OPTIMAL MONETARY POLICY AND THE EXTERNAL VARIABLES: EVIDENCE FROM ASEAN-3

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Abstract

The aim of this paper is to determine the optimal monetary policy rule for small open economies. The rationale behind is that the monetary policy is concerned not only in the output gap and the inflation, but also in the external variables constituting the ground for the analysis. The method is based on Svensson (2000). Further, the paper intends to explore the value of the loss function of the central bank. Using data from ASEAN-3, namely Indonesia, Malaysia and Thailand, the empirical results indicate that (1) the countries do care about the inflation and the output gap. This finding is in accordance with the central banks' objective that price stability is the most important objective of the monetary policy, (2) the exchange rates and terms of trade have impact on the central banks action (3) the specified instrument policy rule have to be considered as optimal in general. Indonesia and Thailand have comparatively smaller value of loss than Malaysia, which could be explained by the central banks of Indonesia and Thailand have been introduced the inflation targeting in 2000, except for Malaysia.

Keywords Grid search, optimal monetary policy.

Introduction

Since the seminal work by Taylor (1993) adopted monetary policy rules in a practical way, researchers have been trying to explore the policy reaction function in different countries. Although an empirical examination of the policy reaction necessitates a general discussion of a number of analytical and technical issues, an important practical issue is the monetary policy objectives considered in the rule. The original specification proposed by Taylor (1993) should contain deviations of the inflation rate and output from their target values, namely inflation gap and output gap. However, an open question still remained on whether other variables systematically affect the behavior of the interest rates.

The motivation of this paper is stimulated by exchange rate bears immense importance in the context of open economies. As stressed by Svensson (2000), the exchange rates can provide several channels, in addition, meet the standard aggregate demand and expectations channels in closed economies: (i) the real exchange rates affects the relative price between domestic and foreign goods, consequently, contributes to the aggregate demand channel; (ii) the exchange rates affects consumer prices directly via the domestic currency price of imports; and (iii) the exchange rates shapes the price of imported intermediate goods, and thus influences the pricing decisions of domestic firms. It therefore seems natural to include the exchange rates as an indicator of monetary policy.

Using three equation models based on Taylor (1999) were the open economy IS curve, an open economy Phillips curve and a link between the interest rates and exchange rates. This macroeconomic model revealed that adding exchange rates depreciation term would enhance the stability of inflation and output. Thus, the model proposes that the role of exchange rates is important in events of endogenous shocks. Smets and Wouters (2003) showed that including the exchange rates in the monetary rule could be quite beneficial in some circumstances, particularly along with the opening up degree of an economy. Guender (2005) explicated the important effect of the real exchange rate on the rate of inflation in the Phillips curve. In his work, he concluded the existence of the direct exchange rate effect on inflation has material consequences in conducting the optimal monetary policy. Edwards (2006) examined the role of the exchange rate in Taylor rule (TR). He found that exchange rate has significant coefficient for most of the inflation targeting countries.

Furthered the exchange rates discussed above, terms of trade (TOT) can be an additional external variable issue. Edwards (1989) argued that TOT shocks may induce a change in the exchange rate as well as the domestic inflation. He associated a negative TOT shock or a "cost push shock" would induce a depreciation of the exchange rate and/or an increase in domestic inflation. This should in turn induce a more stringent position of the central bank and an increase in interest rates. Hence, the inclusion of the TOT variable allows controlling for variations in foreign or controlled prices. Alternatively it may account for supply side shocks that affect monetary policy.[1] The TOT has an especially marked impact on the economies of developing countries (Todaro, 2000; Funke *et al*., 2008). Baxter and Kouparitsas (2000) suggested that TOT fluctuations are twice as large in developing countries as the one in developed countries. The authors attributed this pattern to the heavy reliance of developing countries on commodity exports, whose prices are more volatile than those of manufactured goods. Moreover, because developing countries generally have a high degree of openness to foreign trade, these sharp swings in the TOT affect large share of their economies.

The aim of this paper is to provide evidence relating to the roles of external variables (i.e. exchange rates and terms of trade), other than monetary policy objectives (i.e. output gap and inflation), in the central bank's "true" reaction process. The most appropriate means to identify a "true" policy reaction function is through the construction of an entire macro model – normative analysis, which includes a Phillips curve, aggregate demand curve, a loss function for the authority, *et cetera*. Optimality

[1] An alternative exercise would be to use a measure of underlying inflation, in other words, inflation excluding highly volatile items.

can be given by particular specifications of the central bank's loss function. Therefore, an optimal rule is the one that derived by minimizing a loss function. The ASEAN-3, namely Indonesia, Malaysia and Thailand, are taken up in this study. The results can be used to identify the following hypotheses:

[1] While the price stability is the most important objectives of monetary policy[2], it is postulated that inflation gap and output gap are accounted as monetary policy objectives.

[2] In small open economies, besides output and inflation, there are certain objectives of monetary policy that the central banks focus on. Therefore, this study hypothesizes that other external variable (i.e. exchange rates and terms of trade) as important factors affecting the monetary policy rule – the central bank's instrument.

[3] The optimal policy could involve exchange rates and terms of trade as control variables that should effectively stabilize the economy and thus obtain more precise indicators of economic quantities. These would in turn lead to higher quality policy decisions.

Remaining portion of the study is organized as follow. Section II discusses the analytical framework of this paper. Methodology and data are discussed in section III. Section IV analyzes results; the coefficients obtained from the generalized method of moments (GMM) estimation may used to seek the optimal reaction coefficients that minimize the loss function – the measurement involves the "grid search approach". Finally Section V concludes the study.

The Model

In this paper, the model used to evaluate the performance of monetary policy rules is an extension based on Svensson (2000). Noticeably, it was also used by Ball (1997 and 1999) and Jondeau & Le Bihan (2000). The central banks are supposed to follow a backward looking rule, which its inputs are data on the recent state of the economy.

Considering the following standard macroeconomic model, here we take y_g as the output gap, π_g as the inflation gap, Δe as the exchange rates gap[3], $\overline{tot}$ as the terms of trade and Δr as the interest rates gap, which is supposed to be the instrument of the central bank.

$$y_{g_t} = \lambda y_{g_{t-1}} - \delta_1 \Delta e_{t-1} - \beta \Delta r_{t-1} + \phi_1 \overline{tot}_{t-1} + \varepsilon_t \quad (1)$$

$$\pi_{g_t} = \alpha y_{g_{t-1}} + \pi_{g_{t-1}} - \delta_2 \Delta e_{t-1} + \phi_2 \overline{tot}_{t-1} + \eta_t \quad (2)$$

$$\Delta e_t = \theta \Delta r_t + v_t \quad (3)$$

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2 The evidence is available form central banks' website and Ito and Hayashi (2004). Among others, it is also reported by (1) Indonesia – Fane (2005), (2) Thailand – Hataiseree and Rattanalungkarn (1998) and (3) Malaysia – McCauley (2006).

3 An increase in real effective exchange rate (REER) represents a real appreciation while a decrease represents a real depreciation of the domestic currency relative to its trading partners.

π_g, Δe, Δr and y_g are centered (i.e. they can be expressed in terms of gap with their equilibrium value). Parameters λ, ϕ_1, α, ϕ_2 and θ are positive. Equation (1) interprets open economy IS curve. Output gap (y_g) depends positively on its own past value and terms of trade ($\overline{tot}$); negatively on interest rates gap (Δr) and exchange rates gap (Δe). In addition, ε_t is a demand shock – which a shock in demand other than ascribable to the Δr and the Δe. The period length is assumed to be a quarter so that a change in Δr or Δe or $\overline{tot}$ can be translated into a change in demand with a one-quarter lag.

Equation (2) interprets open economy Phillips curve. The inflation gap (π_g) depends negatively on the lagged Δe and positively on the lag of y_g, the lag of $\overline{tot}$ and a shock. The pressure in the economy – a positive output gap brings up to higher inflation. In the first stance, high demand for goods and services results in price increase of firms. Secondly, higher activity normally pushes up the cost level.[4]

Inflation is influenced by the exchange rates – consumer prices are the combination of the prices for domestically produced and imported goods and services. Changes in the exchange rates will therefore affect consumer prices. Accordingly, the prices for imported goods will change as well.[5] This will in turn affects prices for domestically produced goods due to the competition and changes in firms' costs. As to the changes in prices for imported intermediate goods and changes in wages are resulted from the changes in consumption-based real wages.

Direct price effect can be found between terms of trade and the inflation. Increases in exportable prices will contribute directly to the domestic inflation.[6] The variable η_t is the cost push shock in the model. It shows the rise in π_g as a given level for the y_g, Δe and $\overline{tot}$. The most obvious shock would be an increase in wages indicated by the activity level, but it could also be caused by an increase in international commodity prices, which pushed up enterprises' production costs.

Equation (3) posits a link between the interest rates and exchange rates. It captures the idea that a rise in the interest rates makes domestic assets more attractive, leading to an appreciation. The shock v_t captures other influences on the exchange rate, such as expectations, investor confidence and foreign interest rates. Equation (3) is similar to reduced-form equations for the exchange rates in many textbooks (Ball, 1999).

The fourth equation is the TR. Firstly we suppose that central bank targets one-period lagged output gap and inflation (one period corresponds to one quarter). This backward looking TR is then given by:

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4 e.g. The trade unions will demand higher wage increases and employers will outbid each other in the competition for labor.

5 i.e. The inflation is passed directly into import prices.

6 Since fixed exchange rates policy and intervention in the foreign exchange market strategy are alike, in other words, the country follow a fixed exchange rates policy will be required to intervene in the foreign exchange market to keep the two currencies in line (Broda and Tille, 2003; Broda, 2004). This paper adopted this underlying assumption; thereby an increase in the terms of trade is unambiguously inflationary (c.f. Gruen and Dwyer, 2008).

$$\Delta r_t = \beta_y y_{t-1} + \beta_\pi \pi_{t-1} - \delta_3 \Delta e_{t-1} - \phi_3 \overline{tot}_{t-1} + \zeta_t \quad (4)$$

with theoretical signs of the parameters that β_y & $\beta_\pi > 0$, and δ_3 & $\phi_3 < 0$. As Δr_t is the real terms, the Taylor principle is satisfied; one-percent increase in the inflation rate leads to a more than one percent increase of the nominal interest rates (so as to insure an increase of the interest rate in real terms). ζ_t represents monetary policy shocks (e.g. discretionary decisions of the central bank).

The inclusion of the exchange rates exactly aims to explore the extent of this variable that taken into account for monetary policy decisions. If the behavior of the exchange rates play any role in the central bank's actions, then δ_3 can be expected to be negative and significant.[7] This is because recurrent exchange rates depreciations may induce the central bank to raise real interest rates to avoid price increases and hence keep inflation under control (particularly if a pass-through prevails).

The inclusion of the terms of trade allows control of the variations in foreign and controlled prices. With respect to ϕ_3, a negative terms of trade shock or "cost push shock" would induce a depreciation of the exchange rates and/or increase in domestic inflation[8], which should in turn induces a more stringent position of the central bank and leads an increase in interest rates. This implies that ϕ should be negative.

Followed by Woodford (2003), the central bank's objective is to minimize the loss function subjected to the model of the economy described above:

$$E_t \sum_{\tau=0}^{\infty} \beta^\tau L_{t+\tau} \quad (5)$$

where the policy can be represented by the central bank minimizing the period loss function as below

$$L_t = \mu_y (y_t)^2 + \mu_\pi (\pi_t)^2 + \gamma (\Delta r)^2 \quad (6)$$

and where μ_y, μ_π and γ denote weights attached to the stabilization of inflation, output gap and interest rates, respectively. Equation (6) implies that the exchange rates does not enter explicitly the loss function. The reason for the omission is that changes in the exchange rates can be reflected in the changes in the output gap (Svensson, 2000; Guender, 2005). Consequently, there is no need for the real exchange rates to appear as a separate argument in the loss function. Further, as the discount factor β approaches unity, it can be shown that the loss becomes proportional to the unconditional expected value of the period loss function. This equation is given by:

$$L_t = \mu_y V_y + \mu_\pi V_\pi + \gamma V_r \quad (7)$$

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7 Here, an increase corresponds to an appreciation of the exchange rate.

8 See Edwards (1989).

Here, V_y and V_π respectively stands for the unconditional variance of the output and the inflation. The variance of the monetary policy instrument is frequently inserted in the loss function of the central bank, V_r here is mainly functioned to avoid unrealistic situation of the high interest rate volatility. μ_y, μ_π and γ are the weighs attributed to the output gap stabilization, inflation and interest rate. Finally, the optimal monetary policy rule is then expressed as $(\beta_\pi^*;\beta_y^*)$, which minimizes L, given the weights of μ_y, μ_π and γ (to be discussed in the next section).

Methodology and Data

Generalized method of moments (GMM)

In the structural macroeconomic models, GMM allows us to estimate models of several equations with the same coefficients featuring in different equations. The most important steps in the GMM procedure is the assumption that the independent variables involved are unrelated to the equation's residual. For the past ten years, GMM has been intensively used to estimate small-scale macroeconomic models. (see e.g. Clarida *et al*., 1998; Gali and Gertler, 1999; Smets, 2003; Pei-Tha and Yu, 2009; among others).

In this paper, we have four equations for setting the backward looking TR (from equation (1) to equation (4) in Section II) that simultaneously determine the evolution of the variables. If we attempted to estimate each equation separately, we would expect endogeneity to be a palpable problem, because all five variables would be expectedly interacted to the four equations. Moreover, expectations about the future values of variables cannot be considered exogenous because they depend on both past and current realizations of variables in the system. As the previous sections outlined, we may use GMM to resolve at this issue (see e.g. Greene, 2000; among others). In particular, to compute the GMM estimates, we start by identifying weighting matrix, then, getting a first set of coefficients to update the weighting matrix and eventually iterating coefficients to convergence. To compute the HAC standard errors, we adopt the Newey and West (1994) approach with a Barlett kernel and fixed bandwidth. These calculations are carried out with Eviews 5.1. Again, lags of variables in the system or other variables that may be considered exogenous can also be used as instruments. The following subsection reviews the grid search method in depth as it is less well known than the GMM method considered.

Seeking the optimal reaction coefficients: grid search approach

Grid search method is a direct search algorithm for solving nonlinear optimization, which requires objective function. This methodology involves setting up of grids in the decision space and evaluating the values of the objective function at each grid point. The point corresponded to the best value of the objective function is considered to be the optimum solution.

This study solves the optimization problem by applying technique explained Levieuge (2008).[9] To apply the grid search technique, equation from (1) to (4) in Section II that follow a backward looking rule that can be written as a general matrix system to define the following state-space form model:

$$A_1 X_t = A_2 X_{t-1} + W_t \tag{8}$$

thereby

$$\begin{bmatrix} 1 & 0 & 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & -\theta & 0 & 0 \\ 0 & 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & -1 & 0 & 1 \end{bmatrix} \begin{bmatrix} y_{g_t} \\ \pi_{g_t} \\ \Delta e_t \\ \Delta r_t \\ \overline{tot}_t \\ z_{t-1} \end{bmatrix} = \begin{bmatrix} \lambda & 0 & -\delta_1 & -\beta & \phi_1 & 0 \\ \alpha & 1 & -\delta_2 & 0 & \phi_2 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 \\ \beta_y & \beta_\pi & -\delta_3 & 0 & -\phi_3 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & -1 & 0 & 0 \end{bmatrix} \begin{bmatrix} y_{g_{t-1}} \\ \pi_{g_{t-1}} \\ \Delta e_{t-1} \\ \Delta r_{t-1} \\ \overline{tot}_{t-1} \\ z_{t-1} \end{bmatrix} + \begin{bmatrix} \varepsilon_t \\ \eta_t \\ v_t \\ \zeta_t \\ 0 \\ 0 \end{bmatrix}$$

with Ω as the covariance matrix associated to W, the system can be written like $X_t = BX_{t-1} + S_t$ but now with:

$$B \equiv A_1^{-1} A_2 \tag{9}$$

$$S \equiv A_1^{-1} W_t \tag{10}$$

It is followed by the Σ – the covariances matrix associated with the error terms S can be given by $\Sigma = E\left[SS'\right] = E\left[(A_1^{-1}W_t)(A_1^{-1}W_t)'\right] = A_1^{-1}\Omega(A_1^{-1})'$

Since the objective of the central bank is to minimize the standard quadratic loss function (L), it is then can be subjected to the model of the economy as follows:

$$\begin{cases} \underset{\{\beta_\pi, \beta_y, r\}}{Min} & L = \mu_y V_y + \mu_\pi V_\pi + \gamma V_r \\ s.t. & X_t = BX_{t-1} + S_t \end{cases}$$

Following the works of Jaaskela (2005) and Rudebusch & Svensson (1999) that set μ_y and μ_π equal to one; Jaaskela (2005) and Smets (2002) set $\gamma = 0.25$, this study sets $\mu_y = 1.0$, $\mu_\pi = 1.0$ and $\gamma = 0.25$, which ensures the stabilization of the output gap,

9 The RATS program (i.e. the codes of grid search procedure) in estimating the optimal reaction coefficients and the loss function are from Levieuge (2008). The RATS program of this paper's grid search procedure can be obtained by contacting the author.

the inflation and the interest rate.[10] As the fact that central banks are likely to move their instrument in moderate steps, V_r is often the variance of the interest rate volatility, i.e. $Var(r_t - r_{t-1})$. According to the case here, it is necessary to add an identity formula, $z_t = r_t - r_{t-1}$, in the system as shown above. The optimal monetary policy rule is then the couple $(\beta_\pi^*; \beta_y^*)$ which minimizes L, given the weights of μ_y, μ_π and γ.

Following Svensson (2000), the unconditional contemporaneous covariance matrix of X, devoted V, can be given in vector form by:

$$Vec(V) = \left[I - B \otimes B\right]^{-1} Vec(\Sigma) \tag{11}$$

with Σ the covariance matrix of S. Following this result, unconditional variances for the output gap (V_y) and the inflation (V_π) can be obtained by selecting the appropriate components in $Vec(V)$. In this backward looking rule example, V_y, V_π and V_r are then can be given by the 1^{st}, the 8^{th} and 36^{th} element of $VecV$. In the case here, we consider the 22^{th} instead of the 36^{th} – element of $VecV$ then comes down to consider the previous case, with $Var(r_t)$, instead of $Var(\Delta r_t)$, in the loss function.[11] Given $(\beta_y; \beta_\pi)$ in solving this sequence, the method consists then can be displayed as below,

$$(\beta_y; \beta_\pi) \Rightarrow B, S \text{ and } \Sigma \Rightarrow VecV \Rightarrow L \tag{12}$$

Data

The data are quarterly collected from quarter one of 1995 to quarter four of 2006. All prices series are seasonally adjusted. As an exchange rate variable, this study uses the real effective exchange rates index (2000=100), which indicates that an increase in index means appreciation. As a monetary policy variable, the interest rate is used for

Indonesia, Malaysia and Thailand. The output applied in this study is gross domestic output (GDP), which is known as national output or income. In addition, the study applies data on terms of trade that subject to external shocks. The data sources are IMF, *International Financial Statistics (IFS)*, CD-ROM; IMF, *Direction of Trade Statistics (DOT)*, CD-ROM; The World Bank Group, *World Development Indicators (WDI)*; Thailand, *National Economic and Social Development Board (NESDB)*. The country-specific details are described as follows:

10 The appropriate values of the loss function remain debatable (see Levin and Williams, 2003). The parameter values chosen here are fairly standard in the policy rules literature (Jaaskela, 2005).

11 According to this viewpoint, this case is more general.

Money market rate	: The quarterly series of money market rate from the IFS is used as interest rates.
Real effective exchange rate	: For Indonesia and Thailand, the quarterly series of the real effective exchange rates (REER) index (2000=100) is constructed by the weighted average of major trading partner countries (export plus import). The bilateral exchange rates and the trade share are, respectively, obtained from IFS and IMF, DOT statistics, CD-ROM. For Malaysia, the quarterly series of the real effective exchange rate index (2000=100) is obtained from IFS.
Gross domestic product	: The quarterly series of the nominal gross domestic product (NGDP) is taken from IFS. The NGDP is divided by consumer price index (CPI) to obtain the real terms of this variable – GDP.
Consumer price index	: The quarterly series of consumer price index (CPI) is taken from IFS. The inflation rate is taken from the first difference of the log of CPI level.
Terms of trade	: The series of terms of trade (TOT) is taken from WDI in annual basis. Since the quarterly series of TOT are inaccessible, alternatively, however those data can be interpolated from annual series using RATS procedure DISTRIB to yield quarterly series.[12]

The output gap is the deviation of the current output from the potential one, inflation gap is the deviation of the current inflation from the desired one, real interest rates gap is the difference between current real interest rates and real interest rates at potential output, and real exchange rate gap is the deviation of the current real exchange rate from the real exchange rate at potential output. The potential output, desired inflation, interest rates at potential output, and exchange rate at potential output are constructed by using Hodrick-Prescott (HP) filter. The smoothing parameter, λ, set equals to 1600.

In specific, the time series "Output Gap $-(y_{g_t})$" is calculated as the difference of the logged time series of the current output and the potential one, and then multiplied by 100. Similarly, the time series "changes in the real exchange rate $-(\Delta e_t)$" is calculated as the difference of the logged time series of the current REER and potential REER. To yield the changes in percentage, the time series then are multiplied by 100. Difference between the current real interest rates and the potential ones is calculated the changes in percentage and it can be used to derive time series "changes in the real interest rate $-(\Delta r_t)$".[13] Likewise inflation gap (π_{g_t}) is the difference between the current inflation rates and the potential ones. The time series "terms of trade variable $-(\overline{tot_t})$" is calculated as the quarterly rate of change of the TOT.

[12] The codes for interpolation (i.e. RATS procedure DISTRIB) are available at www.estima.com/Interpolation.shtml.

[13] To derive the real interest rate the quarterly inflation rate was subtracted from the quarterly nominal interest rate.

Results

GMM estimates for parameters values

Using GMM and quarterly data (for Indonesia, Malaysia and Thailand) from the quarter one of 1995 to quarter four of 2006, the estimated model parameters for policy reaction function are reported in Table 1. From Table 1, the J-statistics statistically confirm that the null hypothesis of the instruments variables is exogenous. In other words, the null hypothesis is not rejected for the estimate. The findings for a model in each country that consist all variables, namely the output gap, the inflation gap, the exchange rates gap, the interest rates gap and terms of trade, are discussed as below.

Generally, the estimated parameters for all explanatory variables are in expected sign and statistically significant. Starting with the estimated IS curve parameters, the output gap (λ) process in estimate for policy reaction function takes up more weight. This would suggest that the influence of past output gap on the current one is greater in the estimate. The strength of the transmission channel throughout the interest rate of monetary policy appears low in the β estimate for all the countries, which are -0.2., -0.5 and -0.4 for Indonesia, Thailand and Malaysia respectively. Further, the estimated elasticity of the output gap to the exchange rates gap suggests that the stabilization of output could be effective through the exchange rate transmission channel (see Bofinger and Wollmershauser, 2003; Pei-Tha and Kian-Teng, 2008; McKinnon, 2003). In a similar vein as the exchange rates gap, the stabilization of the output could be effective through the terms of trade.

Considering the estimated Phillips curve, the elasticity of inflation to an increasing output gap proposes that the given increase in capacity utilization (demand pressure) will be translated into marginal costs. The elasticity of inflation to depreciation of the exchange rate suggests that depreciation causes the domestic currency price of the foreign goods increase.[14] The elasticity of inflation to an increase in the terms of trade is unambiguously inflation. Moreover, a positive link between the interest rate and exchange rate of the estimate, the parameter of the exchange rate (θ) suggests that a higher real interest rate leads to a stronger real exchange rate.

Following the Table 1, the estimate of the β_y coefficient for policy reaction function suggests that a positive output gap – overheating – may induce higher inflation than desired one. This should be offset through tightening monetary policy and vice-versa. The estimate of the β_π coefficient for Indonesia and Thailand are greater than one, which means that in order to stabilize the monetary policy, any increases in inflation would be adequately offset by the monetary authority (Taylor, 1993). The estimate of the β_π coefficient for Malaysia is less than one, which means that central bank procyclically responds to inflation deviation from the target. One should be noted, however, that the coefficient of the output gap and the inflation gap are not exactly the same as Taylor (1993) proposed, but they are significant as estimated by Wald

[14] An increase in the exchange rate forces up the optimal price level, in which *ceteris paribus*, induces firms to raise the price of their output so as to minimize the deviation between the optimal price and the actual price charged. At the aggregate level the increase in the domestic price level causes the rate of inflation to rise (cf. Guender, 2005).

coefficient restriction test (see Table 2). Furthermore, the estimate of δ_3 and ϕ_3 coefficients suggest that the exchange rate and the terms of trade constitute an indicator for monetary policy.

Overall, the results of the estimation are in conformity with the expectation and they are economically meaningful. Next, the macroeconomic model in Section II is calibrated with the parameters of the estimate for policy reaction function in Table 1.

Table 1 GMM estimations for the policy reaction function

Parameter	Estimate for policy reaction function		
	Indonesia	Malaysia	Thailand
λ	0.824***	1.498***	0.834***
	(0.040)	(0.206)	(0.071)
δ_1	-0.027*	-0.077*	-0.423***
	(0.016)	(0.047)	(0.134)
β	-0.193***	-0.546**	-0.430***
	0.024	(0.248)	(0.150)
ϕ_1	0.112***	1.302*	0.865**
	(0.037)	(0.763)	(0.410)
α	0.280***	0.172***	0.185***
	(0.033)	(0.050)	(0.045)
δ_2	-0.071***	-0.039***	-0.237***
	(0.018)	(0.009)	(0.065)
ϕ_2	0.118***	0.091**	0.361**
	(0.020)	(0.037)	(0.164)
θ	0.511***	0.860*	0.711**
	(0.151)	(0.477)	(0.283)
β_y	0.181**	0.098***	0.262***
	(0.071)	(0.026)	(0.038)
β_π	1.155***	0.964***	1.391***
	(0.132)	(0.219)	(0.208)
δ_3	-0.073**	-0.071**	-0.082*
	(0.033)	(0.027)	(0.042)
ϕ_3	-0.329***	-0.393*	-0.493*
	(0.020)	(0.227)	(0.260)
J-statistics	0.251	0.250	0.276
nJ-statistics	12.054	11.993	13.240
p-value	0.210†	0.446†	0.278†

Notes: Standard errors are in the parentheses. *, **, and *** denotes statistical significance at the 10%, 5% and 1% levels respectively. The instrumental variables list for the estimates above includes lags of output gap, lags of inflation, lags of interest rate and lags of exchange rate. nJ-statistics is the J-statistics reported in the Eviews are multiplied by the number of regression observations. † denotes do not reject the hypothesis that the overidentifying restrictions are orthogonal to the errors at the 5% level of significance.

Table 2 The Wald test

Hypothesis	Indonesia		Malaysia		Thailand	
	χ^2 statistic	$p-$value	χ^2 statistic	$p-$value	χ^2 statistic	$p-$value
Coefficient of output gap = 0.5	20.10	0.00	233.30	0.00	38.33	0.00
Coefficient of inflation =1.5	6.76	0.00	6.00	0.01	0.27	0.06

Grid search approach for optimized rules

Table 3 summarize the optimized policy rules, unconditional variances of goal variables and loses, for Indonesia, Malaysia and Thailand respectively. The results are generalized by calibrating the model in Section II; the parameter values of these models are chosen from the estimates in the subsection above. Shaded areas indicate the optimal solution of the model that depends on all the state variables (the output gap, the inflation gap, the exchange rates gap, the interest rates gap and terms of trade); the central bank's preference parameters are set; therefore, it assigns a weight of 1 to stabilize the inflation and the output and sets the preferred interests rates stabilization to 0.25.[15] The policy aims at minimizing the output gap and the inflation gap is performed. These findings are discussed as below:

1. *Indonesia*: The parameters of the estimate are λ = 0.8, β = -0.2, δ_1 = -0.03, ϕ_1 = 0.1, α = 0.3, δ_2 = -0.1, ϕ_2 = 0.1, θ = 0.5, δ_3 = -0.1 and ϕ_3 = -0.3. The preference parameters of μ_y, μ_π, and γ are fixed to 1.0, 1.0, and 0.25, respectively. From Table 3, the minimum of the loss function can be computed. It is obtained by so-called optimal reaction coefficients – β_π^* and β_y^*. According to the results reported in Table 3, the optimal monetary policy rule of the estimates is $\Delta r_t = 1.45y_{t-1} + 1.15\pi_{t-1}$ for μ_y = 1.0, μ_π = 1.0, and γ = 0.25. Since, societal loss function is in line with a welfare maximizing policy that aims at the minimization of the output gap and the inflation gap. The loss function is 10.93; the variances V_y, V_π and V_r are 3.18, 5.70 and 8.18, respectively.

2. *Malaysia*: The parameters of the estimate are λ = 1.5, β = -0.5, δ_1 = -0.1, ϕ_1 = 1.3, α = 0.2, δ_2 = -0.04, ϕ_2 = 0.1, θ = 0.9, δ_3 = -0.1 and ϕ_3 = -0.4. The preference parameters of μ_y, μ_π, and γ are fixed to 1.0, 1.0, and

[15] See again footnote 10.

0.25, respectively. From Table 3, the minimum of the loss function can be computed. It is obtained by so-called optimal reaction coefficients – β_π^* and β_y^*. According to the results reported in Table 3, the optimal monetary policy rule of the estimates is $\Delta r_t = 1.45y_{t-1} + 0.25\pi_{t-1}$ for μ_y = 1.0, μ_π = 1.0, and γ = 0.25. Since, societal loss function is in line with a welfare maximizing policy that aims at the minimization of the output gap and the inflation gap. The loss function is 63.39; the variances V_y, V_π and V_r are 37.98, 18.87 and 26.17, respectively.

3. *Thailand*: The parameters of the estimate are λ = 0.8, β = -0.4, δ_1 = -0.4, ϕ_1 = 0.9, α = 0.2, δ_2 = -0.2, ϕ_2 = 0.4, θ = 0.7, δ_3 = -0.1 and ϕ_3 = -0.5. The preference parameters of μ_y, μ_π, and γ are fixed to 1.0, 1.0, and 0.25, respectively. From Table 3, the minimum of the loss function can be computed. It is obtained by so-called optimal reaction coefficients – β_π^* and β_y^*. According to the results reported in Table 3, the optimal monetary policy rule of the estimates is $\Delta r_t = 0.55y_{t-1} + 0.55\pi_{t-1}$ for μ_y = 1.0, μ_π = 1.0, and γ = 0.25. Since, societal loss function is in line with a welfare maximizing policy that aims at the minimization of the output gap and the inflation gap. The loss function is 17.63; the variances V_y, V_π and V_r are 8.39, 7.64 and 6.45, respectively.

Several results for various values of μ_y are also performed. Overall, there are several findings worth mentioning. First, the finding suggests that there are evidence to support the importance of the exchange rates and terms of trade in influencing the optimal monetary policy. Second, the loss function of policy rule specification is aimed at minimizing the output gap and the inflation gap varied across the countries, however, the central banks of Indonesia and Thailand achieved a smaller value of the loss than Malaysia.

Table 3 Optimized policy rules, unconditional variances of goal variables and losses, for Indonesia, Malaysia and Thailand (various results depend on μ_y, μ_π, and γ)

Preference	β_y^*	β_π^*	V_y	V_π	V_r	L
Indonesia						
$\mu_y = 0.0,\ \mu_\pi = 1.0,\ \gamma = 0.25$	1.30	1.45	3.88	5.17	8.08	7.37
$\mu_y = 0.3,\ \mu_\pi = 1.0,\ \gamma = 0.25$	1.30	1.30	3.58	5.42	8.09	8.52

$\mu_y = 0.6,\ \mu_\pi = 1.0,\ \gamma = 0.25$	1.45	1.30	3.43	5.32	8.79	9.58
$\mu_y = 1.0,\ \mu_\pi = 1.0,\ \gamma = 0.25$	1.45	1.15	3.18	5.70	8.18	10.93
Malaysia						
$\mu_y = 0.0,\ \mu_\pi = 1.0,\ \gamma = 0.25$	1.45	0.40	51.89	15.13	32.24	23.19
$\mu_y = 0.3,\ \mu_\pi = 1.0,\ \gamma = 0.25$	1.45	0.25	37.98	18.87	26.17	36.80
$\mu_y = 0.6,\ \mu_\pi = 1.0,\ \gamma = 0.25$	1.45	0.25	37.98	18.87	26.17	48.20
$\mu_y = 1.0,\ \mu_\pi = 1.0,\ \gamma = 0.25$	1.45	0.25	37.98	18.87	26.17	63.39
Thailand						
$\mu_y = 0.0,\ \mu_\pi = 1.0,\ \gamma = 0.25$	0.55	1.00	13.48	5.60	8.90	7.82
$\mu_y = 0.3,\ \mu_\pi = 1.0,\ \gamma = 0.25$	0.55	0.70	9.76	6.56	7.08	11.25
$\mu_y = 0.6,\ \mu_\pi = 1.0,\ \gamma = 0.25$	0.55	0.70	9.76	6.56	7.08	14.18
$\mu_y = 1.0,\ \mu_\pi = 1.0,\ \gamma = 0.25$	0.55	0.55	8.39	7.64	6.45	17.63

Conclusions

This paper adopted GMM procedures in order to obtain the coefficients to uncover the optimal reaction coefficients that minimize the loss function through the "grid search approach". The study ran across the ASEAN-3, namely Indonesia, Malaysia and Thailand.

The test relating to GMM measures revealed outcomes of the estimation that are in conformity with the expectation and they are economically meaningful. The results shed a light that the monetary objectives (i.e. the output gap and the inflation) and the external variables (i.e. exchange rates and terms of trade), which have impact on the central banks' monetary policy reaction function, are not taken as monetary policy objectives in reality. Although price stability is the most important objective of monetary policy for the ASEAN-3, however, the central banks of Indonesia and Thailand have comparatively smaller value of loss than Malaysia, which could be explained by the central banks of Indonesia and Thailand have been introduced the inflation targeting in 2000, except for Malaysia.[16]

In conclusion, since the optimum founded is surely a global minimum, it would depend on all the state variables concerned in this paper. The measurement involves the "grid search approach", which suggests that the optimized policy rule specification is optimal in the sense that it represents solutions to the specified constrained optimization

16 See again footnote 2.

problem. Inherently, these results confirmed the paper's hypothesis mentioned in the introductory section earlier. Further research should incorporate additional explanatory variables into the model. It seems valuable for future research to determine the same issue using forward looking rule to prove whether or not the present result is a general result for the economy analyzed. The same approach can also be replicated for other countries.

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