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MONETARY POLICY AND THE PROPAGATION OF SHOCKS UNDER IMPERFECT EXCHANGE-RATE PASS-THROUGH

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A mis padres que siempre me han dado libertad, a mi madre que siempre me muestra lo positivo, a mis amigos que siempre confían en mí, al Colegio de México por darme la oportunidad de seguir aprendiendo y al profesor Stephen Mcknight por su apoyo y dedicación.

Abstract

The main purpose of this study is to investigate the implications of the degree of exchange-rate pass-through for the propagation of shocks under alterative monetary policy regimes. We develop a small open economy model that includes a number of realistic features for developing countries like Mexico. Business cycle dynamics are generated by the inclusion of four stochastic shocks. An impulse response analysis is conducted to explore the role played by the degree of exchange-rate pass-through in the transmission of different shocks. The main findings of the thesis are as follows. First, the degree of exchange-rate pass-through can play an important role in the propagation of shocks in open economies. This result is most clearly observed under monetary shocks whose effects on the economy are sizeable and amplified as the degree of incomplete pass-through increases. Second, consistent with the existing literature, it is not necessary for the central bank to give an active role for the exchange rate in the setting of monetary policy, even in the presence of real exchange rate volatility. Third, monetary policy shocks generate a different transmission mechanism for the terms of trade under low degrees of pass-through compared to high degrees of pass-through. Consequently, one key policy insight for Mexico is that monetary shocks are likely to have more profound effects on the real economy compared to countries that exhibit small deviations from the law of one price.

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Chapter 1

Introduction

When the Mexican Crisis of 1994 occurred, the Central Bank of Mexico was forced to abandon its fixed exchange rate system. Since then, monetary policy has been moving toward an inflation targeting regime, which finally became the operational monetary framework in 2001. Moreover, Calvo and Reinhart (2000) find evidence that the actions taken by the Mexican central bank seem to exhibit a fear of floating, which is a modern variant of managed floating. In addition, Ball and Reyes (2003) argue that the while inflation has been the number one policy issue for the Mexican central bank, at times this has required occasional intervention to offset inflationary exchange-rate shocks.

Recent studies, have introduced a number of realistic features into small open economy New Keynesian frameworks with the aim of providing better guidance for policymakers. One main improvement has been the widespread inclusion of incomplete international asset markets into standard representative agent dynamic stochastic general equilibrium (DSGE) models.

Another improvement has been the gradual move away from modelling frameworks that assume the law of one price with perfect exchange-rate pass-through. For instance, Ouchen and Ziky (2015) showed that in an environment of low exchange-rate pass-through, a monetary policy that acts to stabilize the nominal exchange was likely to be sub-optimal. The intuition behind this result is that when the law of one price does not hold, there no longer exists a trade-off between output volatility and inflation volatility. These results are consistent with the findings of Justiniano and Preston (2010) who found that even when there is no strong disconnection between the nominal exchange rates and domestic series, the optimal policy should not respond to the nominal exchange rate. Moreover, both these conclusions are in stark contrast to Smet and Wouters (2002) who recommend responding to exchange rate variations.

The aim of this thesis is to investigate the importance of the degree of exchange-rate pass-through for the propagation of shocks for small open developing countries like Mexico. An impulse response analysis is conducted to explore how variations in the degree of exchange-rate pass-through affect the transmission of different domestic and international shocks for a small open economy. The modelling framework employed closely follows the small open DSGE model of Justiniano and Preston (2010), where the domestic economy is characterized by imperfect competition and nominal price rigidities with indexation to past inflation. Furthermore, it it is assumed they there exists a retail sector that operates with monopolistic power to set local currency prices for imports, thereby breaking the law of one price assumption. International asset markets are assumed to be incomplete. However, we extend the framework of Justiniano and Preston (2010) in two important dimensions. First, following Woodford (2003) and McKnight and Mihailov (2014) the utility function of the representative agent is assumed to be non-separable between consumption and real money balances. As discussed by

McKnight and Mihailov (2015), this yields an additional monetary transmission mechanism, where changes in the nominal interest rate result in changes in the demand for money, which affects the output and pricing decisions of firms. This is an important difference from Justiniano and Preston (2010) since they assume a cashless economy and consequently the demand for money plays no role under an inflation targeting policy regime.

The second key departure from Justiniano and Preston (2010) is the consideration of a variety of popular monetary policy regimes. Following Ouchen and Ziky (2015), we consider three alternative specifications for the interest-rate feedback rule: a CPI inflation targeting regime whereby the nominal interest rate responds to variations in CPI inflation and output; a domestic inflation targeting regime where the nominal interest rate reacts to variations in domestic price inflation and output; and a managed float regime that permits the nominal interest rate to respond to adjustments in the real exchange rate.

Business cycle dynamics are generated by the inclusion of four stochastic shocks. The analysis considers three domestic shocks: productivity (technology) shocks, cost-push shocks and monetary shocks, and one external shock: a risk-premium shock. The model is calibrated for Mexico.

The main findings of the thesis are as follows. First, the degree of exchange-rate pass-through can play an important role in the propagation of shocks in open economy. This result is most clearly observed under monetary shocks whose effects on the economy are sizeable and amplified as the degree of imperfect exchange-rate pass-through is increased under all three types of monetary rules.

Second, consistent with the findings of Ouchen and Ziky (2015) it is not necessary for monetary policy to have an active role for the exchange rate, even in the presence of real exchange rate volatility.

Third, an important finding is that monetary shocks generate a different transmission mechanism for the terms of trade under low degrees of exchange-rate pass-through compared to high degrees of pass-through. This is important for Mexico where very high degrees of incomplete pass-through have been estimated between 0.7 and 0.9 (see Hernandez, 2008). Therefore one key policy insight is that for Mexico, monetary shocks are likely to be have a more profound effect on the real economy compared to countries that exhibit small deviations from the law of one price.

This thesis is related to a small literature that has focused on the importance of pricing-to-market assumptions in regard to whether a country employs producer currency pricing or local currency pricing. A key insight of Justiniano and Preston (2010) is that optimal policies do not respond to the nominal exchange rate. They argue that this is optimal because there is a disconnection between nominal exchange movements and the evolution of domestic series, through a delay in the exchange rate pass-through. Different from our results, they find that for small open developed economies cost-push shocks and risk premium shocks have non-negligible effects on output, inflation and interest rate variations, and that policy responses to stabilize the exchange rate exacerbate variability in those series.

To understand these differences, first note that Justiniano and Preston (2010) introduce a cost-push shock in the retail sector. This leads to an appreciation of the exchange rate and a negative deviation from the law of one price, which results in an increase in imported inflation, and a substitution effect towards domestically produced goods, with no changes in overall inflation. Justiano and Preston (2010) also analyse the propagation of risk premium shocks. Similar to our results, they also find that this shock leads to a depreciation of the exchange rate causing an interest rate tightening. They find that under their Taylor rule specification the contractionary effects on the economy from the higher interest rate causes domestic inflation and output to fall. We find a similar interest rate tightening effect, but output actually rises. This key difference arises because the deviations of the law of one price that improve the terms of trade, therefore helping make domestic products more competitive. In our calibration for Mexico, this effect is sufficiently strong such that domestic output rises rather than falls.

Ouchen and Ziky (2015) also investigate how different degrees of exchange-rate pass-through effect the propagation of shocks, but with the key difference that they assume complete international asset markets. Ouchen and Ziky (2015) analyse the implications of four alternative monetary policy regimes for their small open economy: domestic inflation targeting, manage float, CPI inflation targeting and an exchange rate peg. In their analysis, the economy experiences only two kind of shocks: internal shocks (productivity shocks) and external shocks (terms of trade and foreign demand). In our setting, while we also have productivity shock, we depart from Ouchen and Ziky (2015) by considering risk premium shocks due to incomplete asset markets, cost-push shock, and monetary shocks from the inclusion of real balance effects. Similar to our results for productivity results, they find that the degree of exchange-rate pass-through is important for assessing different monetary policy rules. They also found that CPI inflation targeting was the best policy for an economy that exhibited lagged exchange rate pass-through. Under a low degree of pass-through, this enables domestic and the overall inflation to respond sluggishly to shocks, and therefore it is more efficient for the monetary authority to target the overall CPI rather than just domestic prices.

The remainder of the thesis proceeds as follows. Chapter 2 discuss the model and Chapter 3 outlines the log-linearized equilibrium system and discusses its calibration. Chapter 4 presents the results under a CPI inflation targeting monetary policy regime, whereas Chapter 5 considers the implications of targeting domestic and the real exchange rate. Finally, Chapter 6 concludes.

Chapter 2

The Model

This chapter outlines the model economy. Following Justiniano and Preston (2010), we utilize a small open economy framework with incomplete international asset markets. The global economy consists of two countries, Home and Foreign. The Home country is populated by a representative infinitely-lived household, a continuum of domestic good producers and retail firms who import foreign-produced goods, and a monetary authority. Both domestic good producers and retail firms are assumed to operate under imperfect competition and set prices in a staggered way according to Calvo (1983). Market power in the retail sector violates the law of one price resulting in incomplete exchange-rate pass-through. Following Woodford (2003) and McKnight and Mihailov (2015), real money balances enter into the utility function in a non-separable way. Consequently, money demand still plays a role in the economy even if the monetary policy instrument is the nominal interest rate. In what follows, subscripts H and F denote, respectively, variables of Home and Foreign origin, and asterisks denote Foreign variables.

2.1 Representative Household

The period utility function of the representative household is assumed to be non-separable between consumption C and real money balances $m_t \equiv \frac{M_t}{P_t}$:

$$U(C_t, m_t, l_t) \equiv u(C_t, m_t) - v(l_t).$$

In order to find an interior solution, we assume that $u(C_t, m_t)$ is concave and strictly increasing in each argument, and that both consumption and real money balances are normal goods. Moreover, the disutility of labour supply, $v(l_t)$, is assumed to be an increasing convex function.

The representative household chooses real consumption C_t, domestic real money balances m_t and labour supply l_t to maximizes her expected discounted utility:

$$E_0 \sum_{t=0}^{\infty} \beta^t \left[u(C_t, m_t) - v(l_t) \right], \tag{2.1}$$

where $\beta \in (0,1)$ denotes the discount factor and C_t is a composite consumption index:

$$C_t = \left[(1-\alpha)^{\frac{1}{\gamma}} C_{H,t}^{\frac{\gamma-1}{\gamma}} + \alpha^{\frac{1}{\gamma}} C_{F,t}^{\frac{\gamma-1}{\gamma}} \right], \tag{2.2}$$

where $\gamma > 0$ measures the elasticity of substitution between home and foreign goods and $0 < \alpha < 1$ is the share of foreign goods in the domestic consumption bundle. $C_{H,t}$ and $C_{F,t}$ represent, respectively the Dixit-Stiglitz aggregates of domestic and foreign imported products:

$$C_{H,t} = \left[\int_0^1 C_{H,t}(i)^{\frac{\theta-1}{\theta}} di \right]^{\frac{\theta}{\theta-1}},$$

$$C_{F,t} = \left[\int_0^1 C_{F,t}(i)^{\frac{\theta-1}{\theta}} di \right]^{\frac{\theta}{\theta-1}},$$

where $\theta > 1$ is the elasticity of substitution between the differentiated types of goods of both countries.

During period t, the household receives income from wages W_t from supplying labour and profits from the ownership of domestic good producers $\Pi_{H,t}$ and retail firms $\Pi_{F,t}$. In addition, the household receives lump-sum nominal transfers Υ_t from the monetary authority. The household uses its income to purchase goods, money and bonds. Following Justiniano and Preston (2010), the asset market is assumed to be incomplete, where the household can purchase one-period domestic DB_t and foreign bonds FB_t that mature in period $t+1$ with corresponding nominal interest rates i_t and i_t^*. Letting e_t denote the nominal exchange rate and P_t the aggregate price-level, the period budget constraint can be expressed as:

$$\begin{aligned} P_t C_t + DB_t + e_t FB_t + M_t = DB_{t-1}(1+i_{t-1}) + \\ e_t FB_{t-1}(1+i_{t-1}^*)\phi_{t-1}(d_{t-1}) + M_{t-1} + W_t l_t + \Pi_{H,t} + \Pi_{F,t} + \Upsilon_t. \end{aligned} \tag{2.3}$$

Following Justiano and Preston (2010), we assume that there is a debt-elastic interest-rate premium ϕ_t:

$$\phi_t = exp[-\kappa(d_t + \tilde{\phi}_t)],$$

where

$$d_t \equiv \frac{e_t FB_t}{Y^{ss} P_t}.$$

In the above, d_t denotes the ratio of the real quantity of foreign bond holdings (in terms of domestic currency) to steady state output Y^{ss}. If the ratio $d_t > 0$, the household is a net borrower and must repay a premium over the interest rate. As Justiniano and Preston (2010) point out, this debt-elastic interest-rate premium is sufficient to ensure that bond holdings are stationary. The parameter $\tilde{\phi}_t$ denotes an exogenous risk premium shock.

To maximize her utility in consumption goods, the household will allocate expenditures across all types of domestic and foreign goods, both intratemporally and intertemporally. Let $P_{H,t}$ and $P_{F,t}$ denote the respective price sub-index for home and imported consumption good bundles. The home demand for each variety of domestic and imported consumption good is given by:

$$C_{H,t}(i) = \left(\frac{P_{H,t}(i)}{P_{H,t}}\right)^{-\theta} C_{H,t}, \tag{2.4}$$

$$C_{F,t}(i) = \left(\frac{P_{F,t}(i)}{P_{F,t}}\right)^{-\theta} C_{F,t}, \tag{2.5}$$

for all i. The optimal allocation of expenditure across home and foreign goods implies the demand functions:

$$C_{H,t} = (1-\alpha)\left(\frac{P_{H,t}}{P_t}\right)^{-\gamma} C_t, \tag{2.6}$$

and

$$C_{F,t} = \alpha\left(\frac{P_{F,t}}{P_t}\right)^{-\gamma} C_t. \tag{2.7}$$

The consumer price index can be derived as:

$$P_t = \left[(1-\alpha)P_{H,t}^{1-\gamma} + \alpha P_{F,t}^{1-\gamma}\right]^{\frac{1}{1-\gamma}}, \tag{2.8}$$

where

$$P_{H,t} \equiv \left[\int_0^1 P_{H,t}^{1-\theta}(i)di\right]^{\frac{1}{1-\theta}}, \tag{2.9}$$

$$P_{F,t} \equiv \left[\int_0^1 P_{F,t}^{1-\theta}(i)di\right]^{\frac{1}{1-\theta}}. \tag{2.10}$$

The household must optimally choose allocations for aggregate consumption, domestic and foreign bonds, real money balances and labour supply. The first order conditions for C_t, m_t, l_t, DB_t and FB_t from the household maximization problem yields:

$$\beta(1+i_t)E_t\left\{\frac{u_c(C_{t+1},m_{t+1})}{P_{t+1}}\right\}=\frac{u_c(C_t,m_t)}{P_t}, \tag{2.11}$$

$$\frac{u_m(C_t,m_t)}{u_c(C_t,m_t)}=\frac{i_t}{1+i_t}, \tag{2.12}$$

$$\frac{v_l(l_t)}{u_c(C_t,m_t)}=w_t, \tag{2.13}$$

$$\lambda_t=E_t[(1+i_t)\lambda_{t+1}], \tag{2.14}$$

$$\lambda_t e_t=E_t[(1+i_t^*)\beta\phi_t\lambda_{t+1}e_{t+1}], \tag{2.15}$$

where λ_t denotes the Lagrange multiplier. Equation (2.11) is the Euler equation for consumption, (2.12) is the optimal money demand function, and (2.13) is the labour supply condition. Combining equations (2.14) and (2.15) yields the interest-rate parity condition:

$$E_t\left\{\frac{u_c(C_{t+1},m_{t+1})}{P_{t+1}}\left[(1+i_t)-(1+i_t^*)\left(\frac{e_{t+1}}{e_t}\right)\phi_t\right]\right\}=0. \tag{2.16}$$

2.2 Real Exchange Rate, Terms of Trade, Uncovered Interest Parity: Some Identities

In what follows, I define the real exchange rate (for the Home country) as:

$$q_t\equiv\frac{e_tP_t^*}{P_t}.$$

When the law of one price holds, this implies:

$$P_{H,t} = e_t P^*_{H,t} \tag{2.17}$$

and

$$P^*_{F,t} = \frac{P_{F,t}}{e_t}. \tag{2.18}$$

Since $P^*_t = P^*_{F,t}$ for the Foreign country, when the law of one price fails to hold, we have:

$$\psi_{F,t} \equiv \frac{e_t P^*_t}{P_{F,t}} \neq 1, \tag{2.19}$$

which defines the law of one price gap. The relative price of foreign goods in terms of home goods, or the terms of trade for the Home country is defined as:

$$TR_t = \left(\frac{P_{F,t}}{P_{H,t}}\right). \tag{2.20}$$

2.3 Domestic Producers

In the domestic goods market, there are a continuum of monopolistically competitive firms $i \in [0,1]$ that produce differentiated goods. For simplicity, it is assume that the production function of each firm depends only on labour, and is represented by the linear production technology:

$$y_t(i) = \tilde{\varepsilon}_{a,t} l_t(i), \tag{2.21}$$

where $\tilde{\varepsilon}_{a,t}$ is an exogenous technology shock. Given competitive prices for labour, cost minimization yields:

$$mc_t = \frac{w_t}{\tilde{\varepsilon}_{a,t}} \frac{P_t}{P_{H,t}}, \tag{2.22}$$

where mc_t represents real marginal cost and w_t denotes the real wage rate.

Domestic firms set prices in a staggered way according to Calvo (1983), allowing for indexation to past inflation. Similar to Justiniano and Preston (2010), at any time t, there is a constant probability $1-\tau$ that a firm will be randomly selected to adjust its price optimally independently of the past; otherwise with probability $0 < \tau_H < 1$ the firm adjusts price according to the following inflation indexation rule:

$$P_{H,t}(i) = P_{H,t-1}(i) \left(\frac{P_{H,t-1}}{P_{H,t-2}} \right)^{\delta_H}, \tag{2.23}$$

where $\delta_H \in [0,1]$ measures the degree of inflation indexation. For simplicity, it is assumed that the export price of the domestic good is determined by the law of one price $P^*_{H_t} = (1/e_t)P_{H,t}$.

A domestic firm i, faced with changing its price at time t, has to choose $P_{H,t}(i)$ to maximize its expected discounted value of profits, taking as given the indexes $P_{H,t}$, $C_{H,t}$ and $C^*_{H,t}$:

$$\max_{P_{H,t}(i)} E_t \sum_{s=0}^{\infty} X_{t,t+s} (\beta \tau_H)^s \left[P_{H,t}(i) \left(\frac{P_{H,t+s-1}}{P_{H,t-1}} \right)^{\delta_H} - \tilde{\varepsilon}_{cp,t+s} P_{H,t+s} MC_{t+s} \right] Y_{H,t+s}(i),$$

where

$$Y_{H,t+s}(i) = \left(\frac{P_{H,t}(i)}{P_{H,t+s}} \left(\frac{P_{H,t+s-1}}{P_{H,t-1}} \right)^{\delta_H} \right)^{-\theta} (C_{H,t+s} + C^*_{H,t+s})$$

is the demand curve that each firm faces, and $\tilde{\varepsilon}_{cp,t+s}$ is a cost-push shock. The first-order condition is:

$$E_t \sum_{s=0}^{\infty} X_{t,t+s}(\beta \tau_H)^s Y_{H,t+s}(i) \left[P_{H,t}(i) \left(\frac{P_{H,t+s-1}}{P_{H,t-1}} \right)^{\delta_H} - \left(\frac{\theta}{\theta - 1} \right) \tilde{\varepsilon}_{cp,t+s} P_{H,t+s} MC_{t+s}) \right] = 0. \tag{2.24}$$

Solving the above for $P_{H,t}(i)$, gives the following price-setting condition:

$$\tilde{P}_{H,t} = \tilde{\varepsilon}_{cp,t+s} \frac{\theta}{\theta - 1} \frac{E_t \sum_{s=0}^{\infty} (\beta \tau_H)^s X_{t,t+s} Y_{H,t+s}(i) P_{H,t+s} MC_{t+s}}{E_t \sum_{s=0}^{\infty} (\beta \tau_H)^s X_{t,t+s} Y_{H,t+s}(i) \left(\frac{P_{H,t+s-1}}{P_{H,t-1}} \right)^{\delta_H}}, \tag{2.25}$$

where the optimal price is a mark-up $\theta / \theta - 1$ of a weighted average of expected future nominal marginal cost. Then, the aggregate price level evolves according to:

$$P_{H,t} = \left[(1 - \tau_H)(\tilde{P}_{H,t})^{1-\theta} + \tau_H \left(P_{H,t-1} \left(\frac{P_{H,t-1}}{P_{H,t-2}} \right)^{\delta_H} \right)^{1-\theta} \right]^{\frac{1}{1-\theta}}. \tag{2.26}$$

2.4 Retail Firms

In the retail sector, there is a continuum of monopolistically competitive firms indexed by $j \in [0, 1]$, that import differentiated goods from the Foreign country. It is assume that while the law of one price holds for foreign goods, retail firms have the power to determine the domestic currency price of the imported good, which results in a violation of the law of one price for final good consumption.

As in the case of domestic firms, retail firms set prices in a staggered way according to Calvo (1983), where a fraction of $1-\tau_F$ of retail firms set prices in an optimal way, and a fraction $0<\tau_F<1$ adjust prices according to an inflation indexation rule similar to (2.23). It is important to stress that in the analysis τ_F determines the degree of exchange-rate pass-through. A retail firm j that can set its price optimally at time t, imports a good at a cost $e_t P^*_{F,t}(j)$ and chooses a price $P_{F,t}(j)$ to maximize its expected discounted value of profits, taking as given $P_{F,t}$ and $C_{F,t}$:

$$\max_{P_{F,t}(j)} E_t \sum_{s=0}^{\infty} X_{t,t+s}(\beta\tau_F)^s \left[P_{F,t}(j) \left(\frac{P_{F,t+s-1}}{P_{F,t-1}} \right)^{\delta_F} - e_{t+s} P^*_{F,t+s}(j) \right] Y_{F,t+s}(j),$$

where

$$Y_{F,t+s}(j) = \left[\frac{P_{F,t}(j)}{P_{F,t+s}} \left(\frac{P_{F,t+s-1}}{P_{F,t-1}} \right)^{\delta_F} \right]^{-\theta} C_{F,t+s}$$

is the demand function faced by retail firms. The first-order condition is given by:

$$E_t \sum_{s=0}^{\infty} X_{t,t+s}(\beta\tau_F)^s Y_{F,t+s}(j) \left[P_{F,t}(j) \left(\frac{P_{F,t+s-1}}{P_{F,t-1}} \right)^{\delta_F} - \left(\frac{\theta}{\theta-1} \right) e_{t+s} P^*_{F,t+s}(j) \right] = 0. \quad (2.27)$$

Solving for $P_{F,t}(j)$ yields:

$$\tilde{P}_{F,t} = \frac{\theta}{\theta-1} \frac{E_t \sum_{s=0}^{\infty} (\beta\tau_F)^s X_{t,t+s} Y_{F,t+s}(j) P_{F,t+s} e_{t+s}}{E_t \sum_{s=0}^{\infty} (\beta\tau_F)^s X_{t,t+s} Y_{F,t+s}(j)} \left(\frac{P_{F,t+s-1}}{P_{F,t-1}} \right)^{\delta_F}, \quad (2.28)$$

where the aggregate price index for imports evolves according to:

$$P_{F,t} = \left[(1-\tau_F) \tilde{P}_{F,t}^{1-\theta} + \tau_F \left(P_{F,t-1} \left(\frac{P_{F,t-1}}{P_{F,t-2}} \right)^{\delta_F} \right)^{1-\theta} \right]^{\frac{1}{1-\theta}}. \quad (2.29)$$

2.5 Market Clearing and Equilibrium

Goods market clearing conditions for domestic firms requires:

$$Y_{H,t}(i) = C_{H,t}(i) + C^*_{H,t}(i) = \left(\frac{P_{H,t}(i)}{P_H}\right)^{-\theta} \left[C_{H,t} + C^*_{H,t}\right],$$

and aggregating yields

$$Y_t \equiv \int_0^1 Y_{H,t}(i)di = C_{H,t} + C^*_{H,t}, \tag{2.30}$$

where

$$C^*_{H,t} = \alpha \left(\frac{P^*_{H,t}}{P^*_t}\right)^{-\gamma} C^*_t$$

and

$$Y^*_t = C^*_t.$$

Market clearing in the money market requires:

$$\Upsilon = M_t - M_{t-1}, \tag{2.31}$$

and market clearing for domestic bonds

$$DB_t = 0. \tag{2.32}$$

Rational Expectations Equilibrium Given an exogenous sequence for foreign consumption $\{C^*_t\}$, initial conditions for DB_0, FB_0 and M_0 and the exogenous sequence of the shocks, a rational expectations equilibrium for the small open economy consists of a sequence of prices

$\left\{P_t, P_{H,t}, P_{F,t}, \tilde{P}_{H,t}, \tilde{P}_{F,t}, w_t, MC_t, e_t\right\}$, a sequence of allocations $\{C_t, Y_t, L_t, DB_t, FB_t, m_t\}$, and a monetary policy rule i_t satisfying:

- (i) the optimality conditions of the household (2.11-2.13) and the interest-rate parity condition (2.16);
- (ii) the optimality conditions of domestic firms (2.21-2.22), and price-setting behaviour of domestic goods producers (2.25-2.26) and retail firms (2.28-2.29);
- (iii) a monetary policy rule;
- (iv) the goods, money and bond markets clear (2.30-2.32); and
- (v) the consumer price index (2.8).

Chapter 3

The Log-Linearized Model and Calibration

3.1 The Log-Linearized Model

The model of the previous chapter is log-linearized around a deterministic zero-inflation steady state $\pi^{ss} = 0$, where in the steady state, domestic and foreign bonds are zero ($DB^{ss} = FB^{ss} = 0$), and the steady-state terms of trade equals the steady-state nominal exchange rate which equals one: $TR^{ss} = e^{ss} = 1$. All variables (with hats) represents log deviations from their respective steady-states values i.e. $\hat{x}_t = ln\left((x_t)/x^{ss}\right)$. As is common in the existing literature, we assume that the log-deviations for Foreign variables are all equal to zero.

A log-linear approximation to the household Euler equation (2.11) generates the IS equation for this economy:

$$\hat{C}_t = E_t\hat{C}_{t+1} - \sigma[\hat{i}_t - E_t\hat{\pi}_{t+1} + \mu(E_t\hat{m}_{t+1} - \hat{m}_t)], \tag{3.1}$$

where $\sigma \equiv -u_c/u_{cc}C^{ss} > 0$ represents the intertemporal elasticity of substitution in consumption and $\mu \equiv m^{ss}u_{cm}/u_c$ is the degree of non-separability between real money balances and consumption. Log-linearizing (2.12) yields the LM equation

$$\hat{m}_t = \eta_c \hat{C}_t - \eta_i \hat{i}_t, \tag{3.2}$$

where $\eta_c > 0$ and $\eta_i > 0$ are the consumption and interest-rate semi-elasticity of money demand, which are defined as follows:

$$\eta_C \equiv \frac{\sigma^{-1} + \upsilon}{\mu + \sigma_m^{-1}}$$

and

$$\eta_i \equiv \left(\frac{\beta}{1-\beta}\right)\left(\frac{1}{\mu + \sigma_m^{-1}}\right),$$

where $\sigma_m^{-1} \equiv -m^{ss}u_{mm}/u_m$, $\upsilon \equiv C^{ss}u_{cm}/u_m$, and $\mu = s_m\upsilon$, where $s_m \equiv m^{ss}u_m/u_cC^{ss}$.

To derive a relationship for aggregate supply for domestic goods, it is necessary to log-linearize the price-setting equations (2.25-2.26). This generates the so-called New Keynessian Phillips Curve (NKPC):

$$\hat{\pi}_{H,t} - \delta_H \hat{\pi}_{H,t-1} = \beta E_t(\hat{\pi}_{H,t+1} - \delta_H \hat{\pi}_{H,t}) + \frac{(1-\tau_H)(1-\tau_H\beta)}{\tau_H}(\hat{m}c_t + \varepsilon_{cp,t}), \tag{3.3}$$

where the inflation rate for domestic prices is $\hat{\pi}_{H,t} = \hat{P}_{H,t} - \hat{P}_{H,t-1}$ and

$$\widehat{mc}_t = \omega \hat{Y}_t - (1-\omega)\varepsilon_{a,t} + \frac{1}{\sigma}\hat{C}_t - \mu \hat{m}_t + \alpha \widehat{TR}_t. \tag{3.4}$$

The above expression for real marginal cost is obtained by combining the log-linearized versions of (2.13), the aggregate version of the production function (2.21), the cost-minimization condition (2.22), and the CPI index (2.8). Note that (2.8) implies the following expression for the terms of trade $\hat{P}_t - \hat{P}_{H,t} = \alpha \widehat{TR}_t$, after using (2.20).

According to (3.3), domestic-price inflation, $\hat{\pi}_{H,t}$, is driven by current marginal cost, expectations about domestic-price inflation in the next period, and as a result of price indexation, a fraction of past and observed domestic-price inflation. When the indexation to past domestic-price inflation is zero, $\delta_H = 0$, equation (3.3) collapses to the familiar forward-looking version of the NKPC. In contrast to a closed-economy setting, domestic-price inflation, via real marginal cost, not only depends on domestic variables but also on the terms of trade.[1] Finally, the cost-push shock in equation (3.3) captures inefficient variations in firm mark-ups.

After log-linearizing the price-setting conditions for retail firms (2.28-2.29), we can obtain the following aggregate supply for retail goods:

$$\hat{\pi}_{F,t} - \delta_F \hat{\pi}_{F,t-1} = \beta E_t(\hat{\pi}_{F,t+1} - \delta_F \hat{\pi}_{F,t}) + \frac{(1-\tau_F)(1-\tau_F\beta)}{\tau_F}(\hat{\psi}_{F,t}), \tag{3.5}$$

where $\hat{\pi}_{F,t} = \hat{P}_{F,t} - \hat{P}_{F,t-1}$ and $\hat{\psi}$ denotes the log-linearized version of the law of one price gap (2.19):

$$\hat{\psi}_t \equiv \hat{e}_t + \hat{P}^* - \hat{P}_{F,t}.$$

Here, retail price inflation (i.e., the domestic currency price of imports), $\hat{\pi}_{F,t}$, is determined by a fraction of past retail inflation, observed retail inflation, expectations about next period's retail inflation and by deviations of the law of one price $\hat{\psi}_t$.

For the purposes of this study, it is important to derive the relationship between the terms of trade, the law of one price gap and the real exchange rate, in order to analyse the implications of imperfect exchange-rate pass-through. Log-linearizing (2.8), the real exchange rate definition

[1] See McKnight and Mihailov (2015) for further discussion.

and the terms of trade (2.20) yields:

$$\hat{q}_t = \hat{\psi}_t + (1-\alpha)\widehat{TR}_t. \tag{3.6}$$

First-differencing the log-linear version of (2.21), we obtain how the terms of trade adjusts overtime:

$$\widehat{TR}_t - \widehat{TR}_{t-1} = \hat{\pi}_{F,t} - \hat{\pi}_{H,t}. \tag{3.7}$$

By log-linearizing (2.8) and first-differencing, we obtain the CPI inflation index as a weighted combination of domestic-price inflation and imported inflation:

$$\hat{\pi}_t = (1-\alpha)\hat{\pi}_{H,t} + \alpha\hat{\pi}_{F,t}. \tag{3.8}$$

In this economy, the interest-rate parity condition (2.16) determines how the nominal (and hence real) exchange rate fluctuates given domestic and world interest rates. Therefore, combining the log-linear version of (2.16) and (3.6) gives:

$$(\hat{i}_t - E_t\hat{\pi}_{t+1}) = E_t(\hat{q}_{t+1} - \hat{q}_t) - \kappa(\hat{d}_t + \hat{\phi}_t), \tag{3.9}$$

where $\hat{\phi}_t$ captures a risk premium shock, which represents deviations from real interest rate parity and $\hat{d}_t = ln(e_t FB_t/(P_t Y^{ss}))$ is the log real net foreign asset position as a fraction of steady-state output.

As discussed by Justiniano and Preston (2010), in equilibrium households nominal income is equal to: $W_t N_t + \pi_t = P_{H,t}Y_t + (P_{F,t} - e_t P_t^*)C_{F,t}$. Substituting this into the household budget constraint (2.3) and using the market clearing condition for money (2.31) and domestic bonds

(2.32) and then log-linearizing generates:

$$\hat{C}_t + \hat{d}_t = \frac{1}{\beta}\hat{d}_{t-1} - \alpha(\widehat{TR}_t + \hat{\psi}_{F,t}) + \hat{Y}_t. \tag{3.10}$$

The above equation determines the evolution of debt in the model economy. Finally, to obtain a condition for output we log-linearize the goods market clearing condition (2.30):

$$\hat{Y}_t = (1-\alpha)\hat{C}_t + \alpha\gamma\hat{q}_t + \alpha\gamma\widehat{TR}_t.$$

3.2 Monetary Policy Rules

Finally, to complete the log-linearized equilibrium system for this economy, it is necessary to specify a monetary policy rule. Following Ouchen and Ziky (2015), we consider three alternative interest-rate rule specifications.

CIT CPI inflation targeting: the policy rule responds to CPI inflation

DIT Domestic inflation targeting: the policy rule responds to domestic price inflation

MF Managed float: a policy rule that responds to movements in the real exchange rate

CPI Inflation Targeting

Under a CPI inflation targeting policy, the central bank reacts to changes in output and CPI inflation. Formally, such a policy is specified as:

$$\hat{i}_t = \beta_0\hat{i}_{t-1} + (1-\beta_0)(\beta_1\hat{\pi}_t + \beta_2\hat{Y}_t) + \nu_t, \tag{3.11}$$

where $\hat{i}_t$, $\hat{\pi}_t$, $\hat{y}_t$, are log deviations of the interest rate, CPI inflation and output from their steady-state values, $0 < \beta_0 < 1$ is the interest-rate smoothing parameter, $\beta_1 > 0$ is the inflation response coefficient and $\beta_2 > 0$ is the output response coefficient.

Domestic Inflation Targeting

Under a domestic inflation targeting policy, the central bank reacts to changes in output and domestic price inflation:

$$\hat{i}_t = \beta_0 \hat{i}_{t-1} + (1-\beta_0)(\beta_1 \hat{\pi}_{H,t} + \beta_2 \hat{Y}_t) + \nu_t. \tag{3.12}$$

Managed Float

Under a managed float the real exchange rate $\hat{q}_t$ also enters into the interest-rate rule:[2]

$$\hat{i}_t = \beta_0 \hat{i}_{t-1} + (1-\beta_0)(\beta_1 \hat{\pi}_t + \beta_2 \hat{Y}_t + \beta_3 \hat{q}_t) + \nu_t, \tag{3.13}$$

where $\beta_3 > 0$ is the real exchange rate response coefficient.

3.3 Calibration

The baseline parameter values used to compute the equilibrium are summarized in Table 1. As far as is possible, the parameter values are chosen to match estimates for Mexico. In cases where no reliable parameter estimates exists, we use values commonly used in the open-economy New

[2] An alternative specification would be for the nominal exchange rate to enter into the monetary policy rule. See Monacelli (2004) for further discussion.

Keynesian literature.

Following the Mexican estimates of Ramos-Francia and Torres (2008), we set the discount factor $\beta = 0.9962$, the output elasticity of real marginal cost $\omega = 0.82$ and the degree of price stickiness of domestic goods $\tau_H = 0.75$. For the intertemporal elasticity of substitution in consumption, we follow the estimation of Ostry and Reinhart (1992) in setting $\sigma = 0.373$.

Following Mankiw and Summer (1986), we set the consumption elasticity of money demand $\eta_c = 1$, and following Arrau and Gregorio (1991) we set the interest-rate semi-elasticity of money demand $\eta_i = 28$. We follow Woodford (2003) and McKnight and Mihailov (2015) and set a value for real balance effects $\mu = 0.03$. Consistent with the estimates of Bergin and Glick (2004), we choose a value for the substitution between home and foreign goods $\gamma = 1$. We follow McKnight, Mihailov and Pompa-Rangel (2016) in setting the degree of trade openness $\alpha = 0.44$, the degree of inflation indexation of domestic goods $\delta_H = 0.8$, the degree of inflation indexation of imported goods $\delta_F = 0.55$, and the incomplete asset market parameter $\kappa = 0.01$.

In regard to the coefficients for the three alternative specifications for the Taylor-type rules, we follow Carrillo and Elizondo (2015) in setting the interest-rate smoothing parameter $\beta_0 = 0.8$ and the output response coefficient $\beta_2 = 0.5$. Following Schmitt-Grohe and Uribe (2000), the inflation response coefficient is set $\beta_1 = 1.53$, and following estimates by Muhammad (2011) we set the real exchange rate response coefficient $\beta_3 = 0.14$. We also use a higher value of $\beta_3 = 0.55$ calibrated by Ball and Reyes (2004) to analyse the sensitivity of our results.

For illustrative purposes, the analysis consider four different values for the degree of exchange-rate pass-through $\tau_F = 0, 0.5, 0.75, 0.99$.[3]

[3] Estimates by Hernandez (2008) for Mexico suggest a high degree of incomplete exchange-rate pass-through of between 0.7 and 0.9.

Following much of the literature, the disturbances $\left\{\varepsilon_{a,t}, \varepsilon_{cp,t}, \phi_t, \nu_t\right\}$ are independent AR(1) process:

$$\varepsilon_{x,t} = \rho_x \varepsilon_{x,t-1},$$

where $\rho_x \in (0,1)$, $var(\varepsilon_{x,t}) \sim iid(0, \sigma_x^2)$ for $x = a, cp$, ϕ and ν. For the values of the persistence of the shocks, we follow Galí (2008) in setting the persistence of productivity shocks $\rho_{a,t} = 0.9$, monetary shocks $\rho_\nu = 0.5$ and cost-push shocks $\rho_{cp} = 0.5$. For risk premium shocks, we follow Galí and Monacelli (2005) and set $\rho_\phi = 0.8$.

Table 3.1 Benchmark Parameter Values

Parameter	Description	Value	Reference
β	Discount factor	0.9962	Ramos-Francia and Torres (2008)
σ	Intertemporal elasticity of substitution in consumption	0.373	Ostry and Reinhart (1991)
ω	Output elasticity of real marginal cost	0.82	Ramos-Francia and Torres (2008)
τ_H	Degree of price-stickiness	0.75	Ramos-Francia and Torres (2008)
τ_F	Degree of incomplete exchange-rate pass-through	0, 0.5, 0.75, 0.99	
δ_H	Degree of inflation indexation (domestic goods)	0.8	McKnight et al. (2016)
δ_F	Degree of inflation indexation (imported goods)	0.55	McKnight et al. (2016)
μ	Degree of non-separability of the utility function	0.03	Woodford (2003)
η_c	Consumption elasticity of money demand	1	Mankiw and Summers (1986)
η_i	Interest-rate semi-elasticity of money demand	28	Arrau and Gregorio (1991)
γ	Elasticity of substitution between home and foreign goods	1	Bergin and Glick (2004)
α	Degree of trade openness	0.44	McKnight et al. (2016)
κ	Incomplete asset markets parameter	0.01	McKnight et al. (2016)
β_0	Interest-rate smoothing coefficient	0.8	Carrillo and Elizondo (2015)
β_1	Inflation response coefficient	1.53	Schmitt-Grohe and Uribe (2000)
β_2	Output response coefficient	0.5	Carrillo and Elizondo (2015)
β_3	Real exchange rate response coefficient	0.14	Muhammad (2011)
β_{3a}	Real exchange rate response coefficient	0.55	Ball and Reyes (2004)
$\rho_{a,t}$	Persistence of productivity shocks	0.9	Galí (2008)
ρ_v	Persistence of monetary shocks	0.5	Galí (2008)
ρ_{cp}	Persistence of cost-push shocks	0.5	Galí (2008)
ρ_ϕ	Persistence of risk premium shocks	0.8	Galí and Monacelli (2005)

Chapter 4

Baseline Results: CPI Inflation Targeting Rule

This chapter presents the impulse-response analysis for the small open economy model under a CPI inflation targeting interest-rate rule. For each exogenous shock, the impulse response analysis is conducted for four alternative values for the degree of exchange-rate pass-through: $\tau_F = 0, 0.5, 0.75, 0.99$. Recall that $\tau_F = 0$ represents the perfect pass-through benchmark, where there are no deviations from the law of one price.

4.1 Productivity Shocks

I first consider the propagation mechanism of productivity shocks. In each panel of Figure 4.1, the dynamic responses of the main variables are plotted after a one-percentage point positive productivity shock under perfect exchange-rate pass-through (i.e., $\tau_F = 0$). By inspection, after a positive productive shock, this results in an increase in output and consumption and real money balances consequently rise (for transaction purposes). Domestic inflation falls as marginal costs decease and the terms of trade and the real exchange rate depreciates (i.e, increases). Consequently, CPI inflation falls, which under a CPI inflation targeting rule, causes the central bank to reduce the nominal interest rate. These results are consistent with the small open economy analysis of Galí (2008) under complete asset markets.

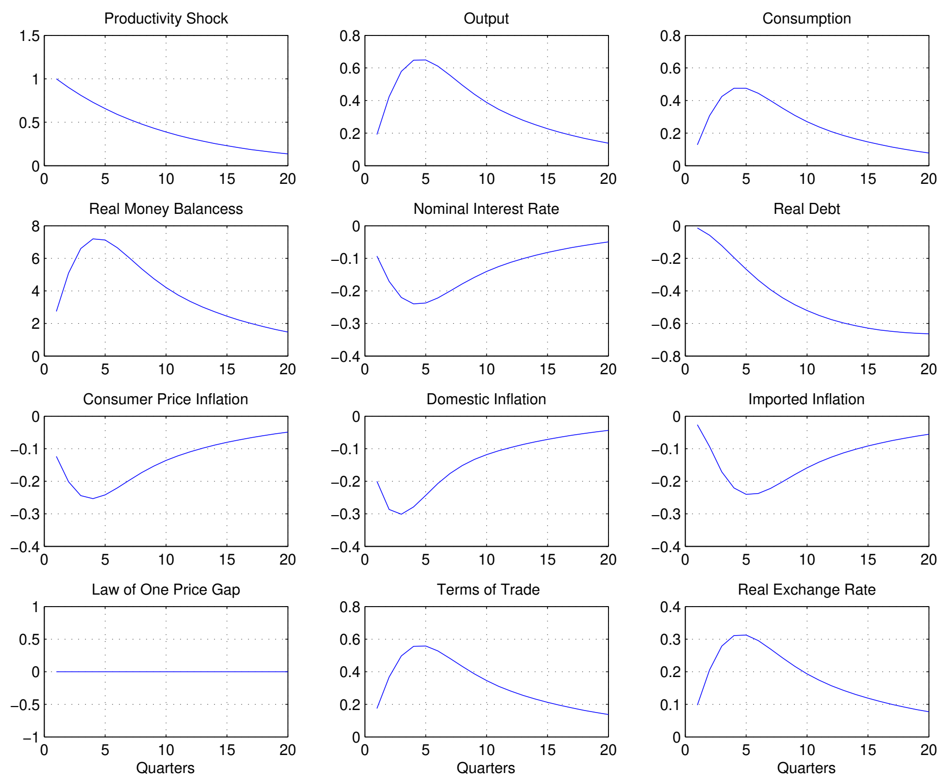

Fig. 4.1 Productivity shocks under perfect exchange-rate pass-through: $\tau_F = 0$

Figures 4.2–4.4 plot the impulse responses of a positive productivity shock under imperfect exchange-rate pass-through. As discussed by Ouchen and Ziky (2015), depending on the variable the degree of imperfect exchange-rate pass-through could lead to either an amplification or contraction of the response to the shock, and these effects are not likely to be symmetric between domestic variables and variables that links the small-open economy with the rest of the world. Figure 4.2 summarizes the results when $\tau_F = 0.5$, whereas Figure 4.3 illustrates the impulse responses when $\tau_F = 0.75$.

From Figure 4.2 we can observe, that similar with the case of perfect pass-through, output increases under a positive productive shock leading to an increase in consumption and real money balances. Domestic inflation falls as marginal costs decease, and consequently, CPI inflation falls, causing the central bank to reduce the nominal interest. However, the depreciation in the terms of trade and the real exchange rate is very similar to the perfect pass-through benchmark.

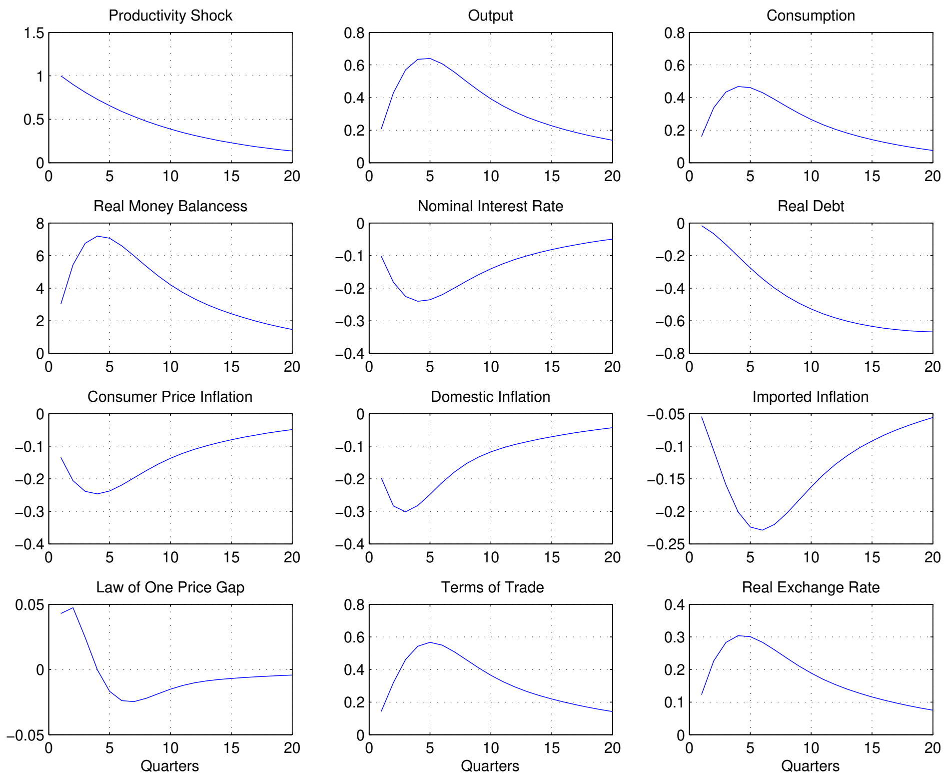

Fig. 4.2 Productivity shocks under imperfect exchange-rate pass-through: $\tau_F = 0.5$

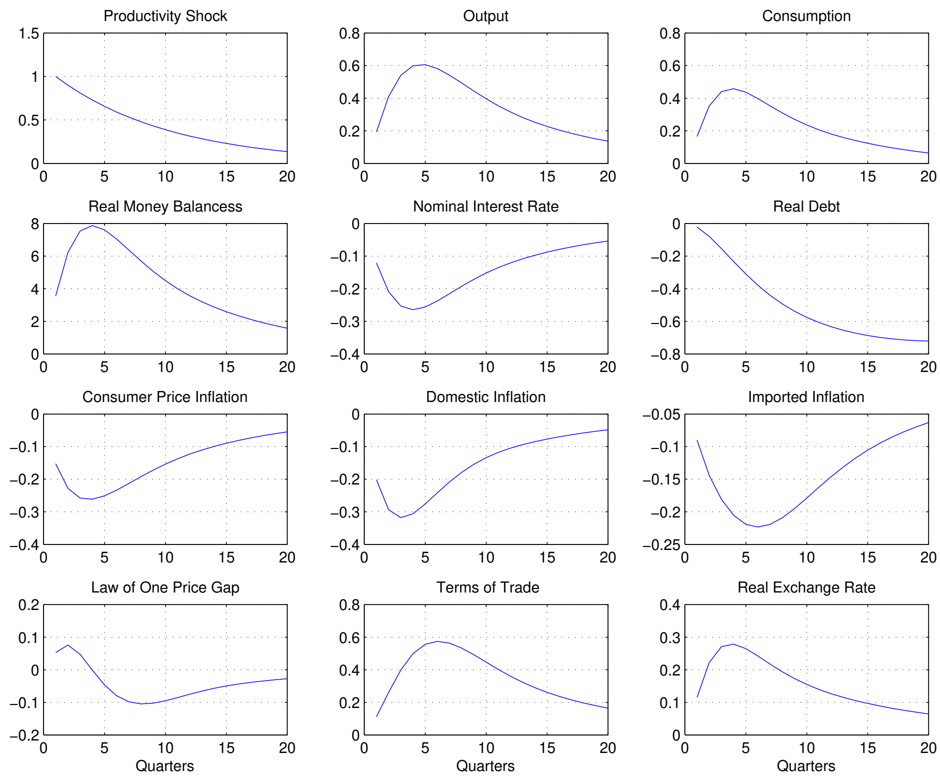

Fig. 4.3 Productivity shocks under imperfect exchange-rate pass-through: $\tau_F = 0.75$

In the extreme case of $\tau_F = 0.99$ where there is almost zero exchange-rate pass-through, Figure 4.4 shows that the responses of output, consumption, trade balance (i.e. real debt), and real exchange rate under productivity shocks are quite similar to the perfect pass-through benchmark. However, domestic inflation falls relatively more, and imported inflation falls relatively less, remaining below their steady-state levels for the examined quarters. A very high degree of imperfect pass-through also has substantial effects on the dynamics of the real exchange rate and the terms of trade. In stark contrast to the other cases, with $\tau_F = 0.99$ the real exchange rate gradually appreciates causing the terms of trade to move further away from its steady state and consumption to actually fall below its steady-state level after 5 periods.

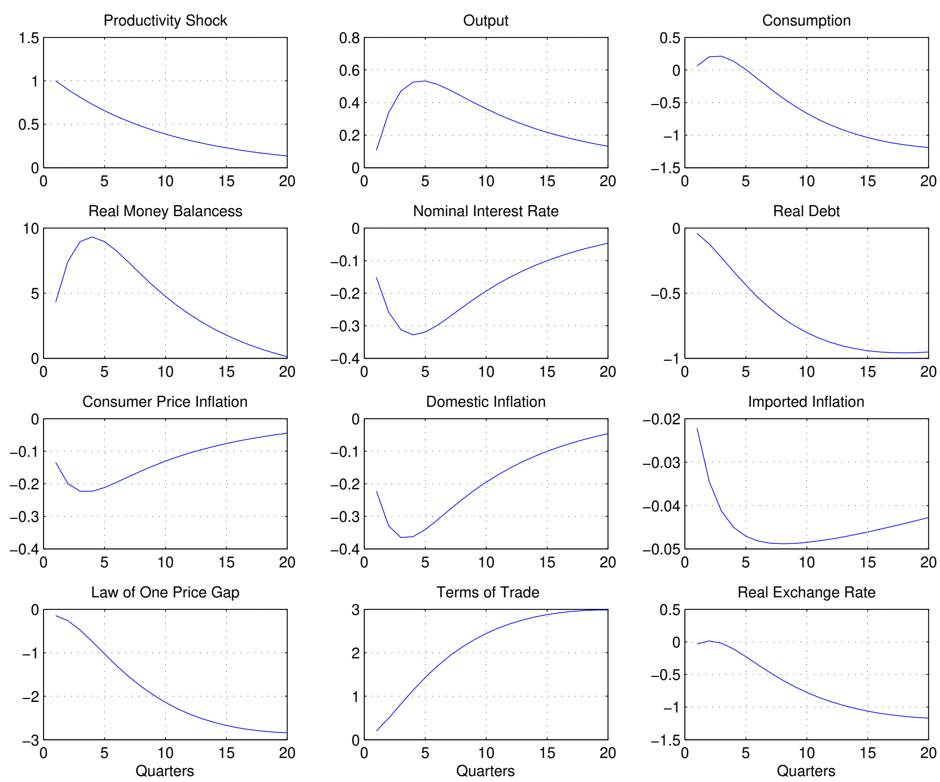

Fig. 4.4 Productivity shocks under imperfect exchange-rate pass-through: $\tau_F = 0.99$

4.2 Risk-Premium Shocks

In this section we consider the impact on the small open-economy of a one percent negative risk-premium shock. Figure 4.5 depicts the impulse response functions under perfect exchange-rate pass-through where deviations from LOP are zero. From the UIP equation (3.9) we observe that this (negative) shock causes a depreciation (i.e., an increase) in the real exchange rate, and this depreciation requires an interest rate tightening. Real debt increases and the terms of trade improves. On the other hand, a rise in the nominal interest decreases the level of output and therefore consumption falls which is accompanied by a fall in real money balances. While domestic inflation falls in response to lower aggregate demand, imported inflation rises, resulting in a higher CPI inflation rate.

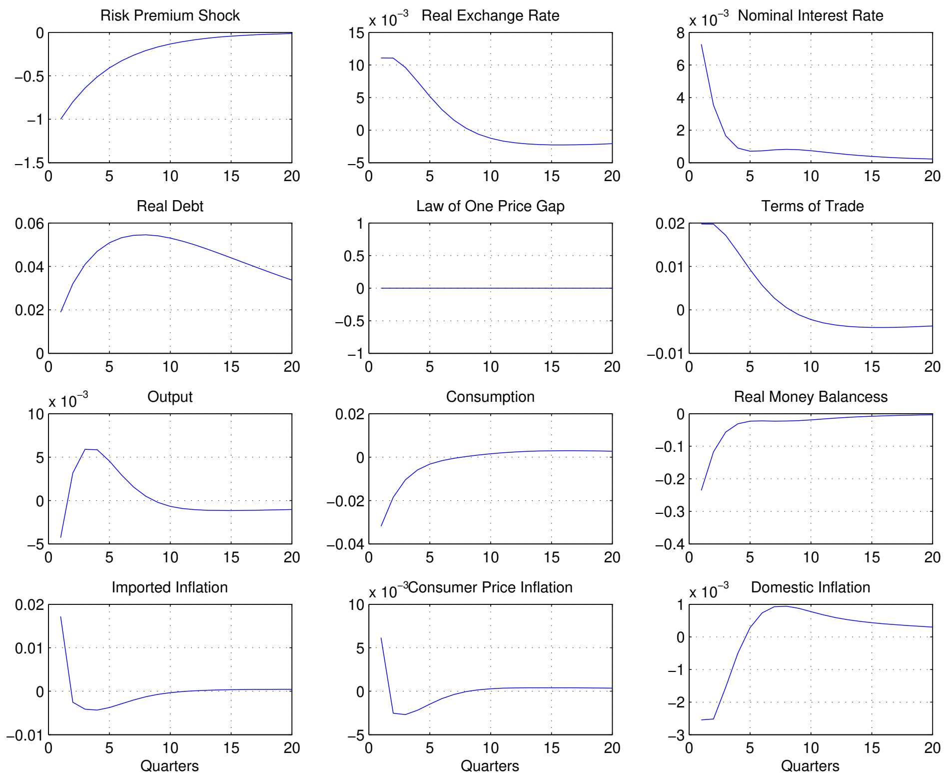

Fig. 4.5 Risk-premium shocks under perfect exchange-rate pass-through: $\tau_F = 0$

The propagation mechanism of risk-premium shocks under imperfect exchange-rate pass-through are illustrated in Figures 4.6–4.8. As in the case of perfect pass-through, this shock causes an increase in the real exchange rate which causes an increase in the nominal interest rate, real debt, and the terms of trade. Surprisingly with imperfect pass-through, the increase in the nominal interest rate does not cause an initial decrease in output, although consumption still falls below its steady-state level. With $\tau_F = 0.5, 0.75$, similar to the perfect exchange-rate benchmark, aggregate inflation rises. However, with $\tau_F = 0.99$ the CPI inflation rate initially falls below its steady-state level. Overall, comparing Figure 4.8 with Figures 4.6 and 4.7, with nearly full imperfect exchange-rate pass-through, raises the volatility and the magnitude of volatility is specially large for those variables that link the domestic economy with the the rest of the world. Furthermore, a very high degree of imperfect pass-through causes a tilting effect on imported inflation.

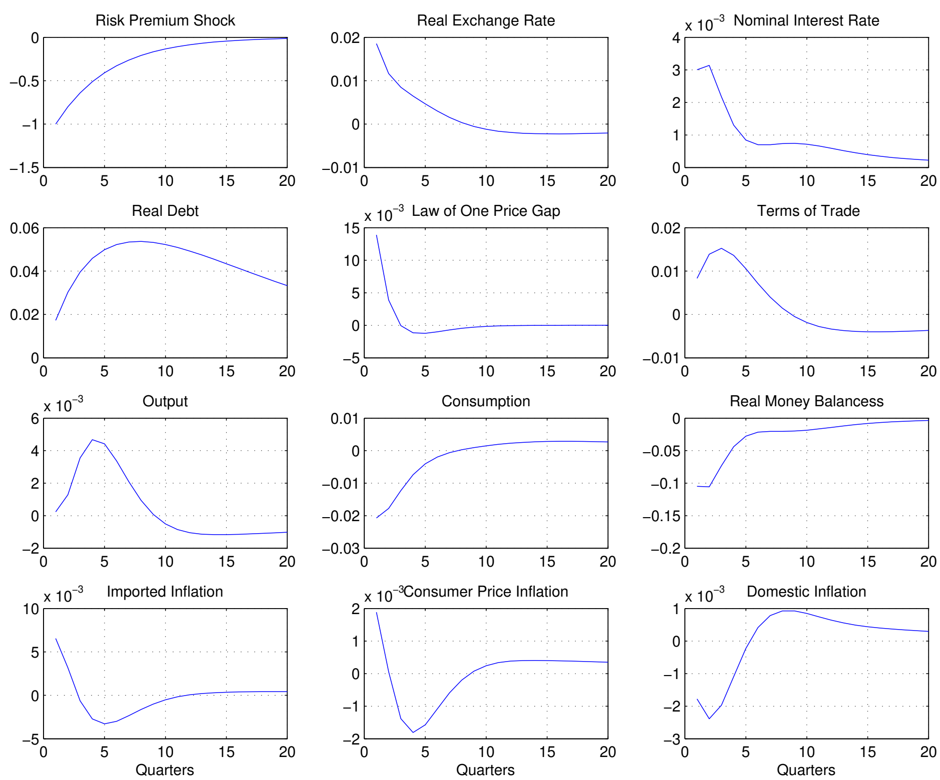

Fig. 4.6 Risk premium shocks and imperfect exchange-rate pass-through: $\tau_F = 0.5$

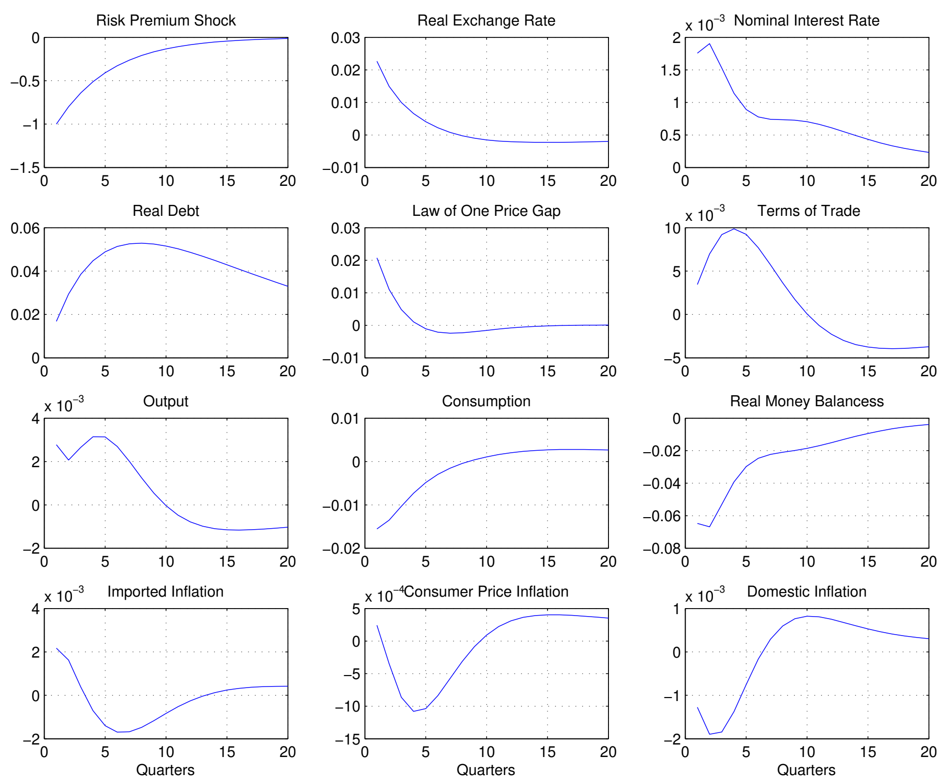

Fig. 4.7 Risk premium shocks and imperfect exchange-rate pass-through: $\tau_F = 0.75$

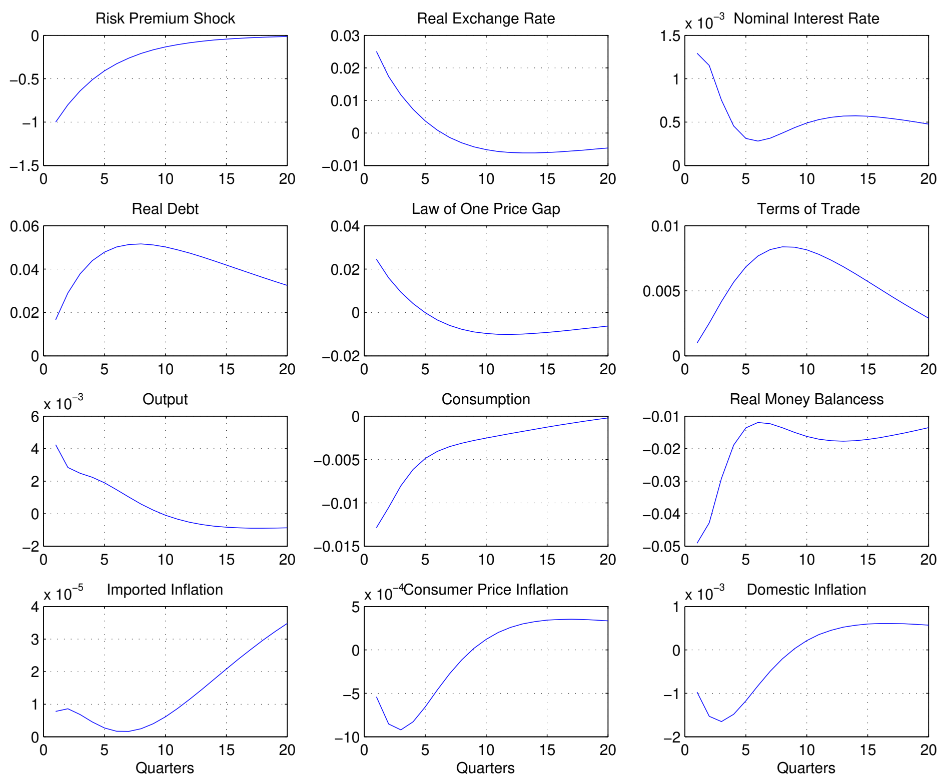

Fig. 4.8 Risk premium shocks and incomplete exchange-rate pass-through: $\tau_F = 0.99$

4.3 Cost-Push Shocks

In this section, we focus on positive cost-push shocks, whereby the marginal cost of domestic firms increases by one percent. As illustrated by Figure 4.9 under complete pass-through, domestic firms reduce their production and thus aggregate output falls, which causes a decrease in consumption and real money balances. The increase in marginal cost causes an increase in domestic inflation and a slight increase in imported inflation which leads to an increase in the consumer price inflation. Cost-push shocks cause an increase in the nominal interest rate due to an increase in overall inflation, an appreciation of the real exchange rate and a deterioration in the terms of trade.

Figures 4.10–4.12 plot the impulse responses under imperfect exchange-rate pass-through. The cost-push shock with imperfect pass-through has the same propagation mechanism as the case of perfect pass-through. With a degree of imperfect exchange-rate pass-through of either $\tau_F = 0.5$ or $\tau_F = 0.75$, shock volatility is increased for the terms of trade and the real exchange rate. In the case of $\tau_F = 0.99$, the cost-push shock leads to a small fall in output and consumption in the first few quarters. However, consumption recovers faster than output and a few quarters later increases beyond the steady state. Initially there is little change in the real exchange rate which overtime starts to depreciate above its steady-state level (in stark contrast to Figures 4.10 and 4.11).

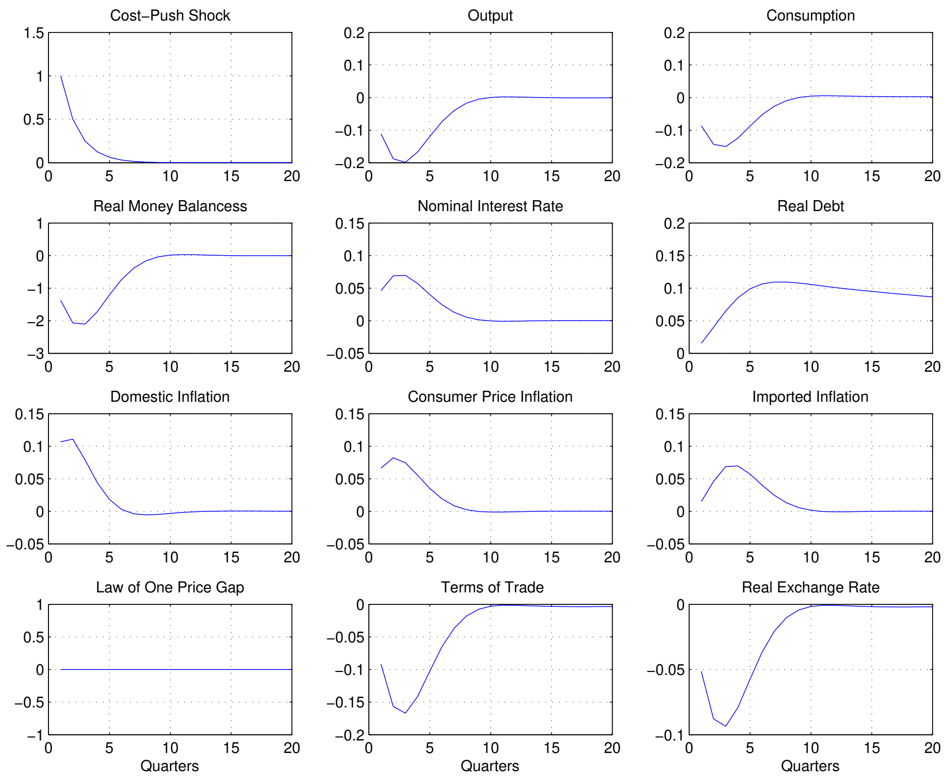

Fig. 4.9 Cost-push shocks and perfect exchange-rate pass-through: $\tau_F = 0$

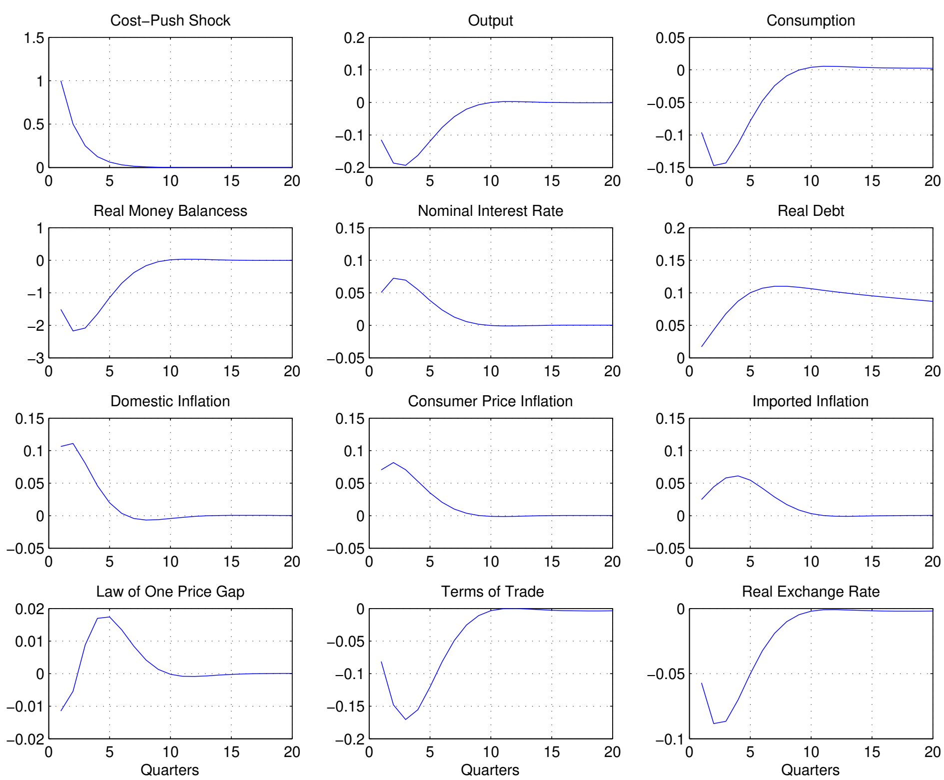

Fig. 4.10 Cost-push shocks and imperfect exchange-rate pass-through: $\tau_F = 0.5$

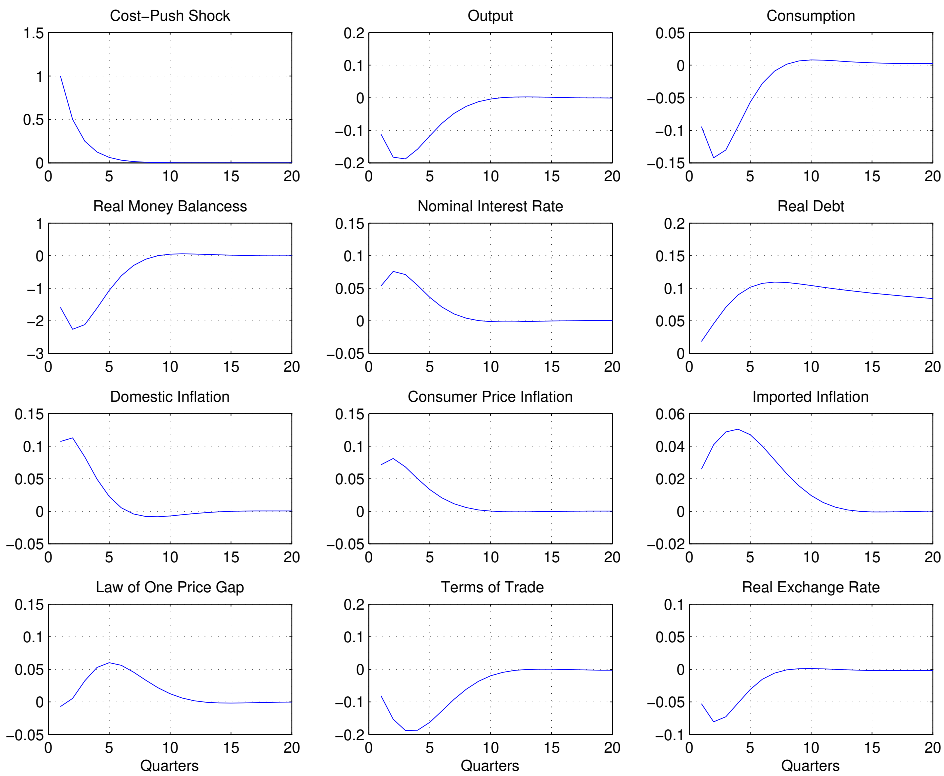

Fig. 4.11 Cost-push shocks and imperfect exchange-rate pass-through: $\tau_F = 0.75$

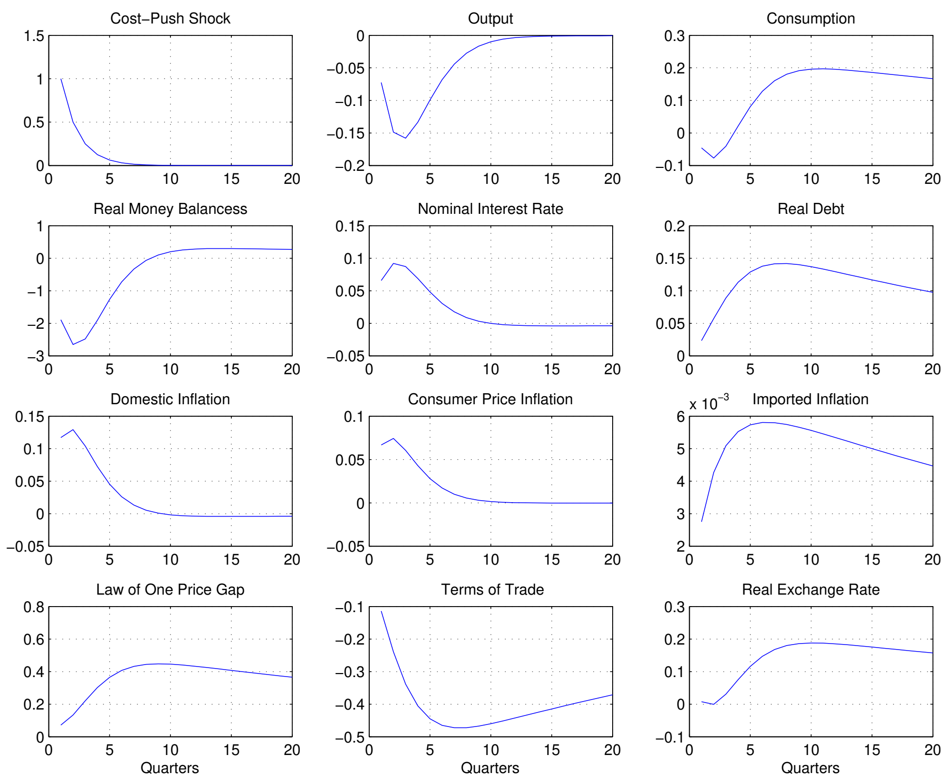

Fig. 4.12 Cost-push shocks and imperfect exchange-rate pass-through: $\tau_F = 0.99$

4.4 Monetary Shocks

We now report the most interesting results of this analysis. In the case of monetary shock a positive change in $\varepsilon_{v,t}$ should be interpreted as a contractionary monetary policy shock leading to a rise in the nominal interest rate. The impulse responses for this shock are displayed in Figure 4.13. Note that in the case of perfect pass-through we do not observe an immediate increase in the nominal interest rate.[1] However, output, consumption and real money balances all immediately fall. The contraction in aggregate demand in the economy decreases domestic inflation, imported inflation and overall inflation, while the terms of trade improve and the real exchange rate appreciates.

Figures 4.14–4.16 illustrate how a monetary shock impacts the economy when we allow for different degrees of incomplete exchange-rate pass-through. Here the nominal interest rate rises immediately and output, consumption and real money balances all decrease. This contraction on the economy leads to a decrease in domestic and foreign inflation and therefore a fall in CPI inflation. But with $\tau_F = 0.5$, incomplete pass-through results in a higher volatility in the terms of trade and the real exchange rate (relative to the perfect pass-through benchmark). For higher degrees of imperfect pass-through result in a fall in the law of one price gap and the real exchange rate appreciates, but contrary to the perfect pass-through benchmark this causes a depreciation in the terms of trade. Therefore, the overall conclusion is that the degree of exchange-rate pass-through plays an important role in the transmission of monetary shocks.

[1]This can be explained by the nature of the interest-rate rule which includes significant interest-rate smoothing.

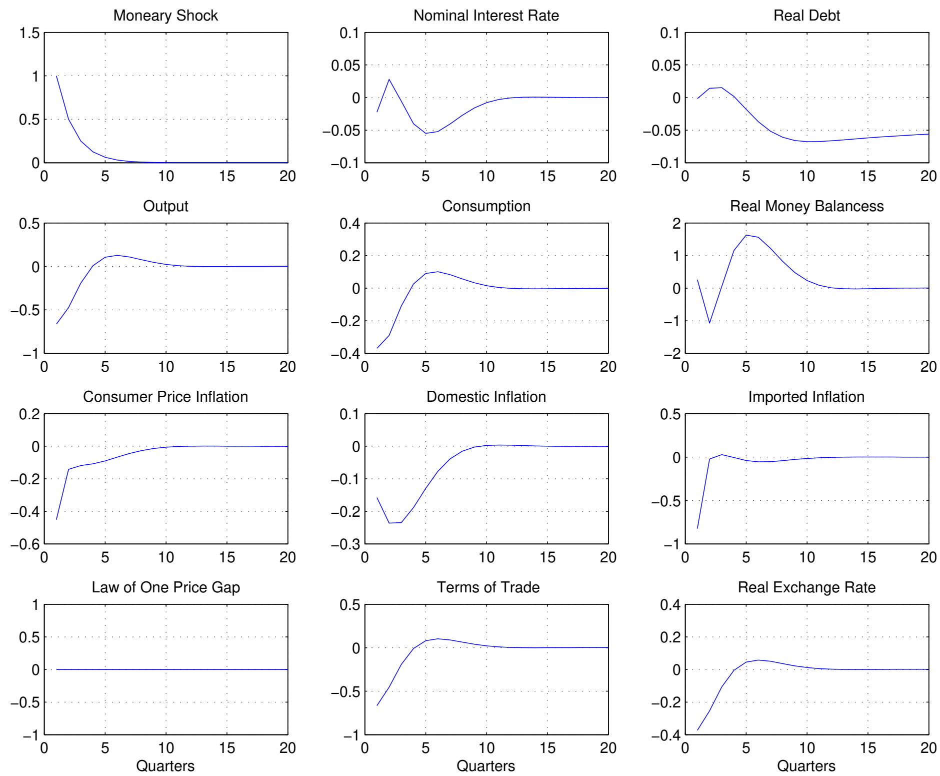

Fig. 4.13 Monetary shocks and perfect exchange-rate pass-through: $\tau_F = 0$

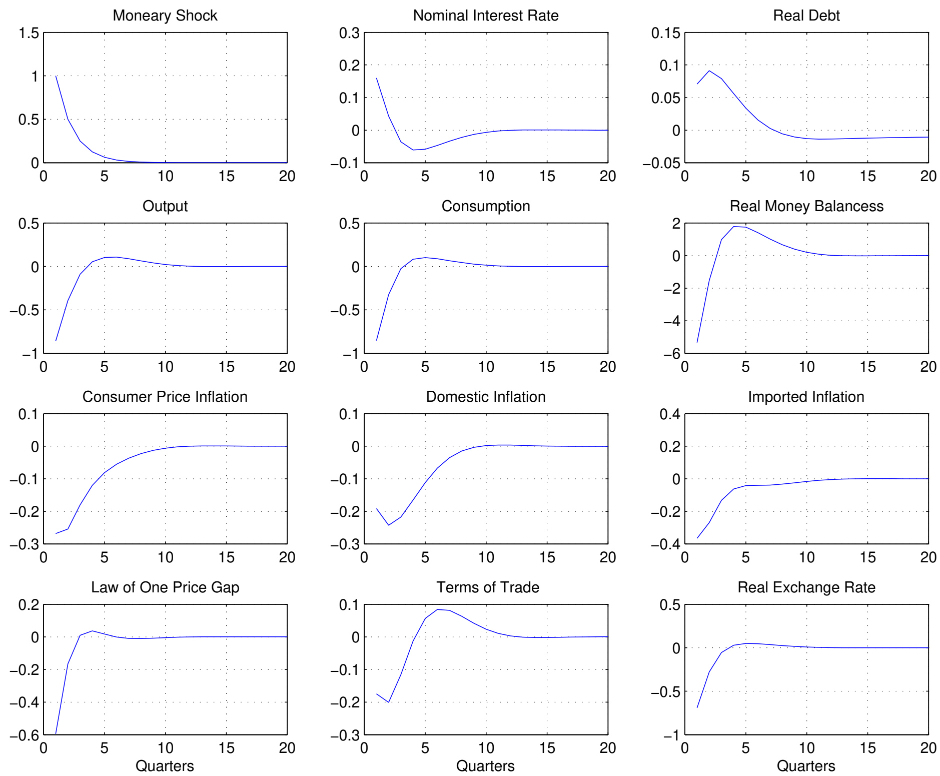

Fig. 4.14 Monetary shocks and incomplete exchange-rate pass-through: $\tau_F = 0.5$

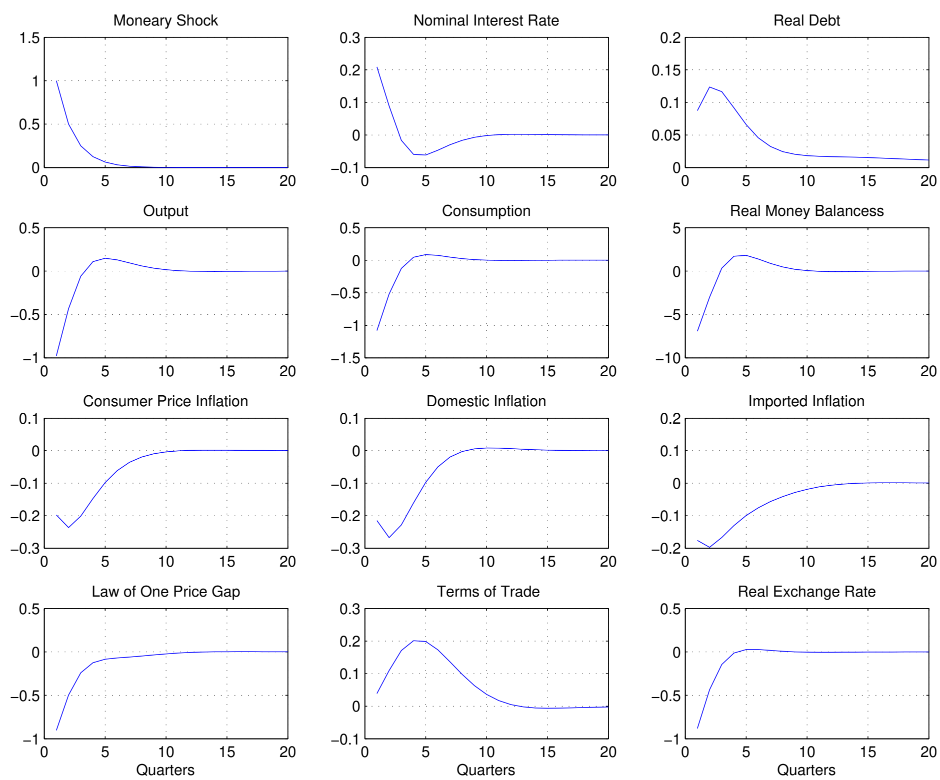

Fig. 4.15 Monetary shocks and incomplete exchange-rate pass-through: $\tau_F = 0.75$

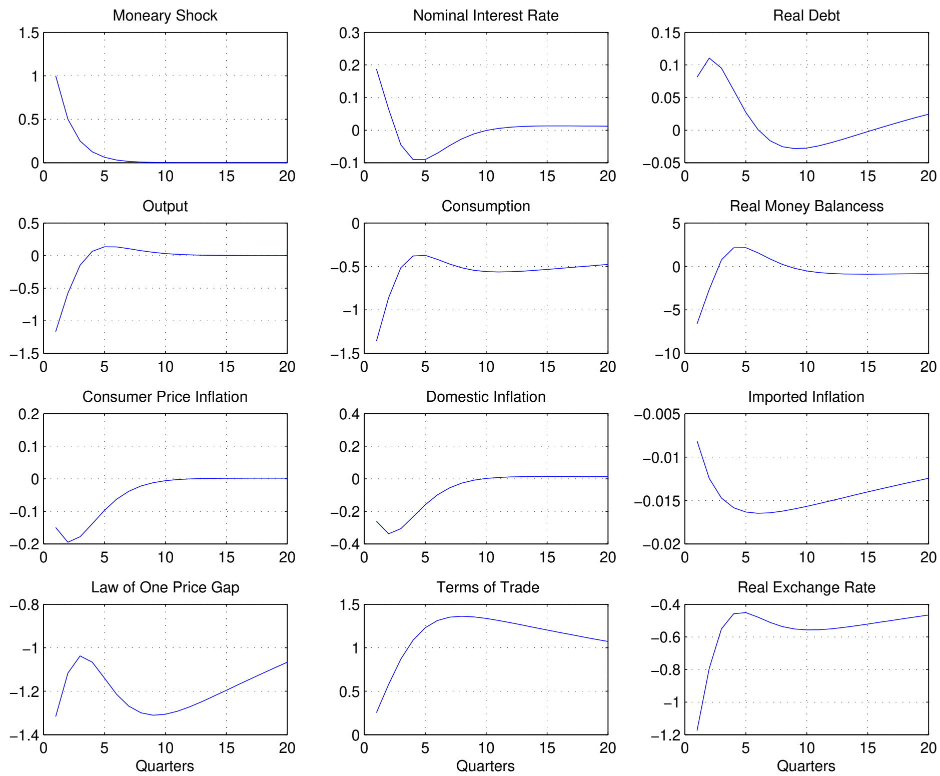

Fig. 4.16 Monetary shocks and incomplete exchange-rate pass-through: $\tau_F = 0.99$

Chapter 5

Propagation of Shocks Under Alternative Monetary Policy Rule Specifications

This chapter undertakes an impulse-response analysis under alternative specifications for the interest-rate feedback rule. As outlined in chapter 3, we consider a domestic inflation targeting (DIT) monetary regime where the interest rate responds to domestic price inflation and output, and a managed float (MF) policy where the real exchange rate also enters into the feedback rule. The purpose of this chapter is examine the robustness of the previous results obtained under a CPI Inflation Targeting (CIT) policy rule. Analogously, to the CIT case, for each of the exogenous shocks, the impulse response analysis is conducted for four alternative values for the degree of exchange-rate pass-through: $\tau_F = 0, 0.5, 0.75, 0.99$.

As discussed in Ouchen and Ziky (2015), monetary policies that stabilize output sacrifice stability in terms of exchange rate volatility causing higher inflation volatility. Moreover, with imperfect degrees of exchange-rate pass-through, the trade-off between output volatility and inflation volatility is almost negligible. Therefore, a flexible exchange rate policy can achieve output stabilization without high inflation volatility.

5.1 Productivity Shocks

The first case we analyse is the impact of positive productivity shocks with perfect exchange-rate pass-through ($\tau_F = 0$). Remembering that, with full pass-through, changes in exchange rates feeds immediately into CPI. The higher response of inflation now allows for a higher response in nominal interest rate. By inspection, we can observe that the impact of a positive productivity shock on the real variables is almost identical, independently of the monetary regime followed. However this is not the case with nominal variables, where there are quantitative differences relative to the CIT benchmark. Figure 5.1 illustrates the results under a DIT policy regime, whereas Figure 5.2 illustrates the impulse responses under a MT policy regime.

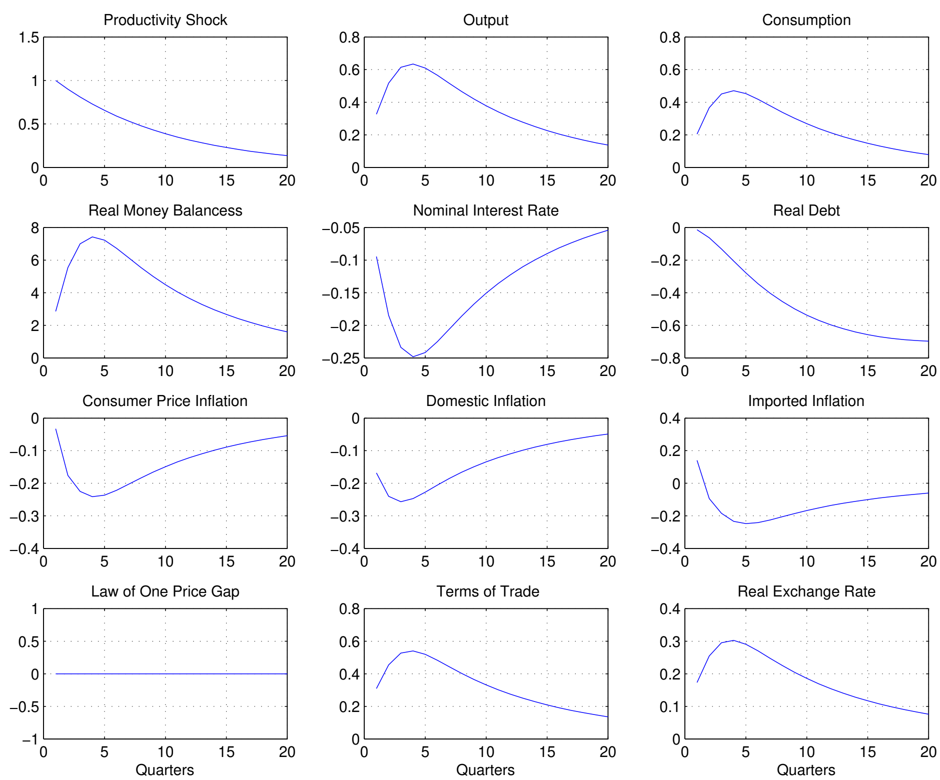

Fig. 5.1 Productivity shocks under perfect exchange-rate pass-through ($\tau_F = 0$): DIT policy regime

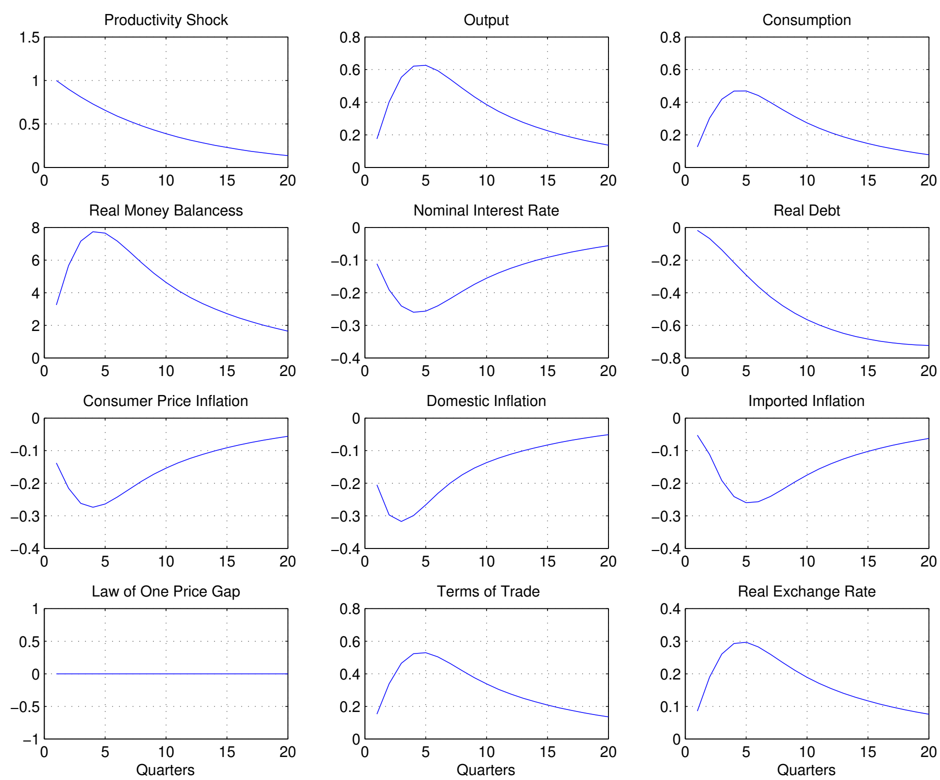

Fig. 5.2 Productivity shocks under perfect exchange-rate pass-through ($\tau_F = 0$): MF policy regime

In each panel of Figure 5.3, and 5.4, the dynamic responses of the main variables are plotted after a one-percentage point positive productivity shock under imperfect exchange-rate pass-through $\tau_F = 0.5$. Similar to the CIT monetary regime, a shock in productivity would lead to an increase in output, consumption and real money balances. Domestic inflation, imported inflation and overall inflation all decrease. While imported inflation falls in all three monetary regimes, the magnitude of the response to the productivity disturbance is larger under CIT and MF. The lower the response of inflation in CIT dramatically limits inflation volatility, compared to the DIT case. The increase in exports leads to a trade balance surplus and real debt falls. Under the three monetary regimes, the central bank reduces the nominal interest rate with a depreciation of the real exchange rate and an improvement in the terms of trade.

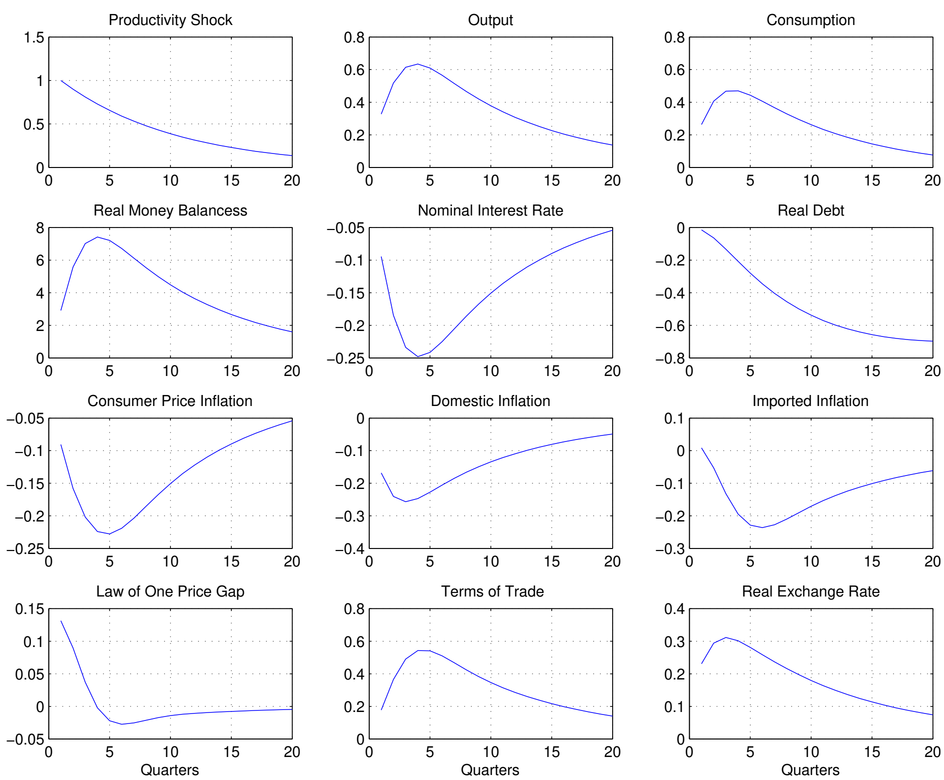

Fig. 5.3 Productivity shocks under imperfect exchange-rate pass-through ($\tau_F = 0.5$): DIT policy regime

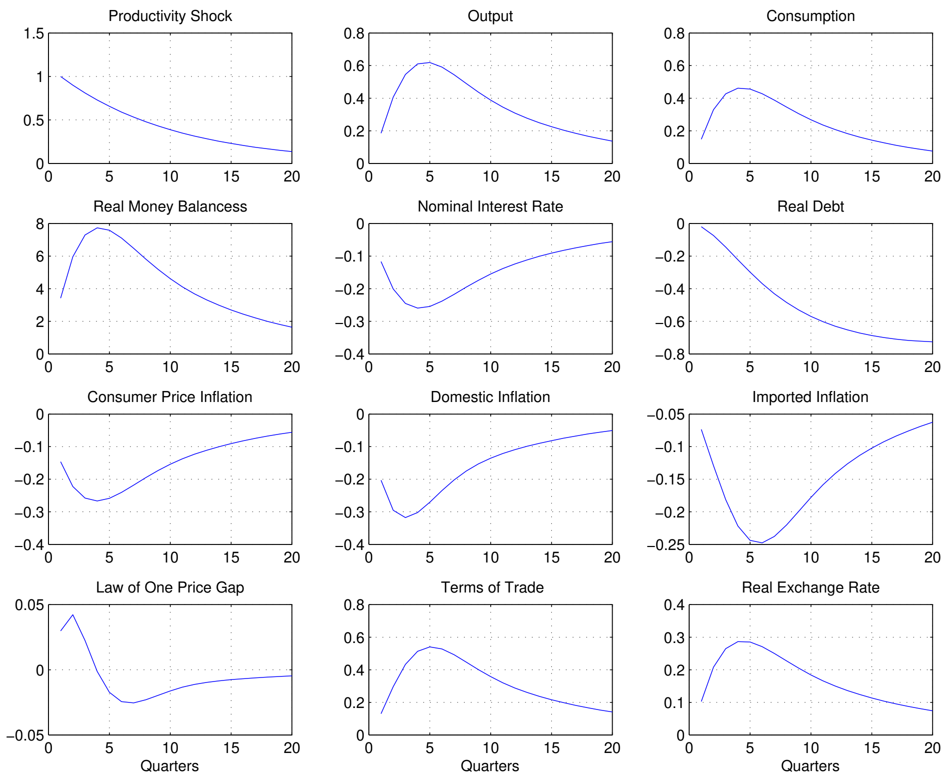

Fig. 5.4 Productivity shocks under imperfect exchange-rate pass-through ($\tau_F = 0.5$): MF policy regime

In the extreme case of $\tau_F = 0.99$, the responses of output, consumption, trade balance, and real exchange rate under productivity shock are quite similar, with the main difference that under DIT, output increases more and nominal interest rate remain negative (see Figure 5.5). Under the benchmark CIT regime, domestic inflation falls and overall inflation fall more. The results under a MF regime are similar to CIT (see Figure 5.6). Varying the degree pass-through has also substantial effects on the volatility of the real exchange rate.

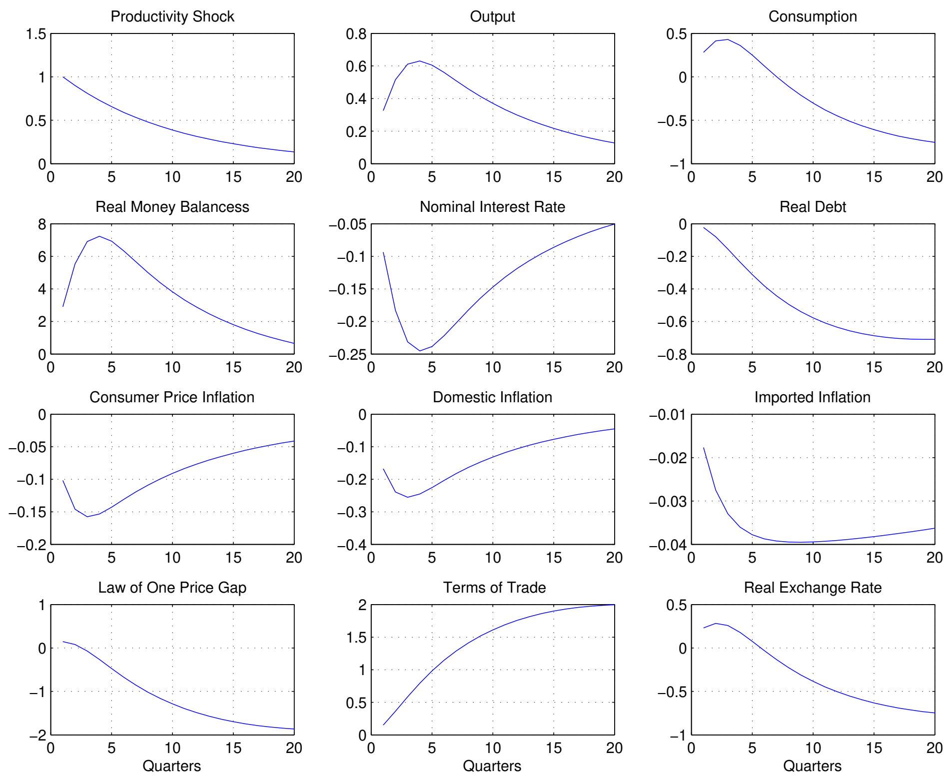

Fig. 5.5 Productivity shocks under imperfect exchange-rate pass-through ($\tau_F = 0.99$): DIT policy regime

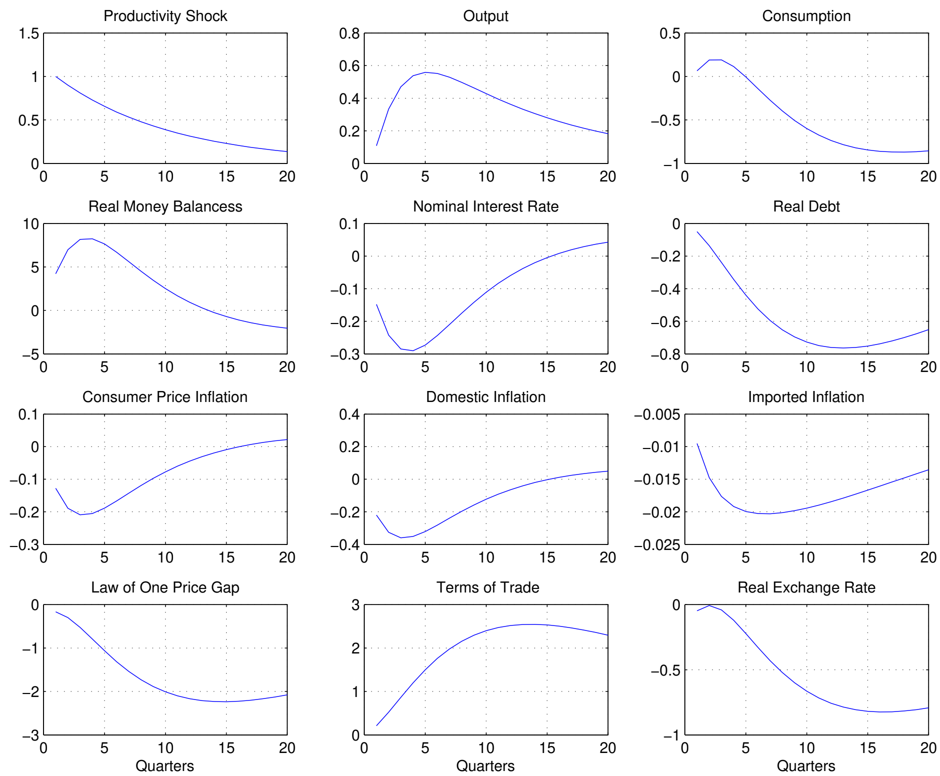

Fig. 5.6 Productivity shocks under imperfect exchange-rate pass-through ($\tau_F = 0.99$): MF policy regime

5.2 Risk-Premium Shocks

This section conducts the impulse response analysis for a one percent negative risk-premium shock. Under perfect pass-through, Figure 5.7 illustrates the impulse response under a DIT policy regime, whereas Figure 5.8 illustrates the results for a MF regime. We know from the previous chapter that under CIT policy rules this shock causes a depreciation (i.e., an increase) in the real exchange rate, and this depreciation calls for an interest rate tightening. Real debt increase and the terms of trade improves. However, the rise in the nominal interest is slightly less pronounced in the DIT regime, where output initially increases, but slightly more volatility in aggregate inflation.

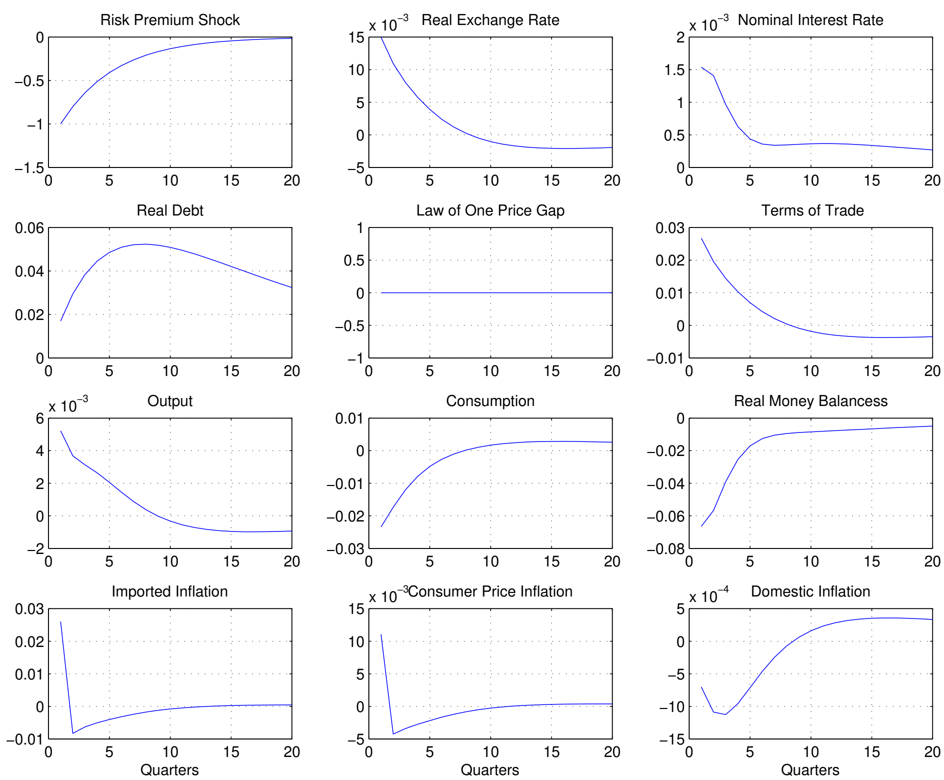

Fig. 5.7 Risk-premium shocks under perfect exchange-rate pass-through ($\tau_F = 0$): DIT policy regime

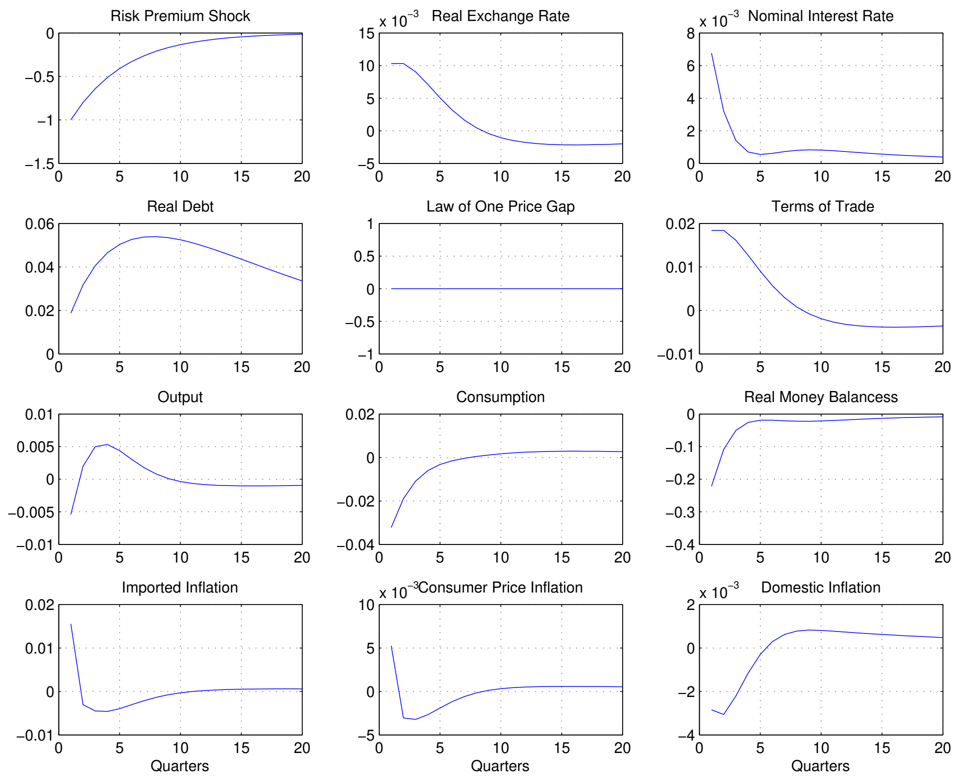

Fig. 5.8 Risk-premium shocks under perfect exchange-rate pass-through ($\tau_F = 0$): MF policy regime

Under imperfect exchange-rate pass-through, Figures 5.9 and 5.10 display the propagation mechanism of risk-premium shocks for the DIT and MF monetary regimes, respectively. As in the case of perfect pass-through, this shock causes an increase in the real exchange rate which causes an increase in the nominal interest rate but with a small rise under DIT. The movement in real debt and the terms if trade is almost the same under both policy regimes, although aggregate inflation is slightly more volatile under DIT.

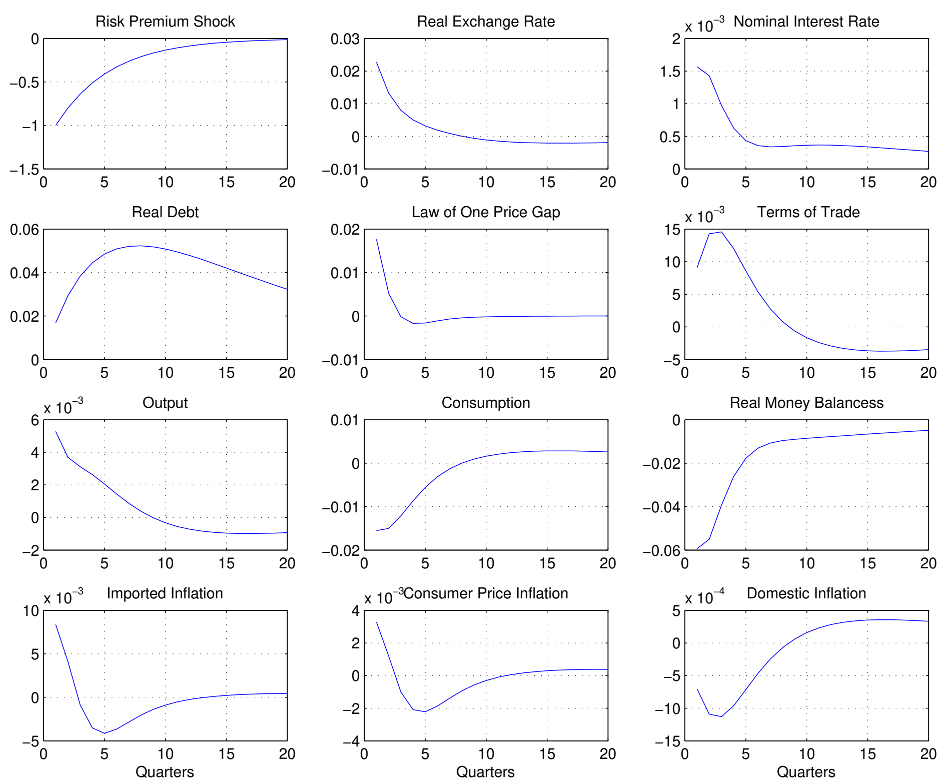

Fig. 5.9 Risk premium shocks and imperfect exchange-rate pass-through ($\tau_F = 0.5$): DIT policy regime

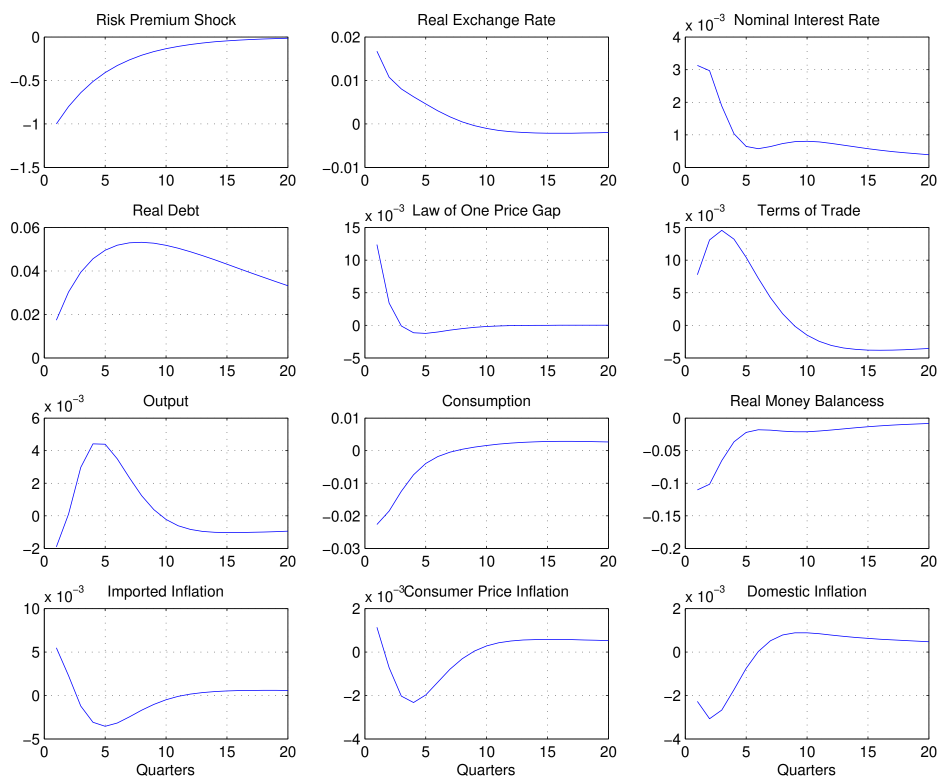

Fig. 5.10 Risk premium shocks and imperfect exchange-rate pass-through ($\tau_F = 0.5$): MF policy regime

To complete the analysis for risk premium shocks, Figures 5.11 and 5.12 show an increase in the real exchange rate with a high degree of incomplete pass-through ($\tau_F = 0.99$). In this setting, we observe that the sign of the impulses responses remains the same, but this degree of pass-through increase the level of volatility in each one with small differences among the regimes. We can observe that under the DIT regime, the volatility in the terms of trade was higher, which was beneficial to imported inflation and CPI inflation. In contrast, under the MF regime, the increase in imported inflation was less pronounced, with less volatility in the deviations on the law of one price gap, and a higher response in the real exchange rate.

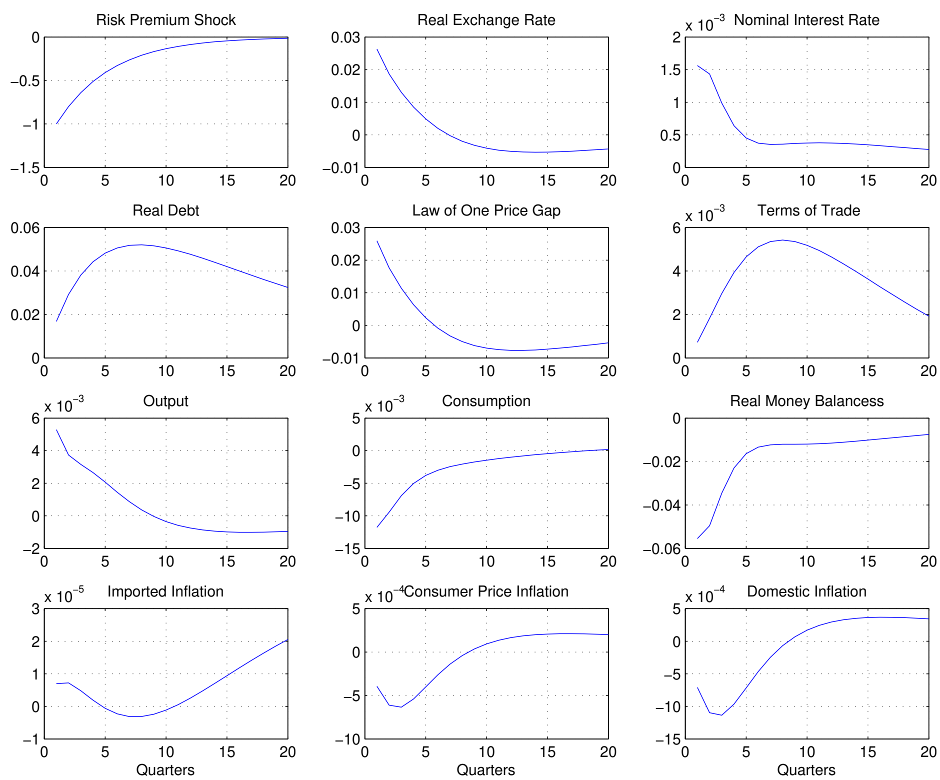

Fig. 5.11 Risk premium shocks and incomplete exchange-rate pass-through ($\tau_F = 0.99$): DIT policy regime

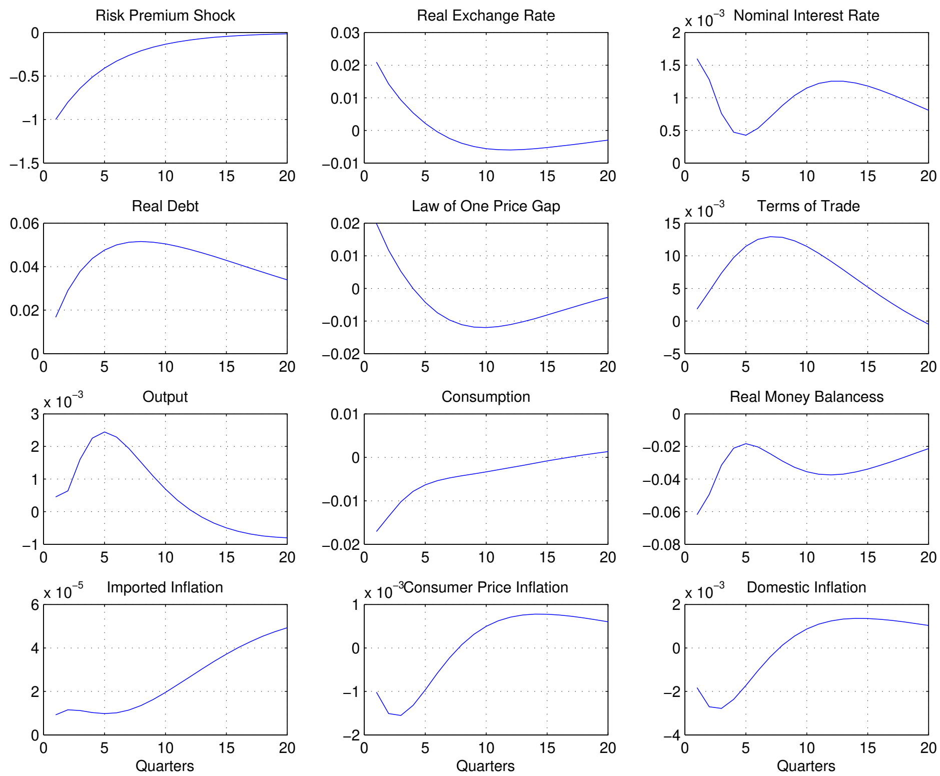

Fig. 5.12 Risk premium shocks and incomplete exchange-rate pass-through ($\tau_F = 0.99$): MF policy regime

5.3 Cost-Push Shocks

For the case of cost-push shocks, the results obtained under a DIT and MMF regime are very similar to the CIT regime presented in chapter 4 under the four alternative values for the degree of exchange-rate pass-through. We therefore do not report these results and move on to monetary shocks.

5.4 Monetary Shocks

Finally, we analyse s contractionary monetary policy shock under both the DIT and MF regimes. Figures 5.13 and 5.14 plot the impulse responses under DIT and MF, repectively, with perfect pass-through. We can observe that this negative shock increases the nominal interest rate under DIT, whereas under MF there is a lag of two periods similar to the CIT regime. The fact that the increase of nominal exchange rate is larger under DIT causes a relatively large increase in real debt in comparison with CIT and MF. There is also a bigger negative effect on output, consumption and real money balances. Unsurprisingly, we find that the dynamics of domestic inflation, imported inflation and overall inflation are quite similar, in percentage and movement, for all three policy regimes.

Figures 5.15 (under DIT) and 5.16 (under MF) depict how a monetary shock impacts the economy with incomplete exchange-rate pass-through ($\tau_F = 0.5$). Similar to a CIT policy rule, the impulse response analysis finds no significant differences under both DIT or MF. A contractionary monetary policy that increase the nominal interest rate is followed by an increase in real debt (at least for the first periods), and a fall in output, consumption and real money balances. This contraction leads to a decrease in domestic and foreign inflation and therefore a

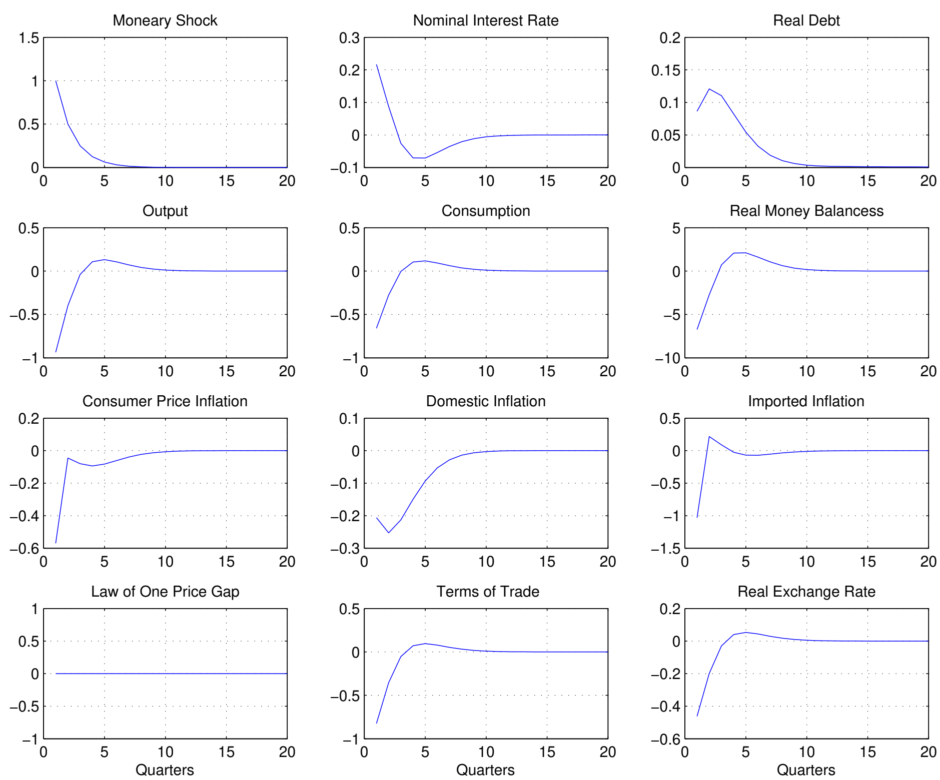

Fig. 5.13 Monetary shocks and perfect exchange-rate pass-through ($\tau_F = 0$): DIT policy regime

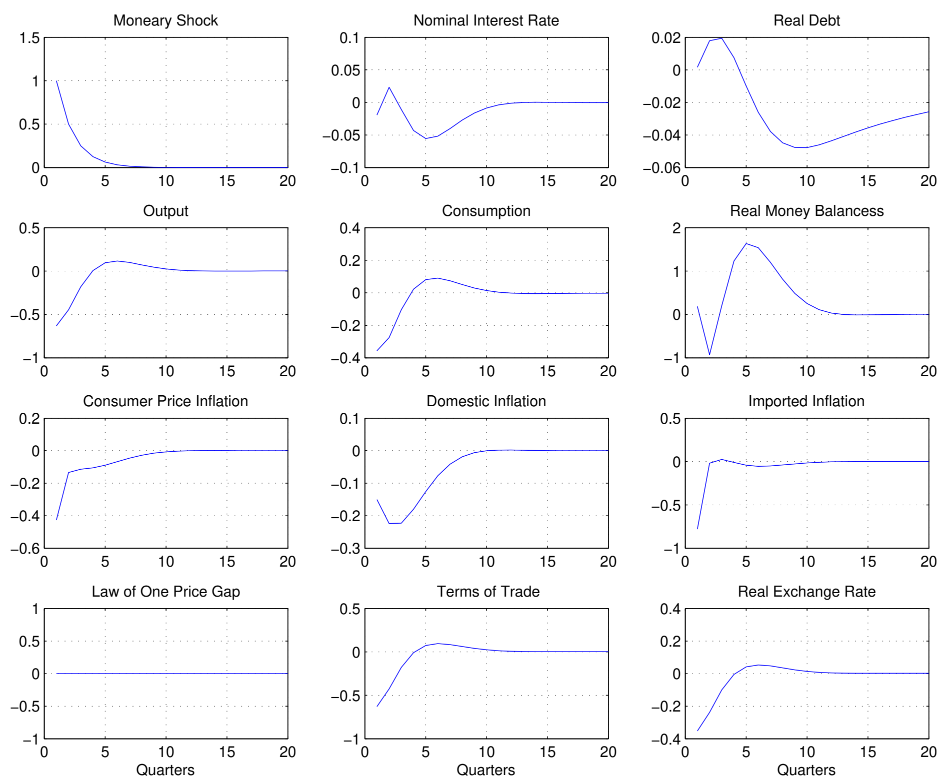

Fig. 5.14 Monetary shocks and perfect exchange-rate pass-through ($\tau_F = 0$): MF policy regime

fall in CPI inflation. But with a pass-through of 0.5, the volatility of the law of one price causes an appreciation in the terms of trade and the real exchange rate.

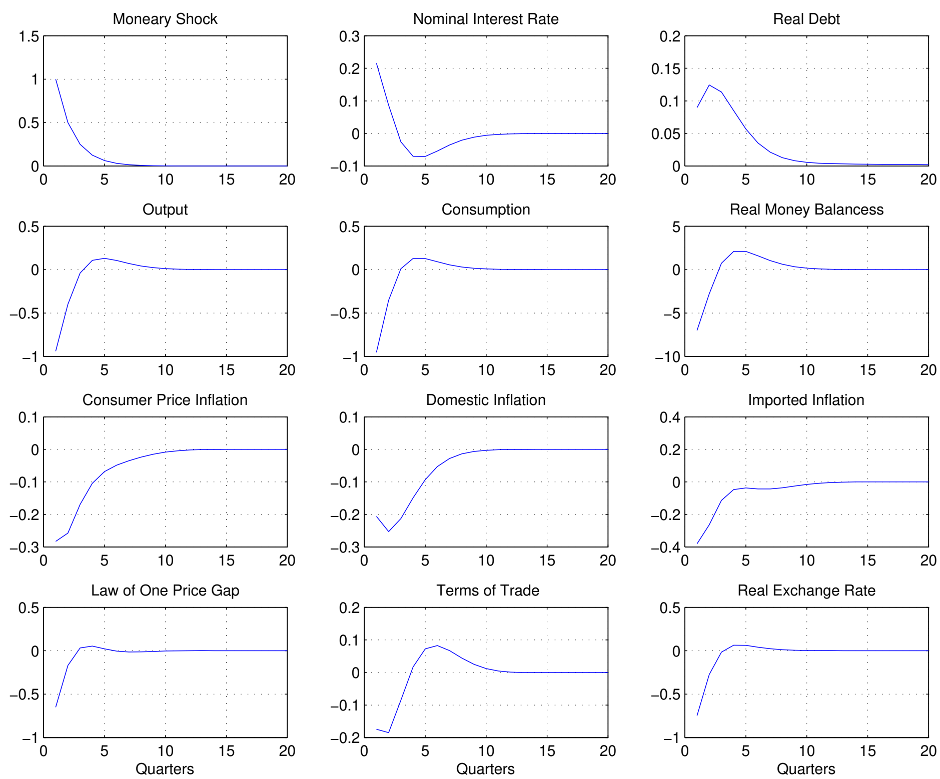

Fig. 5.15 Monetary shocks and incomplete exchange-rate pass-through ($\tau_F = 0.5$): DIT policy regime

Finally, we examine the case of a negative monetary shock setting $\tau_F = 0.99$. Under the three monetary policy regimes a negative monetary shock raises the nominal interest rate by the same amount. But real debt follow a different pattern under CIT and DIT: while real debt increases in both policy regimes, after a few periods it quickly returns to zero. This is not the

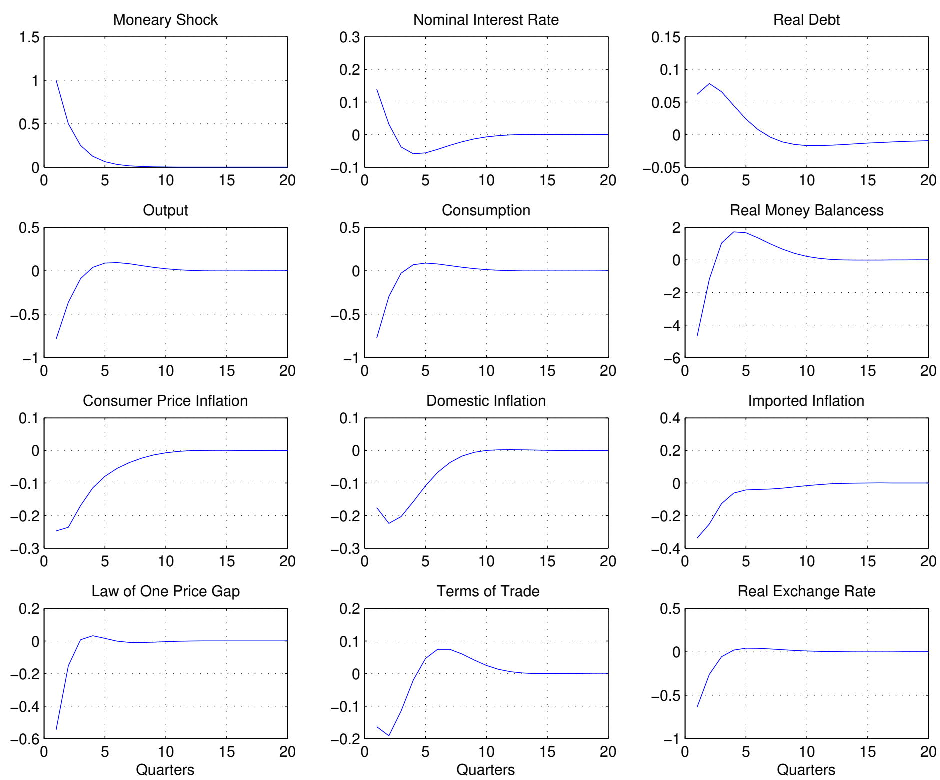

Fig. 5.16 Monetary shocks and incomplete exchange-rate pass-through ($\tau_F = 0.5$): MF policy regime

case under MF where real debt is still increasing after 20 periods. Output, consumption and real money balances all fall in the same proportion and the same trajectories. Under the CIT and DIT regimes, imported inflation is relatively lower in comparison with MF. Domestic and overall inflation also decrease with the same pattern for the three regimes. Finally we observe the same volatility in the law of one price gap under CIT and DIT, but it is magnified under MF. Thus, the terms of trade depreciates more in CIT and DIT than MF. The volatility in law of one price gap is also reflected in the magnitude of appreciation of real exchange rate that is greater under the CIT and DIT monetary policy regimes.

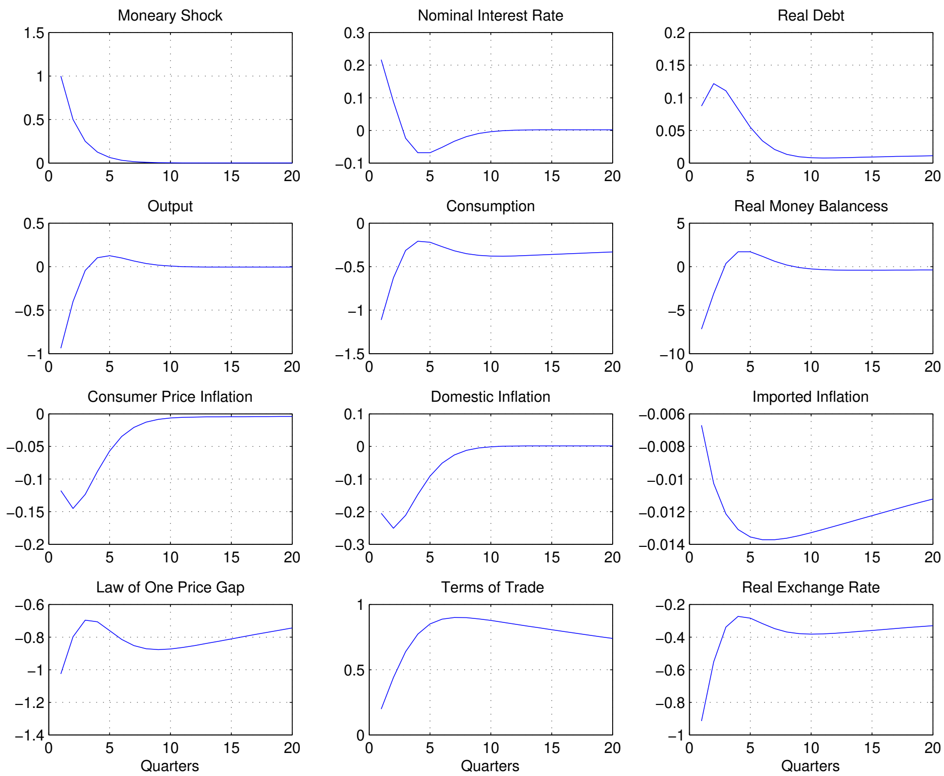

Fig. 5.17 Monetary shocks and incomplete exchange-rate pass-through ($\tau_F = 0.99$): DIT policy regime

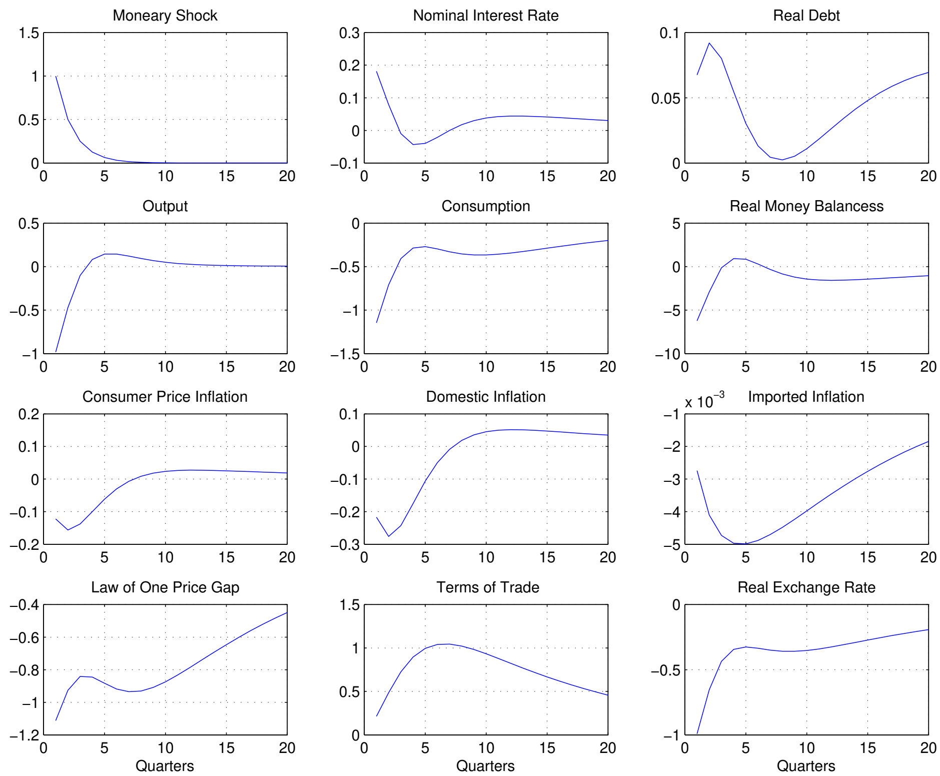

Fig. 5.18 Monetary shocks and incomplete exchange-rate pass-through ($\tau_F = 0.99$): MF policy regime

Chapter 6

Conclusions

This work has developed a small open-economy model that incorporates several important features for a developing economy with the purpose to calibrate the model for Mexico. Following Justiniano and Preston (2010), the model incorporates incomplete asset market, inflation indexation, and imperfect exchange-rate pass-through. Differently to Justiniano and Preston (2010), we allow for real money balances, as in McKnight and Mihailov (2015) and we consider four exogenous shocks: productivity, cost-push, risk-premium and monetary shocks. Following Ouchen and Ziky (2015), our analysis also considers three popular specifications for the interest rate rule that either reacts to the CPI inflation rate, the domestic price inflation rate or the real exchange rate.

To solve the model economy, the equilibrium conditions of the model are log-linearized around a zero-inflation steady-state. Following the seminal studies of Galí (2008) and Galí and Monacelli (2004), the shocks follow independent AR(1) processes with a relatively high value for the persistence term. To derive conclusions for the Mexican economy, we calibrate the deep parameters of model for Mexico. Using Dynare, an impulse response analysis was performed for each shock under different values for the degree of exchange-rate pass-through.

Our results are consistent with the previous literature. A technology shock that leads to an improvement in productivity, reduces real marginal cost and increases output and consumption. This shock resulted in a decrease in the domestic inflation rate and, therefore, a decrease in overall inflation. A novel finding is that the degree of imperfect exchange-rate pass-through plays an important role for the magnitude of the shock.

The next shock we analysed was a risk premium shock that resulted in an immediate increase in the nominal interest rate, real debt and a depreciation of the terms of trade and the real exchange rate. Under imperfect pass-through this caused an increase in output, although domestic consumption did not increase. On the other hand, this shock resulted in a fall in domestic inflation, but this was outweighed by an increase in imported inflation causing an increase in aggregate inflation.

We also examined a cost-push shock, as one may expect this shock had a negative impact on the economy and the transmission of the shock was in the opposite direction to the productivity shock causing output, consumption and real money balances to all decrease. Domestic inflation, imported inflation and overall CPI inflation all increased and the rise in the nominal interest rate while the terms of trade and real exchange rate both appreciated.

Finally, we considered a monetary shock in the spirit of Galí (2008) that generated some of the most important and interesting results from the analysis. A contractionary monetary shock increased the nominal interest rate and decreased output and consumption. This contraction in the economy exerted negative pressure on prices causing a fall in domestic, imported and overall inflation. However, the degree of imperfect exchange-rate pass-through, increased the volatility of the shock and lead to different results for the dynamics of the terms of trade. For the case of perfect pass-through, the monetary shock have a positive effect on terms of trade which became negative if the degree of imperfect pass-through was sufficiently large.

Our results offer some interesting insights for policymakers. To start with, the degree of exchange-rate pass-through is very important for the assessment of monetary policy. In a low pass-through environment, the policymaker can simultaneously strictly target CPI inflation, but still allow high volatility in the nominal exchange rate to stabilize the real economy in face of the shocks. This results emerges because the low-pass-through eliminates the trade-off between output volatility and inflation volatility.

We have also found that the degree of exchange-rate pass-through can play an important role in the propagation of shocks in the open economy, particularly in the case of monetary shocks. This suggests that for inflation targeting countries like Mexico that have a high degree of incomplete exchange-rate pass-through, monetary shocks are likely to play a more important role in driving the business cycle.

For further research, it might be interesting to replicate the analysis of Justiniano and Preston (2010), which explores optimal policy design within an estimated structural model, but using data for Mexico. It might also be important to determine whether policies in a class of generalized Taylor rules optimally responds to exchange rate variations as predicted by theory.

Chapter 7

Appendix

Recent studies by Ball and Reyes (2004) for Mexico and Nogueira (2009) for Brazil, Mexico and South Korea, have investigated the empirical implications for emerging countries that have adopted an explicit inflation targeting regime. Even under inflation targeting, these studies find that there are still strong incentives for central banks in the sample countries to respond to exchange rate deviations from their targeting level. The main reason is that even under inflation targeting, exchange rate shocks are expected to pass-through into domestic inflation.

This active response of the central bank to changes in the exchange rate targeting, can be explicitly modelled under a Managed Float regime. In chapter 5, we analysed the impulse responses for the economy under MF setting $\beta_3 = 0.14$. In this appendix we would like to compare these results against a higher coefficient value of $\beta_3 = 0.55$, as suggested by Ball and Reyes (2004). To maintain consistency with our previous analysis, we first present the case of perfect exchange rate pass-through, followed by an intermediate degree of imperfect exchange-rate pass-through ($\tau_F = 0.5$) and finally the case of a full degree of imperfect rate pass-through ($\tau_F = 0.99$).

Figure 7.1 considers the complete exchange-rate pass-through case. By inspection of Figure 7.1, the impact of a monetary shock under MF with $\beta_3 = 0.55$, affects the economy in a different way from the baseline results using $\beta_3 = 0.14$. With $\beta_3 = 0.55$, the path of nominal interest rate is more volatile, output falls more, domestic inflation is slightly greater, and there are small gains in the terms of trade. The other variables of the economy remain on the same path.

Figure 7.2 depicts the results under imperfect pass-through setting $\tau_F = 0.5$. In this case we do not find any significant differences either in the path or volatility of the main variables of the model, compared to the baseline $\beta_3 = 0.14$ case.

Finally, Figure 7.3 consider the case for $\tau_F = 0.99$ (i.e., no pass-through). Here we find that a higher coefficient for β_3 is costly for the economy since it induces a higher response for CPI inflation and less gains in terms of the appreciation of real exchange rate.

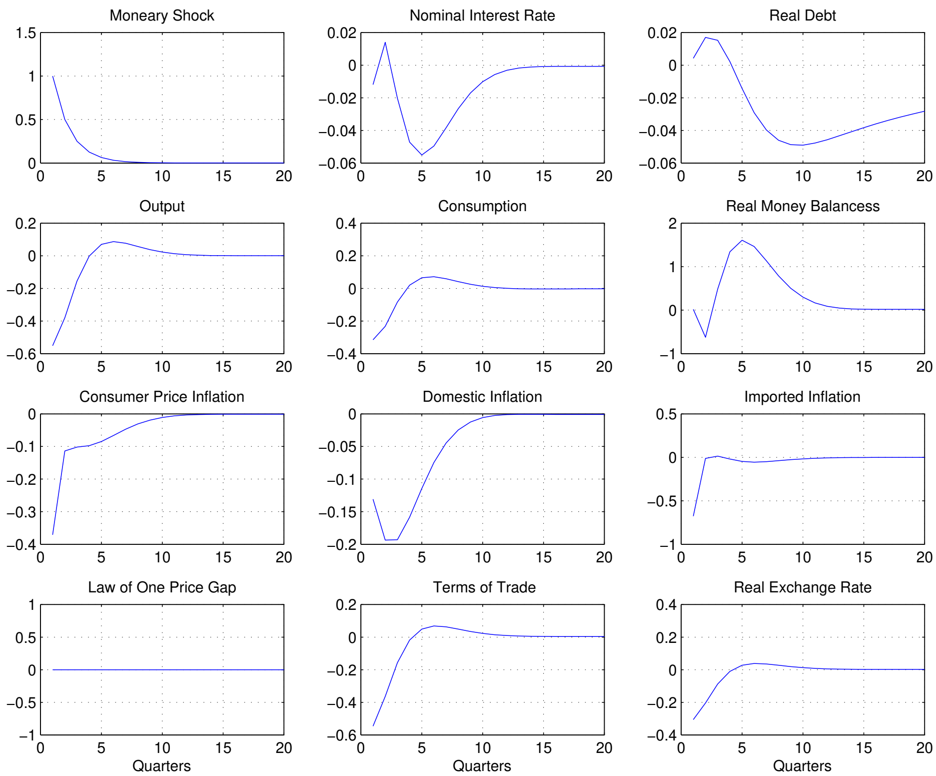

Fig. 7.1 Monetary shocks and complete exchange-rate pass-through ($\tau_F = 0$): MF policy regime ($\beta_3 = 0.55$)

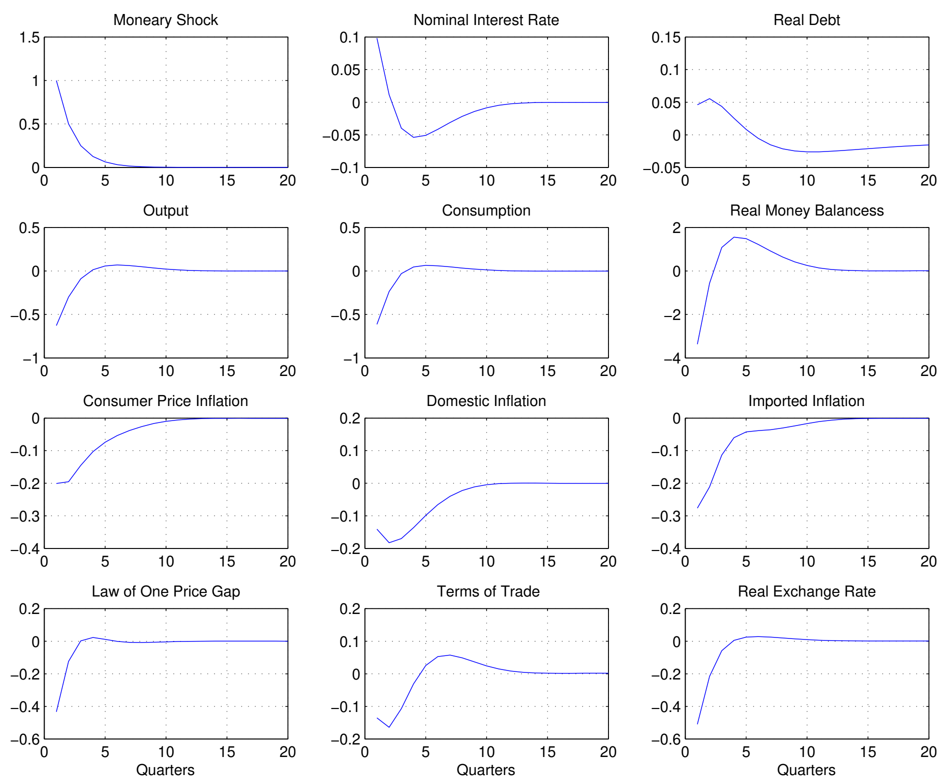

Fig. 7.2 Monetary shocks and incomplete exchange-rate pass-through ($\tau_F = 0.5$): MF policy regime ($\beta_3 = 0.55$)

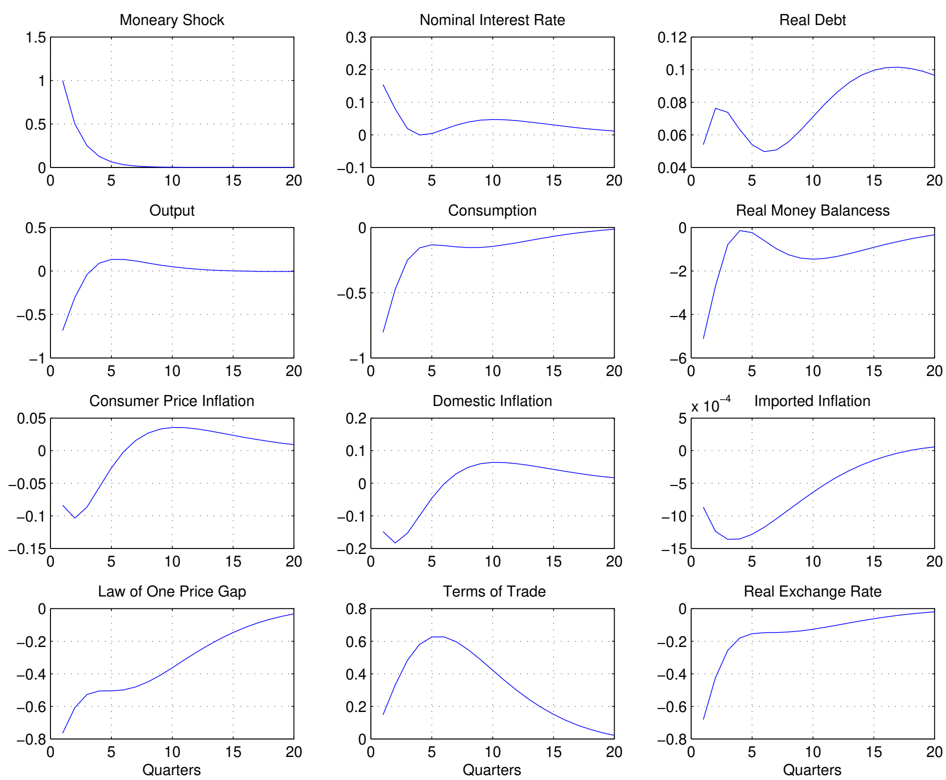

Fig. 7.3 Monetary shocks and incomplete exchange-rate pass-through ($\tau_F = 0.99$): MF policy regime ($\beta_3 = 0.55$)

With these results in mind, we can conclude that the results presented in Chapter 5 are robust. The Mexican Central Bank, should not set a higher weight in the stabilization of the real exchange rate. In the hypothetical case of perfect exchange rate pass-through, the only gain that we found was a small gain in the terms of trade. For the case of imperfect pass-through $\tau_F = 0.5$, we do not find any changes in the path or volatility of the main variables of the model. Finally, for the case of $\tau_F = 0.99$, a higher coefficient for β_3 is more costly for the economy since it induces higher CPI inflation and less gains from the appreciation of the real exchange rate.

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