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RISK APPETITE AND FOREIGN EXCHANGE INTERVENTION IN AN INFLATION-TARGETING FRAMEWORK: THE CASE OF INDONESIA

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ABSTRACT

The use of foreign exchange intervention in an inflation-targeting framework raises the question regarding its role. In addition, in an environment of volatile capital flows, how the risk appetite of foreign investors might impact the economy is worth exploring. This paper examines these issues for Indonesia by developing and estimating a dynamic stochastic general equilibrium model. This study finds that the foreign exchange intervention affects the macroeconomic variables through the portfolio channel. The risk appetite also affects the economy by increasing the price of capital. The foreign exchange intervention helps in stabilizing the economy during the presence of risk appetite shocks and monetary policy shocks.

Keywords: Monetary policy; Foreign exchange intervention; DSGE.
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I. INTRODUCTION

In this paper, a Dynamic Stochastic General Equilibrium (DSGE) model with a sticky price, following, Calvo (1983) is crafted in order to explore the benefits of Foreign Exchange (FX) intervention as an instrument in an emerging market that implements an Inflation-Targeting Framework (ITF). By incorporating a shock to the economy – as this is reflected by the risk appetite of an investor – we estimate a model in the context of Indonesian economy which has been exposed to capital flow volatility.

Our hypothesis is that foreign exchange intervention would be beneficial to complement the policy rate in the emerging market that applies the ITF. The FX intervention impacts macroeconomic variables via the portfolio channel. The risk appetite also increases the price of capital whilst any remaining liquidity in the world markets will be predominantly channeled to emerging economies. Ghosh *et al*. (2016) evidence suggests that FX intervention can result in stabilizing inflation. Moreover, Adler *et al*. (2016) argue that FX intervention stifles exchange rate pressure hence being an integral part of the monetary authority's ITF policy options to achieve macroeconomic stability.

The early literature on the ITF, such as Bernanke et al. (1999) and Bernanke and Mishkin (1997), argue that the exchange rate should be allowed to float in an intervention-free environment and focus on achieving its inflation target as its primary goal (Bernanke and Mishkin, 1997). Bernanke *et al.* (1999) argue that FX intervention could emanate misleading signals to the wider public and to extent affect their expectations. In addition, Ramakrishnan and Vamvakidis (2002) sustain that other macro-indicators such as the money supply or interest rates, might also be stifled by the exchange rate. As such, Amato and Gerlach (2002) are of the view that the monetary authority may set the exchange rate as monetary target if and when the exchange rate is thought to influence the realization of the central bank's inflation target.

In the context of emerging markets, Calvo and Reinhart (2002) produce evidence of the proclivity of central banks to silently intervene in the exchange rate market. The emerging evidence have refueled the lengthy deliberations on the key role that the exchange rate assumes in ITF countries; that is, its influence on the free-float regime. According to Calvo and Reinhart (2002), foreign exchange intervention is intended to support exchange rate stability.

Exchange rate volatility can also be magnified by the volatility in the risk appetite of the market agents (Smales, 2016). Earlier work in the area by Henderson and Rogoff (1982), document the impact of changes in the risk appetite of the market agents on stability. Smales (2016) finds that this changing of risk perception relates to large volatility in foreign exchange assets. This has been documented by (Cadarajat and Lubis, 2012), who show increasing volatility in the Indonesian exchange rate after the global financial crisis being mainly driven by by the offshore market, which reflects foreign investors' risk appetite.

Some recent examples on the effectiveness of FX intervention can be found in Berganza and Broto (2012), Daude *et al.*(2016), Chang *et al.* (2017), and Buffie *et al.* (2018), who suggest that FX intervention enhances the effectiveness of the ITF by stabilizing the exchange rate, and hence the prices of imports. In contrast, Kubo (2017) and Catalán-Herrera (2016) suggest that the effect of FX intervention on output and monetary policy might be rather small.

Drawing on the recent evidence, it has become apparent that the discussion on the impact of FX intervention is still far from conclusive, particularly in the setting of a central bank that practices ITF. In particular, the existing studies (see Ghosh *et al.*, 2016; Alla *et al.*, 2017), do not capture the limited access to the financial sector which is an important feature of an emerging market. In addition, none of these studies explain the transmission of the risk appetite shock to the economy and most importantly they fail to reach to an agreement as to whether FX intervention instrument can be utilized, particularly in the presence of the risk appetite shock. Given that price stability is the main objective of any monetary authority, our study addresses all aforementioned points which are deemed to be of great importance to central banks.

This paper contributes to the literature by providing empirical estimations of FX intervention based on the DSGE model for an emerging market, which features households with limited financial access – a distinct feature of emerging countries. By estimating the model based on Indonesian data, the biggest economy in south-east Asia, we provide useful insights into the utilization of FX intervention as means of stabilizing the economy. Moreover, we gauge the impact of different policies i.e., interest rate policy and interest rate and FX intervention, that aim to stabilize inflation, output, and the exchange rate. Unlike the existing literature on ITF (see Bernanke *et al*. 1999; Bernanke and Mishkin 1997; and Calvo and Reinhart 2002), our study suggests that FX intervention can serve as a tool to stabilize an economy following a capital flow shock.

This study is organized as follows. Section II discusses the small open economy model and the data. Section III provides a discussion on the empirical estimation model and the main findings. Finally, Section IV provides some concluding remarks.

II. MODELLING A SMALL OPEN ECONOMY

A. Methodology

Following Smets and Wouters (2007) and Christiano *et al.* (2005), we construct a continuous-time model, featuring real and nominal rigidities. Since the focus of this paper is on the policy of a single economy, we describe the model from the point of view of one country, which we call the Home or domestic country. The problem of the agents is described in more detail in the Appendix and for our policy setting, we consider exogenous distortionary tax rates on wage and capital income to pay for exogenous government spending, with a government balanced budget constraint. We also allow the government to run a fiscal deficit, use government spending as a stabilisation instrument and borrow from domestic and foreign investors.

To allow the risk appetite to be incorporated, we assume foreign bonds are subject to a premium that depends on the exposure to total foreign debt, as we have already defined in equation (7), where $B^*_{G,t}$ is the amount of government debt denominated in the foreign currency. We assume $\Theta(0)=0$ and $\Theta'<0$ and the following functional form with these properties:

$$\Theta(x) = exp(-\Theta_B x);\ \Theta_B > 0 \tag{1}$$

Following Farhi and Werning (2014) and Alla *et al.* (2017), we contribute by introducing an exogenous *risk-appetite* shock (Ξ_t) in order to determine the impact of the 'Risk On/Risk Off' phenomenon of the global financial system. This phenomenon affects emerging markets, particularly since the global financial crisis. Equation (A.7) can be rewritten as

$$R_t^* = \frac{1}{P_t^{B*}\Theta\left(\frac{S_t\left(w_t B_{F,t}^* - (1-w_t)B_{G,t}^*\right)}{P_{H,t}Y_t}\right) + \Xi_t} \tag{2}$$

Furthermore, government borrowing is the combination of nominal domestic bonds $B_{H,t}$ held by foreign investors. The total stock of domestically held government bonds is therefore defined as:

$$B_{G,t} = \frac{B_{H,t}}{P_t} + \frac{S_t B_{H,t}^*}{P_t} = B_{GH,t} + B_{GF,t} \tag{3}$$

Foreign bond holdings are the sum of assets held by households $B_{F,t}$ and liabilities held by the government $B^*_{G,t}$, and evolve according to

$$P_t^{B*}\left(S_t\left(B_{F,t}^* - B_{G,t}^*\right)\right) = S_t\left(B_{F,t-1}^* - B_{G,t-1}^*\right) - P_t TB_t \tag{4}$$

where the nominal trade balance is the difference between domestic output and private and public consumption and investment, which can be written as follows:

$$P_t TB_t = P_{H,t}Y_t - P_t C_t - P_{I,t}I_t - P_{H,t}G_t \tag{5}$$

We then define $B_{F,t} \equiv \frac{S_t B_{F,t}^*}{P_t}$ to be the foreign bonds stock held by households domestically. Therefore,

$$\begin{aligned} P_t^{B*}P_t\left(B_{F,t} - B_{GF,t}\right) &= \frac{S_t}{S_{t-1}}P_{t-1}\left(B_{F,t-1}^* - B_{G,t-1}^*\right) + P_t TB_t \Rightarrow \\ P_t^{B*}\left(B_{F,t} - B_{GF,t}\right) &= \frac{\Pi_{t-1,t}^S}{\Pi_{t-1,t}}\left(B_{F,t} - B_{GF,t}\right) + TB_t \end{aligned} \tag{6}$$

Then, by analogy with the national budget constraint given in equation (A.32), the government budget constraint is

$$P_t^B B_{GH,t} + P_t^{B*}B_{GF,t} = \frac{1}{\Pi_{t-1,t}}B_{GH,t-1} + \frac{\Pi_{t-1,t}^S}{\Pi_{t-1,t}}B_{GF,t-1} + D_t \tag{7}$$

where the nominal government deficit is given by:

$$P_t D_{,t} = P_{H,t} G_t - W_t N_t T_t^W - (1-\alpha) Y_t^W P_{H,t} MC_t T_t^K \quad (8)$$

Bond price will be written as:

$$P_t^{B*}(B_{F,t} - B_{GF,t}) = \frac{\Pi_{t-1,t}^S}{\Pi_{t-1,t}} B_{GF,t-1}(B_{F,t} - B_{GF,t}) + TB_t \quad (9)$$

Therefore, government bond price will be:

$$P_t^B B_{GH,t} + P_t^{B*} B_{GF,t} = \frac{1}{\Pi_{t-1,t}} B_{GH,t} + \frac{\Pi_{t-1,t}^S}{\Pi_{t-1,t}} B_{GF,t-1} + D_t \quad (10)$$

Fiscal policy tax rates T_t^W is given by:

$$T_t^W = \frac{\frac{P_{H,t}}{P_t} G_t - D_t - (1-\alpha) Y_t^W P_{H,t} MC_t T_t^K}{W_t N_t} \quad (11)$$

We then define FX intervention as:

$$FX_t = \frac{B_{GH,t}}{B_{G,t}} \quad (12)$$

The nominal interest rate R_t is the monetary policy variable, given by a standard Taylor-type rule (Taylor, 1993). Beside the standard inflation and output deviation response, we add an exchange rate depreciation term following (Juhro and Mochtar, 2009) and (Kolasa and Lombardo, 2014):

$$\log\left(\frac{R_t}{R}\right) = \rho_R \log\left(\frac{R_{t-1}}{R}\right) + (1-\rho_R)\left(\theta_\pi \log\left(\frac{\Pi_{t-1,t}}{\Pi}\right) + \theta_y \log\left(\frac{Y_t}{Y}\right) + \theta_s \log\left(\frac{\Pi_{t-1,t}^S}{\Pi^S}\right)\right) + \epsilon_{M,t} \quad (13)$$

This fiscal stabilisation also follows a Taylor-type rule as follows:

$$\log\left(\frac{G_t}{G}\right) = \rho_G \log\left(\frac{G_{t-1}}{G}\right) + (1-\rho_G)\left(\theta_{BG,\Pi} \log\left(\frac{B_{G,t-1,t}}{B_G}\right) + \theta_{G,\pi} \log\left(\frac{\Pi_{t-1,t}}{\Pi}\right) + \theta_{G,y} \log\left(\frac{Y_t}{Y}\right)\right) + \epsilon_{G,t} \quad (14)$$

Finally, FX_t is set at FX_t>0 in the steady state. Then, FX_t responds to changes in the exchange rate depreciation rate Π_t^S and to R_t^* as follows:

$$\log\left(\frac{FX_t}{FX}\right) = \rho_{FX}\log\left(\frac{FX_{t-1}}{FX}\right) + (1-\rho_{FX})\left(\theta_{FX,\Pi^S}\log\left(\frac{\Pi^S_{t-1,t}}{\Pi^S}\right) + \theta_{FX,R^*}\log\left(\frac{R^*_{t-1,t}}{\mathrm{R}^*}\right)\right) + \epsilon_{FX,t} \quad (15)$$

The log-linear structural shock processes are considered to undertake the following AR(1) form:

$$\log A_t - \log A = \rho_A(\log A_{t-1} - \log A) + \epsilon_{A,t} \quad (16)$$

$$\log G_t - \log G = \rho_G(\log G_{t-1} - \log G) + \epsilon_{G,t} \quad (17)$$

$$\log MS_t - \log MS = \rho_{MS}(\log MS_{t-1} - \log MS) + \epsilon_{MS,t} \quad (18)$$

$$\log C^*_t - \log C^* = \rho_{C^*}(\log C^*_t - \log C^*) + \epsilon_{C^*,t} \quad (19)$$

$$\log I^*_t - \log I^* = \rho_{I^*}(\log I^*_t - \log I^*) + \epsilon_{I^*,t} \quad (20)$$

$$\log \Pi^*_t - \log \Pi^* = \rho_{\Pi^*}(\log \Pi^*_t - \log \Pi^*) + \epsilon_{\Pi^*,t} \quad (21)$$

Variables without subscription denote the steady state value of the variable.

B. Data

In this study, we utilize Bayesian methodology and a data set consisting of quarterly data for Indonesia over the period 2000Q1 to 2018Q1. Our dataset includes following variables: output growth, consumption growth, investment growth, and domestic inflation which are sourced from Indonesian Statistics (BPS). The policy and exchange rates are sourced from the central bank of Indonesia, whilst the Terms of Trade (ToT) rate is obtained from Thomson Reuters.

Output, consumption, and investment are measured in real terms; policy rates and exchange rates are nominal; CPI based in year 2012 is a measure of inflation; the ratio USD/IDR serves as a measure of the exchange rate; and ToT are calculated using the index of export and import prices.

Measurement equations have been set up so as to include the measurement error as described in Table 1.

Table 1.
Measurement Equations

This table reports measurement equations in the observable variables

Observable	Model Variables
Output growth	$\Delta \ln Y_{obs,t} = \Delta(\ln Y_t - \ln Y) + \epsilon_{Y,t}$
Consumption growth	$\Delta \ln C_{obs,t} = \Delta(\ln C_t - \ln C) + \epsilon_{C,t}$
Investment growth	$\Delta \ln I_{obs,t} = \Delta(\ln I_t - \ln I) + \epsilon_{I,t}$
CPI inflation	$\Pi_{obs,t} = \Pi_t - \Pi$
Interest rate	$\mathrm{R}_{obs,t} = \mathrm{R}_t - \mathrm{R}$
Change in the exchange rate	$\Pi^S_{obs,t} = \Pi^S_t - \Pi^S$
Terms of trade growth	$\Delta \ln ToT_{obs,t} = \Delta(\ln ToT_t - \ln ToT) + \epsilon_{ToT,t}$

A calibration of the parameters is performed to ensure consistency and we set the discount factor, β, equal to 0.99, hence implying an annual steady-state real interest rate of around 4% (see for e.g. Smets and Wouters (2007). The home bias parameter, γ_C, is set to 0.62 and labour share, α, is set to 0.46 according to (Harmanta *et al.*, 2014). We take the annual labour work data for Indonesia from Feenstra *et al.* (2015) and calibrate the inverse Frisch elasticity of labour to be 0.25. In line with Schmitt-Grohé and Uribe (2003), the elasticity of the risk premium to the level of debt, denoted by Θ_B, is set to 0.001. We also consider data from the Asian Development Bank (ADB), which reports on the bond market in Indonesia[1]. We then calibrate the share of government bonds, ψ, to 0.9, to reflect the average share of government bonds in the market. Table 2 reports the respective calibrated parameters.

Table 2.
Calibrated Parameter Values

This table reports values of all calibrated parameter in columns 3.

Parameter	Symbol	Values
Labour share in production function	α	0.46
Domestic household discount factor	β	0.99
Home bias parameter for consumer goods	γ_C	0.62
Home bias parameter for investment goods	γ_I	0.62
Inverse Frisch elasticity of labour	η	0.25
The elasticity of substitution between domestic and imported consumer goods	μ_C	1.5
The elasticity of substitution between domestic and imported investment goods	μ_I	1.5
Depreciation rate of capital	δ	0.025
Government bond share	ψ	0.9
Risk premium	Θ_B	0.001

1 Data can be downloaded from https://asianbondsonline.adb.org/data-portal/

III. MAIN FINDINGS

The posterior distribution is estimated by maximizing the log posterior density function. The Metropolis-Hastings algorithm is then utilized to estimate the full posterior distribution. In this section we elaborate our findings along with some selected impulse response analysis. Table 3 presents the prior and posterior estimates.

Table 3.
Estimation Results

This table reports our prior and posterior results in columns 3 and 4, respectively. The full posterior distribution is estimated using the Metropolis-Hastings algorithm. Highest Posterior Density (HPD) Interval is reported in column 5 and 6.

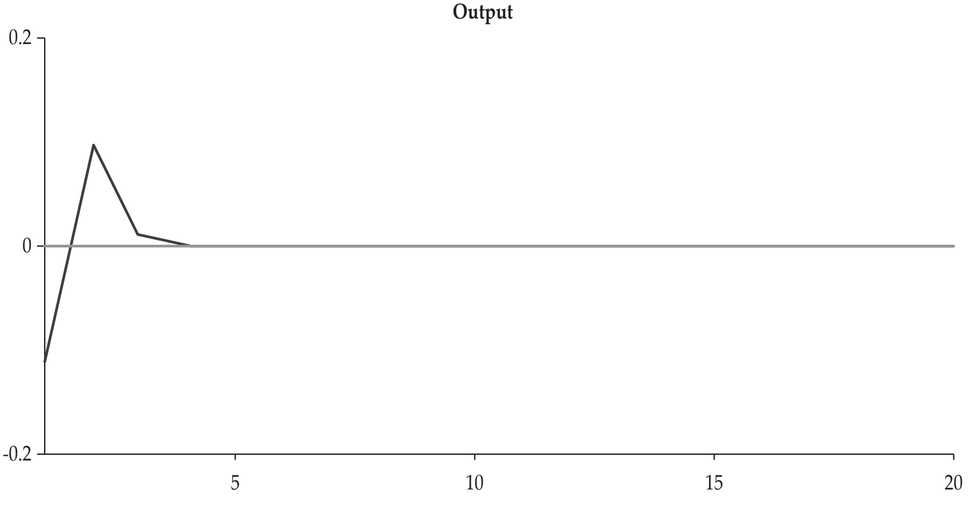
Parameter	Symbol	Prior Mean	Post Mean	90% HPD Interval		Prior	Pstdev
Persistence of total factor productivity shock	ρ_A	0.5	0.282	0.1314	0.417	beta	0.2
Persistence of monetary policy shock	ρ_m	0.5	0.5975	0.1426	0.8873	beta	0.2
Persistence of mark-up shock	ρ_{MS}	0.5	0.4881	0.1611	0.7577	beta	0.2
Persistence of government spending shock	ρ_G	0.5	0.4706	0.1793	0.8	beta	0.2
Persistence of foreign consumption shock	ρ_{C^*}	0.5	0.4684	0.1726	0.7678	beta	0.2
Persistence of foreign investment shock	ρ_{I^*}	0.5	0.5367	0.2514	0.8432	beta	0.2
Persistence of foreign interest rate shock	ρ_{R^*}	0.75	0.7541	0.5164	1	beta	0.2
Persistence of FX intervention shock	ρ_{FX}	0.5	0.8541	0.7859	0.9243	beta	0.2
Persistence of foreign inflation shock	ρ_{Π^*}	0.5	0.1369	0.0543	0.2136	beta	0.2
Share of credit-constrained households	λ	0.5	0.4102	0.3392	0.4788	norm	0.05
Internal habit formation	χ	0.6	0.9646	0.9343	0.998	beta	0.2
Calvo parameter	ϕ	0.5	0.3814	0.2224	0.558	beta	0.2
Risk premium in investment	Θ_I	4	4.2627	3.5941	5.1461	norm	1.5
Labour share in production function	α	0.54	0.5596	0.4821	0.6354	norm	0.05
Elasticity of substitution among goods	ϵ	7	6.7352	6.1852	7.1592	norm	1.5
Risk premium of bonds	Θ_B	0.001	0.1166	0.0782	0.1559	norm	1.5
Risk aversion of households	σ	2	1.9913	1.9072	2.0722	norm	0.05
Interest rate smoothing	ρ_r	0.7	0.9303	0.9133	0.9487	beta	0.1
Inflation weight parameter	θ_π	2	1.9094	1.498	2.3426	norm	0.25
Output weight parameter	θ_Y	0.1	0.1129	0.0377	0.1846	norm	0.05
Government spending weight parameter	θ_G	0.1	0.1251	0.0717	0.1747	norm	0.05
Foreign inflation weight parameter	θ_{FX,Π^S}	0.1	0.104	0.022	0.1851	norm	0.05
Foreign interest rate weight parameter	θ_{FX,R^*}	0.1	0.1008	0.0182	0.1824	norm	0.05
Feedback from exchange rate depreciation	θ_s	0.1	0.0111	0.0035	0.0187	norm	0.05

A. Impulse Response Analysis

The transmission mechanism in the model is depicted through impulse response analysis. We start by describing the impact of the monetary policy shock, the FX intervention shock, as well as the risk premium shock. The impact of the monetary policy shock is displayed in Figure 1.

Figure 1.
Impulse Response to Monetary Policy Shock

This figure plots the impulse response functions of our observed variables output, consumption, investment, inflation, interest rate (Int Rate), exchange rate (Exch. Rate) and Terms of Trade (ToT) to shocks to monetary policy. Here we interpret monetary policy shock as the surprising positive shock to the interest rate which is taken by the authority. Horizontal axis represents time which is according to our data is quarterly



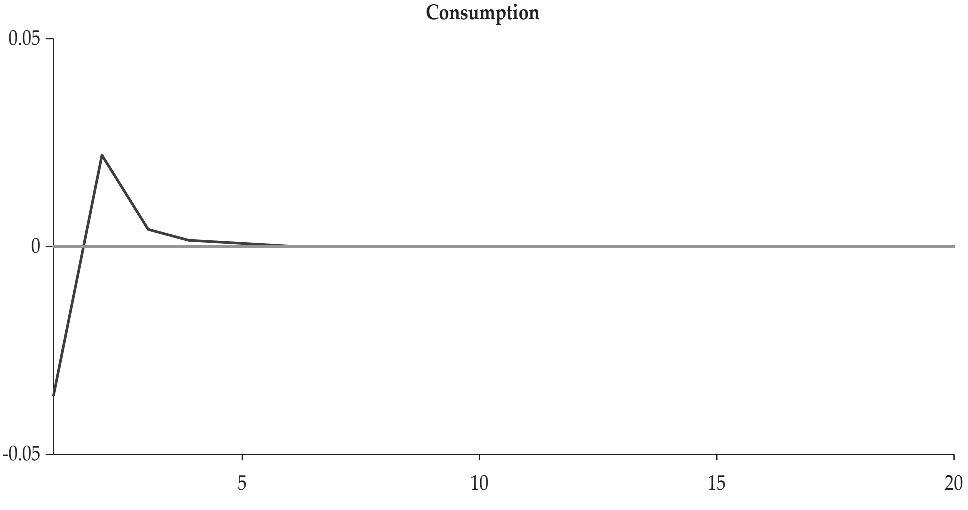


Figure 1.
Impulse Response to Monetary Policy Shock (Continued)

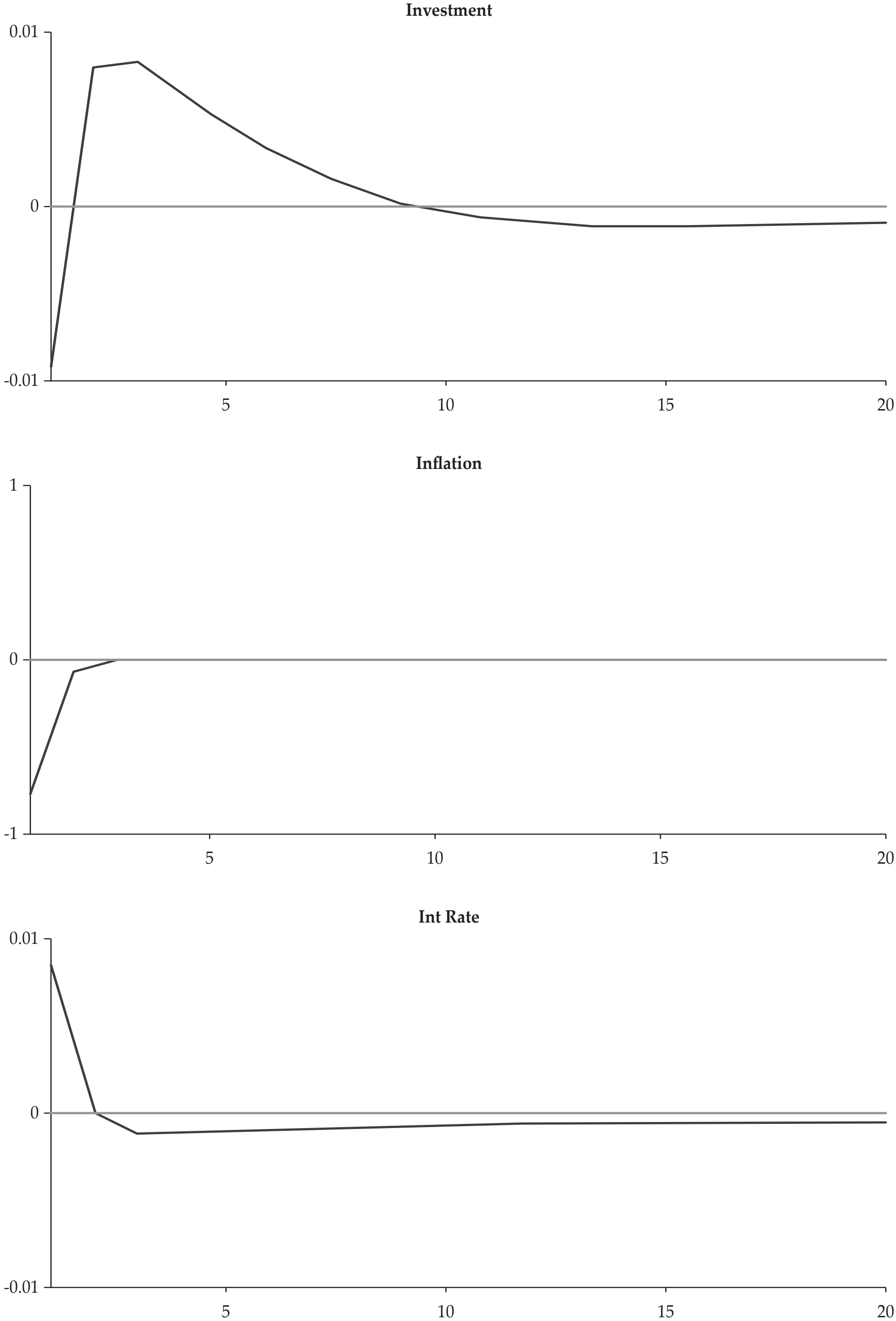
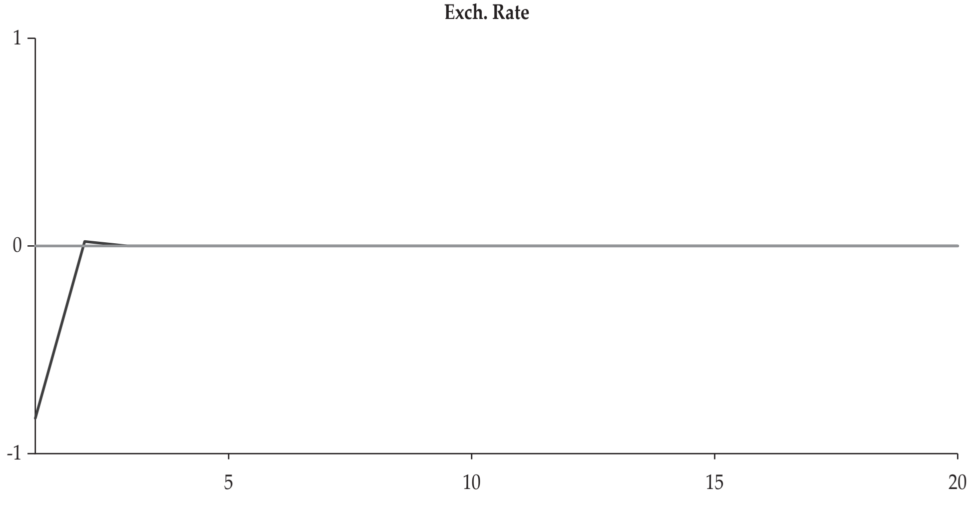


Figure 1.
Impulse Response to Monetary Policy Shock (Continued)



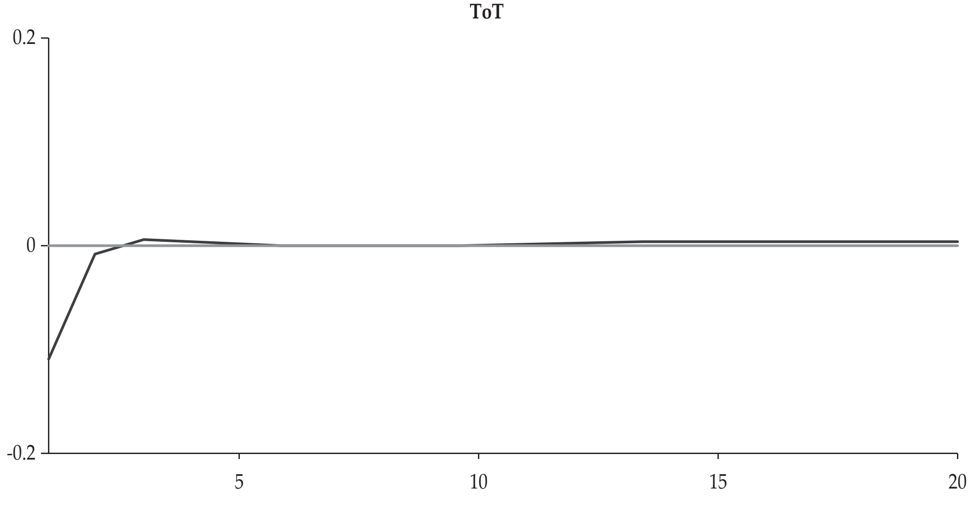
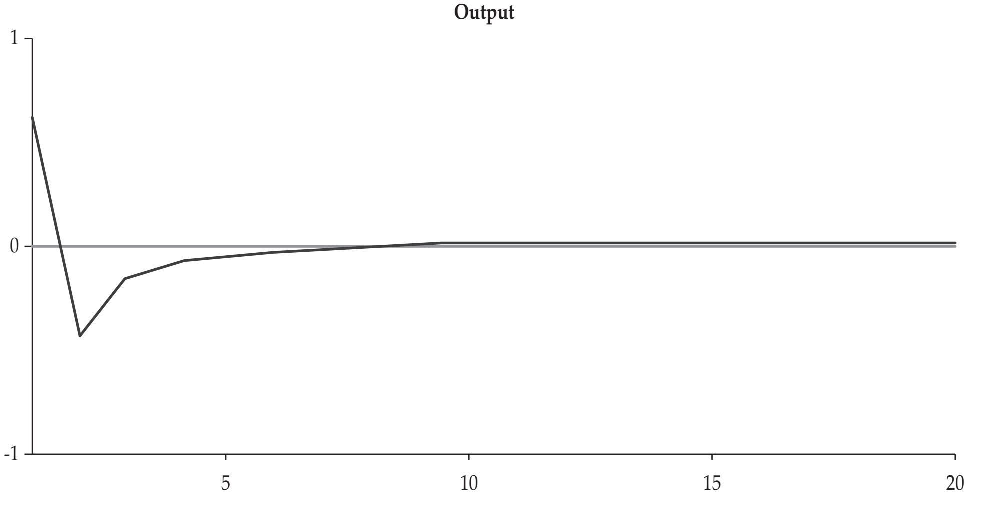


Figure 1 shows that the monetary policy shock affects all the observable variables. Nominal interest rate increases as a result of the positive shock and subsequently the exchange rate appreciates, given the foreign interest rate remains the same, because the UIP holds. Consequently, the ToT is declining. As the cost of fund increases, the household adjusts its consumption downward hence causing inflation to dwindle. As consumption goes down, investment and output also decreases. However, the appreciation of the exchange rate leads to a cheaper import goods which brings the consumption back to the steady-state in the second round. When imports increase and the economy demands more foreign assets (or foreign currency), without FX intervention, nominal exchange rate adjusts to the steady-state. As the nominal interest rate decreases investment starts to go up and subsequently the output is back to its steady-state.

Figure 2.
Impulse Response to FX Intervention Shock

This figure plots the impulse response functions of our observed variables output, consumption, investment, inflation, interest rate (Int Rate), exchange rate (Exch. Rate) and Terms of Trade (ToT) to shocks to FX Intervention. Horizontal axis represents time which is according to our data is quarterly



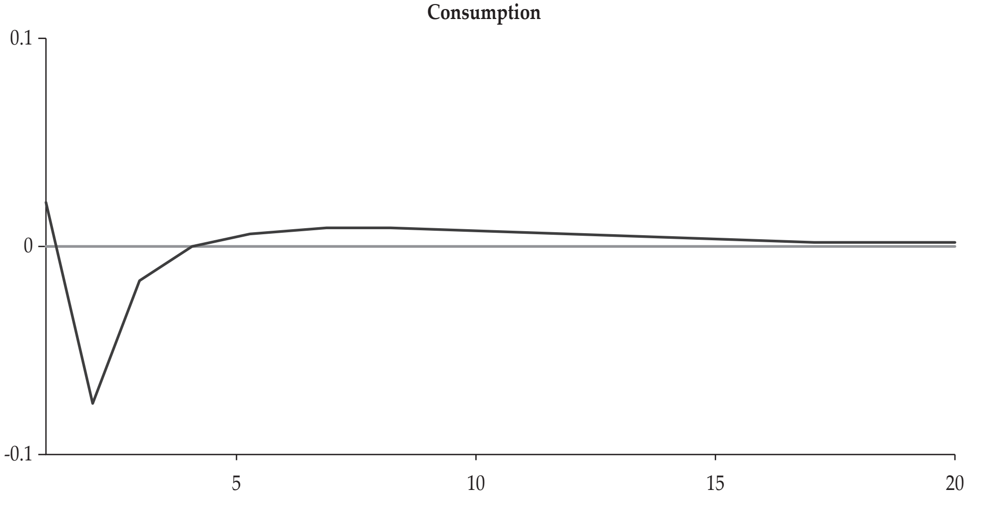


Figure 2.
Impulse Response to FX Intervention Shock (Continued)

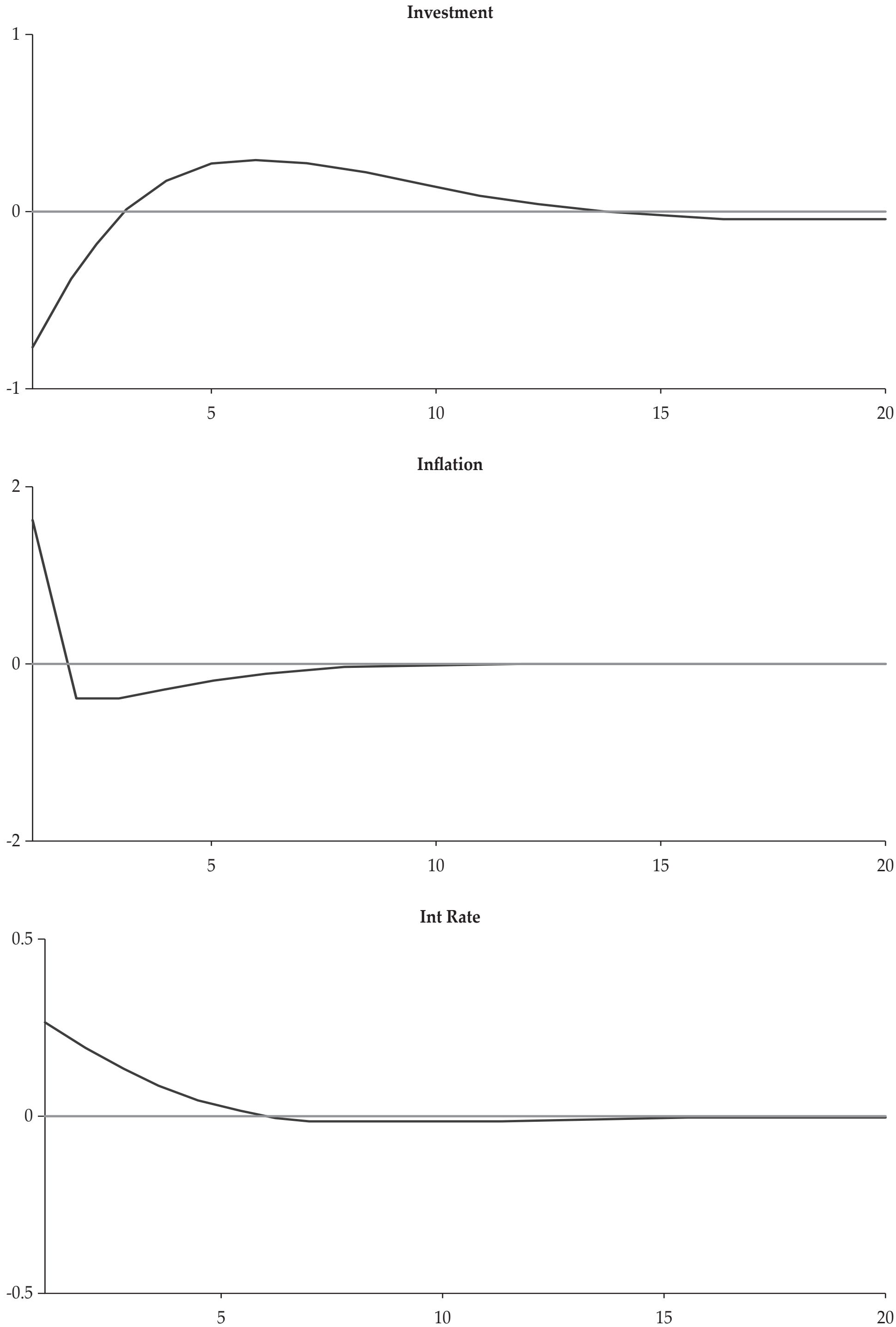
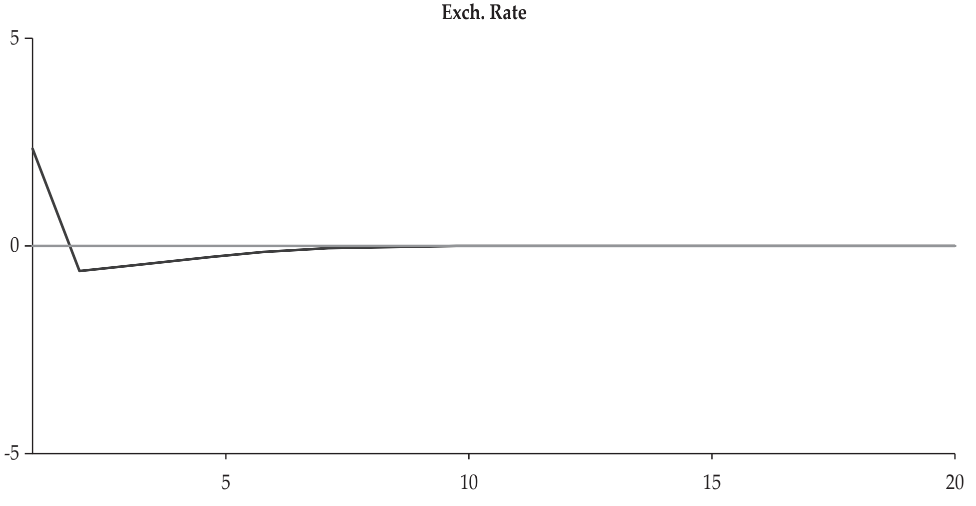
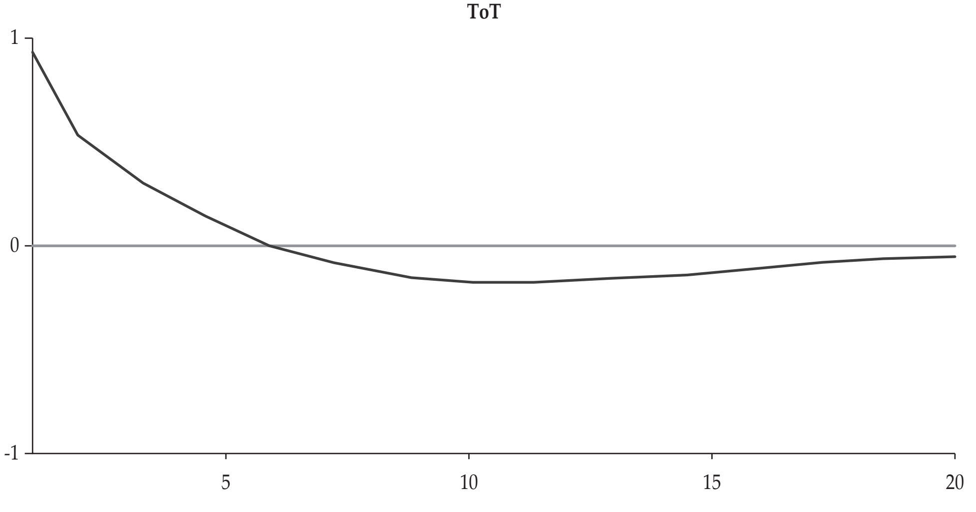


Figure 2.
Impulse Response to FX Intervention Shock (Continued)

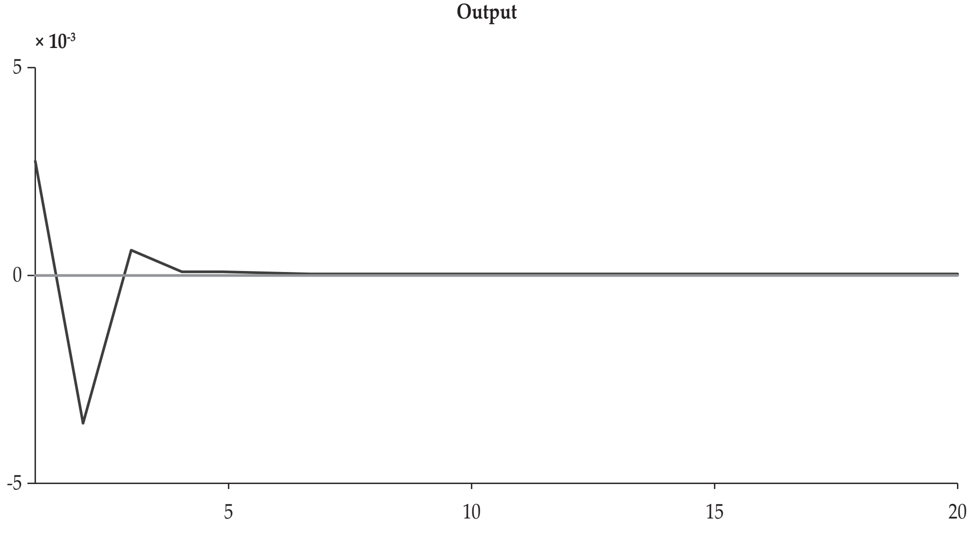




During an episode of positive FX Intervention shock, Figure 2 indicates that the positive FX intervention triggers the exchange rate to depreciate and the ToT to increase. As a result, the output and consumption increase at the time of the shock. However, sudden upsurge in consumption and output initiates the inflation to move up and interest rate to follow in the same fashion. Subsequently, investment goes down as the cost of borrowing increases. Following an increase in the inflation rate, output and consumption are contracted below their steady-state value. As the nominal interest rate increases, the exchange rate appreciates given the UIP holds, which leads to an increase in investment. The appreciation of the exchange rate also alleviates the pressure on domestic inflation as the price of the imported goods becomes cheaper. The reduction of inflation drives consumption up with output moving in the same direction.

Figure 3.
Impulse Response to Risk Appetite Shock

This figure plots the impulse response functions of our observed variables output, consumption, investment, inflation, interest rate (Int Rate), exchange rate (Exch. Rate) and Terms of Trade (ToT) to shocks to Risk Appetite. Horizontal axis represents time which is according to our data is quarterly



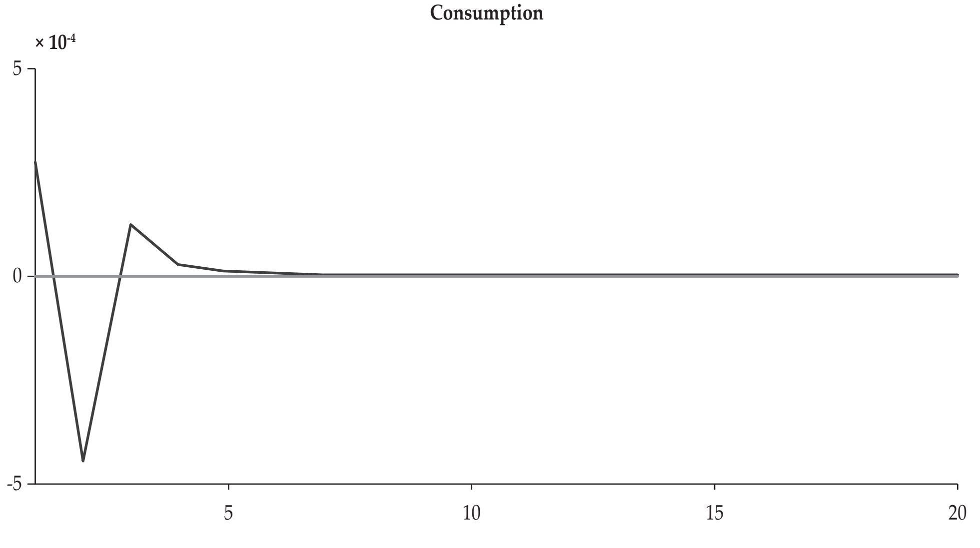


Figure 3.
Impulse Response to Risk Appetite Shock (Continued)

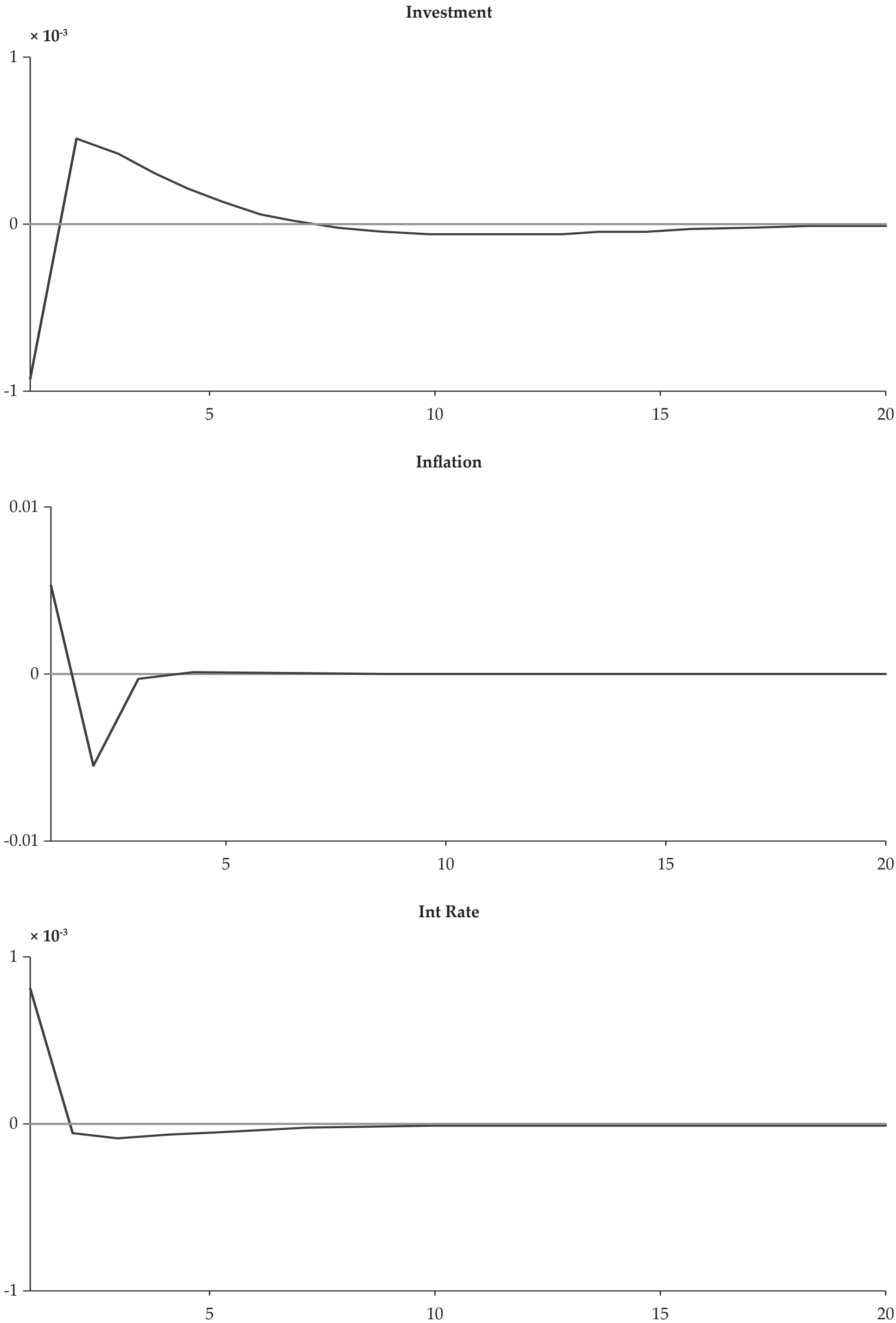
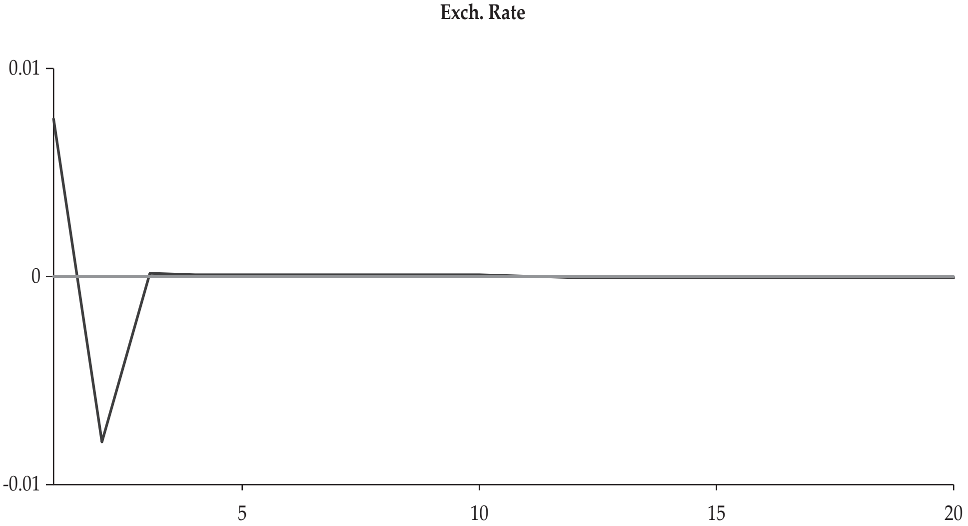
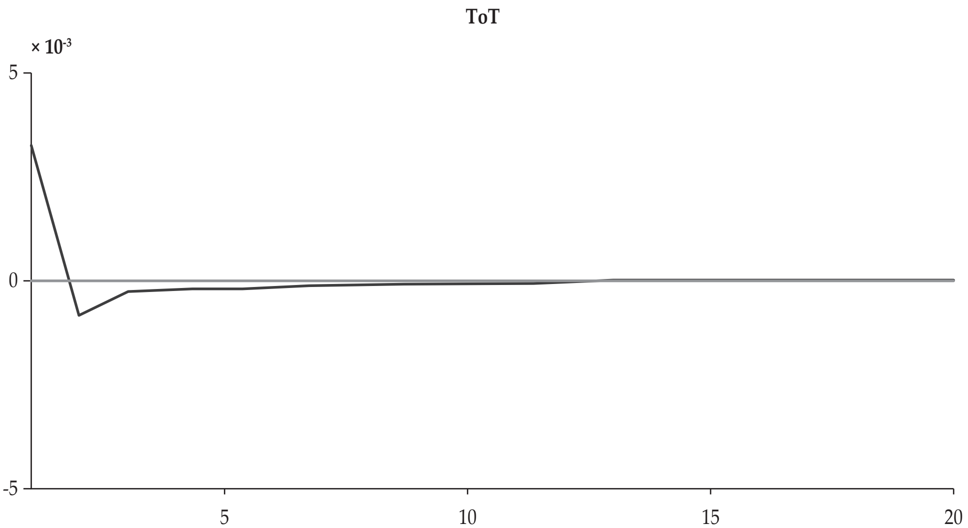


Figure 3.
Impulse Response to Risk Appetite Shock (Continued)





In this context, the risk appetite is fashioned as a supplement to the risk premium. Figure 3 shows the effect of the shock derived from the risk appetite on the respective variables. As the risk premium increases, the nominal interest rate also increases. The upward movement of the domestic interest rate causes the appreciation of the exchange rate which in turn leads to higher inflation. However, an increase in the interest rate drives investment down. As both the inflation and the interest rate increases, households adjust their consumption and drives output down. In addition, the exchange rate is also appreciates following the increased domestic interest rate. The appreciation of the exchange rate leads to cheaper prices of imported goods whilst the adjustment in consumption along with the appreciating exchange rate alleviates inflation pressures. As a result, inflation and interest rates goes down, whilst consumption, investment, and output increases.

B. Variance Decomposition

The variance decomposition of the variables is also explored, (see Figures 4 and 5).

Figure 4.
Variance Decomposition (1)

This figure plots the variation in our observed variables output and consumption into each shock to the system: technology (eps_a), monetary policy (eps_m), fiscal policy (eps_g), mark up (eps_ms), foreign consumption (eps_C), foreign interest rate (eps_R), foreign inflation (eps_pi_star), FX intervention (eps_fx), output error measurement (mes_y), consumption error measurement (mes_c), investment error measurement (mes_i), terms of trade error measurement (mes_tot), risk appetite (eps_phi) thus providing information on the relative importance of each disturbance as a source of variation for each variable.

Output

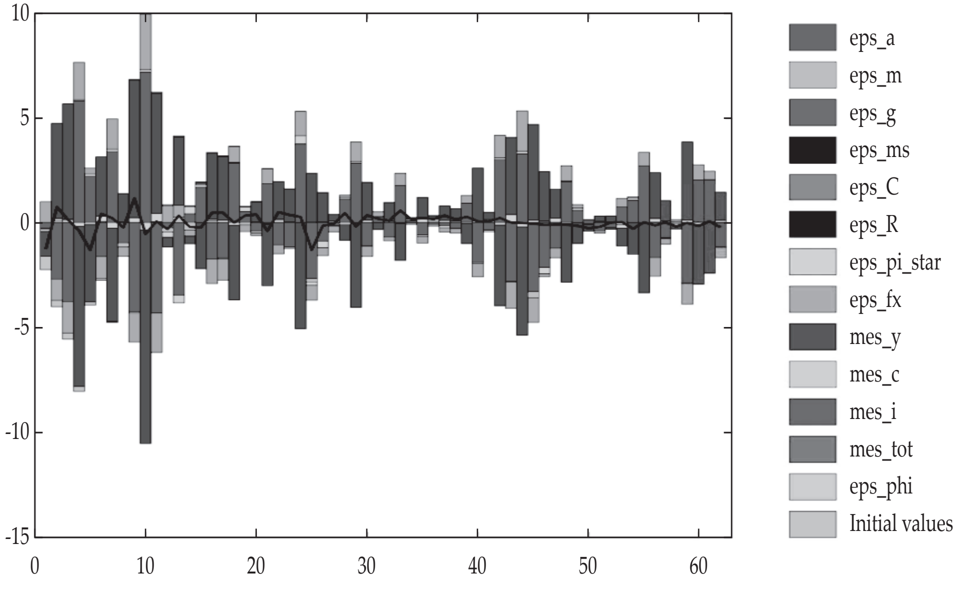


Figure 4.
Variance Decomposition (1) (Continued)

Output

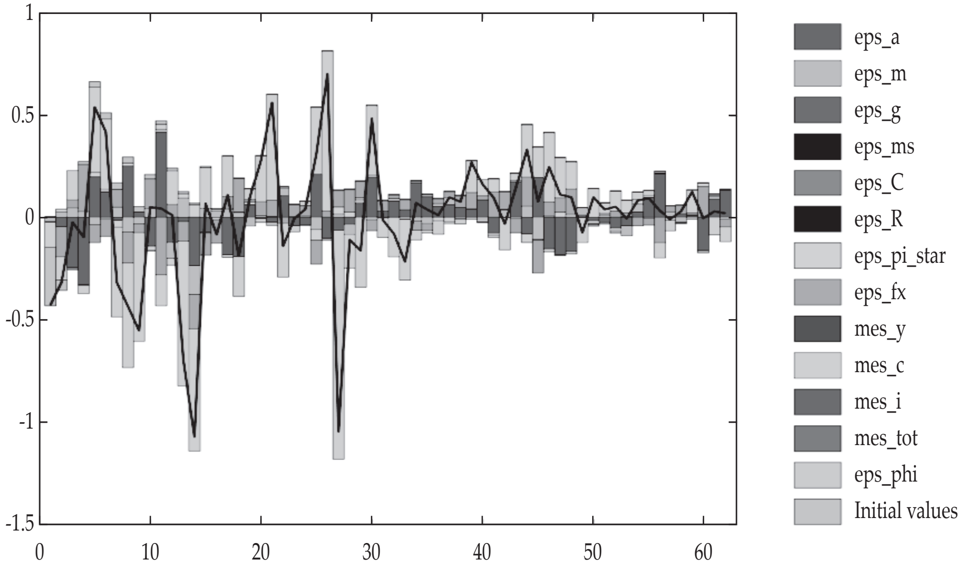
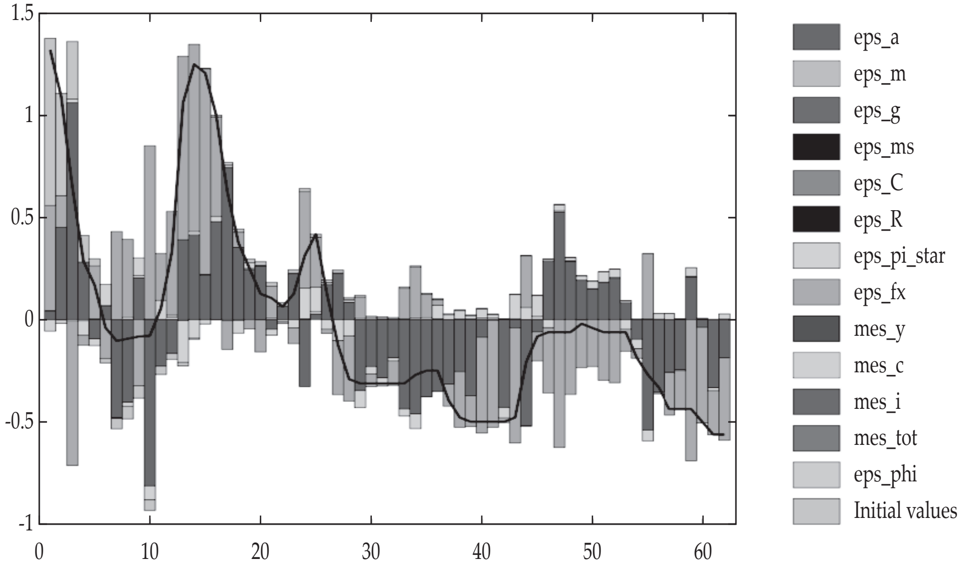


Figure 4 shows that FX intervention may affect real variables such as output and inflation. Figure 4 displays that technology shock (*eps_a*), similar to the standard New-Keynesian DSGE model, and FX intervention (*eps_fx*) are the dominating shocks that affect the output. We may observe the presence of error measurements in output (*mes_y*) in certain periods. Other effects are relatively smaller compared to the technology shock and FX intervention shock. A similar trend can be observed for consumption investment and inflation rate. Technology shock and FX intervention are the major factors in affecting consumption, investment, and inflation.

Figure 5.
Variance Decomposition (2)

This figure plots the variation in our observed variables interest rate and exchange rate into each shock to the system: technology (eps_a), monetary policy (eps_m), fiscal policy (eps_g), mark up (eps_ms), foreign consumption (eps_C), foreign interest rate (eps_R), foreign inflation (eps_pi_star), FX intervention (eps_fx), output error measurement (mes_y), consumption error measurement (mes_c), investment error measurement (mes_i), terms of trade error measurement (mes_tot), risk appetite (eps_phi) thus providing information on the relative importance of each disturbance as a source of variation for each variable.

Interest Rate



Exchange Rate

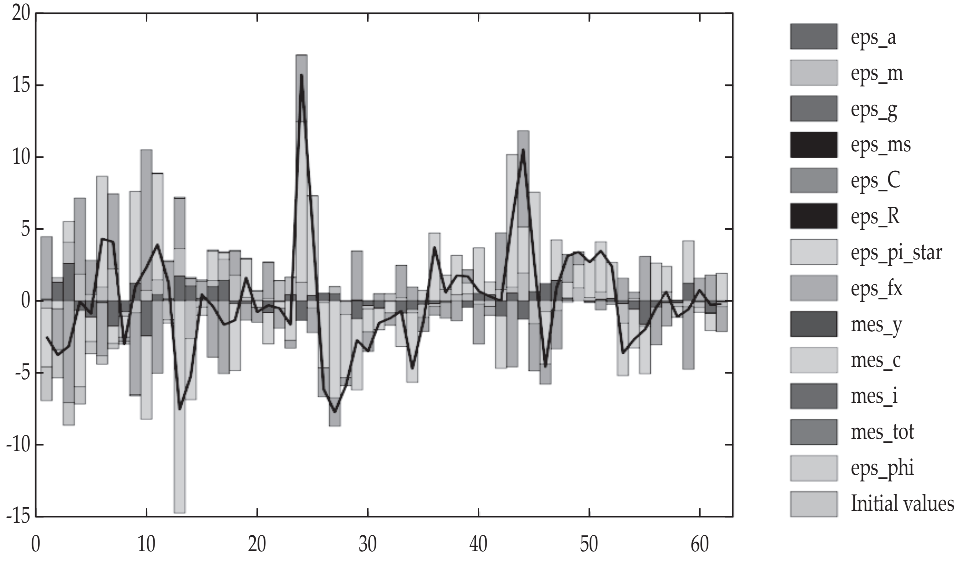


Figure 5 confirms that the effect of FX intervention comes through the interest rate and the exchange rate and finally the ToT. Additionally, eps_fx and eps_a affect the interest rate. Since we set the Taylor rule that responds to the exchange rate, the foreign inflation shock (eps_pi_star) also has a strong presence in the interest rate. As previously mentioned, the exchange rate is affected by the FX Intervention directly. Moreover, foreign inflation has also affected the exchange rate strongly. FX intervention affects inflation by lowering the import price through the perfect exchange rate pass-through to inflation. Figure 5 also shows that ToT is affected by both, eps_a and eps_fx.

C. Model Comparison

To gain more insight into how FX intervention affects the economy, we contrast our model to models without intervention. First, we take the same model and experiment it with the monetary policy—that is, interest rule presence or the full-pledge ITF. Second, we also modified the same model by incorporating the exchange depreciation to the Taylor rule. This is a case of flexible ITF as suggested by Kolasa and Lombardo (2014) and Juhro and Mochtar (2009). The rest of the equations will be similar to our FX intervention model. We then compare our results obtained using the two newly modified models with the results obtained earlier using the FX intervention model. Figures 6 and 7 depict the impulse response of selected variables. Our analysis focuses on the impact of these selected variables on the technology, monetary policy, and risk appetite shocks to observe different implications of these policy options to these specific variables.

Figure 6.
Comparison of Impulse Responses to Total Factor Productivity Shock

This figure compares the impulse response functions of inflation, output, nominal interest rate, and nominal exchange rate to shocks to Total Factor Productivity. Horizontal axis represents time period which is according to our data is quarterly

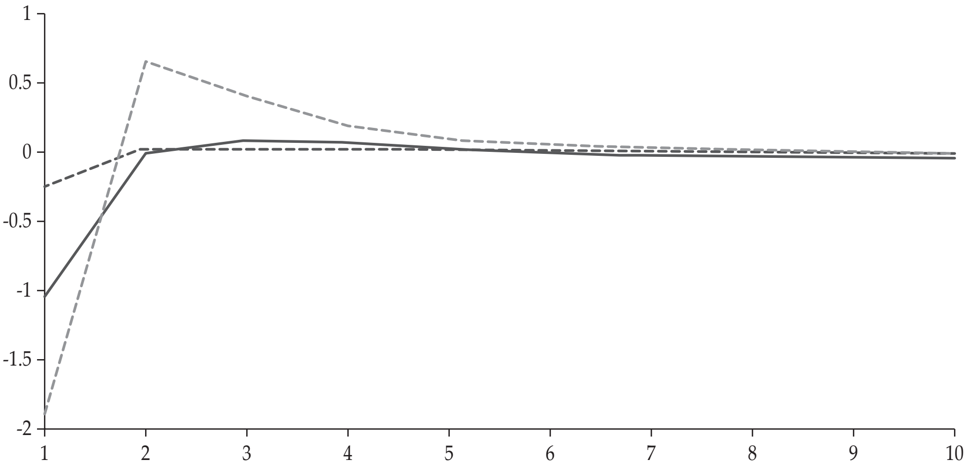


Figure 6.
Comparison of Impulse Responses to Total Factor Productivity Shock (Continued)

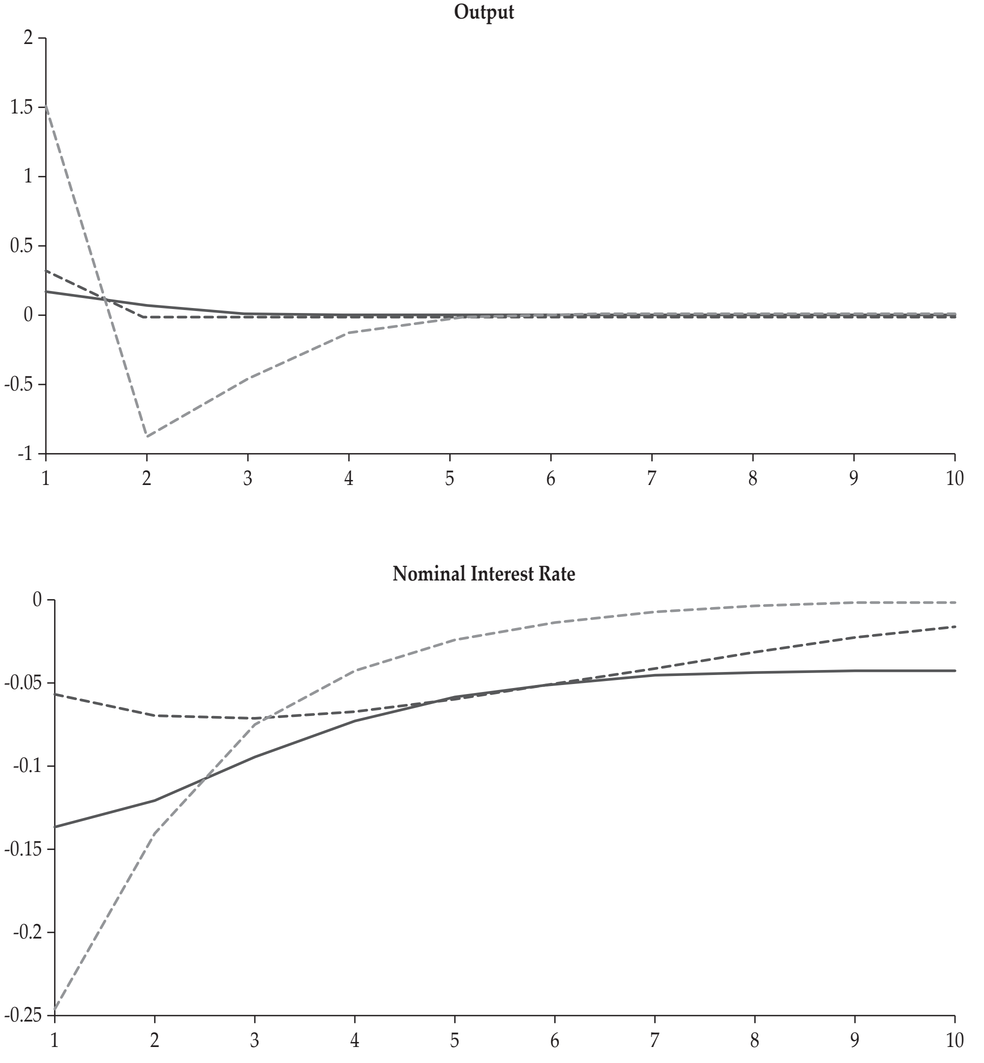


Figure 6.
Comparison of Impulse Responses to Total Factor Productivity Shock (Continued)

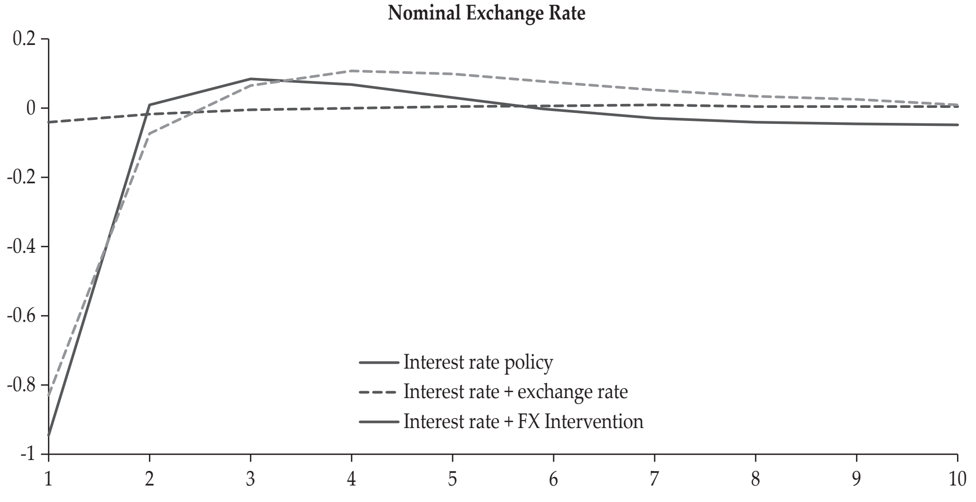


Figure 7 shows that the selected variables are more volatile in the presence of FX intervention. Unlike in Wimanda *et al.* (2012), our results indicate that monetary policy that incorporates the exchange rate depreciation in the Taylor-rule displays more stable variables in the presence of a total factor productivity (TFP) shock. Meanwhile, the FX intervention amplifies the risk perception and expectation during the TFP shock. A keen appreciation in the exchange rate leads to a lower price in the midst of a low interest rate period.

Figure 7.
Comparison of Impulse Responses to Risk Appetite Shock

This figure compares the impulse response functions of inflation, output, nominal interest rate, and nominal exchange rate to shocks to risk appetite. Horizontal axis represents time period which is according to our data is quarterly

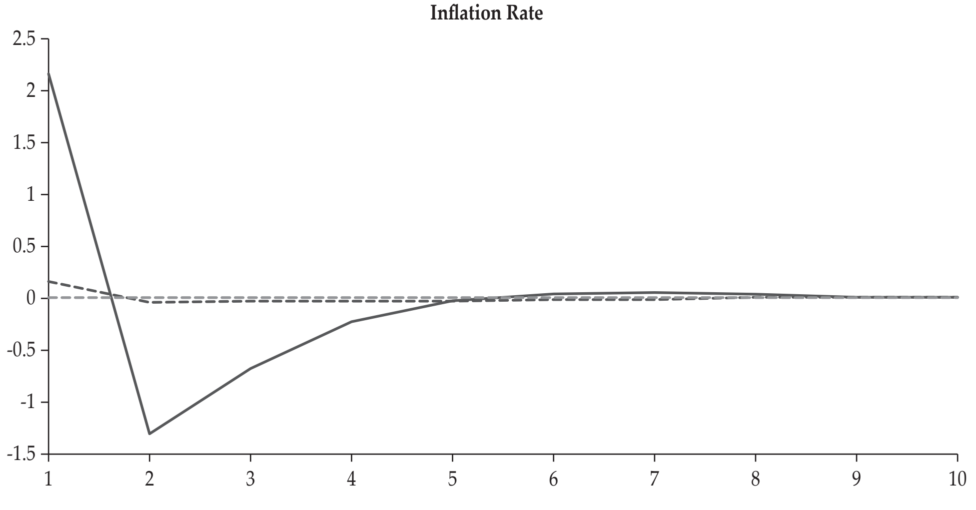
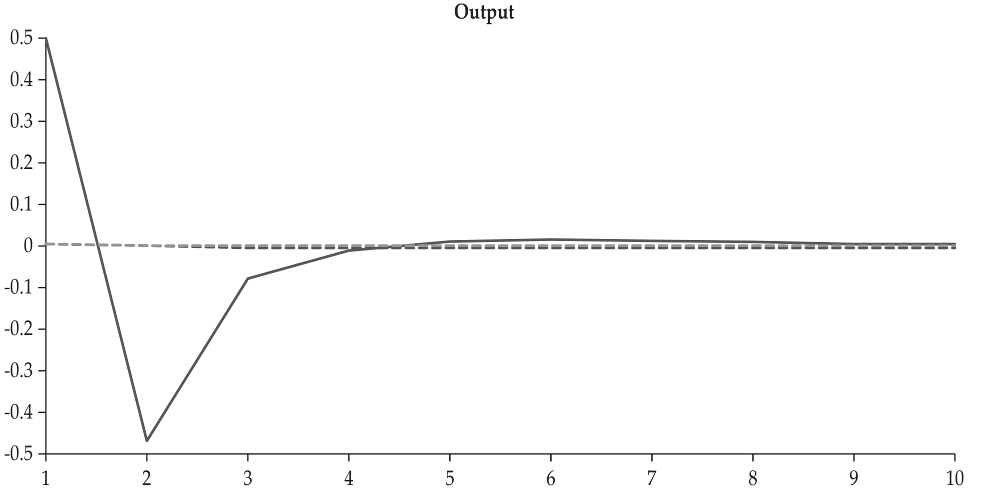


Figure 7.
Comparison of Impulse Responses to Risk Appetite Shock (Continued)



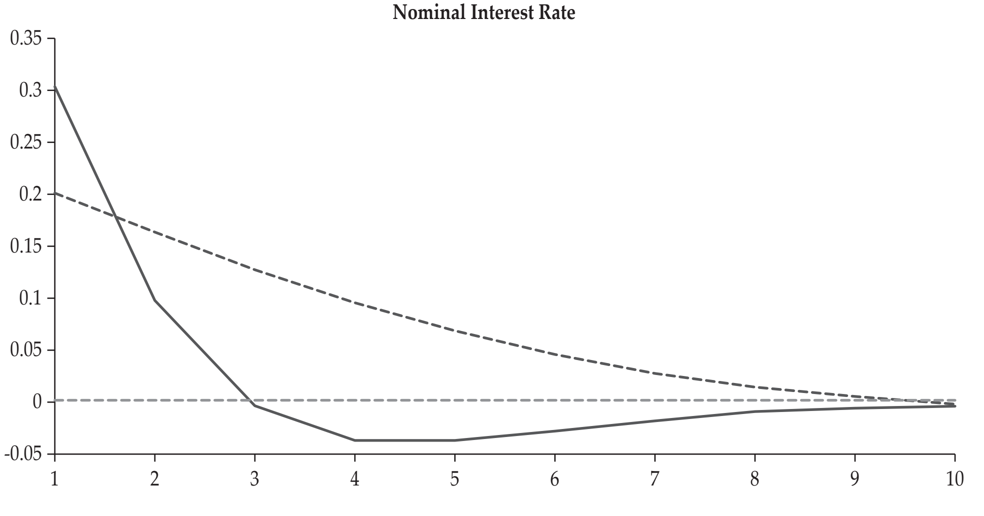
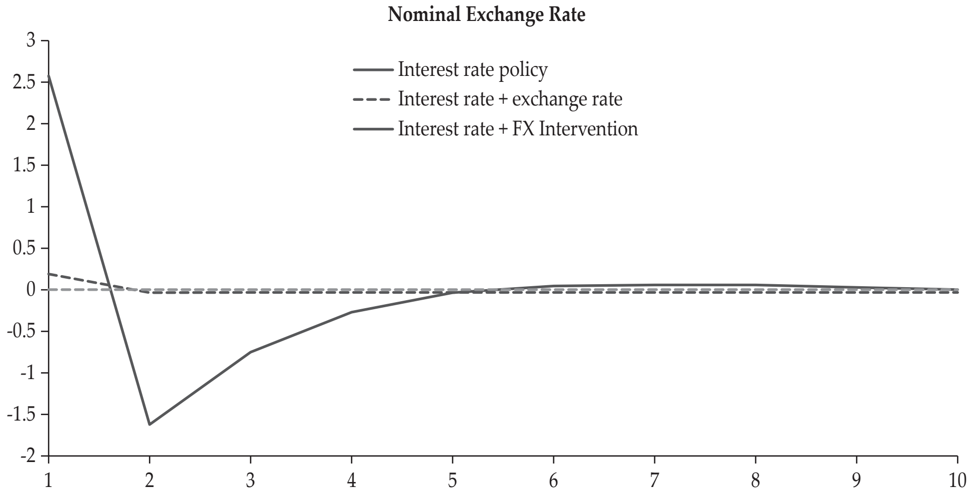


Figure 7.
Comparison of Impulse Responses to Risk Appetite Shock (Continued)



In the presence of a risk appetite shock, the selected variables fluctuate quite a lot under the strict Taylor-rule policy regime, as displayed in Figure 7. FX intervention helps to stabilise the variables during this shock, particularly the exchange rate, which in turn, helps to stabilise inflation and the growth of output.

D. Policy Implications

Our evidence indicates that FX intervention helps to stabilise the economy during an episode of capital flows. Without the FX intervention, the central bank must increase the policy rate to restraint the effect of the risk appetite shocks. Otherwise, the central bank needs to allow a rapid appreciation in the nominal exchange rate (in the case of capital inflows) or depreciation (in the case of capital outflows) as suggested by Ghosh *et al.* (2016). Using the interest rate as the only instrument is demonstrated to be costlier to the economy, in our findings. This FX intervention, however, needs to consider the availability of the foreign reserves of a country. An FX sale intervention requires sufficient foreign reserves and an FX buy intervention will increase the foreign reserves. Investigating the adequate amount of foreign reserves is beyond the scope of this research.

In addition, our findings highlight that FX intervention is not a generic solution for every shock in the economy. For instance, during an episode of positive productivity shock, the use of both interest rate and FX intervention will amplify the shock to the economy. By reducing the cost of borrowing through both the interest rate and the exchange rate, policymakers will aggravate the optimistic view of the agent, which will in turn intensify the impact of the shock on the economy. Our model comparison indicates that a Taylor-rule that increases with the exchange rate depreciation response is the best policy option to stabilise the economy. This paper supports Juhro and Mochtar (2009) in suggesting that a policy rule in Indonesia needs to incorporate the exchange rate.

One other point that needs to be stressed is that intervention in the foreign exchange should not weaken the pledges of the monetary authority to achieve a pre-set target for inflation. An inflation-targeting central bank, within its communication strategy framework, needs to communicate clearly its strategy with regard to the intentions of the FX intervention, which is to tackle specific shocks, in particular the capital flow shocks (Ghosh *et al.*, 2016).

IV. CONCLUDING REMARKS

In this study we provides an in-depth analysis of the use of FX intervention using a DSGE model and producing estimates based on Indonesian data. We find that the central bank actively intervenes in the exchange rate. The FX intervention affects the macroeconomic variables through the portfolio channel. The risk appetite also affects the economy by increasing the price of capital.

To have a better understanding of the use of FX intervention, we also compare our estimated results with a policy simulation where the interest rate policy follows a) strictly the Taylor-rule and b) a policy that addresses inflation, output, and the exchange rate. The evidence suggests that an intervention provides more economic stability during the presence of risk appetite shocks and monetary policy shocks. However, the interest rate policy that addresses the exchange rate as well as follows the standard Taylor-rule is found to be more effective in stabilizing the macroeconomy during TFP shocks.

These findings have a direct implication for policymakers. Our results suggest that FX intervention can be used to complement interest rate policy, especially when external shocks such as risk appetite shocks need to be dealt with. However, policymakers need to be cautious in identifying shocks to provide the right policy mix to tackle the issue. We simulate the economy under three different shocks, a positive productivity shock, monetary policy shock, and risk appetite shock, and our findings indicate that FX intervention may not be the best complement for handling positive productivity shocks to the economy.

Although this study provides interesting findings, it also leaves avenues for future research. First, it would be interesting to incorporate the availability of foreign reserves into the FX intervention. On the one hand, piling up foreign reserves while performing an FX buy intervention may incur investment costs. On the other hand, implementing an FX sale intervention may be restricted by the amount of foreign reserves available for the central bank to conduct the operation. Second, macroprudential instruments such as capital flow management may strengthen or diminish the effect of FX intervention. Furthermore, macroprudential tools aimed directly at the banking system, such as loan-to-value or reserve requirements, may have different implications. It would be worth combining this analysis with our framework.

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TECHNICAL APPENDIX -A

We consider a continuous-time model with infinite horizon which features nominal and real rigidities along the lines of Smets and Wouters (2007) and Christiano *et al.* (2005), among others. Since the focus of this paper is on the policy of a single economy, we describe the model from the point of view of one country, which we call the Home or domestic country. We will describe the problem of each of the agents in the following sections.

A. Households

Following the approach of Batini *et al.* (2010), we set the households to consist of two types: regular ones which pay taxes and do not face any constraints in the financial market, and credit-constrained ones which consume purely from their wages. We create this set-up to represent the conditions of Indonesia, which has a proportion of households that may not have access to the financial market. According to The World Bank (2010), about 60% of the population of Indonesia has access to formal financial services.

A.I. Regular (Non-Credit-Constrained) Households

There are (1-λ) regular households that have access to financial markets. These uniform households seek to maximise the following objective function:

$$\max_{C_{1,t},L_{1,t}} \mathbb{E}\left[\sum_{s=0}^{\infty} \beta^s U(C_{1,t+s}, N_{1,t+s})\right] \quad (A.1)$$

where $C_{1,t+s}$ is a consumption index for regular households, $L_{1,t}$ is leisure, which we define as $L_{1,t}$=1-$N_{1,t}$. $N_{1,t}$ is the total time the regular households spend on labour (working). The parameter β is the discount factor. We then define the consumption function as follows:

$$U_{1,t} = U\left(C_{1,t}, L_{1,t}\right) = \frac{\left(C_{1,t} - \chi\, C_{1,t-1}\right)^{(1-\eta)(1-\sigma)}\left(1 - N_{1,t}\right)^{\eta(1-\sigma)} - 1}{1-\sigma} \quad (A.2)$$

The parameter η represents the *Frisch elasticity of labour supply*, σ represents risk aversion, and χ represents the consumption habit formation.

The households then face a nominal budget constraint, which is given by

$$P_t^B\, B_{H,t} + P_t^{B*} S_t B_{F,t}^* = B_{H,t-1} + S_t B_{F,t-1}^* + P_t W_t (1 - T_t^W) H_{1,t} - P_t C_{1,t} + \Gamma_t \quad (A.3)$$

where W_t is the pre-tax real wages, a proportional labour tax is given by T_t^w, and the nominal firm profits transfer is given by Γ_t. $B_{H,t}$ is domestic bond bought at nominal price P_t^B and denominated in the home currency and $B^*_{F,t}$ is foreign bond bought at nominal price P_t^{B*} and denominated in foreign currency. S_t is the nominal exchange rate.

Maximising equation (1) subject to the budget constraint we have

$$P_t^B = \mathbb{E}_t \left[\frac{\Lambda_{t,t+1}}{\Pi_{t,t+1}}\right] \tag{A.4}$$

$$P_t^{B*} = \mathbb{E}_t \left[\frac{\Lambda_{t,t+1}}{\Pi_{t,t+1}}\frac{S_{t+1}}{S_t}\right] \tag{A.5}$$

$$\frac{U_{L,1,t}}{U_{C,1,t}} = \frac{\eta}{1-\eta}\frac{C_{1,t}-\chi C_{1,t-1}}{1-N_{1,t}} = -W_t(1-T_t^W) \tag{A.6}$$

$$R_t^* = \frac{1}{P_t^{B*}\Theta\left(\frac{S_t\left(\psi\, B_{F,t}^* - (1-\psi)B_{G,t}^*\right)}{P_{H,t}Y_t}\right)} \tag{A.7}$$

where $B^*_{G,t}$ is the amount of government debt denominated in the foreign currency. Parameter ψ represents the share of government and private debt. If $\psi = 0.5$ then government and private debt can be substituted perfectly, and the composition of government and private debt has no real or nominal effects. If $\psi > 0.5$ then the market perceives government debt to be less risky than private debt and if $\psi < 0.5$ it is the other way around.

The endogenous risk premium Θ induces imperfect asset substitutability between domestic and foreign bonds, which allows the FX intervention to have real effects in the economy. Next, we rewrite equation (4) as

$$1 = \mathbb{E}_t \left[\frac{\Lambda_{t,t+1}}{\Pi_{t,t+1}}\right] R_t \tag{A.8}$$

We define $\Pi_{t,t+1} = \frac{P_{t+1}}{P_t}$ and $\Pi_{t,t+1}^* = \frac{P_{t+1}^*}{P_t^*}$ as the home and foreign CPI inflation rates and $\Pi_{t,t+1}^S = \frac{S_{t+1}}{S_t}$ as the rate of change of the nominal exchange rate[2]. We can then rewrite equation (5) as

$$1 = R_t^*\, \Theta\left(\frac{S_t B_{F,t}^*}{P_{H,t}Y_t}\right)\mathbb{E}_t \left[\frac{\Lambda_{t,t+1}}{\Pi_{t,t+1}}\Pi_{t,t+1}\right] \tag{A.9}$$

[2] Since the currency of an emerging market country is usually the term currency, we interpret a positive Π^S as the depreciation rate and a negative one as the appreciation rate.

Equations (8) and (9) also represent the uncovered interest rate parity (UIP) condition.
Credit-constrained Households

A.II. Credit-constrained Households
There are λ credit-constrained households that have to consume out of their wage income. Their consumption can be written as follows:

$$C_{2,t} = W_t(1 - T_t^W)N_{2,t} \quad \text{(A.10)}$$

These credit-constrained consumers need to choose $C_{2,t}$ and $L_{2,t}$=1-$N_{2,t}$, to maximise their utility function, which is the same to equation (1), subject to equation (10). The first-order conditions are now the same for both types of households:

$$\frac{U_{L,2,t}}{U_{C,2,t}} = \frac{\eta}{1-\eta}\frac{C_{2,t} - \chi C_{2,t-1}}{1 - N_{2,t}} = -W_t(1 - T_t^w) \quad \text{(A.11)}$$

A.III. Aggregate Consumption and Labour Supply
Summing the regular and credit-constrained households, we write the total consumption and labour supply as follows:

$$C_t = \lambda C_{2,t} + (1-\lambda)C_{1,t} \quad \text{(A.12)}$$

$$N_t = \lambda N_{2,t} + (1-\lambda)N_{1,t} \quad \text{(A.13)}$$

A.IV. Consumption Demand
The consumption of both households consists of domestic and foreign goods (imports), which form a composite index of

$$C_t = \left[\gamma_C^{\frac{1}{\mu_C}} C_{H,t}^{\frac{\mu_C - 1}{\mu_C}} + (1-\gamma_C)^{\frac{1}{\mu_C}} C_{F,t}^{\frac{\mu_C - 1}{\mu_C}}\right]^{\frac{\mu_C}{1-\mu_C}} \quad \text{(A.14)}$$

with $C_{H,t}$ and $C_{F,t}$ representing the consumption of home and foreign goods respectively. γ_C represents the share of domestic goods within the economy, which is also known as the 'home bias'. The parameter μ_C represents the elasticity of substitution between domestic goods and imported goods.

Here we assume that the price of imported goods will be directly passed on to the price domestically. This view is supported empirically by Rahadyan and Lubis (2018). They argue that, even though the level of nominal exchange rate pass-through may not have transmitted directly to inflation, the volatility of the nominal exchange rate amplifies the effect of the pass-through. Therefore, we may assume that the nominal exchange rate has a perfect pass-through to the inflation. The corresponding price index is denoted by

$$P_t = \left[\gamma_C \, P_{H,t}^{1-\mu_C} + (1-\gamma_C) P_{F,t}^{1-\mu_C}\right]^{\frac{1}{1-\mu_C}} \tag{A.15}$$

where $P_{H,t}$ and $P_{F,t}$ are the prices of domestic goods and imported goods in the home country respectively.

Maximising total consumption in (14) subject to a given aggregate expenditure of $P_t C_t = P_{H,t} C_{H,t} + P_{F,t} C_{F,t}$ results in

$$C_{H,t} = \gamma_C \left(\frac{P_{H,t}}{P_t}\right)^{-\mu_C} C_t \tag{A.16}$$

$$C_{F,t} = (1-\gamma_C) \left(\frac{P_{F,t}}{P_t}\right)^{-\mu_C} C_t \tag{A.17}$$

B. Firms

Firms consist of the wholesale sector, retail, and capital producers. Wages are taxed at the proportional rate of T_W. We follow Galí and Monacelli (2005) in assuming that the price-setting behaviour of firms follows Calvo pricing and the Law of One Price holds.

B.I. Wholesale Sector

First, we define the production technology, which follows the Cobb-Douglas function as follows:

$$Y_t^W = F(A_t, N_t, K_{t-1}) = (A_t N_t^{\alpha}) K_{t-1}^{1-\alpha} \tag{A.18}$$

where Y_t^W is the output of the wholesale sector, A_t is the total factor productivity, N_t is the labour input and K_t is the capital input. The wholesale firms sell goods to the retailers at a nominal price of P_t^W. The wholesale profit maximisation is written as

$$F_{N,t} = \alpha \frac{Y_t}{N_t} \frac{P_t^W}{P_t} = W_t \tag{A.19}$$

$$F_{K,t} = (1-\alpha) \frac{Y_t}{K_{t-1}} \frac{P_t^W}{P_t} = r_t^K \tag{A.20}$$

where P_t is the price index of final consumption goods.

B.II. Retail Sector

There is a continuum of retailers indexed by $j \in (0,1)$ which convert goods they purchase from the wholesale sector, producing a differentiated output Y_t^j and selling it at price $P_{H,t}$. The final good is a Constant Elasticity of Substitution (CES) aggregate of a continuum of intermediaries:

$$Y_t(j) = \left(\int_0^1 Y_t(j)^{\frac{\epsilon-1}{\epsilon}} \, dj \right)^{\frac{\epsilon}{\epsilon-1}} \tag{A.21}$$

The profit maximisation problem for this type of firm is

$$\max_{Y_t(j)} P_{H,t} \left(\int_0^1 Y_t(j)^{\frac{\epsilon-1}{\epsilon}} \, dj \right)^{\frac{\epsilon}{\epsilon-1}} \left(\int_0^1 P_{H,t}(j) \, Y_t(j) \, dj \right) \tag{A.22}$$

where ϵ is the elasticity of substitution.

These goods are bundled into final goods and lead to total demand for home good j given by

$$Y_t(j) = \left(\frac{P_{H,t}(j)}{P_{H,t}} \right)^{-\epsilon} Y_t \tag{A.23}$$

where we can define the aggregate price index of home-produced goods as follows:

$$P_{H,t} = \left[\int_0^1 P_{H,t}(j)^{1-\epsilon} \right]^{\frac{1}{1-\epsilon}} \tag{A.24}$$

Every period, each firm faces a fixed probability 1-ϕ that it will be able to update its prices. Denoting the optimal price at time t for home good j as $P^{\#}_{H,t}(j)$, the firms are allowed to re-optimise prices and maximise expected discounted profits by solving

$$\max_{P^{\#}_{H,t}(j)} \mathbb{E} \sum_{s=0}^{\infty} \phi^k \frac{\Lambda_{t,t+k}}{P_{H,t+k}} Y_{t+k}(j) \left[P^{\#}_{H,t}(j) - P^{W}_{t+k} \right] \tag{A.25}$$

Substituting in the demand Y from equation (A.23), then taking the first-order conditions with respect to the new price and rearranging, leads to

$$P_{H,t}^{\#} = \frac{\epsilon}{\epsilon - 1} \frac{\mathbb{E} \sum_{k=0}^{\infty} \phi^k \frac{\Lambda_{t,t+k}}{P_{H,t+k}} \left(P_{H,t+k}\right)^{\epsilon} Y_{t+k} P_{t+k}^{W}}{\mathbb{E} \sum_{k=0}^{\infty} \frac{\Lambda_{t,t+k}}{P_{H,t+k}} \left(P_{H,t+k}\right) Y_{t+k}} \quad \text{(A.26)}$$

We then drop the index *j* because all firms face the same marginal cost and update to the same reset price. Hence, the right-hand side of the equation is independent of firm size or price history. The real marginal cost is defined by $MC_t = \frac{P_t^W}{P_{H,t}}$, and we also introduce *k* periods of price inflation as follows:

$$\Pi_{H,t,t+k} = \frac{P_{H,t+k}}{P_{H,t}} = \frac{P_{H,t+1}}{P_{H,t}} \frac{P_{H,t+2}}{P_{H,t+1}} \cdots \frac{P_{H,t+k}}{P_{H,t+k-1}} \quad \text{(A.27)}$$

Now we rewrite equation (A.5) as

$$\frac{P_{H,t}^{\#}}{P_{H,t}} = \frac{\epsilon}{\epsilon - 1} \frac{\mathbb{E} \sum_{k=0}^{\infty} \phi^k \Lambda_{t,t+k} \left(\Pi_{H,t,t+k}\right)^{\phi} Y_{t+k} MC_{t+k}}{\mathbb{E} \sum_{k=0}^{\infty} \phi^k \Lambda_{t,t+k} \left(\Pi_{H,t,t+k}\right)^{\phi} \left(\Pi_{H,t,t+k}\right)^{-1} Y_{t+k}} \quad \text{(A.28)}$$

We introduce a mark-up shock MS_t to the real marginal cost MC_t and write the expression (A.28) more compactly by denoting the numerator and denominator as $X_{1,t}$ and $X_{2,t}$ respectively. Write the result in recursive form gives

$$\frac{P_{H,t}^{\#}}{P_{H,t}} = \frac{X_{1,t}}{X_{2,t}} \quad \text{(A.29)}$$

where

$$X_{1,t} - \phi\beta \mathbb{E}_t[\Pi_{t+1}^{\epsilon}] = \frac{1}{1 - \frac{1}{\epsilon}} Y_{t+k} U_{C,t} MC_{t+k} MS_t \quad \text{(A.30)}$$

$$X_{2,t} - \phi\beta \mathbb{E}_t[\Pi_{t+1}^{\epsilon-1}] = Y_{t+k} U_{C,t} \quad \text{(A.31)}$$

Using the aggregate producer price index $P_{H,t}$ and the fact that all resetting firms will choose the same price, by the Law of Large Numbers we can find the evolution of the price index as given by

$$P_{H,t}^{1-\epsilon} = \phi P_{H,t-1}^{1-\epsilon} + (1 - \phi) {P_{H,t}^{\#}}^{1-\epsilon} \quad \text{(A.32)}$$

which can be written in the following form:

$$1 = \phi\left(\Pi_{H,t-1,t}\right)^{\epsilon-1} + (1-\phi)\left(\frac{P^{\#}_{H,t}}{P_{H,t}}\right)^{1-\epsilon} \qquad \text{(A.33)}$$

Using the demand of output, we can then write the price dispersion that gives the average loss in output as

$$\Delta_t = \frac{1}{J}\sum_{j=1}^{J}\left(\frac{P_{i,t}(j)}{P_{i,t}}\right)^{-\epsilon} \qquad \text{(A.34)}$$

for non-optimising firms j=1,⋯,J. It is not possible to track all $P_{j,t}$ but, as it is known that a proportion 1-ϕ of firms will optimise prices in period t, and from the Law of Large Numbers that the distribution of non-optimised prices will be the same as the overall distribution, price dispersion can be written as a law of motion:

$$\Delta_{i,t} = \phi\Pi^{\epsilon}_{H,t-1,t}\Delta_{t-1} + (1-\phi)\left(\frac{X_{1,t}}{X_{2,t}}\right)^{-\epsilon} \qquad \text{(A.35)}$$

Using this, aggregate final output is given as a proportion of the intermediate output:

$$Y_t = \frac{Y^W_t}{\Delta_t} \qquad \text{(A.36)}$$

B.III. Capital Producers

Capital producers purchase investment goods from home and foreign firms at real price $\frac{P^I_t}{P_t}$, selling at real price Q_t to maximise the expected discounted profits:

$$\mathbb{E}\sum_{k=0}^{\infty}\Lambda_{t,t+k}\left[Q_{t,t+k}\left(1 - S\left(\frac{I_{t+k}}{I_{t+k-1}}\right)\right)I_{t+k} - \frac{P^I_t}{P_t}I_{t+k}\right] \qquad \text{(A.37)}$$

where total capital accumulates according to

$$K_t = (1-\delta)K_{t-1} + \left(1 - S(X_t)\right)I_t \qquad \text{(A.38)}$$

The first-order condition yields

$$Q_t\left(1 - S(X_t) - X_tS'(X_t)\right) + \mathbb{E}_t\left[\Lambda_{t,t+1}\,Q_{t,t+1}S'(X_{t+1})\frac{I^2_{t+1}}{I^2_t}\right] = \frac{P^I_t}{P_t} \qquad \text{(A.39)}$$

where we define

$$S(X_t) \equiv \phi_x (X_t - X)^2 \tag{A.40}$$

The relative price of capital Q_t will equal $\frac{P_t^I}{P_t}$. Finally, we define R_t^K as the gross real return of capital, given by

$$R_t^K = \frac{(1-\alpha)\,\frac{Y_t^W}{K_{t-1}}\frac{P_t^W}{P_t}(1-T_t^K) + (1-\delta)Q_t}{Q_{t-1}} \tag{A.41}$$

where T_t^K is a tax on corporate profits, which we assume to be exogenous in this model.

C. Investment Demand

Parallel to the consumer goods, the domestic, export and import demand for investment goods will have the same conditions. We express the aggregate price of investment goods as P_t^I. The investment demand is satisfied by domestic and foreign good (imports), maximising

$$I_t = \left[\gamma_I^{\frac{1}{\mu_I}} I_{H,t}^{\frac{\mu_I - 1}{\mu_I}} + (1-\gamma_I)^{\frac{1}{\mu_I}} I_{F,t}^{\frac{\mu_I - 1}{\mu_I}}\right]^{\frac{\mu_I}{1-\mu_I}} \tag{A.42}$$

with $I_{H,t}$ and $I_{F,t}$ representing the investment using home and foreign goods respectively. γ_I represents the share of domestic goods used for investment in the economy. The parameter μ_I represents the elasticity of substitution between domestic and imported goods. The corresponding price index is denoted by

$$P_t^I = \left[\gamma_I {P_{H,t}^I}^{1-\mu_I} + (1-\gamma_I){P_{F,t}^I}^{1-\mu_I}\right]^{\frac{1}{1-\mu_I}} \tag{A.43}$$

where $P_{H,t}^I$ and $P_{F,t}^I$ are the prices of domestic and imported goods in the home country respectively.

Maximising total investment in equation (A.42) subject to a given aggregate investment of $P_t I_t = P_{H,t}^I I_{H,t} + P_{F,t}^I I_{F,t}$ results in

$$I_{H,t} = \gamma_I \left(\frac{P_{H,t}^I}{P_t}\right)^{-\mu_I} I_t \tag{A.44}$$

$$I_{F,t} = (1-\gamma_I)\left(\frac{P_{F,t}^I}{P_t}\right)^{-\mu_I} I_t \tag{A.45}$$

D. External Demand

As in the standard literature on small open economies, we take the foreign aggregate consumption and investment, denoted by C_t^* and I_t^* respectively, as exogenous. The exogenous approach is taken because we focus on emerging markets, which have the same features as the small open economy. We formulate the foreign demand for exported consumer goods as follows:

$$C_{H,t}^* = (1-\gamma_C^*)\left(\frac{P_{H,t}^*}{P_t^*}\right)^{-\mu_C^*} C_t^* \tag{A.46}$$

We define the real exchange rate of consumption goods as the relative aggregate consumption price $s_t \equiv \frac{P_t^* S_t}{P_t}$. We then rewrite the demand for exports as

$$C_{H,t}^* = (1-\gamma_C^*)\left(\frac{P_{H,t}^*}{P_t^* s_t}\right)^{-\mu_C^*} C_t^* \tag{A.47}$$

where $P_{H,t}^*$ and P_t^* indicate the price of domestic goods and foreign aggregate consumption in the foreign currency. In addition, we assume that the Law of One Price for differentiated goods in the traded sector holds. Therefore, the exchange rate will have perfect pass-through to export prices and the price of consumption goods will be P_t=$S_t P_{H,t}^*$. Similarly, we assume that the home country has a perfect exchange rate pass-through for imports, which implies P_t^*=$P_{F,t}^*$, $S_t P_t^*$=$P_{F,t}$, and thus $s_t = \frac{P_{F,t}}{P_t}$. We then write

$$C_{H,t}^* = (1-\gamma_C^*)\left(\frac{1}{TOT_t}\right)^{-\mu_C^*} \tag{A.48}$$

where $ToT_t \equiv \frac{P_{F,t}}{P_{H,t}}$ are the terms of trade.

We formulate the foreign demand for exported investment goods as follows:

$$I_{H,t}^* = (1-\gamma_I^*)\left(\frac{P_{H,t}^{I*}}{P_t^{I*}}\right)^{-\mu_I^*} \tag{A.49}$$

We define the real exchange rate for investment as the relative aggregate investment price $s_t^I \equiv \frac{P_t^{I*} S_t}{P_t^I}$. Then, we adjust the demand for exported investment goods to be

$$I_{H,t}^* = (1-\gamma_I^*)\left(\frac{P_{H,t}^{I*}}{P_t^{I*} s_t}\right)^{-\mu_I^*} I_t^* \tag{A.50}$$

where $P^{I*}_{H,t}$ and P_t^{I*} indicate the prices of domestic goods and foreign aggregate investment in the foreign currency. As with consumption, we assume that the Law of One Price for differentiated goods holds for investment goods. Therefore, the price of investment goods will be $P_t^{I*}=S_t P^{I*}_{H,t}$. We also assume that the home country has a perfect exchange rate pass-through for imports, which implies $P_t^{I*}=P^{I*}_{F,t}$, $S_t P_t^{I*}=P^{I}_{F,t}$, and thus $s_t = \frac{P^I_{F,t}}{P^I_t}$. We then write

$$I^*_{H,t} = (1-\gamma^*_I)\left(\frac{1}{TOT_t}\right)^{-\mu^*_I} \quad \text{(A.51)}$$

Therefore, the total exports are given by

$$EX_t = C^*_{H,t} + I^*_{H,t} \quad \text{(A.52)}$$

E. Market Clearing

A resource constraint implies the following:

$$Y_t = C_{H,t} + C^*_{H,t} + I_{H,t} + I^*_{H,t} + G_t \quad \text{(A.53)}$$

where G_t is the government spending.