THE MONETARY POLICY REACTION FUNCTION: EVIDENCE FROM ASEAN-3

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ABSTRACT

The aim of this paper is to determine the central bank's reaction process. Our estimation of this process uses the extension of structural vector autoregression (SVAR) modelling based on the Svensson (2000) method. The idea that monetary policy is not only concerned with the output gap and inflation, but also with external variables, constitutes the basis for the analysis. Using data from Indonesia, Malaysia and Thailand, the empirical results indicate that the selected countries do care about inflation and the output gap. This is consistent with the central banks' position that: (i) price stability is the most important objective of monetary policy, (ii) the exchange rates and terms of trade, which impact central bank actions, are not, in reality, considered monetary policy objectives and (iii) interest rates are a useful measure for the monetary authorities' counter-cyclical policies.

Keywords: impulse response functions, reaction function, SVAR, and Taylor rule

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 function necessitates a general discussion of a number of analytical and technical issues, an important practical issue regards the set of monetary policy objectives considered in the rule. The original specification proposed by Taylor (1993) states that objectives should contain deviations from the target values of the inflation rate and output, namely, inflation and

output gaps. However, an open question remains as to whether or not other variables systematically affect the behaviour of interest rates.

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

However, the role of exchange rates in monetary policy rules is still under debate, and a consensus is far from being reached. To have a better understanding of the mechanism by which these instruments affect exchange rates, it is worth probing the actual behaviours of central banks:

Officially, Floaters Directly Intervene in the Foreign Exchange Market

Actual policies, however, often diverge from official declarations. Empirical work by Calvo and Reinhart (2002) and Levy-Yeyati and Sturzenegger (2005), found that, in practice, countries that officially allow their exchange rate to float will frequently intervene in the foreign exchange market. While foreign exchange reserves were highly volatile in those countries which are not enforcing a floating currency, the volatility of the nominal exchange rate was relatively low compared to countries that enforce a floating currency policy. Reinhart (2000) called this finding "an epidemic case of fear of floating", in which a free-floating exchange rate increases foreign exchange volatility. Thus, countries appear to face a greater fear of floating, as they have much narrower variations of the nominal exchange rate.[1]

Sterilisation of Foreign Exchange Market Interventions

Central banks carry out equal foreign and domestic asset transactions in opposite directions in order to nullify the impact of their foreign exchange

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[1] Calvo and Reinhart (2002) argue that the "fear of floating" depends on high-liability dollarisation, financial fragility and strong balance sheet effects. When liabilities are denominated in foreign currencies while assets are in the local currency, unexpected depreciations of the exchange rate deteriorate bank and corporate balance sheets and threaten the stability of the domestic financial system.

operations on the domestic money supply. Sterilisation has no effect on the domestic money supply; it leaves the interest rates unchanged (Jurgensen, 1983).[2] In recent studies, for example, Kwack (2001), Bofinger and Wollmershauser (2001) and Cavoli and Rajan (2006) found that, on average, there has been almost complete sterilisation in Asian countries, including Korea, Malaysia, Thailand, Philippines, Indonesia and others. Thus, a high rate of sterilisation and the foreign exchange market intervention yields little change to the exchange rate.

Using Interest Rates to Stabilise Exchange Rates

The tendency of central banks to indirectly influence the exchange rate by interest rate adjustments can be largely confirmed (even for developed countries) by empirical work on monetary policy rules. Influential studies, for example, by Calvo and Reinhart (2002), have found that the volatility of interest rates in countries with a fear of floating is significantly higher than in other of countries that adopt true floats. From this finding, they concluded that there has been an apparent change to the way monetary-exchange rate policy has been conducted in several emerging markets—interest rate policy is (at least partially) replacing foreign exchange intervention as the preferred means for smoothing out exchange rate fluctuations (Calvo and Reinhart, 2002). Moreover, in practice, the majority of emerging market economies in Asia tend to place a lot of weight on exchange rate movements in the setting of monetary policy (Ito and Hayashi, 2004).

Furthermore, terms of trade (TOT) can be an additional external variable issue. Edwards (1989) argued that TOT shocks might induce changes in the exchange rate and domestic inflation. He associated a negative TOT shock, or a "cost-push shock", with a depreciation of the exchange rate and/or an increase in domestic inflation. This in turn induces a more stringent position from the central bank and an increase of interest rates. Hence, the inclusion of the TOT variable allows for controlling for variations in foreign or controlled prices. Alternatively, it may account for supply side shocks that affect monetary policy.[3] 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 those 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.

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[2] C.f. Jurgensen (1983), see Chapter V for a detailed treatment of the sterilisation issue.

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

Therefore, the sharp swings in the TOT affect a large share of their economies (Mendoza, 1995; Kose, 2002; Broda, 2004).

The aim of this paper is to provide evidence relating to the roles of exchange rates and terms of trade, other than as monetary policy objectives, for the central bank's reaction process. The three selected ASEAN countries, i.e., Indonesia, Malaysia and Thailand, are taken up in this study. This paper also attempts to investigate the propagation of shocks amongst the interest rates' determinants, including monetary policy variables. The results can be used to support the following hypotheses:

> H_1: While price stability is the most important objective of monetary policy, [4] it is postulated that inflation and output gaps are also regarded as monetary policy objectives for capturing the stable inflation adoption, given the interest rates.

> H_2: In small open economies, aside from output and inflation, there are certain monetary policy objectives that central banks focus on. Therefore, this study hypothesises that other external variable (i.e., exchange rates and terms of trade) are important factors that affect monetary policy—the central bank's interest rates.

The following section will introduce the methodology used in conducting the structural vector autoregression (SVAR). The analytical framework of this paper will be discussed, followed by a discussion of the data and empirical results. The final section concludes the study.

METHODOLOGY

An ordinary vector autoregression (VAR) model describes the dynamic movements of endogenous variables according to their past values. It is expressed as:

$$x_t = k + B_1 x_{t-1} + B_2 x_{t-2} + \ldots + B_q x_{t-q} + u_t; \qquad u_t \sim i.i.d.(0, \Sigma_u)$$
$$= k + B(L)x_t + u_t$$

(1)

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[4] The evidence is available from the central bank's 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).

where x_t is a vector of endogenous variables, k is a vector of constants, Bs are matrices of coefficients, u_t is a vector of disturbances, and L is the lag operator. This is a very generalised model, which imposes no restriction on the form of $B(L)$, in other words, the dynamic relationship among variables. It is known that VAR models are particularly useful for forecasting.

One weakness of VAR as a tool for economic analysis is that each equation has no economic interpretation. This is problematic for analyzing monetary policy effects, as the technique cannot tell what is the "monetary policy" in a VAR (Cooley and Leroy, 1985). Thus, to measure the true monetary policy effect, it needs to "identify" the underlying "structure" of the economy reflected in the VAR, in particular, that of the monetary policy reaction and its innovation. This is what the SVAR approach intends to do. A structural VAR can be expressed as:

$$A_0 x_t = c + A(L)x_t + \vartheta_t; \qquad \vartheta_t \sim i.i.d.(0, D) \tag{2}$$

The structure of simultaneous determination in the economy is now explicitly represented in the matrix A_0. Each equation is assumed to represent a specific economic relationship, such as monetary policy reaction or exchange rates, and thus the innovation ϑ represents the exogenous shocks in it. Because ϑ is assumed to be an exogenous shock, they are orthogonal to each other. In other words, the variance matrix D is a diagonal matrix by assumption.

From the viewpoint of a SVAR, an ordinary VAR from equation (1) can be regarded as the reduced form of equation (2). Multiplying both sides of the equation (2) by A_0^{-1},

$$\begin{aligned} x &= A_0^{-1}c + A_0^{-1}A(L)x_t + A_0^{-1}\vartheta_t \\ &= k + B(L)x_t + u_t \end{aligned}$$

Accordingly, the relationship between the structural and reduced form parameters is:

$$c = A_0 k, \quad A(L) = A_0 B(L) \tag{3}$$

$$A_0 u_t = \vartheta_t \Leftrightarrow A_0^{-1} D (A_0^{-1})' = \Sigma_u \tag{4}$$

The problem of estimating the structural VAR in equation (2) is that it is a system of simultaneous equations, and thus the OLS estimator will be

biased and inconsistent. A usual procedure is to estimate the reduced form VAR of equation (1) by OLS, and recover the structural parameters using the relationship from equations (3) and (4). If A_0 is estimated, other structural parameters can be recovered by (3). A_0 (together with D) is recovered using (4). However, at the same time, as A_0 and D contain n^2 unknown parameters, Σ_u contains only $n(n+1)/2$ information, as it is a symmetric matrix. Therefore, at least $n(n+1)/2$ additional restrictions are required for the identification of A_0.

There are several ways to specify the restrictions to achieve the identification of the structural parameters. One procedure is to use the restrictions implied by a fully specified macroeconomic model. An alternative procedure is to choose the set of variables and identification restrictions that are broadly consistent with the preferred theory and prior empirical research. This approach was described by Leeper et al. (1996) as an informal approach to applying more formal prior beliefs about econometric modelling, which is also applied in this study.

SPECIFICATION

Taylor's (1993) standard theory of the monetary policy rule, i.e., the Taylor rule (TR), can be written in general form as:

$$\Delta r = \mathrm{f}\,(y_g, \pi_g) \tag{5}$$

In line with the purpose of this study, the reaction function can be extended to cover the other external variables, namely, exchange rates and terms of trade.[5] The general form of the augmented reaction function can be specified as follows:

$$\Delta r = \mathrm{f}\,(y_g, \pi_g, \Delta e, \overline{tot}) \tag{6}$$

where Δr denotes the change in real interest rates—the difference between current real interest rates (r_t) and real interest rates at potential one (r_t^*); y_g denotes the output gap—the deviation of the output, y_t, from its potential

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[5]   The reaction function may also contain interest rate lags if central banks choose to smooth interest rates (Goodfriend, 1991).

one, y_t^*; π_g denotes the inflation gap—the deviation of the inflation rate, π_t, from its target value, π_t^*; Δe denotes the change in the real exchange rate— the deviation of the current real exchange rate (e_t) from the real exchange rate at potential output (e_t^*); $\overline{tot}$ denotes the terms of trade variable—the quarterly rate of change of the terms of trade.

Thus, this study estimates SVAR modelling for the backward-looking TR reaction function, which resembles the macroeconomic model set up by Svensson (2000). Among others, it is also used by Ball (1999), Clarida et al. (1998), Jondeau and Le Bihan (2000) and Walsh (2003). With certain modifications, the final model feasibly incorporates the π_g, y_g, Δr, Δe [6] and $\overline{tot}$.

Overall, the proposed model is rather conventional—it remains in the context of a small, open economy framework. The adapted structural model can be written as follows:

$$y_{g_t} = \lambda y_{g_{t-1}} - \delta_1 \Delta e_{t-1} - \beta \Delta r_{t-1} + \phi_1 \overline{tot}_{t-1} + \varepsilon_t \tag{7}$$

$$\pi_{g_t} = \alpha y_{g_{t-1}} + \pi_{g_{t-1}} - \delta_2 \Delta e_{t-1} + \phi_2 \overline{tot}_{t-1} + \eta_t \tag{8}$$

$$\Delta e_t = \theta \Delta r_t + v_t \tag{9}$$

$$\Delta r_t = \beta_y y_{g_{t-1}} + \beta_\pi \pi_{g_{t-1}} - \delta_3 \Delta e_{t-1} - \phi_3 \overline{tot}_{t-1} + \zeta_t \tag{10}$$

$$\overline{tot}_t = \varpi_t \tag{11}$$

where the parameters λ, ϕ_1, α, ϕ_2, θ and β_π are positive and the parameters δ_1, β, δ_2, δ_3 and ϕ_3 are negative. The ε_t, η_t, v_t, ζ_t and ϖ_t are structural disturbances.

Equation (7) is an augmented, open-economy IS curve with output gap shocks responding to innovations in exchange rates, interest rates and

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[6] An increase in the 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.

terms of trade. Innovations $\overline{tot}$ are expected to be positive[7], while innovations in Δe and Δr are expected to be negative.

Equation (8) is an augmented, open-economy Phillips curve. This equation allows inflation to respond endogenously to innovations in the output gap, exchange rates and terms of trade. The expected signs of π_g are positive on y_g and $\overline{tot}$ and negative on Δe. Equation (9) posits a link between interest rates and exchange rates, relating positive innovations in Δe and Δr.

Equation (10) represents the TR monetary policy reaction function. The function allows the monetary authority to adjust short-term interest rates subjected to changes in the output gap, inflation, exchange rates and terms of trade innovations. The expected positive sign on most innovations reflects the countercyclical policy taken by the monetary authority. For example, the positive signs on y_g and π_g indicate that the monetary authority has attempted to stabilise the output gap and inflation by raising short-term interest rates. The negative signs on Δe and $\overline{tot}$ show that monetary authority has tried to stabilise the exchange rate and improve the terms of trade by reducing the short-term interest rate.

The recurrent exchange rate depreciations may induce the central bank to raise real interest rates to avoid price increases and, hence, keep inflation under control. It also provides a simple tool to explore the nature of the documented "fear of floating" phenomenon, as well as an intervention in the foreign exchange market. On the other hand, a negative term of trade shock or "cost-push shock" would induce a depreciation of the exchange rate and/or an increase in domestic inflation[8], which should in turn induce a more stringent position of the central bank and lead to an increase in interest rates. Equation (11) assumes that the terms of trade are a structural disturbance, uncorrelated with other shocks.

Table 1 summarises the five structural equations. The rows present the dependent variables in each equation. The columns present the explanatory variables indicated by the shaded cells and asterisks in each equation. Shaded cells indicate the contemporaneous relationships. Asterisks

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[7] Theory predicts that a country with fixed exchange rates or an intervention in the foreign exchange market will adjust a worsening terms of trade through contraction of output (C.f. Kose and Riezman, 2001; Broda and Tille, 2003, p. 2; Broda, 2004).

[8] See Edwards (1989).

indicate the lagged variables that appear in the equations for each dependent variable. The lag structure of monetary policy is discussed in the context of controllability of economic aggregates by monetary authorities.[9] Given the measuring approach employed here, Akaike's information criterion (AIC) is used for the lag selection criteria.[10] In other words, the study assumes that dependent variables respond to independent variables after determined quarters.

Table 1
Contemporaneous and the Lag Structure of the SVAR Model

Dependent variables	Independent variables				
	y_g	π_g	Δr	Δe	$\overline{tot}$
y_g	*		*	*	*
π_g	*	*		*	*
Δr	*	*	*	*	*
Δe			*	*	
$\overline{tot}$					*

Notes: y_g = output gap; π_g = inflation gap; Δr = changes in the real interest rate; Δe = changes in the exchange rate; $\overline{tot}$ = quarterly change of the terms of trade.

Finally, equation system (5) is estimated by using the structural vector autoregression (SVAR) of the SVAR subroutine in the RATS version 6.1.[11] Furthermore, given the nonlinearity of the equations, the study used Wald statistic to test whether the restriction imposed are justified. Nine plausible restrictions are imposed on the structural parameters, which are based on economic reasons, on the SVAR model summarised in Table 1. An accepted hypothesis shows that the parameters are zero, i.e., the restrictions imposed are accepted.

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[9] Some sources assume the period of time is one year, or four quarters (Ball, 1999; Korhonen, 2002; Roisland and Sveen, 2003, p. 89); some empirical evidence suggests that it takes a year for policy to affect inflation through the direct exchange rate channel and two years through the output channel (see, e.g., Reserve Bank of New Zealand, 1996; Lafleche, 1996).

[10] Toda and Yamamoto (1995) used Akaike's information criterion (AIC) for the lag selection criteria of their VAR model; other examples, such as Ito and Sato (2006), used the likelihood ratio (LR) test for the lag selection of their VAR model.

[11] The related RATS programs for estimating the model for this study are applied, for which the codes are a modification of the STRUCVAR.PRG program and the SVAR program obtained from Professor Dr. James D. Hamilton—Department of Economics, University of California.

DATA

The data are quarterly, collected from quarter one of 1995 to quarter four of 2006. All price 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 the index means appreciation. As a monetary policy variable, interest rates from Indonesia, Malaysia and Thailand are used. The output variable 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 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); and Thailand, National Economic and Social Development Board (NESDB). The specific details are described as follows.

Country-Specific Variables

Money market rate	:	The quarterly series of money market rates obtained from the IFS is used for interest rates.
Real effective exchange rate	:	For Indonesia and Thailand, the quarterly series of the real effective exchange rate (REER) index (2000 = 100) is constructed by the weighted average of major trading partner countries (exports plus imports). 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 collected from IFS. The NGDP is divided by the consumer price index (CPI) to obtain the real terms of this variable — GDP.
Consumer price index	:	The quarterly series of consumer price index (CPI) data is collected from IFS. The inflation rate is collected from the first difference of the log of the CPI level.
Terms of trade	:	The series of terms of trade (TOT) is collected from WDI on an annual basis. Because the quarterly series of TOT are inaccessible, alternatively, the data can be interpolated from the annual series using the RATS procedure DISTRIB to yield a quarterly series.[12]

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

The output gap is the deviation of the current output from the potential one. 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. The difference between the current real interest rates and the potential ones is calculated as a percentage point change, and it can be used to derive the time series "changes in the real interest rate/interest rates gap $-(\Delta r_t)$".[13] For the time series "changes in the real exchange rate/exchange rates gap $-(\Delta e_t)$", the differences between the logged time series of current REER and potential REER are used to calculate the percentage point change in the exchange rate. The time series "inflation gap $-(\pi_{g_t})$" is calculated as the difference between the current inflation rates and the potential ones. The potential output, desired inflation, interest rates at potential output (i.e., interest rates in the base period), and exchange rate at potential output (i.e., exchange rates in the base period) are constructed by using the Hodrick-Prescott (HP) filter.[14] The smoothing parameter, λ, is set equal to 1600. Finally, the time series "terms of trade variable $-(\overline{tot_t})$" is calculated as the quarterly rate of the change of the TOT.

EMPIRICAL ANALYSIS AND RESULTS

The results of the estimation are summarised in Table 2. Following the Phillips-Perron's unit root test, for Indonesia, Malaysia and Thailand, the results confirmed that the Δr_t, y_{g_t}, Δe_t and $\overline{tot_t}$ are integrated of order one, $I(1)$; except y_{g_t} of Malaysia and π_{g_t} of all estimated countries are $I(1)$. For this reason, the SVAR models take the first-difference of variables, which are $I(1)$ except ones of $I(0)$ process in level form to ensure the stability of variables.[15] The lag order of the SVAR models is selected based on AIC.

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

[14] A potential level is an equilibrium level.

[15] C.f. Ito and Sato (2006, p. 9).

Table 2
Result of Estimation for the SVAR Model

Dependent variable	Independent variable(s)	Indonesia Estimated parameters [*t*–statistic]	Malaysia Estimated parameters [*t*–statistic]	Thailand Estimated parameters [*t*–statistic]	Estimated structural variances
y_{g_t}	$y_{g_{t-1}}$	0.491 [3.102]***	0.947 [10.293]***		[a] 1.040 RESET test (1): 2.450 (0.100)
	$y_{g_{t-4}}$		0.635 [6.300]***	0.490 [3.816]***	
	$y_{g_{t-5}}$			0.452 [3.401]***	[b] 0.729 RESET test (2): 1.843 (0.185)
	Δr_{t-3}	–0.196 [–2.333]**	–1.466 [–2.485]**	–0.507 [–4.050]***	
	Δr_{t-4}			–0.553 [–3.877]***	[c] 0.702 RESET test (1): 0.187 (0.670)
	Δe_{t-3}		–0.213 [–1.925]*		
	Δe_{t-5}	–0.093 [–1.779]*	–0.438 [–4.373]***	**–0.098 [–1.179]**	
	$\overline{tot}_{t-3}$	0.491 [2.410]**			
	$\overline{tot}_{t-4}$			**0.668 [0.998]**	
	$\overline{tot}_{t-5}$	0.344 [1.991]**	2.172 [2.702]***		
π_{g_t}	$y_{g_{t-2}}$	0.588 [4.00]***			[a] 0.762 RESET test (6): 2.341 (0.105)
	$y_{g_{t-5}}$	0.441 [2.916]***	0.049 [3.126]***	**0.049 [1.352]**	[b] 0.021 RESET test (1): 1.226 (0.281)
	$\pi_{g_{t-1}}$		0.540 [3.661]***	0.255 [2.029]***	
	$\pi_{g_{t-2}}$	0.246 [1.433]			[c] 0.055 RESET test (1): 0.742 (0.399)
	$\pi_{g_{t-3}}$			0.346 [2.674]***	
	Δe_{t-1}	–0.266 [–7.075]***	–0.056 [–3.906]***		
	Δe_{t-4}			**–0.027 [–1.357]**	
	$\overline{tot}_{t-1}$			0.650 [3.882]***	

(continued)

Table 2 (*continued*)

Dependent variable	Independent variable(s)	Indonesia Estimated parameters [*t*-statistic]	Malaysia Estimated parameters [*t*-statistic]	Thailand Estimated parameters [*t*-statistic]	Estimated structural variances
Δr_t	$\overline{tot}_{t-2}$	0.406 [1.652]*			
	$\overline{tot}_{t-3}$		**0.212 [1.183]**		
	$\overline{tot}_{t-4}$			0.621 [3.279]***	
	$y_{g_{t-1}}$			0.220 [1.854]*	[a] 1.605 RESET test (4): 2.848 (0.108)
	$y_{g_{t-2}}$	0.462 [1.926]*	0.089 [2.562]**		
	$y_{g_{t-3}}$	1.085 [4.540]***		0.550 [4.637]***	[b] 0.028 RESET test (1): 0.256 (0.620)
	$y_{g_{t-4}}$	0.813 [3.741]***			
	$\pi_{g_{t-1}}$			1.550 [3.694]***	[c] 0.324 RESET test (1): 0.034 (0.856)
	$\pi_{g_{t-2}}$		0.650 [2.642]***	0.653 [1.879]*	
	$\pi_{g_{t-3}}$	1.025 [3.823]***		0.795 [2.239]**	
	Δr_{t-1}	−0.722 [−4.858]***	−0.383 [−3.017]***		
	Δr_{t-2}		−0.303 [−3.305]***		
	Δr_{t-4}			**0.127 [0.998]**	
	Δe_{t-1}	−0.352 [−3.411]***		−0.141 [−2.092]**	
	Δe_{t-2}		−0.059 [−2.575]**		
	Δe_{t-5}	−0.366 [−4.073]***			
	Δe_{t-6}	−0.505 [−4.427]***			
	$\overline{tot}_{t-1}$	−1.131 [−2.810]***	−0.405 [−1.782]*	−0.798 [−1.635]*	
	$\overline{tot}_{t-2}$	−1.002 [−2.200]**			

Table 2 (*continued*)

Dependent variable	Independent variable(s)	Indonesia Estimated parameters [*t*-statistic]	Malaysia Estimated parameters [*t*-statistic]	Thailand Estimated parameters [*t*-statistic]	Estimated structural variances
Δe_t	$\overline{tot}_{t-4}$	−1.006 [−3.646]***			[a] 0.591 RESET test (2): 1.662 (0.209)
	$\overline{tot}_{t-5}$	−1.003 [−3.190]***			
	Δr_{t-1}			0.926 [2.857]***	
	Δr_{t-3}	0.820 [3.179]***	**1.004 [1.357]**		[b] 2.359 RESET test (1): 21.874 (0.000)
	Δr_{t-5}	0.939 [2.877]***			
	Δe_{t-1}	0.758 [6.039]***	0.578 [3.947]***	0.535 [3.574]***	[c] 1.899 RESET test (1): 0.597 (0.446)
$\overline{tot}_t$	$\overline{tot}_{t-1}$	1.251 [8.173]***	1.313 [8.855]***	0.914 [6.266]***	[a] 2.676 RESET test (1): 0.717 (0.403)
	$\overline{tot}_{t-4}$	0.977 [4.857]***	0.581 [2.571]**	0.748 [4.675]***	[b] 0.033 RESET test (1): 0.021 (0.887) [c] 0.076 RESET test (1): 0.238 (0.628)

Notes: The adjusted sample period is quarterly from 1995–2006. *, **, and *** denotes statistical significance at the 10%, 5% and 1% levels respectively. [a], [b], and [c] denotes Indonesia, Malaysia and Thailand, respectively. ( ) is $p-$ value. Specification tests on the imposed restrictions: Indonesia: Wald statistic $\chi^2(9) = 1.175$ (0.998); Malaysia: Wald statistic $\chi^2(9) = 2.675$ (0.976); Thailand: Wald statistic $\chi^2(9) = 0.804$ (0.999).

Given the nonlinearity of the equations, the study used the Wald statistic to test whether or not the restrictions imposed were justified. The model required only nine exclusion restrictions (see Table 1). The computed Wald statistics for Indonesia, Malaysia and Thailand are indicated by the statistic $\chi^2(9) = 1.175$ (0.998), $\chi^2(9) = 2.657$ (0.976), and $\chi^2(9) = 0.804$ (0.999), respectively, which strongly accepted the hypothesis.

Overall, although some of the variables are not significant, the parameters had the expected sign; the parameters are indicated by the shaded cells. Those insignificant and incorrect expected sign variables are not reported in the table. In spite of these unsatisfactory outcomes, the results are still meaningful because they demonstrated that most of the important parameters are statistically significant. In addition, each estimated equation has a smaller variance[16] and passes the Ramsey RESET test, indicating a good specification. The findings are summarised as follows:

Indonesia

Based on the AIC and the level form, a lag length of six was chosen for the SVAR model.[17] The main empirical results can be drawn from Table 2. First, innovations to y_g, π_g, Δe and $\overline{tot}$ had the expected signs on innovation to interest rates (equation 10), implying that interest rate innovations responded positively to output and inflation innovations and responded negatively to exchange rate and terms of trade innovations. Hence, this finding confirmed the paper's postulated hypotheses.

Second, the estimates of the output gap (equation 7) once again offered the most striking evidence. The exchange rates and terms of trade not only had the correct sign but also appeared statistically significant. Moreover, the interest rate innovations did play an important role on innovations to the output gap. This result would also provide preliminary evidence as to whether or not exchange rates, interest rates and/or terms of trade are important factors of the output gap.

Finally, the estimates of the inflation function (equation 8) offered additional evidence that exchange rate and terms of trade innovations simply could not be ruled out, for which these variables had the correct sign and were statistically significant.

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[16] The variance might be larger in the misspecified model (C.f. Thomas, 1997).

[17] This study ran the SVAR as the stationarity suggested in the first paragraph in the section on empirical analysis and results; however, the results are unfavourable (not presented here). The insignificant response of the interest rate gap to the inflation gap and the positive response of the interest rate gap to the exchange rates gap (recurrent exchange rate depreciations induced the central bank to reduce interest rates) seem to be inconsistent with the central bank's monetary policy. This indicated that the level form would be acceptable for running the vector autoregression model because differencing may discard valuable information and does not yield asymptotic efficiency in an autoregressive time series (Hamilton, 1994; Hsing and Lee, 2004, p. 9; Raghavan and Silvapulle, 2008).

Malaysia

Based on the AIC and the first difference form (with the conditions as discussed above), a lag length of five was chosen for the SVAR model. The main empirical results can be drawn from Table 2. Primarily, innovations to y_g, π_g, Δe and $\overline{tot}$ had the expected signs for innovation to interest rates (equation 10), implying that the interest rate innovations responded positively to the output and inflation innovations and responded negatively to the exchange rate and terms of trade innovations. Hence, these findings confirmed the paper's postulated hypotheses.

Second, the estimates of the output gap (equation 7) once again offered the most striking evidence. The exchange rate and terms of trade not only had the correct signs but were also statistically significant. Besides, the interest rate innovations do play an important role for innovations to the output gap. This result provides preliminary evidence as to whether or not exchange rates, interest rates and/or terms of trade are important factors of the output gap.

Consequently, the estimates of the inflation function (equation 8) offered additional evidence, such as the exchange rates, which had the correct sign and were significant. Terms of trade, in turn, had the expected sign but were statistically insignificant. However, more importantly, this latter result suggested that the terms of trade innovations simply could not be ruled out.

Thailand

Based on the AIC and the first-difference form (with the conditions as discussed above), a lag length of five was chosen for the SVAR model. The main empirical results can be drawn from Table 2. First, innovations to y_g, π_g, Δe and $\overline{tot}$ had the expected signs for innovation to interest rates (equation 10), indicating that the interest rate innovations responded positively to the output and inflation innovations and responded negatively to the exchange rate and terms of trade innovations. Thereby, this finding is consistent with the hypotheses postulated in paper.

In the next place, the estimates of the output gap (equation 7) offered extra evidence such as the interest rates innovations, which apparently reflected the roles of monetary policy. In particular, a significant and negative sign of Δr reflected that monetary authority attempted to curb inflationary pressures by raising interest rates (actual output was above the potential one).

While the exchange rate and terms of trade innovations had the correct sign, they appeared to be statistically insignificant. Nevertheless, more importantly, this result suggested that exchange rate and terms of trade innovations simply could not be ruled out. This finding would provide preliminary evidence as to whether or not exchange rates, interest rates and/or terms of trade are important factors of the output gap.

Finally, the estimates of the inflation function (equation 8) offered additional evidence such as the terms of trade, which had the correct sign but was also significant. Exchange rates, in turn, had the expected sign but were statistically insignificant. More importantly here, the consequent result suggested that the exchange rate innovations simply could not be ruled out.

Impulse Response Functions (IRs) Results

Another constructive way to describe the relationship between the variables in the SVAR model is through the IRs. The IRs reveal the responses of the variables to innovation in each structural shock. Figures 1 – 3 provide the estimated impulse response function of the interest rates (Δr) for Indonesia, Malaysia, and Thailand, respectively. From these figures, the accumulated impulse responses are presented; the vertical axis indicates the approximate percentage change, and the horizontal axis represents the quarterly time horizon. The findings are discussed as below:

Indonesia

The response of the interest rate gap (Δr) to a shock to the output gap (y_g), inflation gap (π_g), or the lagged Δr is positive during some periods. Figure 1A demonstrates that a shock in Δr is transmitted into Δr immediately and diminished down to zero after several quarters. Figure 1B demonstrates that monetary policy responds to y_g after three quarters. Figure 1C indicates the immediate response of monetary policy to the π_g shocks. On the other hand, in Figure 1D, the response of the interest rate gap (Δr) to a shock to the exchange rates gap (Δe) is negative during certain periods. Shock in the Δe can be transmitted into policy interest rates with a lag of one quarter, along with the effect approaches dropping down to zero after quarter three. In the case of terms of trade ($\overline{tot}$), Figure 1E, a negative shock in this variable drives the rise in interest rates – tightened monetary policy. This effect starts with a lag of one quarter and then gradually dies out to zero after one year.

Malaysia

Figure 2A demonstrates that a shock in Δr is transmitted into Δr immediately and positively. Figure 2B indicates that monetary policy responds to y_g positively after two quarters. The effect starts in the third quarter and then dies out to zero in the third year. Figure 2C demonstrates the response of monetary policy to the π_g shocks. Unlike y_g, this effect starts after one quarter and then dies out to zero in the third year. Thus, the output gap and inflation induce the monetary authority to change their policy stance for a longer time period. From Figure 2D, shock in Δe is transmitted into interest rates policy negatively. The effect starts in the second quarter and then approaches zero after quarter four. Figure 2E plots the response of interest rates as a result of a shock in the terms of trade. The effect starts with a lag of one quarter and approaches zero after quarter two.

Thailand

The response of the Δr to a shock to the y_g, π_g, or the lagged Δr is positive. Figures 3A and 3B indicate that shocks in Δr and y_g transmit into interest rates immediately, but Figure 3C indicates that shock in the π_g transmitted into interest rates with a lag of one quarter. In the case of the exchange rate and terms of trade, a shock in these variables enhances interest rates. The effect of shocks to Δe and $\overline{tot}$ starts with a lag of two quarters, but dies out to zero differently. In other words, Δe approaches zero after quarter three, and $\overline{tot}$ approaches zero after quarter five.

The impulse response function for the interest rates presented in Figures 1–3 have a correct response during some of the periods to a shock to the lagged interest rates, output gap, inflation, exchange rates and terms of trade. Overall, the central banks' reaction function follows the TR even if the monetary authorities do not apply it in reality. The results suggest that the central banks would raise the interest rates in response to an increase in the output and inflation gaps. Furthermore, the central banks would also take action if the exchange rate deviates from its trend. If currency depreciation were greater than what the central banks would expect, central banks would intervene in the foreign exchange market by raising interest rates, and vice-versa. The central banks also monitor the terms of trade performance. A negative term of trade shock or a "cost-push shock" would induce depreciation in the exchange rate and/or an increase in domestic inflation and

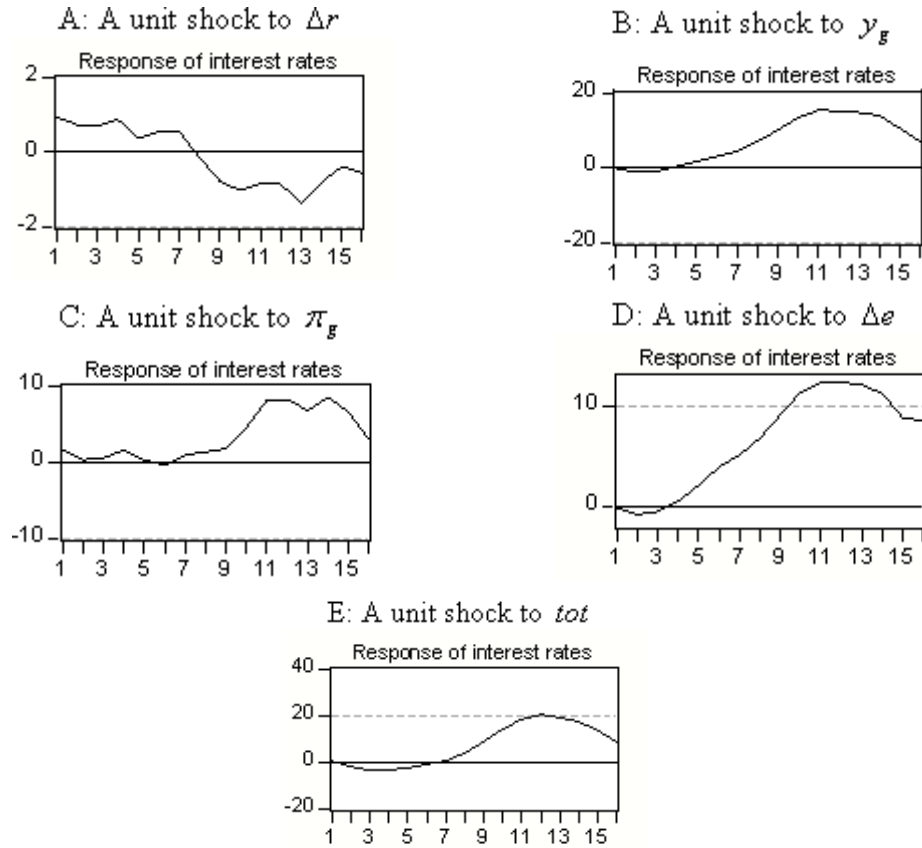would in turn induce a more stringent position of the central bank and an increase in the interest rates.

A: A unit shock to Δr

Response of interest rates

B: A unit shock to y_g

Response of interest rates

C: A unit shock to π_g

Response of interest rates

D: A unit shock to Δe

Response of interest rates

E: A unit shock to *tot*

Response of interest rates

Figure 1. Impulse Response Functions of the Interest Rates for Indonesia

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A: A unit shock to Δr

Response of interest rates

B: A unit shock to y_g

Response of interest rates

C: A unit shock to π_g

Response of interest rates

D: A unit shock to Δe

Response of interest rates

E: A unit shock to $\overline{tot}$

Response of interest rates
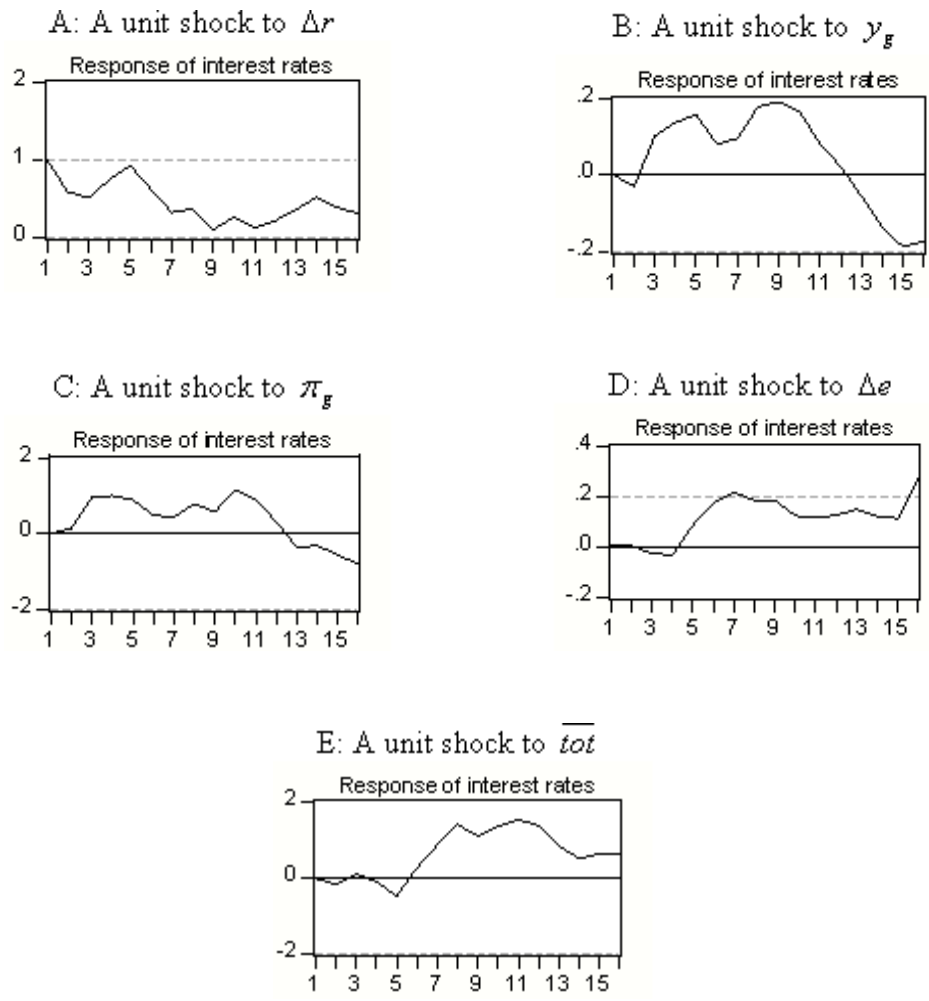
Figure 2. Impulse Responses Function of the Interest Rates for Malaysia

A: A unit shock to Δr

Response of interest rates

B: A unit shock to y_g

Response of interest rates

C: A unit shock to π_g

Response of interest rates

D: A unit shock to Δe

Response of interest rates
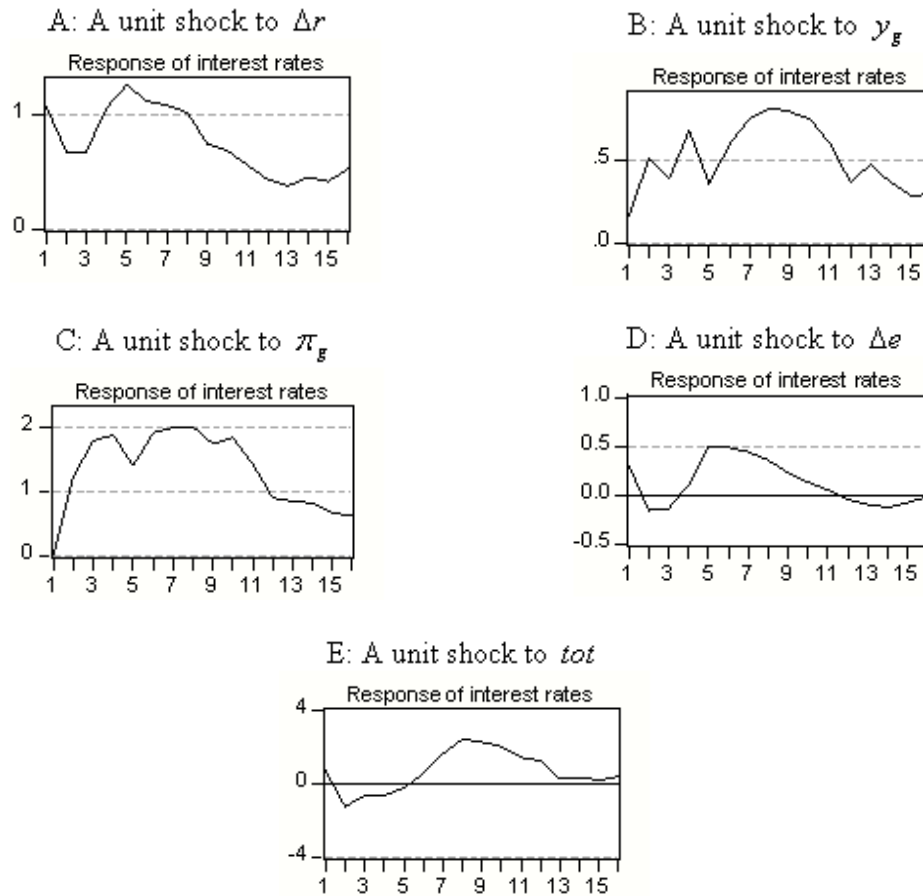
E: A unit shock to *tot*

Response of interest rates

Figure 3. Impulse Response Functions of the Interest Rates for Thailand

CONCLUSION

In determining the monetary policy reaction function, this paper used SVAR modelling, based on the Svensson method, to investigate the importance of external variables (exchange rates and terms of trade) other than monetary objectives (output and inflation) in selected ASEAN-3 economies, namely, Indonesia, Malaysia and Thailand.

The advantage of using the SVAR approach is that restrictions imposed were based on an economic foundation. A number of key results emerged from this approach. First, the results reveal that the selected countries do care about inflation and the output gap. Second, the results suggested that the exchange rates and terms of trade, which have an impact on

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the central banks' actions, are not considered monetary policy objectives in reality. Third, the interest rate is a useful measure of the monetary authorities' counter-cyclical policy.

In conclusion, estimation using the SVAR model is helpful for investigating variables, other than monetary policy objectives, that relate to the response of the central banks to different variable issues. The quarterly Indonesian, Malaysian and Thailand data give clear evidence in favour of our hypotheses.

Further research should incorporate additional explanatory variables into the model. It seems valuable for future research to investigate the same issue using different SVAR models to prove whether or not the present results are generally applicable to other economies. It can also be done for other countries.

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