Exchange Rate Targeting in an Estimated Small Open Economy*

Amos C Peters†

University of North Carolina at Chapel Hill

Job Market Paper

Abstract

This paper discusses the role of the exchange rate in monetary policy formulation. It examines how the exchange rate is determined and whether or not it should be included in a Taylor rule specification. The paper then investigates whether emerging market economies systematically target the real exchange rate. By estimating a dynamic optimizing small open economy model with nominal rigidities, the paper is able to assess within a structural context, how central banks respond to fluctuations in the exchange rate. The results are mixed. For South Africa and Mexico the results do not support the hypothesis that emerging market economies target the real exchange rate while for Indonesia and Thailand the results provide some evidence to indicate that the monetary authority actively targets the exchange rate thus exhibiting a 'fear of floating'.

Keywords: Small Open Economy, Exchange Rate Targeting, Fear of Floating, Maximum Likelihood Estimator.

JEL Classification: E52, E58, F31, F41

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†**Corresponding address:** Department of Economics, University of North Carolina, Gardner Hall, CB 3305, Chapel Hill, NC 27599-3305. Tel:(919) 619-8162, Email: acpeters@email.unc.edu

Introduction

Do Central Banks in emerging market economies respond to movements in the exchange rate? If they do, to what extent? The basic question itself is not novel. Ball (1999), Svensson (2000), Clarida, Gali, and Gertler (2001), Taylor (2001) and Lubik and Shorfheide (2007) among others all sought to understand the role of the exchange rate in monetary policy formulation. This paper contributes to this literature by applying such questions to emerging market economies.

The theoretical literature has not hitherto provided a conclusive answer to this question. Ball (1999) proposes a modified Taylor rule with the exchange rate included on the basis that exchange rate movements affect domestic inflation through a channel separably identifiable from domestic demand and supply shocks. He finds that in an open economy setting the central bank should optimally respond to exchange rate fluctuations with 0.1 of the weight of inflation. The end result is a marginal improvement upon the original Taylor (1993) rule.

Svensson (2000) and Batini, Millard, and Harrison (2000) have similar conclusions. Clarida, Gali, and Gertler (2001) however find that the optimal monetary policy problem in an open economy is isomorphic to that of a closed economy. This result is bolstered by Dib (2003) who finds that estimation and simulation results for Canada show that monetary policy shocks lead to similar effects on macroeconomic variables in both small open and closed economy models. The natural implication of this result is that the policy objective of exchange rate smoothing is unnecessary, all that is required is to smooth output and inflation variation as is the case in a closed economy but with the understanding that the structure of the reduced form is different in an open economy. Notwithstanding this conclusion, Clarida, Gali, and Gertler (1998) have found empirical evidence to suggest that in major industrialized countries the exchange rate does play a role in monetary policy formulation, although it is quantitatively small.

Kim (2003) employs a structural VAR approach with data on net purchases of foreign currency, to the United States and finds evidence to suggest that the Federal Reserve pursues sterilized intervention. Lubik and Schorfheide (2007) estimate a monetary policy reaction function for Australia, New Zealand, the United Kingdom, and Canada. In a fully specified small open economy structural model based on Gali and Monacelli (2002)their findings indicate that the Bank of England and the Bank of Canada explicitly responded to exchange rate movements over the decade of the eighties and the nineties whereas the central banks of Australia and New Zealand did not. Dib (2003), although not explicitly addressing this question, did estimate a monetary policy rule with the real exchange rate for Canada over a similar period but found the estimates on the exchange rate coefficient small and statistically insignificant.

The exchange rate is critical to the determination of both net exports and inflation since changes in the price of foreign goods are partially passed through to domestic prices (Taylor, 2000). There is also a linkage between the exchange rate and interest rate that is manifest through the capital market. In this paper this will be evident via the uncovered parity condition. Taylor (2000) has pointed out that the policy evaluation research that informed the original proposal for a policy rule (Taylor, 1993) did indeed consider the role of the exchange rate. Notwithstanding the exclusion of the exchange rate in a U.S-based policy rule, Taylor (2000) states the following

> *"Simulation of my multicountry model and other models led me to believe that if the Fed reacted strongly to the exchange rate then the inflation-output performance in the United States would deteriorate. It was for that reason that I omitted the exchange rate in the rule I proposed in Taylor (1993) as a guideline for the United States. However, it is clear that the same conclusion would not necessarily be reached for other countries, especially small open economies. A country's size openness, capital mobility, market completeness and elasticities would matter greatly..."* p. 16

It is on this basis that this paper applies emerging market economy data to address questions about the role of the exchange rate in monetary formulation. Calvo and Reinhart (2002) have documented that emerging market economies have a reluctance to allow their currencies to float fully, a phenomenon they refer to as a 'fear of floating'. This suggests that the cost of exchange rate fluctuations for small open economies may be high in practice. Thus focusing exclusively on smoothing inflation and real output variation may be sub-optimal.

To provide some additional rationale for the explicit inclusion of the exchange rate in the Taylor rule, I present a simple model discussed in Ball (1999). Consider the following three equations:

(i) $y_t = \lambda y_{t-1} - \beta r_{t-1} - \delta e_{t-1} + \varepsilon_t$

(ii) $\pi_t = \pi_{t-1} + \alpha y_{t-1} - \gamma(e_{t-1} - e_{t-2}) + \eta_t$

(iii) $e_t = \theta r_t + \nu_t$

where y represents output, r is the real interest rate, e is the real exchange rate defined as foreign currency purchasing unit per unit domestic currency purchasing unit, so that an increase in e is an appreciation. The shocks are ε, η, and ν. All variables are defined as deviations from equilibrium. All parameters in the model are strictly positive.

Equation (i) is a standard open economy IS equation where output is decreasing in both the real interest rate and the real exchange rate but also depends on one period lagged output and a demand shock. Equation (ii) is a Phillips curve equation which specifies current inflation as a function of past inflation and output, a one period change in the real exchange rate and a supply shock. Equation (iii) is a pseudo uip condition that positively relates changes in the real interest rate to changes in the real exchange rate.

Ball (1999, 2000) argues that the best way to stabilize output and inflation is to target "long-run inflation", which he describes as a measure of inflation that filters out the transitory effects of exchange rate fluctuations. This variable is defined below:

$$\text{(iv)} \quad \pi_t^* = \pi_t + \gamma e_{t-1}$$

where are all variables are as previously defined. Targeting π^* keeps inflation volatility stable but has the additional benefit of keeping output variability lower than when when the central bank targets π. The reason for this is because targeting $\pi*$ does not induce output contractions unless they are essential for long-run inflation stability (Ball, 2000). In an open economy if exchange rate movements are transitory in nature it may not be necessary for the central bank to adjust interest rates since these transitory exchange rate fluctuations will reverse themselves, thus the central bank only responds when exchange rate fluctuations are permanent.

Given that the exchange rate channel (the effect of exchange rates on import prices) is the most rapid channel from monetary policy to inflation, this provides a clear incentive for central banks to respond to exchange rate fluctuations more aggressively to control inflation, since they know they will get a faster response. However this implies larger swings in interest rates which will undoubtedly increase output volatility.

After the central bank has settled on the variables to target, it must them pursue a strategy for attaining the target. Taylor (1993) and many others advocate the use of a Taylor rule where the central bank raises interest rates when either inflation or output transcend their targets, otherwise referred to as "leaning against the wind". The above equations imply that an exchange rate augmented Taylor specification is optimal (Ball, 2000)and by optimal I refer to the rule that minimizes the weighted sum of the variances of output and inflation. The augmented rule is hereunder:

(v) $wr_t + (1 - w)e_t = ay_t + b\pi_t^*$

Ball (2000) refers to the above rule as a "Monetary Conditions Index" because the variable on the left hand side of the equation is a weighted average of the real interest rate and real exchange rate, however this can be rewritten as a Taylor rule:

(vi) $r_t = (a/w)y_t + (b/w)\pi_t^* + (1 - w/w)e_t$

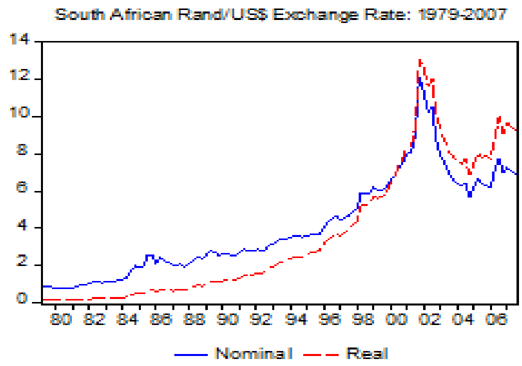
Bask (2006) also evaluates whether it is appropriate to include the exchange rate in a Taylor specification. By embedding three alternative specifications of an augmented Taylor rule, one with lagged data, the second with contemporaneous data, and the final with expectations, into a small open economy model developed by Gali and Monacelli (2005), Bask (2006) is able to show that the only specification that yields a unique rational expectations equilibrium is an augmented Taylor rule with contemporaneous data.

Methodologically, this paper is similar to Lubik and Schorfheide (2007). I opt to use structural estimation of a monetary policy rule in a general equilibrium model of a small open economy instead of employing a partial equilibrium or single equation approach. However instead of using Bayesian inference, I opt for a frequentist approach and employ the standard maximum likelihood estimation methodology á la Bergin (2002, 2003) and Dib (2003). The Taylor rule specification is both augmented with an exchange rate term and contemporaneous in nature.

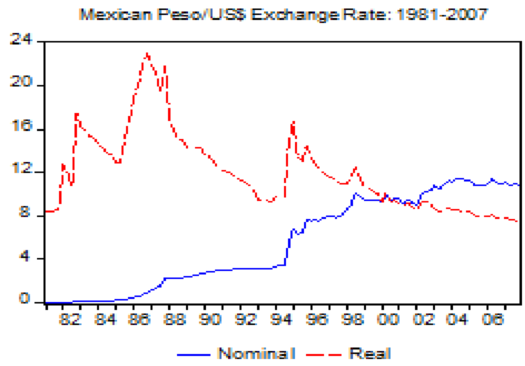
The paper is organized as follows. The next section provides some background information on the policy regimes of the countries under review. This is then followed by a presentation of the structural small open economy model with nominal rigidities in section 3. Section 4 presents the model solution and discusses calibrated parameters, it then describes the data and outlines the estimation procedure. Section 5 presents the estimation results, highlighting the hypothesis test of exchange rate targeting. Section 5 also presents impulse response functions, that allow for a discussion of macroeconomic dynamics in emerging market economies. Section 6 concludes the paper.

2 Institutional Background

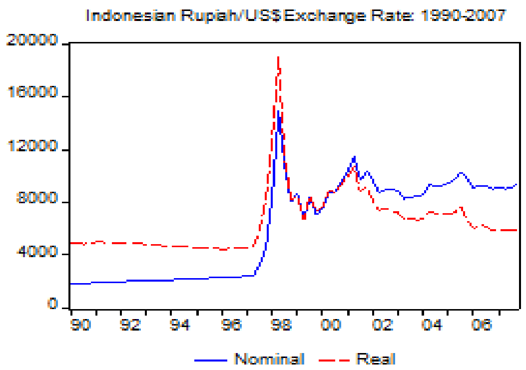
Figure 1 shows the real and nominal exchange rates for South Africa, Mexico, Indonesia, and Thailand. In the case of South Africa, 1980-1985 was a period of considerable reform to the exchange rate arrangements aimed at developing the market for foreign exchange and introducing a floating exchange rate system. Like many other countries, South Africa had undergone the disintegration of the Bretton Woods system of fixed exchange rates in the previous decade. The 1985-1984 period was characterized by socio-political events that forced monetary authorities to take more direct measures to manage the exchange rate. After the national unity government took office and South Africa's international financial relations normalized, the government and central bank took steps to develop a forward exchange rate market, and relax foreign exchange rate controls. After 1995 the South African Reserve Bank took an eclectic approach to monetary policy including the use of monetary growth targets and informal "inflation" targeting. After February 2000, South Africa formally adopted a more transparent and comprehensive inflation targeting strategy with some success. The most notable exchange rate event in recent South African history can be observed in figure 1a. Between September and December of 2001, the South African rand depreciated against the dollar by 42 percent after a steady decline earlier in the year. The president of South Africa set up the Myburgh Commission of Inquiry to investigate the reasons for the depreciation and assess whether or not capital controls had been violated. The findings indicated that this episode was due to;(i) a continued slowdown in the global economic activity, (ii) contagion from events in Argentina, (iii) a worsening in the current account balance in the fourth quarter of 2001, and (iv)complete shift from surplus in the financial account of the balance of payments in the third quarter to a deficit in the fourth quarter.(Bhundia and Gottschalk, 2003). In Mexico, prior to 1994, the monetary policy regime defended a predetermined exchange rate. During the 1994-1995 period Mexico experienced a currency crisis that forced them to transition to a fully floating regime. The onset of the currency crisis was brought about by accumulated fragilities in the early 1990's because of large capital inflow and financial liberalization, coupled with adverse external and domestic shocks endured in 1994. This created a balance of payment and financial crisis. Moreover, as can be seen in figure 2b there was a considerable divergence in US CPI and Mexican CPI as Mexican CPI increased by considerably more than US CPI causing the real and nominal exchange rate to diverge considerably. This meant that Mexicans could increase their purchasing power by exchanging Pesos for Dollars to spend on imported goods. Under pressure the monetary authorities had to relinquish defense of the parity and allow full flexibility.(Carsterns and Werner, 1999) This marked a shift in policy from an exchange rate nominal anchor to monetary policy as the nominal anchor. The Bank of Mexico adopted an intermediate target, a ceiling on the growth rate of base money with a view to influencing interest rates. After some initial diffi-



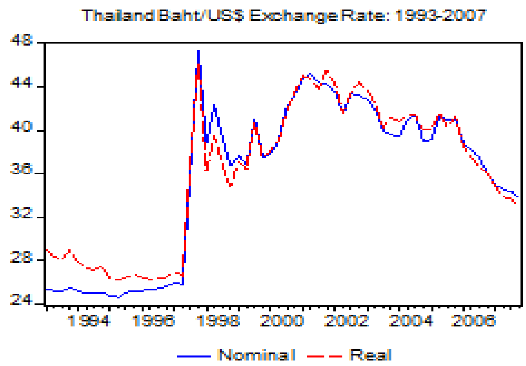
(a) South Africa



(b) Mexico



(c) Indonesia



(d) Thailand

Figure 1: Real and Nominal Exchange Rate for South Africa, Mexico, Indonesia and Thailand

culties with this approach the Bank of Mexico adjusted and refined their monetary approach to reflect an annual inflation objective set jointly by the Federal Government and the Bank of Mexico, rules defined on the behavior of the monetary base and quantitative commitments on the accumulation of net international reserves and variation in net domestic credit.

Prior to the Asian financial crisis of 1997, Indonesia and Thailand followed a less flexible crawling band or managed float arrangements (Sahminan, 2005). Specifically Indonesia followed a crawling band exchange rate while Thailand pegged its currency to a basket of currencies. The figures for these countries clearly show lower volatility prior to 1997 then massive depreciation. Indonesia incurred up to 75 % depreciation in its currency. However in the aftermath of the Asian financial and currency crisis Indonesia and Thailand adopted more flexible exchange rate regimes with occasional unannounced intervention.

3 The Model

The model I present is a structural dynamic money in the utility function (MIU) model for a small open economy which was developed by Dib (2003) but has its genesis in Dib (2002), Ireland (2001,2003), and Kollmann (2001, 2002). Monetary policy is described by an interest rate rule, and the exchange rate is introduced in the consumer budget constraint via the foreign bond market. It also features in the profit function of firms that import intermediate goods.

There are five agents in this model, namely the representative consumer, a continuum of domestic intermediate good producers and importers, a final goods producer or aggregator and the central bank. The model is characterized by incomplete markets, so there is a risk premium associated with asset transactions. The risk premium is an increasing function of a monotonic transformation of the external debt to output ratio. This feature has the additional positive externality of making the model stationary á la Schmitt-Grohé and Uribe (2003).

Domestic intermediate firms operate in a monopolistically competitive market and produce a differentiated intermediate good some of which is exported and some of which is purchased by the aggregator. Similarly intermediate firms import a homogeneous good from abroad to produce a differentiated intermediate good which they then sell to the aggregator. All intermediate firms are constrained to set their price only when they receive a random signal á la Calvo (1983). The aggregator then takes the differentiated intermediate domestic goods and imported goods and produces a composite domestic intermediate good and a composite imported intermediate good. These composite domestic and imported intermediate goods are subsequently converted to a final good using a CES technology. The final good is split between investment and consumption. Domestic agents have no control or influence on external prices and interest rates.

Although this model does not have credit frictions, a key feature of many emerging market economies, the presence of capital adjustments costs, domestic and import price rigidities, an endogenous risk premium reflecting departures from UIP, and the assumption of incomplete access to international financial markets are all features of the model that are well suited to the emerging market economies I study.

3.1 Households

Households in this economy obtain utility from consumption, c_t, real money balances, M_t/p_t, and leisure time, $1-h_t$. All households are identical, which allows for the selection and analysis of a representative household. This households' preferences are described by the expected utility function hereunder:

$$U_0 = E_0 \sum_{t=0}^{\infty} \beta^t u(c_t, M_t/p_t, h_t), \tag{1}$$

where $\beta \in (0,1)$ is the discount factor, M_t is the nominal money balance, p_t is the general consumer price level, and h_t represents time spent working. The single period household utility function is specified as:

$$u(.) = \frac{\gamma a_t}{\gamma - 1} \log \left[c_t^{\frac{\gamma-1}{\gamma}} + b_t^{\frac{1}{\gamma}} \left(\frac{M_t}{p_t} \right)^{\frac{\gamma-1}{\gamma}} \right] + \eta \log(1-h_t), \tag{2}$$

where $\gamma > 1$ is the constant elasticity of substitution between consumption and real money balances, and $\eta > 0$ is the weight on leisure in the utility function. There are two shocks embedded in the utility function, namely a_t and b_t. The first represents a taste shock and the second a shock to money demand. The shocks follow a first order autoregressive process:

$$\log(a_t) = (1-\rho_a)\log(a) + \rho_a \log(a_{t-1}) + \varepsilon_{at} \tag{3}$$

and

$$\log(b_t) = (1-\rho_b)\log(b) + \rho_b \log(b_{t-1}) + \varepsilon_{bt} \tag{4}$$

where $\rho_a, \rho_b \in (-1,1)$ are the autoregressive coefficients and a and b are constants. The disturbance terms, ε_{at} and ε_{bt}, are assumed to be distributed normally with zero mean and standard deviations of σ_a and σ_b respectively.

The household begins each period with an endowment of capital, k_t, nominal money, M_t, nominal domestic bonds, B_{t-1}, and nominal net foreign bonds, B^*_{t-1}. Foreign bonds are denominated in foreign currency. In every period the household makes an optimal consumption, c_t, investment, i_t, and saving decision and decides how to allocate savings among various assets, namely domestic and foreign bonds which they can purchase on the capital market. They receive income from supplying labor and capital to domestic intermediate firms for which they earn a nominal wage, W_t, and a rental rate, R_{kt} respectively. The representative household earns interest payments from its previous bond holdings, dividends from its shares of intermediate good and importer firms, and a lump sum transfer, T_t from the central bank. Capital evolves according to the following evolution equation:

$$k_{t+1} + \Psi(k_{t+1}, k_t) = (1-\delta)k_t + i_t \tag{5}$$

where $\delta \in (0,1)$ is the constant rate of capital depreciation, i_t is investment, and $\Psi(k_{t+1}, k_t)$ is a capital adjustment cost function. The following functional form is given to the capital adjustment cost function: $\frac{\psi}{2}\left(\frac{k_{t+1}}{k_t} - 1\right)^2 k_t$; where $\psi > 0$ is the capital adjustment parameter. From this specification, one can observe that in the steady state, total and marginal capital adjustment costs are equal to zero.

The household's budget constraint is stated hereunder:

$$p_t(c_t + i_t) + M_t + \frac{B_t}{R_t} + \frac{e_t B^*_t}{\kappa_t R^*_t} \leq R_{kt}k_t + W_t h_t + M_{t-1} + B_{t-1} + e_t B^*_{t-1} + T_t + D^d_t + D^f_t \tag{6}$$

where R_t and R^*_t are the gross nominal domestic and foreign interest rate, e_t is the nominal exchange rate and is defined as the price of foreign currency in terms of domestic currency. The dividends are aggregated across j monopolistically competitive domestic intermediate firms, $D^d_t = \int_0^1 D^d_t(j)dj$, and j importer firms,$D^f_t = \int_0^1 D^f_t(j)dj$. Deviation from uncovered interest rate parity is measured by the endogenous risk premium, κ_t. In part this endogenous country-specific risk premium is introduced to make the small open economy model stationary à la Schmitt-Grohé and Uribe (2003). The steady state is unique provided the risk aversion parameter is not equal to zero. In the event that risk aversion is equal to zero, $\kappa_t = 1$ which implies that the nominal domestic and foreign interest rate are jointly equal to β^{-1}. Under this circumstance the model becomes non-stationary and temporary shocks can have permanent effects on endogenous variables in the system.

The risk premium is defined as:

$$\kappa_t = \exp\left(-\frac{\varphi e_t \tilde{B}_t^*}{p_{dt} y_t}\right) \tag{7}$$

where φ is the risk premium parameter, $\tilde{B}_t^*$ is the average level of foreign debt, p_{dt} is the price of domestic output, and y_t is real output. Essentially the endogenous risk premium is an increasing function of the debt to gross domestic product (GDP), which although functional, has a desirable intuitive appeal.

The foreign interest rate evolves exogenously according to the following:

$$\log(R_t^*) = (1 - \rho_{R^*})\log(R^*) + \rho_{R^*}\log(R_{t-1}^*) + \varepsilon_{R^*t} \tag{8}$$

where $\rho_{R^*} \in (-1, 1)$ is the autocorrelation coefficient and ε_{R^*t} is a serially uncorrelated disturbance term that is distributed normally with zero mean and standard deviation, σ_{R^*}.

The household maximizes discounted lifetime utility by choosing the vector of control variables $\{c_t, M_t, h_t, k_{t+1}, B_t, B_t^*\}$, subject to the budget constraint (6), and the capital evolution equation (5). The first order conditions are presented below:

$$\lambda_t = \frac{a_t c_t^{-\frac{1}{\gamma}}}{c_t^{\frac{\gamma-1}{\gamma}} + b_t^{\frac{1}{\gamma}}(M_t/p_t)^{\frac{\gamma-1}{\gamma}}} \tag{9}$$

$$\lambda_t - \beta E_t\left(\frac{p_t \lambda_{t+1}}{p_{t+1}}\right) = \frac{a_t b_t^{\frac{1}{\gamma}}(M_t/p_t)^{-\frac{1}{\gamma}}}{c_t^{\frac{\gamma-1}{\gamma}} + b_t^{\frac{1}{\gamma}}(M_t/p_t)^{\frac{\gamma-1}{\gamma}}} \tag{10}$$

$$\lambda_t \frac{W_t}{p_t} = \frac{\eta}{1 - h_t} \tag{11}$$

$$\psi\left(\frac{k_{t+1}}{k_t} - 1\right) + 1 = \beta E_t\left[\frac{\lambda_{t+1}}{\lambda_t}\left(\frac{R_{kt+1}}{p_{t+1}} + 1 - \delta + \frac{\psi}{2}\left(\frac{k_{t+2}^2}{k_{t+1}^2} - 1\right)\right)\right] \tag{12}$$

$$\frac{1}{R_t} = \beta E_t\left[\frac{p_t \lambda_{t+1}}{p_{t+1}\lambda_t}\right] \tag{13}$$

$$\frac{1}{\kappa_t R_t^*} = \beta E_t\left[\frac{e_{t+1} p_t \lambda_{t+1}}{e_t p_{t+1} \lambda_t}\right] \tag{14}$$

The uncovered interest parity condition (UIP) is derived by combining equations (13) and (14)and is stated here:

$$\frac{R_t}{\kappa_t R_t^*} = \frac{e_{t+1}}{e_t} \tag{15}$$

3.2 Aggregation Sector

The aggregator firm is a perfectly competitive firm that takes a continuum of differentiated domestic intermediate goods and imported foreign intermediate goods, and through a Dixit-Stiglitz technology, converts them to a domestic intermediate and imported intermediate composite good. It then proceeds to combine the composite goods into a final good by using a constant elasticity of substitution (CES) technology.

3.2.1 Domestic and Imported Composite Goods

The composite domestic intermediate good and the composite imported intermediate good y_{ft} are produced by combining a continuum of differentiated domestic intermediate goods $y_{dt}(j)$ and differentiated imported intermediate goods $y_{ft}(j)$, indexed by $j \in [0,1]$. Specifically y_{dt} is assumed to be given by:

$$y_{dt} \leq \left(\int_0^1 y_{dt}(j)^{\frac{\theta-1}{\theta}} dj \right)^{\frac{\theta}{\theta-1}} \tag{16}$$

where $\theta > 1$ is the constant elasticity of substitution. The demands for individual varieties of the domestic intermediate good are the solution to a profit maximization problem $p_{dt}y_{dt} - \int_0^1 p_{dt}(j)y_{dt}(j)dj$, subject to (16), and given the domestic output price p_{dt} and the price of the domestic intermediate good $p_{dt}(j)$. The resulting demand for any variety is of the form:

$$y_{dt}(j) = \left(\frac{p_{dt}(j)}{p_{dt}} \right)^{-\theta} y_{dt} \tag{17}$$

The domestic output price is a producer price index (PPI) computed as follows:

$$p_{dt} \leq \left(\int_0^1 p_{dt}(j)^{1-\theta} dj \right)^{\frac{1}{1-\theta}} \tag{18}$$

By symmetry, the profit maximization problem in the import sector results in the following demand for each imported intermediate good variety:

$$y_{ft}(j) = \left(\frac{p_{ft}(j)}{p_{ft}} \right)^{-\theta} y_{ft} \tag{19}$$

The import price is the an importer price index (IPI) computed as follows:

$$p_{ft} \leq \left(\int_0^1 p_{ft}(j)^{1-\theta} dj \right)^{\frac{1}{1-\theta}} \tag{20}$$

3.2.2 The Final Good

The domestic and imported intermediate good are combined using the following aggregation technology to produce the final good, z_t:

$$z_t = [(1-\omega_f)^{\frac{1}{\nu}} y_{dt}^{\frac{\nu-1}{\nu}} + \omega_f^{\frac{1}{\nu}} y_{ft}^{\frac{\nu-1}{\nu}}]^{\frac{\nu}{\nu-1}} \tag{21}$$

where $\omega_f > 0$ is the share of the imported intermediate good in the final good, and $\nu > 0$ is the constant elasticity of substitution between the domestic intermediate good and the imported intermediate good. This final good is then apportioned to consumption and investment. Thus, the resource constraint becomes:

$$z_t = c_t + i_t \tag{22}$$

The demands for the domestic and imported intermediate goods are derived from the profit maximization problem $p_t z_t - p_{dt} y_{dt} - p_{ft} y_{ft}$, subject to (21), and given the composite domestic intermediate good price, p_{dt}, the composite imported intermediate good price, p_{ft}, and the price of the final good, p_t. The resulting demand functions for the composite domestic and imported intermediate good is of the form:

$$y_{dt} = (1-\omega_f) \left(\frac{p_{dt}}{p_t}\right)^{-\nu} z_t \tag{23}$$

$$y_{ft} = (\omega_f) \left(\frac{p_{ft}}{p_t}\right)^{-\nu} z_t \tag{24}$$

Here the demand for domestic and imported intermediate goods are inversely related to the relative prices of domestic and imported goods respectively. In this case ν is also the price elasticity of demand. The consumer price index (CPI) is a weighted average of domestic and imported prices and is specified as follows:

$$p_t = [(1-\omega_f) p_{dt}^{1-\nu} + \omega_f p_{ft}^{1-\nu}]^{\frac{1}{1-\nu}} \tag{25}$$

3.3 Intermediate Goods Sector

3.3.1 Domestic Intermediate Goods

Each domestic firm, j, produces a differentiated intermediate good, $y_t(j)$, by using $k_t(j)$ and $h_t(j)$ with the following constant returns to scale production function:

$$y_t(j) = k_t(j)^{\alpha}[A_t h_t(j)]^{1-\alpha}, \qquad \alpha \in (0,1) \tag{26}$$

where α is the share of capital in output and A_t is an exogenous technology shock that evolves according to:

$$\log(A_t) = (1-\rho_A)\log(A) + \rho_A \log(A_{t-1}) + \varepsilon_{At} \tag{27}$$

where $\rho_A \in (-1,1)$, $A > 0$, and ε_{At} is a disturbance term that is assumed to be normally distributed with zero mean and standard deviation, σ_A. Some of the domestic intermediate good is used domestically, $y_{dt}(j)$, and the remainder is exported, $y_{xt}(j)$, so that:

$$y_t(j) = y_{dt}(j) + y_{xt}(j) \tag{28}$$

Foreign demand for domestic exports is specified in the same way as domestic demand (17) and this is by assumption:

$$y_{xt}(j) = \left(\frac{p_{dt}(j)}{p_{dt}}\right)^{-\theta} y_{xt} \tag{29}$$

Here y_{xt} represents aggregate exports. Domestic producers do not have the ability to price discriminate so the export price is $p_{dt}(j)/e_t$. The aggregate foreign demand for domestic exports is specified as:

$$y_{xt} = \left(\frac{p_{dt}}{e_t p_t^*}\right)^{-\tau} \tag{30}$$

where $\tau > 0$ is the price elasticity of domestic aggregate exports, p_t^* is the exogenous world price level measured in foreign currency. The world price level evolves as follows:

$$\log(p_t^*/p_{t-1}^*) = (1-\rho_{\pi^*})\log(\pi^*) + \rho_{\pi^*}\log(p_{t-1}^*/p_{t-2}^*) + \varepsilon_{\pi^* t} \tag{31}$$

where $\pi^* = p_t^*/p_{t-1}^*$ is the world gross inflation rate, π^* is the steady state world gross inflation rate, and $\rho_{\pi^*} \in (-1,1)$ is the the autoregressive coefficient. The disturbance term $\varepsilon_{\pi^* t}$ is distributed normally with zero mean and standard deviation, σ_{π^*} and is serially uncorrelated.

The domestic intermediate good producers are Calvo (1983) firms that sell their output at a price $\bar{p}_{dt}(j)$ in monopolistically competitive domestic and foreign markets. Each period a random fraction $(1-\phi)$ of firms are able to reset their price, while all other firms keep their prices unchanged. When firms eventually set their price, they must take into account that the price may be fixed for many periods. On average the price remains unchanged for $1/(1-\phi)$ periods.

The domestic producer j, when setting its price, chooses k_t, h_t, and $\bar{p}_{dt}(j)$ to maximize the expected discounted flow of profits as follows:

$$\max_{\{k_t(j),h_t(j),\bar{p}_{dt}(j)\}} E_0\left[\sum_{t=0}^{\infty}(\beta\phi)^l\lambda_{t+l}D^d_{t+l}(j)/p_{dt+l}\right] \tag{32}$$

subject to the production function (26) and to the demand functions hereunder:

$$y_{dt+l}(j)=\left(\frac{\bar{p}_{dt}(j)}{p_{dt+l}}\right)^{-\theta}y_{dt+l} \tag{33}$$

$$y_{xt+l}(j)=\left(\frac{\bar{p}_{dt}(j)}{p_{dt+l}}\right)^{-\theta}y_{xt+l} \tag{34}$$

The profit function is specified as follows:

$$D^d_{t+l}(j)=\bar{p}_{dt}(j)y_{t+l}(j)-R_{kt+l}k_{t+l}(j)-W_{t+l}h_{t+l} \tag{35}$$

Profits are discounted by $(\beta^l\lambda_{t+l})$, where λ_{t+l} is the marginal utility of consumption in period $t+l$.

The first order conditions are presented below:

$$\frac{W_t}{p_t}=(1-\alpha)\frac{y_t(j)}{h_t(j)}q_t\tilde{p}_{dt} \tag{36}$$

$$\frac{R_{kt}}{p_t}=\alpha\frac{y_t(j)}{k_t(j)}q_t\tilde{p}_{dt} \tag{37}$$

$$\bar{p}_{dt}(j)=\frac{\theta}{\theta-1}\frac{E_t\sum_{l=0}^{\infty}(\beta\phi)^l\lambda_{t+l}y_{t+l}(j)q_{t+l}}{E_t\sum_{l=0}^{\infty}(\beta\phi)^l\lambda_{t+l}y_{t+l}(j)/p_{dt+l}} \tag{38}$$

where $\tilde{p}_{dt}=p_{dt}/p_t$ and q_t is the Lagrangian multiplier applied to the production function constraint. It represents the real marginal cost of the firm in units of the final good.

The aggregate domestic price index is

$$p_{dt}^{1-\theta}=\phi p_{dt-1}^{1-\theta}+(1-\phi)\bar{p}_{dt}^{1-\theta} \tag{39}$$

After combining equations (38) and (39) with some algebraic manipulation, I can derive the New Keynesian Phillips curve:

$$\hat{\pi}_{dt} = \beta\hat{\pi}_{dt+1} + \frac{(1-\beta\phi)(1-\phi)}{\phi}\hat{q}_t \tag{40}$$

The hatted variables are log linearized around their respective steady state values.

3.3.2 Imported Intermediate Goods

Homogeneous intermediate goods are imported by a continuum of domestic importer firms indexed by $j \in [0, 1]$. The goods are produced by foreign countries and purchased by the domestic importer firms at the world price p_t^*. The domestic firms upon receiving this homogeneous intermediate imported good produce a differentiated good, $y_{ft}(j)$, which they then proceed to sell in the local monopolistically competitive market for the subsequent production of y_{ft}. As it was with the domestic intermediate good producers, domestic importers of intermediate goods are also Calvo (1983) firms that sell their output at a price $\bar{p}_{ft}(j)$, in monopolistically competitive domestic. Each period a random fraction $(1 - \phi)$ of firms are able to reset their price, while all other firms keep their prices unchanged. When firms eventually set their price, they must take into account that the price may be fixed for many periods. Again on average the price remains unchanged for $1/(1 - \phi)$ periods.

The importer j, when setting its price, chooses a price $\bar{p}_{ft}(j)$ to maximize the expected discounted flow of profits given the nominal exchange rate, e_t, the foreign price level, p_t^*, and the price of the composite imported good, as follows:

$$\max_{\{\bar{p}_{ft}(j)\}} E_0 \left[\sum_{t=0}^{\infty} (\beta\phi)^l \lambda_{t+l} D_{t+l}^f(j)/p_{ft+l} \right] \tag{41}$$

subject to

$$y_{ft+l}(j) = \left(\frac{\bar{p}_{dft}(j)}{p_{ft+l}} \right)^{-\theta} y_{ft+l} \tag{42}$$

where the profit function is defined below:

$$D_{t+l}^f(j) = (\bar{p}_{ft}(j) - e_{t+l}p_{t+l}^*) y_{ft+l}(j) \tag{43}$$

From above one can observe that the nominal marginal cost is $e_t p_t^*$ in every period t so that the real marginal cost is in fact the real exchange rate defined as $s_{ft} = e_t p_t^*/p_{ft}$. The importers' discount factor is $\beta^l \lambda_{t+l}$. The first order condition is presented below:

$$\bar{p}_{ft}(j) = \frac{\theta}{\theta - 1} \frac{E_t \sum_{l=0}^{\infty} (\beta\phi)^l \lambda_{t+l} y_{ft+l}(j) e_{t+l} p^*_{t+l} / p_{ft+l}}{E_t \sum_{l=0}^{\infty} (\beta\phi)^l \lambda_{t+l} y_{ft+l}(j) / p_{ft+l}} \tag{44}$$

The aggregate import price index is

$$p_{ft}^{1-\theta} = \phi p_{ft-1}^{1-\theta} + (1 - \phi) \bar{p}_{ft}^{1-\theta} \tag{45}$$

Combining the first order condition (44) with the aggregate import price index (45) yields the New Keynesian Phillips curve:

$$\hat{\pi}_{ft} = \beta \hat{\pi}_{ft+1} + \frac{(1 - \beta\phi)(1 - \phi)}{\phi} \hat{s}_{ft} \tag{46}$$

where the real exchange rate in units of the composite imported good can be rewritten as $\hat{s}_{ft} = \hat{s}_t - \hat{\tilde{p}}_{ft}$ where $\tilde{p}_{ft} = p_{ft}/p_t$. This is basically an expression of the law of one price as a function of the real exchange rate, and a function of the terms of trade.

3.4 The Central Bank

This paper assumes that the central bank in the emerging market economy actively manages the short term interest rate, R_t in response to deviations of output, y_t, inflation, π_t, growth of money supply, μ_t, and the real exchange rate, s_t, from their respective steady states. This is essentially a modified or augmented Taylor rule, where the monetary authority responds to output and inflation gap by using a combination of the short term nominal interest rate and the growth of money supply as instruments. These are assumed to be the sole instruments at the disposal of the central bank. For example, there are no capital controls imposed. This procedure follows Ireland (2003), Dib (2003), and Lubik and Schorfheide (2007). The Taylor rule is specified as:

$$\log(R_t/R) = \rho_y \log(y_t/y) + \rho_\pi \log(\pi_t/\pi) + \rho_\mu \log(\mu_t/\mu) + \rho_s \log(s_t/s) + \log(v_t) \tag{47}$$

Where R, y, π, μ, and s are the steady state values of R_t, y_t, π_t, μ_t, and s_t, respectively. The monetary policy disturbance term, v_t, itself follows the autoregressive process

$$\log(v_t) = \rho_v \log(v_{t-1}) + \varepsilon_{vt} \tag{48}$$

where $\rho_v \in [0, 1)$ is the autoregressive coefficient and ε_{vt} is a serially uncorrelated shock with zero mean and standard deviation σ_v. This is a generalized Taylor rule following Ireland (2003) and it is flexible to the extent that it allows money and interest rates to respond endogenously to shocks that affect inflation and output. This version nests a class of interest rules and monetary growth rules that allows for greater flexibility and takes into account that many emerging market economies pursue some type of monetary objective.

3.5 Equilibrium

Market clearing requires that $M_t = M_{t-1} + T_t$, $B_t = 0$, $\tilde{B}_t^* = B_t^*$, for all $t \geq 0$. Also in a symmetric equilibrium , all domestic producers as well as importers are identical. This implies that $y_t = y_t(j)$, $y_{dt} = y_{dt}(j)$, $y_{xt} = y_{xt}(j)$, $p_{dt} = p_{dt}(j)$, $k_t = k_t(j)$, $h_t = h_t(j)$, $y_{ft} = y_{ft}(j)$, and $p_{ft} = p_{ft}(j)$, $\forall\ j \in [0, 1]$ and $t \geq 0$.

For analytical convenience some variables within the model are redefined. Let $r_{kt} = R_{kt}/p_t$ and $w_t = W_t/p_t$ denote the real rental rate on capital and the real wage respectively. The following definitions, $\pi_{dt} = p_{dt}/p_{dt-1}$, $\pi_{ft} = p_{ft}/p_{ft-1}$, $\tilde{p}_{dt} = p_{dt}/p_t$, $\tilde{\tilde{p}}_{dt} = \bar{p}_{dt}/p_{dt}$, $\tilde{p}_{ft} = p_{ft}/p_t$, $\tilde{\tilde{p}}_{ft} = \bar{p}_{ft}/p_{ft}$, and $b_t^* = B_t^*/p_t^*$, represent PPI and IPI inflation rates, the relative prices of domestic and imported goods, and real foreign bonds respectively. The entire non-linear system, both equilibrium relationships and definitions necessary to solve the model, can be found in Appendix A. The current account is specified in Appendix A and is derived by substituting the resource constraint into the budget constraint.

4 Data and Methodology

4.1 Model Solution and Calibration

To find a solution to the non-linear equilibrium system summarized in Appendix A, I log-linearized each variable around its steady state. The complete log-linearized equilibrium system is presented in Appendix B. Steady state values for the system are summarized in Appendix C.

The Blanchard and Khan (1980) solution method was employed, resulting in a state-space solution of the form:

$$\mathbf{S}_{t+1} = \Theta \mathbf{S}_t + \Omega \varepsilon_{t+1} \tag{49}$$

and

$$\mathbf{F}_t = \mathbf{U}\mathbf{S}_t \tag{50}$$

where $\mathbf{S}_t$ is a vector of state variables, and includes the six shocks in the model a_t, b_t, R_t^*, A_t, π_t^*, and v_t as well as capital k_t; $\mathbf{F}_t$ is a vector of control variables, and ε_{t+1} is a vector of shocks. This is a system that expresses state variables (which include predetermined and exogenous variables) as functions of their past values plus some random disturbance term, and control variables as functions of state variables. The vector ε_{t+1} here would contain the technology shock, the money demand shock, the monetary policy shock, the taste shock, the world interest rate shock, and the world inflation shock. The matrices Θ, Ω, and $\mathbf{U}$ are VAR coefficients that depend on deep structural parameters of the model. These structural parameters describe private agents' taste and technologies as well as parameters of the central bank's policy rule (Ireland, 2003). The constraints linking the elements of these matrices must be derived through numerical implementation of the Blanchard and Khan solution method since no closed form can be obtained. It is this solution that is then used to estimate the model and perform simulations.

Because not all parameters can be estimated some have to be calibrated prior to estimation. Table 1 shows calibrated values for six parameters and two steady state values for each of the emerging market economies under consideration.

For Mexico, South Africa, Thailand and Indonesia the subjective discount factor β is set at 0.9706, 0.9255, 0.9773, and 0.9630 respectively which implies respective annual steady state real interest rates of 12.13 , 32.2, 9.29 and 15.38 percent for the sample period. The weight on leisure η is set to 0.814 so as to ensure that workers spend one third of their time working. The capital adjustment cost is set to 20. This provides reasonable results and is based on the assumption that capital adjustment costs are likely higher in emerging market economies than in industrial economies. Dib (2003) sets this parameter to 15 for Canada and Ireland sets this parameter equal to 10 for the United States. The risk premium parameter φ is set to 0.006, which implies a risk premium of 99 basis points based on Allan Huang country risk (check) ratings[1]. The capital share parameter α and the rate of depreciation δ are assigned the commonly used values of 0.36 and 0.0025 respectively, which are fairly standard values used in the literature. The exception is Mexico where I use 0.03225 which is the implied quarterly depreciation rate implied by the annual value 0.129 that Schmitt-Grohe and Uribe (2001) employ for Mexico. There is limited evidence on the degree of imperfect competitiveness in developing countries (Schmitt-Groh and Urib,2001). The commonly assumed markup in the literature is 10 %, however it is reasonable to conjecture that the markup in emerging market countries is

[1] www.sju.edu/faculty/watkings/countryrisk.htm

higher (Cook and Devereux, 2006). The markup for South Africa is assumed to be 30 percent based on the work of Fedderke and Schaling (2005), so the parameter that measures the degree of monopoly power in the domestic and imported intermediate goods market, θ is set equal to 4.33. Since I don't have direct evidence for the other countries I use a 20 % markup following Cook and Devereux (2006) among others. The fraction of imported goods in the final good, ω_f is set to 0.241 and this is based on the import to GDP ratio for the sample period[2]. Finally the steady state value of the money demand shock is set to 0.74 based on the sample ratio of real consumption per capita to real money balances per capita. In this model the external debt to gdp ratio is set and for Mexico, South Africa, Indonesia and Thailand it is 0.4243, 0.1738, 0.7379, and 0.5467 respectively during the sample period. The parameter b is computed by looking at the average real money balance to consumption ratio or the consumption velocity of money over the respective sample periods.

4.2 Data and Study Area

I examine Mexico, South Africa, Indonesia, and Thailand, four emerging market economies spread across three continents. The data for this study were obtained from the International Monetary Fund International Financial Statistics online database. The period under review for South Africa is from the second quarter of 1979 to the third quarter of 2007. For Indonesia, the sample runs from the first quarter of 1990 to the fourth quarter of 2007. The period under review for Mexico is from the first quarter of 1981 to the last quarter of 2007. The Thailand data series is from the first quarter of 1993 to the fourth quarter of 2007.

Household expenditure was employed as a measure of consumer spending, M2 was used to measure nominal money balances, the 3 month treasury bill rate is used to measure the policy controlled interest rate except in the case of Thailand were I use the commercial lending interest rate due to missing observations for the treasury bill rate, the consumer price index is used to measure CPI inflation, and finally the 3 month U.S treasury bill rate is employed to measure world or foreign interest rates. Nominal money balances and consumption are deflated by the GDP deflator and then divided by population size to derive per capita measures. Ideally, labor force is preferable to population size, but in the absence of this measure across the sample countries, population was the next best alternative. The real exchange rate is computed by multiplying the end of period nominal exchange rate by the ratio of the US GDP deflator and

[2]To compute this average, I use the World Development Indicators database

the respective domestic GDP deflator. The real exchange rate for all countries exhibited strong co-movement with its nominal countepart[3], with correlation coefficients in excess of 95 %.

All variables are are transformed by the natural logarithm function and since the model implies stationary series, all variables are tested for stationarity. For all countries the real exchange rate, real consumption and real money balance series are detrended by the Hodrick-Prescott filter. The United States interest rate, domestic interest rate and domestic CPI inflation are not detrended but were all found to be stationary in levels. The exception was Thailand and Mexico, where the non-stationary domestic interest rate was filtered by the Hodrick-Prescott filter. The objective is to transform the empirical observations so that they closely match model variables. Thus for the interest and inflation rates, I use gross rates prior to applying the natural logarithm. The result is a set of deviations from trend variables that are all stationary.

4.3 Estimation

Since the model solution is in state space form driven by six shocks, its parameters can be estimated by maximum likelihood. Let $\Phi = (\gamma, \rho_\pi, \rho_\mu, \rho_y, \rho_s, \rho_v, \sigma_v, \phi, \nu, \tau, \rho_b, \sigma_b, \rho_A, \sigma_A, \rho_a, \sigma_a, \rho_{R^*}, \sigma_{R^*}, \rho_{\pi^*}, \sigma_{\pi^*})'$ be a vector of structural parameters. I estimate this by maximizing the following likelihood function:

$$L(\varepsilon, \Phi) = \frac{T}{2} \ln |\Sigma| + \frac{1}{2} \sum_{t=1}^{T} \varepsilon_t' \Sigma^{-1} \varepsilon_t \tag{51}$$

where $\varepsilon_t \sim N(0, \Sigma)$ and Σ is the variance-covariance matrix. The Kalman filter is employed to evaluate the likelihood function for the sample as described in Hamilton (1994).

5 Empirical Results

5.1 Estimation Results

Table 2 reports the estimated results and their respective standard errors for the four emerging market economies under consideration. For each country, almost all the coefficients are statistically significant and economically meaningful. Before describing the key results of the estimated Taylor rule, lets first examine the other estimated coefficients to provide some context within which to make a proper assessment.

[3]The base year for the GDP deflator was 2000 and was consistent across countries

The estimated value of γ the constant elasticity of substitution between consumption and real balances is 0.0214 for South Africa, 0.0239 for Mexico, 0.0246 for Indonesia, and 0.1137 for Thailand and is statistically significant at the 5% level in all cases. The parameter ν is the price elasticity of aggregate imports, it essentially measures the elasticity of substitution between domestic and imported goods. The estimated value for South Africa is very near 0 and statistically insignificant. For Thailand the estimated value is 0.8337 but like South Africa is highly statistically insignificant. Thus as Dib (2003) suggests, this implies that the final good is produced using a Leontief technology, where imports are used in a fixed proportion, ω_f. However for Mexico it has a large magnitude of 2.3723 and for Indonesia it is 0.7968, taking on significance in both case. The price elasticity of aggregate exports τ is estimated at 1.4773 for South Africa, 1.1536 for Mexico, 0.7955 for Indonesia, and 0.8807 for Thailand and is highly statistically significant in all cased except for Thailand. The sum of ν and τ for all countries exceeds one, thus satisfying the the Marshall-Lerner condition, though in the case of Thailand the results are are not statistically significant.

The probability that the price of an intermediate good remains the same is ϕ. This also determines the degree of nominal price rigidity in the domestic and imported intermediate goods sectors. The estimated value of ϕ for South Africa is 0.5347, for Mexico it is 0.8358, for Indonesia it is 0.5181 and for Thailand is is 0.9295 and is statistically significant in all instances. This implies that 46.53% and 48.19 % of domestic producers and importers in South Africa and Indonesia are allowed to adjust prices in any given period. Prices in South Africa and Indonesia remain unchanged for approximately 2.149 and 2.075 periods respectively, whereas only 16.42 % and 7.05 % of domestic producers and importers in Mexico and Thailand respectively are allowed to adjust prices so that prices remain unchanged for 6.09 periods in Mexico and 14.18 periods in Thailand. The parameter estimates for Mexico and Thailand are within allowable limits, they imply a degree of price rigidity particularly in the case of Thailand that is unusually high.

The key coefficients of the Taylor rule are now reported. The coefficients on the output gap ρ_y and inflation ρ_π are both positive and statistically significant for South Africa and Mexico. The coefficient on the output gap is near zero and statistically insignificant for both Indonesia and Thailand whereas the coefficient on the inflation gap is positive in both countries but only significant in the case of Indonesia. The output gap parameters estimates for South Africa, Mexico, Indonesia, and Thailand are 0.0098, 0.2128, 0.000, and 0.0143 respectively, whereas the inflation gap parameters are 0.8496, 1.0779, 0.8098, and 0.3375 respectively. The coefficient on money growth ρ_μ is 0.6545 for Mexico, 0.1901 for Indonesia, and 0.477 for Thailand and significant for all. For South Africa it is estimated to be 0.1803 but it is not statistically significant. The coefficient on the real exchange rate ρ_s in both South Africa and Mexico is near zero and likewise not statistically significant, but for Indonesia and Thailand the coefficients are 0.0862 and 0.0952 respectively, small but significant at the 10 % level. The estimate of the autoregressive coefficient, ρ_v is positive and statistically significant in all cases except Thailand. The estimated values are 0.2593, 0.5931, 0.2525 and 0.2181 for South Africa, Mexico, Indonesia and Thailand respectively. The estimates of the standard deviation of the monetary policy shock, σ_v are 0.0201, 0.0662, 0.0283 and 0.0142 for South Africa, Mexico, Indonesia, and Thailand respectively and they are all highly significant.

The results are not surprising. South Africa and Mexico results indicate that their respective monetary authorities place considerable importance on output and inflation variability, a result not inconsistent with their stated claims. Moreover the significance of money growth is also not inconsistent with the stated objectives of the Bank of Mexico. In both countries the real exchange rate is not shown to matter. The appropriate way to interpret this result is to state that it does not provide evidence to support the claim that monetary authorities in South Africa and Mexico target the real exchange rate by adjusting a policy controlled interest rate. Given the focus of these countries on inflation targeting and flexible exchange rates and the fact that these countries also extensively use capital controls, I believe these results are most reasonable.

The results for the south east asian countries of Indonesia and Thailand show that their respective monetary authorities actively target the real exchange rate. Overall what is clear is that monetary objectives are important. Its apparent that these countries target in various ways, some measure of money. Moreover inflation stabilization which is widely considered to be the primary mandate of most central banks is an objective that these countries pursue. The main difference is that Mexico and South Africa seem to consider the output gap explicitly while not using monetary policy tools to respond to fluctuations whereas Indonesia and Thailand do respond to real exchange rate volatility but have not discernable response to output volatility. Overall, Thailand and Indonesia are more open economies than South Africa and Mexico as measured by imports to GDP, and are likely to place a higher premium on exchange rate predictability, so this also is a likely reason for this result.

The other domestic shocks in the model namely money demand ρ_b, technology ρ_A, and preferences ρ_a are estimated at 0.9301, 0.9431, and 0.8951 for South Africa, 0.7098, 0.4927, and 0.9969 for Mexico, 0.9885, 0.9902, and 0.9294 for Indonesia, and 0.8479, 0.9903, and 0.7686 for Thailand respectively, all with high levels of significance, thus exhibiting high levels of persistence. Their respective standard deviations are all significant with the exception of the standard deviation of technology disturbance for Thailand.

The auto-regressive coefficients on the foreign shocks namely the world nominal interest ρ_{R^*} and inflation rate ρ_{π^*} are estimated at 0.8202 and 0.753 for South Africa, 0.9202 and 0.2466 for Mexico, 0.8144 and 0.5918 for Indonesia, and 0.8805 and -0.0843 respectively for Thailand. They are all highly significant. The respective standard deviation parameter values are statistically significant for all countries except for the Thailand standard deviation of the inflation disturbance which is barely insignificant.

5.2 Impulse Response Functions

Model dynamics can be analyzed by computing impulse response functions which are reported in figures 2-25 for all the countries under consideration. I selectively report the case of South Africa while noting that the impulse response functions for the other countries are remarkably similar.

Figures 2-25 show the impulse responses of several macroeconomic variables within the model to a 1 % shock to monetary policy, technology, and the world nominal interest rate shock using the values obtained from the maximum likelihood estimation. The macroeconomic variables under consideration are output, consumption, the real interest rate, money growth, ppi, ipi and cpi inflation, the real exchange rate, intermediate good exports and imports, and relative domestic and imported intermediate good price.

Figures 2-7 show the impulse responses for South Africa. Figures 1 and 2 show the responses of the key macroeconomic variables to a 1 % positive monetary shock. A tightening of monetary policy results in the real interest rate rising. As a result, output, consumption, money growth and ipi, cpi, and ppi inflation all fall before returning to their respective steady state values. As a result of the rising interest rate, the real exchange rate appreciates causing exports to be less competitive and decline. The price of imports rises whereas the price of exports falls. This causes agents to switch from imported goods to domestic goods, and consequently causes imports to decline as well. Because imports decline by relatively more than exports, net exports actually rise. Dib (2003) also obtained this result which is counter to the usual theoretical prediction but can be explained by nominal rigidity in the import sector which implies a slower and more gradual adjustment in the import price.

Figures 3 and 4 show the responses of the key macroeconomic variables to a 1 % positive technology shock. Output and consumption both rise and are very persistent. Monetary growth rises initially but quickly becomes negative. The real interest rate response is negative and persistent. The cpi and ppi inflation responses are negative as expected whereas ipi inflation response is initially positive but becomes negative after four quarters.

The positive technology shock causes a depreciation in the real exchange rate and a decrease in the domestic intermediate good price. This causes an increase in foreign demand for domestic goods causing exports to rise. The price of the foreign intermediate good rises, however the impulse response for imports shows a highly persistent positive initial response.

Figures 5 and 6 show the impulse responses to a 1 % positive shock to the foreign interest rate, for South Africa represented by the US 3-month treasury bill rate. This shock leads to 5 quarter increase in output before it returns to its steady state value and a simultaneous decrease in consumption over the same period. In keeping with the UIP response, the real interest rate rises above its steady state value gradually returning in about 8 quarters. PPI, IPI, CPI inflation and money growth all rise above their steady state values and return to equilibrium in roughly 8 quarters.

The real exchange rate initially depreciates by about 2 % but returns to its steady state in approximately 10 quarters. This depreciation results in a rise in exports and a simultaneous fall in imports.

Overall the model dynamics seem to match the standard New Open Economy predictions.

6 Conclusion

I specify and estimate a dynamic optimizing small open economy model with nominal rigidities, using maximum likelihood methods. The results for South Africa and Mexico indicate that while there is strong evidence to suggest that the central bank responds to deviations of inflation from steady state, with a very small response to fluctuations in the output gap, there is little evidence to support the claim that the South African and Mexican monetary authorities use interest rate adjustments to systematically respond to fluctuations in the real exchange rate. This may reflect two possibilities; either these countries have a truly flexible arrangement and are not particularly concerned with quarterly fluctuations in the real exchange rate, or the authorities are concerned about exchange rate volatility but use alternative measures to mitigate it, such as capital controls or foreign exchange rate intervention. Indonesia and Thailand on the other hand do use monetary policy to respond to exchange rate volatility. The results also show that these countries have limited to no response to output variation. Indonesia and Thailand are more open to international trade than South African and Mexico and as a result are more likely to place a higher premium of exchange rate predictability. The common thread in the analysis is that countries appear to pay attention to inflation and money growth.

Table 1: Calibrated Parameters

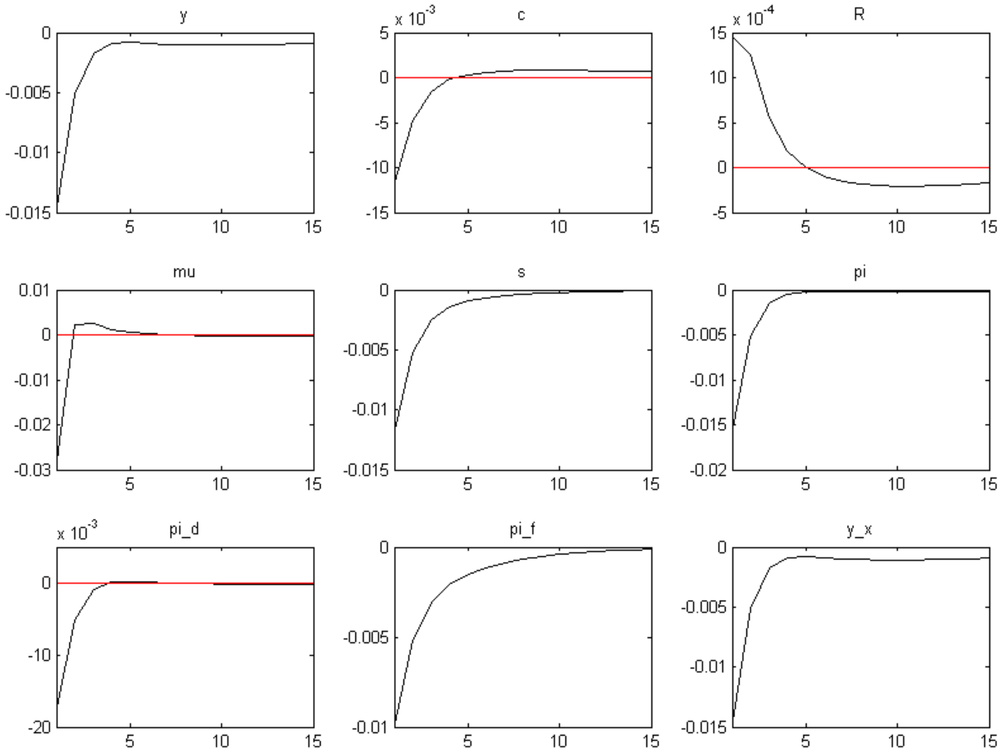
Parameter	Mexico	South Africa	Thailand	Indonesia
β	0.9255	0.9706	0.9773	0.9630
η	1.315	0.814	1.315	1.315
ψ	20	20	20	20
φ	0.006	0.006	0.006	0.006
α	0.36	0.36	0.36	0.36
δ	0.03225	0.025	0.025	0.025
θ	6	4.333	6	6
ω_f	0.23	0.241	0.55	0.275
b	0.53	0.74	6.52	2.83
External Debt to GDP	0.4243	0.1738	0.5467	0.7379

Table 2: Maximum Likelihood Estimates with Standard Errors

Parameters	Mexico Est	Std. Err	South Africa Est	Std. Err	Indonesia Est	Std. Err	Thailand Est	Std. Err
γ	0.0239	0.0042	0.0214	0.0092	0.0246	0.0041	0.1137	0.0371
ν	2.3723	0.7980	4.5×10^{-7}	0.0000^{a}	0.7968	0.1698	0.8337	2.2948
τ	1.1536	0.2275	1.4773	0.0622	0.7955	0.1439	0.8807	2.4354
ϕ	0.8358	0.0569	0.5347	0.1603	0.5181	0.1620	0.9295	0.0206
ρ_b	0.7098	0.0661	0.9301	0.0534	0.9885	0.0139	0.8479	0.0670
σ_b	0.0512	0.0038	0.0330	0.0033	0.0417	0.0024	0.0435	0.0061
ρ_A	0.4927	0.0772	0.9431	0.0225	0.9902	0.0056	0.9903	0.0147
σ_A	0.4191	0.2612	0.0634	0.0148	0.0837	0.0201	0.1074	0.1375
ρ_a	0.9969	0.0033	0.8951	0.0339	0.9294	0.0262	0.7686	0.1049
σ_a	0.0684	0.0226	0.0414	0.0094	0.0749	0.0069	0.0553	0.0176
ρ_{R^*}	0.9202	0.0159	0.8202	0.0201	0.8144	0.0637	0.8805	0.0569
σ_{R^*}	0.0063	0.0007	0.0084	0.0006	0.0045	0.0005	0.0036	0.0003
$\rho_{\pi*}$	0.2466	0.0186	0.7530	0.0323	0.5918	0.0742	-0.0843	0.0138
$\sigma_{\pi*}$	0.8155	0.4495	0.0184	0.0016	0.8470	0.1623	1.5034	1.0096
ρ_v	0.5931	0.1313	0.2593	0.0601	0.2525	0.0823	0.2181	0.2265
σ_v	0.0662	0.0188	0.0201	0.0016	0.0283	0.0015	0.0142	0.0029
ρ_y	0.2128	0.0694	0.0098	0.0039	0.0000	0.0001	0.0143	0.0531
ρ_π	1.0779	0.3685	0.8406	0.1497	0.8098	0.0204	0.3375	0.2535
ρ_μ	0.6545	0.1039	0.1803	0.1434	0.1901	0.0237	0.4777	0.1044
ρ_s	0.0000	0.0013	8×10^{-7}	0.0000^{b}	0.0862	0.0490	0.0952	0.0548
Sample Size	108		114		72		60	
Log Likelihood	-1087.91		-1226.35		-450.39		-983.05	

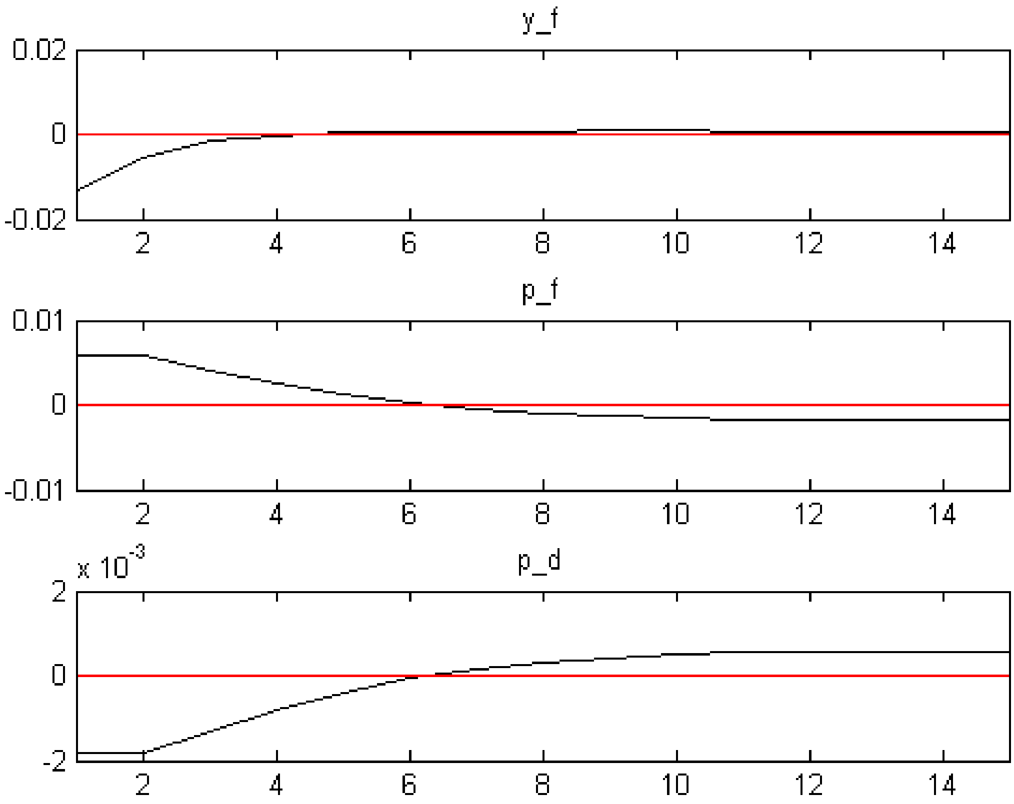
Note:- a: t-stat is 0.0213, b: t-stat is 0.0186.

Figure 2: Empirical Impulse Responses to a Monetary Policy Shock (South Africa Quarterly Data 1979 – 2007)



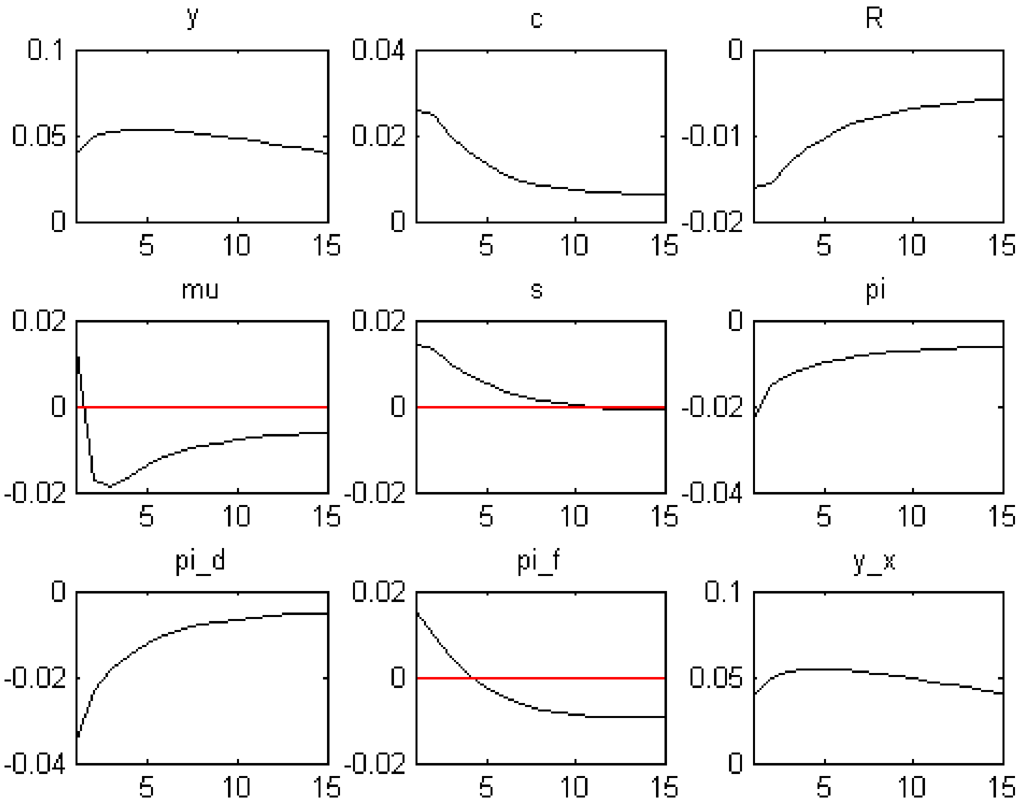
Note: The empirical impulse responses are given by the solid line.

Figure 3: Empirical Impulse Responses to a Monetary Policy Shock Model (South Africa Quarterly Data 1979 – 2007)



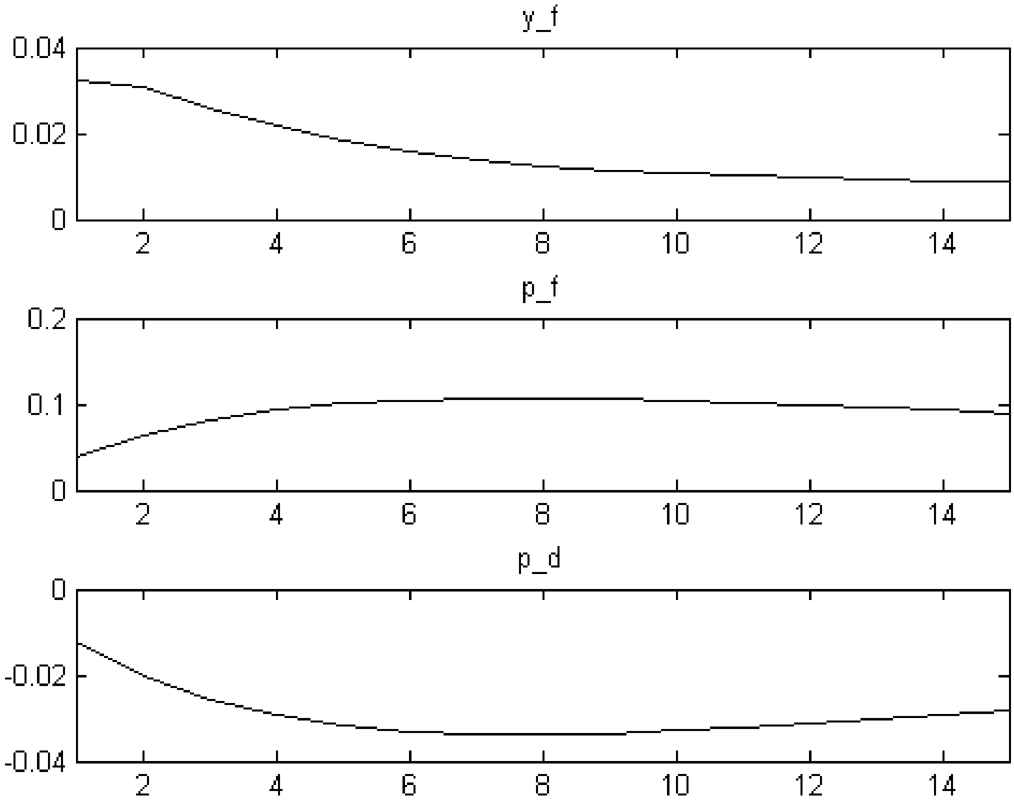
Note: The empirical impulse responses are given by the solid line.

Figure 4: Empirical Impulse Responses to a Technology Shock (South Africa Quarterly Data 1979 – 2007)



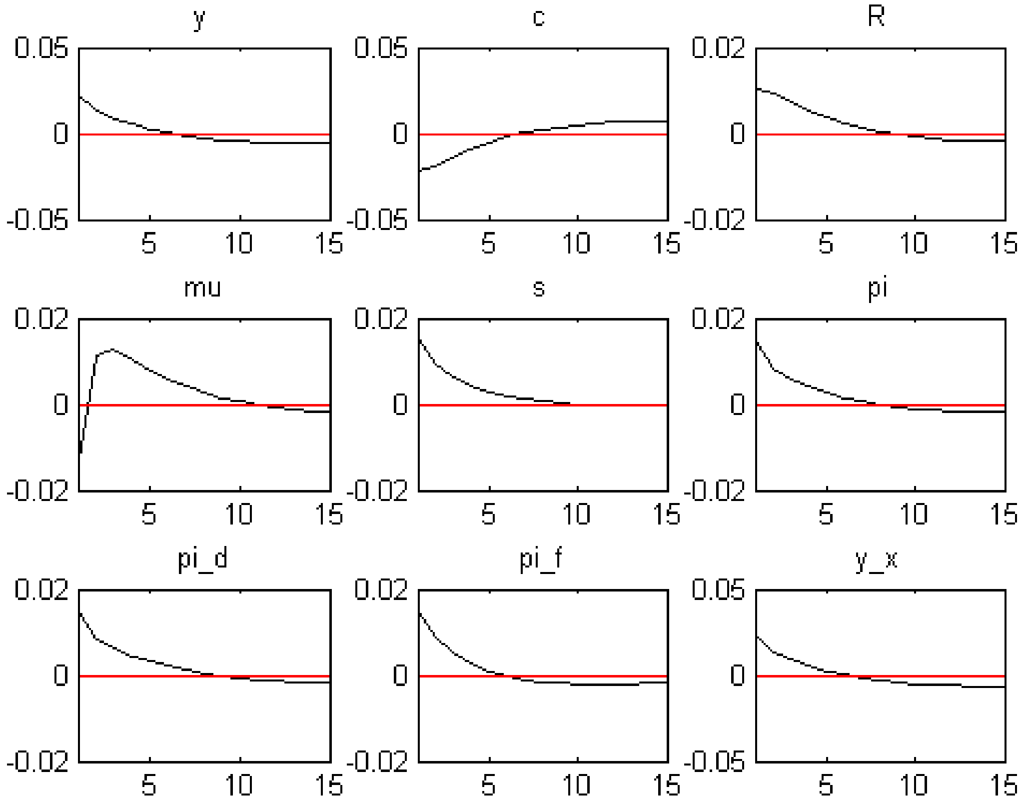
Note: The empirical impulse responses are given by the solid line.

Figure 5: Empirical Impulse Responses to a Technology Shock (South Africa Quarterly Data 1979 – 2007)



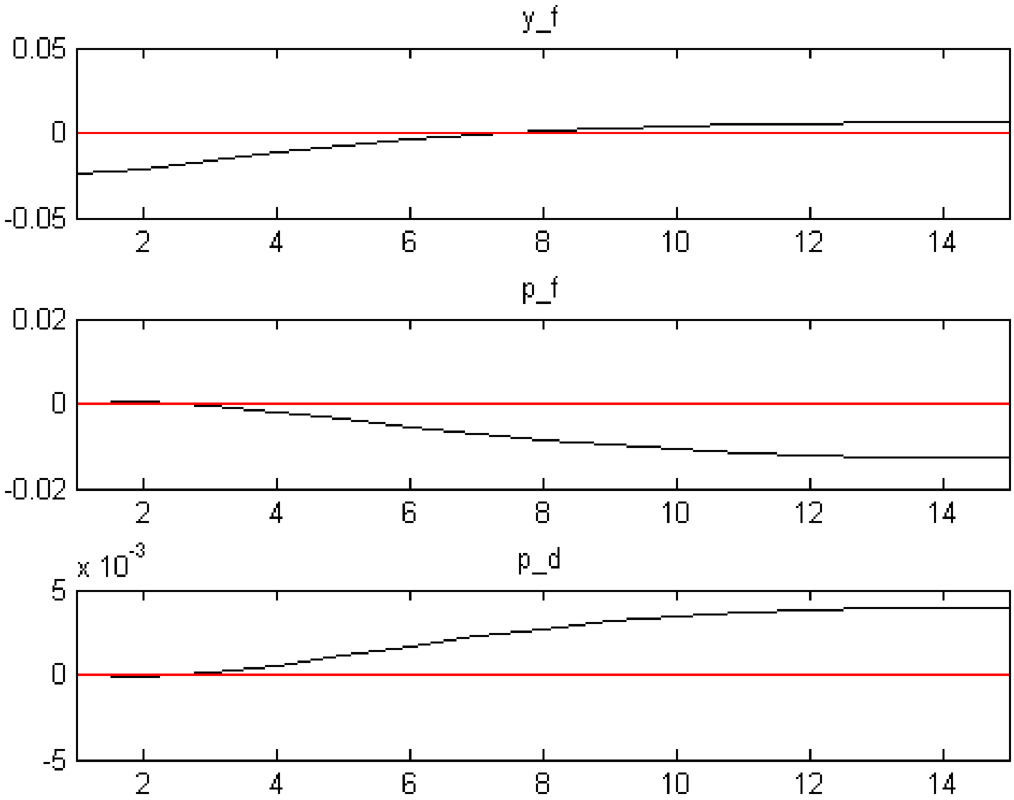
Note: The empirical impulse responses are given by the solid line.

Figure 6: Empirical Impulse Responses to a Foreign Interest Rate Shock (South Africa Quarterly Data 1979 – 2007)



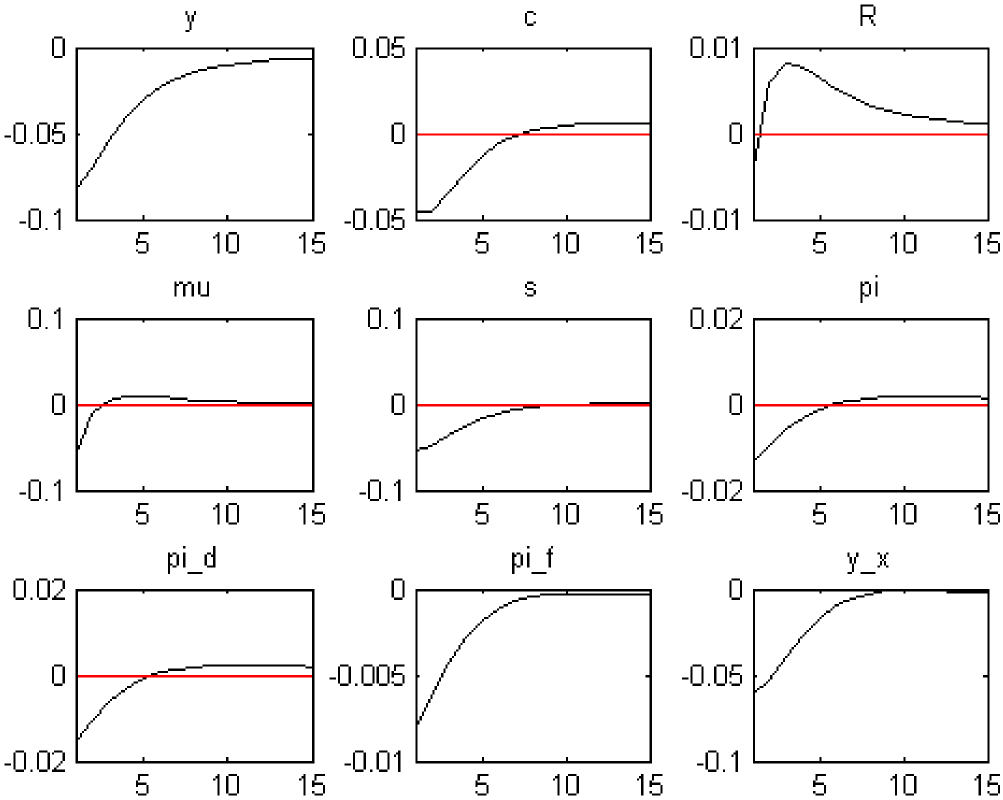
Note: The empirical impulse responses are given by the solid line.

Figure 7: Empirical Impulse Responses to a Foreign Interest Rate Shock (South Africa Quarterly Data 1979 – 2007)



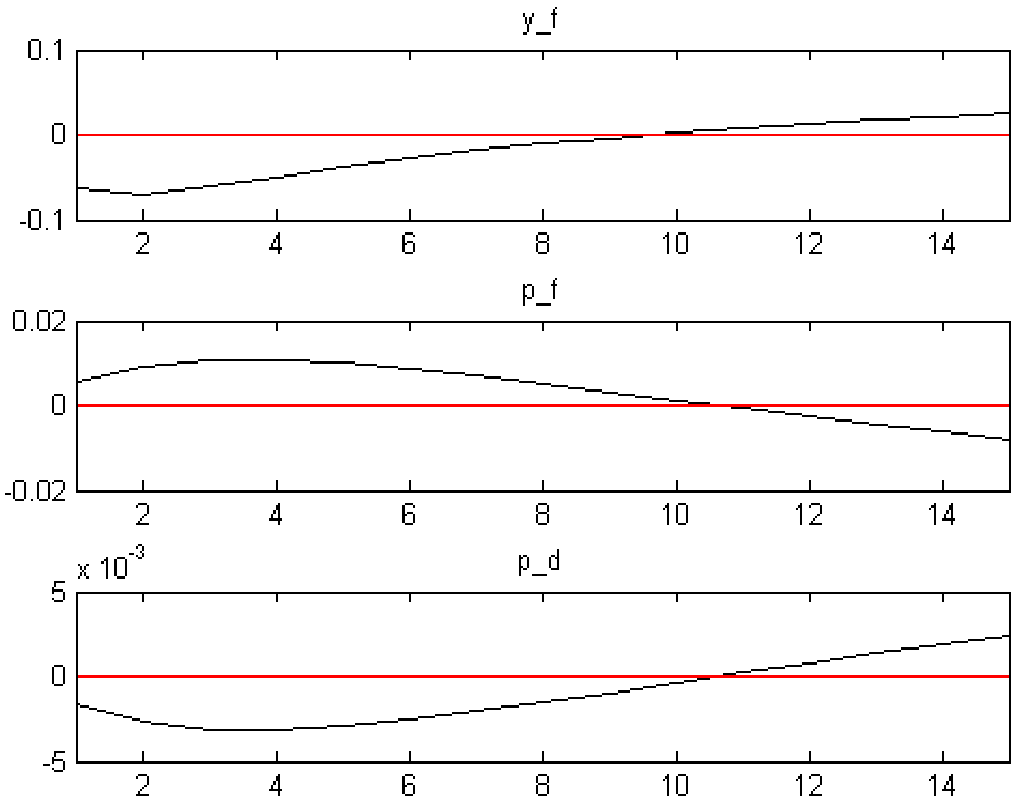
Note: The empirical impulse responses are given by the solid line.

Figure 8: Empirical Impulse Responses to a Monetary Policy Shock (Mexico Quarterly Data 1981 – 2007)



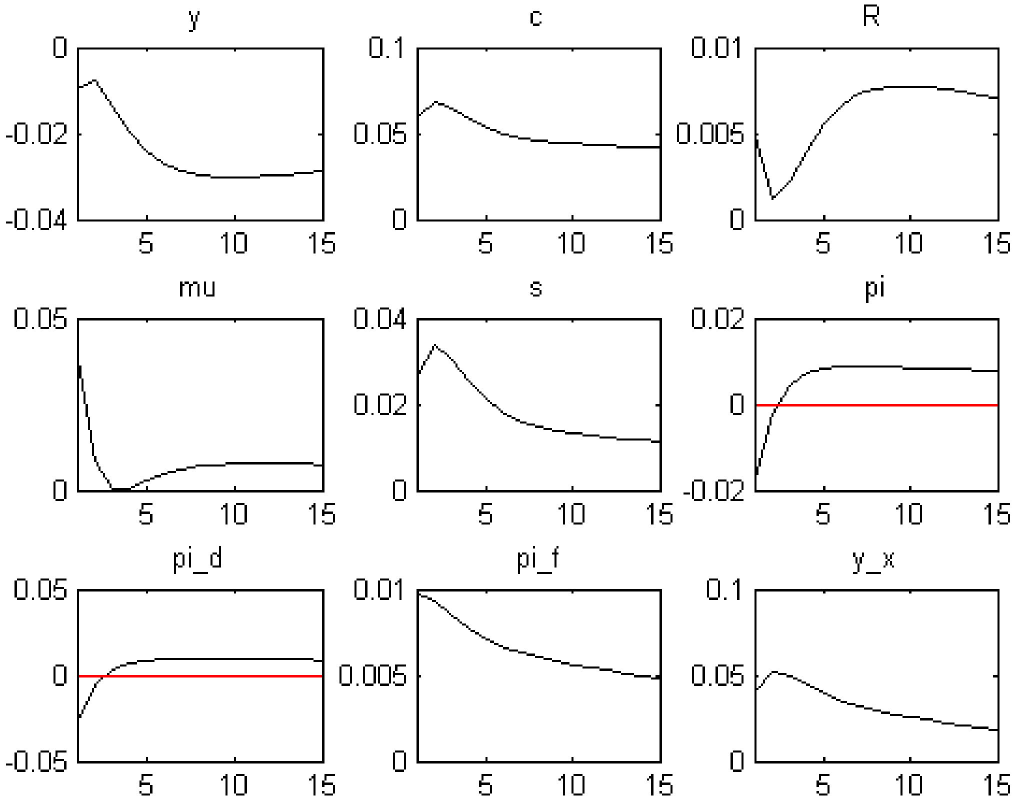
Note: The empirical impulse responses are given by the solid line.

Figure 9: Empirical Impulse Responses to a Monetary Policy Shock Model (Mexico Quarterly Data 1981 – 2007)



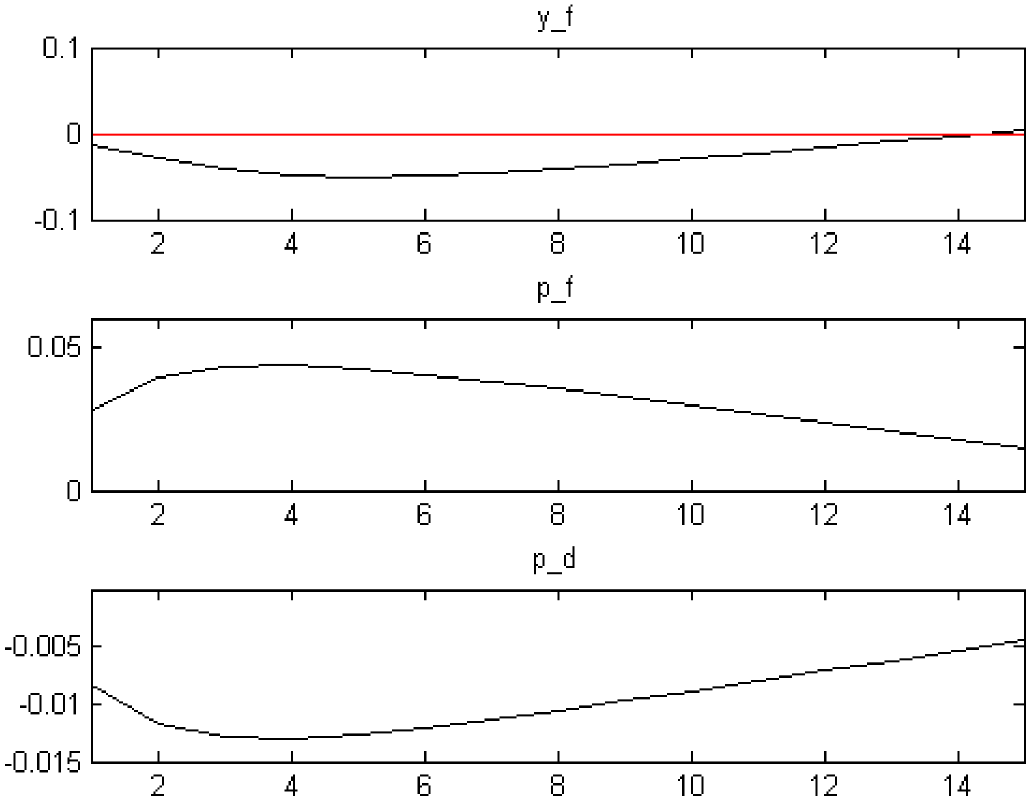
Note: The empirical impulse responses are given by the solid line.

Figure 10: Empirical Impulse Responses to a Technology Shock (Mexico Quarterly Data 1981 – 2007)



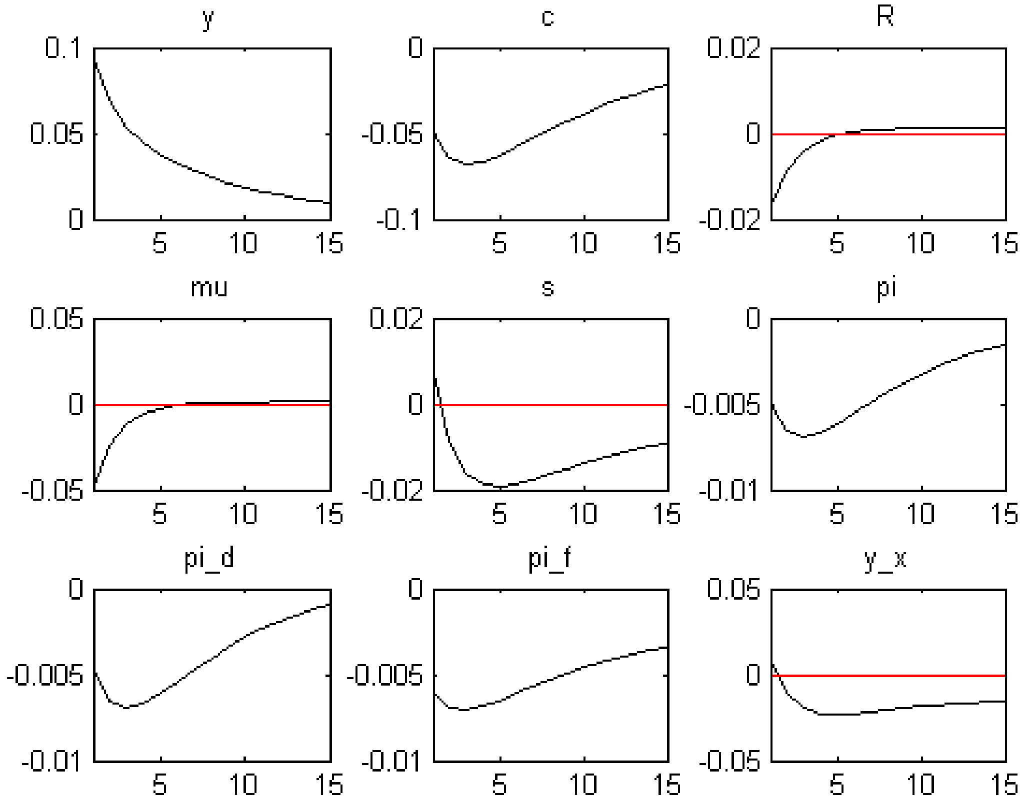
Note: The empirical impulse responses are given by the solid line.

Figure 11: Empirical Impulse Responses to a Technology Shock (Mexico Quarterly Data 1981 – 2007)



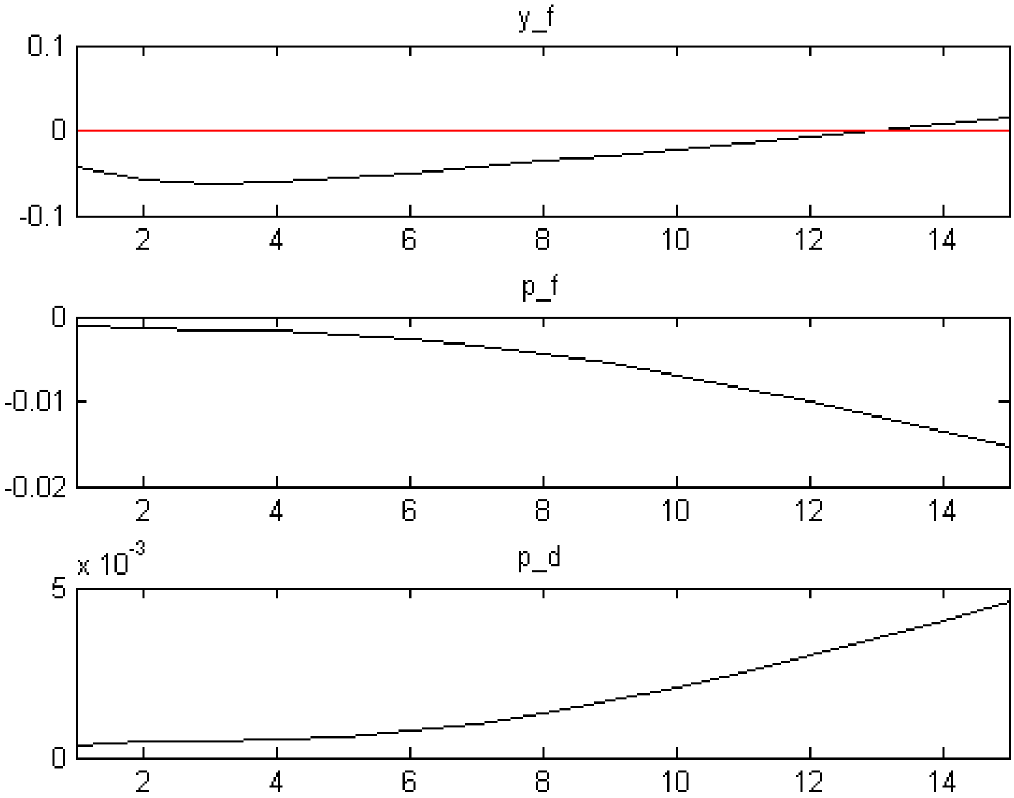
Note: The empirical impulse responses are given by the solid line.

Figure 12: Empirical Impulse Responses to a Foreign Interest Rate Shock (Mexico Quarterly Data 1981 – 2007)



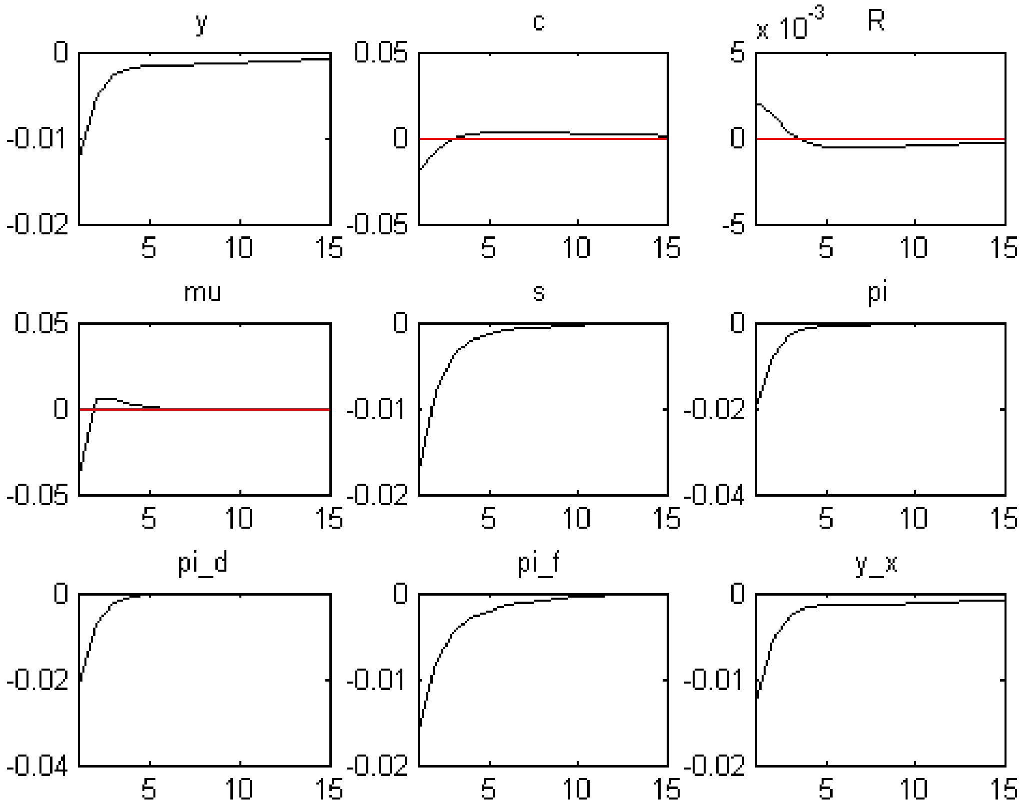
Note: The empirical impulse responses are given by the solid line.

Figure 13: Empirical Impulse Responses to a Foreign Interest Rate Shock (Mexico Quarterly Data 1981 – 2007)



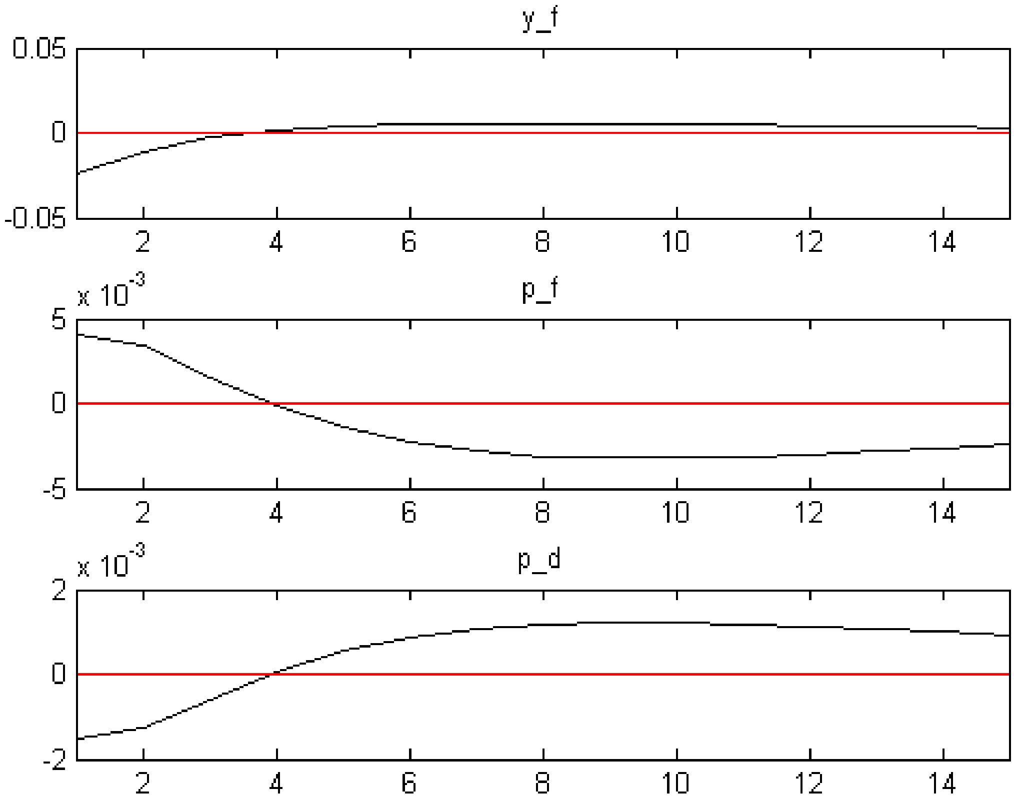
Note: The empirical impulse responses are given by the solid line.

Figure 14: Empirical Impulse Responses to a Monetary Policy Shock (Indonesia Quarterly Data 1990 – 2007)



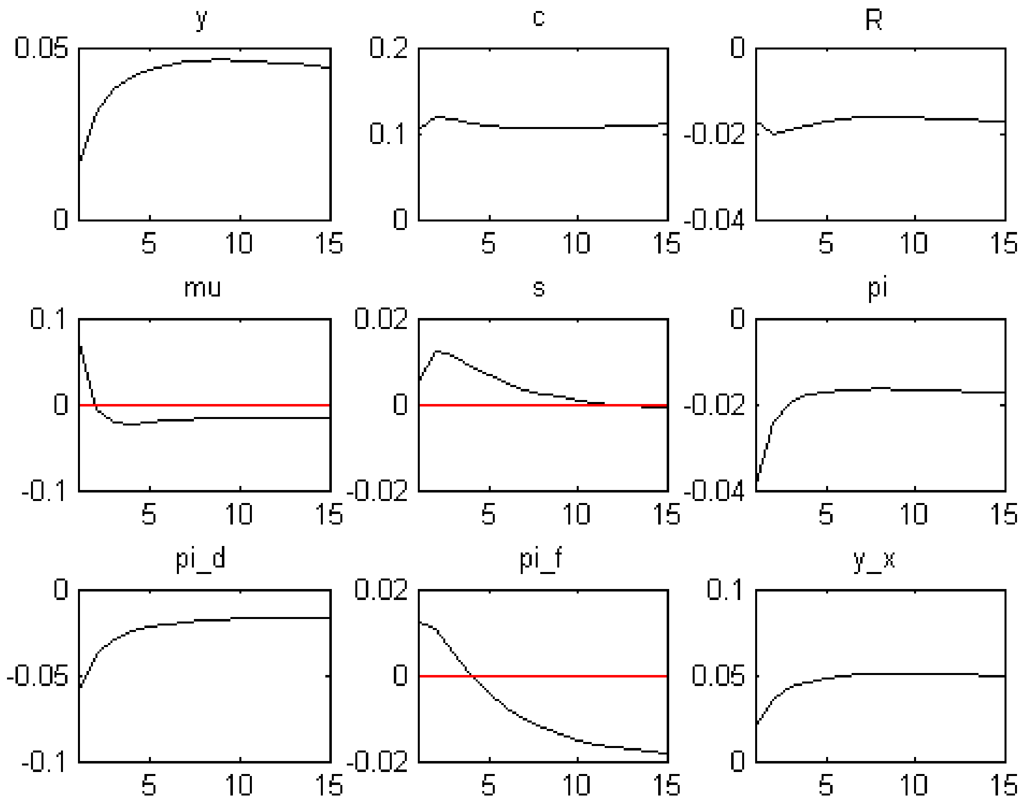
Note: The empirical impulse responses are given by the solid line.

Figure 15: Empirical Impulse Responses to a Monetary Policy Shock Model (Indonesia Quarterly Data 1990 – 2007)



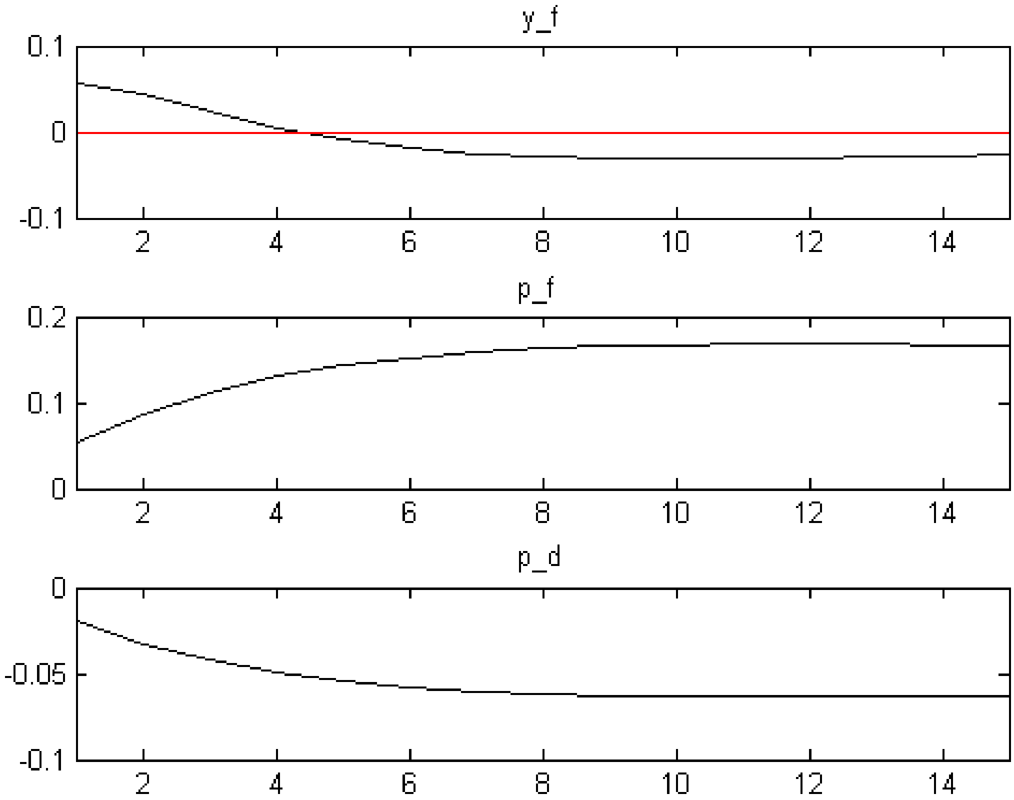
Note: The empirical impulse responses are given by the solid line.

Figure 16: Empirical Impulse Responses to a Technology Shock (Indonesia Quarterly Data 1990 – 2007)



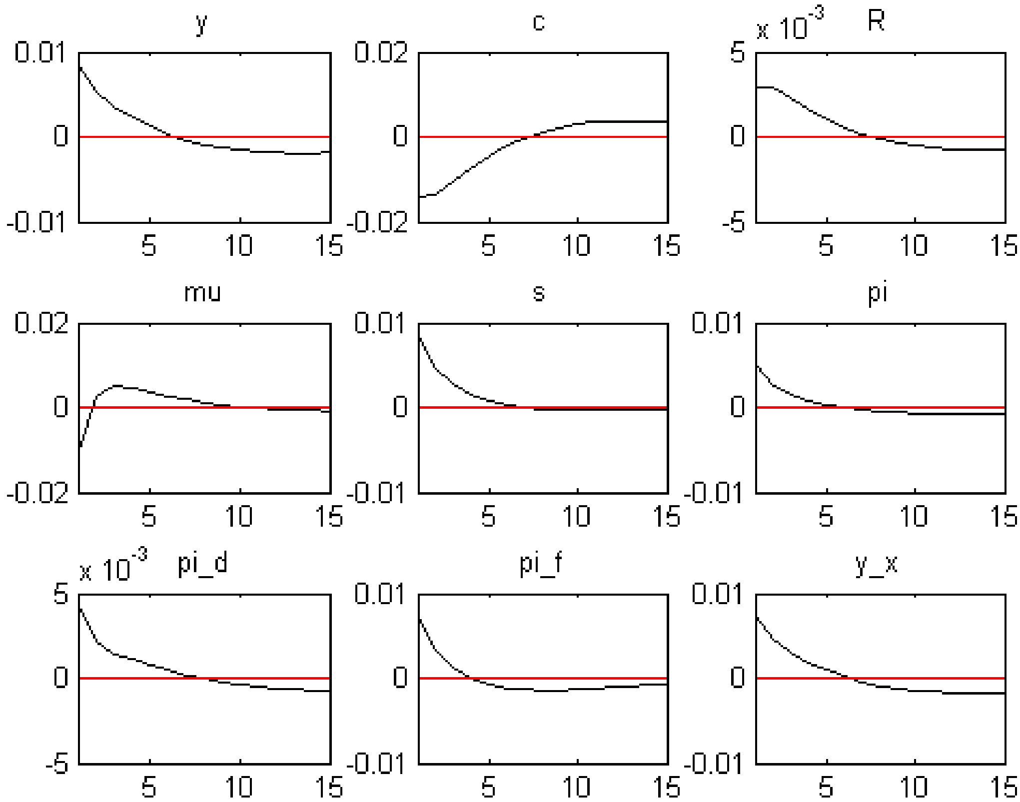
Note: The empirical impulse responses are given by the solid line.

Figure 17: Empirical Impulse Responses to a Technology Shock (Indonesia Quarterly Data 1990 – 2007)



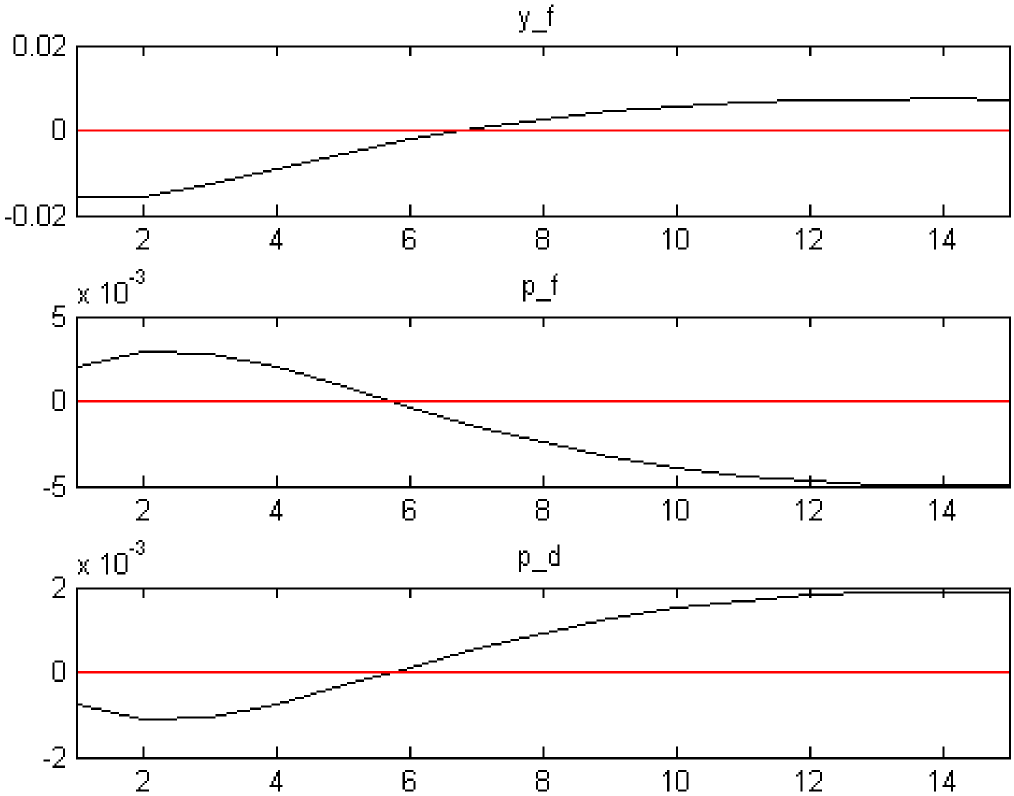
Note: The empirical impulse responses are given by the solid line.

Figure 18: Empirical Impulse Responses to a Foreign Interest Rate Shock (Indonesia Quarterly Data 1990 – 2007)



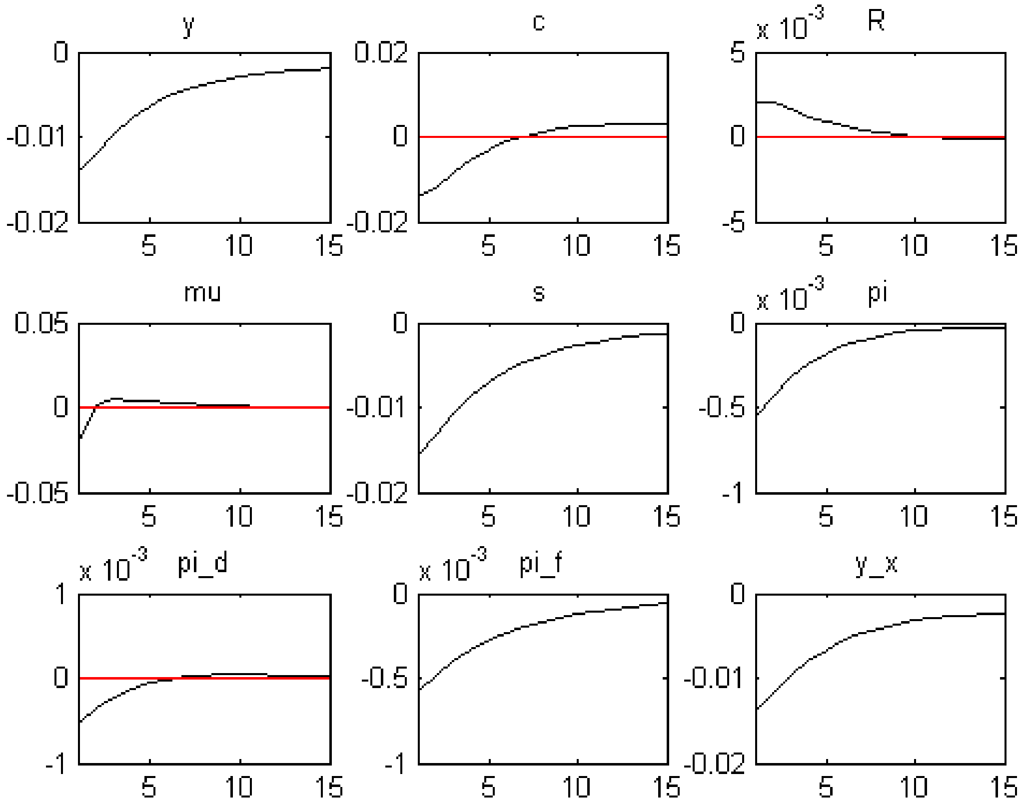
Note: The empirical impulse responses are given by the solid line.

Figure 19: Empirical Impulse Responses to a Foreign Interest Rate Shock (Indonesia Quarterly Data 1990 – 2007)



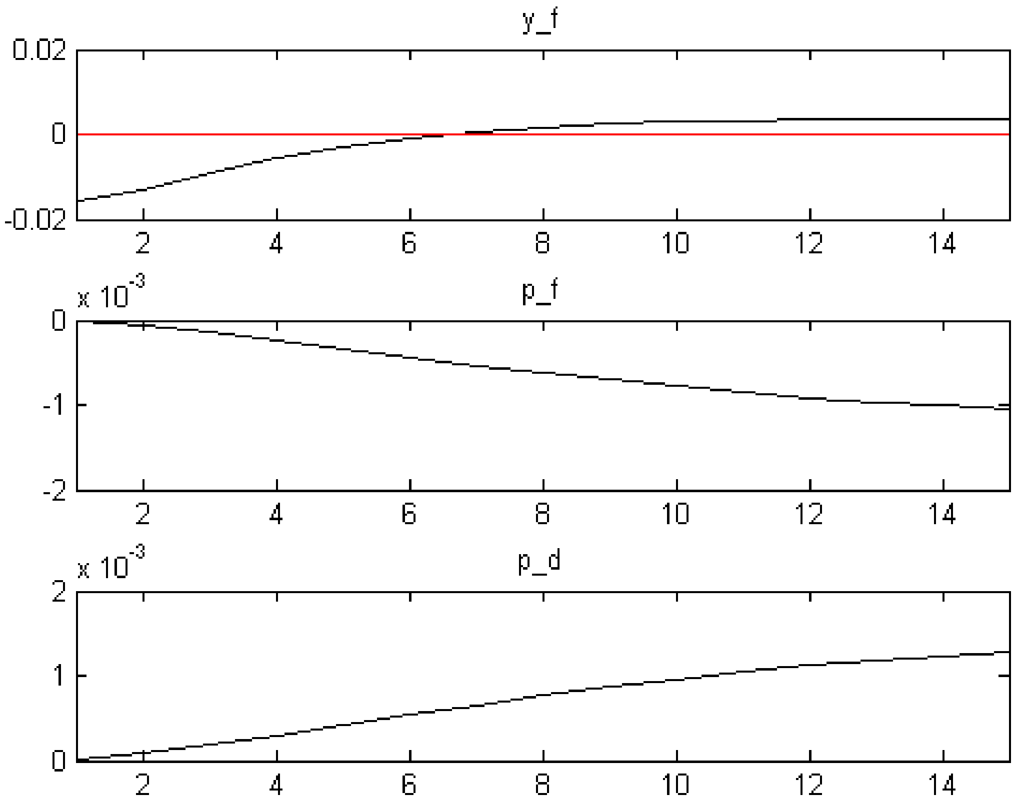
Note: The empirical impulse responses are given by the solid line.

Figure 20: Empirical Impulse Responses to a Monetary Policy Shock (Thailand Quarterly Data 1993 – 2007)



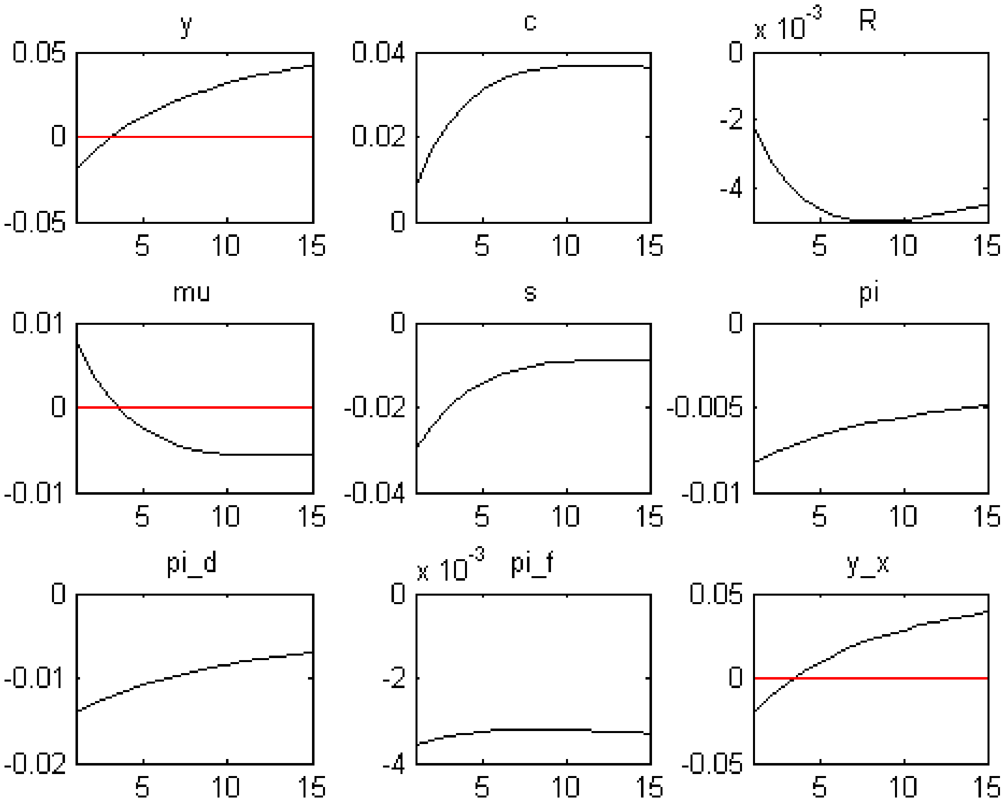
Note: The empirical impulse responses are given by the solid line.

Figure 21: Empirical Impulse Responses to a Monetary Policy Shock Model (Thailand Quarterly Data 1993 – 2007)



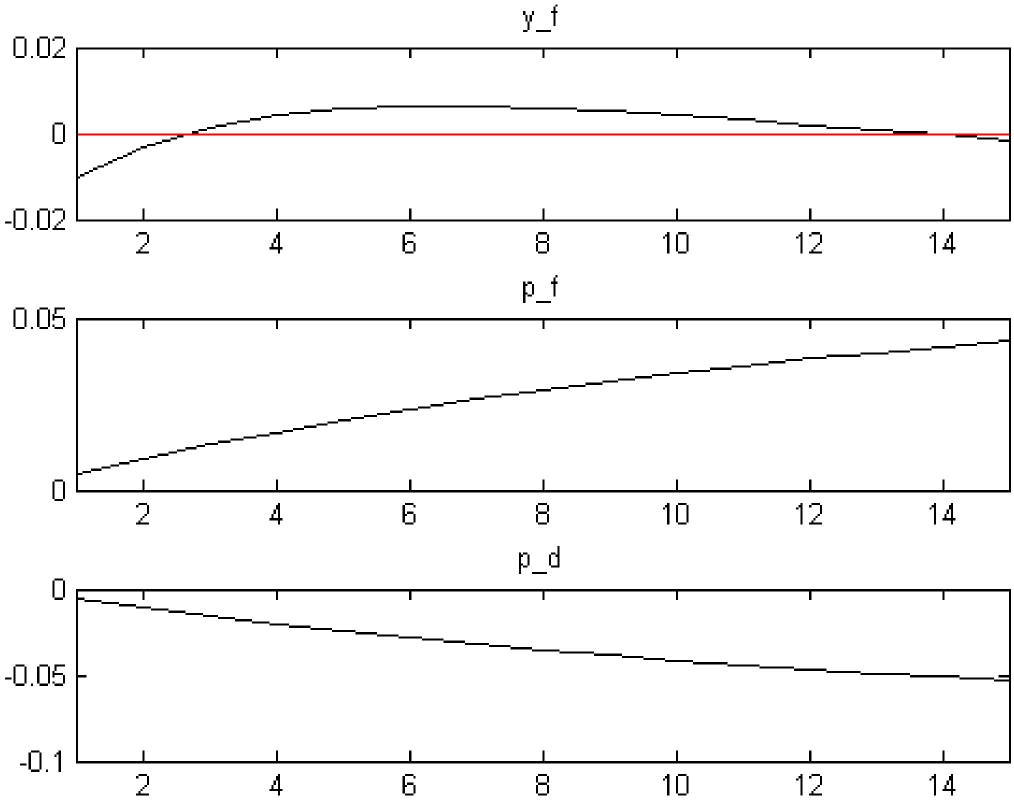
Note: The empirical impulse responses are given by the solid line.

Figure 22: Empirical Impulse Responses to a Technology Shock (Thailand Quarterly Data 1993 – 2007)



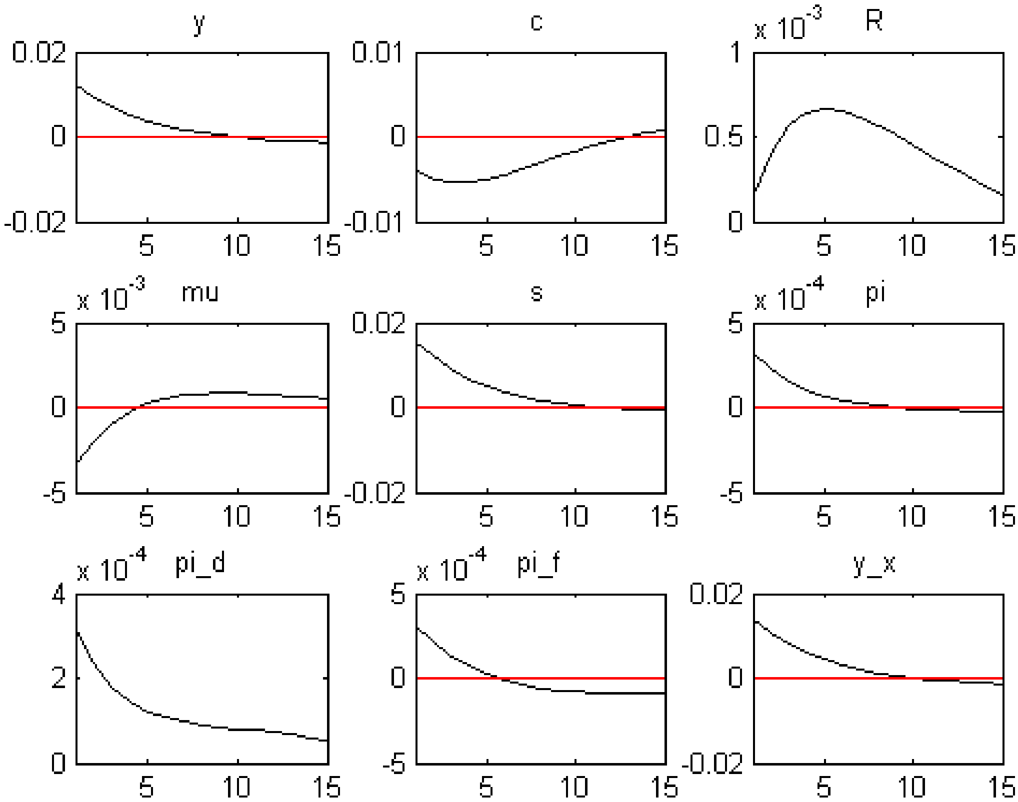
Note: The empirical impulse responses are given by the solid line.

Figure 23: Empirical Impulse Responses to a Technology Shock (Thailand Quarterly Data 1993 – 2007)



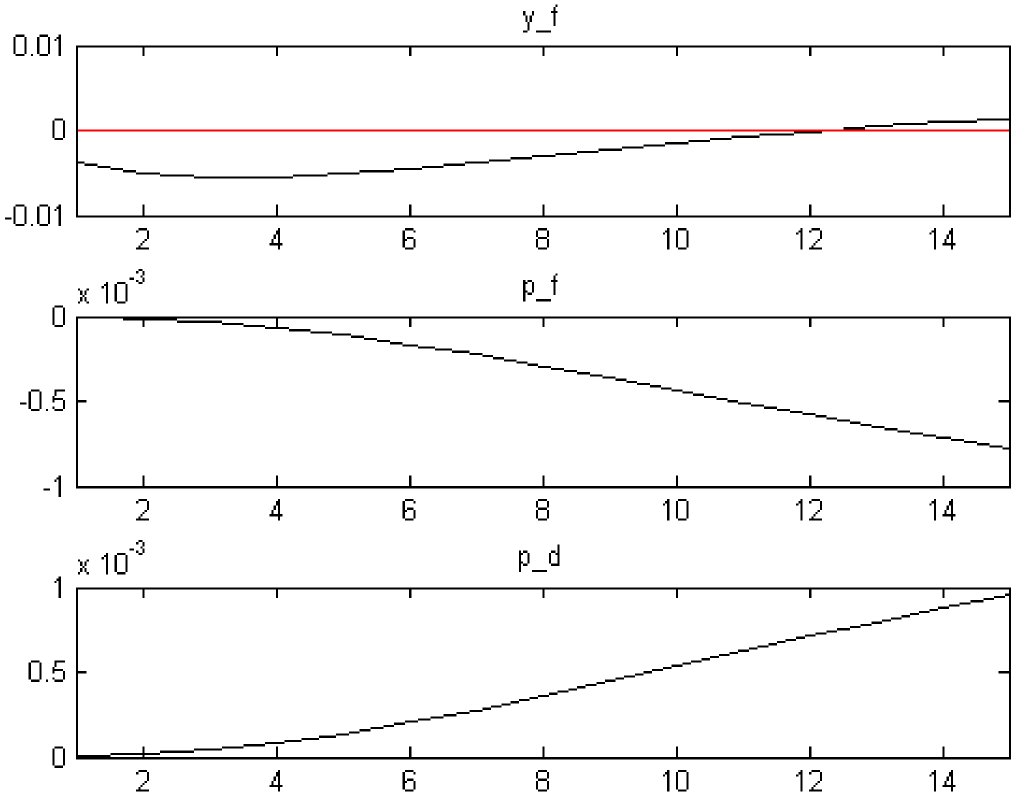
Note: The empirical impulse responses are given by the solid line.

Figure 24: Empirical Impulse Responses to a Foreign Interest Rate Shock (Thailand Quarterly Data 1993 – 2007)



Note: The empirical impulse responses are given by the solid line.

Figure 25: Empirical Impulse Responses to a Foreign Interest Rate Shock (Thailand Quarterly Data 1993 – 2007)



Note: The empirical impulse responses are given by the solid line.

Appendix A: The Non-linear Equilibrium System

$$\lambda_t = \frac{a_t c_t^{-\frac{1}{\gamma}}}{c_t^{\frac{\gamma-1}{\gamma}} + b_t^{\frac{1}{\gamma}} m_t^{\frac{\gamma-1}{\gamma}}} \tag{A-1}$$

$$\lambda_t - \beta E_t\left(\frac{\lambda_{t+1}}{\pi_{t+1}}\right) = \frac{a_t b_t^{\frac{1}{\gamma}} m_t^{-\frac{1}{\gamma}}}{c_t^{\frac{\gamma-1}{\gamma}} + b_t^{\frac{1}{\gamma}} m_t^{\frac{\gamma-1}{\gamma}}} \tag{A-2}$$

$$\lambda_t w_t = \frac{\eta}{1-h_t} \tag{A-3}$$

$$\psi\left(\frac{k_{t+1}}{k_t} - 1\right) + 1 = \beta E_t\left[\frac{\lambda_{t+1}}{\lambda_t}\left(r_{kt+1} + 1 - \delta + \frac{\psi}{2}\left(\frac{k_{t+2}^2}{k_{t+1}^2} - 1\right)\right)\right] \tag{A-4}$$

$$\frac{1}{R_t} = \beta E_t\left[\frac{\lambda_{t+1}}{\pi_{t+1}\lambda_t}\right] \tag{A-5}$$

$$\frac{R_t}{\kappa_t R_t^*} = E_t\left[\frac{s_{t+1}\pi_t}{s_t \pi_{t+1}^*}\right] \tag{A-6}$$

$$\kappa_t = \exp\left(-\frac{\varphi s_t b_t^*}{\tilde{p}_{dt} y_t}\right) \tag{A-7}$$

$$y_t = k_t^{\alpha}[A_t h_t]^{1-\alpha} \tag{A-8}$$

$$w_t = (1-\alpha)\frac{y_t}{h_t} q_t \tilde{p}_{dt} \tag{A-9}$$

$$r_{kt} = \alpha \frac{y_t}{k_t} q_t \tilde{p}_{dt} \tag{A-10}$$

$$\mu_t = \frac{m_t \pi_t}{m_{t-1}} \tag{A-11}$$

$$\tilde{\tilde{p}}_{dt} = \frac{\theta}{\theta-1} \frac{E_t \sum_{l=0}^{\infty} (\beta\phi)^l \lambda_{t+l} y_{t+l} q_{t+l}}{E_t \sum_{l=0}^{\infty} (\beta\phi)^l \lambda_{t+l} y_{t+l} \prod_{i=1}^{l} \pi_{dt+i}^{-1}} \tag{A-12}$$

$$\phi(1/\pi_{dt})^{1-\theta} + (1-\phi)\tilde{\tilde{p}}_{dt}^{1-\theta} = 1 \tag{A-13}$$

$$\tilde{\tilde{p}}_{ft} = \frac{\theta}{\theta-1} \frac{E_t \sum_{l=0}^{\infty} (\beta\phi)^l \lambda_{t+l} y_{ft+l} s_{ft+l}}{E_t \sum_{l=0}^{\infty} (\beta\phi)^l \lambda_{t+l} y_{ft+l} \prod_{i=1}^{l} \pi_{ft+i}^{-1}} \tag{A-14}$$

$$\phi(1/\pi_{ft})^{1-\theta} + (1-\phi)\tilde{\tilde{p}}_{ft}^{1-\theta} = 1 \tag{A-15}$$

$$z_t = c_t + k_{t+1} + \frac{\psi}{2}\left(\frac{k_{t+1}}{k_t} - 1\right)^2 k_t - (1-\delta)k_t \tag{A-16}$$

$$\log(R_t/R) = \rho_y \log(y_t/y) + \rho_\pi \log(\pi_t/\pi) + \rho_\mu \log(\mu_t/\mu) + \rho_s \log(s_t/s) + \log(v_t) \tag{A-17}$$

$$y_{dt} = (1-\omega_f)\tilde{p}_{dt}^{-\nu} z_t \tag{A-18}$$

$$y_{ft} = (\omega_f)\tilde{p}_{ft}^{-\nu} z_t \tag{A-19}$$

$$y_{xt} = \left(\frac{\tilde{p}_{dt}}{s_t}\right)^{-\tau} \tag{A-20}$$

$$y_t = y_{dt} + y_{xt} \tag{A-21}$$

$$\frac{b_t^*}{\kappa_t R_t^*} - \frac{b_{t-1}^*}{\pi_t^*} = \frac{\tilde{p}_{dt} y_{xt}}{s_t} - y_{ft} \tag{A-22}$$

$$(1-\omega_f)\tilde{p}_{dt}^{1-\nu} + \omega_f \tilde{p}_{ft}^{1-\nu} = 1 \tag{A-23}$$

$$\pi_{dt} = \frac{\pi_t \tilde{p}_{dt}}{\tilde{p}_{dt-1}} \tag{A-24}$$

$$\pi_{ft} = \frac{\pi_t \tilde{p}_{ft}}{\tilde{p}_{ft-1}} \tag{A-25}$$

$$\log(a_t) = (1-\rho_a)\log(a) + \rho_a \log(a_{t-1}) + \varepsilon_{at} \tag{A-26}$$

$$\log(b_t) = (1-\rho_b)\log(b) + \rho_b \log(b_{t-1}) + \varepsilon_{bt} \tag{A-27}$$

$$\log(R_t^*) = (1-\rho_{R^*})\log(R^*) + \rho_{R^*} \log(R_{t-1}^*) + \varepsilon_{R^*t} \tag{A-28}$$

$$\log(A_t) = (1 - \rho_A) \log(A) + \rho_A \log(A_{t-1}) + \varepsilon_{At} \tag{A-29}$$

$$\log(\pi_t^*) = (1 - \rho_{\pi^*}) \log(\pi^*) + \rho_{\pi^*} \log(\pi_{t-1}^*) + \varepsilon_{\pi^* t} \tag{A-30}$$

$$\log(v_t) = \rho_v \log(v_{t-1}) + \varepsilon_{vt} \tag{A-31}$$

Appendix B: Log-Linearized System

$$\gamma\left(\frac{a}{m\lambda}\right)\hat{a}_t = \left[\frac{a}{m\lambda} + (\gamma-1)\left(\frac{c}{m}\right)\right]\hat{c}_t + (1-\beta)\hat{b}_t + (\gamma-1)(1-\beta)\hat{m}_t + \gamma\left(\frac{a}{m\lambda}\right)\hat{\lambda}_t \qquad \text{(B-1)}$$

$$\begin{aligned}&\left(\tfrac{a}{m\lambda}\right)\hat{a}_t + \left[\left(\tfrac{a}{m\lambda}\right) - (1-\beta)\right]\hat{b}_t - \left[\left(\tfrac{a}{m\lambda}\right) + (\gamma-1)(1-\beta)\right]\hat{m}_t = \\ &\tfrac{\gamma}{1-\beta}\left(\tfrac{a}{m\lambda}\right)(\hat{\lambda}_t - \beta\hat{\lambda}_{t+1} + \beta\hat{\pi}_{t+1}) + (\gamma-1)\left(\tfrac{c}{m}\right)\hat{c}_t\end{aligned} \qquad \text{(B-2)}$$

$$\hat{h}_t = (\hat{\lambda}_t + \hat{w}_t)\left(\frac{1-h}{h}\right) \qquad \text{(B-3)}$$

$$\psi(\hat{k}_{t+1} - \hat{k}_t) = \hat{\lambda}_{t+1} - \hat{\lambda}_t + (1-\beta+\beta\delta)\hat{r}_{kt+1} + \beta\psi(\hat{k}_{t+2} - \hat{k}_{t+1}) \qquad \text{(B-4)}$$

$$\hat{\lambda}_t - \hat{R}_t = \hat{\lambda}_{t+1} - \hat{\pi}_{t+1} \qquad \text{(B-5)}$$

$$\hat{R}_t - \hat{\kappa}_t - \hat{R}^*_t = \hat{s}_{t+1} - \hat{s}_t + \hat{\pi}_{t+1} - \hat{\pi}^*_{t+1} \qquad \text{(B-6)}$$

$$\hat{\kappa}_t = \left(\frac{\varphi s b^*}{\tilde{p}_d y}\right)(\hat{y}_t + \hat{\tilde{p}}_{dt} - \hat{b}^*_t - \hat{s}_t) \qquad \text{(B-7)}$$

$$\hat{y}_t = \alpha\hat{k}_t + (1-\alpha)\hat{A}_t + (1-\alpha)\hat{h}_t \qquad \text{(B-8)}$$

$$\hat{r}_{kt} = \hat{y}_t + \hat{q}_t - \hat{k}_t + \hat{\tilde{p}}_{dt} \qquad \text{(B-9)}$$

$$\hat{w}_t = \hat{y}_t + \hat{q}_t - \hat{h}_t + \hat{\tilde{p}}_{dt} \qquad \text{(B-10)}$$

$$\hat{\mu}_t = \hat{m}_t - \hat{m}_{t-1} + \hat{\pi}_t \qquad \text{(B-11)}$$

$$\hat{\pi}_{dt} = \beta\hat{\pi}_{dt+1} + \frac{(1-\beta\phi)(1-\phi)}{\phi}\hat{q}_t \qquad \text{(B-12)}$$

$$\hat{\pi}_{ft} = \beta\hat{\pi}_{ft+1} + \frac{(1-\beta\phi)(1-\phi)}{\phi}\hat{s}_{ft} \qquad \text{(B-13)}$$

$$\hat{s}_{ft} = \hat{s}_t - \hat{\tilde{p}}_{ft} \tag{B-14}$$

$$\frac{z}{y}\hat{z}_t = \frac{c}{y}\hat{c}_t + \delta\frac{k}{y}\hat{k}_t \tag{B-15}$$

$$\hat{R}_t = \rho_\pi \hat{\pi}_t + \rho_y \hat{y}_t + \rho_\mu \hat{\mu}_t + \rho_s \hat{s}_t + \log(v_t) \tag{B-16}$$

$$\hat{y}_{dt} = \hat{z}_t - \nu \hat{\tilde{p}}_{dt} \tag{B-17}$$

$$\hat{y}_{ft} = \hat{z}_t - \nu \hat{\tilde{p}}_{ft} \tag{B-18}$$

$$\hat{y}_{xt} = \tau \hat{s}_t - \tau \hat{\tilde{p}}_{dt} \tag{B-19}$$

$$\hat{y}_t = \frac{y_d}{y}\hat{y}_{dt} + \frac{y_x}{y}\hat{y}_{xt} \tag{B-20}$$

$$\frac{sb^*}{\kappa R^* y}(\hat{b}^*_t - \hat{\kappa}_t - \hat{R}^*_t) - \frac{sb^*}{y}(\hat{b}^*_{t-1} + \hat{\pi}^*_t) = \frac{\tilde{p}_d y_x}{y}(\hat{\tilde{p}}_{dt} + \hat{y}_{xt} - \hat{s}_t) - \frac{s y_f}{y}\hat{y}_{ft} \tag{B-21}$$

$$(1-\omega_f)\hat{\tilde{p}}_{dt} + \omega_f \left(\frac{\tilde{p}_f}{\tilde{p}_d}\right)^{1-\nu} \hat{\tilde{p}}_{ft} = 0 \tag{B-22}$$

$$\hat{\pi}_{dt} = \hat{\pi}_t + \hat{\tilde{p}}_{dt} - \hat{\tilde{p}}_{dt-1} \tag{B-23}$$

$$\hat{\pi}_{ft} = \hat{\pi}_t + \hat{\tilde{p}}_{ft} - \hat{\tilde{p}}_{ft-1} \tag{B-24}$$

$$\hat{a}_t = \rho_a \hat{a}_{t-1} + \varepsilon_{at} \tag{B-25}$$

$$\hat{b}_t = \rho_b \hat{b}_{t-1} + \varepsilon_{bt} \tag{B-26}$$

$$\hat{R}^*_t = \rho_{R^*} \hat{R}^*_{t-1} + \varepsilon_{R^*t} \tag{B-27}$$

$$\hat{A}_t = \rho_A \hat{A}_{t-1} + \varepsilon_{At} \tag{B-28}$$

$$\hat{\pi}^*_t = \rho_{\pi^*} \hat{\pi}^*_{t-1} + \varepsilon_{\pi^* t} \tag{B-29}$$

$$\log(v_t) = \rho_v \log(v_{t-1}) + \varepsilon_{vt} \tag{B-30}$$

Appendix C: Steady States

$$\frac{a}{m\lambda} = \frac{c}{m} + 1 - \beta \tag{C-1}$$

$$\frac{c}{m} = \left(\frac{1-\beta}{b^{\frac{1}{\gamma}}}\right)^{\gamma} \tag{C-2}$$

$$h = \frac{wh\lambda}{\eta + wh\lambda} \tag{C-3}$$

$$wh\lambda = \frac{(1-\alpha)(\lambda c)q}{c/y} \tag{C-4}$$

$$\lambda c = [1 + b(1-\beta)^{1-\gamma}]^{-1} \tag{C-5}$$

$$i = \delta k \tag{C-6}$$

$$\frac{c}{y} = \frac{z}{y} - \delta\frac{k}{y} \tag{C-7}$$

$$\frac{z}{y} = \left(1 - \frac{y_x}{y}\right)(1-\omega_f)^{-1} \tag{C-8}$$

$$y = Ah\left(\frac{k}{y}\right)^{\frac{\alpha}{1-\alpha}} \tag{C-9}$$

$$\frac{k}{y} = \frac{\alpha q}{r_k} \tag{C-10}$$

$$r_k = \beta^{-1} - 1 + \delta \tag{C-11}$$

$$q = s = \frac{\theta - 1}{\theta} \tag{C-12}$$

$$R = \kappa R^* = \beta^{-1} \tag{C-13}$$

$$a = \mu = \pi = \pi_d = \pi_f = \tilde{p}_d = \tilde{p}_f = 1 \tag{C-14}$$

$$\frac{y_d}{y} = 1 - \frac{y_x}{y} \tag{C-15}$$

$$\frac{y_x}{y} = \frac{s^\tau}{y} \tag{C-16}$$

$$\frac{y_f}{y} = \frac{\tilde{p}_d y_x}{sy} - (\beta - 1)\frac{b^*}{y} \tag{C-17}$$

$$\frac{sb^*}{\tilde{p}_d y} = ExternalDebttoGDPRatio \tag{C-18}$$

References

Ball, Laurence (1999) 'Policy Rules for Open Economies'. In: John B, Taylor (ed.) Monetary Policy Rules, University of Chicago Press, Chicago. 127-144.

Bask, Mikael (2006) 'Should one augment the Taylor Rule with an Exchange Rate Term?' Helsinki Center of Economic Research Discussion Paper No. 135.

Batini, Nicoletta and Kenny Turnbull (2002)'A Dynamic Monetary Conditions Index for the UK', Journal of Policy Modeling, 24, 257-281.

Batini, Nicoletta, Richard Harrison, and Stephen Millard (2000) 'Monetary Policy Rules for Open Economies', Bank of England Working Paper, September.

Calvo, G.A (1983) 'Staggered prices in a utility-maximizing framework', Journal of Monetary Economics 12: 383-98.

Calvo, G.A and Vincent Reinhart (2002), 'Fear of Floating', Quarterly Journal of Economics, Vol. 117, No. 2, 379-408.

Clarida, Richard, Jordi Galí, and Mark Gertler (2001) 'Optimal Monetary Policy in Open versus Closed Economies: An Integrated Approach', American Economic Review, 91(2), 248-252.

Cook, David, and Michael B. Devereux (2006), 'External Currency Pricing and the East Asian Crisis', Journal of International Economics, Vol. 69(1), 37-63.

Dib, Ali (2002) 'Nominal Rigidities and Monetary Policy in Canada Since 1981', Bank of Canada, Working Paper No. 2002-25.

Dib, Ali (2003)'Monetary Policy in Estimated Models of Small Open and Closed Economies', Bank of Canada, Working Paper No. 2003-27.

Dib, Ali (2003)'An Estimated Canadian DSGE Model with Nominal and Real Rigidities', Canadian Journal of Economics, 36: 949-72.

Fedderke, J. W and Schaling, E., (2005)' Modelling Inflation in South Africa: A Multivariate Cointegration Approach', South African Journal of Economics, Vol. 73, No 1, 79-92

Gal, Jordi and and Tommaso Monacelli (2005) 'Monetary Policy and Exchange Rate Volatility in a Small Open Economy', Review of Economic Studies, 72, 707-734.

Hamilton, James D. (1994), 'Time Series Analysis', Princeton University Press, Princeton, New Jersey.

Ireland, P.N. (2001) 'Sticky-Price Models of the Business Cycle: Specification and Stability', Journal of Monetary Economics, 47:3-18.

Ireland, P.N. (2003) 'Endogenous Money or Sticky Prices', Journal of Monetary Economics, 50: 1623-1648.

Kollmann, R. (2001) 'The Exchange Rate in a Dynamic-Optimizing Business Cycle Model with Nominal Rigidities: A Quantitative Investigation' Journal of International Economics, 55: 243-262.

Kollmann, R. (2002) 'Monetary Policy Rules in the Open Economy: Effects on Welfare and Business Cycles' Journal of Monetary Economics, 49: 989-1015.

, A.T and F. Schorfheide (2007), Do central banks target exchange rates? A structural investigation, Journal of Monetary Economics, 54(4), 1069-1087.

Schmitt-Grohé, S. and Martin Uribe (2003), 'Closing Small Open Economy Models', Journal of International Economics, 61: 163-185.

Schmitt-Grohé, S. and Martin Uribe (2001), 'Stabilization Policy and Costs of Dollarization', Journal of Money, Credit and Banking, 33(2), 482-509.

Svensson, Lars E. O (2000), 'Open Economy Inflation Targeting', Journal of International Economics', 50(1), 155-183.

Taylor, John B (1993), 'Discretion versus Policy Rules in Practice', Carnegie-Rochester Conference Series on Public Policy, Vol. 39, 195-214.

Taylor, John B (2000), 'The Monetary Transmission Mechanism and the Evaluation of Monetary Policy Rules', Central Bank of Chile Working Papers, No. 87.