Monetary Policy in Managing Inflation in Indonesia: A Linear Rational Expectations Model

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Abstract

This paper assesses the (in)effectiveness of monetary policy in managing inflation by employing a linear rational expectations framework. Inflation targeting is currently the main flagship of the Indonesian monetary authority and such objective is carried out within a nearly perfect open economy which is succeptible to changes in external economic situations. We consider a macroeconomic model described by a couple of structural equations which consist of several exogenous variables as shock generators. The model is then solved by implementing undetermined coefficient methods. A series of simulation based on the state space representation of the model with respect to an impulse response function is performed to highlight some of key features of current inflation trends. It is shown that monetary policies (interest rate as operating policy) can effectively affect inflation in the short run, but it has limited power in the longer run. Furthermore, its effectiveness is hampered by the so called fiscal dominance and adverse global shocks. Thus, under such a situation it would be difficult for the monetary authority to set a credible inflation target.

Keywords: Inflation targeting, open economy, rational expectation model, undetermined coefficient method.

1. Introduction

Bank Indonesia as the country's monetary authority is by law given the task of maintaining the value of its currency. Under current policy framework, this is interpreted as inflation targeting (IT). Indeed, IT is increasingly popular amongst central bankers as the ultimate objective of monetary policy and many countries–developed and developing countries–have adopted it with great variation from lite to heavy targeting. See Bernanke et al. (1999) for lessons of inflation targeting in international perspectives.

Indonesia is a typical small open economy with liberalized current as well as capital accounts. Consequently, any disturbances in international markets will be transmitted through these accounts and

thereby affecting the overall domestic economy. The current global crisis has greatly affected the economy–stock market plummeted by more than 50 percent, the exchange rate is among the most depreciated, and domestic commodity prices fluctuated like a roller coaster. However, despite these facts, the growth rate is sustained at 4 to 5 percent, among the highest in the world.

This paper shed lights on the difficulty of maintaining a credible inflation target during the global crisis episode. Headline inflation increased from about 6 percent to a mere 12 percent between January to May 2008, but then as global commodity prices plummeted, the inflation rate declined very rapidly to just over 2 percent. Moreover, food prices seemed to be the main driver in consumer price movements. This variation in inflation poses a question over the effectiveness of inflation targeting.

It seems clear that the current roller coaster in inflation to some extend is associated with international shocks. However, few have involved a serious rigorous modeling attempt in order to assess the impacts of the crisis on a small open economy like Indonesia. Thus, in this paper we use the most up to date modeling techniques to facilitate such assessment. We employ a dynamic open economy macroeconomic model that features rational expectations, optimizing agents, and slowly-adjusting price of goods. Pioneering publications in the area were provided by Obstfeld and Rogoff (1995, 1996). A more recent work can be found in McKibbin and Stoeckel (2009).

In this paper we develop an open economy macroeconomic model governed by a couple structural equations. Since the dynamics of the model are backward and forward looking, we adopt the so-called linear rational expectation model (LREM), which is solved by using undetermined coefficient method, to analyze the macroeconomic model. A rather comprehensive review on analyzing and solving the LREM can be found in Anderson (2006).

Based on the model we then evaluate the impacts global financial crisis and some policy measures. First, it is shown that monetary policy can in fact effectively drive inflation rate toward a certain target, at least in the short run. Second, the effectiveness of a monetary policy is hampered by a fiscal policy that moves nominal interest rate towards opposite direction which suggests the need for a coherent coordination between monetary and fiscal authorities. Third, falling international prices and global recession seem to be the dominant factor explaining the down turn in domestic inflation – rather than exchange rate depreciation.

The organization of the paper is as follows. In Section 2 we describe and solve the LREM by using undetermined coefficient method. In Section 3 we provide the considered Indonesian open economy macroeconomic model. The simulation result and discussion are in Section 4. We conclude in Section 5.

2. Linear Rational Expectation Model

The purpose of this section is to present a further explanation on formulating, solving, and analyzing linear rational expectations models by using undetermined coefficient method based on McCallum (1998).

2.1. Basic Model

Let w_t be a $n_w \times 1$vector of non-predetermined endogenous variables, k_t be a $n_k \times 1$vector of predetermined endogenous variables, and z_t be a $n_z \times 1$vector of exogenous variables. Define the vector of endogenous variables Ω_t as follow:

$$\Omega_t = \begin{bmatrix} w_t \\ x_t \end{bmatrix}. \tag{1}$$

The standard form of LREM under consideration is given by

$$AE_t\Omega_{t+1} = B\Omega_t + Cz_t,$$
$$z_t = \phi z_{t-1} + \varepsilon_t, \tag{2}$$

where E_t is the expectation operator at period t, A is a square matrix of size $n_w + n_k$ represents the structural coefficients matrix for future variables, B is a square matrix of the same size represent those for contemporaneous variable, ε_t is a $n_z \times 1$ white noise vector, and thus z_t is a first-order autoregressive process whose coefficients are collected in ϕ.

2.2. Solution

In this part we provide the solution of (2) based on undetermined coefficient setup, where the solution is assumed in the form of:

$$w_t = Mk_t + Nz_t,$$
$$k_{t+1} = Pk_t + Qz_t,$$

(3)

with M, N, P, Q are to be determined matrices. It is clear that the solution writes the non-predetermined endogenous variables as a linear combination of predetermined endogenous variables and exogenous variables.

From the second equations of (2) and (3) we have

$$E_t z_{t+1} = \phi z_t,$$
$$E_t k_{t+1} = Pk_t + Qz_t.$$

(4)

By substituting into the first equation of (3) we produce

$$E_t w_{t+1} = ME_t k_{t+1} + E_t z_{t+1} = MPk_t + (MQ + N\phi)z_t.$$

(5)

Hence,

$$E_t \Omega_{t+1} := \begin{bmatrix} E_t w_{t+1} \\ E_t k_{t+1} \end{bmatrix} = \begin{bmatrix} MP \\ P \end{bmatrix} k_t + \begin{bmatrix} MQ + N\phi \\ Q \end{bmatrix} z_t.$$

(6)

Together with the fact that

$$Bw_t + Cz_t = B\begin{bmatrix} w_t \\ k_t \end{bmatrix} + Cz_t = B\left(\begin{bmatrix} M \\ I \end{bmatrix} k_t + \begin{bmatrix} N \\ 0 \end{bmatrix} z_t \right) + Cz_t,$$

the basic model (3) can then be written as

$$A\begin{bmatrix} M \\ P \end{bmatrix} k_t + A\begin{bmatrix} MQ + N\phi \\ Q \end{bmatrix} z_t = B\begin{bmatrix} M \\ I \end{bmatrix} k_t + \left(B\begin{bmatrix} N \\ 0 \end{bmatrix} + C \right) z_t.$$

(7)

Next we provide the solution of the model, or in other words, we explicitly determine matrices M, N, P, Q. From (7) it is obvious that the following equalities should be satisfied:

$$A\begin{bmatrix} MP \\ P \end{bmatrix} = B\begin{bmatrix} M \\ I \end{bmatrix} \Leftrightarrow A\begin{bmatrix} MQ + N\phi \\ Q \end{bmatrix} = B\begin{bmatrix} N \\ 0 \end{bmatrix} + C.$$

(8)

Since the square matrices A and B may be singular, the first equality of (8) can be treated as a generalized eigenvalue problem. The generalized Schur decomposition (or qZ-decomposition) then guarantees the existence of unitary matrices q and Z, i.e., $q*q = I$ and $Z*Z = I$, such that

$$qAZ = S, \quad qBZ = T,$$

(9)

where S and T are triangular. If $S := [s_{ij}]$ and $T := [t_{ij}]$ then the ratios $\lambda_i := t_{ii}/s_{ii}$ are the generalized eigenvalues of the pencil matrix $B - \lambda A$. It is known that we can always arranged the eigenvalues λ_i and associated columns of Q and Z descendently in order of their moduli. Premultiply the first equality of (8) by q and consider the fact that $qA = SZ^{-1}$ and $qB = TZ^{-1}$ then we have

$$SH\begin{bmatrix} MP \\ P \end{bmatrix} = TH\begin{bmatrix} M \\ I \end{bmatrix},$$

where $H = Z^{-1}$. By partitioning S, T, dan H we can write

$$\begin{bmatrix} S_{11} & 0 \\ S_{21} & S_{22} \end{bmatrix}\begin{bmatrix} H_{11} & H_{12} \\ H_{21} & H_{22} \end{bmatrix}\begin{bmatrix} MP \\ P \end{bmatrix} = \begin{bmatrix} T_{11} & 0 \\ T_{21} & T_{22} \end{bmatrix}\begin{bmatrix} H_{11} & H_{12} \\ H_{21} & H_{22} \end{bmatrix}\begin{bmatrix} M \\ I \end{bmatrix}$$

(10)

where the first row can be written as

$$S_{11}(H_{11}M + H_{12})P = T_{11}(H_{11}M + H_{12}).$$

The above equality is satisfied only if $H_{11}M + H_{12} = 0$. Hence, we obtain

$$M = -H_{11}^{-1}H_{12}.$$

Since $H = Z^{-1}$, i.e.,

$$\begin{bmatrix} H_{11} & H_{12} \\ H_{21} & H_{22} \end{bmatrix}\begin{bmatrix} Z_{11} & Z_{12} \\ Z_{21} & Z_{22} \end{bmatrix} = \begin{bmatrix} I & 0 \\ 0 & I \end{bmatrix}, \tag{11}$$

we have $H_{11}Z_{12} + H_{12}Z_{22} = 0$ or $H_{12} = -H_{11}Z_{12}Z_{22}^{-1}$. Thus,

$$M = Z_{12}Z_{22}^{-1}. \tag{12}$$

Now, the second row of (10) provides

$$S_{21}(H_{11}M + H_{12})P + S_{22}(H_{21}M + H_{22})P = T_{21}(H_{11}M + H_{12}) + T_{22}(H_{21}M + H_{22}).$$

And further

$$S_{22}(H_{21}M + H_{22})P = T_{22}(H_{21}M + H_{22}).$$

The last equation holds since $H_{11}M + H_{12} = 0$ from the first row case. Again, from (11) we have $H_{21}Z_{12} + H_{22}Z_{22} = I$ or $H_{22} = Z_{22}^{-1} - H_{21}Z_{12}Z_{22}^{-1}$. Together with (12) we then obtain

$$S_{22}Z_{22}^{-1}P = T_{22}Z_{22}^{-1}$$

or, equivalently

$$P = Z_{22}S_{22}^{-1}T_{22}Z_{22}^{-1}. \tag{13}$$

So far we have already identified M and P. From now we will discover N and Q. Recall the second equation of (8). By application of the generalized Schur decomposition as before we can process such that

$$qA\begin{bmatrix} MQ + N\phi \\ Q \end{bmatrix} = qB\begin{bmatrix} N \\ 0 \end{bmatrix} + qC,$$

$$SH\begin{bmatrix} MQ + N\phi \\ Q \end{bmatrix} = TH\begin{bmatrix} N \\ 0 \end{bmatrix} + D, \tag{14}$$

where we define $D := qC$. Furthermore, equality in the first row can be expressed in term of the partition matrices as follows:

$$N - H_{11}^{-1}T_{11}^{-1}S_{11}H_{11}N\phi = -H_{11}^{-1}T_{11}^{-1}D_1.$$

By denoting $G := -H_{11}^{-1}T_{11}^{-1}S_{11}H_{11}$ and $F := -H_{11}^{-1}T_{11}^{-1}D_1$, the last equation can be written as

$$N + GN\phi = F,$$

which can then be transformed into standard linear equation as follows:

$$(I + \phi^T \otimes G)\text{vec}(N) = \text{vec}(F),$$

where vec(·) denotes vectorizations by columns of a matrix and denotes the Kronecker product. And furthermore

$$\text{vec}(N) = (I + \phi^T \otimes G)^{-1}\text{vec}(F). \tag{15}$$

Matrix N therefore can be obtained by inverting the vec(·). Next, the second row of (14) provides

$$S_{22}(H_{21}M + H_{22})Q + (S_{21}H_{11} + S_{22}H_{21})N\phi = (T_{21}H_{11} + T_{22}H_{21})N + D_2.$$

The solution of Q then is given by

$$Q = K_1^{-1}(K_3 - K_2), \tag{16}$$

where

$$K_1 := S_{22}(H_{21}M + H_{22}), K_2 := (S_{21}H_{11} + S_{22}H_{21})N\phi, K_3 := (T_{21}H_{11} + T_{22}H_{21})N + D_2.$$

3. Macroeconomic Structural Equations

In this section we provide the structural equations of Indonesian macroeconomics system considered as an open-economy model, where some external factors related to the economic transactions such as export and import, are taken into account, see McCallum and Nelson (2001). The equations are then formulated into standard linear rational expectations models and solved by undetermined coefficient method.

Most of the variables involve in the model are presented in log-linearized form. Formally, let V_t be the vector of variables and $\overline{V}$ their steady-state, then the vector of log-deviations of V_t is defined as

$$v_t := \log V_t - \log \overline{V}. \tag{17}$$

In the next part we describe the structural equations, endogenous and exogenous variables which involve in the model.

3.1. Structural Equations

There are thirteen equations considered in the model.

1. Output gap

$$\tilde{y}_t = y_t - \overline{y}_t. \tag{18}$$

Output gap $\tilde{y}_t$ is the deviation between actual output y_t and potential output $\overline{y}_t$.

2. Potential output

$$\overline{y}_t = \gamma q_t + e_t^{\overline{y}}. \tag{19}$$

Potential output is influenced by the competitiveness (reflected by the real exchange rate q_t) and the technological shock $e_t^{\overline{y}}$.

3. Price

$$p_t = \Delta p_t + p_{t-1}. \tag{20}$$

We follow the common definition about the inflation rate Δp_t, i.e., the difference of the price in the current and last periods.

4. Real exchange rate

$$q_t = s_t - p_t + e_t^q. \tag{21}$$

Here, s_t is the nominal exchange rate and the shock process e_t^q constitutes *the law of one price* under normalized international price.

5. Uncovered interest parity (UIP)

$$R_t = E_t s_{t+1} - s_t + e_t^s, \tag{22}$$

where R_t is the nominal interest rate and the shock process e_t^s reflects the premium risk premium with non-constant variance and possibly inter-correlated.

6. Real interest rate

$$\lambda_t = R_t + E_t \lambda_{t+1} - E_t \Delta p_{t+1}. \tag{23}$$

7. Consumption-saving

$$\beta B_1 E_t c_{t+1} = B_2 c_t - B_1 c_{t-1} - (1 - h\beta)\lambda_t + e_t^c. \tag{24}$$

The coefficients involve in this equation are the discount factors. The shock process e_t^c describes the stochastic shock relates to the household preferences on the current and forthcoming consumption level c_t and c_{t+1}. The forthcoming consumption depends on the real interest rate. Or, in other words, the intertemporal substitution factor is considered as an indicator which affects the consumption level.

8. Export

$$x_t = b_2 q_t + b_1 y_t^* + e_t^x. \tag{25}$$

The export level is given by x_t. The coefficients b_1 and b_2 are, respectively, the substitution elasticity coefficients between real exchange rate q_t and international output y_t^*, which are exogenously considered.

9. Net export

$$\tilde{x}_t = x_t - b_3 y_t + (b_4 - 1)q_t. \tag{26}$$

The net export level is given by $\tilde{x}_t$. Here, b_4-1 can be seen as the substitution elasticity coefficient between goods and labors in the production processes.

10. Aggregate supply (AS)

$$\Delta p_t = \alpha \tilde{y}_t + \tfrac{1}{2}\left(\Delta p_{t-1} + E_t \Delta p_{t+1}\right) + e_t^p. \tag{27}$$

The aggregate supply equation follows that of Fuhrer-Moore, where the current inflation rate is determined by the average of the last rate and the expectation for the next period. The shock process e_t^p is assumed to have zero mean and constant variance.

11. Aggregate expenditure

$$y_t = \eta_1 c_t + \eta_2 x_t + \eta_3 g_t. \tag{28}$$

The aggregate expenditure exhibits the simplification of $y_t = \eta_1 c_t + \eta_2 x_t + \eta_3 g_t + \eta_4 I_t$, where I_t denotes the invest level. By the equation, it does not mean that invest and import are excluded from the model. Note that the invest has been taken into account in the consumption-saving equation (24), where h denotes the elasticity coefficient between invest level and the real interest rate. Furthermore, the import is exclusively considered as the material input to the production of home-country goods, since most of the import consists of capital and material goods.

12. Monetary policy (MP) rule

$$R_t = (1 - \mu_3)(1 + \mu_1)E_{t-1}\Delta p_t + \tfrac{1}{4}\mu_2(1 - \mu_3)E_{t-1}\tilde{y}_t + \mu_3 R_{t-1} + \mu_4(1 - \mu_3)E_{t-1}\psi_t + e_t^R. \tag{29}$$

The monetary authority is assumed obey the above equation in launching a monetary policy, where the nominal interest rate in the current period influenced by the backward expectation of the inflation rate and the output gap.

13. Weight on inflation rate and output

$$\psi_t = \Delta p_t + y_t - y_{t-1}. \tag{30}$$

The above open-economy macroeconomics model involves 24 endogenous variables and 9 exogenous variables. Endogenous variables consist of non-predetermined (14 variables):

$$y_t, \quad \overline{y}_t, \quad \tilde{y}_t, \quad R_t, \quad q_t, \quad s_t, \quad c_t, \quad \lambda_t, \quad x_t,$$
$$\psi_t, \quad p_t, \quad \Delta p_t, \quad E_t \Delta p_{t+1}, \quad \tilde{x}_t.$$

and predetermined (10 variables):

$$c_{t-1}, \quad R_{t-1}, \quad y_{t-1}, \quad E_{t-1}\psi_t, \quad E_{t-1}\tilde{y}_t, \quad E_{t-1}y_t, \quad \Delta p_{t-1},$$
$$p_{t-1}, \quad E_{t-1}\Delta p_{t+1}, \quad E_{t-1}\Delta p_t.$$

Exogenous variables consist of government expenditure, international output, and all the shocks:

$$e_t^q, \quad e_t^{\overline{y}}, \quad e_t^c, \quad e_t^R, \quad e_t^s, \quad y_t^*, \quad e_t^p, \quad g_t, \quad e_t^x.$$

3.2. State Space Representation

In general, the state space representation of a model is expressed as follows:

$$X_{t+1} = \Lambda X_t + \Phi U_t,$$
$$Y_t = \Gamma X_t + \Pi U_t, \tag{31}$$

where X_t is the system state, U_t is the system input, Y_t is the system output, and Λ, Φ, Γ, Π are the system matrices.

Note that the model (2) and its solution (3) can be written in the form of state space as follow:

$$\begin{bmatrix} k_{t+1} \\ z_{t+1} \end{bmatrix} = \begin{bmatrix} P & Q \\ 0 & \phi \end{bmatrix} \begin{bmatrix} k_t \\ z_t \end{bmatrix} + \begin{bmatrix} 0 \\ I \end{bmatrix} e_{t+1},$$

$$w_t = \begin{bmatrix} M & N \end{bmatrix} \begin{bmatrix} k_t \\ z_t \end{bmatrix},$$

(32)

where

$$X_t := \begin{bmatrix} k_t \\ z_t \end{bmatrix}, \quad \Lambda := \begin{bmatrix} P & Q \\ 0 & \phi \end{bmatrix}, \quad \Phi := \begin{bmatrix} 0 \\ I \end{bmatrix}, \quad \Gamma := \begin{bmatrix} M & N \end{bmatrix}, \quad \Pi := 0, \quad U_t := e_{t+1}, \quad Y_t := w_t,$$

with the matrices are assumed having compatible dimensions.

4. Result and Discussion

In this section we provide the simulation result based on the impulse response function (IRF) approach. Here, we employ a slightly different IRF than that used in the vector autoregression (VAR) based model. While in the later model, shock is defined as one standard deviation of the variable, in the linear rational expectation framework shock refers to one unit (usually one percent) change of the variable as describe in Table 1.

Table 1: Definition of the shocks

| Variable Shock	Notation	Definition
Technology	$e_t^{\bar{y}}$	Productivity increases as 1% of GDP
Government expenditure	g_t	Primary deficit increases as 1% of the government expenditure (not from GDP)
Consumption	e_t^c	Private consumption increases 1%
Export competitiveness	e_t^x	Export volume increases 1%
International price	P_t^*	Exogenous 1% increase
Inflation	e_t^p	Exogenous inflation increases 1%
Nominal interest rate	e_t^R	Domestic interest rate increases 100 *points*
International output	y_t^*	International output increases 1%

Figure 1: Responses of output (left), inflation (center) and nominal interest rate (right) to a monetary tightening
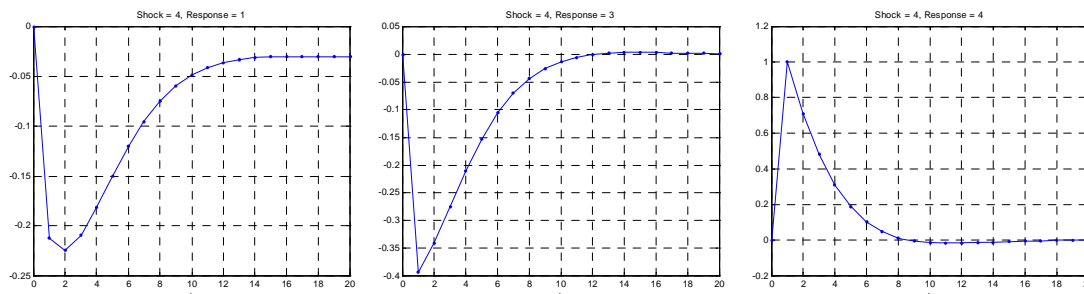
The focus of the analysis will be to provide qualitative answers to the following three questions. First, can a monetary policy affect inflation? Second, how fiscal policy affect inflation? Third, what are the drivers that explain the current slowdown in domestic inflation? For the first question we simulate the effect of a 1 percent (100 basis point) increase in domestic nominal interest rate which represent a monetary tightening (see Figure 1). As expected, such tightening can lower inflation on the expenses of output growth. However, after 10 quarter the effect on inflation completely vanishes suggesting that

the policy is only effective in the short run. Note that, in 2009 Bank Indonesia pursues a relatively lax policy and can be viewed as inflationary.
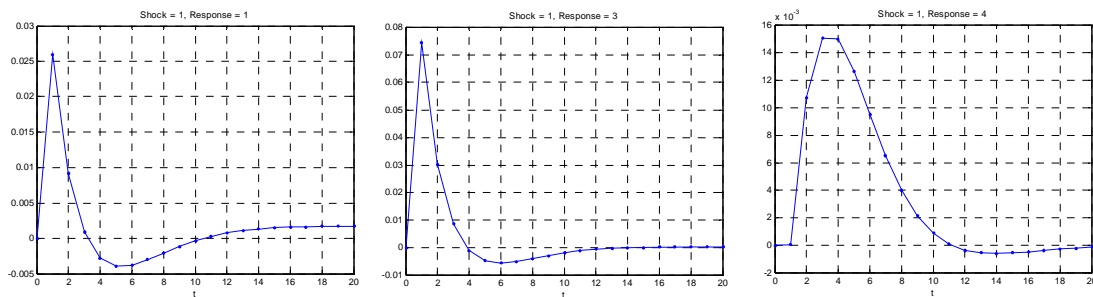
Figure 2: Responses of output (left), inflation (center) and nominal interest rate (right) to a fiscal expansion
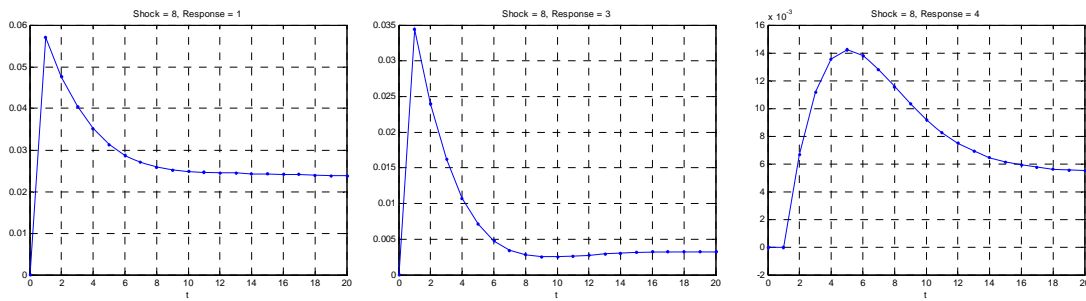
For the second question we simulate the effect of a 1 percent increase in budget deficit (not as percentage of GDP) which reflect the current fiscal stance (Figure 2). Such increase can boost output and inflation, but at the same time create a hike on nominal interest rate. In terms of inflation as the ultimate objective, such policy has the same result as expansionary monetary policy. However, since it increases nominal interest rate (the opposite of lax monetary policy), it tends to jeopardize the effectiveness of monetary policy. If the fiscal shock is sufficiently large, it will dominates the effect of monetary policy. This may partly explain the current difficulty lowering market interest rate. In 2009, Bank Indonesia tries to cut the policy rate but market rates stubornly not responding. Note that, medium term note (MTN) and *sukuk* rates are well above the Bank Indonesia rate making the market rate difficult to cut. Thus fiscal dominance is actually observed.

The third issue is how we can explain the current sliding of domestic inflation? As mentioned above both monetary and fiscal policy are inflationary, but why we have inflation rate that is lowest in six years. According to the law of one price, we have two candidates; falling international price and stronger nominal exchange rate. In addition, global recession which results in a fall in export demand may compress domestic price. Here are the simulation results.

Figure 3: Responses of output (left), inflation (center) and nominal interest rate (right) to a hike in international prices

Figure 4: Responses of output (left), inflation (center) and nominal interest rate (right) to nominal exchange rate depreciation
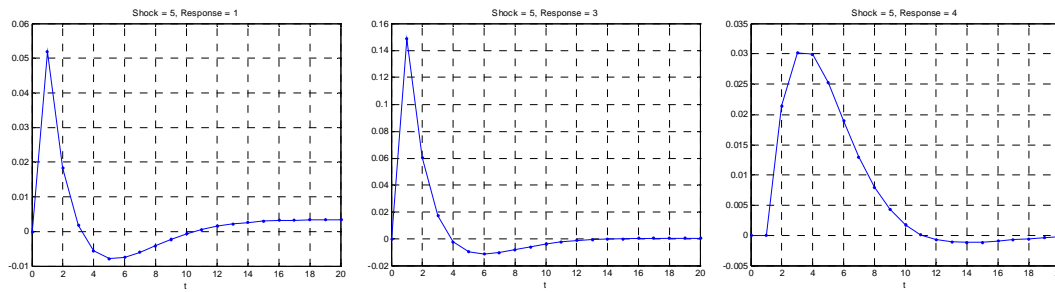
Figure 5: Responses of output (left), inflation (center) and nominal interest rate (right) to an increase in global output
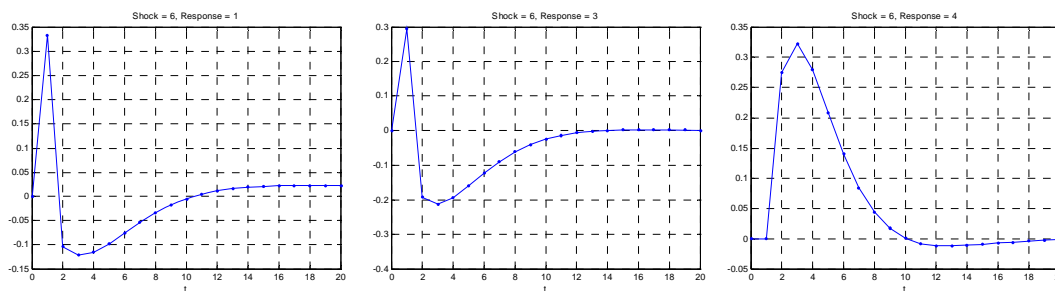

Figure 3 suggests that an increase in international price tends to increase output, interest rate and inflation rate. As we already know, since mid 2008 international commodity prices droped dramatically until mid 2009. Thus the fall in commodity price is a likely candidate for explaining the low inflation. If this is true, then we can expect that in 2010 inflation will increase as commodity price is currently on the upswing trend. Figure 4 suggests that a nominal exchange rate depreciation tend to have an expansionary effect on output, inflation and interest rate. Thus, because the rupiah depreciated in October 2008 and gradually strengthening lately, such exchange rate movement is not the likely candidate for explaining low inflation. Figure 5 suggests that an increase in international output tend to increase domestic output (via export), interest rate and inflation rate. Thus, a global economic crisis will tend to reduce domestic output and press down interest rate and inflation. This is consistent with factual situation.

In summary, the low inflation rate is not the result of monetary as well as fiscal policies. Moreover, exchange rate movement has little to say about low inflation. It is likely that the fall in international prices and output are the factors.

5. Conclusion

In this paper we have developed a theoretical dynamic stochastic general equilibrium (DSGE) model for Indonesia. An open-economy with forward looking agents has been adopted and connections to international market are incorporated.

Based on the model we then evaluate the current phenomena of low inflation. First, it is shown that monetary policy can in fact effectively drive inflation rate toward a certain target, at least in the short run. Second, the effectiveness of a monetary policy is hampered by a fiscal policy that move nominal interest rate towards opposite direction which suggests the need for a coherent coordination between monetary and fiscal authorities. Third, falling international prices and global recession seem to be the dominant factor explaining the down turn in domestic inflation–rather than exchange rate depreciation and domestic policies.

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