BANKING SECTOR AND FINANCIAL FRIC'TON ON
DSGE MODEL: THE CASE OF INDONESIA

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Abstract

We build DSGE model for small open economy with financial friction in the form of collateral constrain on banking sector, designed for Indonesian economy. The constructed model is capable to simulate the shock in BI rate, reserve requirement, bank’s capital, and the shock to the default risk of the bank. By incorporating banking sector into the model, this model also enable us to simulate the impact of any shock originated from banking sector.

Keywords: monetary policy, DSGE with banking sector, macroprudential policy
JEL Classification: E32, E44, E52, E58

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I. INTRODUCTION

Some economy and financial crisis occur in some last decades show the instability of macroeconomy mostly caused from financial/banking sector which is very procylicality. Agung (2010) stated that the level of procylicality of the banking sector in Indonesia is quite high. This is seen from the growing of real credit which is faster than PDB on the expansion period, and the decrease of real credit is higher than the decrease of PDB on the contraction period. The high procylicality of banking sector in Indonesia demand the synergy of monetary policy and macroprudential policy to mitigate the excessive economy fluctuation (business cycle).

The monetary policy is potential to support the stability of financial system through its ability to influence the financial condition and the behavior in financial market through the transmission of balance sheet of firm, and bank as well as risk taking behavior. Vice versa, the condition of the financial system is also potential to influence the monetary stability. To help Bank Indonesia in formulating the policy to influence either monetary stability or financial system, an economy model which has the ability to simulate the effect of the monetary and macroprudential policy toward the sector of financial/banking and economy as a whole is needed.

The purpose of this research is to develop the model DSGE which is completed with financial sector for the needs of simulation of both monetary and macroprudential policy. We expect the benefits of this research to be one powerful tool for Bank Indonesia on conducting monetary policy formulation. This research will also be one of the steps on competence building in developing the model DSGE with feature simulation of various monetary and macroprudential policy for the needs of the development of core model FPAS in the future (according to best practice from advanced countries which today has adopted the DSGE-based core model.

The next section of this paper will analyze the theoretical perspective of the model, particularly the microeconomic underpinning on explaining the economic agent’s behavior. Section three outlines the methodology on constructing, validating, and using the model for simulation. Section four present the result and analysis and section five outline the conclusion and the implication of this research.

II. THEORY

One rare component within a model applied by central bank particularly before the global crisis 2007/2008 is the financial sector with financial frictions. This is very unfortunate because the transmission mechanism of macroeconomy policy depends much on the characteristic of financial sector. As stated by Roger and Vleck (2011), the addition of credit and financial intermediation in the model of macroeconomy which is used by central bank will be very helpful to explain the dynamics of the business cycle influenced by the procyclicality from financial sector. Besides they can mention the important of modeling this balance sheet from households
as well as the influence from durable assets such as housing toward the transmission of the macroeconomy policy.

2.1. Financial Friction Modelling in DSGE Model

Based on the literature which develops until today, there are two main approaches which can be used to insert financial frictions into the model of DSGE: the approach of financial accelerator and collateral constraints. Every approach has weakness and strength which is still debated by economy expert both in the academician and in central bank.

The basic assumption from the approach of financial accelerator is the availability of information asymmetry between the borrower and patient household so that results external finance premium which presents the different between the cost if borrowing money compare to if using own money. External borrowing premium is determined by the amount of net worth from the borrower and this will determine the amount of loan which can be borrowed. Net worth is defined as the numbers of assets belong to the borrower reduced by his liability. In the better economy condition, the borrower has a better net-worth, increases his credit worthiness and decreases his external finance premium. In contrast, when economy condition is bad, the low net-worth will decline the credit worthiness and increases the cost to borrow. The dynamics of external finance premium which is countercyclical is a mechanism that can amplify the response from PDB and investment toward shock. For example, the initial response from PDB to from technology will be accelerated by the increasing of assets price which may occur as the result effect the shock. The high assets price will increase net worth of the borrower which results the decline of external finance premium and in the end will increase the investment. The approach of financial accelerator can help to describe the number of change of the investment and output response which is in the form of hump-shaped toward the change of interest rate which is moderate.

The same as financial accelerator approach, the base mechanism from collateral constraint approach is the movement from asset price interacts with the imperfection located in credit market making a process that enlarges the respond from shock. However, different with financial accelerator approach, net worth from direct borrower will influence the number of loan that can be accepted and do not pass its impact toward external finance premium. In order to provide an insentif for borrower to return its loan, patient household requires that there is collateral when giving a loan. Durable asset for instance land, house or capital goods is usually used as collateral.

At first, both financial accelerator approach and collateral constraint approach assume that borrower can get the fund from the patient household directly without any financial intermediation from bank. By introducing banking sector to DSGE model will give additional method in modeling the financial friction related to the cost or price of intermediation.
The instrument from the macroprudential policy is aimed to prevent or block the effect of procyclicality of financial system. The instruments such as the constraint loan to value ratio, countercyclical capital requirement and time-varying reserve requirement work through either the balance sheet of the financial sector or the balance sheet of the borrower. This make the financial friction and the balance sheet of banking sector which are modelized separately in an explicit way are two requirements that have to be fulfilled in order to be able to simulate the transmission mechanism from the instrument of the macroprudential policy.

Gerali et al (2010) develops the DSGE model which is completed with banking sector which lately many use it as the basic model development for the needs of simulation of macroprudential policies in many central banks. The model which is developed is DSGE model for close economy with friction on credit market in the form of borrowing constraint and banking sector which operates in the condition of monopolistic competitive. In the model, there are agents which functioned as the patient household or patient households and borrower (impatient households and entrepreneur). The two agents of borrower (impatient households and entrepreneur) have to face borrowing constraint in the form of collateral constraint ala Iacoviello (2005) which are related to the number of assets belong to them (housing assets for impatient household and capital goods for entrepreneur). The bank balance sheet which is modelized consists of deposit and capital from the side of liabilities, and loan distributed to the borrower agents from the side of assets. Banks makes the capital accumulation through retained earnings and has to fulfill the requirement of Capital Adequacy Ratio (CAR) determined by the central bank. It is assumed that bank has the market power on gathering market and fund distribution and it determines different interest rate level for the loan given to impatient households and entrepreneur. It is

![Figure 1. the Scheme of Model of Gerali et al (2010)](image-url)
also assumed that there is “stickiness” from the response of the interest rate banking retailers toward the dynamics of the interest rate policy.

Model proposed by Gerali et al (2010) is estimated in Bayesian by using the data from Euro area. That model has been applied to study the role of financial friction and financial intermediation by bank in determining the dynamics of business cycle, particularly how the transmission from the monetary policy to the real sector is influenced by those two. Besides, Angelini et al (2010) also uses this model to learn the extra procyclicality caused by Basel II relative to Basel I. in 2011, Angelini et al reaplicates Gerali model to study the interaction between the monetary policy and macroprudential policy.

2.2. The Characteristic of Banking Sector in Indonesia

One assumption applied in modeling banking sector in DSGE by some central banks is the existence of market power from bank either in fund collection or its distribution; therefore the bank posses the power in determining the level of deposit and credit interest rate. Some empirical researches support this assumption. One of them is Purwanto (2009) who concluded that the dynamics of spread of the banking interest rate (defined as the different of the interest rate of fund distribution reduced by the interest rate of gathering fund interest) most is influenced by the dynamics of the level of banking industry concentration in Indonesia. In that research, that uses Herfindahl-Hirschman Index as the measurement of the level of banking industry concentration. Based on the empirical model estimation using individual monthly data bank (panel) from January 2002 to April 2009, it was concluded that the decrease of interest rate spread along the estimation period was caused by the incline competition in banking sector due to the raising of market share from some of big banks followed by the decrease of market share from bank with big assets. This is in line with the research using Structure-Conduct-Performance approach which correlate the market concentration and market power and the behavior of interest rate determination (Berger et.al, 2004).

Besides, in DSGE model developed in manycentral banks is also assumed to have “stickiness” in the retail banking interest rate if associated with the dynamics of interest rate policy. From the theoretical point of view, bank sees that it is optimal to not always change the interest rate if the demand of the consumers is inelastic in the short term because of the high switching cost (Calem et al., 2006) or because of certain fixed cost (menu cost) in doing the change of interest rate level (Berger and Hannan, 1991). The other theoretical reason which is also stated by economy expert is the needs of bank to maintain its relation with consumer so that it conducts interest rate smoothing to protect consumer from fluctuation of market interest rate (policy). This enables bank to determine the high interest rate when the interest rate policy is low (Berger and Udell, 1992).
In simple way, the rigid short term response from the retail banking interest rate toward the dynamics of interest rate policy can be seen on the result of impulse response in Figure 2.1. that Impulse response comes from bivariate VAR system\(^2\) which consists of variable: (1) BI rate with consumption credit interest rate; (2) BI rate with credit interest rate for firms (measured averagely between investment credit interest rate and working capital credit); and (3) BI rate with Deposit rate (measured averagely for all categories of DPK). It can be seen in Figure 2.1 that the short term response from retail bank interest rate toward the change of BI rate is relatively limited, especially for the consumption credit interest rate. Deposit interest rate and credit interest rate for firms have the response which is relatively the same. Eventhough its value is not as small as the response of the consumption interest rate; it still shows the level of quite high stickiness.

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\(^2\) Every VAR system also consists of exogenous variable, which is the amount of reserve ratio for VAR from the deposit interest rate and the amount of capital, the value of risky assets (ATMR multiply by credit total), and the amount of loan distributed for VAR of loan interest rate.
2.3. The Model Structure

Model which is developed for this research is based on the model of Gerali et al (2010) which has included banking sector into New Keynesian DSGE Model ala Christiano et al (2005). The main modification is conducted by implementing the assumption of small open economy and adding agent of government to enrich the ability to simulate macroeconomy policy. The standard feature of DSGE model which consists of the existence of habit persistence in doing consumption, adjustment cost relate with the investment change, sticky prices and sticky wages modelling; those have been included in this developed model. The complete scheme of the Model can be seen on Figure 3.1.
In the model, there are two groups of household, which are Patient and Impatient Households as well as Entrepreneur. The different of those three agents is in the discount factor, in which Patient Households has higher discount factor value than the value of discount factor of Impatient Households and Entrepreneur\(^3\). Households do the consumption activity, providing labor, paying taxes to government and accumulating housing assets, meanwhile the entrepreneur produces homogeneous intermediate goods by using capital goods bought from capital goods producers and labors from households. Then, the homogeneous intermediate goods produced by entrepreneur is sold to domestic retailer (for domestic market) and exporting retailer (for international market) which will change it into differentiated goods. Final goods producers will act as aggregator that joint intermediate differentiated goods which comes from domestic market and from abroad (goods which is bought from importing retailers).

In the model, there are also capital goods producers and housing producers which use goods produced by final goods producers to produce capital goods and housing with technology which have to face the investment adjustment cost. This adjustment cost makes a possible price for capital goods and housing to be different from the consumption goods price.

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\(^3\) This is to ensure that in the equilibrium of collateral constraint which is stated to have the characteristic of binding and patient households acts as savers, whereas impatient households and entrepreneurs act as borrowers. For further explanation see Iacoviello (2005) and Liu et al (2010)
There are two types of financial instrument provided by Bank for economy agent in the model: saving account (deposit) and loan/credit. The economy agent has to face borrowing constraint if he will borrow money from bank. This borrowing constraint relate with its collateral value, which are housing stocks for households and the value of capital goods for entrepreneur. The differences occur in the discount factor of the economy agents possible the financial flow in equilibrium where patient household acts as the lender (having deposit), while impatient households and entrepreneurs borrow from bank.

The banking sector operates in the condition of monopolistic competitive in which the bank determine the interest rate level both deposit and loan to maximalize the profit that it will get. The amount of loan distributed by bank can be funded by gathered deposit as well as by owned capital. We conduct modification in the model of Gerali et al (2010) by adding risk free asset as part of the assets owned by bank. This risk free asset can be in the form of SBI (certificate of Bank Indonesia) or in the form of SBN (Loan to government). Besides borrowing form bank, entrepreneur and government also has the access coming from abroad.

We conduct a little modification to the initial model developed Gerali et al (2010) in terms of the process of financial intermediation that some agents in this model also has access to some sources of financing from abroad. For the needs of the model simplification, only entrepreneurs and governments who have access to foreign financing.

In accordance with Gerali model approach, we also assume that there is market power of banks in the gathering and distribution market of financing so that bank has the power to determine the level of deposit interest rates and credit interest rates. In addition, it is also assumed that there is “stickiness” in the retail bank interest rate if it is associated with the dynamics of the interest rate policy. The balance sheet of bank included in the model is also slightly more detail than Gerali models with the addition of risk-free assets and the reserve as part of the assets owned by the bank. This is in accordance with the condition of the balance (aggregate) of Indonesia banking which is still showing a big excess liquidity in the form of SBI and SBN. This is a pretty important addition given the existence of excess liquidity that it can affect the transmission of monetary policy and macroprudential policy.

<table>
<thead>
<tr>
<th>Table 1</th>
<th>Bank Balance Sheet</th>
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</thead>
<tbody>
<tr>
<td><strong>Assets</strong></td>
<td><strong>Liabilities</strong></td>
</tr>
<tr>
<td>Total Loan</td>
<td>Deposit</td>
</tr>
<tr>
<td>Risk Free Asset (SBI and SBN)</td>
<td>Capital</td>
</tr>
<tr>
<td>Reserve</td>
<td></td>
</tr>
</tbody>
</table>
Every bank in the model consists of three units, namely two branches of ‘retail’ and a ‘wholesale’ units. The first retail branch is responsible to provide different loan for the impatient Households and entrepreneurs, while the second retail branch is responsible for collecting deposits from patient households. Every wholesale unit operates in the perfect competition market and serves to manage the bank’s overall balance sheet:

\[ RF_t + B_t = (1 - \Gamma_t) D_t + K^b_t \]  

(1)

In which \( RF_t \) is risk free asset, \( B_t \) is the total loan distributed by bank, \( D_t \) is the total deposit which is gathered, \( \Gamma_t \) is the reserve ratio determined by bank and is influenced by reserve ratio requirement determined by central bank, and \( K^b_t \) is the bank capital.

It is assumed that the banks do not have access to capital financing from the outside so the only way to increase their capital through retained earnings:

\[ K^b_t = (1 - \delta^b) K^b_{t-1} + w^b j^b_{t-1} \]  

(2)

Where \( j^b \) is the overall profit generated by the three units of banks, \((1-w^b)\) shows the portion of the dividend distribution of the bank; and \( \delta^b \) shows the resources used in managing the bank capital. The rules regarding dividends are assumed exogenous and fixed, so that bank capital is not a variable choice for the bank. Completely, the utility function of wholesale unit is:
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Where \( \lambda_t^{P} \) is a stochastic discount factor, \( R_t^b \) is a wholesale lending rate, \( R_t^d \) is a wholesale deposit rates, and \( r_t \) a central bank interest rate policy. FOC of the objective function of the wholesale unit illustrates the equation that determines the interest rate on loan and deposit given to loan branch and deposit branch:

\[
Max_{\{\text{risk free, } B_t, D_t\}} = E_0 \sum_{s=0}^{\infty} (\lambda_t)^s \frac{\beta_t^P}{\lambda_t^P} \left[ \Gamma_{t+s} D_{t+s} \right. - \Gamma_{t+s+1} D_{t+s+1} + \left( 1 + r_{t+s} \right) R_{t+s} - R_{t+s+1} \\
+ \left( 1 + R_{t+s}^P B_{t+s} - B_{t+s+1} + D_{t+s+1} - \left( 1 + R_{t+s}^d D_{t+s} \right) \right) \left. + \Delta K_{t+s+1} \right] \left( K_{t+s}^b \right) / \left( K_{t+s+1}^b \right)^{2} R_{t+s+1}^b 
\]

s.t. \( RF_t + B_t = (1 - \Gamma_t) D_t + K_t^b \) (4)

Where \( \lambda_t^P / \lambda_t^P \) is a stochastic discount factor, \( R_t^b \) is a wholesale lending rate, \( R_t^d \) is a wholesale deposit rates, and \( r_t \) a central bank interest rate policy. FOC of the objective function of the wholesale unit illustrates the equation that determines the interest rate on loan and deposit given to loan branch and deposit branch:

\[
R_t^b - r_t = -\left( \omega_t^b B_t \right) - C_{t}^b \left( x_t^{b} \omega_t^b - \nu_{b,t} \right) \left( x_t^{b} \omega_t^b \right) \quad (5)
\]

\[
r_t (1 - \Gamma_t) = R_t^d \quad (6)
\]

In condition \( CAR = \frac{K_t^b}{\omega_t^b B_t} = \nu_{b,t} \) then \( R_t^b = r_t \). While the condition \( CAR > \nu_{b,t} \) then the bank will react by lowering the number of CAR by increasing the amount of loan distribution \( B_t \) (by decreasing \( R_t^b \)), so that the magnitude of the CAR can approach the minimum quantity of rules, \( CAR \approx \nu_{b,t} \).

In condition of \( GWM = \Gamma_t = 0 \), then \( R_t^d / r_t = 1 \), while in a state of \( GWM>0 \) then the bank will experience an increase of opportunity cost in the distribution of funds that banks react to lower costs by reducing the amount of deposits, equivalent to reducing \( R_t^d \).

Following the modifications made by Angelini et al (2011), we also include the variable weights of risky assets \( \omega_t^b \) to allow the calculation of CAR (Capital Adequacy Ratio) that is more realistic on model. This weight variable will be multiplied by the total loan to generate Risk Weighted Assets (RWA). The addition of variable weights also allows the entry of default risk as one of the variables that determine the dynamics of the CAR-owned by banks. The value of \( \omega_t^b \) that determine the amount of RWA depends on the composition of the bank risk assets and the amount of default risk. To illustrate this relationship, we add an ad hoc equation as follows:

\[
\omega_t^b = \rho^{o} \omega_t^{b-1} + (1 - \rho^{o}) \alpha_a b_t^{E} + (1 - \rho^{o}) \alpha_b npl_t
\]

For \( npl_t \), which is a proxy of default risk, we assume the dynamics of the AR (1) with iid errors (independent and identically distributed).
In addition, we also add an ad hoc equation to describe the dynamics of the reserve ratio selected by the bank. Previously we set first the dynamics of the reserve requirement ratio \( \hat{r}_t \) that is determined by the central bank as follows (in the form of log linearization):

\[
\hat{r}_t = \rho_t \hat{r}_{t-1} + \hat{e}_{r,t} \tag{8}
\]

Then, this Reserve requirement ratio will determine the amount of excess reserve \( \hat{e}_t \) which is determined by bank:

\[
\hat{e}_t = \rho_t \hat{e}_{t-1} + (1 - \rho_t) \hat{r}_t + \hat{e}_{r,t} \tag{9}
\]

And the dynamics of reserve is:

\[
\hat{r}_t = \lambda_t \hat{r}_t + (1 - \lambda_t) \hat{e}_t \tag{10}
\]

In this model, the degree of market power held by the banks is determined by the amount (steady state value) the elasticity of the demand of deposit or loan. The lower the absolute value of the elasticity, the higher the monopoly power of the bank is. It is assumed that the credit (deposits) is distributed to (gathered from) households and entrepreneurs is a composite basket of CES (Constant Elasticity of Substitution) from a number of slightly differentiated products offered by the bank-j branch with the elasticities of substitution for \( \varepsilon_{b,H} \), \( \varepsilon_{b,E} \) and \( \varepsilon_{d} \). These three elasticities value will affect the mark-up (for credit) and mark-down (for saving account / DPK) that is set by banks in order to determine interest rate. Or in other words, the value of this elasticity determines the spread between the interest rate policy to credit interest rate (and deposit interest rates). It is assumed that these three elasticities values are stochastic and change that occur in these values can be interpreted as the change in the spread of retail bank interest rate which occurs outside of the influence of monetary policy.

The equation of the credit demand for entrepreneurs \( (b_t^E) \) and impatient households \( (b_t^I) \):

\[
b_t^E(j) = \left( \frac{r_{E}(j)}{r_{E}} \right)^{-\varepsilon_{E}} b_t^E \tag{11}
\]

\[
b_t^I(j) = \left( \frac{r_{I}(j)}{r_{I}} \right)^{-\varepsilon_{I}} b_t^I \tag{12}
\]

The equation of loan demand \( (d_t) \) by patient household:

\[
d_t(j) = \left( \frac{r_{d}(j)}{r_{d}} \right)^{-\varepsilon_{d}} d_t \tag{13}
\]
Loan branch gets wholesale loans $B_t$ from wholesale unit with interest rate $R_t^b$, then distributes it to Households and entrepreneurs by applying two different markups. In order to apply the stickiness and to study the implications of imperfect banks pass-through, it is assumed that each bank faces quadratic adjustment cost if conducting the change of loan interest rate. The amount of the cost is determined by the parameters of $\kappa_{be}$ and $\kappa_{bh}$. The Utility function from loan branch is below:

$$\max_{\{t^{bh}(j), t^b(j)\}} E_0 \sum_{s=0}^{\infty} (\beta_p)^s \frac{\partial \pi^b_s}{\partial \pi} \left[ R_t^{bh}(j) b_t^{bh}(j) + R_t^{be}(j) b_t^{be}(j) - R_t^b B_{t+s}(j) - \frac{\kappa_{bh}}{2} \left( \frac{R_t^{bh}(j)}{R_t^{bh-1}(j)} - 1 \right)^2 \right]$$

subject to

$$b_t^b(j) = \left( \frac{R_t^{bh}(j)}{R_t^{bh-1}(j)} \right)^{b_t^b(j)}$$

$$b_t^e(j) = \left( \frac{R_t^{be}(j)}{R_t^{be-1}(j)} \right)^{b_t^e(j)}$$

$$B_t(j) = b_t(j) + b_t^e(j)$$

Similar to loan branch, deposit branch collects deposit $d_t$ from household and forwards it to the wholesale unit which, then, gives the interest rate $r_t^d$. Utility function of deposits branch are as follows:

$$\max_{\{t^d(j)\}} E_0 \sum_{s=0}^{\infty} (\beta_p)^s \frac{\partial \pi^d_s}{\partial \pi} \left[ R_t^d D_{t+s}(j) - r_t^d D_{t+s}(j) - \frac{\kappa_d}{2} \left( \frac{r_t^d(j)}{r_{t+s-1}^d(j)} - 1 \right)^2 \right]$$

subject to

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

$$D_t(j) = d_t(j)$$

In addition to the banking block above, there are also other blocks of equation representing the agent behavior including the household, the entrepreneur, the producer, the retailer, the government, and the central bank. The simultaneous interaction across market and the agents will be closed with market clearing condition. The full structure of the model is available on the authors.
III. METHODOLOGY

3.1. Data and Variables

For the needs of estimation, it used quarterly data from the first quarter 2004 to the fourth quarter 2011. Data for the real sector used for the estimation are private consumption, private investment, government expenses, export, import, CPI inflation, import deflator, export deflator, and exchange rate. For PDB disaggregation data, export deflator and import deflator use data which comes from PDB publication based on expenses from BPS. In addition, exchange rate and CPI inflation data are gathered from the model database of ARIMBI/ SOFIE. Moreover, for the variable of external sector, it uses data that are already used by ARIMBI and SOFIE which are world PDB, USA inflation and LIBOR.

In banking sector, the data used are BI rate, interest rate and the number of collected third party fund (DPK), bank capital, interest rate and household credit distribution (consumption credit), interest rate and firm credit distribution (investment credit and working capital), the number of SBI (and other monetary operations) owned by bank, the number of receivable (claim) of bank to central government (SBN), the number of reserve (include Cash in Vault) bank and Non Performing Loan (NPL). Moreover, the composition of bank balance sheet used is derived from the Balance Sheet Analysis of Conventional Bank.

3.2. Callibration and Model Validation

As stochastic general equilibrium model, the performance criteria of the model consist of model stability, convergency, and its accuracy; both in simulation and forecast. The DSGE models is a general equilibrium model and the analysis conducted relies on the long-term equilibrium or the steady state.

One technique for determining the steady state is the HP filter. We apply this approach on the component of the bank’s balance sheets including deposits, capital, total loans, placement on SBI, loans to government (SBN), and reserves owned by the bank. Several steady state values for particular variables are obtained from the existing model in Bank Indonesia. This is important to maintain the consistency with the core model used in Bank Indonesia.

Some parameters in the model base on calibrated values from the previously developed model by Bank Indonesia and also from related empirical research results. The rest parameters refer to previous studies, such as CAPU from Gerali et.al (2010), the elasticity of substitution between domestic and foreign goods, and the elasticity of substitution for export goods from Verikios and Zhang (2006). The calibration of the model also uses the result of estimated partial equations on the data.
The focus of this paper is to build a DSGE models that internalize the banking sector. Furthermore, the simulation carried out on this research is restricted to the shock in Bi rate, reserve requirement, bank’s capital, and the shock to the default risk of the bank.

**IV. RESULT AND ANALYSIS**

**4.1. Steady State Condition and Model Callibration**

In determining the steady state value of the real sector variable, it uses realization data for the estimation period (2001Q1 – 2011Q4) as the main guidance. However, writers also consider the steady state value used in DSGE model of developed country or developing country as comparison.

For the disaggregation variable of PDB, based on the data during the estimation period that has been processed using HP Filter, then the gathered result can be seen in Figure 6.

![Graphic 2. Steady State Variable of Dissagregation of PDB Based on Data](image)

In contrast with disaggregation conducted by BPS for investment variable (business and building investments), in investment model is divided into 2 which are housing investment and investment for capital goods. To get the value of steady state from housing investment ratio from total PDB, writers multiply the ratio of housing settlement value for building category (0.4) with the mean of building investments ratio from total investment (0.83), then it is multiplied again with investment ratio toward PDB (0.22). Using this approach (rounding), writers set the value of steady state for housing investment ratio from the total of PDB which is 0.08.
Using the same approach, writers can also get the value of steady state for the variable of bank balance sheet component. However, as seen in Figure 4.3, the results of HP Filter for the variable of bank balance sheet component toward total asset do not show the stability in certain value. Besides using the result of HP Filter presented in Figure 8, it is also used the research result from Gunadi and Budiman (2011) about optimalization the composition of bank portfolio in Indonesia to determine the value of steady state and variable of bank balance sheet which is completely shown on Table 2.
The steady state value of BI rate variable uses the same value used by ARIMBI model which is 5.75%. This value is far different from the value of the mean of HP Filter of BI rate during estimation period which is for about 6.5%. However, for the needs of consistency of ARIMBI core Model, writers use number which is lower. If writers see Figure 4.4 that presents the result of HP filter from many variables of BI rate in model, it is shown that the spread between BI rate and deposit interest rate is unstable. When BI rate is high, spread with deposit interest rate is also high, while whenever BI rate is low, spread with deposit interest rate is low. Since writers use the steady state value of BI rate which is classified as low then for data consistency, it uses a low spread to calculate steady state of deposit interest rate. Using this method, writers set steady state value of deposit interest rate of 4.5%. For setting the steady state value of interest rate of consumption credit, writers add the difference mean between those both interest rate and BI rate during estimation period so that a steady state value of interest rate of consumption credit for about 13.65% and steady state value of interest rate of credit for firm is gathered (working capital and investment) which is 11.4%. Moreover, for
LIBOR interest rate that becomes proxy from foreign interest rate, writers use the same number used in ARIMBI model which is 3%.

In detail, steady state value for entire variables used by model is located on Table 3.

<table>
<thead>
<tr>
<th>Table 3</th>
<th>Steady State Value for the Entire Variable</th>
</tr>
</thead>
<tbody>
<tr>
<td>Variables</td>
<td>Assets</td>
</tr>
<tr>
<td>Consumption to GDP ratio</td>
<td>0.59</td>
</tr>
<tr>
<td>Capital investment to GDP ratio</td>
<td>0.14</td>
</tr>
<tr>
<td>Housing investment to GDP ratio</td>
<td>0.08</td>
</tr>
<tr>
<td>Government expenditure to GDP ratio</td>
<td>0.09</td>
</tr>
<tr>
<td>Import to absorption ratio</td>
<td>0.38</td>
</tr>
<tr>
<td>Export to output ratio</td>
<td>0.44</td>
</tr>
<tr>
<td>Loan to HH to GDP ratio</td>
<td>0.31</td>
</tr>
<tr>
<td>Loan to entrepreneur to GDP ratio</td>
<td>0.71</td>
</tr>
<tr>
<td>Deposit to GDP ratio</td>
<td>1.28</td>
</tr>
<tr>
<td>Importer’s profit margin</td>
<td>0.11</td>
</tr>
<tr>
<td>Exporter’s profit margin</td>
<td>0.08</td>
</tr>
<tr>
<td>Domestic retailer’s profit margin</td>
<td>0.25</td>
</tr>
<tr>
<td>BI rate *</td>
<td>5.75%</td>
</tr>
<tr>
<td>Rate on loan to HH*</td>
<td>13.65%</td>
</tr>
<tr>
<td>Rate on loan to entrepreneur*</td>
<td>11.4%</td>
</tr>
<tr>
<td>Rate on deposit*</td>
<td>4.5%</td>
</tr>
<tr>
<td>Foreign interest rate*</td>
<td>3%</td>
</tr>
<tr>
<td>CAR</td>
<td>0.14</td>
</tr>
<tr>
<td>Bank’s profit to total asset ratio</td>
<td>0.2</td>
</tr>
<tr>
<td>NPL ratio</td>
<td>0.3</td>
</tr>
<tr>
<td>Deposit to bank’s total asset ratio</td>
<td>0.9</td>
</tr>
<tr>
<td>Bank’s capital to total asset ratio</td>
<td>0.1</td>
</tr>
<tr>
<td>Loan to bank’s total asset ratio</td>
<td>0.7</td>
</tr>
<tr>
<td>Risk free asset to bank’s total asset ratio**</td>
<td>0.2</td>
</tr>
<tr>
<td>Reserve to total asset ratio</td>
<td>0.1</td>
</tr>
</tbody>
</table>

Some parts of parameters used in model are calibrated by using the value of model that have been developed by Bank Indonesia and related empirical research result. Capital share in production function is set 0.54 according to the estimation result of MODBI 2012 model. Parameters of CAPU use the value which is used by Gerali et al (2010). The value of home bias parameter is set based on HP Filter value of Indonesia import to absorption ratio during estimation period. Parameter determining elasticity of substitution between domestic and foreign goods and elasticity of substitution for export goods uses the value come from the research of Zhang.
and Verikios (2006). Parameter value for risk premium and cost for bank capital management are gathered by the connection of steady state among any variables located in model. Calvo parameter for labour follows the estimation result from BISMA model (2009). In addition, parameters from ad hoc equations that determines the dynamics from the value of risked asset (equation 3.36) and reserve that has by bank (equation 3.37 - 3.39) use the estimation result of partial equation based on the data during estimation period.

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mark-up parameter in labor market</td>
<td>ε_w</td>
</tr>
<tr>
<td>Depreciation rate of capital</td>
<td>δ_k</td>
</tr>
<tr>
<td>Depreciation rate of housing asset</td>
<td>δ_r</td>
</tr>
<tr>
<td>Cost to managing bank's capital</td>
<td>δ_b</td>
</tr>
<tr>
<td>CAPU parameter 1</td>
<td>ξ_1</td>
</tr>
<tr>
<td>CAPU parameter 2</td>
<td>ξ_2</td>
</tr>
<tr>
<td>Risk premium parameter</td>
<td>ρ^b</td>
</tr>
<tr>
<td>Capital share in production function</td>
<td>α</td>
</tr>
<tr>
<td>Home bias parameter</td>
<td>η</td>
</tr>
<tr>
<td>Elasticity of substitution between domestic and foreign goods</td>
<td>μ</td>
</tr>
<tr>
<td>Elasticity of substitution for export goods</td>
<td>μ^e</td>
</tr>
<tr>
<td>Labour income share of unconstrained household</td>
<td>μ_l</td>
</tr>
<tr>
<td>The probability of given labor (from patient and impatient HH) is selected not to reoptimize its wage</td>
<td>θ_ω_p, θ_ω, θ_ω_i</td>
</tr>
<tr>
<td>Risky weight equation's parameter 1</td>
<td>ρ^α</td>
</tr>
<tr>
<td>Risky weight equation's paremeter 2</td>
<td>α_a</td>
</tr>
<tr>
<td>Risky weight equation's parameter 3</td>
<td>α_b</td>
</tr>
<tr>
<td>Reserve equation's parameter</td>
<td>ρ_T</td>
</tr>
<tr>
<td>Excess reserve equation's parameter</td>
<td>ρ_s</td>
</tr>
</tbody>
</table>

The determination of prior for parameter that is estimated using the same approach by determining calibrated parameter uses the value from model that have been developed in the previous time or from related empirical research. For parameter κ_d, κ_be and κ_br, prior are determined by setting the response of interest rate of bank retail toward shock of interest rate policy according to the estimation result from immediate pass-through done by Harmanta and Purwanto (2012). Moreover, for Taylor rule parameter (φ_, φ_z and φ_y), the value of prior is determined according to the value used by ARIMBI model core. Prior for parameter regulating

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4 Used the parameter calculation based on CES estimation according to the assumption used in model that is developed in this research.
the habit persistence in household consumption activity uses the estimation result of BISMA model (2009). In detail, prior distribution, distribution type and posterior distribution from the parameter of estimation result are located in Table 5.

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Distributions</th>
<th>Prior Distribution</th>
<th>Posterior Distribution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inverse of intertemporal elasticity of substitution for housing $\sigma_z$</td>
<td>normal</td>
<td>2</td>
<td>0.5</td>
</tr>
<tr>
<td>Inverse of intertemporal elasticity of substitution for consumption $\sigma_c$</td>
<td>normal</td>
<td>2</td>
<td>0.1</td>
</tr>
<tr>
<td>Inverse of Frisch elasticity of labour supply $\sigma_n$</td>
<td>normal</td>
<td>2</td>
<td>0.1</td>
</tr>
<tr>
<td>Adjustment cost parameter for deposit rate $K_d$</td>
<td>gamma</td>
<td>3.25</td>
<td>0.2</td>
</tr>
<tr>
<td>Adjustment cost parameter for entrepreneur loan rate $K_{pe}$</td>
<td>normal</td>
<td>3.5</td>
<td>0.2</td>
</tr>
<tr>
<td>Adjustment cost parameter for household loan rate $K_{hi}$</td>
<td>normal</td>
<td>8</td>
<td>0.2</td>
</tr>
<tr>
<td>Adjustment cost parameter for capital investment $K_k$</td>
<td>gamma</td>
<td>2</td>
<td>0.2</td>
</tr>
<tr>
<td>Adjustment cost parameter for housing investment $K_z$</td>
<td>normal</td>
<td>2</td>
<td>0.5</td>
</tr>
<tr>
<td>Adjustment cost parameter for bank’s CAR $K_{kb}$</td>
<td>beta</td>
<td>2</td>
<td>0.2</td>
</tr>
<tr>
<td>Calvo parameter for import goods $\theta_i$</td>
<td>beta</td>
<td>0.5</td>
<td>0.05</td>
</tr>
<tr>
<td>Calvo parameter for domestic goods $\theta_h$</td>
<td>beta</td>
<td>0.5</td>
<td>0.05</td>
</tr>
<tr>
<td>Calvo parameter for export goods $\theta_i^*$</td>
<td>beta</td>
<td>0.5</td>
<td>0.05</td>
</tr>
<tr>
<td>Interest rate smoothing parameter in Taylor rule $\phi_r$</td>
<td>beta</td>
<td>0.75</td>
<td>0.01</td>
</tr>
<tr>
<td>Inflation weight parameter in Taylor rule $\phi_s$</td>
<td>gamma</td>
<td>1.9</td>
<td>0.01</td>
</tr>
<tr>
<td>Output gap parameter in Taylor rule $\phi_f$</td>
<td>normal</td>
<td>0.25</td>
<td>0.01</td>
</tr>
<tr>
<td>Habit persistence parameter in consumption $\zeta$</td>
<td>beta</td>
<td>0.6</td>
<td>0.05</td>
</tr>
</tbody>
</table>

### 4.2. Model Validation

In this part it will learn the dynamics of impulse response resulted by model. The discussion will focus on the simulation of monetary policy in the form of BI rate’s shock, reserve requirement, and default risk.
The increase in BI rate 1% will be transmitted to any interest rate in banking sector. This increase number of interest rate is suited with the number of mark-up and stickness level from each interest rate. Deposit interest rate increase higher than loan interest rate because it has mark-down value and stickness level which is the smallest. Eventhough bank implement a high mark-up value toward loan interest rate on household (consumption credit) but the stickness level from this interest rate is very high. It causes the interest rate of household loan to rise as big as 0.1%. By this stickness, it is seen that the spread of loan interest rate of HH toward BI rate decrease about 0.6%. This decreasing spread only happens during 3 periods and it will back again to its steady state position in the fourth period. The same thing occurs in entrepreneur loan rate which increase 0.2%. By the increase of 0.2% then the spread entrepreneur loan rate toward BI rate also decrease 0.4%. This declining spread only occurs during 2 periods and it will back again to its steady state condition in the third period. The increase of loan rate will be responded by reducing loan distribution, as the result of household demand or entrepreneur. In total, loan distribution by banking decrease 1% (on the lowest point). This declining loan distribution make bank must transfer half of its owned fund into risk free asset (the increase...
is for about 3.5%). This declining loan distribution also makes bank in the declining condition of LDR about 1%.

The increase occurs on deposit rate and loan rate for household cause the consumption decrease. The increase on loan rate either for household or firm cause the decline of capital goods investment and housing asset. In addition, the rising happen on loan rate also causes exchange rate appreciation that will impact on declining export. Import also declines since the decline of the demand for the needs of consumption and investment.

**Reserve Requirement’s Shock**

The increase in reserve requirement rate (GWM) for about 1% will be responded by bank by leveling down its deposit rate according to FOC of utility function of banking sector. This will cause a little reduction in the number of deposit collected by bank. Parallel with the reduction of loanable fund owned by bank, then banks conduct trasfering asset from risk free assets classification to assets with higher return value, which is loan to households and entrepreneur. This condition makes change happen toward total loan that is distributed by banking sector is not too big. Without a significant change toward the number of deposit collected and the number
of loan distributed, then the value LDR or CAR has not changed very much. LDR in the short term period increases because there is an increase in loan distribution caused by transferring assets from asset one classified as risk free assets. CAR has a little progress because the bank profit has increased due to the placement on asset that has a higher return. The insignificant change of deposit number collected and loan number distributed by banking cause the influence from GWM ratio shock to real sector variable (GDP, inflation, and exchange rate) becomes quite insignificant.

**Bank Capital’s Shock**

When the shock of the decline of bank capital happens, bank will react by decreasing loan distribution. This condition will cause the reduction of PDB and inflation. Central bank needs to encourage in the form of the decline of interest rate policy to avoid a higher decline of PDB.

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**Default Risk’s Shock**

The increase in default risk for about 1% will be responded by bank by reducing loan distribution and rising risk free asset that it is owned. The reduction in loan distribution by bank
will cause the decline of LDR. By the increasing of default risk, CAR owned by bank will be decreased as the result of enhancement of risk weighted in RWA calculation. In general, it can be seen that the movement of any components of bank balance sheet is not quite significant. To repair the response of any variable in model because of the shock of default risk, it has been tried to make NPL equation become pro-cyclical to make “semi” financial accelerator mechanism. However, since the influence path from default risk is only from the calculation of risky asset weighted which is also very depend on portfolio choices of bank asset on that time, then the influence of this pro-cyclical is not quite significant. For further development and for repairing impulse response to default risk shock and entrepeneur loan LTV, it will model the influence of this default risk to mark-up value from loan determined by bank.

V. CONCLUSION

In this research, DSGE model is built for small open economy, in which this model has been completed with financial frictions in the form of collateral constraints and banking sector which are designed according to the condition of Indonesia. The model constructed on this paper has succeeded to internalize the banking sector and carry out a series of simulation on the shock in BI rate, reserve requirement, bank’s capital, and the shock to the default risk of the bank.
By internalizing the banking sector in the model, it is now possible to conduct policy analysis to deal with the shock arising from the banking sector. When a sudden decline occurs in the bank’s suddenly (due to significant write-off on the assets), then the central bank needs to provide stimulus in the form of cuts in the BI rate, right in the event of the shock. Delays in BI rate cut by the central bank would lead to a larger decrease in output, which later require larger monetary policy stimulus. These results highlight the importance for the monetary policy to be implemented in time to face the shock stemming from the banking sector.

The analysis of impulse reponse of the model due to the shock of BI rate increase, changes in reserve requirement ratio, and the shock on default risk, confirm our model is valid to use. The simulation shows an increase of BI rate will cause bank to incline its retail interest rate, to decrease its loan distribution and to level up the risk free assets. Then, this will cause the decrease of PDB and inflation. Futhermore, the condition of liquidity excess in Indonesia banking sector make the increase occur on reserve requirement ratio determined by central bank not to have significant influence toward the real sector. This condition occurs because of the lessen of liquidity due to the incline of reserve bank which can be covered by bank by reducing its risk free asset, so that there will be no significant change in the total loan distributed by bank.

Related to default risk, this paper simulated a positive shock of 1% increase over the default risk. The results show the shock will be responded by the bank by a decreasing lending and increasing their risk-free assets. Nevertheless, the result of this simulation shows the limited impact of the effect of the default risk on the rate and the volume of the lending. Instead, the collateral constraint approach does not include the default risk as part of the dynamics of the interest rate and the amount of lending. An ad hoc equation added to the model that links the default risk with the dynamics of the bank’s CAR plays insignificant role.

Based on model validation via a series of simulation, further development is required below:

a) The improvement of model to support broader application relates with interaction between many monetary and macropudential policy. Things that can be implemented are modeling CAR requirement rule, LTV requirement rule and its interaction toward Taylor Rule.

b) Adopting partly or the whole concept of financial friction in the form of financial accelerator as in Bernanke, Gertler and Gilchrist (BGG) into the model.

c) The development of model is not only used as the model for the needs of simulation but also for the needs of projection of macro variable which is related to balance sheet and condition of banking sector.
REFERENCES


Prior - Posterior Graphs
null
Banking Sector and Financial Friction on Dsge Model: The Case of Indonesia