The impacts of economic structures on the performance of simple policy rules in a small open economy

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THE IMPACTS OF ECONOMIC STRUCTURES ON THE PERFORMANCE OF SIMPLE POLICY RULES IN A SMALL OPEN ECONOMY

Abstract

Applying a stochastic dynamic general equilibrium model, the performance of various simple rules is analyzed in a small open economy context. The aspects that are considered in the analysis include the degree of exchange rate pass-through, trade openness, the policy objective and the source and persistency of shocks. The main objective of this analysis is to investigate if the rule reacts to exchange rate performs better than the basic closed economy rule without exchange rate term. Comparison on the performances is also made between the consumer inflation targeting and domestic inflation targeting rules. The results show that adding the exchange rate term to the policy rule enhances improvement especially in the higher pass-through case. The superior rule is the hybrid rule that reacts to the exchange rate term. CPI inflation targeting rules outperform the domestic inflation targeting rules in term of welfare loss. However, more complicated domestic inflation targeting rules generate lower loss in term of relative loss. On the second part of this chapter, comparisons on the performances of different exchange rate regimes are made under different source and persistency of shocks. The floating (pegged) regime is favored under more prominent real (nominal) shocks. The results suggest that emerging countries that experience very large real shocks should float their exchange rate.

1 Introduction

Should the policy reaction function in emerging market react to the exchange rate movements? Given that emerging market is financially unstable and vulnerable to shocks and leads a different economic structure from the closed economy, it is argued that the monetary policy reaction function in the small open economy should consider a direct role for the exchange rate.

The main reasons for such monetary policy are: first, monetary policy rule that contains the exchange rate term may internalize the total effects of policy adjustment on economy; second, this augmented rule improves the effectiveness of simple rule as it incorporates a faster adjustment of interest rate and exchange rate effects on inflationary impulse; third, it prevents the destabilizing effects of real shocks led by the exchange rate misalignment (Adolfson (2007)).

Contrary to this view, some economists and researchers hold the opposite view to prefer the policy rule without a direct exchange rate term. The explanations as mentioned in Taylor (2001) are: first, there is an indirect effect of exchange rate on inflation and output in the policy reaction function; second, the deviation of exchange rate from purchasing power parity such as productivity should not be offset through interest rate adjustments. Adjusting the changes in exchange rate may generate negative effects on real output and inflation.

Apart from the theoretical arguments, the results from the empirical studies are controversial as well. The issue regarding the role of exchange rate in the monetary policy framework for the open economies still open for debates. Focusing on the effects of exchange rate pass-through and trade openness in emerging market environment, this chapter seeks to compare the performances of various simple policy rules with the closed economy rule and if the augmented Taylor rules with exchange rate terms perform better compare to the other rules. Taking into account the economic characters for the emerging East-Asian countries, this chapter seeks to evaluate the role of exchange rate in the design of monetary policy for the emerging countries. This chapter applies two different approaches of analysis which divides it into two main parts. In the first part of this chapter, simulations are carried out to compare a battery of restricted optimized simple policy rules under different degrees of exchange rate pass-through and trade openness. For the robustness purpose, simulations are repeated by considering different persistency and variation of shocks and policy weighting. In the second part of this chapter, a different approach of analysis is conducted to evaluate the exchange rate regimes (flexible, managed floating and fixed exchange rate regimes). Simulations are based on several simple rules which represent different exchange rate regimes. Evaluations on the regimes are based on the source, the persistency and variation of shocks, given different cases of exchange rate pass-through. Evaluations are followed by robustness checking.

The results of simulations show that modifications on the baseline Taylor rule by adding the exchange rate terms and history dependence term (interest rate smoothing term or lagged inflation) improve the baseline rule. These rules perform better under higher exchange rate pass-through but the size of improvement could be smaller for the very high pass-through case when the economy is more open as the price distortion is smaller and the role of exchange rate in adjusting price is smaller under more open economy case. These results are robust under different policy weighting and persistency of shocks. The hybrid rule with exchange rate term outperforms all the other rules. On the other hand, the strict inflation targeting rule performs badly.

The remainder of this paper proceeds as follows. Section two discusses the role of exchange rate in the monetary policy framework. Section three presents the model and discusses the structures of different monetary policy rules. Section four is about the methodology and parameterization. Section five summarizes the main results of first approach. The last section concludes.

2 The role of exchange rate in the monetary policy

Emerging economies exhibit very different economic structures/ features compare to the developed economies. One of the main differences is that these economies are strongly affected by external shocks. This feature has been incorporating into the small open economy model, for instance the New Keynesian model and the New Open Economy Macroeconomic (NOEM) model setups. In the small open economy setup, the foreign sector and external shocks equations are added to the domestic sector counterpart. The monetary policy setup and the economic transmission mechanisms in the open economy also differ to that of the closed economy context.

According to Monacelli (2003), the closed and open economy models are not isomorphic to each other in which the inclusion of the incomplete pass-through in the open economy counterpart differentiates the analysis in its monetary policy from the closed economy counterpart. By allowing the incomplete exchange rate pass-through and deviations from the law of one price in the short-run, exchange rate plays an important role in the economic transmission and monetary policy assessment in the small open economy. Exchange rate can influence the domestic inflation directly through its impacts on import price or indirectly via aggregate demand which is affected by the change in the relative prices between the foreign and domestic goods. Aggregate demand affects inflation via aggregate supply. Due to the exchange rate effect on both aggregate demand and supply relations, the monetary authority in the open economy faces a trade-off between inflation and output variability.

Apart from these, exchange rate also adds to the monetary policy transmission channel in addition to the interest rate channel. As in the case of closed economy, a rise in a shock (for example demand shock) leads to the increase in the interest rate. However, unlike the case in the closed economy that the rise in interest rate does not affect inflation, the rise in interest rate in the open economy may lead to appreciation in exchange rate which may influence the inflation and output movements (Adolfson (2001)). This leaves the monetary authority in the trade-off between inflation and output variability. On the other hand, responding to the exchange rate movements may affect the inflation rate. Therefore, the monetary policy problem in the open economy is no more limited to the trade-off between inflation and output variability, but an additional trade-off between inflation and exchange rate targeting (Dobrynskaya (2008)).

2.1 The role of exchange rate in the monetary policy from different aspects

The role of exchange rate in the monetary policy framework and the effectiveness of a monetary policy are determined by the economic conditions and country specific factors. Among these factors include the degree of exchange rate pass-through and trade openness, the source and persistency of shocks. This section explains how these factors are relevant or link to the choice and effectiveness of monetary policy rule/ regime.

Exchange rate pass-through is the percentage change in the domestic/ imported prices led by a one percentage change in the exchange rate between the importer and exporter currency. Previous studies show that both the exchange rate pass-through and monetary policy rule/ regime are closely linked to each other. According to Dobrynskaya (2008), the optimal degree of intervention depends on the pass-through effect in an economy. In turn, pass-through effect is endogenous to the monetary policy, i.e. pass-through tends to be larger under no exchange rate management case. According to Devereux & Yetman (2009), if the incomplete pass-through is due to the stickiness in price, the degree of pass-through is likely to be determined by the stance of monetary policy such as the one suggested by Taylor (2000). Taylor argues that the decline in the exchange rate pass-through is endogenous to low inflation. Commitment to low inflationary pressure induces lower pass-through rate. In turn, low pass-through rate leads to lower mark-ups and less inflationary and continued low mark-ups. This view is supported by many empirical results, for example Choudhri & Hakura

(2006) and Bussière & Peltonen (2008). According to Devereux & Yetman (2009), the change in the exchange rate pass-through has important implications on the monetary policy stance due to three main reasons. First, the introduction of the partial pass-through feature in the open economy model provides analysis of monetary policy in the open economy which is fundamentally different from the one of a closed economy. Second, due to the deviations from the law of one price, incomplete pass-through generates a short-run trade-off in inflation and output stability. Third, the trade-off in the policy in the forward-looking setup implies different features in commitment and discretionary policy in which the discretionary policy is of sub-optimal.

There are many papers that investigate the implications of incomplete exchange rate pass-through on the monetary policy stance. These studies analyze the change in the degree of exchange rate pass-through due to the change in price stickiness and its implications on the welfare gain of different policy rules or the change in the inflation rate. Devereux et al. (2006) compare three types of policy rules, i.e. the fixed exchange rate, the CPI inflation targeting and the nontraded price targeting rules for an emerging market economy. They demonstrate that the degree of exchange rate pass-through matters in determining the ranking of policy rules. In the high pass-through case, stabilizing exchange rate induces the trade-off between inflation and output stability and the best rule is the nontraded price targeting rule. In the low pass-through case, the best rule is the CPI inflation targeting rule. The reason is when the pass-through is low, the exchange rate movement is not desirable as it no longer acts as an expenditure switching device and the trade-off disappears. Lower pass-through rate implies smaller role of exchange rate channel in transmitting policy and lower impacts of external shocks on domestic economy. In the case of partial pass-through, the response of optimal monetary policy to shock may imply different adjustments in aggregate supply. Adolfson (2001) demonstrates that the performance of a monetary policy rule can be improved marginally by including the exchange rate term in the policy rule. Accounting for the price stickiness and distribution of shocks in the exchange rate pass-through model, Devereux & Yetman (2009) find that exchange rate pass-through is positively correlated with average inflation. Flamini (2005) conducts an analysis on the effect of imperfect pass-through on optimal monetary policy in a new Keynesian small open economy model. The main finding is the type and the degree of pass-through determine the ability of a central bank to stabilize the short-run CPI inflation but not domestic inflation. Delayed pass-through reduces the effectiveness in monetary policy more than incomplete pass-through. The results favor for domestic inflation targeting in the case of incomplete and delayed pass-through as incomplete pass-through reduces the variability of economy with domestic inflation but turns out to increase the trade-off in monetary policy with CPI inflation targeting. The trade-off is larger the more the central bank is emphasized on CPI inflation relative to output stability.

There are many studies that examining how openness is related to the choice or performance of monetary policy. Wang (2005) finds significant correlation between the trade openness and the choice of fixed exchange rate regime. Kollmann (2004) finds higher welfare gain of a monetary union compare to the floating regime under higher openness case. Other studies reveal negative relationship between openness and inflation. The negative relationship is due to the dynamic inconsistency of optimal unrestricted discretionary monetary policy (Alfaro, 2002).

The degree of trade openness could be matter in determining the role of exchange rate in the monetary policy. Theoretically, a more open economy means higher exposure of domestic economy to foreign shocks. Hence, exchange rate plays a greater role in transmitting monetary policy under more open economy, analog to the case of higher pass-through rate (Adolfson (2001)).

The source of shocks is closely linked to the choice and performance of policy regimes. Exchange rate literatures tells us that floating regimes work more effectively in the presence of large external or real shocks as these regimes provide less costly adjustments through relative prices. On the other hand, fixed regimes work well in dealing with more prominent domestic or nominal shocks (Cavoli & Rajan (2003) and Calvo & Mishkin

(2003)). This implies that the nature of shocks is crucial in determining the performance of a policy regime. At the other end, the policy regimes could be matter in determining the transmissions and influences of shocks (Desroches (2004) and Hoffmaister et al. (1997)).

Apart from this, the source of shocks also matters in determining the role of exchange rate as a shock absorber. Exchange rate has a room for stabilizing and can act as a shock absorber only when an economy experiences asymmetric shocks compare to its trading partner (Artis & Ehrmann (2006)). Therefore, under the existence of asymmetric shocks, the cost of relinquish the exchange rate will be high. Using a sample of 38 developing countries, Hoffmann (2005) seeks to compare to what extent the exchange rate regimes matter in utilizing the role of exchange rate as a shock absorber. His results indicate that economies with floating exchange rate regimes tend to experience real exchange rate depreciation, hence more prominent role for the exchange rate to act as a shock absorber under floating regimes.

Previous studies show that emerging countries experience higher pass-through rate into domestic prices (Devereux et al. (2005)). The emerging East-Asian countries also exhibit higher trade openness over time. Higher openness induces greater aggregate volatility. Previous studies indicate that the rise in aggregate volatility due to the same size increase in trade openness in the developing countries is five times higher in that in the developed countries (Giovanni & Levchenko (2008)). These statements imply that emerging countries are weak to the exposure of external shocks. Therefore, the change in the economic structure such as the degree of exchange rate pass-through, trade openness and the source of shocks could be matter in determining the performance of monetary policy in these countries. Due to this condition, this chapter highlights the above aspects/ factors in evaluating the performances of various policy rules.

3 The model

For some exceptions, the model follows Lindé, Nessén & Söderström (2004). This model exhibits the habit formation in consumption, imperfect integration in financial market and gradual pass-through in exchange rate. Habit formation in consumption generates inertia in consumption and output and imperfect financial integration implies that there is a premium on foreign exchange.

The model assumes imperfect pass-through in the short-run where import price is sticky and producer faces quadratic adjustment cost when re-optimizing the price. However, deviations from the law of one price disappear and the pass-through is complete in the long-run. The model assumes a subset of firms re-optimizes prices while the others follow a rule of thumb in setting their prices.

The model applies here is a hybrid New Keynesian/ NOEM model. The basic blocks of the model consist of the aggregate demand/ IS curve, aggregate supply/ Phillips curve (domestic inflation, imported inflation and CPI inflation), UIP (uncovered interest parity) condition, net foreign assets and real profits equations, terms of trade equations (foreign and domestic), foreign sector equations, nominal and real exchange rate equations, exogenous shocks equations and monetary policy rule equations. The model is log-linearized around the steady state. All equations mentioned here are in log deviations from the steady state (with the exception of interest rate) and are denoted in lower case letters. All notations and equations mentioned below here are as indicated in Lindé, Nessén & Söderström (2004), otherwise it will be indicated.

3.1 Imperfect pass-through, terms of trade and real exchange rate

This model assumes the domestic residents consume both domestically produced goods and imported goods. Exchange rate pass-through is not perfect in the short run, implying deviations from the law of one price in the short run. The wedge between the two price levels can be captured in two different terms of trade, i.e. the domestic and foreign terms of trade.

Domestic terms of trade (τ_t) show the log linearized relative price between imported (p_t^m) and domestic goods (p_t^d):

$$\tau_t \equiv p_t^m - p_t^d$$

Foreign terms of trade (τ_t^f) show the logarithmic relative price between the domestically produced good and the imported good on the world market denoted in domestic currency:

$$\tau_t^f \equiv p_t^d - e_t - p_t^f ,$$

where e_t is the log nominal exchange rate and p_t^f is the log foreign currency price of imported good. Due to imperfect pass-through, the law of one price does not hold i.e. $p_t^m \neq p_t^f + e_t$ and the deviation from the law of one price (δ_t) is:

$$\delta_t = p_t^m - p_t^f - e_t = \tau_t + \tau_t^f$$

Given that the non-logarithmized CPI is a product of weighted log domestic and log imported price, the log terms of trade is correlated with the log real exchange rate (q_t):

$$p_t^c = (1-\omega_m) p_t^d + \omega_m p_t^m$$

$$q_t \equiv e_t + p_t^f - p_t^c = -\tau_t^f - \omega_m \tau_t$$

where ω_m denotes the import share in consumption and also the weight on imported inflation. The degree of exchange rate pass-through determines the movements in terms of trade. This effect later is transmitted to the real exchange rate and other economic variables.

3.2.1 Aggregate supply and Phillips curve

The inflation dynamic in this model is described by the hybrid Phillips curves or inflation equations which captures the forward- and backward-looking components. The forward- and backward-looking behaviors may reflect the learning effects, staggered contracts or other institutional arrangements (Garresten, Moons & Aarle (2005)).

There are two sets of firms in this model, i.e. the imported goods and the domestic goods sectors. Firms of imported goods sector import goods from the foreign market at given world prices. The goods are transformed into differentiated goods and are sold to be used for domestic consumption or as an input in production. Combining both domestic and imported inputs, firms in domestic sector produce differentiated goods to be sold to the domestic and foreign market.

The price setting behavior of firms when facing the quadratic adjustment cost (γ_j) is modeled as the minimization of the deviation of the expected log linearized price set ($\hat{p}_{t+s}^j$) from the optimal flexible price ($p_{t+s}^{opt,j}$):

$$\min_{p_t^{opt,j}} E_t \sum_{s=0}^{\infty} \beta^s \left\{ (p_{t+s}^{opt,j} - \hat{p}_{t+s}^j)^2 + \gamma_j (p_{t+s}^{opt,j} - p_{t+s-1}^{opt,j})^2 \right\} \qquad j=d,\, m$$

(*d* denotes domestic sector and *m* denotes import sector)

where the optimal flexible price is derived from the profit maximization process under the absence of adjustment costs. Only $(1-\alpha_j)$ fraction of firms re-optimizes prices. A fraction of α_j from domestic and import sectors are rule of thumb price setters by setting prices ($p_t^{rule,j}$) based on the aggregate price in previous period adjusted for its previous inflation rate.

$$p_t^{rule,j} = p_{t-1}^j + \pi_{t-1}^j , \qquad j=d,\, m$$

Both price setting behaviors determine the aggregate price and inflation for the domestic economy:

$$p_t^j = (1-\alpha_j)\, p_t^{opt,j} + \alpha_j\, p_t^{rule,j}, \qquad j=d,\ m$$

After some substitutions and solving procedures, the log-linearized version of Phillips curves/ inflation equations for the domestic economy can be written as:

$$\pi_t^d = b_{\pi 1} E_t \pi_{t+1}^d + b_{\pi 2} \pi_{t-1}^d + b_{\pi 3} \pi_{t-2}^d + b_y y_t + b_\tau \tau_t + u_t^\pi$$

$$\pi_t^m = c_{\pi 1} E_t \pi_{t+1}^m + c_{\pi 2} \pi_{t-1}^m + c_{\pi 3} \pi_{t-2}^m + c_\tau \left[\tau_t + \tau_t^f \right]$$

where π_t^d and π_t^m are domestic and imported inflation (both in log deviation from steady state) respectively. The composite parameters are given by:

$$b_{\pi 1} = \beta \gamma_d \Psi_d$$

$$b_{\pi 2} = \alpha_d (1 + 2\gamma_d + \beta \gamma_d) \Psi_d \qquad c_{\pi 2} = \alpha_m (1 + 2\gamma_m + \beta \gamma_m) \Psi_m$$

$$b_{\pi 3} = -\alpha_d \gamma_d \Psi_d \qquad c_{\pi 3} = -\alpha_m \gamma_m \Psi_m$$

$$b_y = \frac{\theta (1-\alpha_d)}{1-\theta} \Psi_d \qquad c_\tau = -(1-\alpha_m) \Psi_m$$

$$b_\tau = \kappa (1-\alpha_d) \Psi_d$$

$$c_{\pi 1} = \beta \gamma_m \Psi_m$$

$$\Psi_j = \left[\alpha_j + \gamma_j (1 + 2\beta \alpha_j) \right]^{-1}; \ j=d,\ m$$

where the notations for parameters are summarized in **Table A(3) in Appendix A** as in Lindé, Nessén & Söderström (2004).

The domestic inflation π_t^d depends on the expected future and previous domestic inflation rates, current output, terms of trades and inflation shock. On the other hand, the imported inflation π_t^m is determined by both future and previous imported inflation rate and the short-run price deviation i.e. $\delta = \tau_t + \tau_t^f \neq 0$. This hybrid Phillips curve captures the imperfect pass-through feature of East-Asian countries. The presence of import price stickiness c_τ implies that the domestic currency price cannot be fully adjusted under the exchange rate changes. This creates short-run deviations from the law of one price i.e. $\delta_t = \tau_t + \tau_t^f$. The price stickiness parameter (c_τ) depends on the adjustment cost (γ_j) and the fraction of rule of thumb price setters (α_j). When both parameters are relatively small, the price stickiness is weaker and thus exchange rate pass-through is higher or faster. The CPI inflation equation is a combination of domestic inflation and imported inflation.

$$\pi_t^c = (1-\omega_m) \pi_t^d + \omega_m \pi_t^m$$

The Phillips curves in this model are in hybrid form. Empirical studies show that hybrid Phillips curve matches the data better compared to the purely forward-looking and purely backward-looking Phillips curve. For instance, Christiano et al. (1998) in their VAR studies find that the purely forward-looking Phillips curve is unable to replicate the hump-shaped of impulse response functions. A backward-looking component is introduced to the forward-looking New Keynesian Phillips curve to create the persistence of inflation rate. For example, Altig et al. (2002) introduce the rule of thumb behavior of price setters in the New Keynesian model.

3.3 Aggregate demand and IS curve

As shown in Lindé, Nessén & Söderström (2004), this model assumes that households consume both bundles of domestic and import goods. The households' consumption today is affected by the past aggregate consumption behavior which is denoted by the habit preference parameter (*h*) where $0 \le h \le 1$ and intertemporal elasticity of substitution, $\sigma > 0$:

$$u\left(C_t^j\right)=\frac{\left(C_t^j-hC_{t-1}\right)^{1-\sigma}}{1-\sigma}$$

Household j maximizes her intertemporal utility by choosing the level of consumption, domestic bond holdings and foreign bond holdings.

$$\max_{C_t^j,B_t^j,B_t^{f,j}} E\sum_{k=0}^{\infty}\beta^k u\left(C_{t+k}^j\right) \qquad \text{s.t}$$

$$C_t^j+\frac{B_t^j}{(1+i_t)P_t^c}+\frac{\Xi_t B_t^{f,j}}{(1+i_t^f)\Phi(A_t)P_t^c}=\frac{B_{t-1}^j}{P_t^c}+\frac{\Xi_t B_{t-1}^{f,j}}{P_t^c}+\bar{X}_t^j$$

where B_t^j and $B_t^{f,j}$ are bonds denominated in the domestic and foreign currency respectively; i_t and i_t^f are the domestic and foreign interest rate repectively; P_t^c is the consumer price level; Ξ_t the nominal exchange rate and $\bar{X}_t^j$ the aggregate real profits of household *j*; $\Phi(A_t)=e^{-\phi A_t}$ is the premium to hold foreign bond which depends on the real aggregate net foreign asset in domestic economy $A_t=\frac{\Xi_t B_t^f}{P_t^c}$ (see (Lindé, Nessén & Söderström (2004)) for more details).

The utility maximization problem yields the Euler equation for consumption. After imposing some equilibrium conditions to the log-linearized Euler equation, the IS curve can be expressed as (Lindé, Nessén & Söderström (2004)):

$$\begin{aligned} y_t &= (1-a_y)y_{t-1}+a_yE_ty_{t+1}+a_r\left[i_t-E_t\pi_{t+1}^d\right]+a_{\tau1}\tau_{t-1}+a_{\tau2}\tau_t+a_{\tau3}E_t\tau_{t+1} \\ &\quad +a_{\tau f1}\tau_{t-1}^f+a_{\tau f2}\tau_t^f+a_{\tau f3}E_t\tau_{t+1}^f+a_{yf1}y_{t-1}^f+a_{yf2}y_t^f+a_{yf3}E_ty_{t+1}^f+u_t^y \end{aligned}$$

where lower case letters denote log deviation from the steady state. The composite parameters are given by:

$$a_y=\frac{1}{1+h} \qquad a_{\tau f1}=\frac{h\omega_x\eta}{1+h}$$

$$a_r=-\frac{(1-h)(1-\omega_x)}{(1+h)\sigma} \qquad a_{\tau f2}=-\omega_x\eta$$

$$a_{\tau1}=-\frac{h\eta\omega_m(1-\omega_x)}{1+h} \qquad a_{\tau f3}=\frac{\omega_x\eta}{1+h}$$

$$a_{\tau2}=-\frac{\omega_m(1-\omega_x)(1-h-\eta\sigma-h\eta\sigma)}{(1+h)\sigma} \qquad a_{yf1}=-\frac{h\omega_x\chi_f}{1+h}$$

$$a_{\tau3}=\frac{\omega_m(1-h-\eta\sigma)(1-\omega_x)}{(1+h)\sigma} \qquad a_{yf2}=\omega_x\chi_f$$

$$a_{yf3}=-\frac{\omega_x\chi_f}{1+h}$$

where the notations for parameters are summarized in **Table A(3) in Appendix A**. The hybrid IS curve combines both the forward- and backward-looking components in representing the goods market equilibrium. y_t denotes the domestic output, τ_t the domestic terms of trade, τ_t^f the foreign terms of trade, i_t the domestic short term nominal interest rate, y_t^f the foreign output and u_t^y the demand shocks. All variables except the interest rate are in logarithms form and are given in the form of deviation from the initial steady state.

The hybrid IS curve shows that the domestic output depends on its past output, the expected future output, the real interest rate, its past, current and expected future terms of trade, the past, current and expected future foreign terms of trade and also the past, current and expected future foreign output. The backward-looking component is the results of the 'habit formation' of household consumption while the forward-looking component is explained by the optimal consumption smoothing behavior of rational, intertemporally maximizing agents (Garrestsen, Moons & Aarle (2005)).

Literatures show that the hybrid IS curve matches the data better compare to the forward-looking IS curve (Mayer (2003) and Goodhart & Hofmann (2005)). Therefore, the backward-looking components are added to the forward-looking New Keynesian IS curve through two ways, i.e. through the rule of thumb consumption behavior (e.g. Gali & Gertler (1999)) and the habit formation in household's utility function (e.g. Ratto et al. (2005)). In this model, the backward-lookingness in IS curve is due to the habit formation of household.

3.4 Uncovered interest parity (UIP)

The uncovered interest parity (UIP) condition takes the following form as in Adolfson (2001):

$$E_t \Delta e_{t+1} = i_t - i_t^f + a_t \phi + u_t^e$$

where ϕ is the measurement for the intermediate cost in foreign bond market or risk premium; a_t as net foreign asset holdings in domestic market; u_t^e is the disturbance term. The UIP condition is derived from the household's maximization problem. It shows that the exchange rate adjustment depends on the relative difference rate of domestic interest rate and foreign interest rate, the impacts of risk premium (ϕ) on net foreign asset in domestic market (a_t) and the disturbance term or the exchange rate shock that follows the AR(1) process:

$$u_t^e = \rho_e u_{t-1}^e + \upsilon_t^e$$

3.5 Net foreign assets and real profits

The log-linearized version of the net foreign assets in the domestic market (a_t) is represented by the following equation:

$$a_t = d_a a_{t-1} + d_y y_t + d_x \overline{x}_t + d_\tau \tau_t + d_{\tau f} \tau_t^f + d_{yf} y_t^f$$

where $\overline{x}_t$ and y_t^f are the log-linearized real profit and log-linearized foreign demand respectively given that

$$d_a = \frac{1}{\beta}$$

$$d_y = -\frac{\Gamma_1}{\beta(1-\omega_x)\left[1+(1-\omega_m)\Gamma_1\right]}\Gamma_2^{(\theta-1)/\theta}$$

$$d_x = \frac{\Gamma_1}{\beta\left[1+(1-\omega_m)\Gamma_1\right]}\Gamma_2^{(\theta-1)/\theta}$$

$$d_\tau = \frac{\eta\omega_m\Gamma_1}{\beta\left[1+(1-\omega_m)\Gamma_1\right]}\Gamma_2^{(\theta-1)/\theta}$$

$$d_{\tau f} = -\frac{\eta\omega_x\Gamma_1}{\beta(1-\omega_x)\left[1+(1-\omega_m)\Gamma_1\right]}\Gamma_2^{(\theta-1)/\theta}$$

$$d_{yf} = \frac{\chi_f\omega_x\Gamma_1}{\beta(1-\omega_x)\left[1+(1-\omega_m)\Gamma_1\right]}\Gamma_2^{(\theta-1)/\theta}$$

and

$$\Gamma_1 \equiv \frac{\eta_m(1-\theta+\eta_d\theta)}{\eta_d\eta_m - \eta_m(1-\theta+\eta_d\theta)(1-\omega_m) - \omega_m\eta_d}$$

$$\Gamma_2 \equiv \frac{\eta_d}{(\eta_d - 1)(1-\theta)(1-\kappa)^{1-\kappa}\kappa^{\kappa}}$$

where the notations for parameters are summarized in **Table A(3) in Appendix A**. This equation shows that the net foreign asset hold by the domestic households depends on its last period value a_{t-1}, the foreign and domestic output or demand level, the foreign and domestic terms of trades and the real profit earned, $\overline{x}_t$.

As shown in Lindé, Nessén & Söderström (2004), the real profits equation $\overline{x}_t$ takes the following form:

$$\overline{x}_t = e_y y_t + e_\tau \tau_t + e_{\tau f}\tau_t^f + e_{yf} y_t^f$$

where

$$e_y = \frac{\eta_m - (\eta_m - 1)\omega_m}{\eta_m(1-\omega_x)} - \frac{\eta_d - 1}{\eta_d}\left[1 - \omega_m + \frac{1}{\Gamma_1}\right]$$

$$e_\tau = -\frac{\eta\omega_m}{\eta_m} - \frac{\kappa(\eta_d - 1)(1-\theta)}{\eta_d}\left[1 - \omega_m + \frac{1}{\Gamma_1}\right]$$

$$e_{\tau f} = \frac{(\eta_m - 1)\omega_m}{\eta_m} + \frac{\eta\omega_x\left[\eta_m - (\eta_m - 1)\omega_m\right]}{\eta_m(1-\omega_x)} - \frac{\eta}{\Gamma_1}$$

$$e_{yf} = -\frac{\chi_f\omega_x\left[\eta_m - (\eta_m - 1)\omega_m\right]}{\eta_m(1-\omega_x)} + \frac{\chi_f}{\Gamma_1}$$

The real profits of holding assets depend on both the foreign and domestic output level and terms of trades in both markets.

3.6 Foreign sector and exogenous shocks

In order to close the model, the behavioral equations for the foreign economy have to be specified. As East-Asian countries are small and open economies, they receive the impacts of shocks from the foreign economy exogenously. It is assumed that the foreign sector can be represented by AR(1) processes as in Adolfson (2001):

$$\begin{pmatrix} y_t^f \\ \pi_t^f \end{pmatrix} = \begin{pmatrix} \rho_y^f & 0 \\ 0 & \rho_\pi^f \end{pmatrix}\begin{pmatrix} y_{t-1}^f \\ \pi_{t-1}^f \end{pmatrix} + \begin{pmatrix} \sigma_{yf} & 0 \\ 0 & \sigma_{\pi f} \end{pmatrix}\begin{pmatrix} u_t^{yf} \\ u_t^{\pi f} \end{pmatrix}$$

$$(u_t^{yf}, u_t^{\pi f}) \sim N(0, I)$$

The shocks are uncorrelated zero mean i.i.d. disturbances with variance σ_{yf}^2 and $\sigma_{\pi f}^2$ respectively. The foreign interest rate is assumed to follow a simple Taylor rule:

$$i_t^f = \lambda_\pi^f \pi_t^f + \lambda_y^f y_t^f + u_t^{if}$$

where u_t^{if} is the foreign monetary policy shock with zero mean and variance σ_{if}^2. There are six shocks in this model: three domestic shocks (demand shock, exchange rate shock and cost-push/ inflation shock) and three foreign shocks (foreign demand shock, foreign cost-push shock and foreign monetary policy shock). The domestic shocks are assumed to follow AR(1) processes as in Adolfson (2001) where $u_t^j = \rho_j u_{t-1}^j + \upsilon_t^j$ with $0 \le \rho_j < 1$, $j = y, \pi, e$ and υ_t^j is white noise, $\upsilon_j \sim N(0, \sigma_j^2)$. The AR(1) processes for the domestic output, domestic cost-push and exchange rate shocksare as follows:

$$u_t^y = \rho_y u_{t-1}^y + \upsilon_t^y$$

$$u_t^\pi = \rho_\pi u_{t-1}^\pi + \upsilon_t^\pi$$

$$u_t^e = \rho_e u_{t-1}^e + \upsilon_t^e$$

3.7 Monetary policy rules

This section discusses the optimal simple rules and optimal rules with exchange rate and interest rate smoothing terms.

3.7.1 Optimal and simple rules

According to Rudebusch & Svensson (1998), there are two classes of policy rules: instrument and targeting rules. Optimal policy or the targeting rule determines the optimal policy responses given a set of objectives. It minimizes the objective loss function that deviates from a target variable.

The (unrestricted) optimal policy can be distinguished between discretion and commitment strategies (Garrestsen, Moons & Aarle (2005)). Under the commitment rule, the central bank is credible to set an optimal policy and the agents form expectations according to this rule. Under the discretion rule however, the central bank takes private expectations as given and re-optimizes the policy each period (Söderström (1999)).

As defined by Rudebusch & Svensson (1998), a simple rule or an explicit instrument rule is a monetary policy instrument based rule that reacts explicitly to available information. As this rule shows higher transparency and better communication to the public, it serves as a baseline rule for the comparison of actual policy. (Garrestsen, Moons & Aarle (2005)).

The (restricted) optimal simple rule is a sub-optimal rule which is subject to a conditional or restricted state variable set. Using the sub-optimal information set, this rule serves as a comparison to examine the optimal state-contingent rule’s performance (Dennis (2000)). This chapter focuses on the analysis of (restricted) optimal simple rules.

3.7.2 The formation/ setting of optimal simple rules

The model is closed by assuming a linear interest rate rule for the domestic small open economy. As in Wollmershäuser (2006), the simple rules take the constrained optimization. The minimization of the policy maker’s intertemporal loss function on a restricted state variable set can be written as:

$$\min_{\{i_t\}_{t=0}^{\infty}} E_0 \left[\sum_{t=0}^{\infty} \beta^t \left(\gamma_\pi (\pi_t^{CB})^2 + \gamma_y y_t^2 \right) \right]$$

subject to the state and evolution of the economy. Restrictions are imposed on the response coefficients to short-term interest rate. The weights on inflation and output are assumed to be γ_π and γ_y respectively. By normalizing γ_π to one, γ_y is the relative weight on output stabilization to inflation assigned by the society or central bank. The central bank can target on consumer/ CPI inflation or domestic inflation, i.e. $\pi_t^{CB} = \left\{ \pi_t^c, \pi_t^d \right\}$. However in the real world, most of the central bank target on core CPI inflation or headline CPI inflation.

As shown in Svensson (2003), the scaled intertemporal loss function can be written in the following way when the discount factor β is approaching unity.

$$\lim_{\beta\to 1}(1-\beta)E_0\left[\sum_{t=0}^{\infty}\beta^t\left(\gamma_\pi(\pi_t^{CB})^2+\gamma_y y_t^2\right)\right]=\gamma_\pi Var\left[\pi_t^{CB}\right]+\gamma_y Var\left[y_t\right]$$

A short-run interest rate rule is used by the central bank as a policy instrument in order to minimize the loss function. Meanwhile, the domestic economy is assumed to follow a Taylor simple rule. This policy rule can be regarded as a closed economy rule as it does not react directly to the exchange rate movements.

TR: Taylor rule

$$i_t = \lambda_\pi \pi_t^{CB} + \lambda_y y_t$$

where λ_π is the weight for CPI or domestic inflation, i.e. $\pi_t^{CB} = \left\{\pi_t^c, \pi_t^d\right\}$ and λ_y is the policy reaction's weight on output (y_t). The policy maker is concerned about both inflation (CPI or domestic) and output stability.

This rule is used as a baseline rule for comparisons. This rule is compared with (i) simple rules with exchange rate terms (rule TRE1 and TRE2); (ii) history dependent rules (TRH) including the interest rate smoothing rule (TRS), interest rate smoothing rule with exchange rate term (TRSE) and history dependent with exchange rate term (TRHE); (iii) forecast based inflation targeting rules (FBT), i.e. Taylor rule with forward-looking term (TRF) and with exchange rate term (TRFE) and (iv) strict inflation targeting rule (SIT). These rules take the following forms:

TRE1: TR with the change in nominal exchange rate

$$i_t = \lambda_{\pi 1}\pi_t^{CB} + \lambda_{y1} y_t + \lambda_{\Delta e}\Delta e_t$$

TRE2: TR with the change in real exchange rate

$$i_t = \lambda_{\pi 1}\pi_t^{CB} + \lambda_{y1} y_t + \lambda_{\Delta q}\Delta q_t$$

TRS: TR with smoothing term

$$i_t = (1-\rho_i)(\lambda_{\pi 1}\pi_t^{CB} + \lambda_{y1} y_t) + \rho_i i_{t-1}$$

TRSE: TRS with exchange rate term

$$i_t = (1-\rho_i)(\lambda_{\pi 1}\pi_t^{CB} + \lambda_{y1} y_t + \lambda_{\Delta q}\Delta q_t) + \rho_i i_{t-1}$$

TRH: TR with history dependent term (backward term in inflation)

$$i_t = \lambda_{\pi 1}\pi_t^{CB} + \lambda_{y1} y_t + \lambda_{\pi 2}\pi_{t-1}^{CB}$$

TRHE: TRH with exchange rate term

$$i_t = \lambda_{\pi 1}\pi_t^{CB} + \lambda_{y1} y_t + \lambda_{\pi 2}\pi_{t-1}^{CB} + \lambda_{\Delta q}\Delta q_t$$

TRF: TR with forward-looking term in inflation

$$i_t = \lambda_{\pi 1}\pi_t^{CB} + \lambda_{y1} y_t + \lambda_{\pi 2}E_t\pi_{t+1}^{CB}$$

TRFE: TRF with exchange rate term

$$i_t = \lambda_{\pi 1}\pi_t^{CB} + \lambda_{y1} y_t + \lambda_{\pi 2}E_t\pi_{t+1}^{CB} + \lambda_{\Delta q}\Delta q_t$$

TRHI: Hybrid TR (forward and backward term in inflation)

$$i_t = \lambda_{\pi 1}\pi_t^{CB} + \lambda_{y1} y_t + \lambda_{\pi 2}E_t\pi_{t+1}^{CB} + \lambda_{\pi 3}\pi_{t-1}^{CB}$$

TRHIE: TRHI with exchange rate term

$$i_t = \lambda_{\pi 1}\pi_t^{CB} + \lambda_{y1} y_t + \lambda_{\pi 2}E_t\pi_{t+1}^{CB} + \lambda_{\pi 3}\pi_{t-1}^{CB} + \lambda_{\Delta q}\Delta q_t$$

SIT: Strict inflation targeting rule

$$i_t = \lambda_{\pi 1}\pi_t^{CB}$$

where $\lambda_{\Delta e}$ or $\lambda_{\Delta q}$ are the weights for exchange rate (the change in nominal exchange and the change in real exchange rate); $\lambda_{\pi 1}$, $\lambda_{\pi 3}$ and $\lambda_{\pi 3}$ are the weights on inflation (CPI or domestic) and λ_{y1} is the weight on output. ρ_i is the coefficient for the interest rate smoothing term.

Since the introduction of Taylor rule, many studies have proposed different modifications to the structure of this rule in order to improve the performance of this rule when applying it to the open economy context. However, the results are quite controversial. The augmented Taylor rules with exchange rate terms are included in this analysis as many studies show that adding the exchange rate terms to the simple rules help to improve the performances of the rules (for example Ball (1999), Senay (2001) and Wollmershäuser (2006)). A number of empirical studies also show that the short-run interest rate in some countries reacts to the exchange rate terms (for example Brischetto and Voss (1999) and Mohanty & Klau (2005)). On the other hand, other studies show the opposite or mixed outcomes (for example Côté et. al. (2002) and Taylor (1999)).

Besides comparing the simple Taylor rule with the rules that react to the exchange rate terms, this chapter also includes comparison of the policy rules with smoothing term. Literatures show that interest rate smoothing term is preferred in the analysis of monetary policy rules for several reasons. For instant, Mayer (2004) and Sack & Wieland (1999) claim that the interest rate smoothing term should include in the Taylor rule as it reflects the real or observable fact that the policy maker adjusts the interest rate gradually to the desired level. The preference to gradual adjustment behavior can be explained by three types of uncertainties faced by the policy maker, i.e. the model uncertainty, parameter uncertainty and data uncertainty. On the other hand, Woodford (2002) claims that interest rate smoothing rule outperforms the other rules in stabilizing inflation and output gap without requiring variation of interest rate. Other studies, for example Côté & Lam (2001) compare various simple rules using the vector error correction forecasting model for the Canadian economy. Their results show that the interest rate smoothing rule dominates the other rules by minimizing the volatility of output, inflation and interest rate. The reason for a better performance of this rule as explained in Levin, Wieland & Williams (1998) is that this rule enables policy makers to have greater control over the long term interest rate and thereby it has greater influence over the aggregate demand and inflation. On the other hand, Côté et al. (2002) show that interest rate smoothing rules perform poorly in most models. The reason is exchange rate acts as a stabilizer and shock absorber. Smoothing the fluctuations in exchange rate interferes with the adjustment process, hence causing more volatility in output and inflation.

The history dependent rules and the rules with forecast term are also included in this analysis as previous studies show that these rules outperform the standard Taylor rule. For example, many studies show that the restricted history dependent rules outperform the standard Taylor rule (for instance Levin, Wieland & Williams (1998), Kimura & Kurozumi (2002) and Wohltmann & Winkler (2008)). On the other hand, the rules with forecast terms only perform slightly better relative to the standard rules (Levin, Wieland & Williams (1998)).

Monetary policy literatures show that flexible inflation targeting is preferable over the strict inflation targeting as flexible inflation targeting allows the monetary authorities maintain stability in both inflation and output. In contrast, strict inflation targeting lead to larger output volatility. According to Svensson (1998), strict inflation targeting requires activism in monetary, i.e. achieving inflation stabilization at a relatively short horizon. This generates higher variability in macro variables other than inflation.

3.8 Two highlights – exchange rate pass-through and trade openness

In particular, this study seeks to investigate the effects of exchange rate pass-through and trade openness in the small open economy. In order to get different degrees of exchange rate pass-through and trade openness, the values of parameters are adjusted accordingly. These parameters include the adjustment cost in import sector (γ_m), the fraction of producer in import sector that are rule of thumb price setters (α_m), the share of imports in inputs (κ), the share of imports in consumption (ω_m) and the share of exports in domestic production (ω_x). Following the idea of Adolfson (2001), the first two parameters are adjusted to generate different degrees of exchange rate pass-through while the remaining three parameters are adjusted for the degrees of trade openness[1].

The increase in the adjustment cost and fraction of rule of thumb price setters in import sector induces higher price stickiness in import sector and hence lower pass-through of exchange rate into domestic economy. The intuition is higher adjustment cost discourages (imported sector) firms to re-optimize prices or re-optimize prices less often. On the other hand, higher fraction of firms set prices based on the rule of thumb means prices are more sticky as more and more firms set prices to the previous price level and hence pass-through is low. Both parameters determine the degree of exchange rate pass-through in domestic economy. The analysis of the effects of exchange rate pass-through in this study is based on the percentage change in import prices caused by an unidentified shock to the exchange rate. The degree of exchange rate pass-through can due to a 'genuine' exchange rate or by other economic disturbances (Adolfson (2001)). In this model, it is assumed that the incomplete pass-through is caused by nominal rigidities and the related structural parameter that determine the price stickiness. Following Adolfson (2001), the degree of exchange rate pass-through is constructed through partial derivative of import price equation with respect to the exchange rate, assuming that the expected future inflation is zero.

$$\pi_t^m = c_{\pi 1} E_t \pi_{t+1}^m + c_{\pi 2} \pi_{t-1}^m + c_{\pi 3} \pi_{t-2}^m + c_\tau \left[\tau_t + \tau_t^f \right]$$

$$p_t^m - p_{t-1}^m = c_{\pi 2} \pi_{t-1}^m + c_{\pi 3} \pi_{t-2}^m + c_\tau [p_t^m - p_t^f - e_t]$$

$$p_t^m (1 - c_\tau) = c_{\pi 2} \pi_{t-1}^m + c_{\pi 3} \pi_{t-2}^m + c_\tau [- p_t^f - e_t] + p_{t-1}^m$$

$$p_t^m = \frac{1}{1 - c_\tau} \left[c_{\pi 2} \pi_{t-1}^m + c_{\pi 3} \pi_{t-2}^m + c_\tau [- p_t^f - e_t] + p_{t-1}^m \right]$$

$$\frac{\partial p_t^m}{\partial e_t} = \frac{-c_\tau}{1 - c_\tau} = \frac{c_\tau}{c_\tau - 1} \quad \text{(exchange rate pass-through)}$$

where $c_\tau = -(1 - \alpha_m) \Psi_m$ with $\Psi_m = \left[\alpha_m + \gamma_m (1 + 2\beta \alpha_m) \right]^{-1}$

In order to investigate the effects of different degrees of exchange rate pass-through and trade openness, the values of parameters are adjusted as below:

Table 1:Degrees of exchange rate pass-through (ERPT)

	γ_m	α_m	ERPT= $\frac{c_\tau}{c_\tau - 1}$
Case I: low PT	0.7	0.7	0.1123
Case II: medium PT	0.3	0.3	0.4735
Case III: high PT	0.1	0.1	0.8037

Notes: Exchange rate pass-through (ERPT) is constructed from the Philips curve equation through the partial derivative of import price goods with respect to the exchange rate, assuming that the expectations of the future inflation are zero and discount rate β =0.99

Table 1 displays three different degrees of exchange rate pass-through by setting different values for γ_m and α_m. For simplicity, both parameters assume to take the same value and change at the same rate. However in reality, both parameters may have different values and do not necessarily increase or decrease at the same rate. This analysis only considers the case where both parameters increase or decrease simultaneously but does not consider the case where both parameters move at the opposite directions. It is reasonable to assume both parameters to move at the same direction as it is likely that the increase in the

[1] In Adolfson (2001), the exchange rate pass-through is determined by one parameter only, i.e. the adjustment cost in import sector as her model does not exhibit the rule of thumb price setting behavior.

adjustment cost (γ_m) may induce more firms to change their price setting behavior to rule of thumb price setters in order to avoid the drop of production due to the increase of price and to maintain the market competitiveness.

Countries specific dataset (see **Table 2(a)**) show that East-Asian countries have different degrees of trade openness. Malaysia and Singapore have higher trade openness (which exceeds one) while the other countries such as Indonesia, Korea and Philippines have lower trade openness (below one)[2]. To see if trade openness matters in determining the economics achievement and the policy performance, the values of parameters for κ (fraction of imported intermediate goods for production), ω_m (fraction of imported goods for consumption) and ω_x (fraction of domestic production goods that export to foreign market) are adjusted accordingly. These three parameters determine the degree of trade openness. Countries specific data show that the value for ω_m is very low, consistent to the low imported goods for consumption in East-Asia. The value for κ is higher relative to the other two parameters as East-Asian countries import relatively high fraction of intermediate goods for production (see **Appendix A, Table A(1, 2a and 2b)**). This study considers two cases of trade openness. **Table 2(b)** shows that in the first case, the domestic economy has lower trade openness (as indication for pre-crisis period condition or for those countries with lower trade openness). In the second case, the domestic economy is very open (could be the possible condition for the post-crisis period or for countries that are more open)[3].

Table 2(a): Trade openness, 1990-2006

Countries	1990	1995	1997*	1998*	2000	2005	2006
Indonesia	0.4152	0.4257	0.4409	0.7982	0.5796	0.4996	0.4439
Korea	0.2976	0.4296	0.5107	0.6489	0.6504	0.7728	0.7984
Malaysia	1.34332	1.7051	1.5679	1.8171	1.9212	1.8631	1.8680
Philippines	0.4461	0.5636	0.6668	0.7749	0.8877	0.9686	0.9192
Singapore	3.1324	2.8134	2.7697	2.6852	2.7312	3.4645	3.6847
Thailand	0.6349	0.6907	0.7037	0.7884	0.8890	1.1828	1.2972

Notes: All the data are obtained from Asia Development Bank (ADB) key indicators, 2007

Table 2(b): Degrees of trade openness

	κ	ω_m	ω_x
Case (A): low openness	0.45	0.10	0.25
Case (B): high openness	0.60	0.30	0.40

4 Methodology and parameterization

There is no close way to solve the model. The model has to be solved using the numerical simulations. The optimization procedure is based on the generalized Schur decomposition proposed by Sims (1995) and Klein (1997) as summarized in **Appendix B**. For further details of this method, see Söderlind (1999).

Before running the simulations, all the relevant equations are listed. In sum, this model consists of 18 equations and can be summarized as follows:

(1) $$\pi_t^d = b_{\pi 1} E_t \pi_{t+1}^d + b_{\pi 2}\pi_{t-1}^d + b_{\pi 3}\pi_{t-2}^d + b_y y_t + b_\tau \tau_t + u_t^\pi$$

(2) $$\pi_t^m = c_{\pi 1} E_t \pi_{t+1}^m + c_{\pi 2}\pi_{t-1}^m + c_{\pi 3}\pi_{t-2}^m + c_\tau \left[\tau_t + \tau_t^f\right]$$

[2] Trade openness is defined as the total import and export of goods over the total GDP (see Table I-A(5) In Appendix I-A, Chapter Two).

[3] The degree of trade openness indicated here is for general condition for East-Asia but it may not able to represent the trade openness condition for all individual countries. The fraction of imported goods for consumption is very low (about 10%) for both pre- and post-crisis periods. It is set to be 0.30 in case B in order to capture the effects of larger degree of openness in simulations.

(3) $\pi_t^c = (1-\omega_m)\pi_t^d + \omega_m \pi_t^m$

(4) $y_t = (1-a_y)y_{t-1} + a_y E_t y_{t+1} + a_r \left[i_t - E_t \pi_{t+1}^d \right] + a_{\tau 1}\tau_{t-1} + a_{\tau 2}\tau_t + a_{\tau 3}E_t \tau_{t+1}$

$+ a_{\tau f1}\tau_{t-1}^f + a_{\tau f2}\tau_t^f + a_{\tau f3}E_t \tau_{t+1}^f + a_{yf1}y_{t-1}^f + a_{yf2}y_t^f + a_{yf3}E_t y_{t+1}^f + u_t^y$

(5) $E_t \Delta e_{t+1} = i_t - i_t^f + a_t \phi - u_t^e$

(6) $a_t = d_a a_{t-1} + d_y y_t + d_x \overline{x}_t + d_\tau \tau_t + d_{\tau f}\tau_t^f + d_{yf} y_t^f$

(7) $\overline{x}_t = e_y y_t + e_\tau \tau_t + e_{\tau f}\tau_t^f + e_{yf} y_t^f$

(8) $i_t = \lambda_\pi \pi_t^c + \lambda_y y_t$

(9) $i_t^f = \lambda_\pi^f \pi_t^f + \lambda_y^f y_t^f + u_t^{if}$

(10) $y_t^f = \rho_y^f y_{t-1}^f + u_t^{yf}$

(11) $\pi_t^f = \rho_\pi^f \pi_{t-1}^f + u_t^{\pi f}$

(12) $u_t^y = \rho_y u_{t-1}^y + \upsilon_t^y$

(13) $u_t^\pi = \rho_\pi u_{t-1}^\pi + \upsilon_t^\pi$

(14) $u_t^e = \rho_e u_{t-1}^e + \upsilon_t^e$

(15) $\tau_t = p_t^m - p_t^d$

(16) $\tau_t^f \equiv p_t^d - e_t - p_t^f$

(17) $\Delta q_t = q_t - q_{t-1}$

(18) $q_t = -\tau_t^f - \omega_m \tau_t$

The model is written in a state space representation form and is solved numerically (see **Appendix B)**. Before running the simulations, we need to give values to the parameters, either through calibration or estimation. In this chapter, there is no attempt to estimate parameters but the values of parameters are determined through calibrations and observations on dataset of East-Asian countries. The parameterizations applied in previous studies in the small open economy are quite different, depending on the belief and interpretation of researchers based on a general or specified economy's condition. The parameterizations applied in this chapter are based on the general case for crisis-hit East-Asian countries as a whole. Therefore, the parameterizations may not fully represent the economic conditions for the individual East-Asian countries.

Three parameters are set based on the data of East-Asian economies. These parameters include κ (share of imports in inputs), ω_m (share of imports in consumption) and ω_x (share of exports in domestic production). Following the idea of Lindé, Nessén & Söderström (2004), the value for κ is set by observing the data on imported inputs as percentage of total inputs in the producer and import stages. The value for ω_m is referred to the data of average share of imported inflation in core inflation and ω_x is referred to the data of average export share of GDP. In this study, the value of ω_x is defined as in Lindé, Nessén & Söderström (2004), and the data is obtained from the Asian Development Bank (ADB), 1989-2006, (see **Appendix A, Table A(1)**). The value for ω_x is set to be 0.25 as the approximately value of ω_x for most of the East Asian countries (with Malaysia and Singapore as exceptions) for the periods of 1989-1996 (before crisis). The value of ω_x has increased in the post-crisis period. The data for κ and ω_m are referred to the report of RIETI-TID (2005) on the component of imports for Asian (**see Appendix A, Table A(2a &**

2b)). The values for κ and ω_m are approximately set to be 0.45 and 0.10 respectively. Later, these values are adjusted to generate higher degree of trade.

Table 3: Parameterization

Policy preference	**Supply relation**	**Demand relation**	**Foreign Taylor rule**	**Shock persistence**	**Standard error of shocks**
γ_y =0.5 γ_π =1.0	γ_m =0.1, 0.3, 0.7 α_d =0.5 α_m =0.1, 0.3, 0.7 γ_d =5 ω_m =0.10, 0.3 κ =0.45, 0.60 θ =0.46	η =0.9 η_m =5 η_d =5 σ =1.2 β =0.99 ω_x =0.25, 0.4 h=0.8 χ_f =0.9 ϕ =0.10	λ_π^f =1.5 λ_y^f =0.5	ρ_π =0.7 ρ_y =0.7 ρ_i^f =0.7 ρ_y^f =0.7 ρ_π^f =0.7 ρ_e =0.7	σ_π =0.3 σ_y =0.3 σ_{yf} =0.3 $\sigma_{\pi f}$ =0.3 σ_{if} =0.3 σ_e =0.3

The remaining values of parameters are unobservable and the calibrations are based on the assumption and interpretation of authors. The calibrations applied here are based on the literature of small open economies. The value of import price stickiness (γ_m) and the fraction of producer in import sector that uses the rule of thumb as the pricing strategy (α_m) are essential in the determination on the degree of exchange rate pass-through. Empirical studies show that the degree of exchange rate pass-through differs across countries and over time. The results of Chapter Two show that East-Asian countries exhibit different degrees of exchange rate pass-through and pass-through does not decline in all countries. In order to consider different degree of exchange rate pass-through condition for East-Asian countries, these values are adjusted to generate three different degrees of exchange rate pass-through: the low, medium and high degrees of exchange rate pass-through (see **Table 1**). As empirical studies show that pass-through into import price is highest but that of producer and consumer prices are low, the domestic price stickiness γ_d is assumed to be 5 which is higher than the price stickiness in import sector[4]. The fraction of producer in the domestic sector that applies the rule of thumb in their pricing strategy is assumed to be 0.5, the value that assigned for the small open economy context (for example Flamini (2005) and Justiniano & Preston (2004)). Focusing the analysis in the case of South Korea, Elekdag et al. (2005) set the prior value for this parameter to be 0.6 and report the posterior value of 0.51. Following Cook & Devereux (2006b) who focus the study in crisis-hit East-Asian countries, the discount factor β is set to be 0.99, implying an annualized real interest rate of 4%.

Previous studies report different values for the parameter of elasticity of substitution in multi-goods sectors. Cook and Devereux (2006a) assign the elasticity of substitution between traded and non-traded goods to be 0.66, between imported materials and domestic value added as 0.7 and between domestic goods and imports to be 0.6 in their studies in three East-Asian countries. Cook & Devereux (2006b) set the elasticity of substitution between individual retail goods to be 7.666 to capture the steady state mark-up of 1.15 for the case of East-Asian countries. Elekdag et al. (2005) normalize the elasticity of substitution between domestic and imported goods to be unity in the case study of South Korea. Devereux et al. (2005) assign the value of unity to the elasticity of substitution between traded and non-traded in the analysis of emerging economies.

Taking the value between 0.7 (as in Cook & Devereux (2006a)) and 1 (as in Elekdag et al. (2005)), the value for η or the elasticity of substitution between home and foreign

[4] Adolfson (2001) assigns this parameter to be 10 in her simulations.

goods is set equal to 0.9. A high value of η implies that the domestic output gap is very sensitive to terms of trade movements. Gali & Monacelli (2005) set this parameter to unity. Reducing the value for this parameter does not affect the main findings of analysis. The values for η_m and η_d indicate the mark-up in domestic sector and import sector. These parameters take different values, depending on the model structure and assumptions of authors. Focusing the analysis in Thailand, Tanboon (2008) sets 1.20 to the mark-up for domestic sector. Sutthasri (2007) empirically calculates and shows that the range for this parameter is within 1.13 to 1.32 for Thailand. In this chapter, both η_m and η_d are assumed to share the same value of 5 which implies the mark-up for imported and domestic sectors ($\frac{\eta_m}{1-\eta_m}$ and $\frac{\eta_d}{1-\eta_d}$) of 1.25 which is slightly higher than 1.2, the mark-up in OECD countries in the literature (Choudhri (2005)). Reducing the mark-up for both sectors (i.e. increasing the value of η_m and η_d) does not change the main results of analysis.

Following Lindé, Nessén & Söderström (2004), relative risk aversion, σ takes the value of 1.2. The same value also assigned in Justiniano & Preston (2004) for the small open economy analysis. Elekdag et al. (2005) report the posterior value of 1.67 for this parameter in the case of South Korea when setting the prior value of 3 to this parameter. This value is consistent to the results of Eichenbaum et al. (1988) who found the values of 0.5-3 for this parameter. Barsky et al. (1987) and Hall (1988), on the other hand, suggest the values greater than 5. Testing with different values, Choudhri (2005) finds that this parameter does not generate large variations in the outcomes.

The parameter for technology θ is set equal to 0.46, the values set for the small open economy in literature (for example Lindé, Nessén & Söderström (2004) and Adolfson (2001)). The habit formation parameter, h is assumed to be 0.8 as in Flamini (2004). This value is consistent to the value assigned in Tanboon (2008) of 0.85 for the case of Thailand. Based on the data of 1994 to 2006, GMM estimation indicates the value of 0.84 to 0.88 for this parameter for Thailand (Tanboon, 2008). ϕ measures the cost of intermediation in the foreign bond market. It indicates the degree of vulnerability of domestic financial economy to shocks. If this parameter takes the value away from zero, the domestic financial accelerator and balance sheet are weak (Elekdag et al. (2005)). Elekdag et al. (2005) show that the implied annually risk premium for South Korea take the value of 11-13% when testing with different prior values (0.2 versus 0.07). In this chapter, this parameter is set to be 0.10. The same value also applied in Merola (2006). Testing with a very low value for this parameter does not change the main results of analysis. Lindé, Nessén & Söderström (2004) find that this parameter takes the reasonable range of 0 to 0.115 in the case of small open economy (Sweden). The parameter χ_f is the income elasticity of foreign consumption and is assumed to be 0.9 as in Flamini (2005) and Adolfson (2001). The domestic economy is assumed to follow a Taylor policy rule. The central bank's loss function preference on inflation target is 1.0 and the relative preference for output is 0.5.

Most of the empirical studies on the business cycles and policy regimes or optimum currency area (OCA) for Asia investigate the relative importance of domestic and foreign shocks from the forecast error variance decompositions without giving information on the persistency of shocks. Although some of the Asian or East-Asian countries show certain level of symmetry in shocks, in general most of these countries are driven by country specific shocks and that foreign shocks play a relatively small role in the economic of East-Asia (for example, Sun & An (2008), Chow & Kim (2003) and Hoffmaister & Roldós (1997). Due to the lack of information for the persistency of shocks in East-Asia and that shocks are idiosyncratic and asymmetric, it is hard to make a general assumption on the persistency of shocks for the whole East-Asian countries in this study. Following the step of some studies, this chapter conducts the simulations by assuming all the shocks share the same persistency of

0.7 and standard error of 0.3[5]. The robustness of the results are checked by repeating simulations for different persistencies and standard errors of shocks, alternative parameterization, different policy weighting and different policy targeting. The parameterization is summarized in **Table 3**.

5 Results

5.1 The degree of exchange rate pass-through

The performances of the optimized restricted simple rules are evaluated in terms of policy absolute loss, relative loss of the each rule to the unrestricted and restricted optimized baseline Taylor rule and variances. Assuming the domestic economy is hit by six shocks simultaneously with the same persistency of shocks, various restricted optimized simple rules under different degrees of exchange rate pass-through are compared. All simulations are based on the CPI inflation targeting rules.

Table 4 displays the results of policy reaction coefficients for various rules under three different degrees of exchange rate pass-through. By observing the coefficients of the baseline Taylor rule (rule TR), one may find that the optimized coefficient of the policy rule to inflation impulse becomes larger when the pass-through rate is higher. This is because higher pass-through induces greater external shocks which require greater policy reaction and hence higher coefficient for inflation in the policy rule. The same result also holds for the optimized coefficient of interest rate smoothing term. The optimized coefficient for the smoothing term is relatively smaller for the low pass-through case in compare to higher pass-through case (see rule TRS). This implies higher weight on interest rate stabilization for the high pass-through case compared to the low pass-through case. However, as mentioned in Adolfson (2001), the smoothing coefficient may not necessary larger in the full pass-through case. For instance under low exchange rate pass-through case, the exchange rate disturbance on import price is small but persistent as it takes longer time to reach the steady state due to the low pass-through. Hence, the interest rate can be more persistent in the low pass-through case which induces higher coefficient of smoothing term for the low pass-through case.

The optimized coefficient to exchange rate is increasing in the degree of exchange rate pass-through. This result indicates that exchange rate plays a more important role in transmitting the inflation disturbances when pass-through is higher. Hence, augmenting the policy with exchange rate term induces larger improvement in term of lower welfare loss in the high pass-through case. For the augmented Taylor rule that include the exchange rate term, the coefficients of policy reaction to inflation and smoothing term are decreasing in contrast to the coefficient to exchange rate. This implies higher role of exchange rate relative to these variables in absorbing shock under higher pass-through case.

The optimized coefficient for the current inflation term is negative but to its lagged term is positive in the rules that react to lagged inflation term (rule TRH, TRHE, TRHI and TRHIE). Or equivalently, the optimized coefficient for the current inflation is positive but the expectation term is negative. This is due to the mean reverting behavior of inflation. Assuming that shocks to inflation induce temporary deviation from the steady state, the central bank will raise the interest rate to control the current inflation but reduces the rate for the next period.

The policy absolute loss and relative loss provide comparisons on the performances of various rules. Relative loss (1) indicates the relative loss of each rule to the loss of unrestricted optimized rule that reacts to output and inflation (in this case, CPI inflation). Relative loss (2) is the relative loss of each rule to the loss of restricted optimized Taylor rule, i.e. rule TR. The relative loss (2) shows that the unrestricted optimized rule always performs better than the restricted optimized rule. However, restricted optimized rule can perform

[5] Among the papers that conduct simulations by assuming same persistency or /and standard error for all shocks in their calibrations are Adolfson (2001), Parrado (2004); as priors parameters such as Juillard et. al (2006).

nearly well as the unrestricted optimized rule depending on the policy weight/ objective and economic conditions (for example the degree of trade openness and exchange rate pass-through). The restricted optimized rule could perform closely to the loss of unrestricted optimized rule when the pass-through is very low (see **Table 4**) and the relative weight of output to inflation is very small (see **Table A(5) in Appendix A**). Due to its simple structure and easier to convey to the public, the instrument rule always served as the baseline rule for comparisons and policy evaluations.

Comparing the results of absolute loss and relative loss, it is observed that exchange rate is welfare enhancing. Including the exchange rate term in the baseline Taylor rule reduces the welfare loss and the size of improvement is increasing in the degree of exchange rate pass-through. For instance, adding the exchange rate term in the baseline rule (rule TRE1) when the pass-through rate is high generates lower relative loss of about 8% under unrestricted case and 6% under restricted case. The improvement rate is much higher than the improvement under low pass-through rate of about 2% for both relative loss (1) and (2). Adding the backward-looking components to the baseline rule such as the smoothing term (rule TRS and TRSE) and history dependent term (rule TRH and TRHE) also induces lower welfare loss. These history dependent rules (with and without exchange rate terms) perform better than the baseline rule with exchange rate term (rule TRE1 and TRE2). These rules allow gradual adjustment in prices and provide additional information to the policy maker which helps to reduce the variances or biases in the policy decisions. Similarly, the rules with forward-looking component with and without exchange rate term (rule TRF and TRFE) are welfare enhancing as well. In line with previous studies, the strict inflation targeting rule performs badly in all cases. This rule generates higher welfare loss and variance in output although the variance in consumer and domestic inflation are relatively low.

Apart from these results, the hybrid rules with and without exchange rate term (rule TRHI and TRHIE) outperform the other rules. The hybrid rule with exchange rate term (rule TRHIE) is superior to all rules under three cases of exchange rate pass-through as it incorporates both inertia and expectation on inflation in forming the policy reaction function. Similar to other rules, this rule performs the best under high pass-through case. The results show that exchange rate plays an improving role in the setups of policy rules and suggest that the superior rule should react to exchange rate term and in hybrid form at least in the model applied in this chapter. The role of exchange rate in the design of monetary policy becomes more important by generating higher improvement in term of lower welfare loss the higher the pass-through rate is.

Table 4: Policy rules based on CPI inflation targeting

Policy rules	Structure of rules	Absolute loss	Relative loss (1)	Relative loss (2)	V(y)	V(pi_c)	V(pi_d)
	(I) Low Pass-through (LPT)						
TR	$i_t = 4.0672\pi_t^c + 0.7838 y_t$	9.0475	1.1660	1.0000	14.6269	1.7341	2.1774
TRE1	$i_t = 3.3052\pi_t^c + 0.7388 y_t + 0.6218\Delta e_t$	8.8836	1.1449	0.9819	14.4803	1.6434	2.1287
TRE2	$i_t = 3.8437\pi_t^c + 0.7155 y_t + 0.6509\Delta q_t$	8.8708	1.1432	0.9804	14.4594	1.6411	2.1318
TRS	$i_t = 0.4097(6.9229\pi_t^c + 1.4811 y_t) + 0.5903 i_{t-1}$	8.8606	1.1419	0.9793	14.4449	1.6382	2.1429
TRSE	$i_t = 0.5260(5.7392\pi_t^c + 1.1856 y_t + 0.2637\Delta q_t) + 0.4740 i_{t-1}$	8.8596	1.1418	0.9792	14.4430	1.6381	2.1413
TRH	$i_t = -0.1344\pi_t^c + 1.3147 y_t + 5.1208\pi_{t-1}^c$	8.5466	1.1014	0.9446	13.4515	1.8208	2.2544
TRHE	$i_t = -0.1046\pi_t^c + 1.3104 y_t + 5.0800\pi_{t-1}^c + 0.0127\Delta q_t$	8.5465	1.1014	0.9446	13.4497	1.8217	2.2555
TRF	$i_t = 10.3116\pi_t^c + 1.3733 y_t - 6.0511 E_t\pi_{t+1}^c$	8.8784	1.1442	0.9813	14.0356	1.8607	2.2535
TRFE	$i_t = 7.3369\pi_t^c + 1.0307 y_t - 3.5657 E_t\pi_{t+1}^c + 0.5767\Delta q_t$	8.7977	1.1338	0.9724	14.0089	1.7932	2.2201
TRHI	$i_t = -12.3299\pi_t^c + 1.6414 y_t + 10.4782 E_t\pi_{t+1}^c + 10.5053\pi_{t-1}^c$	8.4250	1.0858	0.9312	13.2371	1.8065	2.3011
TRHIE	$i_t = -14.1222\pi_t^c + 1.7117 y_t + 11.4474 E_t\pi_{t+1}^c + 11.6714\pi_{t-1}^c - 0.2152\Delta q_t$	8.4092	1.0837	0.9294	13.2024	1.8080	2.2987
SIT	$i_t = 2.9495\pi_t^c$	9.7732	1.2595	1.0802	17.4570	1.0447	1.5232
	The absolute loss for the unrestricted optimal rule is 7.7595 (LPT)						

Policy rules	Structure of rules	Absolute loss	Relative loss (1)	Relative loss (2)	V(y)	V(pi_c)	V(pi_d)
	(I) Medium Pass-through (MPT)						
TR	$i_t = 4.3654\pi_t^c + 0.7574y_t$	9.4600	1.2720	1.0000	16.0062	1.4569	1.6466
TRE1	$i_t = 2.7248\pi_t^c + 0.5471y_t + 0.8852\Delta e_t$	9.0059	1.2109	0.9520	15.3979	1.3070	1.7681
TRE2	$i_t = 3.4403\pi_t^c + 0.5082y_t + 0.8975\Delta q_t$	8.9787	1.2073	0.9491	15.3322	1.3126	1.7859
TRS	$i_t = 0.2450(8.7878\pi_t^c + 1.6153y_t) + 0.7550i_{t-1}$	8.9949	1.2095	0.9508	15.3289	1.3305	1.7998
TRSE	$i_t = 0.7058(4.0961\pi_t^c + 0.6422y_t + 0.7928\Delta q_t) + 0.2942i_{t-1}$	8.9736	1.2066	0.9486	15.3071	1.3201	1.7980
TRH	$i_t = -2.1167\pi_t^c + 1.3426y_t + 7.2538\pi_{t-1}^c$	8.5018	1.1432	0.8987	13.8760	1.5635	1.9568
TRHE	$i_t = -1.4926\pi_t^c + 1.2633y_t + 6.4139\pi_{t-1}^c + 0.3461\Delta q_t$	8.4669	1.1385	0.8950	13.8081	1.5628	1.9994
TRF	$i_t = 48.1194\pi_t^c + 5.0276y_t - 38.2074E_t\pi_{t+1}^c$	8.8023	1.1836	0.9305	14.5677	1.5185	1.8389
TRFE	$i_t = 22.1188\pi_t^c + 2.3825y_t - 16.5192E_t\pi_{t+1}^c + 1.2801\Delta q_t$	8.7282	1.1736	0.9226	14.4444	1.5060	1.9173
TRHI	$i_t = -10.4521\pi_t^c + 0.8331y_t + 7.6111E_t\pi_{t+1}^c + 8.1704\pi_{t-1}^c$	8.3946	1.1287	0.8874	13.4491	1.6701	2.0877
TRHIE	$i_t = -10.8971\pi_t^c + 0.7962y_t + 8.5805E_t\pi_{t+1}^c + 8.0006\pi_{t-1}^c + 0.2168\Delta q_t$	8.3352	1.1208	0.8811	13.4214	1.6245	2.0816
SIT	$i_t = 2.9609\pi_t^c$	10.0483	1.3571	1.0622	18.3728	0.8619	1.0556
	The absolute loss for the unrestricted optimal rule is 7.4371 (MPT)						

Policy rules	Structure of rules	Absolute loss	Relative loss (1)	Relative loss (2)	V(y)	V(pi_c)	V(pi_d)
	(III) High Pass-through (HPT)						
TR	$i_t = 5.1006\pi_t^c + 0.9671y_t$	9.6447	1.2963	1.0000	16.3594	1.4650	1.5398
TRE1	$i_t = 2.6532\pi_t^c + 0.5285y_t + 0.9389\Delta e_t$	9.0578	1.2174	0.9391	15.5365	1.2895	1.7216
TRE2	$i_t = 3.4057\pi_t^c + 0.4869y_t + 0.9434\Delta q_t$	9.0276	1.2134	0.9360	15.4608	1.2972	1.7409
TRS	$i_t = 0.2097(9.8849\pi_t^c + 1.7955y_t) + 0.7903i_{t-1}$	9.0518	1.2166	0.9385	15.4613	1.3211	1.7529
TRSE	$i_t = 0.7338(3.9635\pi_t^c + 0.5979y_t + 0.8651\Delta q_t) + 0.2662_i\, i_{t-1}$	9.0234	1.2128	0.9356	15.4354	1.3057	1.7518
TRH	$i_t = -1.9050\pi_t^c + 1.2685y_t + 6.8399\pi_{t-1}^c$	8.5718	1.1521	0.8887	13.9502	1.5967	1.9402
TRHE	$i_t = -1.5849\pi_t^c + 1.2387y_t + 6.4270\pi_{t-1}^c + 0.4766\Delta q_t$	8.4827	1.1401	0.8795	13.8666	1.5494	1.9950
TRF	$i_t = 158.76\pi_t^c + 16.4361y_t - 130.94E_t\pi_{t+1}^c$	8.8406	1.1882	0.9166	14.6524	1.5145	1.8367
TRFE	$i_t = 22.6218\pi_t^c + 2.3939y_t - 17.0349E_t\pi_{t+1}^c + 1.3583\Delta q_t$	8.7871	1.1810	0.9111	14.8993	1.4820	1.8993
TRHI	$i_t = -1.4794\pi_t^c + 1.3237y_t - 0.4422E_t\pi_{t+1}^c + 6.9311\pi_{t-1}^c$	8.5713	1.1520	0.8887	13.9714	1.5856	1.9312
TRHIE	$i_t = -6.8162\pi_t^c + 0.8532y_t + 5.2333E_t\pi_{t+1}^c + 6.5886\pi_{t-1}^c + 0.4908\Delta q_t$	8.4147	1.1310	0.8724	13.5893	1.6200	2.0926
SIT	$i_t = 2.95\pi_t^c$	10.2797	1.3816	1.0658	18.6645	0.9475	0.9867
	The absolute loss for the unrestricted optimal rule is 7.4402 (HPT).						

Notes: Relative loss (1) refers to the ratio of absolute loss of each simply rule to the absolute loss of unrestricted optimized rule that reacts to output and inflation; relative loss (2) indicates the relative loss of each simple rule to the loss of restricted optimized rule that react to both output and inflation, i.e rule TR. The absolute loss for unrestricted rule are 7.7595 (LPT), 7.4371 (MPT) and 7.4402 (HPT).

5.2 The effects of trade openness

How does the trade openness of one economy affect the policies performances? Does trade openness matter in determining the exchange rate pass-through and hence, influences the conduct of monetary policies? Adolfson (2001) states that economy with higher trade openness implies that the economy is more open to external shocks, hence greater impacts of foreign shocks to that economy. Under such condition, the exchange rate channel plays a greater role in the monetary policy transmission similar to the case of high degree of exchange rate pass-through. However, this condition does not necessary hold (as can be seen in the results later).

On the other hand, Ho & McCauley (2003) on their study in several emerging economies show that openness per se is not significantly correlated with exchange rate pass-through. They note that although Latin American countries have lower degree of trade openness than Asian countries have, the pass-through in Latin American countries is stronger than that of Asian countries. However, they find that low income and high inflation history are significantly correlated with exchange rate pass-through.

Following Adolfson (2001), the degree of trade openness is represented by three parameters, the import and export shares (ω_m and ω_x) and share of imported intermediate inputs in production κ. The higher the values of these parameters indicate the more open one economy is. In order to generate higher trade openness κ, ω_m and ω_x take the values of 0.60, 0.30 and 0.40 respectively which are higher than the values set in the previous section[6]. The more open one economy is, the higher are the exposure of foreign disturbances to that economy and greater responses of policy reaction function to such disturbances. The opposite condition holds if the economy has a low degree of trade openness.

Table 5: Effects of higher trade openness on performances of simple rules

Rules	LPT			MPT			HPT		
	Absolute loss	Relative loss (1)	Relative loss (2)	Absolute loss	Relative loss (1)	Relative loss (2)	Absolute loss	Relative loss (1)	Relative loss (2)
TR	8.2443	1.2108	1.0000	8.6983	1.1935	1.0000	8.8591	1.2074	1.0000
TRE1	8.2137	1.2063	0.9963	8.5217	1.1693	0.9797	8.5901	1.1708	0.9697
TRE2	8.2074	1.2054	0.9955	8.4880	1.1646	0.9758	8.5486	1.1651	0.9649
TRS	8.1901	1.2029	0.9934	8.4538	1.1599	0.9719	8.5187	1.1610	0.9617
TRSE	8.1867	1.2024	0.9930	8.4519	1.1597	0.9717	8.5127	1.1602	0.9609
TRH	7.9597	1.1690	0.9655	8.1157	1.1136	0.9330	8.2788	1.1283	0.9345
TRHE	7.9593	1.1690	0.9654	8.0760	1.1081	0.9284	8.1536	1.1113	0.9203
TRF	8.1188	1.1924	0.9848	8.4714	1.1624	0.9739	8.3530	1.1384	0.9429
TRFE	8.1013	1.1898	0.9826	8.2497	1.1319	0.9484	8.3485	1.1378	0.9423
TRHI	7.8918	1.1590	0.9572	8.1151	1.1135	0.9329	8.1980	1.1173	0.9254
TRHIE	7.8844	1.1580	0.9563	8.0289	1.1016	0.9230	8.1517	1.1110	0.9201
SIT	9.1387	1.3422	1.1085	9.4402	1.2953	1.0853	9.6896	1.3206	1.0937

Notes: Relative loss (1) refers to the ratio of absolute loss of each simply rule to the absolute loss of unrestricted optimized rule that reacts to output and inflation; relative loss (2) indicates the relative loss of each simple rule to the loss of restricted optimized rule that react to both output and inflation, i.e. rule TR. The absolute loss for unrestricted rule are 6.8089 (LPT), 7.2881 (MPT) and 7.3372 (HPT).

Table 5 shows the results of objective loss for different restricted optimized CPI inflation targeting simple rules under different degrees of trade openness and exchange rate pass-through. Comparing the results in **Table 5** with the one in **Table 4**, it is observed that the results summarized in both tables are consistent to each other. The augmented Taylor rules with history dependent terms with and without exchange rate terms outperform the baseline Taylor rule. The hybrid rule with exchange rate term is superior to all rules. These rules perform better under high pass-through case. In contrast, the strict inflation targeting rule and the forecast based inflation targeting perform badly in all cases.

[6] The parameterizations for other parameters hold the same.

Apart from these results, it is observed that the size of improvement is larger in **Table 4** than in **Table 5**. This means that the size of improvement is slightly smaller for the more open economy case. The reason is under more open economy (which is analog to greater pass-through case), although the effect of foreign disturbances to the domestic economy is greater, the price distortion due to import price stickiness is smaller. The variability in exchange rate is relatively smaller in compare to lower open economy (see **Table 6**). Exchange rate plays a lower role in adjusting prices. Hence the size of improvement by including the exchange rate term in the baseline rule could be smaller under more open economy case.

Table 6 summarizes the unconditional variances for several variables under different degrees of trade openness and exchange rate pass-through. The variances change as the degrees of openness change. As discussed in Adolfson (2001), a more open economy implies larger reactions of policy to foreign shocks but lower policy response to that of domestic shocks. When the economy is more open, foreign shocks have greater impacts or influences on the domestic variables, for example the price level. This in turn requires larger adjustments in output. Therefore, the domestic economy that is more open may experience greater variability in price level (domestic price) and output. On the other hand, the variability in nominal and real exchange rate becomes smaller the more open the economy is. The reason is exchange rate plays a lower role in price adjustment following greater impacts of foreign shocks on domestic price level. In other words, the stabilization or price adjustment is achieved through output rather than via exchange rate channel (Adolfson, 2001).

Table B.6: Effects of trade openness – comparisons of variances

(A1) Case I: Lower openness								
Rules	**V(y)**	**V(pi_d)**	**V(pi_m)**	**V(pi_c)**	**V(de)**	**V(tau)**	**V(i)**	**V(q)**
<u>TR</u>								
LPT	14.6269	2.1774	7.6463	1.7341	25.7702	67.6450	9.5303	56.7161
MPT	16.0063	1.6466	13.8713	1.4569	21.6085	72.4076	7.8970	61.8679
HPT	16.3594	1.5398	17.6913	1.4650	20.6722	76.8307	8.6851	63.8991
<u>TRHE</u>								
LPT	13.4497	2.2555	7.9478	1.8217	20.2646	68.4413	9.7099	57.7384
MPT	13.8081	1.9995	10.6336	1.5628	15.8241	68.5658	9.5814	57.9402
HPT	13.8666	1.9950	11.9329	1.5494	14.6092	69.4808	9.4330	57.5995
(B) Case II: Higher openness								
Rules	**V(y)**	**V(pi_d)**	**V(pi_m)**	**V(pi_c)**	**V(de)**	**V(tau)**	**V(i)**	**V(q)**
<u>TR</u>								
LPT	14.1828	2.0803	3.0174	1.1529	9.3829	40.2751	4.4347	20.8452
MPT	15.4737	1.5397	4.4448	0.9615	5.8053	42.0751	3.7117	20.9507
HPT	15.9189	1.4120	4.8126	0.8996	5.1683	43.1282	4.2052	21.3067
<u>TRHE</u>								
LPT	13.4627	2.1588	3.0189	1.2280	8.48851	40.0783	4.2343	21.4773
MPT	13.8745	2.0437	3.4201	1.1388	5.5562	39.4153	3.8647	20.0845
HPT	13.9968	2.0848	3.4867	1.1552	4.3175	39.1804	3.6793	19.4907

5.3 Robustness checking

One of the problems that the monetary authorities face when setting the monetary policy is the problem of uncertainty, for example uncertainties about the structure of economy and the types of shocks hitting the economy. According to Apel et al. (1999), the presence of uncertainty means the central bank has a limited knowledge of economic functions and it cannot formulate monetary policy in the optimal manner. One of the solutions to this problem is to search policy rules that are robust under all uncertainties and that are implementable, transparent and sufficiently sophisticated to include the factors that should be considered in the monetary policy decisions. This section investigates the robustness of various restricted optimized simple rules from two main aspects namely uncertainty about persistency of shocks and robustness under different policy weightings. The investigations are conducted by focusing on CPI inflation targeting rules.

5.3.1 Uncertainty about persistency of shocks

The nature and the inertia of shocks are crucial in affecting the monetary policy decision-making. This is because the emerging markets are very open in trade and vulnerable to the hits of external shocks. In the previous section, all shocks are assumed to share the same persistency of 0.7 and standard error of 0.3. However in reality, different types of shocks may have different persistency and the persistency could be higher or lower than 0.7. Since the persistency of shocks may change over time and vary across countries, it is very difficult to know the persistency for different shocks. In order to investigate if the performances of policy rules are robust under different persistency of shocks, robustness tests are conducted by adjusting different persistency for shocks. In the first case, all shocks share the same and higher inertia of 0.8 with the standard error of 0.4. In the second case, domestic shocks are more persistent than the foreign shocks with the inertia of 0.7 versus 0.4 and standard error of 0.3 versus 0.2. The third case assumes that foreign shocks are more persistent than the domestic shocks. The persistency for foreign shocks (foreign policy shock, foreign demand and supply shocks) is 0.9 with the standard error of 0.4. The persistency for domestic shocks (exchange rate shock, domestic demand and supply shocks) is 0.6 with the standard error of 0.3. The analysis is based on CPI inflation targeting rules. The results are summarized in **Table A(4a-c), Appendix A**.

Table 8a: Specifications for shocks (1)

Case I: Same persistency and variation of all shocks	Persistency: 0.8 Standard error: 0.4
Case II: Higher persistency and variation of domestic shocks	Persistency: 0.7 versus 0.4 Standard error: 0.3 versus 0.2
Case III: Higher persistency and variation of foreign shocks	Persistency: 0.9 versus 0.4 Standard error: 0.6 versus 0.3

The results from these three cases indicate that the augmented more complicated Taylor rules are robust under uncertainty about persistency of shocks. The welfare loss is higher for higher pass-through case. Augmenting the baseline rule with exchange rate terms, history dependent term and hybrid form are able to reduce the welfare loss of the baseline rule. These rules perform better under high degree of exchange rate pass-through. The hybrid rule with exchange rate term is superior to other rules. The forecast based inflation targeting and strict inflation targeting rules perform badly. These results hold by changing the persistency of shocks. However, changing the persistency of shocks may change the ranking of these rules. The ranking for the hybrid rule with and without exchange rate term does not change. This type of rule performs the best under different persistency of shocks.

5.3.2 Robustness under different policy weightings

How does the performance of policy rule change by asserting different weightings on the targeted variables in the policy loss function? This section checks the robustness of policy rules by assuming different weightings on policy loss function. In the previous section, the results are based on the simulations of policy loss function under the weightings of 1.0 and 0.5 for both inflation variable and output respectively. The results from previous section are compared with two cases of weightings here. The first case assumes both the weighting on inflation and output variables are 1.0. The second case assumes the weightings on output is 0.1 compared to 1.0 on inflation variable. The analysis is focused on CPI inflation targeting rules. The results are summarized in **Table A(4), Appendix A**.

The results show that it is more welfare beneficial to give higher weight to inflation but a smaller weight to output variable because giving higher weight to output variable may generate higher welfare loss. This implies that stabilizing inflation is less costly compared to output as the public know and expect the future inflation will be lower. The conservative central banker tends to be more inflation averse by asserting higher weight on inflation. As in the case of different persistency of shocks, the more complicated rules perform better than the baseline rule under different weighting and exchange rate pass-through. However, changing the weighting in the loss function may change the ranking on the performances of these rules. On the other hand, the hybrid rule with and without exchange rate term outperforms all the other rules irrespective the degree of exchange rate pass-through and weighting. The size of improvement for these rules becomes larger under higher degree of exchange rate pass-through with the exception of the case where the weight on output is 0.1. Under very low weighting on output variable case, the size of improvement for the high pass-through case is lower than the medium pass-through case. The reason is analog to the case of very open economy case. When the pass-through is very high, the effects of external shocks are very large but the distortion on domestic and consumer prices due to stickiness on import price is very low. Exchange rate plays a small role in adjusting the price. Hence, lower improvement induced by exchange rate under very high pass-through case. Moreover, output is more volatile and needs larger adjustment under higher pass-through case. Stabilization is realized through more on output adjustment. Assigning a very small weight on output stabilization (for instance 0.1) given that the pass-through is very high may affect the efficiency on the performances of the policy rules.

6 Conclusion

The role of exchange rate in the formation of monetary policy for the small and open economy is always a topic of interest among economists and researchers. Previous studies have proposed various modifications on the Taylor rule to be implemented in the open economy context. However, as these studies report controversial results, it is not clear if the augmented more complicated rules perform better than the closed economy rule.

This paper seeks to investigate this issue in the case of small open economy of East-Asian countries, focusing on the impacts of exchange rate pass-through, trade openness, the source and persistency of shocks. Simulations are carried out to compare various simple rules in term of welfare loss and variability. The results suggest the inclusion of exchange rate term in the policy reaction function as this type of rule generates lower loss. Adding the history dependent term in the baseline policy rule also helps to reduce the welfare loss. The hybrid rule with exchange rate term is superior to the other rules. These more complicated rules work more efficient under high degree of pass-through as the size of improvement is higher under higher pass-through case. Besides determined by the degree of exchange rate pass-through, the performances of policy rules also depend on trade openness, weighting of policy reaction function and persistency of shocks. These factors can influence the size of improvement and the ranking on the performances of policy rules. However, these more complicated rules are robust in the sense that they always show improvements irrespective these factors. The strict inflation targeting rule performs badly in all cases. Moreover, the policy maker can influence the domestic inflation indirectly by reacting to exchange rate movements.

To summarize the total results, including the exchange rate term in the monetary policy could be welfare enhancing. However, the effectiveness role of exchange rate depends crucially on the economic structures and features such as the degree of exchange rate pass-through, the source of shocks and trade openness which are of country specific. These factors should be highlighted in the formation of monetary policy rules and decisions.

When it comes to the choice of the best policy regime, there is no one best regime fits for all countries and forever. Rather, it is conditional on the economic circumstances and policy preferences which differ across countries and change over time. Perhaps, the choice of appropriate monetary policy/ regime should allow flexibility and stability elements (for example implementing a flexible inflation targeting or giving a weight to exchange rate in the policy rule) rather than defend on a particular rate as mentioned in Cavoli & Rajan (2003). The flexibility strategies allow the authority to react to various shocks in order to meet other goals when the inflation target is consistent with the target and relinquish other goals to meet the inflation target when the inflation level is far from the target.

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APPENDIX A

Table A(1): Share of exports in domestic production (ω_x)

Countries	1980-96	1999-2006
Indonesia	24.05	31.48
Korea	28.46	33.16
Malaysia	60.82	99.43
Philippines	18.19	45.78
Singapore	138.33	164.42
Thailand	24.64	56.93
Average1	49.08	71.87
Average2	23.84	41.84

Source: the original series for annually export and GDP are obtained from IMF.
Omega_x is calculated as total export over GDP (in percent).
Average1 is the average values of all countries
Average2 is the average values of all countries but exclude Malaysia and Singapore

Table A(2a): Components of imported goods

Countries	Year	Components of imported goods (%)					
		% raw	parts	capital	manufacturing/ material	Consumption ω_m	Intermediate κ
Indonesia	1980	23.7	8.5	17.9	42.4	7.4	74.6
	1990	12.2	28.4	28.4	37.2	7.1	77.8
	2003	20.3	13.5	13.5	46.1	7.6	79.9
Korea	1980	48.0	8.5	14.3	26.6	2.6	83.1
	1990	19.6	16.6	25.4	32.5	5.9	68.7
	2003	19.5	23.0	15.3	33.0	9.2	75.5
Malaysia	1980	15.1	18.0	15.6	34.8	16.4	67.9
	1990	4.7	26.0	27.5	30.4	11.4	61.1
	2003	5.2	47.9	15.0	23.9	7.9	77.0
Philippines	1980	34.6	10.5	15.4	34.5	5.1	79.6
	1990	20.7	15.6	14.4	38.7	10.6	75.0
	2003	9.9	48.8	7.9	25.8	7.7	84.5
Thailand	1980	30.5	11.8	9.7	40.1	8.0	82.4
	1990	10.1	21.6	21.7	37.1	9.5	68.8
	2003	14.5	26.0	18.1	33.1	8.3	73.6

Source: Research Institute of Economy, Trade and Industry, RIETI-TID (2005)
Intermediate goods = total % of the raw, parts and manufacturing/ material.

Table A(2b): Intermediate goods and consumption goods

Countries	Average % consumption goods on total imports		Average % intermediate goods on total imports	
	1980-1996	1999-2005	1980-1996	1999-2005
Indonesia	6.58	7.10	57.03	61.00
Korea	4.82	8.19	45.39	54.83
Malaysia	12.64	7.75	59.62	71.71
Philippines	8.41	8.00	53.31	72.13
Singapore	13.97	11.41	46.89	62.82
Thailand	8.61	7.77	58.95	60.64
Average1	9.17	8.37	53.53	63.86
Average2	7.11	7.77	53.67	62.15

Source: the original series for annually imported intermediate and consumption goods are obtained from Research Institute of Economy, Trade and Industry, RIETI-TID.
The values in the table are calculated by the author.
Average1 is the average values of all countries
Average2 is the average values of all countries but exclude Malaysia and Singapore

Table A(3): Notations for the parameters

Parameter	Notation
θ	technology parameter
β	discount factor
γ_m	adjustment cost of production in import sector
γ_d	adjustment cost of production in domestic sector
α_m	fraction of rule of thumb price setters in import sector
α_d	fraction of rule of thumb price setters in domestic sector
κ	share of imported inputs for production
h	habit formation parameter
ω_x	share of exports in domestic production
ω_m	share of imports in domestic consumption
σ	risk aversion parameter
η	elasticity of substitution between home and foreign goods income elasticity
χ_f	of foreign consumption
η_m	elasticity of substitution across goods in import sector
η_d	elasticity of substitution across goods in domestic sector
ϕ	risk premium in foreign bond market

Table A(4a): Performances of simple rules, persistency =0.8 and std. error=0.4

Rules	Low PT			Medium PT			High PT		
	Absolute loss	Relative loss (1)	Relative loss (2)	Absolute loss (1)	Relative loss (2)	Relative loss (1)	Absolute loss (2)	Relative loss (1)	Relative loss (2)
TR	34.5265	1.0879	1.0000	34.8595	1.2106	1.0000	35.2320	1.2248	1.0000
TRE1	34.2197	1.0783	0.9911	34.2090	1.1880	0.9813	34.3432	1.1939	0.9748
TRE2	34.1981	1.0776	0.9905	34.1633	1.1864	0.9800	34.2893	1.1920	0.9732
TRS	34.1233	1.0752	0.9883	34.0904	1.1839	0.9779	34.2220	1.1897	0.9713
TRSE	34.1154	1.0750	0.9881	34.0888	1.1838	0.9779	34.2162	1.1895	0.9711
TRH	33.1053	1.0432	0.9588	32.5297	1.1297	0.9331	32.7649	1.1390	0.9300
TRHE	33.1044	1.0431	0.9588	32.4423	1.1266	0.9306	32.5221	1.1306	0.9231
TRF	34.1071	1.0747	0.9878	33.3702	1.1588	0.9508	33.5002	1.1646	0.9573
TRFE	33.9232	1.0689	0.9825	33.3264	1.1573	0.9560	33.4999	1.1645	0.9508
TRHI	32.7564	1.0322	0.9487	32.2080	1.1185	0.9239	32.7480	1.1384	0.9295
TRHIE	32.7564	1.0322	0.9487	32.2080	1.1185	0.9239	32.7480	1.1384	0.9295
SIT	36.6007	1.1533	1.0601	36.4347	1.2653	1.0452	36.8484	1.2810	1.0459

Notes: Relative loss (1) refers to the ratio of absolute loss of each simply rule to the absolute loss of unrestricted optimized rule that reacts to output and inflation; relative loss (2) indicates the relative loss of each simple rule to the loss of restricted optimized rule that react to both output and inflation, i.e rule TR. The absolute loss for unrestricted rule are 31.7354 (LPT), 28.7961 (MPT) and 28.7664 (HPT).

Table A(4b): Higher persistency and std. error of domestic shocks

Rules	Low PT			Medium PT			High PT		
	Absolute loss	Relative loss (1)	Relative loss (2)	Absolute loss	Relative loss (1)	Relative loss (2)	Absolute loss	Relative loss (1)	Relative loss (2)
TR	9.0317	1.1656	1.0000	9.4459	1.2717	1.0000	9.6316	1.2961	1.0000
TRE1	8.8568	1.1430	0.9806	8.9661	1.2071	0.9492	9.0154	1.2132	0.9360
TRE2	8.8541	1.1427	0.9803	8.9607	1.2064	0.9486	9.0094	1.2124	0.9354
TRS	8.8480	1.1419	0.9797	8.9837	1.2095	0.9511	9.0404	1.2166	0.9386
TRSE	8.8465	1.1417	0.9795	8.9589	1.2061	0.9484	9.0081	1.2122	0.9353
TRH	8.5308	1.1010	0.9445	8.4866	1.1425	0.8984	8.5555	1.1513	0.8883
TRHE	8.5307	1.1009	0.9445	8.4522	1.1397	0.8948	8.4680	1.1395	0.8792
TRF	8.8632	1.1439	0.9813	8.7908	1.1835	0.9306	8.8290	1.1881	0.9167
TRFE	8.7814	1.1333	0.9723	8.7161	1.1734	0.9227	8.7751	1.1809	0.9111
TRHI	8.4119	1.0856	0.9314	8.3719	1.1271	0.8863	8.5555	1.1513	0.8883
TRHIE	8.3956	1.0835	0.9296	8.3148	1.1194	0.8803	8.3946	1.1297	0.8716
SIT	9.7550	1.2590	1.0801	10.0302	1.3503	1.0619	10.2611	1.3808	1.0654

Notes: Definition of relative loss (1) and (2) are as footnote of Table II(2a). The absolute loss for unrestricted optimized rule are 7.7485 (LPT), 7.4279 (MPT) and 7.4311 (HPT).

Table A(4c): Higher persistency and std. error of foreign shocks

Rules	Low PT			Medium PT			High PT		
	Absolute loss	Relative loss (1)	Relative loss (2)	Absolute loss	Relative loss (1)	Relative loss (2)	Absolute loss	Relative loss (1)	Relative loss (2)
TR	2.6273	1.2415	1.0000	2.7678	1.3162	1.0000	2.8178	1.3357	1.0000
TRE1	2.6273	1.2415	1.0000	2.6761	1.2726	0.9668	2.6888	1.2746	0.9542
TRE2	2.5828	1.2204	0.9830	2.5752	1.2247	0.9304	2.5847	1.2252	0.9173
TRS	2.4988	1.1807	0.9511	2.4999	1.1888	0.9032	2.5149	1.1921	0.8925
TRSE	2.4899	1.1765	0.9477	2.4998	1.1888	0.9032	2.5139	1.1916	0.8921
TRH	2.4928	1.1779	0.9488	2.4684	1.1739	0.8918	2.4859	1.1784	0.8822
TRHE	2.4922	1.1776	0.9486	2.4568	1.1683	0.8876	2.4553	1.1639	0.8713
TRF	2.6258	1.2408	0.9994	2.6441	1.2574	0.9553	2.6567	1.1593	0.9428
TRFE	2.5712	1.2150	0.9786	2.5704	1.2224	0.9287	2.5784	1.2222	0.9150
TRHI	2.3258	1.0990	0.8852	2.3772	1.1305	0.8589	2.4803	1.1757	0.8802
TRHIE	2.3230	1.0977	0.8842	2.3589	1.1218	0.8522	2.3885	1.1322	0.8476
SIT	2.7997	1.3229	1.0656	2.9373	1.3969	1.0612	2.7997	1.3271	0.9936

Notes: Definition of relative loss (1) and (2) are as footnote of Table II(2a). The absolute loss for unrestricted optimized rule are 2.1163 (LPT), 2.1028 (MPT) and 2.1096 (HPT).

Table A(5): Policy rules under different weighting

Rules	Case I γ_π =1.0, γ_y =1.0			Case II γ_π =1.0, γ_y =0.5			Case III γ_π =1.0, γ_y =0.1		
	Absolute loss	**Relative loss (1)**	**Relative loss (2)**	**Absolute loss**	**Relative loss (1)**	**Relative loss (2)**	**Absolute loss**	**Relative loss (1)**	**Relative loss (2)**
Low PT									
TR	15.5689	1.3187	1.0000	9.0475	1.1660	1.0000	3.0710	1.0939	1.0000
TRE1	15.3728	1.3021	0.9874	8.8836	1.1449	0.9819	2.9453	1.0491	0.9591
TRE2	15.3544	1.3005	0.9862	8.8708	1.1432	0.9804	2.9423	1.0480	0.9581
TRS	15.3369	1.2990	0.9851	8.8606	1.1419	0.9793	2.9315	1.0442	0.9546
TRSE	15.3363	1.2990	0.9850	8.8596	1.1418	0.9792	2.9303	1.0427	0.9542
TRH	14.4913	1.2274	0.9308	8.5466	1.1014	0.9446	2.9157	1.0385	0.9494
TRHE	14.4829	1.2267	0.9302	8.5465	1.1014	0.9446	2.9157	1.0385	0.9494
TRF	15.0703	1.2765	0.9860	8.8784	1.1442	0.9813	2.9989	1.0682	0.9765
TRFE	14.9596	1.2672	0.9608	8.7977	1.1338	0.9724	2.9422	1.0480	0.9581
TRHI	14.2633	1.2081	0.9161	8.4250	1.0858	0.9312	2.8864	1.0281	0.9399
TRHIE	14.2406	1.2062	0.9147	8.4092	1.0837	0.9294	2.8847	1.0275	0.9393
SIT	18.2446	1.5464	1.1718	9.7732	1.2595	1.0802	3.2325	1.1514	1.0526
Medium PT									
TR	16.4610	1.3695	1.0000	9.4600	1.2720	1.0000	2.1807	1.1047	1.0000
TRE1	15.8760	1.3208	0.9644	9.0059	1.2109	0.9520	2.1011	1.0644	0.9635
TRE2	15.8255	1.3166	0.9614	8.9787	1.2073	0.9491	2.0987	1.0632	0.9624
TRS	15.8098	1.3153	0.9604	8.9949	1.2095	0.9508	2.1008	1.0642	0.9633
TRSE	15.7963	1.3142	0.9596	8.9736	1.2066	0.9486	2.0985	1.0631	0.9623
TRH	14.5968	1.2144	0.8867	8.5018	1.1432	0.8987	2.0740	1.0517	0.9511
TRHE	14.5291	1.2087	0.8826	8.4669	1.1385	0.8950	2.0655	1.0464	0.9472
TRF	15.2297	1.2670	0.9252	8.8023	1.1836	0.9305	2.1109	1.0694	0.9680
TRFE	15.1043	1.2566	0.9176	8.7282	1.1736	0.9226	2.0910	1.0593	0.9588
TRHI	14.2371	1.1845	0.8649	8.3946	1.1287	0.8874	2.0739	1.0506	0.9510
TRHIE	14.1731	1.1791	0.8610	8.3352	1.1208	0.8811	2.0538	1.0404	0.9418
SIT	18.8280	1.5664	1.1438	10.0483	1.3571	1.0622	2.2114	1.1203	1.0459
High PT									
TR	16.7359	1.3918	1.0000	9.6447	1.2963	1.0000	2.1637	1.0988	1.0000
TRE1	15.9864	1.3294	0.9552	9.0578	1.2174	0.9391	2.0971	1.0650	0.9692
TRE2	15.9288	1.3247	0.9518	9.0276	1.2134	0.9360	2.0947	1.0638	0.9681
TRS	15.9169	1.3237	0.9510	9.0518	1.2166	0.9385	2.0989	1.0659	0.9700
TRSE	15.8984	1.3221	0.9499	9.0234	1.2128	0.9356	2.0947	1.0638	0.9681
TRH	14.6955	1.2221	0.8781	8.5718	1.1521	0.8887	2.1009	1.0669	0.9710
TRHE	14.5706	1.2117	0.8706	8.4827	1.1401	0.8795	2.0578	1.0450	0.9510
TRF	15.2986	1.2722	0.9141	8.8406	1.1882	0.9166	2.1019	1.0674	0.9714
TRFE	15.2282	1.2664	0.9099	8.7871	1.1810	0.9111	2.0848	1.0588	0.9635
TRHI	14.6494	1.2183	0.8753	8.5713	1.1520	0.8887	2.0726	1.0526	0.9579
TRHIE	14.3226	1.1911	0.8558	8.4147	1.1310	0.8724	2.0572	1.0447	0.9508
SIT	19.1541	1.5929	1.1445	10.2797	1.3816	1.0658	2.2386	1.1369	1.1204

Notes: Definition of relative loss (1) and (2) are as footnote of Table II(2a). The absolute loss for unrestricted optimized rule are as follows:
Case I: 11.8064 (LPT), 12.0300 (MPT) and 12.0249 (HPT)
Case II: 7.7595 (LPT), 7.4371 (MPT) and 7.4402 (HPT)
Case III: 2.8075 (LPT), 1.9740 (MPT) and 1.9691 (HPT)

APPENDIX B

Solution and estimation of rational expectation model

This appendix summarizes the solution and estimation of the rational expectation model discussed in Söderlind (1999), Adolfson (2001) and Söderlind (2003).

The complete model of equations (1) to (18) can be written in a state space representation form:

$$\begin{bmatrix} x_{1,t+1} \\ E_t x_{2,t+1} \end{bmatrix} = A \begin{bmatrix} x_{1,t} \\ x_{2,t} \end{bmatrix} + Bi_t + \begin{bmatrix} \varepsilon_{t+1} \\ 0_{n2x2} \end{bmatrix} \tag{1}$$

or $x_{t+1} = Ax_t + Bi_t + \xi_{t+1}$

where $x_{1,t}$ is a $(n_1 \times 1)$ vector of predetermined variables with the initial value $x_{1,0}$ is given. The $(n_2 \times 1)$ vector of non-predetermined or forward-looking variables is denoted as $x_{2,t}$. i_t is a $(k \times 1)$ vector of policy instruments and ε_{t+1} represents a $(n_1 \times 1)$ vector of innovations to $x_{1,t}$.

In this chapter, the predetermined, non-predetermined variables and the shocks are:

$x_{1,t} = \left[i_{t-1} \quad y_t^f \quad i_t^f \quad \pi_t^f \quad u_t^y \quad u_t^\pi \quad u_t^e \quad \tau_t^f \quad a_t \quad \overline{x}_t \quad \tau_t \right]'$ with (11×1) dimensions

$x_{2,t} = \left[y_t \quad \pi_t^d \quad \pi_t^m \quad \pi_t^c \quad q_t \quad \Delta q_t \quad \Delta e_t \right]'$ with (7×1) dimensions

$\varepsilon_t = \left[0 \quad u_t^{yf} \quad u_t^{if} \quad u_t^{\pi f} \quad \upsilon_t^y \quad \upsilon_t^\pi \quad \upsilon_t^e \quad 0 \quad 0 \quad 0 \quad 0 \right]'$ with (11×1) dimensions

Optimal policy with commitment rule

The problem of optimal unrestricted policy under commitment is to minimize the following loss function subject to the constraint in equation (1):

$$J_0 = E_0 \sum_{t=0}^{\infty} \beta^t \left[x_t' Q x_t + 2x_t' U i_t + i_t' R i_t \right]$$

s.t $x_{t+1} = Ax_t + Bi_t + \xi_{t+1}$ where $\xi_{t+1} = (\varepsilon_{t+1}, x_{2,t+1} - E_t x_{2,t+1})$

The problem is solved by forming the Lagrangian function:

$$L_0 = \min_{i_t} E_0 \sum_{t=0}^{\infty} \beta^t \left[x_t' Q x_t + 2x_t' U i_t + i_t' R i_t + 2\rho_{t+1}' (Ax_t + Bi_t + \xi_{t+1} - x_{t+1}) \right] \tag{2}$$

The first order condition with costate vector ρ_{t+1} with respect to i_t and x_t are:

$$-B' E_t \rho_{t+1} = U' x_t + Ri_t$$

$$\beta A' E_t \rho_{t+1} = \rho_t - \beta Q x_t - \beta U i_t$$

Q, *U* and *R* are matrices mapping the targeting variables in the loss function to the state variables (see Adolfson (2001) for more details).

By grouping $x_t = (x_{1,t}, x_{2,t})$ and $\rho_t = (\rho_{1,t}, \rho_{2,t})$ and reorder the rows where $x_{1,t}$ is placing before $\rho_{2,t}$, the result can be written in the following form:

$$GE_t \begin{bmatrix} k_{t+1} \\ \lambda_{t+1} \end{bmatrix} = D \begin{bmatrix} k_t \\ \lambda_t \end{bmatrix} \tag{3}$$

where $k_t = \begin{bmatrix} x_{1,t} \\ \rho_{2,t} \end{bmatrix}$ and $\lambda_t = \begin{bmatrix} x_{2,t} \\ i_t \\ \rho_{1,t} \end{bmatrix}$

Generalized Schur Decomposition

Since matrix G is singular, generalized Schur decomposition is applied here. The square matrices G and D satisfy the following generalized Schur decomposition given that Q and Z are unitary, S and T are upper triangular (Söderlind (1999)).

$$G = QSZ^H \tag{4a}$$

$$D = QTZ^H \tag{4b}$$

The decomposition is reordered to allow the stable generalized eigenvalues to come first. Define the auxiliary variables θ and δ as:

$$\begin{bmatrix} \theta_t \\ \delta_t \end{bmatrix} = Z^H \begin{bmatrix} k_t \\ \lambda_t \end{bmatrix} \tag{5}$$

By applying the generalized Schur decomposition of (4a) and (4b) and premultiply (5) with the non-singular matrix Q^H give the following:

$$Q^H QSZ^H E_t \begin{bmatrix} k_{t+1} \\ \lambda_{t+1} \end{bmatrix} = Q^H QTZ^H \begin{bmatrix} k_t \\ \lambda_t \end{bmatrix} \tag{6}$$

$$SZ^H E_t \begin{bmatrix} k_{t+1} \\ \lambda_{t+1} \end{bmatrix} = TZ^H \begin{bmatrix} k_t \\ \lambda_t \end{bmatrix}$$

$$SE_t \begin{bmatrix} \theta_{t+1} \\ \delta_{t+1} \end{bmatrix} = T \begin{bmatrix} \theta_t \\ \delta_t \end{bmatrix}$$

$$\begin{bmatrix} S_{\theta\theta} & S_{\theta\delta} \\ 0 & S_{\delta\delta} \end{bmatrix} E_t \begin{bmatrix} \theta_{t+1} \\ \delta_{t+1} \end{bmatrix} = \begin{bmatrix} T_{\theta\theta} & T_{\theta\delta} \\ 0 & T_{\delta\delta} \end{bmatrix} \begin{bmatrix} \theta_t \\ \delta_t \end{bmatrix}$$

In order to get a stable solution, we must have $\delta_t = 0$ for all t and the solution is:

$$E_t \theta_{t+1} = S_{\theta\theta}^{-1} T_{\theta\theta} \theta_t \tag{7}$$

given that $S_{\theta\theta}$ is invertible.

Invert (5) and partition:

$$\begin{bmatrix} k_t \\ \lambda_t \end{bmatrix} = \begin{bmatrix} Z_{k\theta} & Z_{k\delta} \\ Z_{\lambda\theta} & Z_{\lambda\delta} \end{bmatrix} \begin{bmatrix} \theta_t \\ \delta_t \end{bmatrix} = \begin{bmatrix} Z_{k\theta} \\ Z_{\lambda\theta} \end{bmatrix} \theta_t \tag{8}$$

Since $\delta_t = 0$, we get the solution $k_0 = \begin{bmatrix} x_{1,0} \\ 0 \end{bmatrix} = Z_{k\theta}\theta_0$ and $\theta_0 = Z_{k\theta}^{-1} k_0$ if $Z_{k\theta}$ is invertible.

The solutions for the other variables are (see Söderlind, 1999 for more details):

$$\begin{bmatrix} x_{2,t} \\ i_t \\ \rho_{1,t} \end{bmatrix} = Z_{\lambda\theta} Z_{k\theta}^{-1} \begin{bmatrix} x_{1,t} \\ \rho_{2,t} \end{bmatrix} \tag{9}$$

Optimal simple rule

Assume that the policy maker could commit to a simple decision rule:

$$i_t = -F \begin{bmatrix} x_{1,t} \\ x_{2,t} \end{bmatrix} \tag{10}$$

Substituting (10) into (1):

$$\begin{bmatrix} x_{1,t+1} \\ E_t x_{2,t+1} \end{bmatrix} = (A - BF) \begin{bmatrix} x_{1,t} \\ x_{2,t} \end{bmatrix} + Bi_t + \varepsilon_{t+1} \tag{11}$$

A necessary condition for a unique equilibrium solution for the expectation difference equations (11) is *(A-BF)* should have the number of stable roots equal to the number of predetermined variables (Söderlind (1999)). Given that *F* implies a unique equilibrium, the solution to the dynamic of the model is:

$$x_{1,t+1} = Mx_{1,t} \tag{12}$$

$$x_{2,t} = Cx_{1,t} \tag{13}$$

where $M = Z_{k\theta} T_{\theta\theta} Z_{k\theta}^{-1}$ and $C = Z_{\lambda\theta} Z_{k\theta}^{-1}$ are obtained using a Schur Decompostion of *(A-BF)*.

The loss function value is:

$$J_0 = x_{1,0}^{'} V x_{1,0} + \frac{\beta}{1-\beta} tr(V\Sigma) \tag{14}$$

where $V = P^{'} \begin{bmatrix} Q & U \\ U^{'} & R \end{bmatrix} P + \beta M^{'} V M$

and $P = \begin{bmatrix} I_{n1} \\ C \\ -F \begin{bmatrix} I_{n1} \\ C \end{bmatrix} \end{bmatrix}$

Under an optimal simple rule, the loss function (14) is minimized subject to the restriction on the decision rule *F* with $x_{1,0}$ is given. This rule depends on the covariance matrix Σ and the initial state vector $x_{1,0}$.