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Simple Model for a Small Open Economy: An Application to the ASEAN-5 Countries

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Abstract

This paper examines the suitability of a simple structural small open economy model in characterising the economic dynamics in five ASEAN economies. The model is a variant of a small open economy model with imperfect competition and nominal rigidities. It is then confronted to the data using maximum likelihood estimation. The structure of the underlying model is able to produce estimated parameters that largely capture the economic characteristics and dynamics of each of the economies in a plausible manner. It enables one to compare and contrast the behaviour of the five economies under consideration, particularly their monetary transmission mechanism. The estimation results are then used to revisit the structural shocks correlation issue in the region, and can also be used as the basis for constructing the relevant approximation for the aggregate welfare function for each of the economies.

JEL classifications: C13, D58, E12, E17
Keywords: ASEAN, small open economy model, maximum likelihood estimation

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1 Introduction

The optimal use of monetary policy for the management of short term economic fluctuations requires better understanding of how monetary policy works and how its effects are transmitted to the economy. In order to understand the effects of monetary policy, the literature has conventionally resorted to the estimation of economic models to provide a description of how monetary policy works in an economy. However, as traditional macroeconometric models tend to be prone to the Lucas critique Lucas Jr (1976), the literature has moved on to seek better models to guide policy. Ireland (2004a) points out that, from the early 1980s, there are two distinct approaches to macroeconomic analysis that are used as the basis for analysis through till the present: the vector autoregressive (VAR) time-series models, following the seminal contribution by Sims (1980); and the dynamic, stochastic, general equilibrium (DSGE) models, following Kydland and Prescott (1982).

VAR models tend to make relatively little appeal to detailed economic theory. They therefore tend to be a lot more flexible when dealing with data. However, these models often unable to expose the deep parameters in the economy. As a consequence, they may still be subject to the Lucas critique since the parameters underlying the models may not be invariant to changes in the policy regime. DSGE models, on the other hand, are based on the micro foundations in economic theory. They are characterised by the deep parameters of the economy, which (in principle) are supposed to be invariant to changes in policy regime. These models are, therefore, often regarded as useful for conducting analysis of the welfare implications of different alternative policy regimes in an economy. The downside, however, is that they are often regarded as too stylised to be useful for the purpose of empirical testing.[1]

Because of their potential ability to deal with the Lucas critique, attempts to make DSGE type models more realistic empirically have been expanding in the past decade. Most of the earlier efforts have been mainly focused on closed economy models. Efforts to apply the models in an open economy setup have only been developed fairly recently. Although contributions to the empirical estimates of open-economy DSGE models in the literature are still relatively few, they are growing in number. As discussed in Lane (2001), there have been some attempts to match the importance of the relationships emphasised in the theoretical models to the empirical data. In general, there are at least two different avenues that have been pursued in order to do this, that is, through calibration exercises or through econometric investigation.

Calibration exercises are conducted by calibrating the structural model parameters to match the unconditional moments in the observed data.[2] Although useful to gain empirical insights into the structural model, this method is often considered to be insufficient in overall empirical evaluation of this class of model. This assessment follows from the argument that monetary shocks only account for a fraction of the aggregate economic fluctuations captured by the unconditional moments. Hence, the transmission mechanism from monetary policy shocks is biased by noise from other sources.

[1] As initially discussed in Lucas Jr (1980).

[2] See, for example, the discussions provided in Kydland and Prescott (1996).

As an alternative, performance of a structural model can be evaluated in terms of its ability to describe the way an economy responds to a particular set of macroeconomic shocks, that is, by calibrating the structural parameters through minimising the distance between the structural model impulse responses from impulse response functions (IRFs) generated by VAR econometric models. Rotemberg and Woodford (1998) provide relatively detailed discussion of this approach. Other examples of the application of the approach include Christiano et al. (2005) and Amato and Laubach (2003) for the case of the US economy in a closed economy setup; and Lindé et al. (2004) for the case of a small open economy setup in Sweden. Although similar in spirit, this method is seen as an improvement on the calibration method mentioned earlier since the IRFs basically summarise the moments of the data and further decompose them into different noise components. This allows one to focus on specific characteristics in the data. Geweke (1999) calls this method the weak econometric interpretation of a structural model.

Recently, efforts to apply DSGE models directly to the data have been growing. This is done by conducting what Geweke (1999) refers to as the strong econometric interpretation of a structural model. This method applies an econometric technique to estimate the structural parameters directly using data. Examples for this approach can be found in Ireland (2004a), among others, where the structural parameters are estimated using maximum likelihood estimation (MLE); and in Lubik and Schorfheide (2005), where the structural parameters are estimated using the Bayesian method of estimation.[3]

The purpose of this paper is to examine the monetary policy transmission mechanism in the case of five ASEAN economies (Indonesia, Malaysia, the Philippines, Singapore and Thailand). In order to do so, the paper estimates a simple small open economy DSGE model for each of the countries using the MLE approach.

The structural DSGE model used in here closely follows the one derived by Gali and Monacelli (2005). It is a version of a small open economy model that features imperfect competition and nominal price rigidities. In addition, the model considers an incomplete pass-through effect, as suggested by Monacelli (2005), and staggered price setting in the domestic import goods market. The model extends the consumers' behaviour side by considering external habit formation in consumers' utility.[4] These modifications are undertaken to capture richer dynamics in the model in order to make a closer representation of actual data.[5] Lastly, as in most of the literature discussing the New Keynesian small open economy models, the model used also treats the foreign sector as approximately closed since the domestic economy is not considered to be big enough to affect the foreign sector.

The estimation results suggest that the model is able to provide reasonable elaboration of the monetary policy transmission mechanisms for each of the ASEAN-5 economies. The paper also uses the results to revisit the issue of structural shock correlations among the

[3] Examples for the application of the MLE procedure to estimate the structural parameters in DSGE models can also be found in, among others, Soderlind (1999), Ireland (2003, 2004b); while examples for the application of the Bayesian method can be found, among others, in Smets and Wouters (2003), Justiniano and Preston (2004) and Liu (2006).

[4] A similar approach can also be seen in Fuhrer (2000), Christiano et al. (2005), Smets and Wouters (2003), etc.

[5] See (Woodford, 2003, ch.5) for discussions on the issue.

group of countries under consideration. Although the pattern of structural correlations obtained under the model are not as strong as suggested by VAR-based studies for the region, it does not contradict their suggested general conclusions.

The rest of the paper is organised as follows. Section 2 describes the basic structure of the simple small open economy model used to characterise the economies under consideration. Section 3 briefly discusses the empirical strategy to apply the model to the data used in estimating the model. Section 4 presents the estimation results and evaluates the impact of various structural innovations to each of the sample economies. Section 5 revisits the issue of structural shock correlations for the ASEAN-5 economies. Section 6 concludes.

2 A Simple Small Open Economy Model

2.1 Households

The economy is assumed to be inhabited by a continuum of representative households (HH) who seek to maximise:

$$E_t \sum_{T=t}^{\infty} \beta^{T-t} \Upsilon_T \left[U\left(C_{T-t} - H_{T-t}\right) - V\left(N_{T-t}\right) \right] \tag{1}$$

subject to an intertemporal budget constraint, which will be described later in this section. In the above equation, E_t denotes the expectation operator taken at time t, β represents the discount factor and $\Upsilon_t \sim (1,1)$ denotes the random HH preference shock with mean and variance equal to 1.

N_t denotes hours of labour and $V(N_t)$ represents the HH disutility out of working, and is defined as follows:

$$V(N_t) = \frac{N_t^{1+\varphi}}{1+\varphi} \tag{2}$$

where φ is the inverse elasticity of labour supply.

$U(\cdot)$ represents HH utility out of consumption that is assumed to take the form of:

$$U\left(C_t - H_t\right) = \frac{\left(C_t - H_t\right)^{1-\sigma}}{1-\sigma} \tag{3}$$

where σ is the inverse elasticity of intertemporal substitution. C_t is the time t composite consumption index of the representative HH that contain both bundles of domestic and imported goods ($C_{D,t}$ and $C_{F,t}$, respectively) defined by:

$$C_t = \left[(1-\alpha)^{\frac{1}{\eta}} C_{D,t}^{\frac{\eta-1}{\eta}} + \alpha^{\frac{1}{\eta}} C_{F,t}^{\frac{\eta-1}{\eta}} \right]^{\frac{\eta}{\eta-1}} \tag{4}$$

$H_t = hC_{t-1}$ represents an external habit formation of the representative HH that is assumed to be taken exogenously at each time t.[6] Notice that under this specification, α

[6] This treatment follows the treatment used in Smets and Wouters (2003), Justiniano and Preston (2004) and Lindé et al. (2004), among others.

measures the degree of openness of the economy and η is the elasticity of substitution between the two categories of goods.

The aggregate domestic and import consumptions are given by the following CES aggregators of the quantities consumed in each type of good:

$$C_{D,t} = \left(\int_{i=0}^{1} C_{D,t}(i)^{\frac{\varepsilon-1}{\varepsilon}} \partial i\right)^{\frac{\varepsilon}{\varepsilon-1}} \text{ and } C_{F,t} = \left(\int_{i=0}^{1} C_{F,t}(i)^{\frac{\varepsilon-1}{\varepsilon}} \partial i\right)^{\frac{\varepsilon}{\varepsilon-1}} \tag{5}$$

where ε is the elasticity of substitution among goods within each bundle category.

The maximisation of (1) is subject to a sequence of an intertemporal budget constraint:

$$\int_{i=0}^{1} [P_{D,t}(i)C_{D,t}(i) + P_{F,t}(i)C_{F,t}(i)]\partial i + E_t(\xi_{t,t+1}D_{t+1}) \leq W_t N_t + D_t + \tau_t \tag{6}$$

where P denotes the price of each good; D_{t+1} is the time $t+1$ nominal pay-off of the portfolio held at the end of period t; W_t is the nominal wage; τ denotes lump sum taxes or transfers; and $\xi_{t,t+1}$ denotes the stochastic discount factor for nominal pay-off ($E_t(\xi_{t,t+1}) = R_t^{-1}$, where R is the gross return). Throughout the model, the representative HH are assumed to have access to a complete set of contingent claims, traded internationally. Further, the model specifies monetary policy in terms of an interest rate rule rather than a money rule. Therefore money is not explicitly introduced in the model and can be thought as only playing the role of a unit of account.

Under this specification, HH optimal allocation of expenditures within each category of goods yields demand functions:

$$C_{D,t}\ (i) = \left(\frac{P_{D,t}(i)}{P_{D,t}}\right)^{-\varepsilon} C_{D,t} \text{ and } C_{F,t}\ (i) = \left(\frac{P_{F,t}(i)}{P_{F,t}}\right)^{-\varepsilon} C_{F,t}; \forall\ i \in [0,1] \tag{7}$$

Equation (7) implies the price indices for domestic and imported goods as follows: $P_{D,t} = \left(\int_{i=0}^{1} P_{D,t}(i)^{1-\varepsilon}\partial i\right)^{\frac{1}{1-\varepsilon}}$ and $P_{F,t} = \left(\int_{i=0}^{1} P_{F,t}(i)^{1-\varepsilon}\partial i\right)^{\frac{1}{1-\varepsilon}}$. The optimal allocation between domestic and imported goods yields the aggregated demand function for each category of goods as follows:

$$C_{D,t}\ = (1-\alpha)\left(\frac{P_{D,t}}{P_t}\right)^{-\eta} C_t \text{ and } C_{F,t}\ = \alpha\left(\frac{P_{F,t}}{P_t}\right)^{-\eta} C_t \tag{8}$$

The above equation implies $P_t = \left[(1-\alpha)P_{D.t}^{1-\eta} + \alpha P_{F,t}^{1-\eta}\right]^{\frac{1}{1-\eta}}$, where P_t is the consumer price index (CPI) at each period t.

Given the above optimality conditions in (7) and (8), the representative HH intertemporal budget constraint can be rewritten as:

$$P_t C_t + E_t(\xi_{t,t+1}D_{t+1}) \leq W_t N_t + D_t + \tau_t \tag{9}$$

It follows that the representative HH problem now is to maximise (1) subject to (9). The resulting first order necessary conditions (FONCs) can be rearranged as follows:

$$\frac{N_t^{\varphi}}{(C_t - hC_{t-1})^{-\sigma}} = \frac{W_t}{P_t} \tag{10}$$

and,

$$\beta R_t E_t \left[\frac{\Upsilon_{t+1}}{\Upsilon_t} \left(\frac{C_{t+1} - hC_t}{C_t - hC_{t-1}} \right)^{-\sigma} \frac{P_t}{P_{t+1}} \right] = 1 \tag{11}$$

where (10) represents the standard intra-temporal optimality conditions for HH labour-leisure choice, and (11) denotes the stochastic Euler equation.

2.2 Domestic inflation, real exchange rate and the terms of trade

Domestic inflation is characterised by the domestic CPI inflation, which in its log-linearisation around its steady state takes the form of:

$$p_t = (1 - \alpha)p_{D,t} + \alpha p_{F,t} \tag{12}$$

where small caps denote the log difference of a variable from its steady state value. Given that the log value of domestic terms of trade is defined as $s_t = p_{F,t} - p_{D,t}$,[7] equation (12) can also be written as $p_t = p_{D,t} + \alpha s_t$. It follows that the domestic inflation ($\pi_t = p_t - p_{t-1}$) can be written as follows:

$$\begin{aligned} \pi_t &= (1 - \alpha)\pi_{D,t} + \alpha \pi_{F,t} \\ &= \pi_{D,t} + \alpha \Delta s_t \end{aligned} \tag{13}$$

The above equation shows that the more open the economy is, the bigger the impact of changes in the domestic terms of trade on the domestic CPI inflation.

The real exchange rate (Q_t) is defined as a ratio between the international prices in terms of domestic currency and the domestic prices $\left(\frac{\varepsilon_t P_t^*}{P_t}\right)$. It follows that the log deviation from the steady state value of Q_t can be written as $q_t = e_t + p_t^* - p_t$, where e denotes the nominal exchange rate and p^* denotes the international prices. In an environment where an incomplete pass-through effect is possible, $e_t + p_t^*$ does not necessarily have to be equal to $p_{F,t}$, i.e. $e_t + p_t^* - p_{F,t} = \psi_t$. The term ψ in the last expression denotes the deviation from the law of one price, in which domestic import price deviates from the domestic value of the international price. Under this set up, q_t can be rewritten as:

$$q_t = (1 - \alpha)s_t + \psi_t \tag{14}$$

The above relationship is derived by substituting equation (12) into the real exchange rate identity. It follows that there are two sources of deviation from aggregate purchasing power parity (PPP) in this framework; namely, the heterogeneity of the consumption basket between the small open economy and the rest of the world, and the deviation from

[7] The term 'domestic' here is included to accomodate the assumed incompleteness in the pass-through effect in the economy. In this case, $p_{F,t} \neq e_t + p_t^*$, where e denotes the nominal exchange rate and p^* denotes international prices, Monacelli (2005)

the law of one price.

2.3 International risk sharing and uncovered interest parity

Under the assumption of a complete international financial market and perfect capital mobility, the expected nominal return from risk free assets must equal the expected domestic currency return from foreign assets. This assumed existence of a complete contingent claims market has implications for an international consumption risk sharing. In equilibrium, movements in the ratio of domestic to foreign marginal utility in consumption must imply a proportional movement in the real exchange rate. Following the arguments in Chari et al. (2002) and Gali and Monacelli (2005), the complete markets assumption and the HH Euler equations in both domestic and foreign economies imply:

$$(C_t - hC_{t-1}) = K\left(C_t^* - hC_{t-1}^*\right) Q_t^{\frac{1}{\sigma}} \tag{15}$$

or, in its log linear approximation form:

$$c_t - hc_{t-1} = y_t^* - hy_{t-1}^* + \frac{(1-h)}{\sigma} q_t + v_t^q \tag{16}$$

Where v_t^q can be interpreted as a shock to the risk premium, and the foreign sector output, $y_t^* = c_t^*$.[8] Note also that the relationship contains both the contemporaneous relationship as well as the effect from including external habit formation in the HH preference structure.

The above assumption also helps to recover the uncovered interest parity (UIP) condition that relates domestic and foreign interest rates. By combining the efficiency conditions for optimal portfolio holdings of both the domestic and foreign sectors, equation (15) can be rewritten as:

$$\frac{\epsilon_{t+1}}{\epsilon_t} = \frac{(1+i_t)}{(1+i_t^*)} \tag{17}$$

or, in its log-linear approximation form

$$i_t - i_t^* = E_t\left(\Delta e_{t+1}\right) \tag{18}$$

2.4 Domestic firms and optimal price setting

2.4.1 Domestic firm technology

There is a continuum of identical monopolistically competitive firms in the economy indexed by $i \in [0,1]$. Each firm produces differentiated outputs (Y) with a representative production function as follows:

$$Y_t(i) = B_t N_t(i) \tag{19}$$

where $b_t = \ln(B_t)$ is the productivity shock that is assumed to follow an AR(1) process $b_t = \rho_b b_{t-1} + v_t^b$, where $v_t^b \sim (0, \sigma_{v^b}^2)$. Let $Y_t \equiv \left[\int_{i=0}^1 Y_t(i)^{\frac{\varepsilon-1}{\varepsilon}} \partial i\right]^{\frac{\varepsilon}{\varepsilon-1}}$ represent the aggregate output. Then integrating the labour employed in each firm will produce: $\int_{i=0}^1 N_t(i) = N_t =$

[8] The last relationship uses the fact that the foreign sector is approximately closed in structure so that in equilibrium $y_t^* = c_t^*$.

$\frac{Y_t}{B_t}$.

The real total costs (TC) faced by firms are $TC_t = \frac{W_t}{P_{D,t}} N_t = \frac{W_t Y_t}{P_{D,t} B_t}$ after substituting N_t by (19). Therefore, the marginal cost is $MC_t = \frac{W_t}{P_{D,t} B_t}$. Then, the log-linear approximation of the marginal costs can be written as:

$$\begin{aligned} mc_t &= w_t - p_{D,t} - b_t \\ &= w_t - [(1-\alpha) p_{D,t} + \alpha p_{F,t}] + \alpha (p_{F,t} - p_{D,t}) - b_t \\ &= w_t - p_t + \frac{\alpha}{1-\alpha} (q_t - \psi_t) - b_t \end{aligned} \tag{20}$$

The third line in the above equation is obtained by using (12), the definition for the domestic terms of trade (s) and (14).

Recall that the log-linear approximation of (10) states that $w_t - p_t = \varphi n_t + \frac{\sigma}{1-h}(c_t - hc_{t-1})$. Therefore, by employing the log-linear version of (19) to substitute for n_t, (20) can also be expressed as

$$mc_t = \varphi y_t + \frac{\sigma}{1-h}(c_t - hc_{t-1}) + \frac{\alpha}{1-\alpha}(q_t - \psi_t) - (1+\varphi) b_t \tag{21}$$

2.4.2 Optimal price setting mechanism

Both domestic producers and importers are assumed to set prices in a staggered fashion following Calvo (1983). Hence, within any period t, there is a fraction $(1-\theta_j)$ of firms that reset their price optimally ($j = D, F$), while the remainder $0 \leq \theta_j \leq 1$ does not. The fraction of firms that does not reset prices is assumed to adjust price by indexing it to the last period domestic CPI inflation as follows:

$$p_{j,t}(i) = p_{j,t-1}(i) + \delta \pi_{t-1} \tag{22}$$

where $\delta \in [0,1]$ represents the degree of price indexation to the previous period's inflation rate. Since each firm has the opportunity to reset its price optimally in some period t, every firm faces the same decision problem, hence setting a common optimal price $P_{j,t}^{new}(i) = P_{j,t}^{new}$. The aggregate price index in sector j evolves according to the following equation:

$$P_{j,t} = \left\{ (1-\theta_j) P_{j,t}^{new(1-\varepsilon)} + \theta_j \left[P_{j,t-1} \left(\frac{P_{t-1}}{P_{t-2}} \right)^{\delta} \right]^{1-\varepsilon} \right\}^{\frac{1}{1-\varepsilon}} \tag{23}$$

For a firm producing domestically, the price setting problem when it wants to reoptimise its price in some period t would be to maximise its expected present discounted value of profits with respect to $P_{D,t}^{new}$ if it was unable to reoptimise in the future:

$$\max_{P_{D,t}^{new}} \sum_{T=t}^{\infty} (\beta\theta_D)^{T-t} E_t \left\{ \xi_{t,T} \left[Y_T(i) \left(P_{D,t}^{new} \left(\frac{P_{T-1}}{P_{t-1}} \right)^{\delta} - P_{D,T} MC_T \right) \right] \right\} \tag{24}$$

subject to the sequence of demand constraints:

$$Y_T(i) = \left[\frac{P_{D,t}^{new}}{P_{D,T}} \left(\frac{P_{T-1}}{P_{t-1}} \right)^{\delta} \right]^{-\varepsilon} Y_T \tag{25}$$

The corresponding FONC of the above problem could be written as:

$$\begin{aligned} & \sum_{T=t}^{\infty} (\beta\theta_D)^{T-t} E_t \left\{ \xi_{t,T} Y_T \left[P_{D,t}^{new} \left(\frac{P_{D,t}^{new}}{P_{D,T}} \right)^{-\varepsilon} \left(\frac{P_{T-1}}{P_{t-1}} \right)^{\delta(1-\varepsilon)} \right] \right\} \\ = & \sum_{T=t}^{\infty} (\beta\theta_D)^{T-t} E_t \left\{ \xi_{t,T} Y_T \left[\frac{\varepsilon}{\varepsilon - 1} \left(\frac{P_{D,t}^{new}}{P_{D,T}} \right)^{-\varepsilon} \left(\frac{P_{T-1}}{P_{t-1}} \right)^{-\delta\varepsilon} P_{D,T} MC_T \right] \right\} \end{aligned} \tag{26}$$

By taking the condition that in the steady state $\xi_{t,t} = \xi = 1$; $P_D^{new} = P_D$ and $MC = \frac{\varepsilon-1}{\varepsilon}$,[9] the first order log-linear approximation of the above equation can be written as:

$$p_{D,t}^{new} = (1 - \beta\theta_D) \sum_{T=t}^{\infty} (\beta\theta_D)^{T-t} E_t \left[p_{D,T} + mc_T - \delta \left(p_{T-1} - p_{t-1} \right) \right]$$

or,

$$p_{D,t}^{new} = (1 - \beta\theta_D) \left(p_{D,t} + mc_t \right) + \beta\theta_D \left[E_t \left(p_{D,t+1}^{new} \right) - \delta\pi_t \right] \tag{27}$$

Substituting (27) into the log-linearised approximation of the Calvo pricing equation for domestic producing firms:

$$p_{D,t} = (1 - \theta_D) \, p_{D,t}^{new} + \theta_D \left(p_{D,t-1} + \delta\pi_{t-1} \right) \tag{28}$$

we can work out the equation that governs the development of the domestic price inflation:

$$\pi_{D,t} = \frac{1}{1 + \beta\delta} \left[\beta E_t \left(\pi_{D,t+1} \right) + \delta\pi_{t-1} + \frac{(1 - \theta_D)(1 - \beta\theta_D)}{\theta_D} mc_t \right] \tag{29}$$

Similarly, the optimal price setting problem for the domestic importing firms could be solved to derive the import price inflation as follows:

$$\pi_{F,t} = \frac{1}{1 + \beta\delta} \left[\beta E_t \left(\pi_{F,t+1} \right) + \delta\pi_{t-1} + \frac{(1 - \theta_F)(1 - \beta\theta_F)}{\theta_F} \psi_t \right] \tag{30}$$

where ψ_t is the marginal cost faced by the firms in this category. The last two equations above show that, for both domestic and imported goods, inflation is governed by expected future inflation, the last period CPI inflation (due to price indexation), and their respective marginal costs – which in the case of importing firms is simply the difference between the domestic imported price and the world price.

As discussed earlier, domestic CPI inflation is a weighted sum of inflation for both domestic and imported goods. Therefore, by substituting (29) and (30) in to (13), the domestic

[9] Variables without time subscript denote their steady state values.

CPI inflation can be expressed as the following:

$$\begin{aligned}\pi_t &= (1-\alpha)\left[\beta E_t(\pi_{D,t+1}) + \frac{(1-\theta_D)(1-\beta\theta_D)}{\theta_D} mc_t - \beta\delta\pi_t + \delta\pi_{t-1}\right] \\ &\quad +\alpha\left[\beta E_t(\pi_{F,t+1}) + \frac{(1-\theta_F)(1-\beta\theta_F)}{\theta_F}\psi_t - \beta\delta\pi_t + \delta\pi_{t-1}\right]\end{aligned}$$

or,

$$\pi_t = \frac{1}{1+\beta\delta}\left[\beta E_t(\pi_{t+1}) + \delta\pi_{t-1} + (1-\alpha)\Gamma_D mc_t + \alpha\Gamma_F\psi_t\right] \tag{31}$$

where $\Gamma_D = \frac{(1-\theta_D)(1-\beta\theta_D)}{\theta_D}$ and $\Gamma_F = \frac{(1-\theta_F)(1-\beta\theta_F)}{\theta_F}$.

2.5 Market clearing condition

In equilibrium, domestic output is being cleared out by both domestic consumption and export of domestic goods consumed by the foreign sector $(C^*_{D,t})$, i.e:

$$Y_t = C_{D,t} + C^*_{D,t} \tag{32}$$

Using both domestic and foreign demand for domestic goods described in (8), the above can be rewritten as:

$$Y_t = (1-\alpha)\left(\frac{P_{D,t}}{P_t}\right)^{-\eta} C_t + \alpha^*\left(\frac{P_{D,t}}{\varepsilon_t P^*_t}\right)^{-\eta} Y^*_t \tag{33}$$

or, in its log-linear approximation

$$y_t = (1-\alpha)c_{D,t} + \alpha c^*_{D,t} \tag{34}$$

where, $c_{D,t} = -\eta(p_{D,t} - p_t) + c_t$ and $c^*_{D,t} = -\eta(p_{D,t} - e_t - p^*_t) + c^*_t$.

By applying (12), the log-linear approximation of both the definition for domestic terms of trade (s) and real exchange rate (q), as well as (14), (34) can also be written as

$$y_t = (1-\alpha)c_t + \alpha y^*_t + \frac{(2-\alpha)\alpha\eta}{1-\alpha}q_t - \frac{\alpha\eta}{1-\alpha}\psi_t \tag{35}$$

where the demand for domestic output is affected positively by domestic consumption, foreign income and real exchange rate; and negatively related to the deviations from the law of one price.

2.6 The monetary sector

The monetary sector in this economy is represented by a policy rule function, which specifies the monetary policy regime for the economy. Conditional on the evolution of the world economy and other exogenous disturbances, the monetary policy rule will also act as a closure for the model in general. In particular, the policy rule is specified to follow a Taylor type rule:

$$i_t = (1-\rho_i)(\kappa_1 E_t\pi_{t+n} + \kappa_2 y_t) + \rho_i i_{t-1} + \upsilon^i_t \tag{36}$$

where υ_t^i is added to represent a possible unexpected monetary policy innovation in the economy. Notice also that the Taylor-type specification above includes a lagged endogenous term. This is done to capture the possible degree of persistence in the interest rate movement to avoid loss of credibility from impulsive large changes in the interest rate.

2.7 Specifying the foreign sector

Since a primary objective of the model is to analyse how a small open economy works, and since the foreign economy is treated as exogenous to the domestic economy, there is some flexibility in specifying the data generating process for the foreign variables. For the sake of convenience, rather than using a structural model, a stylised model for the rest of the world is employed to specify the determination of foreign variables. The path of those variables is assumed to be determined by an unrestricted vector auto regressions (VAR). The reduced form of the foreign sector data generating process is as follows:

$$\mathbf{x}_t^* = \mathbf{A}(L)\,\mathbf{x}_{t-1}^* + \boldsymbol{\upsilon}_t^* \tag{37}$$

where $\mathbf{x}_t^* = \left[y_t^* \quad \left(i_t^* - E_t\pi_{t+1}^*\right)\right]'$, $\mathbf{A}(L)$ is a matrix of coefficients with an appropriate dimension and $\boldsymbol{\upsilon}_t^*$ is a vector of error with the usual properties.

3 Empirical Analysis and Data

3.1 Log-linear approximation of the model

This section summarises the log-linear equilibrium conditions employed for the estimation. The equation for consumption is given by log-linearizing (11) around its non-stochastic steady state value.

$$c_t = \frac{1}{1+h}E_t c_{t+1} + \frac{h}{1+h}c_{t-1} - \frac{(1-h)}{(1+h)\,\sigma}\left(i_t - E_t\pi_{t+1}\right) + \upsilon_t^c \tag{38}$$

where υ_t^c is a random preference shock with mean zero and variance $\sigma_{\upsilon^c}^2$. The real interest rate elasticity of consumption is negatively affected by both the intertemporal elasticity of substitution (σ) and the external habit persistence parameter (h). That is, given σ, a higher degree of habit persistence (h) in this case will tend to lower the impact of real interest rate on consumption.

Movements in nominal interest rate are governed by the interest rate reaction function in (36). Domestic output is determined by the goods market clearing condition (35), and movements in real exchange rate are governed by the international consumption risk sharing mechanism (16).

Domestic CPI inflation, which is given by (31), depends on both expected future and past inflation, as well as the current marginal cost faced by both domestic producers (mc_t) and import retailers (ψ_t). mc is given by (21) and ψ is calculated based on the definition in (14). For the purpose of estimation, ψ is treated as exogenous and is assumed to follow an AR(1) process $\psi_t = \rho_\psi \psi_{t-1} + \upsilon_t^\psi$, where $\upsilon_t^\psi \sim (0, \sigma_{\upsilon^\psi}^2)$.

To complete the system, the external sector is represented by (37) as explained in section 2.7.

$$\begin{bmatrix} y_t^* \\ r_t^* \end{bmatrix} = \begin{bmatrix} \phi_1 & \phi_2 \\ \phi_3 & \phi_4 \end{bmatrix} \begin{bmatrix} y_{t-1}^* \\ r_{t-1}^* \end{bmatrix} + \begin{bmatrix} \upsilon_t^{y^*} \\ \upsilon_t^{r^*} \end{bmatrix} \tag{39}$$

3.2 Estimation strategy

The complete representation of the system to be estimated, consisting of ten equations in ten variables $(c, i, y, q, \pi, mc, \psi, b, y^*, r^*)$, is outlined in Appendix A. The approximate solution to this linear system of the model can be obtained by applying the methods of Blanchard and Kahn (1980). The solution takes the form of state space representation of a dynamic system as follows:

$$\mathbf{s}_{t+1} = \mathbf{\Pi s}_t + \mathbf{W}\boldsymbol{\varepsilon}_{t+1} \tag{40}$$

and,

$$\mathbf{f}_t = \mathbf{Us}_t \tag{41}$$

where,

$$\begin{aligned} \mathbf{s}_t &= \begin{bmatrix} \pi_{t-1} & c_{t-1} & i_{t-1} & y_{t-1}^* & r_{t-1}^* & b_t & \upsilon_t^c & \upsilon_t^q & \upsilon_t^i & \psi_t & \upsilon_t^{y^*} & \upsilon_t^{r^*} \end{bmatrix}' \\ \mathbf{f}_t &= \begin{bmatrix} mc_t & y_t & q_t & y_t^* & r_t^* & \pi_t & c_t \end{bmatrix}' \\ \boldsymbol{\varepsilon}_t &= \begin{bmatrix} \upsilon_t^b & \upsilon_t^c & \upsilon_t^q & \upsilon_t^i & \upsilon_t^\psi & \upsilon_t^{y^*} & \upsilon_t^{r^*} \end{bmatrix}' \end{aligned}$$

and $\mathbf{\Pi}, \mathbf{W}$ and $\mathbf{U}$ are the conformable matrices of coefficients derived from the model.[10]

Given the above state-space representation, parameters in the model can be estimated using the maximum likelihood estimation as described in (Hamilton, 1994, chapter 13). The estimation is conducted using data on seven observable variables ($\pi, y, i, q, \psi, y^*$and r^*), while leaving the other three variables (mc, c and b) to be endogenously determined in the system.[11] In order to produce the results, data are de-meaned before initiating the maximum likelihood procedure.

3.3 Data

Quarterly data from 1989 to 2004 for the five ASEAN nations are used for the purpose of analysing the small open economy model.[12] The data are mostly collected from the CEIC Asia database except for the TWI of exchange rate data for Singapore, Malaysia and the Philippines, which are taken from the IMF estimates in the International Financial Statistics (IFS) data base. For the purpose of analysing the small open economy model, real exchange rates for Indonesia and Thailand are calculated by multiplying their nominal exchange rate data with the ratio between the US and domestic price indices. The foreign

[10]The solution here is obtained following the procedure proposed by Ireland (2004a).

[11]To conduct the maximum likelihood estimation of the model's parameters, I use the maximum likelihood routines provided in *Dynare* version 3.065. The optimizer used for the mode of computation is the fminunc routine in MATLAB.

[12]An exception applies to the cases of Malaysia and Thailand due to a data availability issue. Data for Malaysia start from 1991 and data for Thailand start from 1993.

sector in the empirical analysis is represented by the US economy, in which its quarterly data for the relevant years are collected from the IFS data base.

In this section, particular attention is paid to the construction of the approximate measure for the deviation from the law of one price (ψ). As shown in (14), this measure is defined as the difference between real exchange rate (q) and the product of the degree of home biasedness ($1-\alpha$) and the domestic terms of trade (s).

Unfortunately, precise data on domestic and imported price level (P_D and P_F) for the countries under consideration are not readily available. To deal with this issue, P_F is approximated by a relevant index of import prices, calculated as the ratio between the nominal and the constant price import data for each of the countries obtained from the CEIC database. Relation (12) is then employed in order to get an approximation for P_D. The degree of openness (α) used to derive P_D is approximated by an average of import share in the Gross Domestic Product (GDP). In order to get a more sensible magnitude, in the case of Singapore and Malaysia, α is adjusted. In the case of Singapore, α is defined as the ratio between non re-exported imports over GDP, while for the case of Malaysia it is defined as the ratio between the sum of consumption and intermediate imports over GDP.[13] Approximate values of α for each country within the group are assumed to be constant over the sample period under consideration and shown in Table 1.

Table 1: Approximate values for the degree of openness

Country	α
Indonesia	0.30
Malaysia	0.65
Philippines	0.49
Singapore	0.80
Thailand	0.48

Table 1 suggests that, in terms of economic openness, Singapore is the most open one and Indonesia is the least open within the group of countries considered in this study. The series of ψ for each of the countries are then derived using the values of α reported in Table 1 and the relationships mentioned above.

4 Estimation Results

In order to produce the results, parameter estimations for each of the individual countries were conducted by imposing several assumptions. First, parameters in the monetary policy reaction function in each country are assumed to be fixed following the estimates for each of the five economies under consideration as provided in Ramayandi (2007).[14] Second, since the foreign sector is exogenous with respect to the domestic economy, its

[13] Information obtained from the Economic Survey of Singapore 1995; 2000; 2006 and the Annual Report of the Bank Negara Malaysia 1991; 1992; 1994; 2001; 2003 are used to calculate the relevant import share.

[14] An exception applies for the case of the Philippines, where the previous GMM estimate for its policy reaction function parameters fail to satisfy the Blanchard and Kahn conditions for the stability of the model. In this case, parameters for the policy reaction function are re-estimated together with the rest of the structural parameters in the system.

VAR(1,1) representation is estimated separately. Therefore, parameters representing the foreign sector in the system are pre-fixed when estimating the rest of the parameters in the system. Parameters for the foreign sector block are reported in Appendix B. Third, coefficients for the degree of openness (α) and the discount factor (β) are also exogenously fixed.[15] Values for α are as reported in Table 1. Values for β are calculated as $(1+\bar{\imath})^{-0.25}$, where $\bar{\imath}$ (the long-run equilibrium rate of interest) is approximated by the average interest rate over the chosen sample. Table 2 reports the approximate values for β.

Table 2: Approximate values for the discount factor

Country	β
Indonesia	0.963
Malaysia	0.988
Philippines	0.972
Singapore	0.992
Thailand	0.984

4.1 Parameter estimates

Table 3 provides a summary of the estimation results for each of the five economies under consideration.

Table 3: Estimated parameters

Para	Indonesia		Malaysia		Philippines		Singapore		Thailand	
meter	Est.	se	Est.	se	Est.	se	Est.	se	Est.	se
δ	0.92	(0.10)	0.49	(0.21)	0.49	(0.10)	0.61	(0.13)	0.65	(0.43)
σ	0.86	(0.19)	0.32	(0.06)	0.09	(0.21)	0.17	(0.02)	0.74	(1.78)
θ_D	0.92	(0.01)	0.82	(0.03)	0.76	(0.00)	0.83	(0.14)	0.94	(0.02)
θ_F	0.91	(0.06)	0.89	(0.15)	0.77	(0.01)	0.89	(0.10)	0.98	(0.06)
φ	1.99	(0.55)	1.99	(0.46)	1.00	(1.83)	4.79	(12.65)	1.49	(0.42)
η	0.003	(0.07)	0.39	(0.08)	0.08	(0.03)	0.29	(0.04)	0.43	(0.26)
h	0.77	(0.06)	0.55	(0.13)	0.97	(0.08)	0.25	(0.07)	0.81	(0.04)
ρ_ψ	0.99	(0.01)	0.99	(0.01)	0.88	(0.06)	0.99	(0.01)	0.85	(0.11)
ρ_b	0.61	(0.06)	0.81	(0.02)	0.89	(0.05)	0.91	(0.09)	0.60	(0.39)
ρ_i	0.54	–	0.69	–	0.55	(0.09)	0.85	–	0.70	–
κ_1	1.15	–	1.66	–	0.72	(0.14)	1.27	–	2.65	–
κ_2	0.00	–	0.19	–	1.60	(0.39)	0.94	–	0.00	–
σ_b	0.46	(0.08)	0.16	(0.02)	0.01	(0.01)	0.01	(0.01)	0.37	(0.05)
σ_c	0.03	(0.003)	0.05	(0.01)	0.02	(0.002)	0.12	(0.02)	0.05	(0.03)
σ_i	0.035	–	0.07	–	0.02	(0.002)	0.006	–	0.016	–
σ_ψ	0.08	(0.01)	0.06	(0.01)	0.10	(0.01)	0.03	(0.002)	0.07	(0.02)
σ_q	0.09	(0.02)	0.10	(0.02)	0.05	(0.01)	0.14	(0.02)	0.11	(0.09)

Parameters obtained from the estimation lie within the commonly accepted range of plausible values in the literature.[16] Overall, the empirical exercise suggests that the estimated

[15] This assumption is made following common practice in the literature, e.g. Christiano et al. (2005), Smets and Wouters (2003), Laxton and Pesenti (2003), etc. Moreover, α is also fixed in this analysis due to its role in generating the series for ψ.

[16] See, for example, the prior set for an empirical estimation conducted using the Bayesian approach in Smets and Wouters (2003), Lubik and Schorfheide (2005), Justiniano and Preston (2004) and Kam et al. (2006).

parameters, despite of a few that are found to be noisy, are significantly different from zero in terms of magnitude. The estimation also produces series of smoothed shocks to each of the economies as plotted in Appendix C.

The degree of price indexation (δ) is relatively similar for the cases of Malaysia, the Philippines, Singapore and Thailand (around the value of 0.5 and 0.65), where the last two countries tend to be indexing more heavily relative to the earlier two. The estimate for Indonesia stands out from the group with a value a little over 0.9, suggesting that the non re-optimising firms are adjusting their price by indexing very heavily to the last period inflation.

The degree of Calvo price stickiness for prices of domestic goods (θ_D) and imported goods (θ_F) indicates different average duration in the implicit price contracts across the group of countries.[17] The average duration of implicit price contracts for domestic goods ranges from around 1 year in the case of the Philippines to around 4 years in the case of Thailand. The average duration for Malaysia, Singapore and Indonesia falls in between the two; with around 1.5 years for both Malaysia and Singapore; and around 3 years for Indonesia. The order in terms of average duration in the implicit price contracts for the case of imported goods remains similar to the one in the case of domestic goods prices. That is, around 1 year for the Philippines, around 2 and a quarter years for Malaysia and Singapore, around 2 and 3 quarter years for Indonesia, and tends to be a lot more persistent in the case of Thailand.

The estimate for inverse elasticity of labour supply (φ) turns out to be equal to 1 or above in all cases. This suggests that a percentage change in nominal wage will tend to induce a less than proportional change in labour supply. The Philippines data suggests the lowest value of 1 (in which case changes in labour supply tend to be proportional to changes in wage rate), and Singapore's data suggests the highest (4.79). Unlike the other cases, however, both the estimates for Singapore and the Philippines are found to be noisy.

The elasticity of substitution between home and imported goods (η) is found to be relatively small in all cases. This suggests that the degree of substitutability between home and imported consumption goods is relatively small, with the smallest degree of substitutability found in the case of the Philippines and Indonesia. In interpreting this degree of substitutability between home and imported goods, it is useful to note that the domestically produced consumption goods also comprise the non-tradables. Therefore, a low elasticity of substitution between the two categories of goods makes sense.

The point estimate for the degree of habit persistence (h) varies quite widely among the group. External habit formation over past consumption is estimated to range from 0.25 in the case of Singapore to 0.97 in the case of the Philippines. The point estimate of the inverse elasticity of inter-temporal substitution (σ) also varies quite widely among the group (see Table 3). Smaller values of σ imply that households are less willing to accept deviations from a uniform pattern of consumption over time. Both the estimate of h and σ are informative to the interest elasticity of consumption in the model. For any given value of σ, higher values of h penalise the impact of the real rate of interest on

[17] The average duration of price contracts is calculated as $\frac{1}{1-\theta_j}; j = D, F$.

consumption. All else equal, a percentage point increase in the real interest rate reduces the impact on consumption by about 0.15, 0.9, 0.17, 3.5 and 0.14 percentage points for the cases of Indonesia, Malaysia, the Philippines, Singapore and Thailand respectively. Consumption appears more sensitive to real interest rate changes in both Singapore and Malaysia, relative to Indonesia, the Philippines and Thailand. This observation seems consistent with the different degrees of financial market development in these countries.

Movements of nominal interest rate in the model are assumed to be governed by the likely historical conduct of monetary policy in each country, approximated by the relevant policy reaction function. Parameters for the policy reaction function of each of the economies are reported in Table 3 as ρ_i, κ_1 and κ_2 (taken from the result of GMM estimation exercise conducted for each country). As discussed earlier, the parameters for the Philippines are re-estimated together with the rest of the other structural parameters in the model. Interestingly, most of the values for the policy reaction function parameters turn out to be much the same as the values obtained from a single equation GMM exercise (that is, 0.55 for ρ_i and 0.72 for κ_1). κ_2 turns out to be the only exception (1.6 relative to 1.22 obtained from the GMM exercise). The higher value obtained in this case turns out to be sufficient to satisfy the Blanchard and Kahn condition for stability of the model.

Estimates for ρ_ψ and ρ_b suggest that the exogenous productivity and deviation from the law of one price shock in the model are persistent. The degree of persistence in ψ is very high, especially for the case of Indonesia, Malaysia and Singapore. The degree of persistence in b tends to be relatively lower, where the lowest is commonly shared by Indonesia and Thailand (around 0.6). This last observation is also accompanied by a relatively high standard deviation for the innovation in productivity shock (σ_b) for the two countries. The high σ_b for the two economies arises because of the relatively large spikes around the Asian financial crisis period in both Thailand and Indonesia.[18] The relatively short duration of the spikes contributes to the relatively lower persistence of the series. Additionally, the spikes also justify the occurrence of a break in the potential output of the two countries.

4.2 Impulse responses and variance decomposition

This section uses the estimated model to analyse the impulse responses to various structural shocks and the contribution of these various structural shocks to the variance in the forecast error of the endogenous variables at various time horizons. Both the impulse responses and the variance decompositions reported in this section are produced based on the monetary policy reaction function employed in the estimation. The resulting plots and tables for the impulse responses and the variance decomposition, respectively, are constructed based on a standard deviation of innovation in each of the structural shocks.

4.2.1 Impulse response analysis

Appendix D plots the complete set of the impulse responses for each of the economies given a temporary one standard deviation innovation in the structural shocks. Figures 6

[18] See Figures 1 and 5 in Appendix C

to 10 plot the impulse responses to a productivity shock for each of the economies in the group. Following a one time positive innovation of this shock, the group shares a generally similar inverted hump-shaped impact on inflation. Inflation initially falls, reaching its trough after two or three quarters before reverting to its steady state value. The period needed to revert to steady state, however, slightly differs. Indonesia and Thailand have a duration of around 10 quarters, Malaysia takes around 20 quarters, while the Philippines and Singapore show a more persistent impact by taking slightly more than 30 quarters. The initial drop in inflation results from a fall in marginal cost following an increase in productivity.

Given the monetary policy reaction function, monetary authorities react by reducing their nominal rate. This move, together with changes in inflation expectation, affects consumption. The impact on consumption varies among the sample countries. In Indonesia, Malaysia and Thailand, consumption increases in a hump-shaped manner for about five to six years following a temporary increase in productivity, reaching its peak after a little over a year before closing back in to its stationary value. In the Philippines and Singapore, consumption initially falls. In the former case consumption reverts to its steady state value within about 5 years, whereas in the latter it increases after 3 quarters before reverting to its steady state value within about seven years. Under the assumed monetary policy reaction function, nominal interest rate reduction in Indonesia, Malaysia and Thailand is higher than the drop in their expected inflation. As a result, the real rate of interest falls initially and consumption rises. In the case of the Philippines and Singapore, the real interest rate initially went up, hence tends to suppress consumption.

The impact of productivity shocks on the real exchange rate also varies. Due to the fall in the real interest rate, the real exchange rate in Indonesia, Malaysia and Thailand depreciates, reaching a peak after a couple of quarters, then reverting to its steady state value. In the case of Singapore and the Philippines, an initial increase in the real interest rate leads to an appreciation of the real exchange rate initially before it starts to depreciate a couple of quarters later. In other words, given a positive innovation in productivity, the short run appreciation in the nominal exchange rate is outweighed by a drop in prices in the cases of Indonesia, Malaysia and Thailand, while it is the other way around in the cases of the Philippines and Singapore.[19] The reaction in the output gap follows the movement in consumption, amplified by the effect of the real exchange rate at the beginning, and moderated by it in the medium term.

Figures 11 to 15 plot the impulse responses to a preference (demand) shock (υ^c). The impact of a one time shock in preference is typically short lived, where in most cases it dies away after around 2 to 3 years. A positive innovation in consumption demand increases consumption, hence, increasing the output gap, inducing depreciation in the real exchange rate, and pushing up marginal costs and inflation. A typical response of the monetary authority in the model is to increase the nominal interest rate. Following the increase in interest rate, consumption falls in the next period, easing pressure on the output gap and inflation. As a result, monetary policy also loosens up, relaxing pressures on the real exchange rate to depreciate, and hence pushing down marginal costs. In the

[19] Note that by definition $q_t = e_t + p_t^* - p_t$.

case where monetary policy reacts to both innovation in inflation and the output gap (as in the cases of Malaysia, the Philippines and Singapore), an initial rise in the rate of interest is actually enough to disinflate the economy before it settles down to the steady state equilibrium.

Figures 16 to 20 plot the impulse responses to a positive innovation in monetary policy (υ^i). As in the case for the preference shock, impacts of this type of demand shock are also relatively short-lived. The impact of a tightening in monetary policy tends to die away after about two years before being completely gone within around three to four quarters later. An increase in the nominal interest rate when the monetary policy is tightened, immediately reduces consumption and appreciates the real exchange rate. As a result, marginal costs, inflation and the output gap falls. As the effect of a one time tightening in monetary policy disappears, the economy moves back to its steady state position.

The case of the Philippines, however, deserves a particular mention since inflation rises quite considerably before heading back to its stationary value. A rise in inflation in this case is mainly driven by the underlying characteristics of the monetary policy reaction function of the Philippines. A coefficient $\kappa_1 < 1$ in the case of the Philippines suggests that the monetary policy tends to accommodate inflation.[20] A rise in expected inflation after an initial one time (unexpected) increase in the nominal interest rate is not matched by at least a one to one response in monetary policy. Hence, the real rate of interest tends to decrease rather than increase, stimulating consumption and having a depreciating effect on the real exchange rate. The latter raises marginal costs, hence (together with an increase in consumption) pushing inflation up.

Figures 21 to 25 plot the responses to a positive shock to the real exchange rate (υ^q). Like the other type of demand shocks discussed previously, this shock also tends to be relatively short-lived. Marginal costs, the output gap and inflation rise following a depreciation in the real exchange rate. As a result, monetary policy is tightened, hence suppressing consumption. The rise in interest rate induces an appreciation in real exchange rate, hence loosening up marginal costs and forcing the output gap to go down before reverting back to its steady state. In the cases of Singapore and Malaysia, where the degree of openness is considerably higher, this effect also brings inflation down to a negative value before reverting back to zero.

The impact of a standard deviation innovation in the deviation from the law of one price (LOP), ψ, is plotted in Figures 26 to 30. The direct effect of a positive innovation in the deviation from the law of one price is to increase inflation, and reduce both the output gap and marginal costs. However, as a lower output gap also lowered marginal costs further, the final impact of a positive shock in ψ on inflation is indeterminate, depending on both the direct effect of ψ on inflation and the indirect effect through marginal costs that is summed up as the net effect of ψ on inflation. Except for the case of Indonesia, the net effect on inflation tends to be negative. As a result, monetary authorities react by loosening their policy stance, hence stimulating consumption and depreciating the real exchange rate to lead the economy back to its steady state.

[20] See, for example, Clarida et al. (2000) and Walsh (2003) for a more detailed discussion about the stabilising nature of monetary policy.

In the case of Indonesia, however, the net effect of an innovation in ψ on inflation tends to be positive. The combination of the relatively smaller degree of openness and the relatively non-substitutable nature of its domestic and imported consumption in this case dampens the negative effect of ψ on both the output gap and marginal costs. As a consequence, the impact on inflation is dominated by the direct impact of ψ. Therefore, monetary policy is tightened in this case, hence suppressing consumption and appreciating the real exchange rate.

The impact of the shock in ψ tends to be persistent across the sample countries, especially for the cases of Indonesia, Malaysia and Singapore. This strong persistent impact can be attributed to the very high degree of persistence in the estimated process for ψ, especially in the case of the last three countries mentioned.

Figures 31 to 40 plot the impulse responses to an international shock. Due to the way the model is specified, the impact of an international shock on the domestic economy kicks in through changes in the foreign output gap. Since the foreign output gap is negatively affected by the corresponding real rate of interest, the effect of shocks to foreign interest rates on the domestic economy would simply be the inverse of the shocks to the foreign output gap on the domestic economy with a lag. However, foreign real interest rate shocks have a more persistent impact on the domestic economy because of the relatively higher persistence in the foreign real interest rate processes.

The response of the domestic output gap to an international shock is generally similar. The domestic output gap goes up following a positive innovation in the foreign output gap. Depending on the impact on marginal costs, the impact on inflation varies in the short to medium run. For the cases of Indonesia and the Philippines, the marginal cost rises in the following quarter, therefore inducing a positive inflationary effect. In the case of Singapore, Malaysia and Thailand (to a lesser extent), the marginal cost does not increase by much relative to its pre-shock value, hence keeping away the inflationary pressure.

4.2.2 Variance decomposition

This section looks at the contribution of the structural shocks to the forecast error variance of the endogenous variables at various time horizons.

Table 5 provides the contribution of each of the seven shocks to inflation variations in each of the economies in the group. Productivity shock $\left(\upsilon^b\right)$ appears to be a very important factor in explaining variation in inflation within the group of countries under consideration. This dominance also appears to be stronger as the time horizon lengthens. In the cases of Indonesia and Malaysia, it even appears as the only factor that governs almost all of the variation; while it does not appear to be as extreme in the other cases.

Although the role of other shocks in Indonesia and Malaysia is minuscule, consumption preference shock (υ^c) and monetary policy innovation $\left(\upsilon^i\right)$ appear to have a small but non-negligible effect in the short run. In the case of Malaysia the role dies away after a year. In the case of Indonesia, however, the role of the consumption preference shock declines in a year, but stays constant up to about 10 years after. The role of monetary policy innovations in Indonesia, although relatively small, build up as the horizon lengthens.

This pattern is also found in the case of Thailand, where the consumption preference shock also shares a significant role in determining its inflation variation (accounting for around 20 per cent in the short run and nearly 17 per cent in the longer run).

Real exchange rate shock (υ^{q}) also plays a significant role in explaining the short-run inflation variation in the Philippines; while the importance of the deviation from the LOP shock $\left(\upsilon^{\psi}\right)$ increases in the longer term. For the case of Singapore, the most open economy in the group, foreign shocks also appear as a significant determinant of inflation variation (accounting for more than 30 per cent of the variation).

The contribution of the seven different shocks to the variation in the output gap is presented in Table 6. In Indonesia, there are three shocks that govern the output gap variations in the short run, that is, the shock on consumption preference, on productivity and on interest rate innovations. The role of the consumption preference and the interest rate shocks decline after a year, replaced by the increasing role of the productivity shock in determining the output gap variations in the longer run. The latter pattern also appears in the case of Malaysia, where initially the shocks to consumption preference and the shocks to the real exchange rate share an almost equally dominant role in governing the output gap variations in the short term, but replaced by the role of productivity shock in the longer term.

In the short run, the case of Thailand is similar to the case of Malaysia. However, the role of both the shocks to the consumption preference and the interest rate remain the most important even in the longer run. Although the contribution from the productivity shock, in this case, increases in the longer run, it remains relatively small. A similar feature also appears in the case of the Philippines. The increasing role of the productivity shock, in this case, is also accompanied by an increasing role of interest rate innovations and the shock to the deviation from the LOP in the longer run. In the case of Singapore, the persistence dominance of the shocks to the consumption preference and the real exchange rate in explaining the output gap variations is also accompanied by a similar persistence in the contribution of the shock to the interest rate innovations.

Table 7 shows the decomposition of the interest rate variations. In the very short run, variation of the interest rate is mainly driven by the shock to the interest rate innovations, except for the case of Malaysia (driven mainly by the productivity shocks) and Singapore (driven mainly by both the shocks to the consumption preference and the real exchange rate). For the case of the Philippines, the shocks to the consumption preference and the real exchange rate also significantly affect interest rate variation in the short run. In the longer run, the productivity shocks tend to gain importance in determining the variation of the interest rate in all cases.

The decomposition in the forecast error variance of marginal cost is provided in Table 8. For the cases of Indonesia and Malaysia, the variation is mainly attributable to the productivity shocks. In the Philippines, the shocks to the consumption preference, the real exchange rate and the deviation from the LOP are the three main drivers in the short run. In the longer run, however, the role of both the shocks to the consumption preference and the real exchange rate decrease, while the role of the shocks to the deviation from the LOP increases. In Singapore, the shocks to the consumption preference and the real exchange rate are the main drivers in the short run. Although still dominant, the effect of the previously mentioned shocks in Singapore decreases and the role of the shock to the deviation from the LOP also becomes significant in the longer run. Variation in the marginal costs in Thailand is mainly driven by three shocks, namely, the shocks to the consumption preference, productivity and the real exchange rate.

As can be seen in Table 9, in the short run consumption variation is primarily driven by the shock to the consumption preference. Although decreasing, the role of this shock remains significant in the longer run for the case of Thailand and the Philippines (to a lesser extent). Additionally, for the case of the Philippines, the role of the shock to the deviation from the LOP increases to match the contribution of the shock to the consumption preference in the longer run. In all other cases, the role of the latter shock diminishes after a year, and being replaced by the role of the productivity shock (in the case of Indonesia), and the shock to the deviation from the LOP (in the cases of Malaysia and Singapore).

Table 10 provides the contribution of each of the seven shocks to the variation in the real exchange rate. This behaviour in explaining the variation in the real exchange rate over time varies across countries. Although decreasing, the role of the shocks in relation to the real exchange rate remain important in the longer run for the case of Indonesia. In the cases of the Philippines and Thailand, the role of this shock remains about as strong in the longer run. In Thailand, however, its role is coupled with the role of the consumption preference shock in explaining the real exchange rate variations. The cases of Malaysia and Singapore are largely similar, where the role of the real exchange rate shock decreases over time, being replaced by the role of the shock to the deviation from the LOP. The difference is that in the case of Singapore, foreign shocks are also important in guiding the variation in its real exchange rate.

4.2.3 Qualification of the results

The previous argument has outlined the general findings obtained from empirical estimation. The results seem to provide a plausible explanation of the economic dynamics for the group of economies under consideration. This section qualifies the results by mainly focusing on how the monetary policy transmission mechanism affects the dynamics of inflation (π) and output gap (y) in those economies.

The impulse response analysis points out that role of monetary policy in affecting inflation and the output gap in the model mainly comes through its effect on consumption and the real exchange rate. Given that the instrument for conducting monetary policy (nominal interest rate in this case) is governed by fluctuations in (expected) inflation and the output gap, the interest rate in this model plays the role of a stabilising tool to moderate fluctuations in the economy. In the case where monetary policy is accommodative towards inflation (the case of the Philippines), a monetary policy shock tend to introduce more volatility to the inflation dynamics. In the case where the economy is more open (Malaysia and Singapore), inflation tends to be more volatile given a shock to the real exchange rate. Especially for the case of Singapore, this observation seems to justify the actual conduct of monetary policy that centres on exchange rate management. As Singapore's economy relies a lot more heavily on international trade than other economies in the group, the exchange rate channel appears to be more important.[21]

The analysis of the forecast error variance decomposition reveals the shocks that mainly drive interest rate fluctuations. For the cases of Indonesia, Malaysia and Thailand (to a lesser extent), the productivity shock plays a significant role in explaining the interest rate fluctuation. For these three countries, this shock is also identified as the main factor behind the fluctuation in inflation. This, therefore, justifies that the conduct of monetary policy in the three countries being more heavily weighted in the developments of inflation.

For the case of the Philippines, the shocks to the consumption preference and the real exchange rate share a more significant role in the very short run, while the shocks to productivity and the deviation from the LOP play a more significant role in the longer run. The shocks to the consumption preference and the real exchange rate in this case are identified as the main driver of output gap fluctuation, while the shocks to productivity and the deviation from the LOP are identified as the main factors that drive inflation variations. This suggests that the monetary authority in the Philippines is more concerned with the developments in the output gap in the short run, but switches more attention to the developments of inflation in the longer run. The case of Singapore looks very similar to the case of the Philippines, where the monetary authority in the very short run seems to put more emphasis on the developments of the output gap, and switches more attention to inflation in the longer run. This is seen from the increasing importance of the productivity and the foreign output gap shocks in driving the fluctuations in Singapore's interest rate.

5 Revisiting the Structural Shock Correlations

Following the Asian crisis in 1997, interest in economic integration and cooperation has grown substantially in East Asia as well as in the ASEAN. Considerable research has been undertaken in looking at the issue of whether or not the region satisfies the requirements set out in the theory of optimum currency areas (OCA), introduced by Mundell (1961). A number of studies have focussed on assessing the symmetry of structural shocks.[22] A group of countries that face symmetric structural shocks is argued to favour similar policy responses, hence making it a candidate for a currency area.

Following the contribution by Bayoumi and Eichengreen (1994), the literature generally relies on the VAR-based Blanchard and Quah (1989) decomposition method to identify the structural shocks needed for analysing similarities in the region's exposure to those shocks. This method disentangles the structural disturbances exposed to an economy into two types of shocks, a supply side and a demand side. Strong correlation in the supply side shocks are considered to be more relevant to identifying the suitability of a region to form a monetary or currency arrangement since they are (in principle) unaffected by variations in demand management policies.

[21] See Parrado (2004) and McCallum (2006) for the discussion on the conduct of monetary policy in Singapore.

[22] For example, Bayoumi and Eichengreen (1994), Bayoumi et al. (2000), Zhang et al. (2003), Huang and Guo (2006), Ahn et al. (2006) etc.

Most of the studies conducted for the region analyse the symmetry of supply disturbances for countries in East Asia, where the ASEAN-5 countries considered in this study are commonly nested in the sample. Particularly for the cases of five ASEAN countries under consideration, the supply shocks are generally found to be positively correlated. The strength and the significance of the correlations, however, vary depending on the data frequency chosen or the sample period taken for the analysis. As discussed by de Brouwer et al. (2006), the correlations tend to be relatively weaker for the studies that rely on samples prior to the Asian financial crisis, and turn stronger when the post-crisis data is included.

Given that the estimated simple model for a small open economy is able to provide reasonable explanation of the dynamics for each of the ASEAN-5 economies considered, this section revisits the issue of assessing symmetries in structural shocks by looking at the pattern of correlations in the productivity shocks produced by the model. The model's specific structure provides an estimate of a series for the productivity shock that represents a relatively more accurate measure of supply shocks for these economies.[23] Table 4 reports the pair-wise correlation coefficients of the productivity disturbances for the ASEAN-5 economies.

Table 4: Correlation of productivity shocks

	Indonesia	Malaysia	Philippines	Singapore	Thailand
			Full sample		
Indonesia	1.00				
Malaysia	0.41*	1.00			
Philippines	0.03	0.23*	1.00		
Singapore	-0.17	0.05	0.08	1.00	
Thailand	0.39*	0.51*	0.41*	0.27*	1.00
			Omitting crisis period (1997:Q2-1998:Q4)		
Indonesia	1.00				
Malaysia	0.12	1.00			
Philippines	-0.02	0.19**	1.00		
Singapore	0.04	0.23*	0.06	1.00	
Thailand	0.40*	0.39*	0.40*	0.23*	1.00

Note: * Significant at 5 per cent level
** Significant at 10 per cent level

In general, Table 4 provides a similar pattern of correlations to those reported by the earlier VAR-based studies. The pair-wise coefficients of correlation for the productivity shock are generally positive and significantly different from zero in many of the cases. The strength of correlations, however, tends to be weaker than those obtained from a VAR-based studies that include the post-crisis data, e.g. Zhang et al. (2003), Kawai and Motonishi (2005), Huang and Guo (2006), Ahn et al. (2006) etc. The pattern of correlations also does not concur very well with those obtained under VAR-based analyses, where including post crisis data tends to generate significant positive correlations across almost all the

[23] The measures of supply shock obtained from bi-variate VAR models are often inaccurate. For example, in the case of five ASEAN countries considered in this paper, the series obtained is significantly led by demand specific policy variables Ramayandi (2006).

five ASEAN countries in the sample.[24] The pattern of productivity shock correlations generated from the estimated simple small open economy model of this study looks more like the pattern emerging from the VAR-based studies that exclude the post-crisis sample, e.g. Bayoumi et al. (2000). That is, the correlations are only significant across some but not all of the ASEAN-5 economies, and the significant pair-wise correlation linked the group together through a chain of country to country significant correlations.

Table 4 also reports the productivity shock correlation coefficients when the Asian financial crisis period is omitted from the sample. The omission of the crisis sample reduces the strength of productivity shock correlations a little. However, it does not substantially alter the pattern of correlations shown when the crisis period is included. Productivity shocks in Thailand are still positively and significantly correlated with the other four countries in the sample. This observation reinforces the suspicion that increasing correlations in the structural shocks among the ASEAN-5 nations are enhanced by the common shocks experienced during the Asian financial crisis. Therefore, the strength of correlation coefficients is lowered once this effect is omitted from the sample.

In general, however, the results obtained from the estimated small open economy model do not contradict the results obtained from VAR-based studies in terms of symmetry of the supply shocks among the ASEAN-5 economies. Nevertheless, the strength of correlations is found to be weaker than those often reported in the latest VAR-based studies. As the findings of these studies are often quoted as evidence of integration within the region, the pattern of the productivity shock correlations in Table 4 argues that the degree of integration, in terms of the supply shocks symmetry in the region, may not be as strong as what tend to be concluded in the latest VAR-based studies.

6 Concluding Remarks

In this paper, estimation of the parameters for a simple small open economy model is conducted using data from five different small open economies in ASEAN. The structure of the underlying model is able to produce estimated parameters that largely capture the economic characteristics and dynamics of each of the countries under consideration in a relatively plausible manner.

The price level is found to have varying degrees of stickiness within the five economies in the group, with the lowest found for the case of the Philippines and the highest found for the case of Thailand. Labour supply is found to be mostly inelastic, with the most inelastic found in the case of Singapore and the least found in the case of the Philippines (where the point estimate suggests that labour supply elasticity is approximately unitary). Imported and domestically produced consumption goods are found to be imperfect substitutes in all cases; where in the case of Indonesia, the data suggests that both goods are almost perfectly non-substitutable. In terms of consumption sensitivity towards changes in interest rate, the countries under consideration seem to be divided into two different groups. For Indonesia,

[24] Ahn et al. (2006), for example, reports very high positive and significant correlations across all the ASEAN-5 economies, except for the Philippines. Zhang et al. (2003), using quarterly data shows that correlations of the supply shocks are positive and significant across all the ASEAN-5 countries, except for the pair-wise cases: Indonesia and the Philippines, and Thailand and the Philippines.

Thailand and the Philippines, the sensitivity tends to be relatively low, and in Malaysia and Singapore, the sensitivity tends to be relatively higher. The estimate for a standard deviation of productivity shock in the cases of Indonesia and Thailand appears to be a lot higher than the other countries in the group, which is mainly due to a large downward fluctuation in productivity of these two countries during the Asian financial crisis. This observation justifies the claim that these two countries suffered a harder hit from the crisis relative to the rest of the group. Lastly, from the re-estimation of the parameters for a monetary policy reaction function for the Philippines, the data supports the single equation estimation results that suggest that monetary policy in the Philippines tends to be accommodative towards inflation.

The impulse response functions presented in this paper provide a qualitative way of understanding dynamic behaviour in response to the various shocks for the economies within the group. They also provide us with a description of the transmission of monetary policy to the rest of the economy. The forecast error variance decomposition provides insights over the main drivers behind fluctuations in the economic variables described in the model. It suggests that the movements in interest rates are consistent with the underlying objective of monetary policy within each of the sample countries to target inflation and the output gap.

The simple small open economy model presented in this study is relatively successful in describing the dynamic characteristics of the economies within the ASEAN-5 group of countries. There are different extensions that can be pursued from the findings of the model estimation in this study. The results can be used to revisit the issue of structural shocks symmetry among the group of countries considered. Although the estimated productivity shocks obtained are positively correlated in general, the strength of correlations are not as strong as the ones commonly obtained from a VAR-based analysis. It suggests that the commonality in terms of structural shocks among the countries in the region may not be as strong as what tend to be suggested by the VAR-based studies.

Another possible extension to the results is to use the estimated models to approximate the aggregate welfare function facing each of the economies. The resulting approximated welfare function can then be used to assess whether or not monetary policy in each of the countries has been conducted optimally. Further, it can also be used to analyse the welfare implications of different policy regimes for each of the economies.

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APPENDIX

A Summary of the complete system

1. CPI Inflation:

$$\pi_t = \frac{1}{1+\beta\delta}\left[\beta E_t\left(\pi_{t+1}\right) + \delta\pi_{t-1} + (1-\alpha)\,\Gamma_D mc_t + \alpha\Gamma_F\psi_t\right]$$

2. Marginal cost equation:

$$mc_t = \varphi y_t + \frac{\sigma}{1-h}\left(c_t - hc_{t-1}\right) + \frac{\alpha}{1-\alpha}\left(q_t - \psi_t\right) - (1+\varphi)\,b_t$$

3. Euler equation for consumption:

$$\left(c_t - hc_{t-1}\right) = E_t\left(c_{t+1} - hc_t\right) - \frac{(1-h)}{\sigma}\left(i_t - E_t\pi_{t+1}\right) + \upsilon_t^c$$

4. Goods market clearing condition:

$$y_t = (1-\alpha)\,c_t + \alpha y_t^* + \frac{\alpha\,(2-\alpha)\,\eta}{(1-\alpha)}q_t - \frac{\alpha\eta}{(1-\alpha)}\psi_t$$

5. Interest reaction function:

$$i_t = (1-\rho_i)\left(\kappa_1 E_t\pi_{t+n} + \kappa_2 y_t\right) + \rho_i i_{t-1} + \upsilon_t^i$$

6. International consumption risk sharing condition:

$$\frac{(1-h)}{\sigma}q_t = \left(c_t - hc_{t-1}\right) - \left(y_t^* - hy_{t-1}^*\right) + \upsilon_t^q$$

7. Domestic aggregate productivity:

$$b_t = \rho_b b_{t-1} + \upsilon_t^b$$

8. Deviation of the law of one price:

$$\psi_t = \rho_\psi\psi_{t-1} + \upsilon_t^\psi$$

9. External block:

$$y_t^* = \phi_1 y_{t-1}^* + \phi_2\left(i_{t-1}^* - E_t\pi_t^*\right) + \upsilon_t^{y^*}$$

$$\left(i_t^* - E_t\pi_{t+1}^*\right) = \phi_3 y_{t-1}^* + \phi_4\left(i_{t-1}^* - E_t\pi_t^*\right) + \upsilon_t^{r^*}$$

B Parameters for the foreign sector block

Parameter	Estimate	Std. Error
ϕ_1	0.87	(0.06)
ϕ_2	-0.01	(0.02)
ϕ_3	0.07	(0.068)
ϕ_4	0.95	(0.03)
σ_{y^*}	0.005	–
σ_{r^*}	0.005	–

C Shocks (smoothed)

Notes on the shock signs:

eas = Productivity shock $\left(\upsilon^b\right)$
eis = Demand/preference shock (υ^c)
emp = Monetary policy/interest rate innovation $\left(\upsilon^i\right)$
eq = Real exchange rate shock (υ^q)
epsi = Innovation in the deviation from the law of one price $\left(\upsilon^\psi\right)$
eys = Foreign output gap shock $\left(\upsilon^{y^*}\right)$
ers = Foreign real interest rate shock $\left(\upsilon^{r^*}\right)$

Figure 1: Smoothed shocks: Indonesia

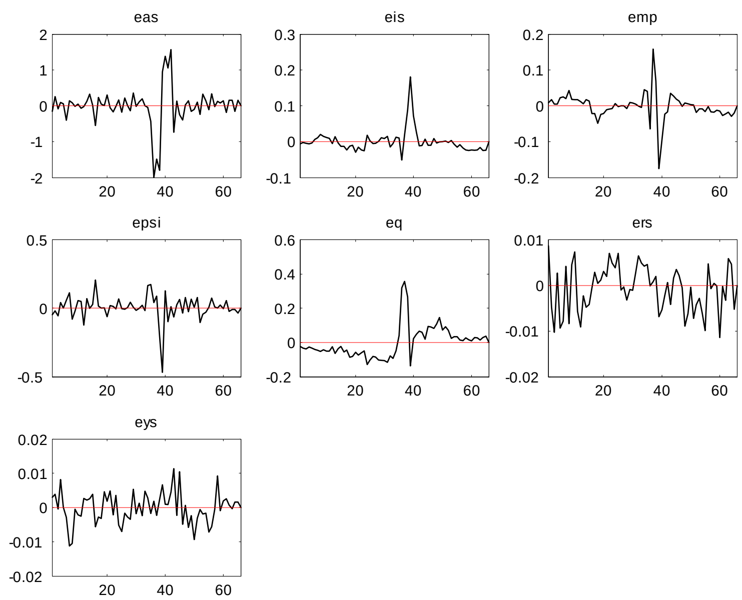


Figure 2: Smoothed shocks: Malaysia

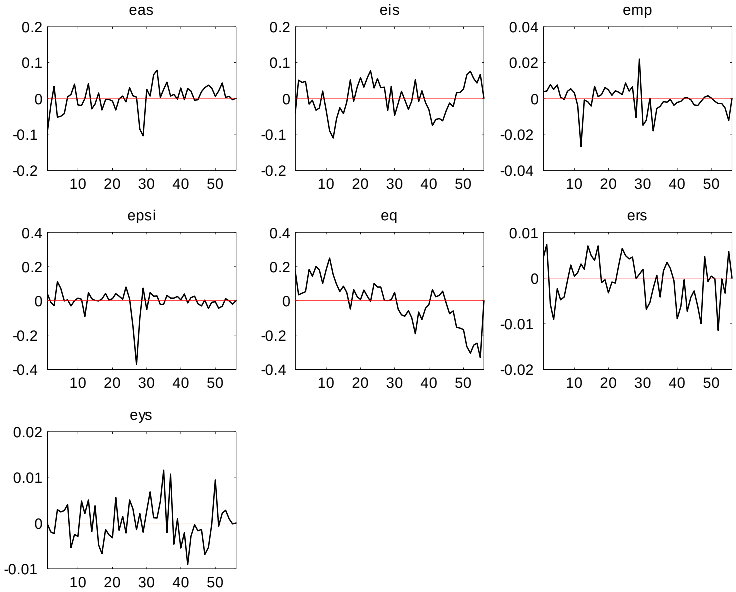


Figure 3: Smoothed shocks: The Philippines

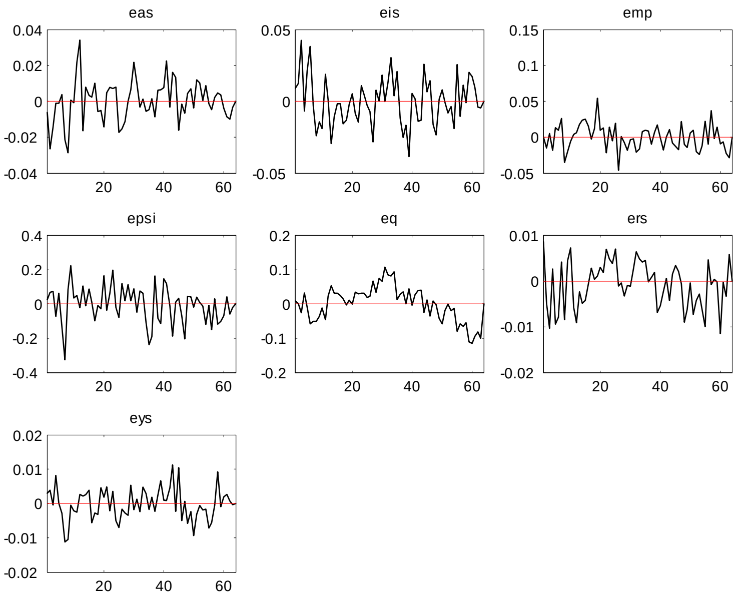


Figure 4: Smoothed shocks: Singapore

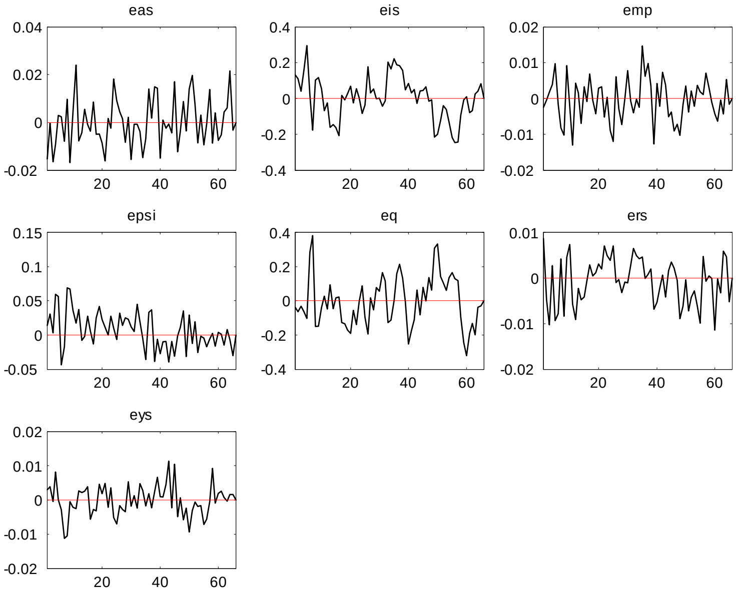
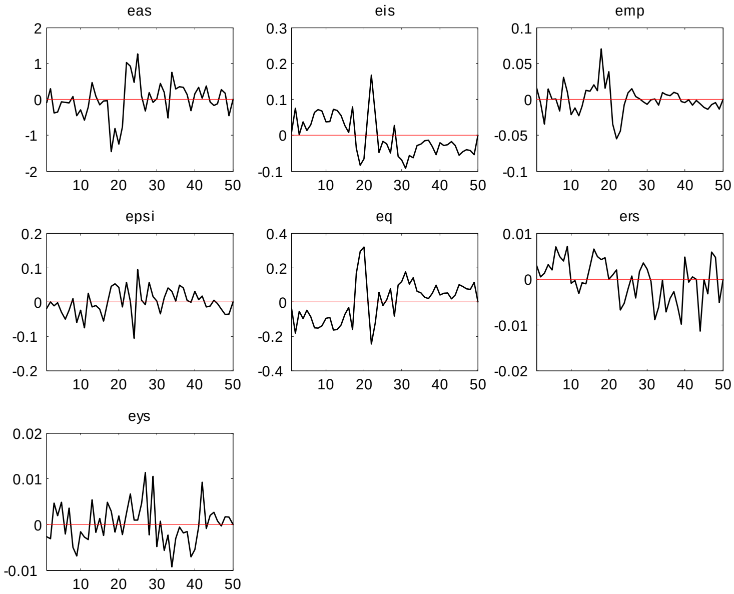


Figure 5: Smoothed shocks: Thailand



D Impulse responses

Notes on the shock signs:

p	= Inflation (π)
y	= Domestic output gap (y)
i	= Nominal interest rate (i)
mc	= Marginal cost (mc)
c	= consumption (c)
q	= Real exchange rate (q)

D.1 Productivity shock

Figure 6: Impulse responses to a productivity shock: Indonesia

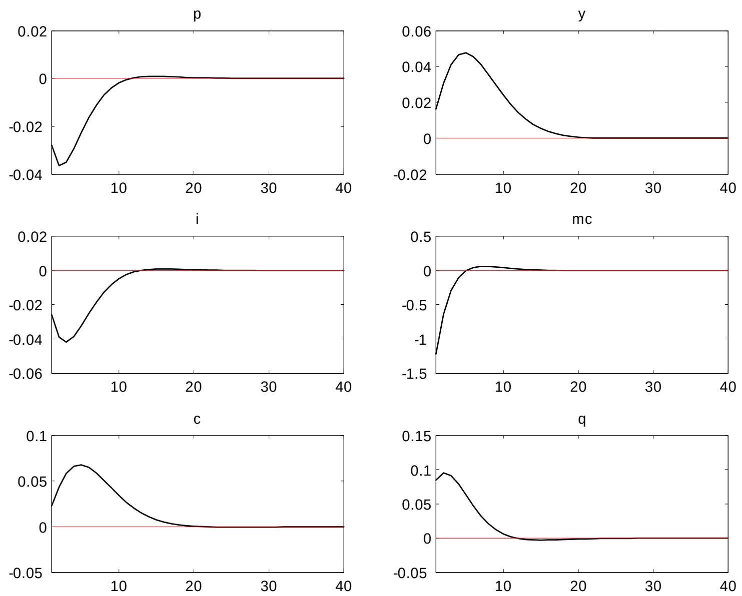


Figure 7: Impulse responses to a productivity shock: Malaysia

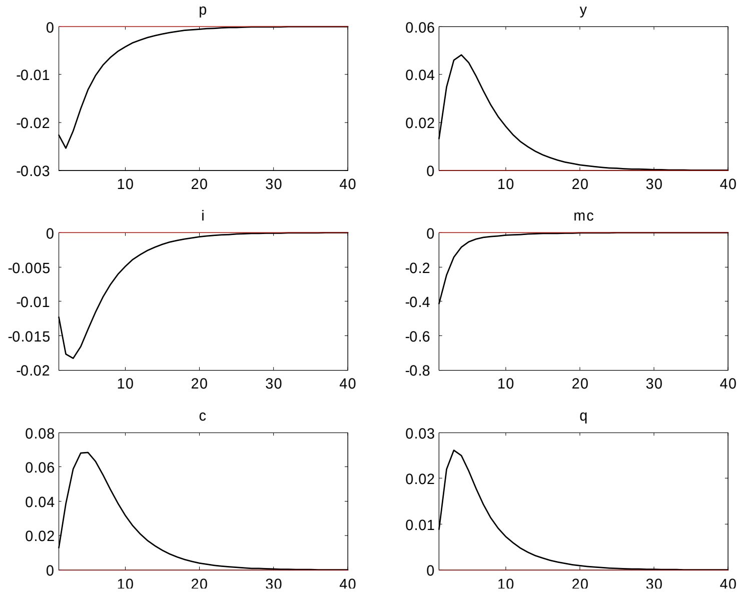


Figure 8: Impulse responses to a productivity shock: The Philippines

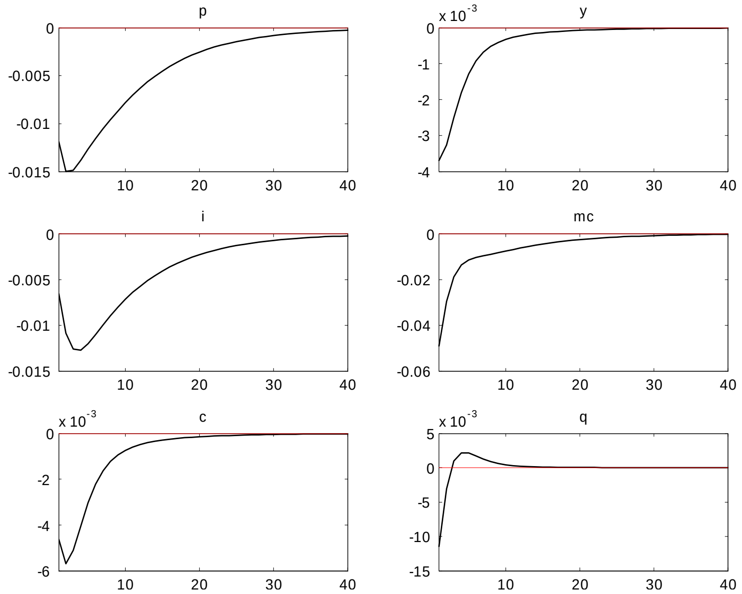


Figure 9: Impulse responses to a productivity shock: Singapore

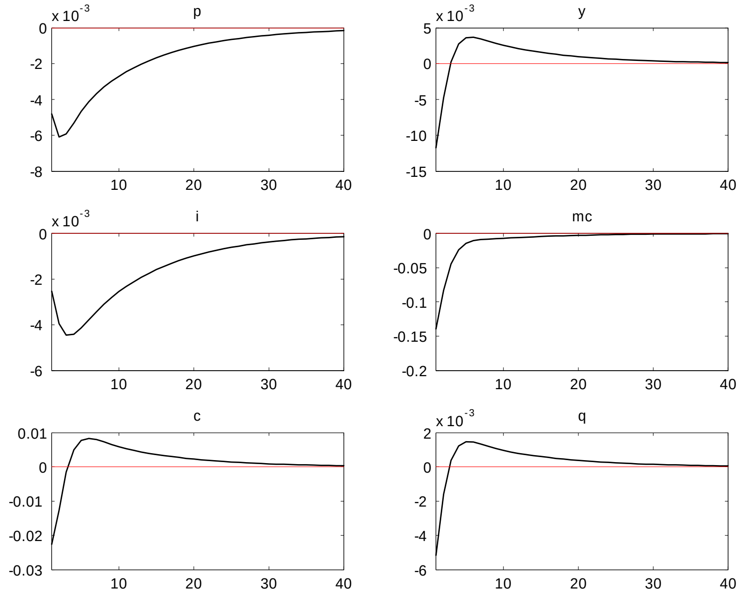
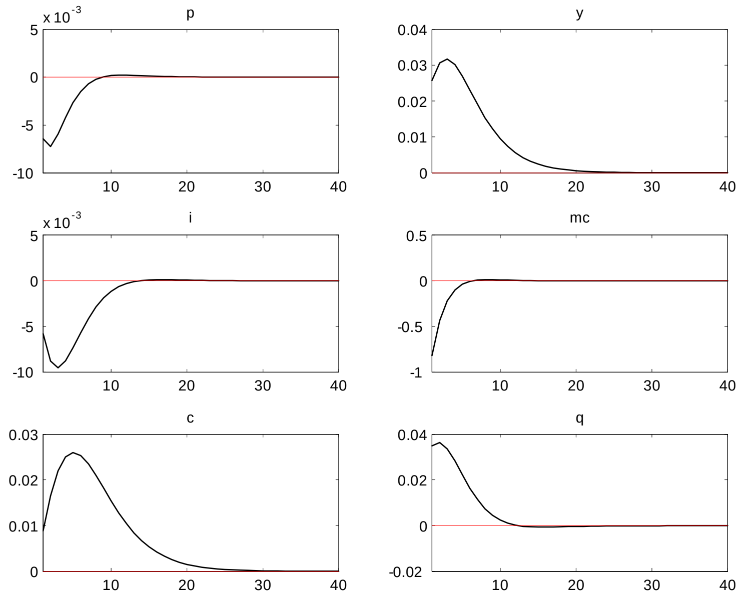


Figure 10: Impulse responses to a productivity shock: Thailand



D.2 Preference shock

Figure 11: Impulse responses to a preference shock: Indonesia

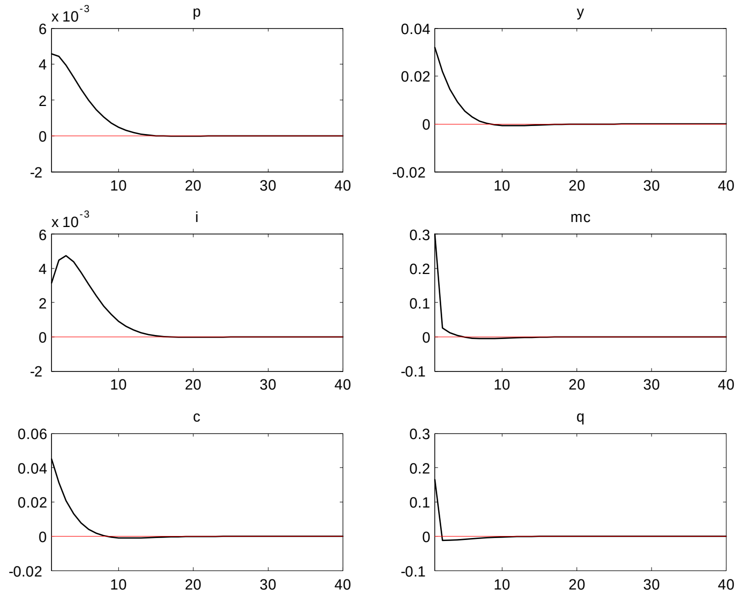


Figure 12: Impulse responses to a preference shock: Malaysia

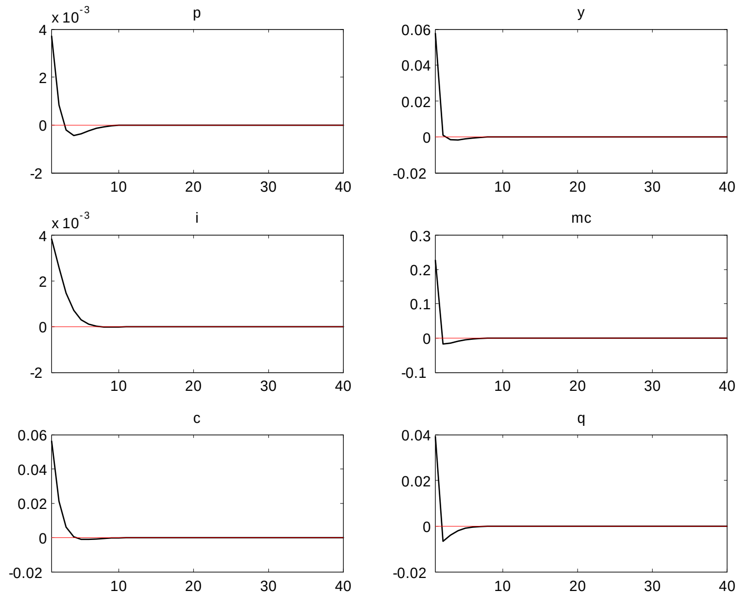


Figure 13: Impulse responses to a preference shock: The Philippines

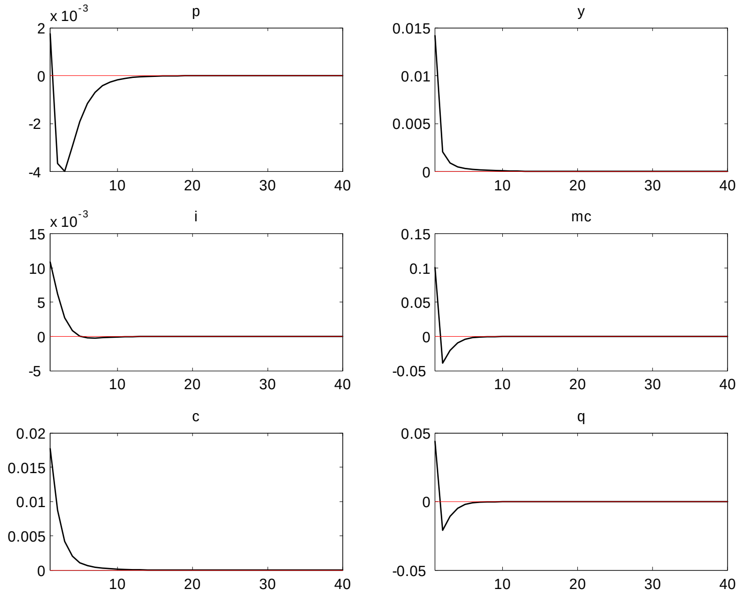


Figure 14: Impulse responses to a preference shock: Singapore

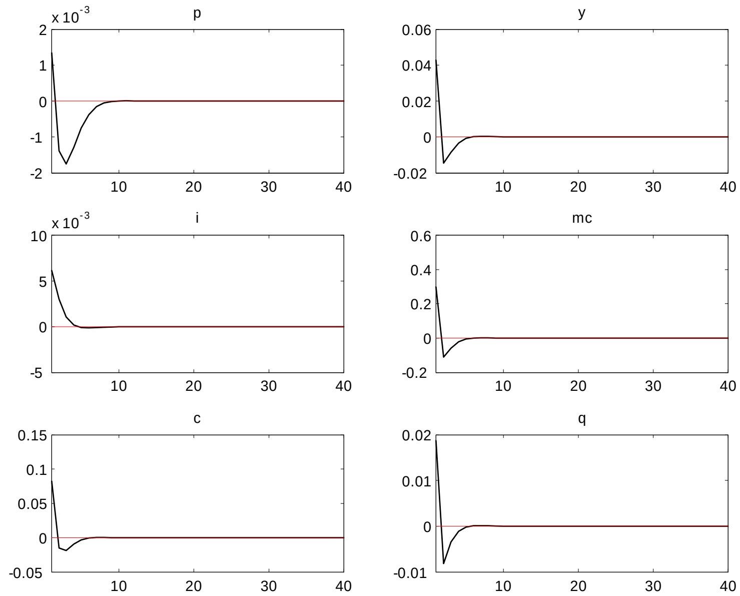
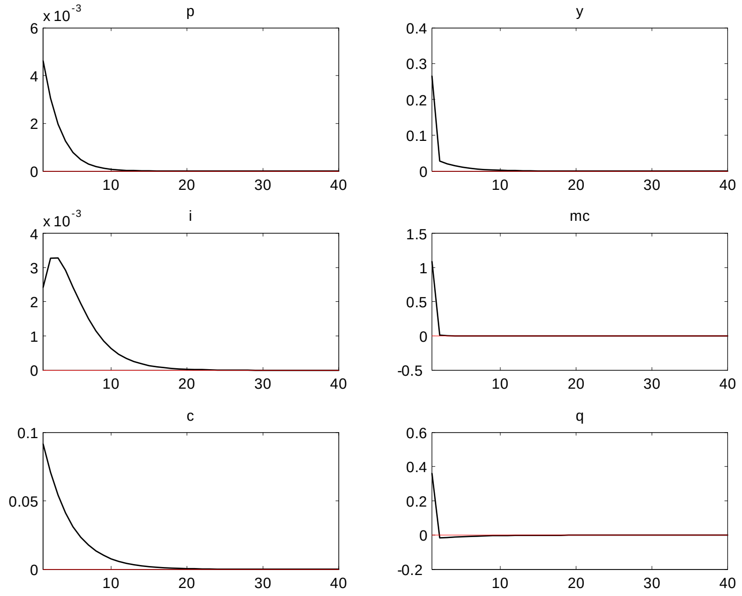


Figure 15: Impulse responses to a preference shock: Thailand



D.3 Innovation to the rate of interest

Figure 16: Impulse responses to an innovation to the rate of interest: Indonesia

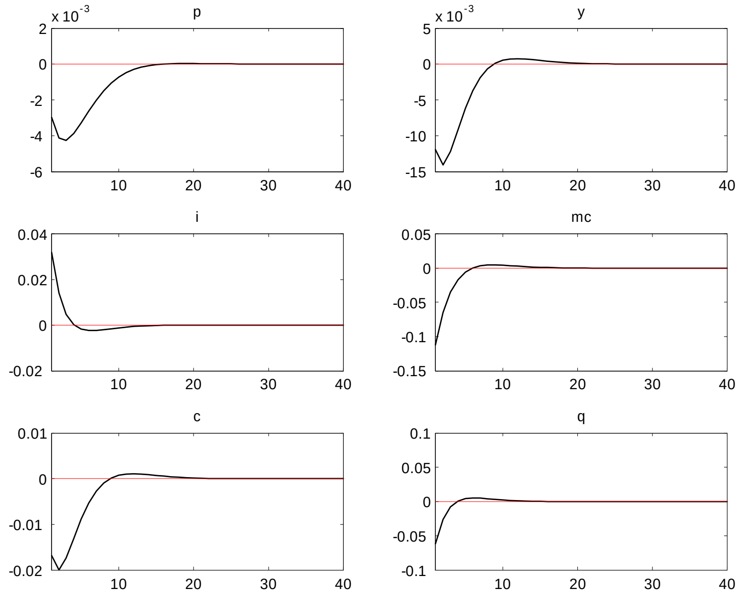


Figure 17: Impulse responses to an innovation to the rate of interest: Malaysia

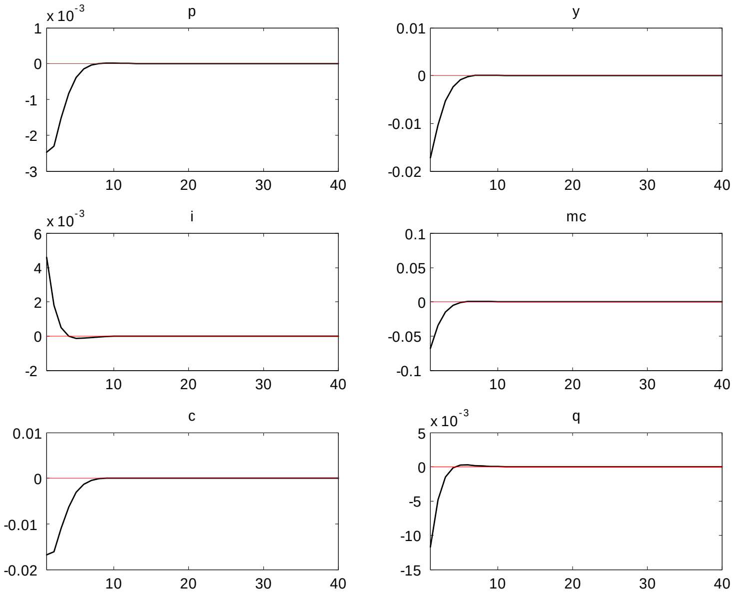


Figure 18: Impulse responses to an innovation to the rate of interest: The Philippines

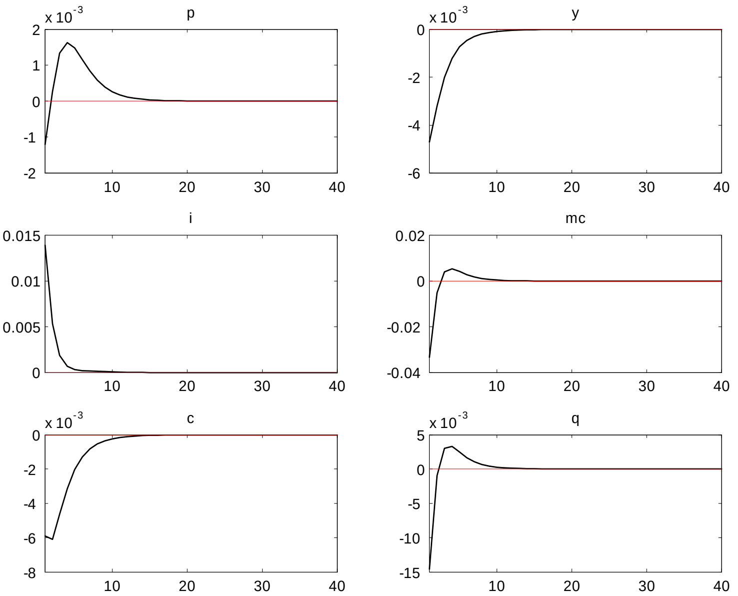


Figure 19: Impulse responses to an innovation to the rate of interest: Singapore

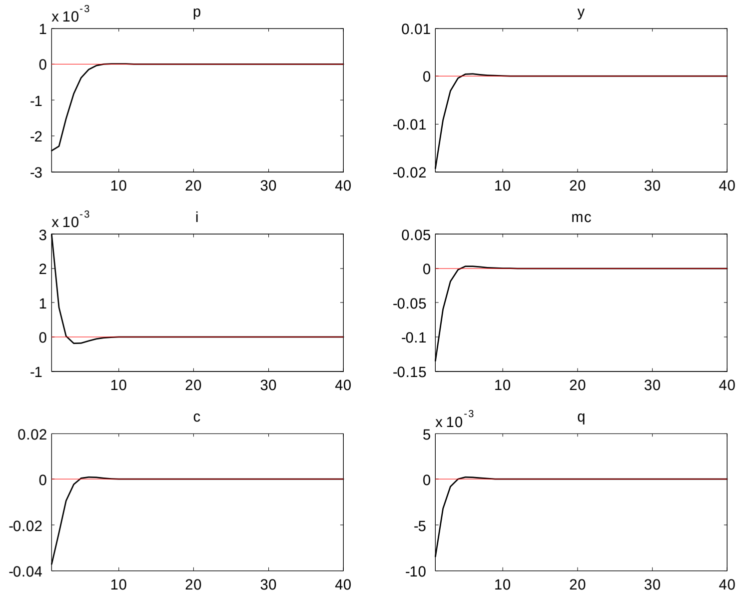
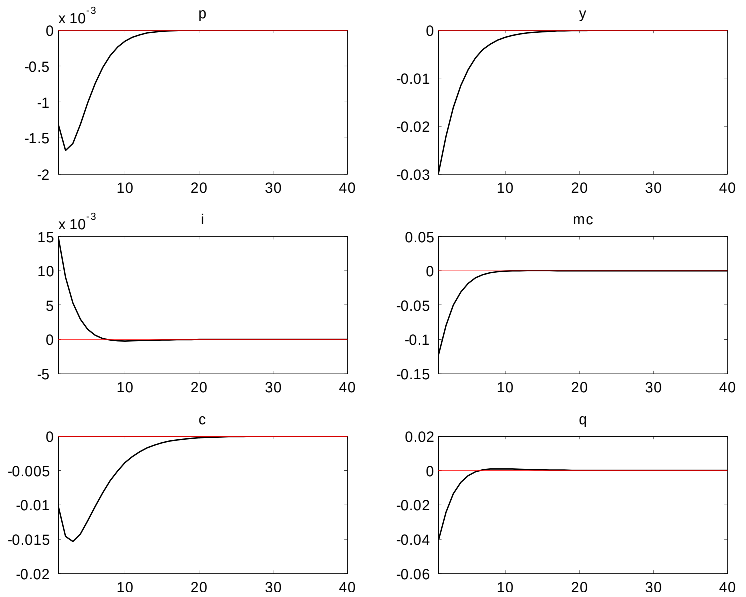


Figure 20: Impulse responses to an innovation to the rate of interest: Thailand



D.4 Real exchange rate shock

Figure 21: Impulse responses to a Real exchange rate shock: Indonesia

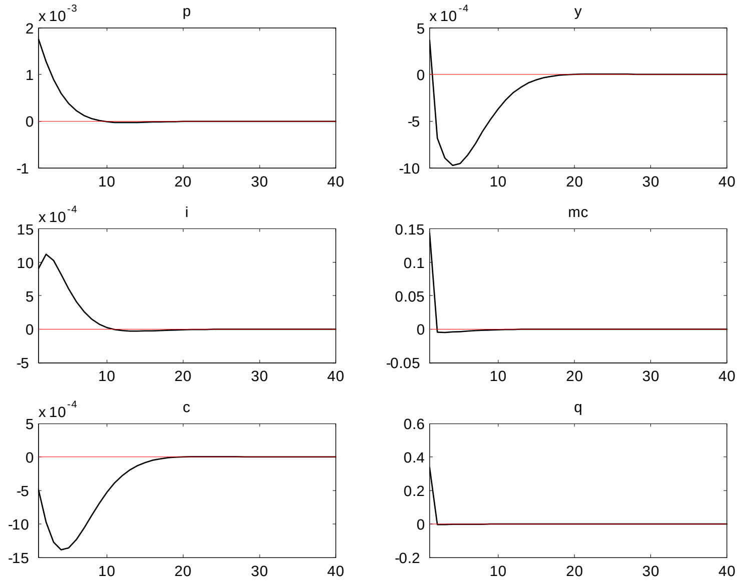


Figure 22: Impulse responses to a Real exchange rate shock: Malaysia

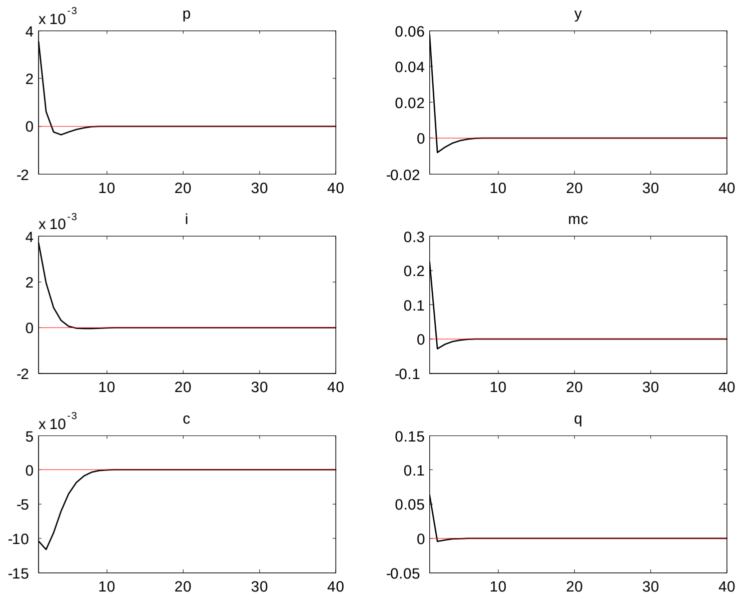


Figure 23: Impulse responses to a Real exchange rate shock: The Philippines

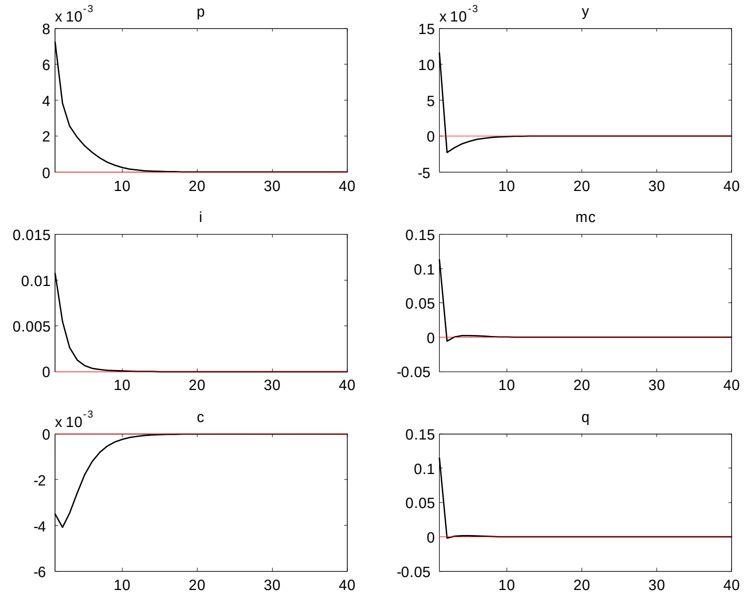


Figure 24: Impulse responses to a Real exchange rate shock: Singapore

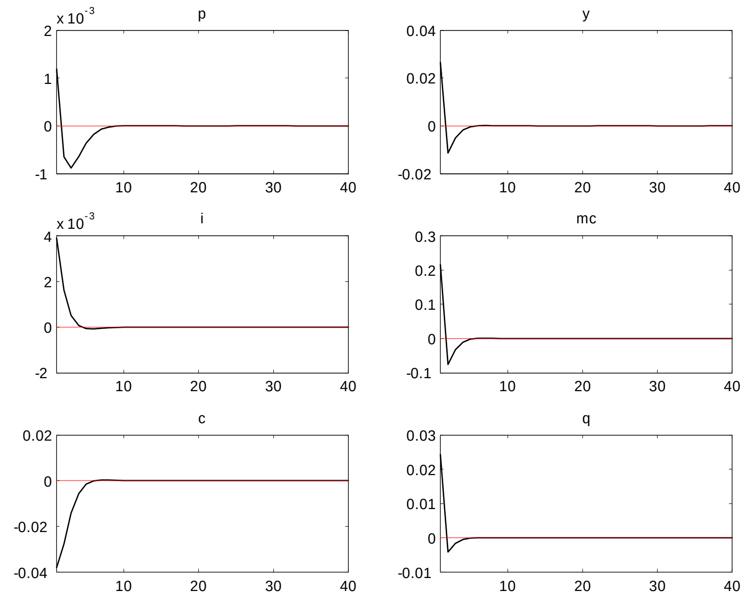
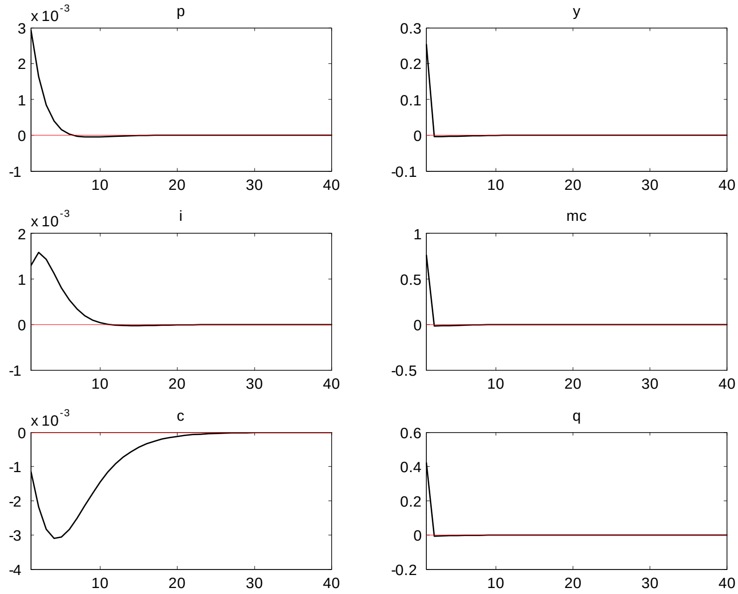


Figure 25: Impulse responses to a Real exchange rate shock: Thailand



D.5 Shock to the deviation of the law of one price (LOP)

Figure 26: Impulse responses to a shock to the deviation of the LOP: Indonesia

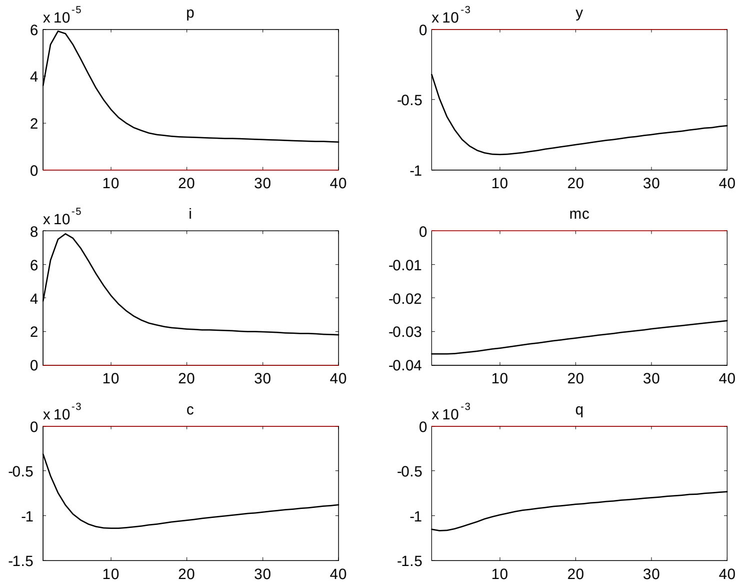


Figure 27: Impulse responses to a shock to the deviation of the LOP: Malaysia

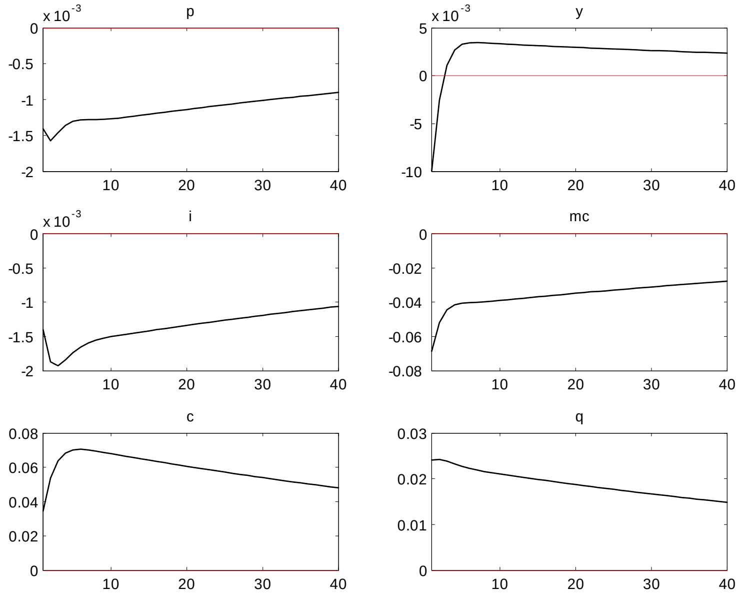


Figure 28: Impulse responses to a shock to the deviation of the LOP: The Philippines

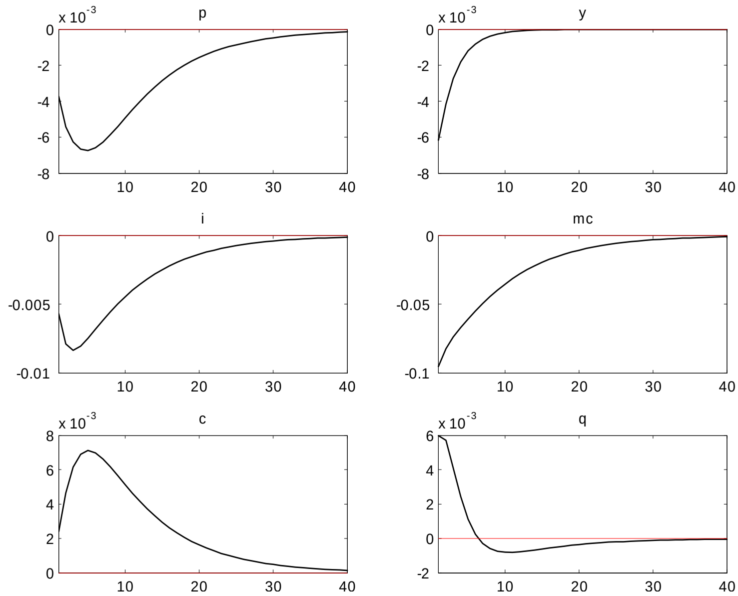


Figure 29: Impulse responses to a shock to the deviation of the LOP: Singapore

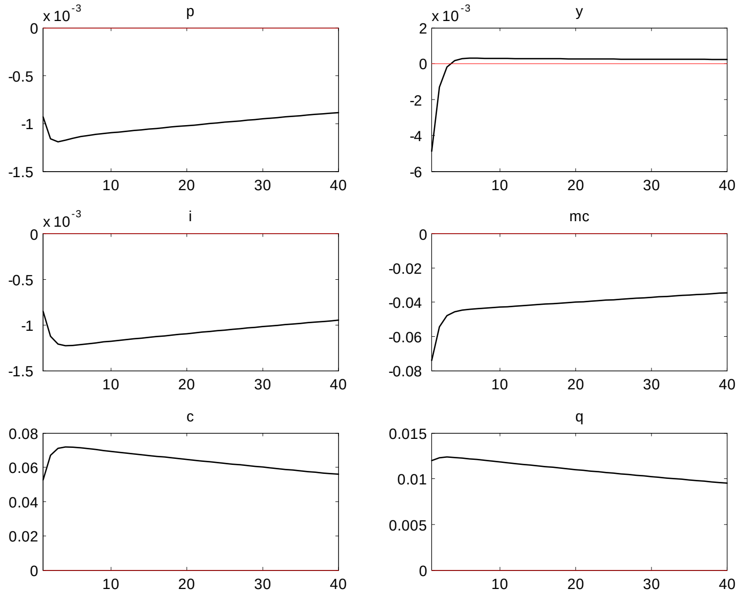
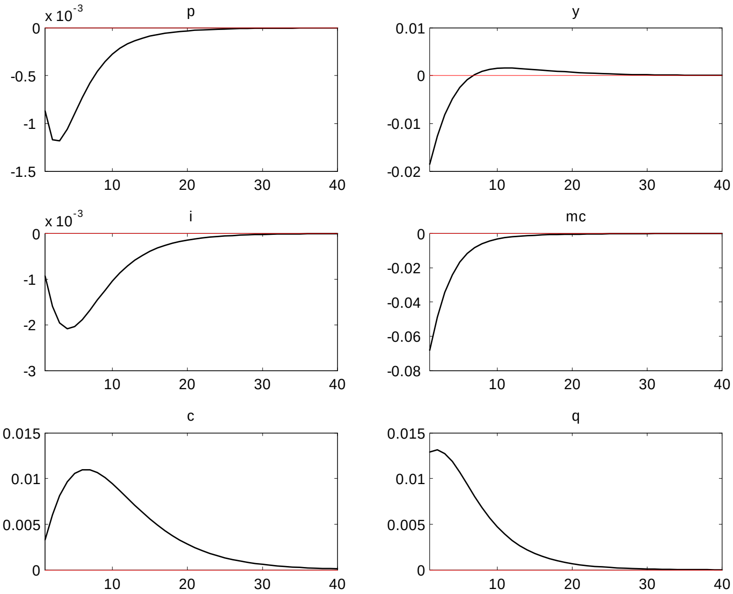


Figure 30: Impulse responses to a shock to the deviation of the LOP: Thailand



D.6 International shocks

D.6.1 Foreign output gap shock

Figure 31: Impulse responses to a foreign output gap shock: Indonesia

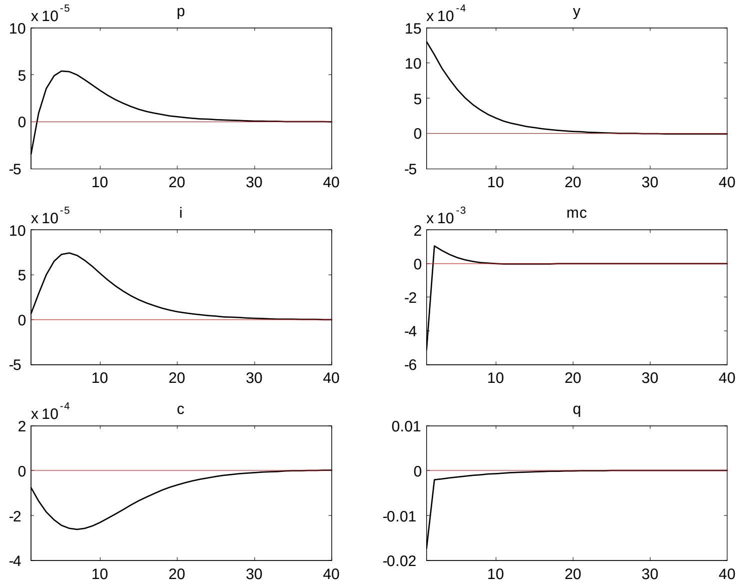


Figure 32: Impulse responses to a foreign output gap shock: Malaysia

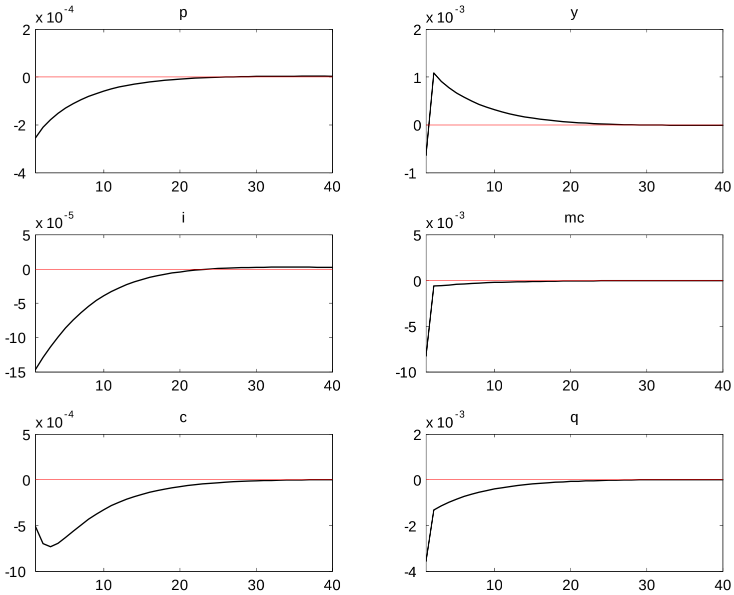


Figure 33: Impulse responses to a foreign output gap shock: The Philippines

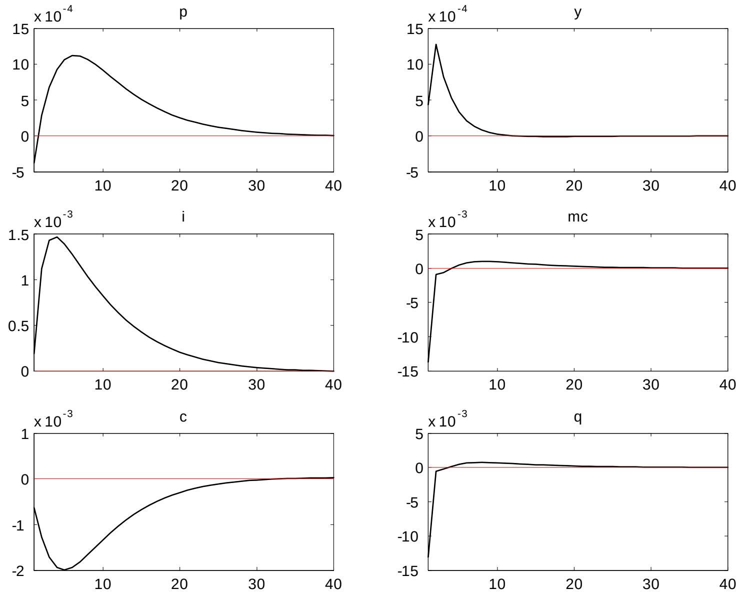


Figure 34: Impulse responses to a foreign output gap shock: Singapore

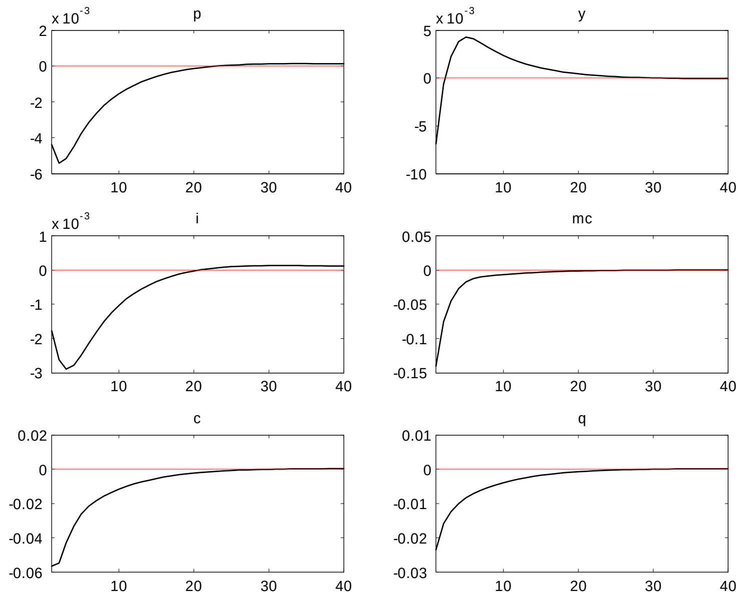
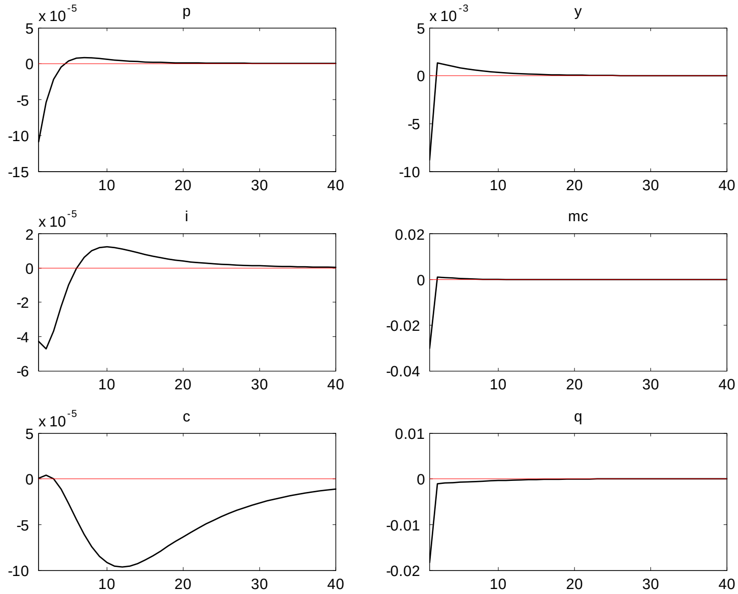


Figure 35: Impulse responses to a foreign output gap shock: Thailand



D.6.2 Foreign real interest rate shock

Figure 36: Impulse responses to a foreign real interest rate shock: Indonesia

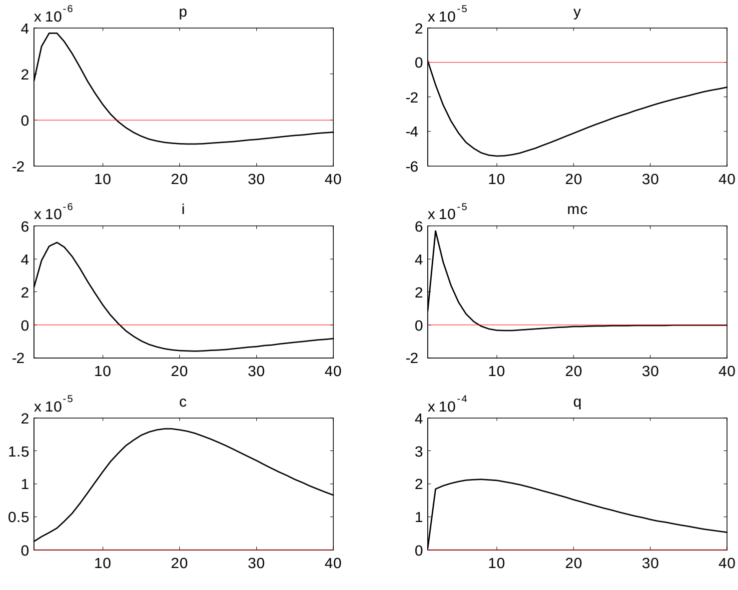


Figure 37: Impulse responses to a foreign real interest rate shock: Malaysia

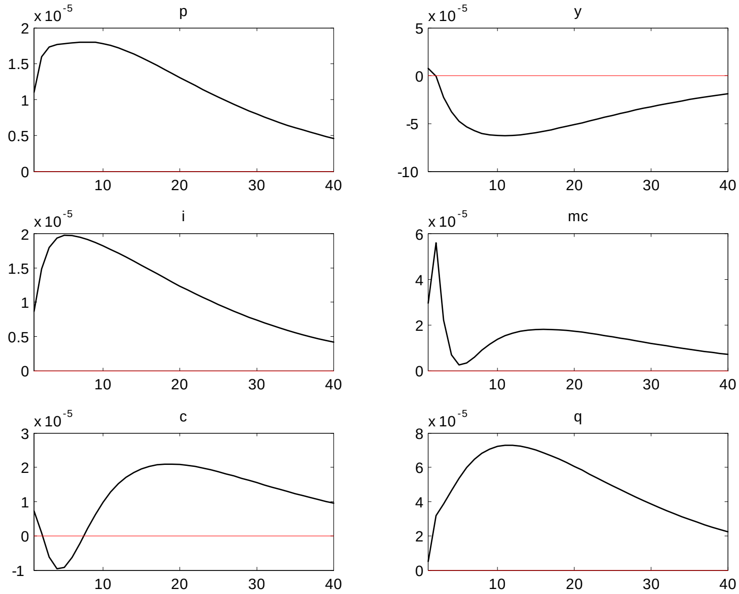


Figure 38: Impulse responses to a foreign real interest rate shock: The Philippines

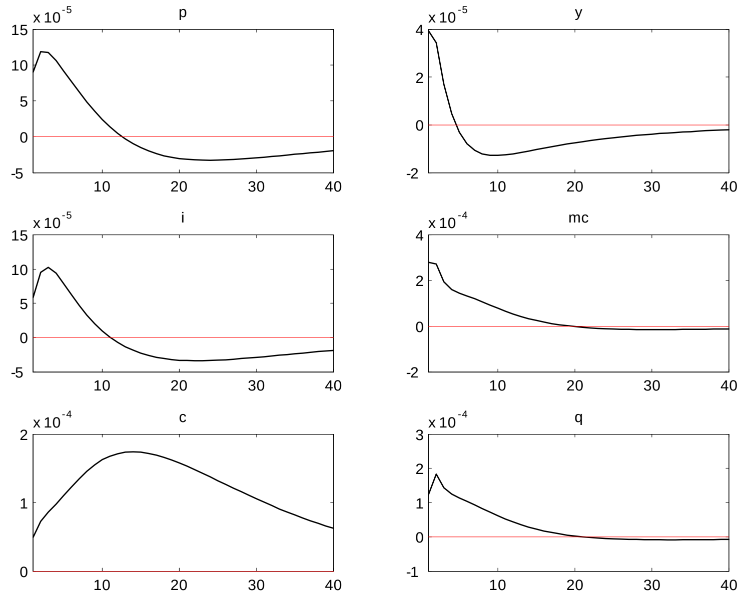


Figure 39: Impulse responses to a foreign real interest rate shock: Singapore

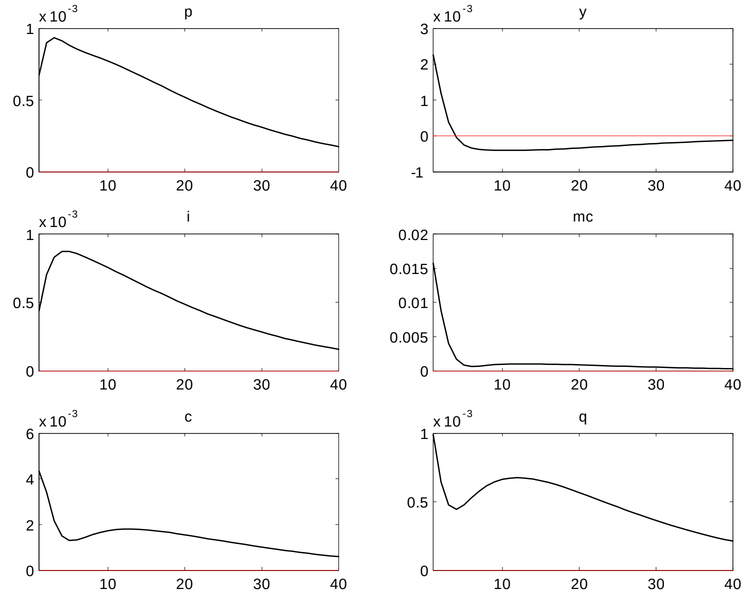
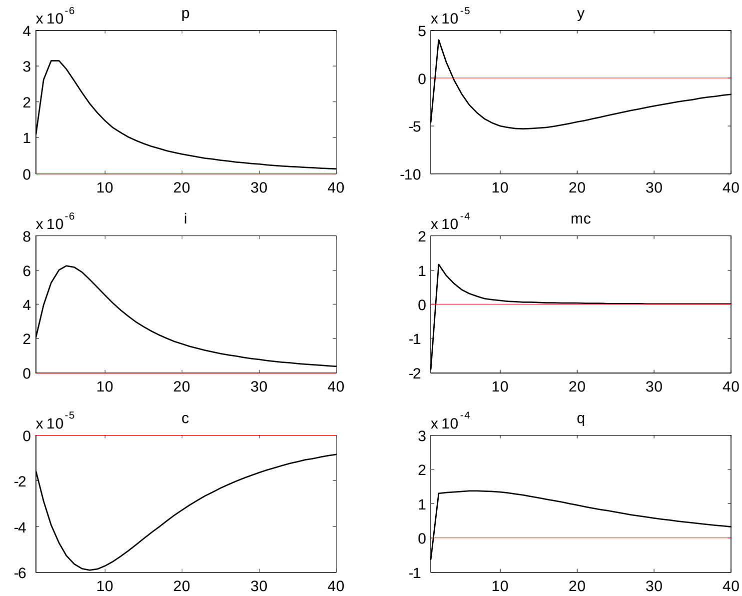


Figure 40: Impulse responses to a foreign real interest rate shock: Thailand



E Variance decompositions

Table 5: Variance decomposition of inflation (in per cent)

	Quarter	υ_t^b	υ_t^c	υ_t^q	υ_t^i	υ_t^ψ	$\upsilon_t^{y^*}$	$\upsilon_t^{r^*}$
Indonesia	1	95.98	2.56	0.38	1.08	0.00	0.00	0.00
	2	96.74	1.86	0.22	1.19	0.00	0.00	0.00
	3	96.94	1.62	0.16	1.28	0.00	0.00	0.00
	4	96.97	1.54	0.13	1.36	0.00	0.00	0.00
	8	96.82	1.51	0.11	1.55	0.00	0.00	0.00
	12	96.78	1.52	0.11	1.58	0.00	0.00	0.00
	20	96.78	1.52	0.11	1.58	0.00	0.00	0.00
	40	96.78	1.52	0.11	1.58	0.00	0.00	0.00
Malaysia	1	93.71	2.52	2.28	1.11	0.36	0.01	0.00
	2	96.39	1.21	1.07	0.95	0.37	0.01	0.00
	3	97.15	0.87	0.77	0.81	0.39	0.01	0.00
	4	97.43	0.75	0.66	0.73	0.43	0.01	0.00
	8	97.56	0.63	0.55	0.61	0.63	0.01	0.00
	12	97.37	0.61	0.54	0.60	0.87	0.01	0.00
	20	96.94	0.61	0.53	0.59	1.32	0.01	0.00
	40	96.15	0.60	0.53	0.58	2.13	0.01	0.00
Philippines	1	67.05	1.35	24.26	0.66	6.61	0.06	0.00
	2	74.20	3.34	13.23	0.30	8.88	0.05	0.00
	3	75.33	4.25	9.09	0.44	10.79	0.10	0.00
	4	75.40	4.11	7.13	0.61	12.58	0.16	0.00
	8	74.29	2.83	4.48	0.66	17.34	0.40	0.00
	12	73.68	2.40	3.81	0.57	19.05	0.49	0.00
	20	73.46	2.21	3.50	0.52	19.78	0.52	0.00
	40	73.45	2.18	3.45	0.52	19.87	0.52	0.00
Singapore	1	43.85	3.42	2.66	11.03	1.64	36.53	0.86
	2	46.76	2.88	1.42	8.57	1.71	37.68	0.98
	3	47.89	3.40	1.31	6.70	1.82	37.81	1.07
	4	48.94	3.34	1.20	5.55	1.98	37.82	1.18
	8	51.75	2.54	0.89	3.93	2.81	36.46	1.62
	12	52.99	2.27	0.79	3.51	3.70	34.72	2.02
	20	53.30	2.10	0.73	3.25	5.44	32.62	2.56
	40	51.47	1.99	0.69	3.07	9.04	30.86	2.88
Thailand	1	56.34	28.72	11.57	2.35	1.01	0.02	0.00
	2	66.11	21.38	7.85	3.17	1.48	0.01	0.00
	3	69.57	18.41	6.38	3.75	1.88	0.01	0.00
	4	70.63	17.20	5.78	4.17	2.22	0.01	0.00
	8	70.40	16.51	5.41	4.77	2.91	0.01	0.00
	12	70.29	16.48	5.40	4.80	3.02	0.01	0.00
	20	70.28	16.47	5.40	4.80	3.04	0.01	0.00
	40	70.28	16.47	5.40	4.80	3.05	0.01	0.00

Table 6: Variance decomposition of output gap (in per cent)

	Quarter	υ_t^b	υ_t^c	υ_t^q	υ_t^i	υ_t^ψ	$\upsilon_t^{y^*}$	$\upsilon_t^{r^*}$
Indonesia	1	18.60	71.30	0.01	9.97	0.01	0.12	0.00
	2	39.62	49.10	0.02	11.15	0.01	0.10	0.00
	3	56.72	33.56	0.03	9.61	0.01	0.07	0.00
	4	68.01	24.16	0.03	7.72	0.02	0.06	0.00
	8	83.31	12.36	0.03	4.24	0.03	0.04	0.00
	12	85.28	10.88	0.03	3.74	0.04	0.03	0.00
	20	85.43	10.73	0.03	3.69	0.08	0.03	0.00
	40	85.38	10.73	0.03	3.69	0.14	0.03	0.00
Malaysia	1	2.37	46.11	46.04	4.10	1.38	0.01	0.00
	2	16.07	38.67	39.35	4.66	1.23	0.02	0.00
	3	32.37	30.93	31.69	3.99	0.99	0.02	0.00
	4	44.23	25.45	26.11	3.32	0.87	0.02	0.00
	8	60.35	17.97	18.44	2.35	0.86	0.02	0.00
	12	62.61	16.85	17.29	2.20	1.03	0.02	0.00
	20	62.88	16.56	16.99	2.16	1.39	0.02	0.00
	40	62.47	16.44	16.87	2.15	2.05	0.02	0.00
Philippines	1	3.11	49.39	33.48	5.52	8.48	0.03	0.00
	2	5.17	45.41	30.78	7.34	10.98	0.32	0.00
	3	6.47	43.55	29.74	7.91	11.91	0.42	0.00
	4	7.25	42.67	29.26	8.06	12.30	0.45	0.00
	8	8.39	41.76	28.70	8.02	12.66	0.47	0.00
	12	8.67	41.58	28.58	7.99	12.70	0.48	0.00
	20	8.81	41.50	28.53	7.98	12.71	0.47	0.00
	40	8.83	41.49	28.52	7.97	12.71	0.47	0.00
Singapore	1	4.44	58.70	22.47	11.94	0.77	1.53	0.16
	2	4.52	57.20	23.26	12.78	0.72	1.35	0.18
	3	4.38	57.42	23.25	12.64	0.70	1.44	0.18
	4	4.54	57.16	23.10	12.52	0.69	1.82	0.18
	8	5.68	55.53	22.44	12.17	0.68	3.31	0.19
	12	6.24	54.89	22.18	12.03	0.68	3.78	0.20
	20	6.62	54.54	22.04	11.95	0.69	3.94	0.23
	40	6.72	54.44	22.00	11.93	0.72	3.94	0.25
Thailand	1	0.49	51.51	47.04	0.66	0.25	0.06	0.00
	2	1.15	51.19	46.24	1.00	0.36	0.06	0.00
	3	1.85	50.84	45.67	1.17	0.41	0.06	0.00
	4	2.48	50.53	45.26	1.26	0.42	0.06	0.00
	8	3.73	49.90	44.57	1.33	0.42	0.06	0.00
	12	3.94	49.79	44.46	1.33	0.42	0.06	0.00
	20	3.97	49.78	44.44	1.33	0.43	0.06	0.00
	40	3.97	49.78	44.44	1.33	0.43	0.06	0.00

Table 7: Variance decomposition of interest rate (in per cent)

	Quarter	υ_t^b	υ_t^c	υ_t^q	υ_t^i	υ_t^ψ	$\upsilon_t^{y^*}$	$\upsilon_t^{r^*}$
Indonesia	1	39.66	0.59	0.05	59.71	0.00	0.00	0.00
	2	63.74	0.88	0.06	35.32	0.00	0.00	0.00
	3	75.32	1.01	0.06	23.61	0.00	0.00	0.00
	4	80.56	1.07	0.06	18.32	0.00	0.00	0.00
	8	84.83	1.17	0.05	13.96	0.00	0.00	0.00
	12	84.91	1.19	0.05	13.85	0.00	0.00	0.00
	20	84.92	1.19	0.05	13.85	0.00	0.00	0.00
	40	84.92	1.19	0.05	13.85	0.00	0.00	0.00
Malaysia	1	74.56	7.24	6.79	10.44	0.96	0.01	0.00
	2	87.03	4.03	3.31	4.59	1.02	0.01	0.00
	3	91.32	2.70	2.10	2.82	1.05	0.01	0.00
	4	93.08	2.09	1.60	2.14	1.09	0.01	0.00
	8	94.47	1.48	1.13	1.51	1.42	0.00	0.00
	12	94.26	1.40	1.07	1.42	1.85	0.00	0.00
	20	93.49	1.37	1.05	1.40	2.70	0.00	0.00
	40	92.02	1.35	1.03	1.37	4.23	0.00	0.00
Philippines	1	12.34	17.75	20.44	41.48	7.97	0.03	0.00
	2	25.28	14.62	15.78	29.99	14.10	0.23	0.00
	3	35.19	11.46	12.25	22.76	17.94	0.41	0.00
	4	41.60	9.34	10.01	18.47	20.05	0.53	0.00
	8	51.31	6.22	6.68	12.30	22.79	0.69	0.00
	12	53.74	5.46	5.87	10.80	23.41	0.72	0.00
	20	54.91	5.12	5.50	10.12	23.63	0.73	0.00
	40	55.13	5.06	5.43	10.00	23.64	0.72	0.00
Singapore	1	8.80	52.46	20.79	12.35	1.00	4.34	0.26
	2	20.18	43.11	16.23	8.88	1.82	9.15	0.63
	3	29.72	34.20	12.76	6.89	2.44	13.02	0.98
	4	36.00	28.29	10.56	5.71	2.90	15.28	1.26
	8	45.98	19.44	7.25	3.94	4.34	17.04	2.01
	12	48.73	16.99	6.34	3.44	5.73	16.24	2.53
	20	49.33	15.37	5.73	3.12	8.39	14.92	3.15
	40	46.72	14.14	5.27	2.87	13.76	13.80	3.44
Thailand	1	12.91	2.27	0.65	83.84	0.33	0.00	0.00
	2	25.53	3.81	0.97	68.91	0.78	0.00	0.00
	3	35.35	4.80	1.09	57.48	1.27	0.00	0.00
	4	41.59	5.36	1.12	50.19	1.73	0.00	0.00
	8	48.14	6.07	1.06	41.75	2.99	0.00	0.00
	12	48.16	6.17	1.05	41.21	3.42	0.00	0.00
	20	48.09	6.17	1.04	41.15	3.54	0.00	0.00
	40	48.09	6.17	1.04	41.15	3.54	0.00	0.00

Table 8: Variance decomposition of marginal cost (in per cent)

	Quarter	υ_t^b	υ_t^c	υ_t^q	υ_t^i	υ_t^ψ	$\upsilon_t^{y^*}$	$\upsilon_t^{r^*}$
Indonesia	1	92.25	5.60	1.28	0.78	0.08	0.00	0.00
	2	93.52	4.50	1.02	0.83	0.13	0.00	0.00
	3	93.66	4.31	0.98	0.86	0.19	0.00	0.00
	4	93.62	4.29	0.97	0.87	0.25	0.00	0.00
	8	93.41	4.26	0.97	0.86	0.49	0.00	0.00
	12	93.21	4.25	0.96	0.86	0.72	0.00	0.00
	20	92.84	4.23	0.96	0.86	1.12	0.00	0.00
	40	92.11	4.19	0.95	0.85	1.89	0.00	0.00
Malaysia	1	60.58	18.21	17.91	1.62	1.66	0.02	0.00
	2	66.59	14.86	14.76	1.65	2.12	0.02	0.00
	3	67.94	14.00	13.91	1.61	2.52	0.02	0.00
	4	68.19	13.70	13.60	1.57	2.92	0.02	0.00
	8	67.50	13.29	13.19	1.53	4.48	0.02	0.00
	12	66.55	13.06	12.96	1.50	5.91	0.02	0.00
	20	64.86	12.72	12.62	1.46	8.33	0.02	0.00
	40	61.96	12.15	12.06	1.40	12.43	0.02	0.00
Philippines	1	6.45	28.99	36.60	3.24	24.17	0.55	0.00
	2	7.19	26.46	29.35	2.66	33.89	0.44	0.00
	3	7.11	24.13	25.80	2.37	40.20	0.39	0.00
	4	6.89	22.25	23.60	2.23	44.68	0.36	0.00
	8	6.39	18.45	19.54	1.90	53.43	0.30	0.00
	12	6.27	17.23	18.25	1.77	56.19	0.29	0.00
	20	6.23	16.65	17.63	1.71	57.49	0.28	0.00
	40	6.23	16.55	17.54	1.70	57.70	0.28	0.00
Singapore	1	9.80	44.96	23.39	9.14	2.75	9.84	0.13
	2	11.18	43.06	22.11	9.23	3.57	10.72	0.14
	3	11.48	42.48	21.54	8.95	4.34	11.07	0.14
	4	11.53	41.99	21.25	8.81	5.10	11.19	0.14
	8	11.31	40.56	20.52	8.52	7.91	11.04	0.13
	12	11.06	39.40	19.93	8.27	10.43	10.78	0.13
	20	10.57	37.48	18.96	7.87	14.71	10.27	0.13
	40	9.64	34.13	17.27	7.17	22.32	9.36	0.12
Thailand	1	27.36	48.19	23.62	0.61	0.19	0.04	0.00
	2	32.52	44.54	21.84	0.81	0.26	0.03	0.00
	3	33.68	43.69	21.42	0.88	0.30	0.03	0.00
	4	33.90	43.50	21.34	0.91	0.32	0.03	0.00
	8	33.92	43.46	21.32	0.93	0.34	0.03	0.00
	12	33.93	43.45	21.32	0.93	0.34	0.03	0.00
	20	33.93	43.45	21.32	0.93	0.34	0.03	0.00
	40	33.93	43.45	21.32	0.93	0.34	0.03	0.00

Table 9: Variance decomposition of consumption (in per cent)

	Quarter	υ_t^b	υ_t^c	υ_t^q	υ_t^i	υ_t^ψ	$\upsilon_t^{y^*}$	$\upsilon_t^{r^*}$
Indonesia	1	18.62	71.39	0.01	9.98	0.00	0.00	0.00
	2	39.64	49.16	0.02	11.17	0.01	0.00	0.00
	3	56.76	33.58	0.03	9.63	0.01	0.00	0.00
	4	68.08	24.15	0.03	7.74	0.01	0.00	0.00
	8	83.39	12.32	0.03	4.24	0.02	0.00	0.00
	12	85.37	10.83	0.03	3.73	0.03	0.00	0.00
	20	85.53	10.69	0.03	3.69	0.06	0.00	0.00
	40	85.48	10.68	0.03	3.69	0.11	0.00	0.00
Malaysia	1	3.32	64.49	2.19	5.73	24.27	0.01	0.00
	2	16.29	35.73	2.39	5.33	40.25	0.01	0.00
	3	28.49	20.46	1.82	3.69	45.52	0.01	0.00
	4	35.69	13.42	1.33	2.57	46.99	0.01	0.00
	8	38.82	6.02	0.62	1.17	53.37	0.00	0.00
	12	32.92	4.43	0.46	0.86	61.33	0.00	0.00
	20	24.32	3.17	0.33	0.62	71.56	0.00	0.00
	40	16.20	2.11	0.22	0.41	81.06	0.00	0.00
Philippines	1	5.15	81.81	2.14	9.14	1.63	0.13	0.00
	2	9.11	69.28	3.31	12.89	4.99	0.42	0.00
	3	11.72	60.09	3.81	13.98	9.57	0.82	0.00
	4	13.02	53.77	3.87	13.70	14.39	1.24	0.00
	8	13.33	42.15	3.31	11.32	27.58	2.31	0.01
	12	12.85	38.58	3.03	10.37	32.52	2.63	0.02
	20	12.59	36.91	2.90	9.92	34.94	2.71	0.04
	40	12.55	36.64	2.88	9.85	35.32	2.70	0.06
Singapore	1	3.19	42.17	8.98	8.58	17.17	19.80	0.12
	2	2.66	27.73	8.74	7.61	28.72	24.41	0.12
	3	2.06	22.43	7.33	6.13	37.50	24.44	0.11
	4	1.79	18.99	6.21	5.14	44.54	23.22	0.10
	8	1.54	12.14	3.97	3.29	61.36	17.63	0.07
	12	1.33	9.19	3.01	2.49	69.98	13.95	0.07
	20	1.00	6.40	2.09	1.73	78.83	9.87	0.07
	40	0.63	3.96	1.30	1.07	86.88	6.11	0.05
Thailand	1	0.92	97.70	0.02	1.24	0.13	0.00	0.00
	2	2.49	94.88	0.04	2.26	0.33	0.00	0.00
	3	4.67	91.52	0.08	3.10	0.64	0.00	0.00
	4	7.14	88.06	0.12	3.68	1.01	0.00	0.00
	8	14.69	78.14	0.20	4.36	2.61	0.00	0.00
	12	17.01	74.76	0.22	4.33	3.68	0.00	0.00
	20	17.43	73.72	0.22	4.29	4.34	0.00	0.00
	40	17.43	73.65	0.22	4.29	4.41	0.00	0.00

Table 10: Variance decomposition of real exchange rate (in per cent)

	Quarter	υ_t^b	υ_t^c	υ_t^q	υ_t^i	υ_t^ψ	$\upsilon_t^{y^*}$	$\upsilon_t^{r^*}$
Indonesia	1	4.70	18.02	74.57	2.52	0.00	0.20	0.00
	2	9.99	17.01	70.03	2.78	0.00	0.19	0.00
	3	14.37	16.24	66.53	2.68	0.00	0.18	0.00
	4	17.38	15.71	64.15	2.58	0.00	0.18	0.00
	8	20.82	15.12	61.37	2.52	0.01	0.17	0.00
	12	20.91	15.10	61.29	2.52	0.01	0.17	0.00
	20	20.92	15.10	61.28	2.52	0.01	0.17	0.00
	40	20.92	15.10	61.27	2.52	0.02	0.17	0.00
Malaysia	1	1.25	24.24	63.05	2.15	9.12	0.20	0.00
	2	7.50	21.09	53.55	2.13	15.54	0.19	0.00
	3	14.20	18.20	45.82	1.84	19.76	0.18	0.00
	4	18.80	16.10	40.44	1.63	22.87	0.17	0.00
	8	22.93	12.30	30.88	1.24	32.50	0.14	0.00
	12	21.25	10.70	26.87	1.08	39.97	0.13	0.00
	20	17.84	8.87	22.27	0.90	50.02	0.11	0.00
	40	13.65	6.78	17.03	0.69	61.77	0.08	0.00
Philippines	1	0.80	12.74	83.67	1.42	0.25	1.11	0.00
	2	0.85	15.00	81.23	1.39	0.45	1.08	0.00
	3	0.85	15.63	80.48	1.44	0.54	1.07	0.00
	4	0.86	15.76	80.24	1.51	0.57	1.06	0.00
	8	0.90	15.77	80.09	1.58	0.58	1.07	0.00
	12	0.91	15.77	80.06	1.58	0.59	1.08	0.00
	20	0.91	15.76	80.05	1.58	0.61	1.09	0.00
	40	0.91	15.76	80.05	1.58	0.61	1.09	0.00
Singapore	1	1.53	20.27	34.08	4.12	8.25	31.68	0.06
	2	1.31	18.74	27.27	3.66	13.17	35.79	0.06
	3	1.15	16.85	23.95	3.23	17.49	37.29	0.06
	4	1.10	15.36	21.78	2.94	21.30	37.47	0.06
	8	1.07	12.02	17.04	2.30	33.01	34.49	0.08
	12	1.00	10.26	14.54	1.96	41.35	30.78	0.11
	20	0.84	8.22	11.66	1.57	52.50	25.06	0.15
	40	0.61	5.88	8.34	1.13	65.95	17.95	0.15
Thailand	1	0.39	41.84	57.08	0.53	0.05	0.11	0.00
	2	0.82	41.59	56.66	0.72	0.11	0.11	0.00
	3	1.17	41.43	56.36	0.77	0.16	0.11	0.00
	4	1.42	41.32	56.16	0.78	0.20	0.11	0.00
	8	1.72	41.18	55.91	0.78	0.30	0.11	0.00
	12	1.72	41.17	55.89	0.78	0.33	0.11	0.00
	20	1.72	41.17	55.88	0.78	0.33	0.11	0.00
	40	1.72	41.17	55.88	0.78	0.33	0.11	0.00