advis Budiman (2011) "Optimization of Bank Portfolio Composition in Indonesia", Kajian Stabilitas Keuangan No. 17, September.
- Harmanta and Nur Purwanto (2012) "Stickiness of Retail Rate of Indonesia Banking Sector", Catatan Riset No. 14/ 39 /DKM/BRE/CR, Bank Indonesia, December.
- Harmanta and Nur Purwanto and Fajar Oktiyanto (2012) "Banking Sector on DSGE Model", Bank Indonesia Working Paper No.WP/16/2012.
- Harmanta and Tarsidin and M. Barik Bathaluddin and Idham (2012) "ARIMBI with Macroprudential Policy." Bank Indonesia Working Paper, No. WP/08/2012.
- Iacoviello, M. (2005) "House Prices, Borrowing Constraints and Monetary Policy in the Business Cycle" *American Economic Review*, Vol. 95(3), pp. 739-764.
- Liu, Zheng and Pengfei Wang and Tao Zha (2010) "Do credit constraints amplify macroeconomic fluctuations?," Working Paper 2010-01, Federal Reserve Bank of Atlanta.
- Purwanto, Nur M. Adhi (2009) "Determinants of Banks Interest Rate Spread." Bank Indonesia Occasional Paper, No. OP/03/2009.
- Tjahjono, Endy Dwi and Harmanta and Nur M. Adhi Purwanto and Justina Adamanti (2010) "Short-Term Forecast Model for Indonesian Economy (SOFIE) 2010." Bank Indonesia Working Paper, No. WP/23/2010.
- Vicek, Jan and Scott Roger (2012) "Macrofinancial Modeling at Central Banks: Recent Developments and Future Directions," IMF Working Papers 12/21, International Monetary Fund.
- Wimanda, Rizki E. and Nur M. Adhi Purwanto and Tarsidin and Fajar Oktiyanto (2012) "Respecification and Reestimation on Macroeconomic Model of Bank Indonesia." Bank Indonesia Working Paper, No. WP/15/2012.
- Zhang, X. and Verikios, G. (2006) "A Remington Parameter Estimation for a Computable General Equilibrium Model: A Database Consistent Approach," Economics Discussion Working Papers No. 06–10, The University of Western Australia, Department of Economics.
- Zhang, Longmei (2010) "Bank Capital Regulation, the Lending Channel and Business Cycles," Discussion Paper Series 1: Economic Studies, Deutsche Bundesbank.

# **Discussion**<sup>11</sup>

Dr. Shanaka Jayanath Peiris noted that the paper used the Gerali *et al.* (2010) model with additional features such as a housing finance channel, inflation and households. An interesting conclusion was that the use of macroprudential policy (loan-to-value (LTV) in the paper) combined with monetary policy would be more effective in bringing down inflation and credit growth. Said result suggests coordination between monetary policy and macroprudential policy, which may depend on the type of shock. Likewise notable was the inclusion of reserve requirement in the model. There was uncertainty whether the degree of excess reserves has a direct impact on the lending rate.

One participant requested clarifications on the necessity of distinguishing the policy rate from the short-term Teasury bill rates, and on whether adjustment cost should be applied on all asset types for symmetry.

Another participant noted that implicit in the model was financial friction, which is about the inability to hedge and automatically swap bonds. It may be worthwhile to investigate whether economic agents who do not hedge due to prohibitive costs will have an impact on the paper's result. Furthermore, the LTV and the policy rate seemed to reinforce each other in minimizing shocks to output when they move in the same direction (towards tightening in the paper). However, in some countries, LTV was being tightened at a time when monetary policy was being eased. Thus, the possibility of both moving in opposite directions should be considered.

One participant mentioned that the discussion on the comparative advantage of different instruments in different situations is useful. However, there was not enough information to confirm the effect of macroprudential tools on output.

Dr. Harmanta mentioned that moving forward, suggestions will be considered to fine tune their model. In particular, adjustment costs on all asset types and opposing directions of macroprudential policy will be considered.

<sup>&</sup>lt;sup>11</sup> Dr. Shanaka Jayanath Peris of the International Monetary Fund was the discussant of the paper.





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