MONETARY POLICY PRIORITIES: MANAGING EXCHANGE RATE VS. INFLATION CONTROL

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Abstract

Mongolian economy's adopting inflation targeting monetary policy framework, while facing trouble with defining suitable role of the exchange rate in the framework. This paper aimed to suggest an optimal monetary policy priority using a small open economy DSGE model with extension of natural resource sector. The parameters of the model are calibrated using literature, empirical findings of different studies and country specific indicators. We simulated the model with 4 different policy rules to analyze effect in the economy: plain vanilla IT in an open economy, IT in an open economy, IT with exchange rate band and exchange rate based IT. The model allowed us to investigate the effects of demand, supply and monetary policy shocks to the economy. According to our finding, demand and monetary policy shocks created less volatility of inflation and output but high volatility to foreign debt. Supply shock created very high volatility of inflation, interest rate and foreign debt in IT with exchange rate band and exchange rate based IT rules. We recommend the BoM to consider the volatility of exchange rate at some level aside an inflation in the implementation of monetary policy.

Keywords: Monetary policy framework, Inflation targeting, DSGE model, Exchange rate regime, Policy rules and instruments

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1. Moving toward inflation targeting

Defining the suitable role of the exchange rate is a challenging issue for many developing economies that are adopting inflation targeting monetary policy frameworks. Specifically for small open countries, because the economy is very vulnerable to exchange rate and external shocks, an important issue they face is whether or how to take the exchange rate into account in an IT framework.

The Mongolian monetary policy is aimed to sustain price stability by curbing inflation at low and stable level according to the Central bank law[4]. Even though monetary authorities give importance on inflation, they historically intervened foreign exchange market to smooth volatility of exchange rate. Only since the crisis in 2009, the BoM (Bank of Mongolia) has claimed to intervene less in order to let the exchange rate float. The fact that intervening a lot in the foreign exchange market can be explained by the economic conditions of the high exchange rate pass through, output instability and underdeveloped financial market. Since 30% of domestic consumption is made up from imported goods and the same percent of import prices contributes consumer price basket, output and inflation are moderately reliant on the exchange rate. Also, one third of total deposits are denominated in foreign currency, high dollarization makes the financial system vulnerable to exchange rate shocks. Moreover, the economy is heavily dependent on mineral exports, accounting 90 percent of total exports and 38 percent of GDP as of 2012, which makes the output conditional on commodity prices.

Therefore, if policymakers implement inflation-oriented policy and let the exchange rate float fully, the high exchange rate pass-through[5] and instability of the financial and external sector will lead to higher inflation and economic instability. On the other hand, if policymakers focus only on stabilizing exchange rate, and intervening foreign exchange market, excess domestic currency will bring more pressure on inflation. Another big issue of Mongolian monetary policy is an absence policy rule. Because central bank do not define the policy rule, steps to achieve the main objective are not coherent. This dilemma challenged us to seek better solution for monetary policy choice.

2. Mongolian monetary policy framework

Before 2007, monetary policy used to be driven by money aggregates, the BoM used reserve money as its operational target. However reserve monetary and money supply growths were mostly higher than its target rate during the framework. Since 2007, money demand, money velocity and multiplier became unstable, lessening the interrelation between monetary aggregates and inflation; therefore, the BoM decided to implicitly shift the framework to inflation targeting[6].

In 2008, the inflation rate was 23.2%, which is 3.8 times higher than its target level, the highest in last 10 years. This acceleration of inflation was mostly due to expansionary fiscal policy, accelerated money growth and peaked food price. Inflation rate fallen to 1.9% in 2009 and again upturned to 14.3% in 2010 because of increase in meat price as well as money transfer to citizens. In 2011, even though there was a sudden increase in food and oil price, inflation rate was within its target level, in 2012 it increased again due to food prices. In 2013, inflation increased mostly because of sudden depreciation of exchange rate and an increase in

[4] As stated in the Central Bank Law, "The main objective of the Bank of Mongolia is to maintain stability of the national currency – togrog". This is also verified by yearly State Monetary Guidelines.
[5] Gan-Ochir, (2009) and Batsukh, (2008).
[6] Annual report 2009, Bank of Mongolia.

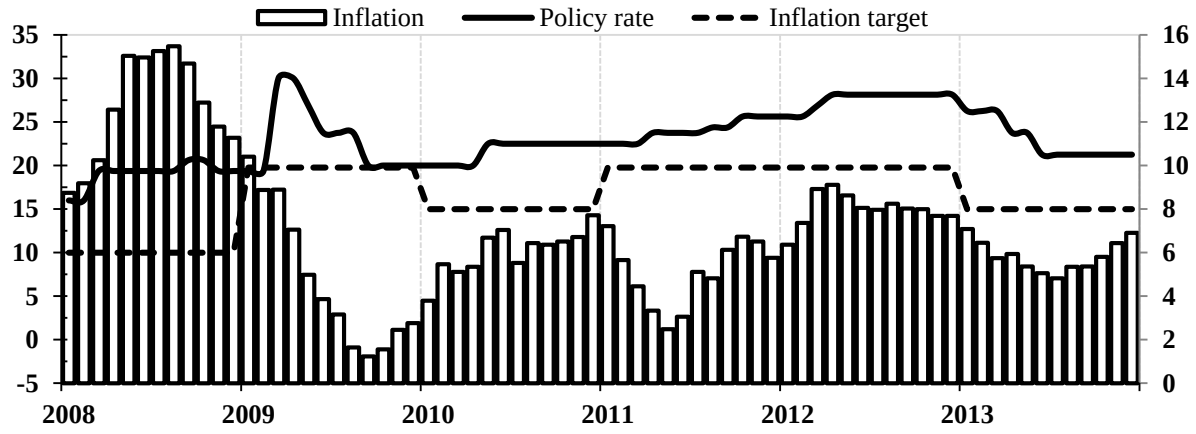
administrative prices. Summarizing achievement of inflation targeting, 2 of 6 years inflation was lower than its target level.

TABLE 1 INFLATION TARGET AND PERFORMANCE

	Inflation	
	Target (%)	**Actual (%)**
2007	5	14
2008	6	23.2
2009	9.9	1.9
2010	8	14.3
2011	9.9	9.4
2012	9.9	14.2
2013	8	12.3

Source: *Monetary Policy Guidelines, Monthly bulletin of BoM*

FIGURE 1: INFLATION TARGET AND PERFORMANCE

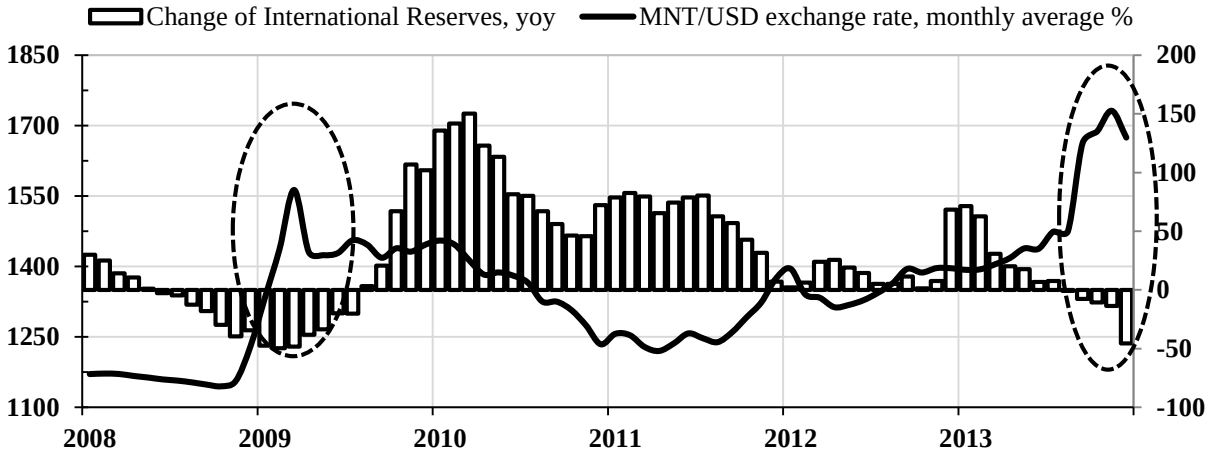


Source: *Monetary Policy Guidelines, Monthly bulletin of BoM*

The BoM raised a policy rate from 9.75% to 14% in 2009 in order to prevent high volatility of domestic currency. As the economy faces crisis by the end of 2009, interest rate was decreased gradually. Then, the BoM raised the policy rate 2times to 13.25% in 2012 to offset excess demand from expansionary fiscal policy. In 2013, they decreased policy rate 3 times to 10.5% as inflation pressures decline.

Demand for foreign currency increased greatly in 2009 due to shrinkage of foreign currency inflow, instability of the global economy, and country's increased trade deficit. The BoM traded its international reserves to wipe excess supply of domestic currency and inject more foreign currency into the economy which almost drained entire international reserves, causing the BoM no longer intervene directly in the foreign exchange market. As a result, the dollar to togrog rate overshot from 1200 to 1563 within 3 months and started to appreciate slowly. In 2013, the same story is likely to be repeated where the exchange rate has depreciated by 12.7 percent within a month due to increasing import and high demand of foreign currency. (Figure 2).

FIGURE 2: EXCHANGE RATE AND INTERNATIONAL RESERVES CHANGE



Source: www.mongolbank.mn

Here arises the question, what would be the priority of monetary policy for small open economies like Mongolia? Should it ignore exchange rate fluctuations? Next chapter tries to answer the question by comparing different monetary policy frameworks and research works that were studied in this field.

3. Review of the international experiences and literature

The choosing the preferred exchange rate regime for developing economies has evolved sizably over the past couple of decades. Mussa et al. (2000) find that developing countries have been moving their exchange rate regimes toward greater flexibility, getting to expanding opportunities from an increasingly integrated global economy and to changes in their own economic situations. Moreover, the results show that, facing generally larger macroeconomic shocks than the advanced countries, developing countries with flexible exchange rates placed substantially greater importance on the stability of their exchange rates than did the G–3, and significantly greater importance on average than did the other industrial countries with floating rates. From this experience, it is clear that developing countries that maintain relatively flexible exchange rate regimes typically use both monetary policy adjustments and official intervention to influence the exchange rate.

How does economic performance differ across exchange rate regimes? Rogoff et al. (2003) explored this question empirically for using the natural classification of de facto exchange rate regimes. The findings suggest that exchange rate flexibility becomes more valuable as countries mature in terms of their access to international capital markets and as they develop their financial systems. Particularly for developing countries, the inflation benefit associated with exchange rate pegs is great if it is an explicit, publicly announced policy goal.

IMF review of exchange rate regimes in 1999 suggests the following conditions are likely to influence whether some form of pegged exchange rate regime is judged to be appropriate:

- ✓ The degree of involvement with international capital markets is low;
- ✓ The share of trade with the country to which it is pegged is high;
- ✓ The shocks it faces are similar to those facing the country to which it pegs;
- ✓ It is willing to give up monetary independence for its partner's monetary credibility;
- ✓ Its economy and financial system already extensively relies on its partners' currency;
- ✓ Because of high inherited inflation, exchange rate based stabilization is attractive;
- ✓ Its fiscal policy is flexible and sustainable;

- ✓ Its labor markets are flexible;
- ✓ It has high international reserves.

On the contrary to the pegged exchange rate regime, a genuine floating exchange rate allows more flexibility for monetary policy in times of exchange rate pressures and economic struggle. Also, provided that the exchange rate really does move up and down in response to market forces, businesses and financial institutions are forced to identify the risks inherent in foreign exchange risk. Central bank independence is important to help mitigate fears that the lack of exchange rate anchor could let loose the money-printing demon.

The fixed-to-float framework of exchange rate has been very cautious, considering a number of challenges typically associated with fear of floating: concerns about losing a transparent nominal anchor and policy credibility, potential exchange rate losses associated with currency mismatches in corporate balance sheets, weaknesses in banks' risk management practices and lack of hedging markets and instruments to cover against exchange rate risks, underdeveloped financial markets, and fears of worsening of external competitiveness should the currency appreciate. Otker-Robe et al.(2007) Using six country's experiences suggest that those that work on mitigating risks associated with floating can achieve a smoother exit from their pegged regimes, even when the elements supporting greater flexibility are not fully in place before the move to greater flexibility.

4. The Role of Exchange Rate in Inflation-Targeting Emerging Economies

The exchange rate plays an important role in monetary policy for emerging economies that have adopted inflation targeting or considering moving on IT framework. Inflation targeting emerging economies generally have less flexible exchange rate arrangements and intervene more frequently in the foreign exchange market. However, their sharper focus on the exchange rate may cause some confusion about the commitment of their central banks to the inflation target and may also complicate policy implementation.

The policy and operational role of the exchange rate within the monetary framework of inflation-targeting emerging economies as well as emerging economies with other anchors make the transition to inflation targeting reflects strong, uncertain, and heterogeneous exchange rate channels for a number of reasons including high pass-through from the exchange rate to inflation, the impact on output of exchange rate movement, balance sheet mismatches, underdeveloped financial markets, and lower overall policy credibility(Stone et al. (2009), Filardo et al.(2011), Calvo and Reihart (2000), Engel (2011).

Pass-through from the exchange rate to inflation: Pass-through from the exchange rate to inflation is especially important for emerging economies, in part reflecting lower policy credibility. Ho and McCauley (2003) comparing the experience of 12 emerging market inflation targeting countries with six industrial country counterparts argue that emerging market economies tend to be relatively more exposed to exchange rate fluctuations for various structural and historical reasons. Gagnon and Ihrig (2004) propose that the anti-inflationary actions and credibility of the monetary authority are important factors behind the reduced pass-through of exchange rate changes to domestic inflation via evidence from a sample of 11 industrial countries that inflation-targeting (IT) exhibited a marked change in monetary behavior in the 1990s and that pass-through declined more sharply in IT countries than elsewhere. Frankel et al. (2005) using a new data set prices of eight narrowly defined brand commodities, find the empirical support for significant determinants of the pass-through coefficient include per capita incomes, bilateral distance, tariffs, country size, wages, long-term inflation, and long-term exchange rate variability.

Output stability: Bahmani-Oskooee and Kutan (2008) investigated the impact of real depreciation on output both short-run and long-run in experience of nine emerging economies. The result shows that in short-run, real depreciation is expansionary in Belarus, Latvia, Poland, and Slovak Republic; contractionary in Czech Republic, Estonia, Hungary, and Russia; and has no effect in Lithuania. However, in almost none of the country, the short-run effects lasted into the long-run. Aghion et al. (2007) offer empirical evidence that real exchange rate volatility can have a significant impact on long-term rate of productivity growth, but the effect depends critically on a country's level of financial development. They find that for countries with relatively low levels of financial development, exchange rate volatility generally reduces growth, whereas for financially advanced countries, there is no significant effect. But the using exchange rate to smooth output volatility can create confusion regarding the commitment to an inflation target or objective.

Financial and External stability: Mussa et al.(2000) pointed out that prudential risks and vulnerabilities in the banking system present challenges when moving toward a flexible-exchange-rate arrangement. Currency mismatch is a disparity in the currencies in which assets and liabilities are denominated. Because of, liabilities may be denominated in a foreign currency, while assets are allocated in domestic currency, leading to compel huge losses when there is a devaluation of the domestic currency. Currency mismatches appeared generally in emerging economies than in developed economies as conclusion of Allen et al.(2002). Stone et al. (2009) found that prolonged foreign exchange intervention to stabilize the exchange rate can lead the authorities to take on a large share of currency risk, encouraging further large capital inflows and increasing the risk of a sudden stop. There are trade-offs between using exchange rate management to address financial and external stability concerns and using it to promote price and output stability.

Underdeveloped financial market: Underdeveloped domestic financial markets reduce the scope for exchange rate flexibility by amplifying exchange rate shocks and constraining policy implementation. Developed money markets and government security markets also provide more policy options. Weak interest rate transmission from underdeveloped money markets can compel a leading policy role for the exchange rate. Furthermore, underdeveloped money and security markets can raise the costs of sterilization and result in large liquidity creation from capital inflows. The absence of developed money markets also can inhibit the adoption of inflation targeting under which a short-term interest rate is used as the operating target.

Central bank Credibility: A high degree of overall policy credibility frees up the exchange rate to float and enhances policy implementation and thus is necessary for the adoption of a full-fledged inflation-targeting nominal anchor. These preconditions to inflation targeting framework including institutional independence, a well-developed technical infrastructure, economic structure, a healthy financial system, all inflation-targeting central bank needs a mandate to pursue the inflation target and autonomy to set its monetary instruments accordingly to support and motivate the commitment to low inflation. Batini et al.(2005) Find that for most emerging economies, however, with lacking technical capabilities and central bank autonomy, would be better off sticking with a conventional policy framework, such as an exchange rate peg or money growth. They argue that there is not appear to be necessary for emerging market countries to meet a stringent set of institutional, technical, and economic "preconditions" for the successful adoption of inflation targeting. Instead, the feasibility and success of inflation targeting appear to depend more on the authorities' commitment and ability to plan and drive institutional change after the introduction of inflation targeting. Lack of credibility will lead to fear of floating, high interest rate volatility and pro-cyclical interest rate policies. Furthermore, it may give rise to liability dollarization and limit the central bank's ability to act as an effective

lender of last resort, all of which feed this fear of large exchange rate fluctuates (Calvo and Reinhart, 2000).

Stone et al. (2009) test that policy trade-off is gauged using a small economic model to simulate the impact of shocks on both advanced and emerging economies under different policy rules. In general, the analysis tends to confirm the finding of earlier analysis that advanced or financially robust economies have little to gain from including the exchange rate explicitly in their policy reaction function, particularly in response to demand shocks. At the same time, the analysis suggests that financially vulnerable emerging economies might benefit from including the exchange rate in the reaction function in a limited way, but that too much emphasis on the exchange rate is likely to be harmful. Including the exchange rate the policy reaction function appears to help mitigate the impacts of risk premium shocks and cost-push shocks, and especially by dampening interest rate and exchange rate volatility. Ball (1999) a similar result in that in a closed economy, inflation targeting and Taylor rules perform well in stabilizing both output and inflation. In an open economy, however, these policies perform poorly unless they are modified. Specifically, if policymakers minimize a weighted sum of output and inflation variances, their policy instrument should be an MCI based on both the interest rate and the exchange rate.

Therefore, the establishing a more systematic, consistent, and market-based role for the exchange rate is a key to making the transition to inflation targeting. Because of, an effective role for the exchange rate in policy implementation under an inflation-targeting framework can reduce conflicts between the inflation objective and other considerations. Transparency for the role of the exchange rate with respect to policy objectives, operation procedures, and ex post evaluation reduces the possibility of confusion about the inflation target. Low operational transparency may lead markets question whether a change in the policy interest rate or a foreign exchange market intervention is aimed at supporting the inflation target or only at managing exchange rate itself.

4.1. The Role of Exchange Rate in Mongolian Economy

Mongolia is a small open economy. Therefore exchange rate volatility has considerable effect on prices of export and import. The fluctuation of the exchange rate affects directly to these prices and indirectly to the domestic goods and services through imported inputs.

Batsukh (2008) analyzed the cycle and trend correlation between Mongolian CPI and nominal exchange rate of togrog against U.S dollar. According to the result, cycle and trend coefficients of exchange rate to CPI are 0.49 and 0.89 respectively with a lagged effect. This result was also proven by Gan-Ochir (2009) where he measured the exchange rate pass through to consumer price inflation in Mongolia, analyzing monthly data from a recursive VAR model. The accumulated impact of exchange rate shock on consumer prices was 10 percent by the end of the fifth month after the depreciation shock introduced, and 55 percent by the end of the ninth month, showing high pass through of exchange rate of consumer prices. An early study by Davaajargal (2005) and Khulan (2005)also found the lagged effect of exchange rate on consumer price starting from the third month intense till the sixth month after exchange rate shock. In recent years, studies such as Gan-Ochir (2011), Avralt-Od and Davaadalai (2010) resulted similar results of high pass through of exchange rate to inflation in Mongolia using SVAR and SBVAR models.

Narantuya et al. (2009) evaluated the impact of the global financial and economic crisis in the Mongolian economy for four consequent quarters of 2009.They concluded that the impact of the global financial and economic crisis affected domestic output straightforwardly through the drop in foreign trade since there were no room for counter-cyclical monetary or fiscal policy.

Furthermore, they marked that monetary policy measures against rapidly increased inflation resulted even more bust in the real sector.

Tuvshintugs (2009) argued that the BoM's monetary policy decisions before the crisis were not independent from the government. Even though the BoM was to conduct monetary policy to achieve the goal of low stable inflation, political pressure from the government or parliament made them to choose a monetary policy which supports an economic growth and employment resulting even worse macroeconomic circumstances. According to his view, the BoM does not have an enough power to oppose the parliament and its independence is inferior regarding the legal environment.

Recently, Avralt-Od et al.(2011) Examined the medium term outlook of the Mongolian economy using the DSGE model. They concluded that less involvement of central bank in the foreign exchange market and increasing income in mining sector would lead higher demand and appreciation of real exchange rate in the economy. Even though real exchange rate appreciation might decrease the production of tradable sector, the government investment would accumulate both social and private capital resulting stable economic growth. They warned that any attempt to decrease the real exchange rate appreciation may cause crowding out effect on private investment and slow down economic growth in the medium term.

In May 2011, a staff team of the IMF assessed research on Mongolian financial stability. They concluded that Mongolian financial stability has been re-established after the banking crisis of 2008-09,however the banking system is heavily exposed to several risks including exchange rate risks due to maturity mismatches and unhedged foreign currency lending. From their findings of the assessment, foreign currency lending has increased, and lending to unhedged borrowers rendered the system vulnerable to foreign exchange induced credit risk; the current level of dollarization exposed the Mongolian financial system to risk.

However, above mentioned researchers analyzed the effect of exchange rate in the economy, no research was done to compare the monetary policy rules using a DSGE model which opened us a gap in the field to study.

5. A small open economy model

We used small open economy Dynamic Stochastic General Equilibrium (DSGE) model with natural resource sector based on Roger, Rest repo & Garcia (2009) to evaluate the performances of alternative IT approaches. Total output consists of two types of goods. The first one is a composite good produced by monopolistically competitive firms both for domestic consumption and export. The second good is a natural resource commodity for export. The economy consists of the following agents: two types of households, some participating in asset markets and others not; natural resource producing firms, composite good producer, and a central bank in charge of monetary policy. The development of each agents movements are described in Appendix 1.

5.1. Log-linearised equations of the model

The empirical analysis employs a log-linear approximation of the models optimality conditions around a non-stochastic steady state. We here shown the key structural equations that emerge from the analysis. All variables are properly interpreted as log deviations from their respective steady state values.

$$Domestic\ production: \hat{y}_t^d = \hat{t}_t[\alpha^\eta + (1-\alpha)^\eta] + \left[\alpha^\eta \cdot \widehat{im}_t + (1-\alpha)^\eta \cdot \hat{l}_t\right]; \quad \textbf{(1)}$$

$$Marginal\ cost: \widehat{mc}_t^r = [[1-\alpha]^\eta \cdot [\hat{w}_t - \hat{p}_t] + [\alpha]^\eta \cdot \hat{q}_t] - \hat{t}_t \cdot ([1-\alpha]^\eta + [\alpha]^\eta); \quad \textbf{(2)}$$

$$Export\ demand: \hat{x}_t^d = \gamma \cdot \hat{x}_{t-1}^d + (1-\gamma)[\tau \hat{q}_t + \hat{y}_t^*] \quad (3)$$

$$Risk\ premium: \hat{\phi}_t = \phi_0\left(\hat{b}_{t+1}^* - \hat{y}_t\right) - \phi_1\left((\tau-1)\hat{q}_t + \hat{y}_t^*\right) + \phi_2(\widehat{im}_t) + \phi_3(\hat{q}_t) \quad (4)$$

$$Phillips\ curve: \hat{\pi}_t = (\beta/1+\beta\mu)\hat{\pi}_{t+1} + (\mu/1+\beta\mu)\hat{\pi}_{t-1} + (\varsigma/1+\beta\mu)\widehat{mc}_t^r \quad (5)$$

$$Real\ exchange\ rate: \hat{q}_t = (1-\phi^s)\hat{q}_{t+1} + \phi^s\hat{q}_{t-1} - (\hat{\imath}_t - \hat{\pi}_{t+1}) + (\hat{\imath}_t^* - \hat{\pi}_{t+1}^*) + \hat{\phi}_t \quad (6)$$

Policy rules

$$Plain\ vanilla\ IT: \hat{\imath}_t = \omega \cdot \hat{\imath}_{t-1} + (1-\omega)[\delta\hat{\pi}_t + \varrho\hat{y}_t] + \nu_t \quad (7)$$

$$Open\ economy\ IT: \hat{\imath}_t = \omega \cdot \hat{\imath}_{t-1} + (1-\omega)[\delta\hat{\pi}_t + \varrho\hat{y}_t + \chi(\hat{q}_t - \epsilon \cdot \hat{q}_{t-1})] + \nu_t \quad (8)$$

$$Exchange\ rate\ band\ IT: \hat{\imath}_t = \omega \cdot \hat{\imath}_{t-1} + (1-\omega)[\delta\hat{\pi}_t + \varrho\hat{y}_t + (\chi+\psi) * (\hat{q}_t - \epsilon \cdot \hat{q}_{t-1})] + \nu_t \quad (9)$$

$$Exchange\ rate\ based\ IT: \hat{q}_t = \rho_q\hat{q}_{t-1} + \left(1-\rho_q\right)[\delta\hat{\pi}_t + \varrho\hat{y}_t] + \nu_t \quad (10)$$

where $\hat{y}_t^d$- total production, $\hat{t}_t$- total factor productivity, $\widehat{im}_t$- imported intermediate input, $\hat{l}_t$- labor input, $\widehat{mc}_t^r$-real marginal cost of production, $\widehat{w}_t$- nominal wage rate per unit of work supplied, $\hat{p}_t$- price level, $\hat{q}_t$- real exchange rate, $\hat{x}_t^d$- export demand, $\hat{y}_t^*$- foreign real income, $\hat{\pi}_t$- aggregate inflation rate, $\hat{\imath}_t^*$- foreign nominal interest rate, $\hat{\pi}_{t+1}^*$-expected foreign inflation rate, $\hat{\phi}_t$- risk premium[7], $\hat{b}_{t+1}^*$ - projected external debt in period $t+1$.

$\hat{\imath}_t \equiv i_t - (\bar{r} + \pi^T)$- Deviation of policy target interest rate from its long-run steady-state value.
$\hat{\pi}_t \equiv \pi_t^f - \pi^T$- Deviation of inflation forecast from the inflation target.
$\hat{y}_t \equiv y_t - \bar{y}_t$- Deviation of real output from the estimated level of potential output.

Foreign economy is specified as the closed economy variant of the model as described in Mona celli (2005). Because the foreign economy is exogenous to the domestic economy, we assumed that the paths of ($\hat{y}_t^*$,$\hat{\pi}_t^*$,$\hat{\imath}_t^*$) are determined by a vector autoregressive processes of order one.

6. Methodology

We calibrated the parameters of the model and we used Dynare toolbox in Matlab software to solve a log-linearized model and run policy simulations. The main variables are output gap, inflation, exchange rate and interest rate.

6.1. Calibration

The model is calibrated based on literature, values taken from findings of different studies and country specific indicators. Parameters of monetary policy rule are changeable depending on which policy decision to make.

TABLE 2 CALIBRATION OF PARAMETERS

Definition	Parameters	Mongolia	Source
Utility function			
Subjective discount factor of dynamic household	β^a	0.99	Literature
Subjective discount factor of static household	β^s	0	Literature
Weight of static household consumption	∂	0.29	Calculation
Coefficient of relative risk aversion	σ	1.5	Adolfson et al. (2008)
Production function			

[7] Risk premium depends on debt, external current balance and balance sheet effect of currency movements as defined in (Cespedes, Chang, & Valesco, 2004).

Weight of imported factor	α	0.4	National Statistics
Probability of not re-optimizing price	ϑ	0.23	Bank of Mongolia
Mining production to GDP ratio	q_y	0.16	Statistical yearbook 2012
External debt to GDP ratio	b_y	1.6	Bank of Mongolia
Elasticity of home exports to exchange rate	τ	5	Roger et al. (2009)
Shock inertia			
Fiscal shock	ρ_y	0.8	-
Oil price shock	ρ_c	0.8	-
Monetary policy shock	ρ_R	0.8	-
Policy parameters			
Persistence of interest rate	ω	0.7	ARIMA
Coefficient on deviation of inflation from target	k	2	Literature

Source: *Author's selection*

The discount factor (β^a) is 0.99 and (β^s) is 0.0 which are the values based on the literature. The risk aversion coefficient (σ) is 1.5, within the range commonly used for this parameter, in line with Adolf son et al. (2008).Elasticity of domestic exports to exchange rate (τ) is 5.0; which represents a strong competitiveness power of domestic producers in small open economy as in Roger, Restrepo & Garcia (2009).The coefficient on the exchange rate (χ) is chosen as 0.85 which is between 0.00-2.25 as in the Taylor rule (1993).Since imported goods are production inputs, we assume for simplicity that the elasticity of substitution between labor and imported goods is unity. Furthermore, the coefficient on deviation of inflation from target (κ) set as 2.0 the same as other emerging economies.

External debt to GDP ratio and mining output to GDP ratios were 1.60 and 0.16 respectively at the end of 2012 in national statistics which were assumed as a steady state. We chose (α) equal to 0.40same as an import to GDP ratio as the end of 2012in national statistics. The probability of not re-optimizing price (θ) is 0.23, for people's expectation of not changing the price was 0.23 in the inflation expectation survey of December 2012 by BoM.

The coefficients on the output gap (ϱ), inflation gap (δ) and exchange rate (χ) are unlike in the different policy rules (see Table 3). The calibration of these coefficients is based on Roger, Restrepo & Garcia (2009).

TABLE 3 CALIBRATION OF POLICY PARAMETERS

	Policy rules	Coefficient on Inflation gap	Coefficient on Output gap	Coefficient on Exchange rate	Coefficient on Real exchange rate lag
		δ	ϱ	χ	ε
1	Plain vanilla IT	2.4	1.6	0	0
2	Open economy IT	1.8	0.8	0.75	0
3	IT with exchange rate band	1.8	0.8	0.75	1
4	Exchange rate based IT	1.8	0.8	1	-

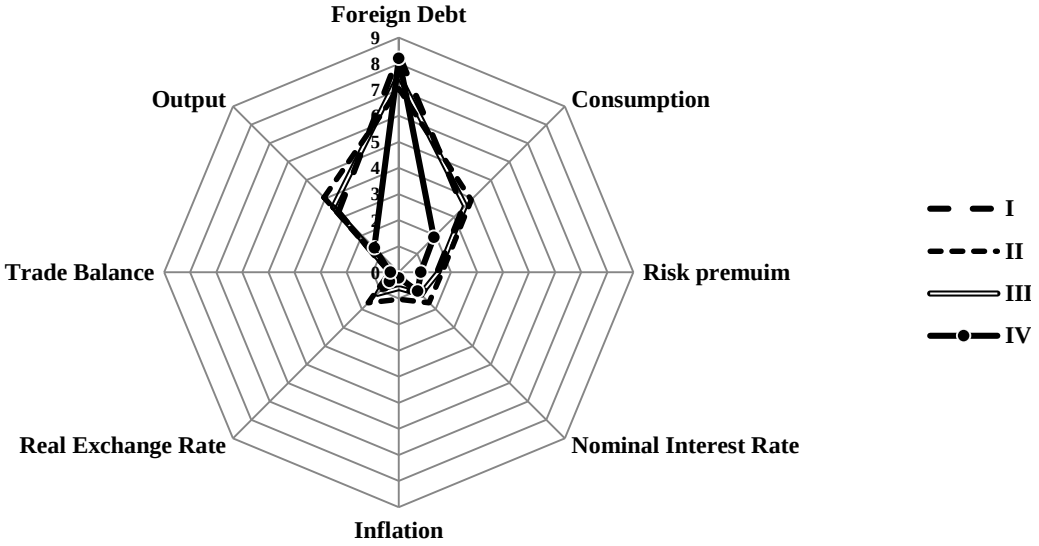
Source: *Author's selection*

7. Simulation

We simulated an above mentioned DSGE model to analyze the impulse responses to the different economic shocks. The effect of demand, supply and monetary policy shocks are considered in a following different policy rules: Plain vanilla inflation targeting in an open

economy, open economy inflation targeting, inflation targeting with exchange rate band and exchange rate-based inflation targeting. The radars showed the highest variability of observables from its steady state value since shocks were introduced in different policy rules.

FIGURE 3 VARIABILITY OF INDICATORS IN ALTERNATIVE POLICY RULES DURING DEMAND SHOCK



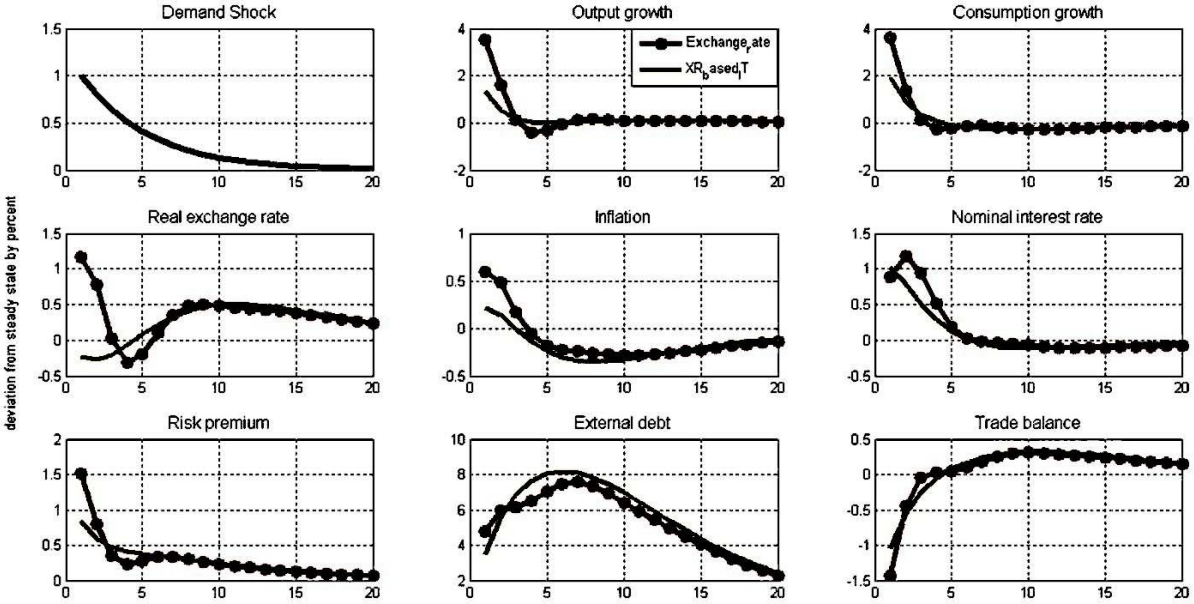
I The plain vanilla, II open economy, III exchange rate-band IT IV exchange rate based IT

Source: *Author's calculation*

In case of the demand shock (Figure 3), for almost all policy rules, the volatility of output tends to be higher than for inflation, and the volatility of the foreign debt tends to be much higher than all other variables in response to demand shock. The optimal monetary policy rule for inflation during demand shock is inflation targeting with exchange rate band and optimal policy rule for output growth is exchange rate based inflation targeting.

We examined the positive demand shock effect on the economy in 2 selected policy rules. The responses of selected variables namely, output, consumption, inflation, trade balance, external debt, real and nominal exchange rate are shown in Figure 4. Figures represent deviations of variables from their steady state in percent. The result shows that an increase in domestic demand leads to increase in domestic GDP, consumption and imports. Excess demand also puts upward pressure on inflation. In response to the positive output gap and higher inflation, the central bank raises real interest rates, which also leads to real appreciation of the local currency. The trade balance worsens in response to the rise in consumption relative to output and the loss of competitiveness. The exchange rate plays a key role in restoring equilibrium, both through its effect on dampening demand pressures, and via direct pass-through effects on tradable goods prices.

FIGURE 4: RESPONSESTO DEMAND SHOCK

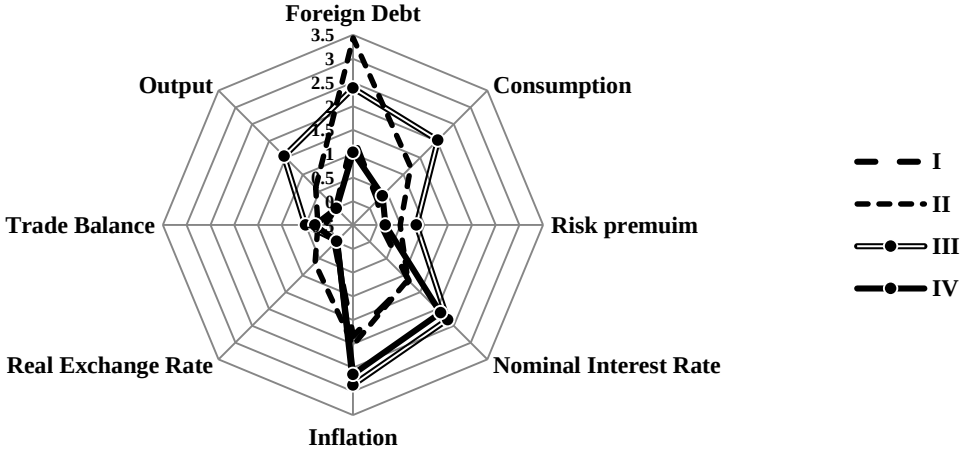


Source: *Author's calculation*

The second shock describes positive supply shock effects in the economy. During the supply shock plain vanilla IT rule creates least volatility of the variables compared to other rules. Exchange rate based IT and IT with the exchange rate band causing very high volatility of foreign debt, inflation and nominal interest rate. The optimal monetary policy rule for inflation during supply shock is plain vanilla IT in an open economy and optimal policy rule for output growth is exchange rate based IT (Figure 5).

Supply shock effect is illustrated with exchange rate based inflation targeting and plain vanilla inflation targeting rules comparably, in Figure 6. The supply shock leads demand and output to fall at the same time as inflation rises, resulting in conflicting objectives for monetary policy. In addition, in both cases, the initial rise in inflation results increases in nominal interest rate and appreciation of real exchange rate, which is reinforced by an increase in real interest rate.

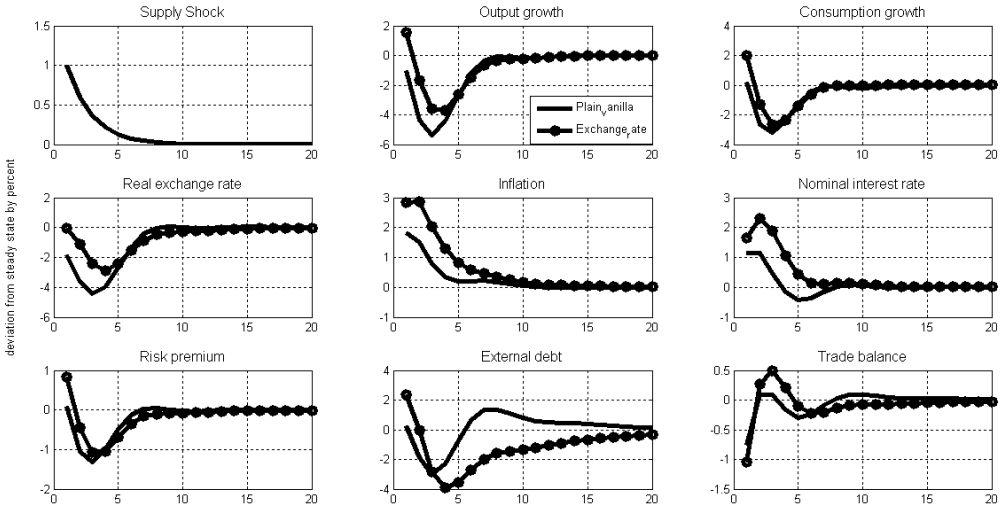
FIGURE 5 VARIABILITY OF INDICATORS IN ALTERNATIVE POLICY RULES DURING SUPPLY SHOCK



I The plain vanilla, II open economy, III exchange rate-band IT IV exchange rate based IT

Source: *Author's calculation*

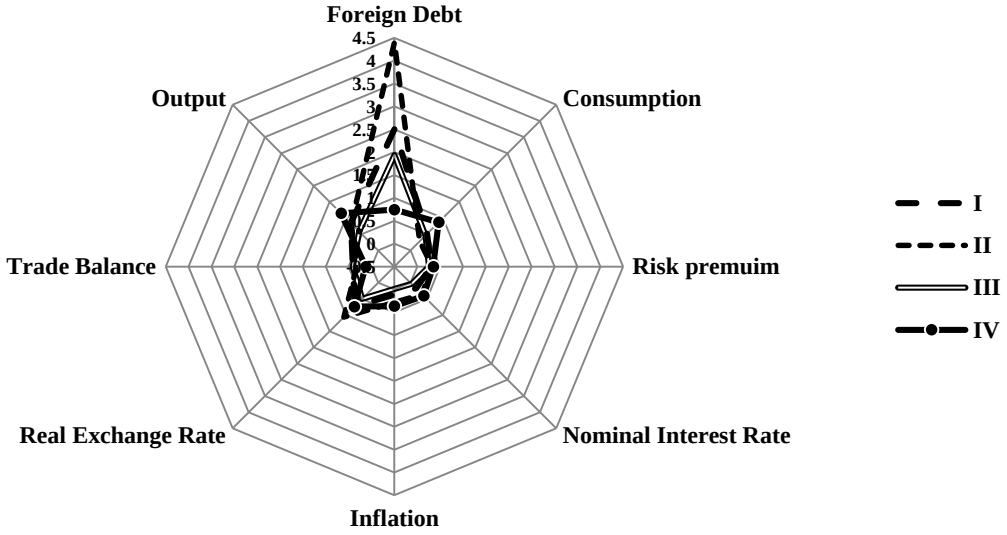
FIGURE 6 RESPONSES TO SUPPLY SHOCK



Source: *Author's calculation*

A third shock describes monetary tightening policy shock effect (increasing nominal interest rate) in the economy. In this shock, inflation and output volatilities are small and similar for all policy rules (Figure 7). However volatility of foreign debt is very high in the open economy inflation targeting policy rule. The optimal policy rule for both inflation and output in monetary shock is IT with the exchange rate band.

FIGURE 7 VARIABILITY OF INDICATORS IN ALTERNATIVE POLICY RULES DURING MONETARY POLICY SHOCK

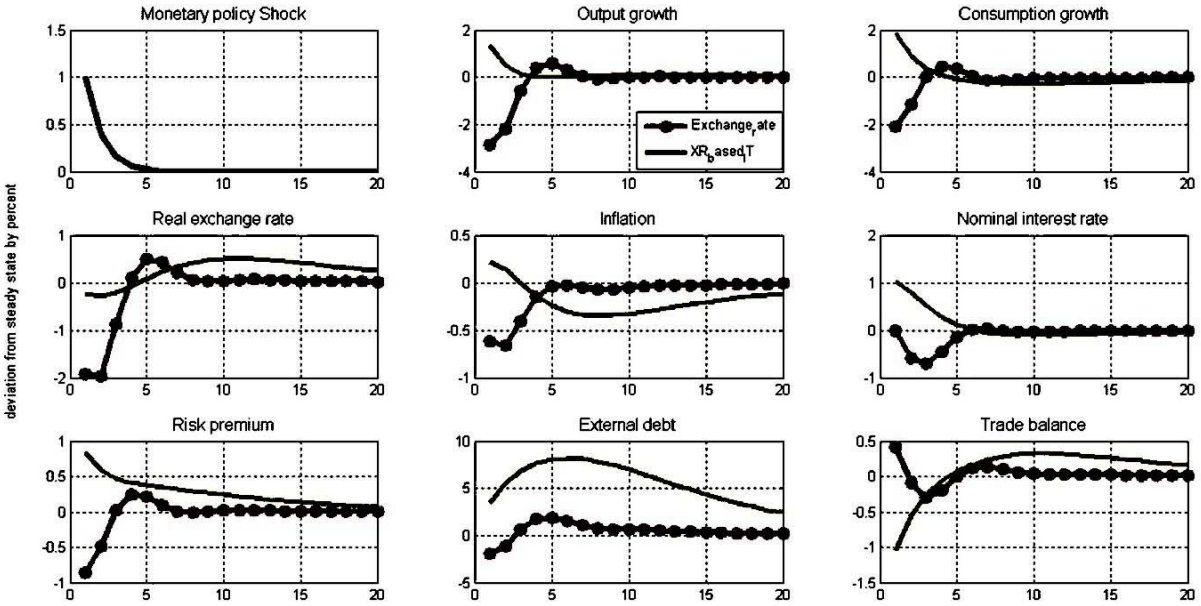


I The plain vanilla, II open economy, III exchange rate-band IT, IV exchange rate based IT

Source: *Author's calculation*

The effect of tightening monetary policy shock was compared in IT with exchange rate band and exchange rate based IT rules in Figure 8.An increase in nominal interest rate increases real interest rates, making the monetary conditions tighter. At the same time, the increase in nominal interest rate supports the inflow of capital to the economy, leading to the appreciation of real exchange rate. Real exchange rate appreciation causes decrease in both inflation and output.

FIGURE 8 RESPONSES TO MONETARY POLICY SHOCK



Source: *Author's calculation*

The results of optimal policy rules for output growth and inflation are compared in Table 4. Generally, inflation targeting with the exchange rate band is more appropriate for less volatility of inflation while exchange rate based inflation targeting seems to be suitable for less volatility of output growth.

TABLE 4 SHOCK EFFECTS ON OUTPUT GAP AND INFLATION

	Output growth	Inflation
Demand Shock	Exchange rate-based inflation targeting	Inflation targeting with exchange rate band
Supply Shock	Exchange rate based inflation targeting	Plain vanilla Inflation targeting in an open economy
Monetary Policy Shock	Inflation targeting with exchange rate band	Inflation targeting with exchange rate band

Source: *Author's selection*

8. Conclusion

Mongolian monetary policy aim to stabilize inflation, yet the BoM intervenes foreign exchange market. BoM is intending to switch to the inflation targeting monetary policy framework since 2007. However, due to high exchange rate pass through and decline of capital inflow in the economy, monetary authorities are confronting the dilemma between inflation and exchange rate oriented policies.

Motivated by the theoretical literature, we intended to find out whether it is optimal for the central bank to react to movements in the nominal exchange rate when macroeconomic performance is evaluated by means of inflation and output variability. For this reason, we analyzed different monetary policy rules using calibrated small open economy DSGE model for Mongolia.

According to the model result, for almost all cases of policy rules, the volatility of output tends to be higher than volatility of inflation. The response of the foreign debt is much higher than of all other variables in case of demand shock, proving high sensibility of foreign debts. In case

of a supply shock, plain vanilla IT rule created least volatility of all the variables while exchange rate based IT and IT with exchange rate band created much higher volatility of foreign debt, inflation and nominal interest rate. In case of monetary policy shock, response of inflation and output are small and similar for all policy rules. However variability of foreign debt is very high in the open economy inflation targeting policy rule. Generally, inflation targeting with the exchange rate band is more appropriate for less volatility of inflation while exchange rate based inflation targeting seems to be suitable for less volatility of output growth. In case of Mongolia, because monetary policy shock creates certain variability in the economy, it is important for the BoM to consider the volatilities of exchange rate at some point in the implementation of inflation targeting.

We recommend the BoM to implement the monetary policy rule in the decision making process instead of a discrete policy system. Policy tools that are based on rules leave less room for policy error and they act as an effective pre-commitment device. To mitigate the possible drawbacks generated by discretion, central banks may choose for a clearly stated, transparent and an accountable decision making process.

9. Appendix

9.1. Model and equilibrium definition

9.1.1. Households

We assume a continuum of infinitely-lived households, indexed by $i \in [0,1]$**.** A fraction of $(1-\mathfrak{a})$ of households have access to capital markets where they can trade a full set of contingent securities, and buy and sell physical capital (which they accumulate and rent out to firms). We use the term optimizing or Ricardian to refer to that subset of households. The remaining fraction $(\mathfrak{a})$ of households do not own any assets not have any liabilities; they just consume their current labor income.

We refer to them as a rule-of-thumb (or non-Ricardian) consumers[8] and each has the same form of the utility function and a different budget constraint. A representative household derives utility from consumption basket (C_t^j) and disutility from labor (L_t^j):

$$\mathbb{E}_0 \sum_{t=0}^{\infty} (\beta^j)^t \left[\left(\left(C_t^j - \vartheta C_{t-1}^j \right)^{1-\sigma} - 1 \right) / (1-\sigma) - \left(L_t^j \right)^{\varphi} \right] \quad \textbf{(11)}$$

where $\beta^j \in (0,1)$ is the subjective discount factor, σ is the coefficient of relative risk aversion, ϑ is the degree of habit formation in consumption, L^j is the preference weight on the leisure for household $j = [a, \mathrm{s}]$. This introduces an element of inertia into consumption, and is a fairly standard feature of New Keynesian models.

9.1.1.1. Optimizing households[9]

Let C_t^a, and L_t^a represent consumption and leisure for optimizing households (hence we use a superscript "a" to refer to optimizing households' variables). Preferences are defined by the discount factor $\beta^a \in (0,1)$ and the period utility $U(C_t^a, L_t^a)$. Optimizing households seek to maximize:

$$\mathbb{E}_0 \sum_{t=0}^{\infty} (\beta^a)^t \left[U(C_t^a, L_t^a) \right] \quad \textbf{(12)}$$

Subject to the sequence of budget constraints

[8] (Campbell & Mankiw, 1989)

[9] Hand-to-mouth households are sometimes called non-savers, liquidity-constrained, rule-of-thumb consumers, or static optimizers while savers (optimizing) are called dynamic optimizers.

$$C_t^a = (W_t/P_t)L_t^a + D_t/P_t + B_{t+1}^*/(1+i_t^*)\phi \cdot (Q_t/Q_{t-1}) \cdot P_{t+1}^*/P_t^* - (S_t/P_t)B_t^* + (B_{t+1}/(1+i_t)) \cdot (P_{t+1}/P_t) - (B_t/P_t) + (TR/P_t) \quad \textbf{(13)}$$

That is, nominal consumption is equal to wage income, $W_t L_t^a$, plus dividends, D_t plus foreign financing or saving measured by the change external debt position, $(S_t B_{t+1}^*/(1+i_t^*)\phi) - S_t B_t^*$, plus domestic financing or saving (debt or assets), $B_{t+1}/(1+i_t) - B_t$, plus transfer (or taxes if it is negative) from the government, TR. Foreign debt is assumed to be denominated in foreign exchange, and is converted to domestic currency terms by multiplying by the nominal exchange rate S_t. In addition, instead of expressing debt growth or asset growth as $S_t B_{t+1}^* = S_t B_t^* \cdot (1+i_t^*)\phi$, we divide both sides by $(1+i_t^*)\phi$.

The problem of the *optimizing* reduces to maximizing with respect to consumption, real money balances, labor supply in both sectors, and domestic and foreign assets, subject to the constraint with the Lagrangian function associated with it is:

$$\mathbb{E}_0 \sum_{t=0}^{\infty} (\beta^a)^t \left[\begin{array}{c} \{((C_t^a - \vartheta C_{t-1}^a)^{1-\sigma} - 1)/(1-\sigma) - (L_t^a)^{\varphi}\} - \\ -\lambda_t \left\{ C_t^a - \left(\begin{array}{c} (W_t/P_t)L_t^a + D_t/P_t + (B_{t+1}^*/(1+i_t^*)\phi) \cdot \\ \cdot (Q_t/Q_{t+1}) \cdot (P_{t+1}^*/P_t^*) - (S_t/P_t)B_t^* + \\ +(B_{t+1}/1+i_t) \cdot (P_{t+1}/P_t) - B_t/P_t + TR/P_t \end{array} \right) \right\} \end{array} \right] \quad \textbf{(14)}$$

The first order conditions with respect to C_t^a, L_t^a, B_{t+1} and B_{t+1}^* are:

$$\boldsymbol{C_t^a}: \ (1-\sigma) \cdot (C_t^a - \vartheta \cdot C_{t-1}^a)^{1-\sigma-1}/(1-\sigma) - \lambda_t = 0; \quad (C_t^a - \vartheta \cdot C_{t-1}^a)^{-\sigma} = \lambda_t; \quad \textbf{(15)}$$

$$\boldsymbol{L_t^a}: \ -\varphi \cdot (L_t^a)^{\varphi-1} + \lambda_t \cdot (W_t/P_t) = 0; \quad \varphi \cdot (L_t^a)^{\varphi-1} = \lambda_t \cdot W_t/P_t; \quad \textbf{(16)}$$

$$\boldsymbol{B_{t+1}^*}: \ \lambda_t \cdot (1/(1+i_t^*)\phi) \cdot (Q_t/Q_{t+1}) \cdot (P_{t+1}^*/P_t^*) - \mathbb{E}_0[\lambda_{t+1} \cdot \beta(S_{t+1}/P_{t+1})] = 0; \quad \lambda_t = \mathbb{E}_0[\lambda_{t+1} \cdot \beta^a (1+i_t^*)\phi \cdot (S_{t+1}/P_{t+1}) \cdot (Q_{t+1}/Q_t) \cdot P_t^*/P_{t+1}^*]; \quad \lambda_t = \mathbb{E}_0[\lambda_{t+1} \cdot \beta^a (1+i_t^*)\phi \cdot (Q_{t+1}/Q_t) \cdot (P_t^*/P_{t+1}^*)]; \quad \textbf{(17)}$$

$$\boldsymbol{B_{t+1}}: \ \lambda_t \cdot \left(1/1+i_t\right) \cdot \left(P_{t+1}/P_t\right) - \mathbb{E}_0[\lambda_{t+1} \cdot \beta^a (1/P_{t+1})] = 0; \quad \lambda_t = \mathbb{E}_0\left[\lambda_{t+1} \cdot \beta^a \left(1+i_t\right)(P_t/P_{t+1})\right]; \quad \textbf{(18)}$$

Euler equation:

$$\begin{array}{l} C_t^a - \vartheta \cdot C_{t-1}^a = \mathbb{E}_0 (C_{t+1}^a - \vartheta \cdot C_t^a)\left[\beta^a \left(1+i_t\right)(P_t/P_{t+1})\right]^{-\frac{1}{\sigma}}; \\ [(C_{t+1}^a - \vartheta \cdot C_t^a)/(C_t^a - \vartheta \cdot C_{t-1}^a)]^{\sigma} = \beta^a \left(1+i_t\right)() \, P_t/P_{t+1}; \\ [(\bar{C}^a - \vartheta \cdot \bar{C}^a/\bar{C}^a - \vartheta \cdot \bar{C}^a)]^{\sigma} \cdot \sigma\left((1/1-\vartheta)(\hat{c}_{t+1}^a - \vartheta \hat{c}_t^a) - 1/(1-\vartheta)(\hat{c}_t^a - \vartheta \hat{c}_{t-1}^a)\right) = \bar{\beta}^a (1+\bar{\imath})\bar{\pi}(\hat{\imath}_t - \hat{\pi}_{t+1}); \\ \sigma\left(1/(1-\vartheta)\,(\hat{c}_{t+1}^a - \vartheta \hat{c}_t^a) - (1/(1-\vartheta))(\hat{c}_t^a - \vartheta \hat{c}_{t-1}^a)\right) = (\hat{\imath}_t - \hat{\pi}_{t+1}); \\ \hat{c}_t^a = (\vartheta/(1+\vartheta)\hat{c}_{t-1}^a + 1/(1+\vartheta)\,\hat{c}_{t+1}^a - (1/\sigma)((1-\vartheta)/(1+\vartheta)) \cdot (\hat{\imath}_t - \hat{\pi}_{t+1}). \end{array} \quad \textbf{(19)}$$

The supply of labor:

$$\begin{array}{l} \varphi \cdot (L_t^a)^{\varphi-1} = (W_t/P_t) \cdot (C_t^a - \vartheta \cdot C_{t-1}^a)^{-\sigma}; \\ [\varphi \cdot (L_t^a)^{\varphi-1} \cdot (P_t/W_t)]^{-\frac{1}{\sigma}} = C_t^a - \vartheta \cdot C_{t-1}^a; \\ \left[\varphi \cdot \overline{L_t^a}^{\varphi-1} \cdot (\bar{P}/\bar{W})\right]^{-\frac{1}{\sigma}} \left[1 - (1/\sigma)\left(\{\varphi-1\}\hat{l}_t^a + \hat{p}_t - \hat{w}_t\right)\right] \\ \qquad = [\bar{C} - \vartheta \bar{C}] \cdot [1 + (1/(1-\vartheta))(\hat{c}_t^a - \vartheta \hat{c}_{t-1}^a)]; \\ \left[1 - 1/\sigma\left(\{\varphi-1\}\hat{l}_t^a + \hat{p}_t - \hat{w}_t\right)\right] = [1 + (1/1-\vartheta)(\hat{c}_t^a - \vartheta \hat{c}_{t-1}^a)]; \\ \hat{l}_t^a = (1/\{\varphi-1\}) \cdot \{\hat{w}_t - \hat{p}_t - \sigma \cdot [(1/1-\vartheta)(\hat{c}_t^a - \vartheta \hat{c}_{t-1}^a)]\}; \end{array} \quad \textbf{(20)}$$

9.1.1.2. Rule-of-thumbs households

Rule-of-thumb households do not attempt (or are just unable) to smooth their consumption path in the face of fluctuations in labor income. Each period they solve the static problem, i.e., they maximize their period utility $U(C_t^s, L_t^s)$ subject to the constraint that all their labor income is consumed, that is:

$$P_t \cdot C_t^s = W_t \cdot L_t^s \quad \textbf{(21)}$$

And where a"***s***" superscript is used to denote variables specific to rule-of-thumb households. Since the only assets that the hand-to-mouth households can hold is money, their subjective discount factor set to zero ($\beta^s = 0$) to avoid that these consumers could smooth consumption by changing their money holdings. The first order conditions with respect to C_t^s is:

$$\begin{aligned} & C_t^s = W_t \cdot (L_t^s / P_t) \\ & \bar{C}(1 + \hat{c}_t^s) = \overline{W} \cdot (\bar{L}/\bar{P}) \cdot (1 + \widehat{w}_t - \hat{p}_t + \hat{l}_t^s) \\ & (1 + \hat{c}_t^s) = (1 + \widehat{w}_t - \hat{p}_t + \hat{l}_t^s) \\ & \hat{c}_t^s = \widehat{w}_t - \hat{p}_t + \hat{l}_t^s \\ & \hat{c}_t = \mathfrak{d} \cdot \hat{c}_t^s + (1 - \mathfrak{d}) \cdot \hat{c}_t^a \end{aligned} \quad \textbf{(22)}$$

9.1.2. Production Sectors

Output in the economy consists of two types of goods. The first is a composite good produced by monopolistically competitive firms for both domestic consumption and export. The second good is a natural endowment commodity for export.

The domestically-produced composite good (Y_t^d), is produced using a CES production technology with inputs of labor (L_t), and an imported input (IM_t). This production function is particularly convenient of its generality, given that it embeds a Cobb-Douglas or even a Leontief technology, depending on the size of the elasticity of input substitution, (η).

$$\begin{aligned} & {Y_t^d}^{\frac{\eta-1}{\eta}} = T^{\frac{\eta-1}{\eta}} \cdot \left[\alpha {IM_t}^{\frac{\eta-1}{\eta}} + (1-\alpha) {L_t}^{\frac{\eta-1}{\eta}} \right]; \\ & F_t = \alpha {IM_t}^{\frac{\eta-1}{\eta}} + (1-\alpha) {L_t}^{\frac{\eta-1}{\eta}}; \\ & Y^d \, \bar{Y}^{d\frac{\eta-1}{\eta}} \left(1 + (\eta-1)/\eta \cdot \hat{y}_t^d\right) = \bar{T}^{\frac{\eta-1}{\eta}} (1 + (\eta - 1/\eta) \cdot \hat{t}_t) \cdot \bar{F} \cdot \left(1 + \hat{F}_t\right); \\ & \hat{y}_t^d = \hat{t}_t [\alpha^\eta + (1-\alpha)^\eta] + \left[\alpha^\eta \cdot \widehat{im}_t + (1-\alpha)^\eta \cdot \hat{l}_t\right]; \end{aligned} \quad \textbf{(23)}$$

Where T is total factor productivity, (α) is the share of the imported good in production-the openness of the economy, (η) is the elasticity of substitution in production. The firm's problems is to choose inputs (L_t) to (IM_t) minimize its costs

$$min \rightarrow W_t L_t + S_t P_t^* IM_t + \lambda_t \left[{Y_t^d}^{\frac{\eta-1}{\eta}} - T^{\frac{\eta-1}{\eta}} \left[\alpha {IM_t}^{\frac{\eta-1}{\eta}} + (1-\alpha) {L_t}^{\frac{\eta-1}{\eta}} \right] \right] \quad \textbf{(24)}$$

where W_t is the nominal wage, S_t is the nominal exchange rate, P_t^* is the price of imports, λ_t is the Lagrange multiplier or marginal cost of production. Production costs reflect the costs of the labor and the imported inputs, as well as labor.

$$TC = W_t N_t + S_t P_t^* I_t; \quad \textbf{(25)}$$

The first order conditions with respect to L_t and IM_t are:

$$\boldsymbol{L_t}: \; W_t = \lambda_t \cdot T^{\frac{\eta-1}{\eta}} \cdot (1-\alpha) \cdot (\eta - 1/\eta) \cdot {L_t}^{-\frac{1}{\eta}} \quad \textbf{(26)}$$

$$
\begin{aligned}
&\boldsymbol{IM_t}:\ S_t P_t^* - \lambda_t \cdot T^{\frac{\eta-1}{\eta}} \cdot \alpha \cdot (\eta - 1/\eta) \cdot IM_t^{\frac{\eta-1}{\eta}-1} = 0;\\
&S_t P_t^* = \lambda_t \cdot T^{\frac{\eta-1}{\eta}} \cdot \alpha \cdot (\eta - 1/\eta) \cdot IM_t^{-\frac{1}{\eta}}\\
&\left[(W_t/\lambda_t \cdot T^{\frac{\eta-1}{\eta}} \cdot (1-\alpha) \cdot (\eta - 1/\eta))\right]^{-\eta} = L_t;\\
&\left[S_t P_t^*/(\lambda_t \cdot T^{\frac{\eta-1}{\eta}} \cdot \alpha \cdot (\eta - 1/\eta))\right]^{-\eta} = IM_t;
\end{aligned}
\qquad \textbf{(27)}
$$

Total cost

$$
\begin{aligned}
&TC = Y_t^d/T \cdot \left(W_t^{1-\eta} \cdot [(1-\alpha)]^{\eta} + S_t P_t^{*1-\eta} \cdot [\alpha]^{\eta}\right)^{\frac{1}{1-\eta}};\\
&MC_t^n = 1/T \cdot \left(W_t^{1-\eta} \cdot [(1-\alpha)]^{\eta} + S_t P_t^{*1-\eta} \cdot [\alpha]^{\eta}\right)^{\frac{1}{1-\eta}};\\
&MC_t^r = (1/T) \cdot \left((W_t/P_t)^{1-\eta} \cdot [(1-\alpha)]^{\eta} + Q_t^{1-\eta} \cdot [\alpha]^{\eta}\right)^{\frac{1}{1-\eta}};\\
&MC_t^{r\,1-\eta} = (1/T)^{1-\eta}\left[(W_t/P_t)^{1-\eta} \cdot [(1-\alpha)]^{\eta} + Q_t^{1-\eta} \cdot [\alpha]^{\eta}\right];\\
&Z_t = (W_t/P_t)^{1-\eta} \cdot [(1-\alpha)]^{\eta} + Q_t^{1-\eta} \cdot [\alpha]^{\eta};\\
&\overline{MC}^{r\,1-\eta}(1 + (1-\eta) \cdot \widehat{mc}_t^r) = (1/\bar{T})^{1-\eta} \cdot \bar{X} \cdot (1 + \hat{x}_t - (1-\eta) \cdot \hat{t}_t);\\
&\overline{MC}^{r\,1-\eta} = (1/\bar{T})^{1-\eta} \cdot \bar{X};\\
&(1-\eta) \cdot \widehat{mc}_t^r = \hat{x}_t - (1-\eta) \cdot \hat{t}_t;\\
&\widehat{mc}_t^r = [[1-\alpha]^{\eta} \cdot [\hat{w}_t - \hat{p}_t] + [\alpha]^{\eta} \cdot \hat{q}_t] - \hat{t}_t \cdot ([1-\alpha]^{\eta} + [\alpha]^{\eta});
\end{aligned}
\qquad \textbf{(28)}
$$

9.1.3. Phillips curve

Intermediate firms are assumed to set nominal prices sluggishly, according to the stochastic time dependent rule proposed by Calvo (1983). Each firm resets its price with probability $1-\theta$ each period, independently of the time elapsed since the last adjustment. Thus, for each period a measure $1-\theta$ of producers reset their prices, while a fraction θ keep their prices unchanged. In other words, a fraction θ of domestic sales, follows a simple, backward-looking approach to price setting, remaining parts take a forward-looking optimization to price setting, and adjust their prices on a random basis. A firm resetting its price in period t will seek to maximize

$$\mathbb{E}_t \sum_{k=0}^{\infty} (\beta\theta)^k \, [P_t(z) - MC_{t+k}^n] Y_{t+k}^d(z) \qquad \textbf{(29)}$$

where (β) is the subjective rate of time preference, θ is the fraction of periods in the year that prices are not adjusted, $Y_{t+k}^d(z)$ is the expected production of each firm, (z) between periods (t) and $(t+k)$, MC_{t+k}^n is the expected nominal marginal cost of production between (t) and $(t+k)$. Subject to the sequence of demand constraints

$$Y_{t+k}^d(z) = (P_{t+k}/P_t(z))^{\varepsilon} \cdot Y_{t+k}^d \qquad \textbf{(30)}$$

where $P_t(z)$ represents the price chosen by firms resetting prices at time t and Y_{t+k}^d is total domestic production between (t) and $(t+k)$. The demand for an individual firm's output depends on the relative price of its output and total output of the economy. Firms are monopolistic competitors, facing downward sloping demand curves. The result of the optimization problem is combined with the Calvo type pricing:

$$
\begin{aligned}
&P_t = \left\{\theta[P_{t-1}(P_{t-1}/P_{t-2})^{\mu}]^{1-\varepsilon} + (1-\theta)\left[P_t^{opt}\right]^{1-\varepsilon}\right\}^{\frac{1}{1-\varepsilon}}\\
&\mathbb{E}_t \sum_{k=0}^{\infty} (\beta\theta)^k \, [P_t(z) - MC_{t+k}^n](P_{t+k}/P_t(z))^{\varepsilon} \cdot Y_{t+k}^d \to max\\
&\mathbb{E}_t \sum_{k=0}^{\infty} (\beta\theta)^k \left[P_t(z)(P_{t+k}/P_t(z))^{\varepsilon} \cdot Y_{t+k}^d - MC_{t+k}^n (P_{t+k}/P_t(z))^{\varepsilon} \cdot Y_{t+k}^d\right]\\
&P_t(z) = (\varepsilon/(1-\varepsilon)) \cdot \left(\left(\sum_{k=0}^{\infty} (\beta\theta)^k \, MC_{t+k}^n \cdot Y_{t+k}^d(z)\right)/\sum_{k=0}^{\infty} (\beta\theta)^k \, Y_{t+k}^d(z)\right);\\
&P_t(z) \cdot \sum_{k=0}^{\infty} (\beta\theta)^k \, Y_{t+k}^d(z) = (\varepsilon/(1-\varepsilon)) \cdot \sum_{k=0}^{\infty} (\beta\theta)^k \, MC_{t+k}^n \cdot Y_{t+k}^d(z);
\end{aligned}
\qquad \textbf{(31)}
$$

$\sum_{k=0}^{\infty}(\beta\theta)^k P_t(z)Y_{t+k}^d(z) = \bar{P}\cdot\bar{Y}\cdot\sum_{k=0}^{\infty}(\beta\theta)^k\left(1+\hat{p}_t(z)+\hat{y}_{t+k}^d(z)\right);$
$\varepsilon/(1-\varepsilon)\cdot\sum_{k=0}^{\infty}(\beta\theta)^k MC_{t+k}^n\cdot Y_{t+k}^d(z) = \varepsilon/(1-\varepsilon)\cdot\overline{MC}\cdot\bar{Y}\sum_{k=0}^{\infty}(\beta\theta)^k\left(1+\widehat{mc}_{t+k}^n+\hat{y}_{t+k}^d(z)\right);$
$\sum_{k=0}^{\infty}(\beta\theta)^k\left(1+\hat{p}_t(z)+\hat{y}_{t+k}^d(z)\right) = \sum_{k=0}^{\infty}(\beta\theta)^k\left(1+\widehat{mc}_{t+k}^n+\hat{y}_{t+k}^d(z)\right);$
$\left(\left(1+\hat{p}_t(z)\right)/1-\beta\theta\right)\sum_{k=0}^{\infty}(\beta\theta)^k\left(\hat{y}_{t+k}^d(z)\right) = \sum_{k=0}^{\infty}(\beta\theta)^k\left(1+\widehat{mc}_{t+k}^n+\hat{y}_{t+k}^d(z)\right);$
$\left(\left(1+\hat{p}_t(z)\right)/(1-\beta\theta)\right) = \sum_{k=0}^{\infty}(\beta\theta)^k+\sum_{k=0}^{\infty}(\beta\theta)^k(\widehat{mc}_{t+k}^n);$
$\left(\left(1+\hat{p}_t(z)\right)/(1-\beta\theta)\right) = (1/1-\beta\theta)+\sum_{k=0}^{\infty}(\beta\theta)^k(\widehat{mc}_{t+k}^n);$
$\hat{p}_t(z) = (1-\beta\theta)\sum_{k=0}^{\infty}(\beta\theta)^k(\widehat{mc}_{t+k}^n);$
$\hat{\pi}_t = (\beta/(1+\beta\mu))\hat{\pi}_{t+1}+(\mu/(1+\beta\mu))\hat{\pi}_{t-1}+(\varsigma/(1+\beta\mu))\widehat{mc}_r^R$

9.1.4. Export demand

Demand for exports of the domestically-produced composite good, X_t depends on the real exchange rate, (Q_t) and foreign demand, Y_t^*:

$$X_t = [(P_t/S_tP_t^*)^{-\tau}Y_t^*]^{1-\gamma}X_{t-1}^{\gamma}$$
$$X_t = [(Q_t)^{\tau}Y_t^*]^{1-\rho_{x^d}}X_{t-1}^{\rho_{x^d}} \quad \textbf{(32)}$$

where (ρ_{x^d}) is the degree of persistence in domestic exports, (τ) is the real exchange rate elasticity of demand for domestically-produced exports.

$$\bar{X}\cdot(1+\hat{x}_t) = [(\bar{Q})^{\tau}\cdot\bar{Y}^*]^{1-\gamma}\cdot\bar{X}^{\gamma}\cdot\left[1+\gamma\cdot\hat{x}_{t-1}^d+(1-\gamma)[\tau\hat{q}_t+\hat{y}_t^*]\right]$$
$$(1+\hat{x}_t) = \left[1+\gamma\cdot\hat{x}_{t-1}^d+(1-\gamma)[\tau\hat{q}_t+\hat{y}_t^*]\right] \quad \textbf{(33)}$$
$$\hat{x}_t^d = \gamma\cdot\hat{x}_{t-1}^d+(1-\gamma)[\tau\hat{q}_t+\hat{y}_t^*]$$

Aggregate spending on the domestically produced good

$$\hat{y}_t^d = (\bar{c}/\bar{y}^d)\hat{c}_t+(\bar{x}^d/\bar{y}^d)\hat{x}_t^d \quad \textbf{(34)}$$

Production of the second endowment type good

$$\hat{x}_t^{CM} = \hat{q}_t+\hat{p}_t^{CM} \quad \textbf{(35)}$$

9.1.5. Equilibrium conditions and identities

The total output of the economy is the sum of the domestic consumption and exports of the domestically produced goods, together with the exports of exported resource commodity:

$$\hat{y}_t = (\bar{c}/\bar{y})\hat{c}_t+(\bar{x}^d/\bar{y})\hat{x}_t+(\bar{x}^{CM}/\bar{y})\hat{x}_t^{CM} \quad \textbf{(36)}$$

Where $(\bar{c}/\bar{y}),(\bar{x}^d/\bar{y})$ and $(\bar{x}^{CM}/\bar{y})$ are shares of consumption, exports of domestically produced good, and exports of the natural resource commodity, in total production. GDP is equal to total output minus imports:

$$G\hat{D}P_t = \hat{y}_t-\alpha_y(\bar{y}^d/\bar{y})(\widehat{im}_t+\hat{q}_t) \quad \textbf{(37)}$$

The balance of payments is built adding up the consumer, government, and firm resource constraints:

$$(\bar{c}/\bar{y})\hat{c}_t = \hat{y}_t-\alpha_y(\bar{y}^d/\bar{y})(\widehat{im}_t+\hat{q}_t)+(\bar{b}^*/\bar{y})(1/(1+\bar{\imath}^*)\bar{\phi})\left[\pi_{t+1}^*+\hat{b}_{t+1}^*-\right.$$
$$\left.(\hat{q}_{t+1}-\hat{q}_t)-(1+\hat{\imath}_t^*)-\hat{\phi}_t\right]-(\bar{b}^*/\bar{y})\hat{b}_t^* \quad \textbf{(38)}$$

The net change in foreign debt is equal to the current account balance, which is composed of the trade balance and interest payments abroad.

9.2. Monetary policy operation and instruments

In 2007, monetary policy shifted into a different framework and made changes in monetary policy operation. In along with these changes in operation, a policy rate was introduced and it has become the principal instrument of monetary policy as well as the indicator of policy stance.

Policy rate is used as the discount rate at auction for 1 week CBB that has the lowest risk in the interbank market. It is regulated consistent with the current economic situation and its anticipated future tendency. In order to improve the transmission mechanism of monetary policy, the interest rate corridor was introduced in March 2013. For the monetary policy implementation, following instruments are used:

Central Bank's Bill: 1 and 4 weeks of CBBs are used in open market operation. 1 week CBB has two types of tender, which are policy rate tender with pre-announced allotment volume, policy rate tender with free allotment volume. 4 weeks CBBs are tendered with variable interest rate tender with ceiling rate and pre-announced allotment volume. The volume of CBB is approved by the governor of the BoM.

Reserve requirements: It is one of the policy instruments used to monitor money supply and manage liquidity within the interbank market. The banks are required to maintain reserves holdings under the arrangement facilitates, as they always have the necessary funds at their disposal. The reserve requirement system is averaged on maintenance period of 2 weeks which allows banks to determine the amount of funds held on the current account of the central bank. According to the Central Bank Law, this ratio must not be higher than 30 percent of bank's total assets.

Overnight repo: The central bank offers the standing facility of overnight repo to fulfill the reserve requirements of banks, with certain collateral. The overnight repo rate is ceiling of the corridor or 2 points higher than the policy rate and volume of the loan shall not exceed the required reserve. The maturity is from closing of the clearing settlement of current day to opening of clearing settlement of the following working day.

Repo: Repo financing is a deal whereby central bank purchases securities under the condition to resell at a predetermined price on the specified date. The repo financing rate is set to 0.5 percentage points above the policy rate. The accepted securities are CBBs, government bonds, and Mongolian Mortgage Corporation bonds.

Intra-day repo: The purpose of the intra-day facility is to maintain bank's liquidity and to keep the ordinary function of the banking payment system as the source of funds to be obtained during the trading day. The BoM do not issue interest earnings from this type of facility and repo is collateralized with securities accepted by the central bank.

10. References

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