Monetary Transmission Mechanism with Varying Degree of Openness

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Abstract

Using Gali and Monacelli(2005) DSGE model of a small open economy, this paper analyzes how varying degree of openness with different kinds of disturbances could affect monetary transmission mechanism and the choice of monetary policy regimes, including inflation targeting and exchange rate targeting. The analysis shows that higher degree of openness causes the slope of the dynamic IS curve to be steeper and the slope of Phillips curve to be flatter. Three key results can be drawn from this study. First, for a given degree of openness, there is no clear-cut evidence which regime performs best from the welfare perspective as it depends on the type of shocks. Second, as the economy becomes more open, global supply shocks do not necessarily translate into higher inflation volatility and output volatility. This is due to higher sensitivity of domestic output to a given change in interest rate. Finally, by extending the basic model to include partial indexation of price, the Phillips curve can have both backward and forward-looking elements. Our analysis implies that so long as the central bank can anchor inflation expectations, the problem of choosing monetary policy regimes e.g. whether inflation targeting or exchange rate targeting does not matter as much.

1 Introduction

“As Thailand becomes more open, does inflation targeting policy using interest rate as an instrument still appropriate?”

The effectiveness of the long-utilized interest rate based inflation targeting monetary policy of Thailand has been a hot topic for the debate whether it is still appropriate with an increasing degree of openness structure of Thailand. Arising the advocate supporting the use of interest rate based inflation targeting, and the opponent suggesting Thailand should reconsider and doubt the effectiveness of the policy regime.

With an explicit structure of the small open and export based economy, there arises interesting studies questioning the effectiveness of monetary policy using interest rate as a policy instrument. With higher degree of openness, domestic inflation is argued to have suffered from external supply shock and thus become an inefficient target in operating monetary policy. Saicheu et al.(2012) and Ramangkul(2012) have proposed the idea that monetary authority will have less control over interest rate which is the major policy instrument if the country has higher degree of openness. Looking ahead, greater interest rate differential between domestic interest rate and US interest rate, this would inevitably increase the potential conflict between maintaining international competitiveness and inflation targeting framework; therefore, the monetary authority will lose its independence in controlling policy instrument or interest rate. Moreover, with the current growing degree of openness, the ratio of export to GDP of Thailand can possibly reach 100% in 2014.

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The country now facing the question, whether it is optimal for Thailand, to opt for exchange rate targeting instead of inflation targeting which has suffered from external supply pressure, making it difficult to target? High degree of openness measured from the amount of import and export, together with free capital flow, some economist proposed that exchange rate might be a better transmission mechanism while interest rate is presumed to lose its effectiveness under this economic condition. With plentiful international reserves in intervening in exchange rate movement, different from the 1997 Tom Yum Kung crisis in which the authority failed to maintain strict control over exchange rate, exchange rate targeting in coordination with governmental sector could be a proper regime for Thailand economic structure.

On the other side, supporting the use of interest rate based inflation targeting, the Bank of Thailand stated that inflation rate of Thailand is not much influenced by world price level as tradable goods account for only 35% of the consumption basket. Moreover, it is argued that, Thailand domestic inflation is affected not only by the uncontrollable external supply shock, but also by the controllable expected supply shock and the domestic demand shock. According to Chai-Anant et al.(2008), considered the past data of Thailand, the impulse response analysis of Small Model impiles that the impact of exchange rate on inflation is short-lived compared to the impact from interest rate in the case of Thailand; therefore, exchange rate should be used to control only temporary inflation shocks to help contain inflation expectation. As Pongsaparn et al.(2011) mentioned, with threecriteria, (1.)controllability of policy instrument and monetary conditions (2.)the degree of counter cyclicality and (3.)the effectiveness of an instrument in affecting inflation and output, the result shows that interest rate outperforms other instruments. Considering past performance of the Bank of Thailand, with clear communication, transparency, and accountability, the performance of monetary policy is always maintained in good position; thus, enhancing the performance of interest rate as a policy instrument.

This has provided an ideal ground for the analysis of optimal monetary policy with varying degree of openness and under alternative disturbances. The degree of openness is expected to have and effect not only on the supply side of the economy but also the demand side. The goal of this research is to study the role of exchange rate as a monetary transmission mechanism, to test whether interest rate does become an ineffective instrument in targeting inflation by employing monetary efficient frontier trade-off analysis, impulse response function analysis, and the cyclical properties of several macroeconomic variables analysis. The paper employs small open economy, dynamic stochastic general equilibrium(DSGE) model of Gali and Monacelli(2005) as a baseline throughout the whole study due to three major advantages. First, the model is micro-founded; thus, not vulnerable to Lucas critique. Second, DSGE model gives an explicit welfare based analysis which is beneficial in ranking each policy regime by welfare. Third, we can explicitly analyze the impulse response function of different kinds of disturbances to fully understand the stochastic process. Moreover, the model is further augmented with the taxonomy of policy regimes from Stone et al.(2009) to enrich the comparison.

The paper is organized as follow: We begin by addressing previous study and the literature review in section (2.). Next, I explained the overview of the small open economy model from Gali and Monacelli(2005) and employ two monetary policy regimes from the study: Domestic inflation based Taylor rule, simple Taylor-typed rules targeting domestic inflation, and CPI inflation based Taylor rule, simple Taylor-type rule targeting CPI inflation. In section (5), by assuming that varying degree of openness have an effect on the slope of Phillips curve and the dynamic IS curve, I further incorporate alternative policy choices into the model. Several types of disturbances are analyzed: domestic and world output shock, demand shock, and supply shock. Finally, the paper study how varying degree of anchor inflation expectation affects the performance of each monetary policy approaches by focusing on the Taylor curve analysis.
2 Literature Review

Monetary Policy is a powerful tool that has successfully saved the economy from several economic crises in the past making it crucially important for economists to have an accurate understanding in how monetary policy could induced such effects. Due to different economic structure of advanced economy and emerging economy, it is necessary for emerging economy to have a different characteristic of monetary policy from advanced economy. As Calvo and Mishkin(2003) identified five fundamental differences between emerging and advanced economy: (1.)Weak fiscal institution (2.)Weak financial institution including governmental prudential regulation and supervision (3.)Low credibility of monetary institution (4.)Currency substitution and and liability dollarization (5.)Vulnerability to and immediate stops of capital flow.

The first three elements, weak fiscal, financial, and monetary institution, certainly make the economy vulnerable to economic crisis. Also, low regulation and supervision could possibly lead to the financial crisis. Due to the following outlined reasons, Calvo and Mendoza(2000) has express their doubt, under inflation targeting, whether allowing too much discretion to monetary authority in emerging economies will lead to poor performance. As Mishkin(2004) points out inflation targeting can be worked in emerging countries; however, institutional developments are necessitated.

Moreover, he mentioned that, due to the five fundamental structures of emerging economy, these countries have greater concerns over exchange rate fluctuations than advanced economies do and there is rational to intervene in exchange rate market in emerging economies. The only concern is that they can go too far. With too strong intention in dampening exchange rate movement, it runs the risk of transforming exchange rate into nominal anchor and take precedence over inflation target. As Calvo and Reinhart(2002) points out an evidence from small open economy suffered from the pervasive global financial crisis, particularly among emerging economies, provoke the central bank to pay attention to the role of exchange rate movement, arising the case “fear of floating”.

Also, there exist several researches in contrast with the aforementioned view. According to Obstfeld and Rogoff(1995), whether short or long term substantial departures from purchasing power parity, policy reaction to exchange rate is undesirable since there exist some deviations of exchange rate that should not be offset by interest rate movement and will have an adverse effect on inflation and output, worse than solely from exchange rate movement itself. Supported by Taylor(2001), interest rate should not react directly to exchange rate movement, indirect effect of exchange rate is preferred since temporary exchange rate fluctuation may not have an effect on inflation expectation and interest rate, reacting to such short-run deviation could instead result in a more harmful swing. Also, several existing literatures doubt the role of exchange rate in conducting monetary policy, Bernanke et al (1999) did not explicitly mentioned the necessity of considering exchange rate when conducting monetary policy.

The role of exchange rate under inflation targeting approach, especially in emerging economy, is highly discussed in several existing literatures. According to Eichengreen et al.(1999), with relatively weak financial market, disturbances, and large capital flow can easily lead to exchange rate excessive volatility due to negligence of exchange rate in monetary policy. In addition, Amato and Gerlach(2002) suggest, for the low credibility central bank in emerging economy, exchange rate intuitively becomes the focal point for inflation expectation. Depreciation tends to have large inflationary effect in emerging economies with low inflation history. Cavoli and Rajan(2006) find that it is optimal to include the optimally weight of exchange rate into the reaction function for emerging economies(calibrated for Thailand data), but they find that the optimal weight placed on exchange rate movement is quite low.

More unique and perfect control over exchange rate in conducting monetary policy can be seen in the case of Singapore, with the small and extremely open economic structure. As expressed in
Monetary Authority of Singapore(2001a), “The primary objective of monetary policy is to ensure low inflation as a sound basis for sustained economic growth. In Singapore, monetary policy is centered on management of the exchange rate rather than money supply or interest rates. This reflects the fact that, in small and open Singapore economy, the exchange rate is the most effective tool in maintaining price stability.” The mentioned statement is supported by McCallum(2006), it is optimal for the highly open economic structure like Singapore to employ exchange rate as an operating instrument instead of interest rate. The comparison of macroeconomic variable under two different regimes are presented, showing that conducting policy via exchange rate instrument outperforms via interest rate instrument.

In this research paper, I also focus on the role of openness on the “slope” of the Phillips curve which links the dynamic of inflation to the level of real economic activities. There is a growing body of literatures that explores the outlined hypothesis; however, the results are still conflicting. According to Rogo(2006) with greater degree of globalization, competition will increase, making price becomes more flexible; thus, steepen the Phillips curve and inflation will rise more for a given rise in output. However, there exist several studies arguing the study of Rogo(2006). On the other aspect, the IMF(2006) finds that as globalization or higher degree of openness increase competition, it will be more difficult to raise price, and thus flatten the Phillips curve. However, Ball(2006) suggests that even though the view of IMF fits the trend with the data, trade is a better explanation for flattered Phillips curve than globalization, and the regression analysis shows that the effect is small and could be weaker if control for average inflation and credibility. Also, Wynne and Kersting (2007) and Ihrig et al. (2007) report weak or no relation at all. The overall conclusion is that the evidence of the relation between openness and slope of the Phillips curve is scattered and still inconclusive.

Another avenue of this research focus on the role of central bank’s credibility. As Mishkin(1999) points out, nominal anchor is needed for successful monetary policy since it generates price stability and help weaken time-inconsistencies problem playing an important role in achieving long-run price stability. Michael Woodford has also put it, “not only do expectations about policy matter, but, at least under current conditions, very little else matters”. King(2005) has further emphasis the following standpoint that expectations are of fundamental in conducting monetary policy since it matters the behavior of household and firms, thus reflect central bank’s credibility.

3 The Small Open Economy DSGE Model

In this present section, we first follow the DSGE model of Gali and Monacelli(2005) for small open economy

3.1 Households
The representative household maximize utility function of the form

$$E_0 \sum_{t=0}^{\infty} \beta^t \left( \frac{C_{t+1}^{1-\sigma}}{1-\sigma} - \frac{N_{t+1}^{1+\rho}}{1+\rho} \right)$$  \hspace{1cm} (1)$$

subject to budget constraints:

$$\int_0^1 P_{H,t}(j)C_{H,t}(j) dj + \int_0^1 P_{t,t}(j)C_{t,t}(j) dj di + E_t \{ Q_{t+1}D_{t+1} \} \leq D_t + W_t N_t + T_t$$  \hspace{1cm} (2)$$

where $N_t$ denotes hours of labour, $Q_{t,t+1}$ is the stochastic discount factor for one period ahead, $D_{t+1}$ is the nominal pay-off in period $t+1$ of the portfolio held at the end of period $t$, $W_t$ is
the nominal wage, $T_t$ denotes the lump-sum transfers/taxes and $C_t$ is the composite consumption index defined by

$$C_t \equiv [(1 - \alpha)^{\frac{1}{\gamma}}(C_{H,t})^{\frac{\gamma - 1}{\gamma}} + \alpha^{\frac{1}{\gamma}}(C_{F,t})^{\frac{\gamma - 1}{\gamma}}]^{\frac{\gamma}{\gamma - 1}}$$

$$C_{H,t} \equiv \left(\int_0^1 C_{H,t}(j)^{\frac{1}{\gamma - 1}} dj\right)^{\frac{\gamma - 1}{\gamma}}$$

$$C_{F,t} \equiv \left(\int_0^1 (C_{i,t})^{\frac{1}{\gamma - 1}} di\right)^{\frac{\gamma - 1}{\gamma}}; \quad C_{i,t} \equiv \left(\int_0^1 (C_{i,t})^{\frac{1}{\gamma - 1}} dj\right)^{\frac{\gamma - 1}{\gamma}}$$

We can rewrite the intratemporal optimality condition as follows

$$C_t^{\sigma} N_t^{\gamma} = \frac{W_t}{P_t}$$

which we obtain the intertemporal first order condition of the household optimization problem as

$$\beta \left(\frac{C_{t+1}}{C_t}\right)^{-\sigma} \left(\frac{P_t}{P_{t+1}}\right) = Q_{t,t+1}$$

Log-linear approximation of equation(6) and (7) where $R_t = \frac{1}{E_t\{Q_{t,t+1}\}}$ yields the euler equation for consumption as

$$w_t - p_t = \sigma c_t + \varphi n_t$$

$$c_t = E_t\{c_{t+1}\} - \frac{1}{\sigma}(r_t - E_t\{\pi_{t+1}\} - \rho)$$

where the lower case denote the logs of the respective variables.

### 3.1.1 Inflation, real exchange rate, and terms of trade

The consumer price index(CPI) is here defined as $P_t \equiv [(1 - \alpha)(P_{H,t})^{-\eta} + \alpha(P_{F,t})^{1-\eta}]^{\frac{1}{1-\eta}}$ which gives the log linear approximation as

$$p_t \equiv (1 - \alpha)p_{H,t} + \alpha p_{F,t}$$

$$= p_{H,t} + \alpha s_t$$

Next, the terms of trade is defined as the difference between foreign goods in terms of home goods($s_t \equiv p_{F,t} - p_{H,t}$). It follows that domestic inflation and CPI inflation are linked according to

$$\pi_t = \pi_{H,t} + \alpha \Delta s_t$$

As the exchange rate is defined as $Q_{i,t} \equiv \frac{s_t P_i^j}{P_t}$ of which the two countries CPI are expressed in terms of domestic currency. $\alpha$ is the degree of openness measuring the share of domestic consumption allocated to imported goods. Following Gali and Monacelli(2005)which derive the relationship between the terms of trade and exchange rate as

$$q_t = s_t + p_{H,t} - p_t$$
3.1.2 International risk sharing

Under the assumption of complete financial markets, a first order condition analogous to (5) must hold for each household in any country. Equating them yields:

\[
\beta \left( \frac{C_{t+1}}{C_t} \right)^{-\sigma} \frac{P_t}{P_{t+1}} = \beta \left( \frac{C^i_{t+1}}{C^i_t} \right)^{-\sigma} \left( \frac{P^i_t}{P^i_{t+1}} \right) \left( \frac{\bar{c}^i_{t+1}}{\bar{c}^i_{t+1}} \right)
\]

(11)

combining with the real exchange rate definition, the following holds

\[
C_t = \vartheta_i(C^i_t)Q^\frac{1}{2}_{i,t}
\]

(12)

where \( \vartheta_i \) is a constant which generally depend on initial conditions regarding relative net asset positions. We then log (12) and integrating over \( i \) which yields

\[
c_t = c^*_t + \frac{1}{\sigma} q_t
\]

\[
= c^*_t + \frac{(1 - \alpha)}{\sigma} s_t
\]

(13)

where \( c^*_t = \int_0^1 c^i_t di \) is the index for world consumption (in log terms). The second equality is derived by plugging in equation (30) which will be shown in section (5).

3.1.3 Uncovered interest parity

With the assumption of perfect international financial markets, the uncovered interest parity is defined as follow:

\[
r_t - r^*_t = E_t \{ \Delta e_{t+1} \}
\]

(14)

combining with the definition of (log) terms of trade yields:

\[
s_t = (r^*_t - E_t \{ \pi^*_t \}) - (r_t - E_t \{ \pi_H,t+1 \}) + E_t \{ s_{t+1} \}
\]

(15)

3.2 Firms

3.2.1 Technology

Each firm produces with a linear technology production function: \( Y_i(j) = A_t N_i(j) \) where \( j \in [0, 1] \) denotes the good variety, \( a_t \equiv \log A_t \), follows AR(1), \( a_t = \rho_a a_{t-1} + \varepsilon_t \). which gives the log linear approximation of the aggregate relationship as:

\[
y_t = a_t + n_t
\]

(16)

Hence, the marginal cost will be given by

\[
mc_t = -\nu + w_t - p_{H,t} - a_t
\]

\[
= -\nu + (w_t - \bar{p}) + (p_H - p_{H,t}) - a_t
\]

\[
= -\nu + \sigma c_t + \varphi n_t + \alpha s_t - a_t
\]

\[
= -\nu + \sigma c^*_t + \varphi y_t + \alpha s_t - (1 + \varphi) a_t
\]

\[
= -\nu + \sigma c^*_t + \varphi y_t + s_t - (1 + \varphi) a_t
\]

(17)

where the third equality use equation (6) and (8) to plugged in, the fourth equality use the realtionship from equation (16), and the fifth equality use equation (13).
### 3.2.2 Price-setting

Assume Calvo(1983) staggered price setting, each firm reset prices with probability \(1 - \theta\) while keep price unchanged with probability \(\theta\). We obtain the optimal price setting rule for forward looking firm:

\[
\bar{p}_{H,t} = \mu + (1 - \beta \theta) \sum_{k=0}^{\infty} \beta^k \mathbb{E}_t\{mc_{t+k} + p_{H,t}\}
\]

where \(\bar{p}_{H,t}\) is the (log) of newly domestic prices, \(\mu \equiv \log \left( \frac{\varepsilon}{\varepsilon - 1} \right)\) which is the (log) of steady state mark-up.

### 3.3 Equilibrium

#### 3.3.1 Goods market clearing

The market clearing condition in the representative “home” economy is given by \(y_{H,t} = c_{H,t} + c_{H,t}^*\) which says that domestic output is equal to the sum of domestic consumption and rest of the world consumption of domestic produced goods, export. Plugging in the definition of aggregate domestic output\(^1\) and following the first order log-linear approximation around the symmetric steady state, we obtain:

\[
y_t = c_t + \frac{\alpha \omega}{\sigma} s_t
\]

where \(\omega \equiv \sigma \gamma + (1 - \alpha)(\sigma \eta - 1)\)

As this condition holds for all countries, by aggregating over all countries we derived the market clearing condition as \(y_t^* = c_t^*\). Combining this condition with (19) and (12) yields

\[
y_t = y_t^* + \frac{1}{\sigma_\alpha} s_t
\]

where \(\sigma_\alpha \equiv \frac{\sigma}{(1 - \alpha) + \alpha \omega}\)

Combining equation (19) with euler equation (8), we get

\[
y_t = E_t\{y_{t+1}\} - \frac{1}{\sigma} (r_t - E_t\{\pi_{t+1} + \rho\}) - \frac{\alpha \omega}{\sigma} E_t\{\Delta s_{t+1}\}
\]

\[
= E_t\{y_{t+1}\} - \frac{1}{\sigma} (r_t - E_t\{\pi_{H,t+1} + \rho\}) - \frac{\alpha \Theta}{\sigma} E_t\{\Delta s_{t+1}\}
\]

\[
= E_t\{y_{t+1}\} - \frac{1}{\sigma_\alpha} (r_t - E_t\{\pi_{H,t+1} + \rho\}) + \alpha \Theta E_t\{\Delta y^*_{t+1}\}
\]

where \(\Theta \equiv (\sigma \gamma - 1) + (1 - \alpha)(\sigma \eta - 1) = \omega - 1\)

#### 3.3.2 Supply side equilibrium

Following the Calvo sticky price setting, we can derive inflation dynamics in terms of marginal cost as follow

\[
\pi_{H,t} = \beta E_t\{\pi_{H,t+1}\} + \lambda \bar{mc}_t
\]

where \(\lambda \equiv \frac{(1 - \beta \theta)(1 - \theta)}{\theta}\)

In determining the marginal cost, we follow equation (17) and using (8) to substitute for \(s_t\) which

\[
C_{H,t} = (1 - \alpha) \left( \frac{P_{H,t}}{P_t} \right)^{-\eta} C_t \quad \text{and} \quad C^*_t = \alpha \left( \frac{P_{H,t}}{\varepsilon_t P_t} \right)^{-\eta} C_t
\]
can be rewrite as
\[ mc_t = -\nu + (\sigma_\alpha + \varphi)y_t + (\sigma - \sigma_\alpha)y_t^* - (1 + \varphi)a_t \]  
(23)

3.3.3 Equilibrium dynamics

We first define the domestic output gap \( x_t \) as the deviation between domestic output from its natural level:
\[ x_t \equiv y_t - \bar{y}_t \]  
(24)

where the domestic natural output can be found by imposing \( mc_t = -\mu \) in equation (24)
\[ \bar{y}_t = \Omega + \Gamma a_t + \alpha \Psi y_t^* \]  
(25)

\( \Omega \equiv \frac{\nu - \mu}{\sigma_\alpha + \varphi}, \Gamma \equiv \frac{(1 + \varphi)}{\sigma_\alpha + \varphi}, \Psi \equiv \frac{-\Theta \sigma_\alpha}{\sigma_\alpha + \varphi} \)

Following (23), we know that
\[ \bar{mc}_t = (\sigma_\alpha + \varphi)x_t \]  
(26)

Combine with (22) we get the New Keynesian Phillips Curve (NKPC) as follow
\[ \pi_{H,t} = \beta E_t\{\pi_{H,t+1}\} + \kappa_x x_t \]  
(27)

where \( \kappa_x \equiv \lambda(\sigma_\alpha + \varphi) \)

From (21) and (25) we can derive IS equation for small open economy in terms of output gap as follows:
\[ x_t = E_t\{x_{t+1}\} - \frac{1}{\sigma_\alpha}(r_t - E_t\{\pi_{H,t+1}\} - \bar{r}_t) \]  
(28)

where
\[ \bar{r}_t \equiv \rho + \sigma_\alpha \Gamma(1 - \rho_a)a_t + \alpha \sigma_\alpha(\Theta + \Psi) E_t\{\Delta y^*_{t+1}\} \]  
(29)

4 Simple Monetary Policy Rules

This section outlines alternative policy regimes that will be used to analyse small open economy. Following two regimes of Gali and Monacelli(2005) which has interest rate responds to domestic inflation in the first regime and CPI inflation in the second.

**Domestic Inflation-based Taylor Rule** (DITR, for short)
\[ r_t = \rho + \phi_\pi \pi_{H,t} + v_t \]

**CPI Inflation-based Taylor Rule** (CITR, for short).
\[ r_t = \rho + \phi_\pi \pi_t + v_t \]

where \( v_t \) is an external component.

5 Under imperfect substitutability between domestic-foreign goods and different foreign goods

Next, we assume imperfect substitutability, both between domestic and foreign goods(\( \eta = 3 \)), and between different foreign goods(\( \gamma=3 \)), thus \( \omega \) is greater than 1 (\( \omega > 1 \))
Under this assumption, varying degree of openness will affect the sensitivity of domestic inflation to output gap and output gap to interest rate. From the Phillips curve equation, higher degree of openness will reduce terms of trade change necessary to absorb change in domestic output relative to world output, thus less effect on marginal cost and domestic inflation. From the dynamic IS curve equation, higher degree of openness will raise the sensitivity of output gap to interest rate. Thus, the slope of both Phillips curve and dynamic IS-monetary policy (IS-MP) curve are both flatter with higher degree of openness and vice versa.

With imperfect substitutability between domestic-foreign goods ($\eta \neq 1$), we can rewrite the relationship between terms of trade and real exchange rate as

$$ q_t = s_t + p_{H,t} - p_t = (1 - \alpha) s_t $$

where the last equality is derived by plugged in $p_t - p_{H,t} = \alpha s_t$ which holds only under imperfect substitutability of domestic and foreign goods.

Next we incorporate three hybrid CPI inflation targeting regimes from Stone et al. (2009): Plain Vanilla CPI Inflation targeting, Open Economy CPI inflation targeting, and Exchange rate based CPI inflation targeting.

The Plain Vanilla approach, practiced mostly in robust advanced economy, has interest rate responds systematically to inflation and output gap. Exchange rate does not appear explicitly in the reaction function. In Open Economy regime, practiced mostly in vulnerable emerging economy, interest rate responds to inflation and output gap. Exchange rate is now another argument in the reaction function. In Exchange Rate Based regime, exchange rate is an operating instrument in place of interest rate, reacting to inflation and output gap.

**Plain Vanilla CPI Inflation Targeting** (PV-CIT, for short):

$$ r_t = \rho_r r_{t-1} + (1 - \rho_r) \left( \pi_t + \pi_{H,t+1} \right) + (1 - \rho_r) \gamma \pi_t + (1 - \rho_r) \delta x_t + v_t $$

**Open Economy CPI Inflation Targeting** (OE-CIT, for short):

$$ r_t = \rho_r r_{t-1} + (1 - \rho_r) \left( \pi_t + \pi_{H,t+1} \right) + (1 - \rho_r) \gamma \pi_t + (1 - \rho_r) \delta x_t + (1 - \rho_r) \chi (q_t - \nu q_{t-1}) + v_t $$

**Exchange Rate Based CPI Inflation Targeting** (EB-CIT, for short):

$$ q_t = \rho_q q_{t-1} + (1 - \rho_q) \gamma \pi_t + (1 - \rho_q) \delta x_t + v_t $$

where $v_t$ is an exogenous component.

### 5.1 Analysis under different kinds of disturbances

#### 5.1.1 Domestic Productivity and World Output Shock

Following Gali and Monacelli (2005) calibrated stochastic process of domestic productivity and world output shocks:

$$ a_t = 0.66 a_{t-1} + \epsilon_a^t \quad \sigma_a = 0.0071 $$

$$ y_t^* = 0.86 y_{t-1}^* + \epsilon_t^* \quad \sigma_{y^*} = 0.0078 $$

with $\text{corr}(\epsilon_a^t, \epsilon_t^*) = 0.3$

From table(1), under all regimes, as the economy becomes more open, there is a clear increase in terms of trade and nominal exchange rate smoothness. With higher degree of openness, if the monetary policy does not dampen exchange rate movement, domestic productivity and world

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2 See the discussion of impulse response in Section 5.1.4

3 see Monacelli (2013)
output shock will generate higher domestic inflation and output variability. By adding exchange rate as another argument into the reaction function, dampening exchange rate movement as the economy becomes more open, domestic inflation variability decreased. Moreover, by utilizing exchange rate as an operating instrument gives central bank direct control in smoothing exchange rate movement, output variability and domestic inflation variability decreased.

<table>
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<th>DTR</th>
<th>CITR</th>
<th>PV-CIT</th>
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<td>Domestic inflation</td>
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<td>0.28</td>
<td>0.06</td>
<td>0.03</td>
<td>0.16</td>
</tr>
<tr>
<td>CPI inflation</td>
<td>0.32</td>
<td>0.29</td>
<td>0.16</td>
<td>0.03</td>
<td>0.23</td>
</tr>
<tr>
<td>Nominal interest rate</td>
<td>0.38</td>
<td>0.43</td>
<td>0.13</td>
<td>0.16</td>
<td>0.32</td>
</tr>
<tr>
<td>Terms of trade</td>
<td>0.81</td>
<td>0.76</td>
<td>0.78</td>
<td>0.79</td>
<td>0.80</td>
</tr>
<tr>
<td>Exchange rate(1st diff)</td>
<td>0.53</td>
<td>0.4</td>
<td>0.41</td>
<td>0.44</td>
<td>0.44</td>
</tr>
<tr>
<td>Real exchange rate</td>
<td>0.48</td>
<td>0.45</td>
<td>0.47</td>
<td>0.47</td>
<td>0.48</td>
</tr>
<tr>
<td>( \alpha = 0.4 )</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Output</td>
<td>0.95</td>
<td>0.87</td>
<td>0.96</td>
<td>1.04</td>
<td>1.00</td>
</tr>
<tr>
<td>Domestic inflation</td>
<td>0.26</td>
<td>0.32</td>
<td>0.07</td>
<td>0.03</td>
<td>0.09</td>
</tr>
<tr>
<td>CPI inflation</td>
<td>0.44</td>
<td>0.33</td>
<td>0.26</td>
<td>0.03</td>
<td>0.19</td>
</tr>
<tr>
<td>Nominal interest rate</td>
<td>0.39</td>
<td>0.49</td>
<td>0.16</td>
<td>0.16</td>
<td>0.24</td>
</tr>
<tr>
<td>Terms of trade</td>
<td>0.64</td>
<td>0.57</td>
<td>0.61</td>
<td>0.63</td>
<td>0.59</td>
</tr>
<tr>
<td>Exchange rate(1st diff)</td>
<td>0.47</td>
<td>0.34</td>
<td>0.29</td>
<td>0.37</td>
<td>0.22</td>
</tr>
<tr>
<td>Real exchange rate</td>
<td>0.064</td>
<td>0.057</td>
<td>0.060</td>
<td>0.062</td>
<td>0.058</td>
</tr>
</tbody>
</table>

Table 1: cyclical properties from domestic productivity and world output shock

5.1.2 Supply Shock

In this section, we first focus the analysis on inflation dynamics under interest rate based regimes. Consider the supply side in New Keynesian Phillips Curve for small open economy

\[
\pi_{H,t} = \beta E_t\{\pi_{H,t+1}\} + \kappa_\alpha x_t + \epsilon_t^\pi
\]  

From the above equation, domestic inflation and supply shock will be related by

\[
\pi_{H,t} = \epsilon_t^\pi
\]  

We can see that supply shock will directly affect domestic inflation in the supply-side partial equilibrium. However, if we consider both demand and supply side by plugging IS-MP into the New Keynesian Phillips Curve, the relationship between domestic inflation and policy shock, supply shock can be shown by

under Taylor rule regime: \( \pi_{H,t} = \frac{\sigma_\alpha}{\sigma_\alpha + \kappa_\alpha \phi_\pi} \epsilon_t^\pi - \frac{\kappa_\alpha}{\sigma_\alpha + \kappa_\alpha \phi_\pi} \epsilon_t^r \)

under PV,OE regime: \( \pi_{H,t} = \frac{\sigma_\alpha}{\sigma_\alpha + \kappa_\alpha \gamma (1 - \rho_\pi)} \epsilon_t^\pi - \frac{\kappa_\alpha}{\sigma_\alpha + \kappa_\alpha \gamma (1 - \rho_\pi)} \epsilon_t^r \)

Notice that both \( \frac{\sigma_\alpha}{\sigma_\alpha + \kappa_\alpha \phi_\pi} \) and \( \frac{\sigma_\alpha}{\sigma_\alpha + \kappa_\alpha \gamma (1 - \rho_\pi)} \) is less than 1. Though the economy is highly open, only partial effect of the supply shock that affects domestic inflation. The table below shows how increasing degree of openness affects each parameter.

From the table(2), as the degree of openness(\( \alpha \)) increases, supply shock will have less effect on inflation while policy shock will growing in its importance under all regimes. The IS-MP-PC can explain the intuition behind. With supply and policy shock, Phillips curve shift up(from positive supply shock) while IS-MP shifts down(from positive policy shock). As the economy becomes
more open to international trade, the slope of both graph decrease. While decreasing the slope of Phillips curve as the economy becomes more open will increase the effect of supply shock on inflation, flattered slope of the IS-MP curve will increase the effect of monetary policy on domestic inflation. With greater degree of openness, the effect on the slope of IS-MP is more than the effect on the slope of Phillips curve, thus, inflation dynamics is under control.

\begin{align*}
\text{Table 2: Effect of varying degree of openness on particular parameter in inflation dynamic equation}
\end{align*}

Even though small open economy are expected to suffer badly from external supply shock, if considered both demand and supply side of the economy, it will not suffer more from external supply shock as the economy becomes more open to international trade. On the contrary, policy shock becomes more effective in curbing the effect on domestic inflation. This can be explained by the effect of varying degree of openness on the sensitivity of output gap to interest rate change. With higher degree of openness, output gap is more sensitive to interest rate through the stronger effect of terms of trade change on output: more open economy will shift consumption expenditure toward foreign goods through real exchange rate appreciation and finally result in further lower output and aggregate demand; thus, more effect on output. Moreover, by deriving inflation dynamics, we notice that, domestic demand disturbances and inflation expectation also play an important role in explaining inflation dynamics and these two variables can be controlled by monetary policy. Therefore, inflation is not all affected by uncontrollable external shocks.

Notice that the central bank could also suppress domestic inflation variability from both supply shock and policy shock by giving more weight to inflation, either domestic or CPI, in the reaction function. Higher weight on inflation in the reaction function(higher $\phi$ in DITR and CITR; higher $\gamma$ in PV, OE regimes) will not only lower the effect of supply shock on domestic inflation but also the effect of policy rate on domestic inflation, thus, the variance of domestic inflation.

In conducting efficient monetary policy, policy makers aim at minimizing the welfare loss while facing a tradeoff between CPI inflation variability and output gap variability. Here, we evaluate macroeconomic performance and the permanent inflation-output variability tradeoff by efficient policy frontier or Taylor curve. In constructing the Taylor Curve, we follow the approach of Taylor(1979) employing nonlinear optimization in minimizing the quadratic loss function$^4$, subject to constraints imposed by the structure of the small open economy with supply shock($\sigma_t^{\pi H} = 0.5\%$). For each welfare loss, with a particular weight($\omega$) given to the variance of inflation and variance of output, we obtain the optimal path for reaction function and a point on the Taylor Curve. With $\omega = 0$, policy makers give highest attention in minimizing output gap variability and therefore, result in the highest point of the Taylor curve. With more attention in minimizing inflation variability and less attention in controlling output gap variability, $\omega$ increases from 0 to 1, output gap variability increases while cpi inflation variability decreases; thus, result in the downward sloping Taylor curve.

$^4$ Loss $= \omega \text{Var}(\pi_t) + (1-\omega)\text{Var}(x_t)$
Below, the Taylor Curve with 0.5% standard deviation cost push shock is constructed. The results confirm the parameter analysis from the table(2). In all regimes, as the economy becomes more open($\alpha$ increases from 0.3 to 0.7), optimal policy rule can better control CPI inflation variability and output gap variability, thus improve the long-run macroeconomic tradeoff by shifting in the efficient policy frontier.

From figure(2), either low or high degree of openness, plain vanilla approach performs best as well as open economy approach in controlling the trade-off between variance of CPI inflation and output gap. By adding output gap as another argument into the reaction function, optimal monetary policy can better control output gap variability as we can see that CITR which targets only CPI inflation has the highest output gap variability compare to all other regimes. Moreover, either low or high degree of openness, interest rate is a better operating instrument in curbing the effect from the supply shock compare to real exchange rate.

5.1.3 Demand Shock

In the present section, we consider the effect of 0.5% standard deviation demand shock on the small open economy.

Consider figure(3), an upward sloping Taylor curve shows that there is little or no scope for the long-run tradeoff between output gap variability and CPI inflation variability. As output gap variability increased, CPI inflation variability will also increased. The lowest coordinate signifies the most forceful policy response to demand shock, equivalently, the greatest sum of the optimal parameter in the reaction function. With lower degree of policy forcefulness, lower sum of the optimal parameter in the reaction function, the point on the Taylor curve increases in an upward sloping manner. Moreover, as the economy becomes more open, output gap variability reduced but not with CPI inflation variability.
From figure(3), under EB-CIT, demand shock has no effect on output gap variability and CPI inflation variability. The result is in accordance with cyclical properties in table(3). It can be explained that, under interest rate based regimes, since consumption and import increased with positive domestic demand shock, exchange rate depreciates with terms of trade deterioration ($s_t$ increased); thus, negatively affect inflation and output gap variability via direct pass-through effect. By employing exchange rate as an operating instrument, along with the perfect exchange rate pass-through structure of the model, exchange rate smoothness can perfectly minimize exchange rate effect on inflation and output gap.

<table>
<thead>
<tr>
<th>a = 0.3</th>
<th>CITR</th>
<th>CIT</th>
<th>PV-CIT</th>
<th>OE-CIT</th>
<th>EB-CIT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Output</td>
<td>0.33</td>
<td>0.33</td>
<td>0.31</td>
<td>0.25</td>
<td>0.00</td>
</tr>
<tr>
<td>Domestic inflation</td>
<td>0.11</td>
<td>0.11</td>
<td>0.08</td>
<td>0.06</td>
<td>0.00</td>
</tr>
<tr>
<td>CPI inflation</td>
<td>0.11</td>
<td>0.11</td>
<td>0.08</td>
<td>0.08</td>
<td>0.00</td>
</tr>
<tr>
<td>Nominal interest rate</td>
<td>0.17</td>
<td>0.17</td>
<td>0.08</td>
<td>0.17</td>
<td>0.50</td>
</tr>
<tr>
<td>Terms of trade</td>
<td>0.33</td>
<td>0.33</td>
<td>0.31</td>
<td>0.25</td>
<td>0.00</td>
</tr>
<tr>
<td>Exchange rate(1st diff)</td>
<td>0.55</td>
<td>0.55</td>
<td>0.56</td>
<td>0.44</td>
<td>0.00</td>
</tr>
<tr>
<td>Real exchange rate</td>
<td>0.33</td>
<td>0.33</td>
<td>0.31</td>
<td>0.25</td>
<td>0.00</td>
</tr>
<tr>
<td>a = 0.4</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Output</td>
<td>0.25</td>
<td>0.21</td>
<td>0.23</td>
<td>0.18</td>
<td>0.00</td>
</tr>
<tr>
<td>Domestic inflation</td>
<td>0.07</td>
<td>0.08</td>
<td>0.05</td>
<td>0.04</td>
<td>0.00</td>
</tr>
<tr>
<td>CPI inflation</td>
<td>0.12</td>
<td>0.11</td>
<td>0.11</td>
<td>0.04</td>
<td>0.00</td>
</tr>
<tr>
<td>Nominal interest rate</td>
<td>0.11</td>
<td>0.17</td>
<td>0.06</td>
<td>0.10</td>
<td>0.22</td>
</tr>
<tr>
<td>Terms of trade</td>
<td>0.11</td>
<td>0.09</td>
<td>0.10</td>
<td>0.08</td>
<td>0.00</td>
</tr>
<tr>
<td>Exchange rate(1st diff)</td>
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<td>0.17</td>
<td>0.20</td>
<td>0.16</td>
<td>0.00</td>
</tr>
<tr>
<td>Real exchange rate</td>
<td>0.07</td>
<td>0.05</td>
<td>0.06</td>
<td>0.05</td>
<td>0.00</td>
</tr>
<tr>
<td>a = 0.9</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Output</td>
<td>0.22</td>
<td>0.15</td>
<td>0.19</td>
<td>0.15</td>
<td>0.00</td>
</tr>
<tr>
<td>Domestic inflation</td>
<td>0.06</td>
<td>0.07</td>
<td>0.04</td>
<td>0.03</td>
<td>0.00</td>
</tr>
<tr>
<td>CPI inflation</td>
<td>0.15</td>
<td>0.11</td>
<td>0.13</td>
<td>0.03</td>
<td>0.00</td>
</tr>
<tr>
<td>Nominal interest rate</td>
<td>0.09</td>
<td>0.16</td>
<td>0.06</td>
<td>0.08</td>
<td>0.17</td>
</tr>
<tr>
<td>Terms of trade</td>
<td>0.07</td>
<td>0.05</td>
<td>0.06</td>
<td>0.05</td>
<td>0.00</td>
</tr>
<tr>
<td>Exchange rate(1st diff)</td>
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<td>0.11</td>
<td>0.14</td>
<td>0.11</td>
<td>0.00</td>
</tr>
<tr>
<td>Real exchange rate</td>
<td>0.01</td>
<td>0.01</td>
<td>0.01</td>
<td>0.01</td>
<td>0.00</td>
</tr>
</tbody>
</table>

Table 3: cyclical properties from domestic productivity and world output shock(Figure6)

Moreover, table(3) shows that exchange rate based inflation targeting approach will generate highest interest rate variability with perfect stability in other aspects. Also, when comparing between open economy to plain vanilla, open economy regime will generate higher stability in all dimensions but nominal interest rate. This implies that, by adding exchange rate as another argument into the reaction function or dampening exchange rate movement from demand shock, it can help minimize pass-through to inflation and leads to stronger interest rate that the central bank will respond. To dampen the demand effect and control CPI inflation within target, the authority has to increase real interest rate, making the real exchange rate appreciate. Such appreciation will have two effects: aggregate demand and output will be decreased from expenditure-switching, inflation will decreased from lowered output or since import price will not increased rapidly with currency appreciation, and finally bring back the equilibrium.

However, only domestic demand shock can induced such effect. With foreign generated demand shock, currency will appreciate as a result of stronger balance of trade and exchange rate smoothness will not be helpful.
5.1.4 Monetary Policy Shock

Here, we perform stochastic simulation with monetary policy shock\(^5\). We assume external component of interest rate and exchange rate \(v_t\) follows an AR(1) process: 
\[
v_t = 0.87 v_{t-1} + \epsilon_t, \quad \sigma_v = 1\%
\]
to study how the central bank can employ their operating instrument in affecting the whole economy.

Under DITR, CITR, PV-CIT and OE-CIT positive policy shock will lead to immediate reduction in domestic inflation and output gap as a result of the downward shift of the IS-MP curve. Domestic inflation and output gap will immediately fall. The explanation behind comes from the downward shifting of the IS-MP curve\(^6\). Higher interest rate will also generate capital inflow and leads to domestic currency appreciation, lower terms of trade, and lower output.

Recall from the beginning of section(5), with the assumption of imperfect substitution of goods from different origins, the slope of Phillips curve and the IS-MP curve flattered. Therefore, output and domestic inflation will be more sensitive to policy rate due to flattered PC and IS-MP curve. Moreover, considered the demand side, with flattered IS-MP curve from greater degree of openness, there will be less terms of trade necessary to absorb output change, thus terms of trade and real exchange rate will be less sensitive to policy change.

Under EB-CIT, with positive policy shock, imported inflation will instantly increase via direct exchange rate pass-through channel. An increase in the CPI inflation will decrease the real exchange rate. Exchange rate appreciation will make the country lose its competitiveness, lower export, lower terms of trade, and thus, lower output and aggregate demand. With direct exchange rate pass-through of lower exchange rate together with lower demand, domestic inflation will decrease. To induced exchange rate appreciation, the central bank has to buy domestic currency while selling foreign currency, generating shortage in domestic currency, and thus, increase interest rate. With higher degree of openness, real exchange rate will be less sensitive to policy shock; therefore, less effect on other variable.

In conclusion, as the economy becomes more open, output gap and domestic inflation will be more sensitive to policy change under interest rate based regime while both will become less sensitive to policy change under exchange rate based regime.

\[\text{Figure 5: Irf of policy shock under DITR with varying degree of openness}(\alpha = 0.1, 0.4, 0.9)\]

\(^5\)In this paper, when analyse impulse response function, we assume, for simplicity: the dynamic IS curve takes the form: 
\[
0.08 E_t(x_{t+1}) + 0.73 x_{t-1} - 0.05 \frac{1}{\sigma_n} (\sigma - E_t(\pi_{H,t+1}) - \bar{r}_t)
\]
the Phillips curve takes the form: 
\[
\frac{\beta}{1+\beta \mu} E_t(\pi_{H,t+1}) + \frac{\mu}{1+\beta \mu} \pi_{H,t-1} + \lambda (\sigma + \eta) x_t
\]
\(^6\)the IS-MP curve is abbreviated for IS-monetary policy and is derived by combining the monetary policy to dynamic IS curve.
Figure 6: Irf of policy shock under CITR with varying degree of openness ($\alpha = 0.1, 0.4, 0.9$)

Figure 7: Irf of policy shock under PV-CIT with varying degree of openness ($\alpha = 0.1, 0.4, 0.9$)

Figure 8: Irf of policy shock under OE-CIT with varying degree of openness ($\alpha = 0.1, 0.4, 0.9$)

Figure 9: Irf of policy shock under EB-CIT with varying degree of openness ($\alpha = 0.1, 0.4, 0.9$)
Notice here that if we restrict the analysis to the special case of Gali and Monacelli(2005) which assumes, for simplicity, log utility and unit elasticity of substitution between domestic and foreign goods and goods of different foreign countries ($\sigma = \eta = \gamma = 1$). In this special assumption, varying degree of openness will affect only CPI inflation. Thus, under DITR regime (like closed economy), only CPI inflation will be affected from varying degree of openness, others remain unaffected. However, under CITR regime (in this case like open economy), since monetary policy target CPI inflation in the reaction function, varying degree of openness affects not only CPI inflation but other cyclical properties. With greater degree of openness, output gap can be improved via variation in terms of trade ($s_t$). Thus, output falls less with higher degree of openness relative to its natural level. Therefore, the traditional case where policy rule becomes less efficient as the economy become more open could occur as the analysis is restricted to the traditional case.

Figure 10: Irf of policy shock under DITR with varying degree of openness (the blue line represent $\alpha = 0.1$, the red line represent $\alpha = 0.4$, the black line represent $\alpha = 0.9$)

Figure 11: Irf of policy shock under CITR with varying degree of openness (the blue line represent $\alpha = 0.1$, the red line represent $\alpha = 0.4$, the black line represent $\alpha = 0.9$)

5.2 Partial Indexation of Price

In this section, I further extend the model by incorporating the assumption of partial indexation which assumes prices adjust by indexing to last period inflation. The adjusted NKPC hence becomes

$$
\pi_{H,t} = \frac{\beta}{(1+\beta\xi)}E_t(\pi_{H,t+1}) + \frac{\xi}{(1+\beta\xi)}\pi_{H,t-1} + \lambda \tilde{mc}_t
$$

where $\lambda \equiv \frac{(1-\beta\theta)(1-\theta)}{\theta(1+\beta\xi)}$

Recall the relationship between marginal cost and output gap from the model section as

$$
\tilde{mc}_t = (\sigma_\alpha + \varphi)x_t
$$

Combine with (23) we get the New Keynesian Phillips Curve (NKPC) as follow

$$
\pi_{H,t} = \frac{\beta}{(1+\beta\xi)}E_t(\pi_{H,t+1}) + \frac{\xi}{(1+\beta\xi)}\pi_{H,t-1} + \lambda(\sigma_\alpha + \varphi)x_t
$$

Parameter $\xi$ represent degree of price indexation (for firms that are not re-optimizing). Here, we construct the Taylor Curve where $\mu = 0.3$ (degree of forward looking in NKPC is 0.76 and degree of backward looking is 0.23) and $\xi = 0.6$ (degree of forward looking in NKPC is 0.62 and degree of backward looking is 0.38).

\textsuperscript{7} derivation can be seen in appendix A

\textsuperscript{8} the result is performed under 0.5\% equal standard deviation demand and supply shock. However, under only supply shock, domestic productivity and world output shock, Taylor curve also move in the same direction.
By decreasing $\xi$ from 0.6 to 0.3, or equivalently increase the degree of forward looking in Phillips curve form 0.62 to 0.76 and decreasing the degree of backward looking from 0.38 to 0.23, Taylor curve of all regimes shift in. Thus, the trade-off position is improved. As King(2005) points out the importance of expectation channel that if economic agents based their decision on future expectation, then the expected to conduct monetary policy affects today’s outcome, which means the central bank is credible and can better anchor inflation expectation. The result is consistent with the economic implication of NKPC that the forward looking term represent the central bank credibility while the backward looking term is explained by price adjustment inertia. With higher degree of backward looking and lower degree of forward looking, or equivalently, higher price adjustment cost together with lower central bank credibility, the permanent tradeoff position is worsen and the Taylor curve shifts out. Therefore, monetary policy is more effective under higher degree of forward looking in Phillips curve(lower $\xi$) and less effective under lower degree of forward looking(higher $\xi$).

Notice here that, with higher degree of price indexation(higher $\xi$) or higher degree of backward looking in the New Keynesian Phillips curve, the slope of Phillips curve will be flattered, increasing the effect of supply shock and decreasing the effect of policy shock on domestic inflation. Here we reconsider the effect of domestic inflation to policy shock(interest rate shock) and external supply shock from section 5.1.2.

under Taylor rule regime: $\pi_{H,t} = \frac{\sigma_{\alpha}}{\sigma_{\alpha} + \kappa_{\alpha} \varphi_{H,t}} \beta_{H,t}^{\pi} - \frac{\kappa_{\alpha}}{\sigma_{\alpha} + \kappa_{\alpha} \varphi_{H,t}} \beta_{H,t}^{r}$

under PV,OE regime : $\pi_{H,t} = \frac{\sigma_{\alpha}}{\sigma_{\alpha} + \kappa_{\alpha} \gamma (1 - \rho_r)} \beta_{H,t}^{\pi} - \frac{\kappa_{\alpha}}{\sigma_{\alpha} + \kappa_{\alpha} \gamma (1 - \rho_r)} \beta_{H,t}^{r}$

where $\kappa_{\alpha} = \lambda(\sigma_{\alpha} + \varphi)$ and $\lambda \equiv \frac{(1 - \beta \theta)(1 - \theta)}{\theta(1 + \beta \xi)}$

From table(4), higher degree of backward looking in Phillips curve, meaning that the central bank can less anchor inflation expection or the central bank is losing its credibility, external supply disturbances will thus growing in its effect on domestic inflation while interest rate will lose its effectiveness in stabilizing the effect from external supply shock.

<table>
<thead>
<tr>
<th>$\xi$</th>
<th>Taylor Rule</th>
<th>PV,OE regime</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$\sigma_{\alpha}$</td>
<td>$\kappa_{\alpha}$</td>
</tr>
<tr>
<td>0.1</td>
<td>0.188</td>
<td>0.542</td>
</tr>
<tr>
<td>0.2</td>
<td>0.189</td>
<td>0.541</td>
</tr>
<tr>
<td>0.3</td>
<td>0.191</td>
<td>0.540</td>
</tr>
<tr>
<td>0.4</td>
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</tr>
<tr>
<td>0.5</td>
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<td>0.538</td>
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<tr>
<td>0.6</td>
<td>0.195</td>
<td>0.537</td>
</tr>
<tr>
<td>0.7</td>
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</tr>
<tr>
<td>0.8</td>
<td>0.198</td>
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</tr>
<tr>
<td>0.9</td>
<td>0.199</td>
<td>0.534</td>
</tr>
<tr>
<td>1</td>
<td>0.201</td>
<td>0.533</td>
</tr>
</tbody>
</table>

Table 4: Effect of varying degree of backward looking in Phillips Curve on particular parameter in inflation dynamic equation

Figure 12: Taylor Curve with varying degree of forward looking in NKPC(the non-dash line represent the case when $\xi= 0.3$ and the dash line represent the case $\xi = 0.6$ under 0.5% demand and supply shock.)
6 Conclusion

In this paper, we examine the performance of alternative inflation targeting monetary policy regimes under different kinds of disturbances. This paper employs Gali and Monacelli(2005)'s framework and focus on the case of imperfect substitutability of goods from different countries where varying degree of openness have significant effect on the sensitivity of inflation to output gap and output gap to interest rate change. Our monetary policy frameworks include:(a.) DITR, (b.) CITR, (c.) PV-CIT, (d.) OE-CIT, (e.) EB-CIT. Three main conclusions can be drawn.

First, there is no clear-cut evidence which monetary approach performs best for small open economy. The answer depends on the types of shock the economy encountered and the degree of openness of each country. Whether monetary policy should target exchange rate or dampen exchange rate volatility, the answer relies on whether the characteristic of economic disturbances has an effect on destabilizing exchange rate movement.

Second, due to the characteristic of the small open economy which takes world price as given, it is expected to be fully affected by world cost push shock. Moreover, external world supply shock is expected to transferred more into the economy via higher degree of openness, making inflation becomes more volatile and inefficient for the central bank to pay attention to in conducting monetary policy. However, the findings show that world external supply shock will has less destabilizing effect as the economy becomes more open to international trade while interest rate will growing in effect in stabilizing shocks instead.

Finally, by extending the model to incorporate the assumption of partial indexation of price, the results show that with higher degree of forward looking in the Phillips curve, meaning that the central bank can better anchor inflation expectation, monetary policy becomes more effective in coping with external disturbances for all regimes since the monetary authority can focus more on output stabilization. Thus, as long as the authority can well anchoring inflation expectation, it does not matter much which monetary policy regime is employed.

Certain caveats do exist and worth consider here. In this model, the parameter is mostly obtained from Gali and Monacelli(2005). Some are obtained from the parameter in Thai macro model of Chai-Anant et al.(2008). However, to improve the study, a precise parameterization to fit with Thailand economic structure is beneficial and improve the accuracy of the analysis.

A Appendix: Optimal Price Setting in Calvo Model with Partial indexation of Price

In this model firms are assumed to set price in Calvo(1983) staggered type. Each firm reset price each period with probability $1 - \theta$ while keep price unchanged with probability $\theta$. Let $\bar{P}_{H,t}(j)$ denote the price set by firm $j$ and adjusting its price in period $t$. Following Gali and Monacelli(2005), individual firm’s problem is to maximize expected profit:

$$\max_{\bar{P}_{H,t}} \sum_{k=0}^{\infty} \theta^k E_t\{Q_{t,t+k}[Y_{t+k}(\bar{P}_{H,t} - MC_{t+k}^n)]\}$$

subject to the sequence of demand constraints

$$Y_{t+k}(j) \leq \left( \frac{\bar{P}_{H,t}}{\bar{P}_{H,t+k}} \right)^{-\epsilon} \left( C_{H,t+k} + \int_0^1 C_{H,t+k}^d ds \right) \equiv Y_{r+k}(\bar{P}_{H,t})$$

Thus, we obtain:

$$\bar{p}_{H,t} - p_{H,t-1} = \beta \theta E_t\{\bar{p}_{H,t+1} - p_{H,t}\} + \pi_{H,t} + (1 - \beta \theta) \hat{c}_t$$  \hspace{1cm} (A1)
After some algebraic manipulation, substitute $\tilde{m}c_t = mc_t^p - p_{H,t} + \mu$, we obtain an alternative price setting rule which correspond to equation(17) in the text as follow

$$\tilde{p}_{H,t} = \mu + (1 - \beta\theta) \sum_{k=0}^{\infty} (\beta\theta)^k E_t \{ mc_{t+k} + p_{H,t+k} \}$$

Here, we assumed partial indexation of price. Firms are assumed to adjust prices by indexing to last period inflation. The dynamics of the domestic price index are described by the equation

$$P_{H,t} \equiv \left[ \theta \left( \frac{P_{t-1}}{P_{t-2}} \right) \right]^{1-\epsilon} + (1 - \theta) \tilde{p}_{H,t}^{1-\epsilon}$$

which can be log-linearized around zero-inflation steady state to yield

$$\pi_{H,t} = (1 - \theta)(\tilde{P}_{H,t} - P_{H,t-1}) + \xi \theta \pi_{H,t-1}$$

Combine the above equation with (A1) yields

$$\pi_{H,t} = \frac{\beta}{1 + \beta \xi} \pi_{H,t+1} + \frac{\xi}{1 + \beta \xi} \pi_{H,t-1} + \frac{(1 - \beta \theta)(1 - \theta)}{\theta(1 + \beta \xi)} \tilde{m}c_t$$

B Appendix : Parameterization

B.1 Emerging economy model parameter

Most parameters are obtained from Gali and Monacelli(2005)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\sigma$</td>
<td>Coefficient of relative risk aversion</td>
<td>1</td>
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<tr>
<td>$\eta$</td>
<td>Elasticity of substitution of domestic and foreign goods</td>
<td>3</td>
</tr>
<tr>
<td>$\nu$</td>
<td>Elasticity of substitution of different foreign goods</td>
<td>3</td>
</tr>
<tr>
<td>$\varphi$</td>
<td>Inverse labour supply elasticities</td>
<td>3</td>
</tr>
<tr>
<td>$\mu$</td>
<td>Steady state mark-up</td>
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<tr>
<td>$\epsilon$</td>
<td>Elasticity of substitution between differentiated goods(same origins)</td>
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</tr>
<tr>
<td>$\theta$</td>
<td>Probability of not re-optimizing</td>
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<tr>
<td>$\beta$</td>
<td>Subjective discount rate</td>
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<tr>
<td>$\alpha$</td>
<td>Degree of openness</td>
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</table>

B.2 Monetary Policy parameter

<table>
<thead>
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<th>Parameter</th>
<th>Description</th>
<th>Value</th>
<th>Source</th>
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<tbody>
<tr>
<td>$\rho_r$</td>
<td>Interest rate smoothing</td>
<td>0.87</td>
<td>Chai-anant et al(2008).</td>
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<tr>
<td>$\rho_q$</td>
<td>Exchange rate smoothing</td>
<td>0</td>
<td>Stone et al(2009).</td>
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<tr>
<td>$\phi_\pi$</td>
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<td>$\gamma$</td>
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<tr>
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<td>$\chi$</td>
<td>Coefficient on exchange rate OE regime</td>
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<td>Stone et al(2009).</td>
</tr>
<tr>
<td>$\nu$</td>
<td>Weight on change in the exchange rate</td>
<td>0.5</td>
<td>Stone et al(2009).</td>
</tr>
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</table>

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