CHAPTER 4

Capital inflows and the real exchange rate: Analytical framework and econometric evidence

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4.1 Introduction

The magnitude of the capital inflows recorded by developing countries in recent years has raised a variety of issues in the context of macroeconomic management. One of the main challenges faced by policy markers around the world has been how to limit the potentially adverse effects of these inflows on the real exchange rate and the current account. Figure 4.1 illustrates the behavior of the real exchange rate in a group of Asian and Latin American countries since the early 1990s. In most Latin American countries, the real exchange rate experienced a significant real appreciation since the beginning of the inflow episode; in Asia, such a phenomenon was less common. More specifically, while countries like Chile and Malaysia (and, to a greater extent, Korea and Indonesia) have managed to avoid a significant real appreciation, others like Argentina, Mexico (prior to the December 1994 peso crisis), Peru, and the Philippines have recorded a strong real appreciation. In Brazil, the real exchange rate also appreciated significantly between 1991 and end 1994, prior to the adoption of the Real stabilization plan.

As argued in several recent studies, two key factors determine the evolution of the real exchange rate in response to a surge in capital inflows. The first is the macroeconomic policy response. In several countries in Latin America (most notably, Argentina and Mexico and, more recently, Brazil), a fixed (or predetermined) exchange rate has played a key initial role in the authorities' strategy to reduce inflation. But as a

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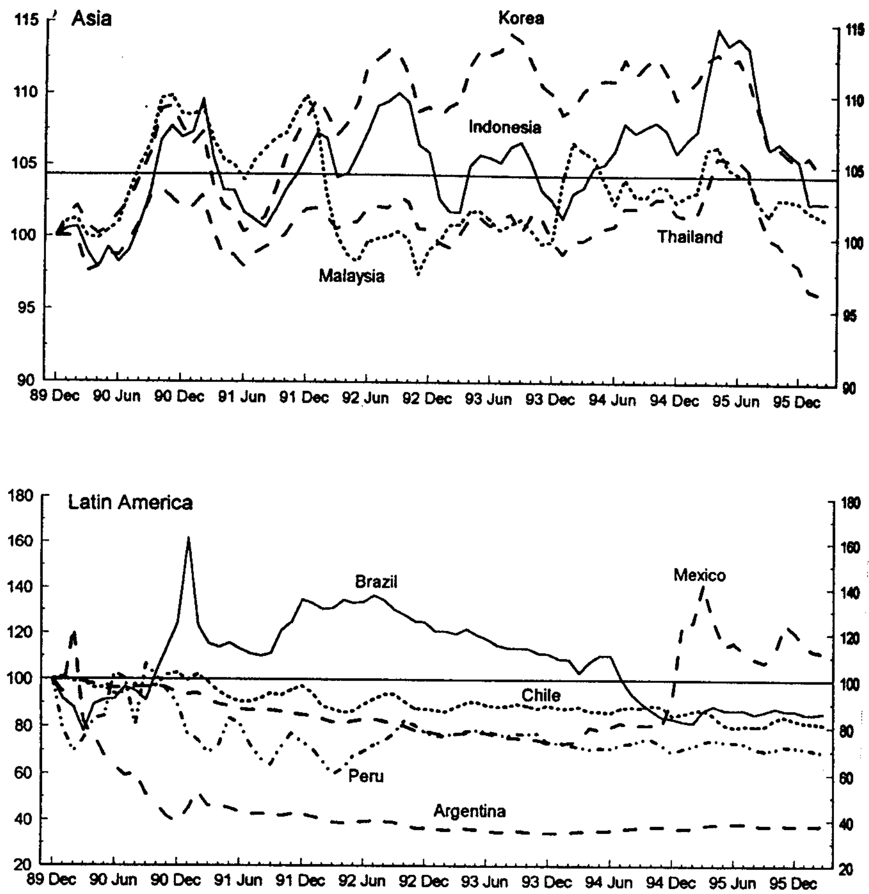


Figure 4.1. Real exchange rates in Asia and Latin America (December 1989 = 100). *Note*: An increase is a depreciation. *Source*: IMF, Information Notice System.

result of inertial factors, continued increases in prices of nontraded goods have often led to upward pressure on the real exchange rate.[1]

The second factor that determines the impact of capital inflows on the real exchange rate relates to the composition of these flows, and their effects on the composition of aggregate demand. As documented by

[1] Another important element in the policy response during the early phase of the capital inflows episode has been sterilization. But as emphasized by numerous authors – see, notably, Calvo, Leiderman, and Reinhart (1996), and Frankel and Okongwu (1996) – sterilization has been largely ineffective.

various researchers, a large proportion of capital inflows to Latin America in the past few years has taken the form of portfolio investment rather than foreign direct investment, in contrast with what occurred in some Asian countries. The fact that capital flows to Latin America were associated mostly with an increase in consumption (with a large component consisting of expenditure on nontradable goods), rather than investment, may explain the large real appreciation observed in some countries. Table 4.1 shows indeed that in Latin America private consumption (as a proportion of GDP) rose by more, and total investment by less, than in Asia since the early 1990s.[2]

The purpose of this chapter is to provide an analytical and quantitative framework for the study of the macroeconomic effects of capital inflows (and their determinants) on short-term fluctuations of the real exchange rate in a fixed (or predetermined) exchange rate regime. Section 4.2 presents the conceptual framework. Section 4.3 develops an econometric model (based on vector autoregression techniques) linking capital inflows, domestic and foreign interest rates, government spending, money base velocity, and the cyclical (or short-term) component of the real exchange rate. The analysis focuses on four countries: Korea, Mexico, the Philippines, and Thailand.[3] Generalized variance decompositions are used to assess the relative importance of various factors in explaining real exchange rate fluctuations, whereas the effects of shocks to world interest rates and government spending are assessed using generalized impulse response functions. The concluding section summarizes the main results of the chapter and discusses some implications of the analysis.

4.2 Analytical Framework

The link between capital movements and the real exchange rate has been addressed in a number of recent studies. A detailed analysis of the effects of various "pull" (domestic) and "push" (external) factors on these variables has been provided by Agénor (1996), in the context of a flexible

[2] For a more detailed discussion, see Calvo, Leiderman, and Reinhart (1996) and the recent study by Corbo and Hernández (1996), which compares the experiences of four Latin American countries (Argentina, Chile, Colombia, and Mexico) and five East Asian countries (Indonesia, Korea, Malaysia, the Philippines, and Thailand) with capital inflows.

[3] While the choice of countries was partly dictated by data availability, the selected group presents some interesting contrasts regarding the macroeconomic effects of inflows. See Corbo and Hernández (1996), Glick and Moreno (1995), and Koenig (1996). All these countries did not, however, pursue a fixed (or predetermined) exchange rate regime during the whole sample period – an issue to which we return.

Table 4.1. *Asia and Latin America: Macroeconomic indicators (annual averages; in percent of GDP, unless otherwise noted)*

	1983–89	1990–95	1994	1995
Asia[a]				
Real GDP[b]	6.3	6.5	7.0	7.4
Consumer price inflation[b]	6.7	8.0	7.6	7.6
Private consumption	62.4	58.4	58.2	58.8
Private saving[c]	22.9	22.0	22.2	22.6
Fiscal balance[d]	–4.2	–2.3	–2.0	–1.9
Current account balance	–0.7	–2.1	–1.7	–2.9
Real effective exchange rate[e]	–3.8	–1.0	1.6	–0.4
Net capital inflows	2.0	3.6	3.4	4.0
Change in reserves	–1.4	–1.6	–1.3	–0.7
Total saving	24.6	27.7	28.2	28.5
Total investment	25.0	29.8	29.9	31.3
Latin America[f]				
Real GDP[b]	2.1	2.6	4.9	0.8
Consumer price inflation[b]	180.5	230.8	263.6	40.8
Private consumption	64.1	67.3	67.5	65.8
Private saving	16.4	13.9	13.9	15.5
Fiscal balance[d]	–4.4	–0.1	0.1	–0.5
Current account balance	–0.6	–1.8	–2.8	–1.8
Real effective exchange rate[e]	–0.3	3.5	6.0	–1.2
Net capital inflows	0.7	3.3	2.3	3.6
Change in reserves	–0.2	–1.5	0.7	–2.3
Total saving	20.1	18.5	18.0	18.2
Total investment	20.0	20.5	21.1	20.0

[a] India, Indonesia, Korea, Malaysia, the Philippines, Taiwan, and Thailand.
[b] Annual percentage change. An increase is an appreciation.
[c] For Indonesia, private saving data for 1983–89 refer to 1988–89 only.
[d] Reflects only central government expenditures and revenues, implying the fiscal balance does not equal net public sector saving.
[e] An increase is an appreciation.
[f] Argentina, Brazil, Chile, Colombia, Mexico, Peru, and Venezuela.
Source: International Monetary Fund *World Economic Outlook* database.

price, two-sector optimizing model of a fixed exchange rate economy. A key feature of the model is the assumption that domestic private borrowers (lenders) face an upward- (downward-)sloping supply curve of funds on world capital markets, and internalize the effect of capital market imperfections in making their portfolio decisions. This leads to a setting in which capital is imperfectly mobile internationally – a feature of the model that appears to be well supported by the evidence for developing countries (Agénor and Montiel, 1996). By allowing domestic interest rates to be determined through the equilibrium condition of the money market instead of foreign interest rates (as implied by uncovered interest rate parity, under perfect capital mobility), feedback effects on capital inflows induced by changes in overall domestic macroeconomic conditions can be better analyzed.[4]

Formally, consider a small open economy in which perfect foresight prevails and four types of agents operate: households, producers, the government, and the central bank. The nominal exchange rate (defined as the home currency price of foreign currency) is devalued at the constant rate ε. The economy produces both traded and nontraded goods, using capital and homogeneous labor. The capital stock in each sector is fixed, and labor is perfectly mobile across sectors.

4.2.1 *Households*

Households supply labor inelastically and consume both traded and nontraded goods. Consumption decisions follow a two-step process: households first determine the optimal level of total consumption, and then allocate that amount between consumption of the two goods. If we assume that government expenditure does not yield direct utility, the representative household's discounted lifetime utility can be written as

$$\int_0^\infty \left\{ \ln m + \frac{c^{1-\eta}}{1-\eta} \right\} e^{-\rho t} dt, \quad \rho > 0 \tag{1}$$

where ρ denotes the rate of time preference (assumed constant), c total consumption expenditure, and m real money balances, measured in terms of the price of the consumption basket, P. The parameter η is positive and different from unity. The instantaneous utility function is assumed to be additively separable in consumption and real money balances. Households hold three categories of financial assets in their portfolios: domestic money (which bears no interest), domestic govern-

[4] The model does not require the rate of time preference to be equal at all times to the world interest rate, as is the case (to ensure a stationary level of consumption) in standard, infinite-horizon optimizing models of small open economies. This is particularly important when analyzing the effect of changes in the world interest rate, since the arbitrary assumption that such shifts are accompanied by an equal change in the rate of time preference is not required.

ment bonds (the real stock of which is b), and foreign bonds b^*. Real wealth of the representative household a can thus be defined as

$$a = m + b + b^*. \tag{2}$$

Both b and b^* are measured in terms of the price of the consumption basket. Specifically, $b^* \equiv EB^*/P$, where E is the nominal exchange rate and B^* represents foreign borrowing measured in foreign currency terms.

The flow budget constraint is given by[5]

$$\dot{a} = q + ib - c - \tau + (i^* - \theta)b^* + \varepsilon b^* - \pi a, \tag{3}$$

where q denotes net factor income (derived later), τ the real value of lump-sum taxes, i the domestic nominal interest rate, and π the domestic inflation rate. The term $-\pi a$ accounts for capital losses on total wealth resulting from inflation, and εb^* the capital gain resulting from the increase in the domestic currency value of foreign assets due to exchange rate depreciation. The rate of return on foreign bonds $i^* - \theta$ consists of an exogenous "base" (or risk-free) interest rate i^* and an endogenous discount θ, which captures risk factors and is positively related to the outstanding level of foreign assets held by the household.[6]

Specifically, we use the linear approximation $\theta \simeq \gamma b^*/2$, where $\gamma > 0$. In the first stage of the consumption decision process, households treat ε, π, q, i, i^*, and τ as given, internalize the effect of their portfolio decisions on θ, and maximize (1) subject to (2) and (3) by choosing a sequence $\{c, m, b, b^*\}_{t=0}^{\infty}$. Let $r = i - \pi$ denote the domestic (consumption-based) real rate of interest and $\sigma = 1/\eta$ the intertemporal elasticity of substitution. The optimality conditions are given by:

$$c^{\eta}/m = i, \quad \Rightarrow \quad m = c^{\eta}/i, \tag{4}$$

$$b^* = (i^* + \varepsilon - i)/\gamma, \tag{5}$$

$$\dot{c}/c = \sigma(r - \rho), \tag{6}$$

together with the transversality condition $\lim_{t\to\infty} (e^{-\rho t} a_t) = 0$. Equation (4) is the money demand function and is derived by equating the marginal rate of substitution between consumption and real money balances to the opportunity cost of holding money, the domestic nominal interest rate.

[5] Except as otherwise indicated, partial derivatives are denoted by corresponding subscripts, while the total derivative of a function of a single argument is denoted by a prime. A sign over a variable refers to the sign of the corresponding partial derivative. Also, by definition, $\dot{x} \equiv dx/dt$.

[6] See Agénor (1996, 1997) for a detailed discussion of this specification.

Equation (5) indicates that holdings of foreign bonds are positively related to the difference between the sum of the risk-free foreign interest rate and devaluation rate, and the domestic interest rate. Equation (6) shows that total consumption rises or falls depending on whether the domestic real interest rate exceeds or falls below the rate of time preference.

In the second stage of the consumption decision process, the representative household maximizes a Cobb-Douglas subutility function $v(c_N, c_T)$, where c_N denotes purchases of nontraded goods, and c_T expenditure on traded goods, subject to the budget constraint $P_N c_N + Ec_T = Pc$, where $P_N(E)$ denotes the price of the home (traded) good.[7] The solution to this program yields the familiar result according to which the representative household sets the marginal rate of substitution between home and traded goods equal to their relative price $z \equiv E/P_N$, that is, the real exchange rate:

$$c_N/c_T = \delta z/(1-\delta), \tag{7}$$

where δ denotes the share of home goods consumption in total consumption expenditure, which is allocated according to

$$c_N = \delta z^{1-\delta}c, \quad c_T = (1-\delta)z^{-\delta}c. \tag{8}$$

The consumer price index P is thus:

$$P = P_N^{\delta}E^{1-\delta}, \quad 0 < \delta < 1 \tag{9}$$

so that

$$\pi = \varepsilon - \delta\dot{z}/z. \tag{10}$$

4.2.2 *Supply side*

Technology for the production of both traded and nontraded goods is characterized by decreasing returns to labor:

$$y_h = y_h(n_h), \quad y_h' > 0, \ y_h'' < 0, \tag{11}$$

where y_h denotes output of good h (with $h = N, T$), and n_h the quantity of labor employed in sector h. From the first-order conditions for profit maximization, the labor demand functions can be derived as

[7] The world price of the traded good is normalized to unity.

$$n_T^{d}{}' = n_T^d\left(\bar{w}_T\right), \quad n_N^d = n_N^d\left(z\bar{w}_T\right), \tag{12}$$

where w_T is the product wage in the traded goods sector. Nominal wages are perfectly flexible. w_T is thus determined by the equilibrium condition of the labor market:

$$n_T^d\left(w_T\right) + n_N^d\left(zw_T\right) = n^s,$$

where n^s denotes the (exogenous) supply of labor. This equation implies that the equilibrium real wage (measured in terms of traded goods) is negatively related to the real exchange rate:

$$w_T = w_T(z). \quad w_T' < 0, \ \left|w_T'\right| < 1. \tag{13}$$

Substituting this result in equations (12), and noting that $d(zw_T)/dz > 0$ yields the sectoral supply functions:

$$y_N^s = y_N^s\left(\bar{z}\right), \quad y_T^s = y_T^s\left(\overset{+}{z}\right). \tag{14}$$

4.2.3 *Government and the central bank*

The only function of the central bank is to ensure the costless conversion, at the official parity, of domestic money into foreign money, and vice versa. Since there is no credit, the real money stock is equal to

$$m = z^{\delta}R, \tag{15}$$

where R is the central bank's stock of net foreign assets, measured in foreign currency terms. Real profits of the central bank consist of interest on its holdings of foreign assets $i^*z^{\delta}R$, and capital gains on reserves $\varepsilon z^{\delta}R$, which are transferred to the government.

The government consumes only home goods, in quantity g_N. For simplicity, it is also assumed to compensate private agents for the loss in interest income incurred as a result of imperfections in world capital markets.[8] It balances its budget by levying lump-sum taxes on households. Setting the constant level of domestic bonds to zero, the budget constraint of the government is thus

$$\tau = z^{\delta-1}g_N + \theta b^* = \left(i^* + \varepsilon\right)z^{\delta}R. \tag{16}$$

[8] This assumption is, of course, somewhat artificial, since households are assumed to make their portfolio decisions without internalizing the fiscal policy rule. However, for the purpose at hand, it does simplify the algebra, without affecting the main implications of the analysis. Agénor (1997) provides a full treatment.

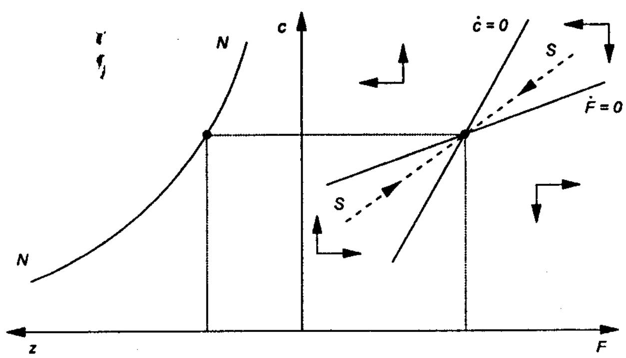


Figure 4.2. Steady-state equilibrium.

4.2.4 *Market-clearing conditions*

To close the model requires specifying the equilibrium conditions for the home goods market and the money market. The former condition is given by

$$y_N^s = \delta z^{1-\delta} c + g_N. \tag{17}$$

Using equation (4), the equilibrium condition of the money market can be solved for the market-clearing interest rate:

$$i = i(\overset{+}{c}, \overset{-}{m}). \tag{18}$$

4.2.5 *Dynamic structure and steady state*

As described in detail by Agénor (1996), the dynamic structure of the model can be reduced to a first-order differential equation system involving two variables: private consumption c (which is a jump variable) and the economy's net stock of foreign assets $F = R + B^*$, which evolves gradually over time as a result of changes in the current account balance:

$$\dot{F} = i^* F + y_T^s - c_T. \tag{19}$$

The steady-state equilibrium of the model is depicted in Figure 4.2. The curve NN on the left-hand side of the figure shows the combinations of consumption and the real exchange rate that are consistent with equilibrium in the market for nontraded goods (equation (17)). On the right-hand side of the figure, the locus $[\dot{F} = 0]$ gives the combinations of c and F for which the current account is in balance (derived from equation (19)), whereas the locus $[\dot{c} = 0]$ depicts the combinations of c and F

for which consumption does not change over time. Saddlepath stability requires that the $[\dot{c} = 0]$ curve be steeper than $[\dot{F} = 0]$ curve. The saddlepath *SS* slopes downward, so that a current account deficit, for instance, must be accompanied by a higher level of private consumption and an appreciating exchange rate. The steady-state solution is obtained by setting $\dot{c} = \dot{F} = 0$. From equation (9), $\tilde{\pi} = \pi_N = \varepsilon$, where π_N is the nontraded goods inflation rate. From equation (6),

$$\tilde{r} = \tilde{i} - \varepsilon = \rho. \tag{20}$$

Substituting this result in (5) yields

$$\tilde{b}^* = (i^* - \rho)/\gamma, \tag{21}$$

and from (4) and (20):

$$\tilde{m} = m(\tilde{c}, \rho + \varepsilon). \tag{22}$$

Finally, from equation (19),

$$\tilde{y}_T^s - \tilde{c}_T = i^* \tilde{F}.$$

Thus, the steady-state solution of the model is such that the current account must be in equilibrium, domestic inflation and the rate of inflation in the price of home goods are equal to the devaluation rate, and the real interest rate is equal to the rate of time preference – so that the domestic nominal interest rate is equal to the rate of time preference plus the devaluation rate. Real holdings of foreign bonds are proportional to the difference between the world interest rate and the rate of time preference, indicating that in the long run domestic private agents can be net creditors (debtors) only to the extent that their rate of time preference is lower (greater) than the foreign discount rate.

4.2.6 *Shocks, capital flows, and relative prices*

To illustrate the functioning of the model, consider a permanent, unanticipated increase in government spending on home goods g_N, financed by an increase in lump-sum taxes (equation (16)). This shock has no long-term effect on the domestic nominal interest rate, as implied by equation (20), and no effect on private holdings of foreign assets, as implied by equation (21). The associated increase in lump-sum taxes exerts a negative wealth effect, which leads private agents to reduce consumption. The "crowding out" effect is not complete, however, so that the real exchange rate must appreciate to maintain equilibrium of the market for nontraded goods. The fall in private spending is associated with a reduction in real money balances, since domestic interest rates do not change (equation (22)). But the shock has an ambiguous effect on the economy's stock of net foreign assets. The reason is that the appreciation of the real exchange rate has an adverse effect on output of traded goods. Since both production and consumption of traded goods fall, the net effect on the trade balance cannot be ascertained a priori; thus, whether the service account surplus (and thus the economy's stock of net foreign assets) must increase or not cannot be determined unambiguously.[9] The two panels in Figure 4.3 illustrate the two cases.

On impact, since the increase in lump-sum taxes associated with the rise in government spending represents a negative wealth effect, private consumption always falls. But the movement in the real exchange rate is now ambiguous and depends on the strength of consumption smoothing effects. If the degree of intertemporal substitution is low (so that private consumption changes by a relatively small amount, implying that net absorption of home goods rises), the real exchange rate will appreciate. Real money balances also fall on impact. But since both private consumption and money holdings fall, the domestic nominal interest rate (and thus the interest rate differential) may either rise or fall on impact; with a low degree of intertemporal substitution it tends to rise – as illustrated in both panels of Figure 4.3. The increase in the rate of return on domestic assets implies that holdings of foreign bonds must fall, so that the economy experiences capital inflows. Because of the monotonicity of the adjustment path toward the new long-run equilibrium, the stock of net foreign assets continuously rises or falls during the transition according to whether it rises or falls in the new steady state. During the transition, consumption rises (falls), and the real exchange rate appreciates (depreciates), if net foreign assets increase (decline).

Consider now the effects of a permanent reduction in the world risk-free interest rate, i^*, and suppose that the country is initially a net creditor ($\tilde{F} > 0$).[10] The long-run effects are a reduction in aggregate

[9] As shown by Agénor (1996) – and, in a related context, by Penati (1987) – the outcome depends, in particular, on the sensitivity of production in the traded goods sector to changes in relative prices.

[10] Many economists have attributed a large role to the cyclical reduction in interest rates in the United States in explaining the surge in capital inflows to developing countries in the early 1990s. See Calvo, Leiderman, and Reinhart (1996), Fernández-Arias (1996), Fernández-Arias and Montiel (1996), and Frankel and Okongwu (1996). Agénor (1996) discusses the effects of various other shocks in the foregoing model, in particular, a positive money demand shock, and an increase in productivity in the tradable sector.

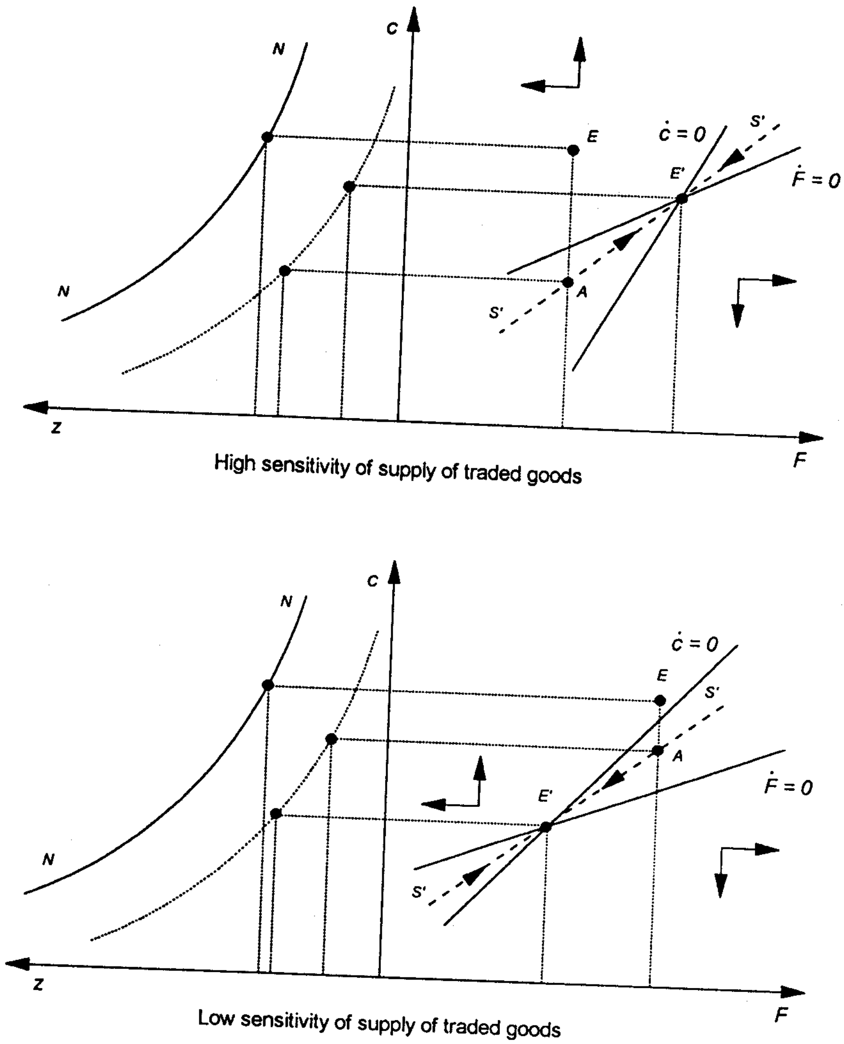


Figure 4.3. Increase in government spending on home goods.

consumption, a depreciation of the real exchange rate, and a reduction in total holdings of foreign assets. At the initial level of the real exchange rate, the reduction in the world interest rate lowers interest income. To maintain external balance, consumption must therefore fall. At the same time, the reduction in the rate of return on foreign assets reduces private demand for foreign bonds. Since consumption falls, real money balances – with the nominal interest rate remaining constant – must also fall. Thus, at the initial level of relative prices, the overall stock of foreign assets falls – compounding the initial negative effect on interest income and the current account. The reduction in consumption expenditure lowers demand for nontraded goods and leads to a depreciation of the real exchange rate, together with an increase in output of traded goods. The fall in consumption of traded goods and the expansion of output of tradables bring about the required improvement in the trade balance, which restores external equilibrium.

Since the steady-state stock of foreign assets falls, the transition (given the permanent nature of the shock and the monotonic nature of the adjustment path) must involve a sequence of current account deficits. However, on impact the real exchange rate may either appreciate or depreciate. The initial effect of a reduction in the rate of return on foreign assets is a fall in interest income for the economy as a whole (since overall holdings of foreign assets cannot change on impact), a reduction in the private demand for foreign bonds, and an increase in the demand for domestic currency holdings. This instantaneous portfolio shift takes place through an inflow of capital (a discrete reduction in private holdings of foreign bonds) and an offsetting movement in central bank holdings of foreign assets, which leads (under unsterilized intervention) to a discrete increase in the real money stock. However, whether domestic interest rates rise or fall to maintain equilibrium in the money market cannot be ascertained a priori, because the real exchange rate (and thus aggregate consumption) may appreciate or depreciate on impact.

Intuitively, the ambiguity emerges as a result of conflicting wealth and intertemporal effects on consumption. On the one hand, the expected future reduction in interest income (induced by the reduction in the world interest rate *and* the level of financial wealth) tends to reduce immediately (at the initial level of the real exchange rate) private expenditure and increase saving. On the other, a reduction in the world interest rate encourages agents to save less (and consume more) today, since the rate of return on foreign assets has fallen (intertemporal effect). Because the initial effect on aggregate consumption is ambiguous, the real exchange rate may either appreciate or depreciate on impact.

If the degree of intertemporal substitution is large, aggregate consumption will rise on impact, and the real exchange rate will appreciate. This is the case characterized in the upper panel in Figure 4.4. Because consumption of both home and traded goods increases, the trade balance (which, in the initial equilibrium, is characterized by a deficit equal in

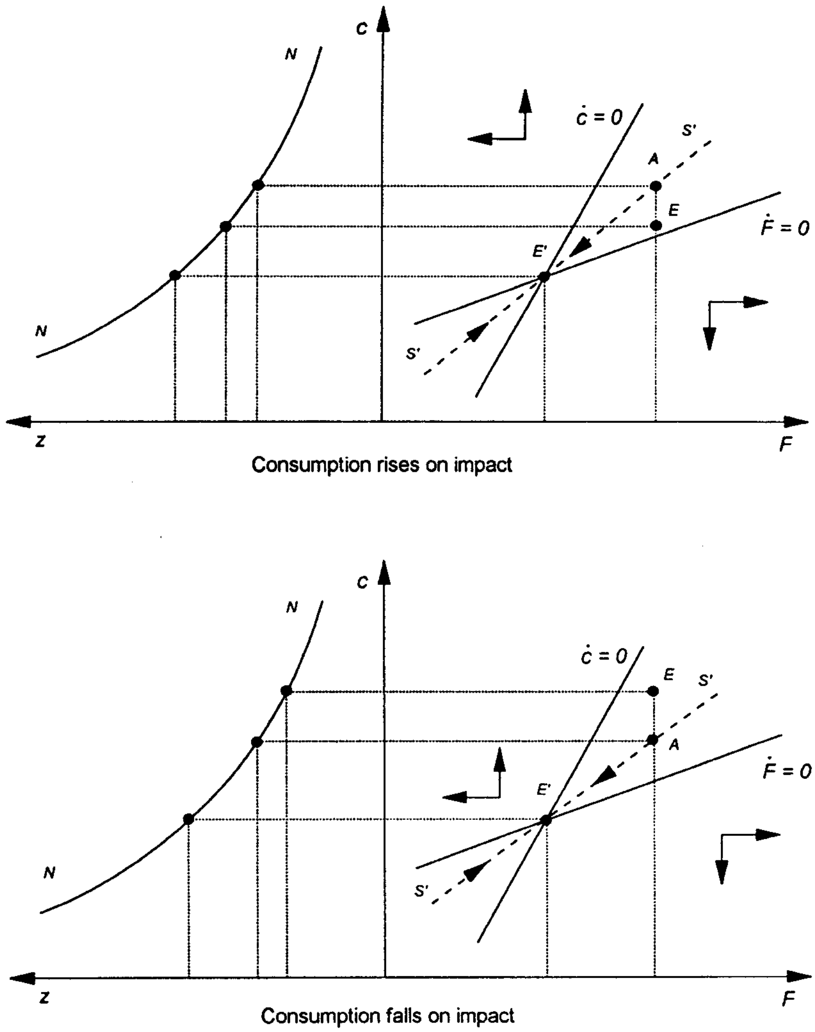


Figure 4.4. Reduction in the world interest rate (net creditor country).

absolute value to interest income on net foreign assets) tends to deteriorate. The real appreciation leads to a reduction in output of traded goods, which compounds the effect of the increase in consumption on the trade deficit. Since interest income received on the initial stock of assets always falls, the economy generates a current account deficit on impact. Real money balances unambiguously increase whereas private holdings of foreign bonds fall. The increase in the domestic money stock (induced by the discrete portfolio adjustment) tends to lower the domestic interest rate on impact, but the increase in consumption tends to raise it. The net effect is in general ambiguous. The increase in domestic interest rates, of course, reinforces the effect of a reduction in the world interest rate on the demand for foreign bonds, and further stimulates capital inflows.

The transition period is characterized by a continuous reduction in the stock of foreign assets (associated with current account deficits), a fall in consumption, and a depreciation of the real exchange rate. The fall in consumption and the expansion in output of traded goods (resulting from the real depreciation) tend to reverse over time the adverse effect of the initial appreciation on the trade balance. The trade deficit falls over time, eventually turning into a trade surplus. However, because interest payments continue to fall with the reduction in the stock of assets, improvements in the trade balance are not large enough to prevent the current account from remaining in deficit until the new steady state is reached. Because the devaluation rate does not change, the nominal interest rate must fall in order to return to its initial value and ensure equality between the real interest rate and the rate of time preference. And since the domestic interest rate falls, holdings of foreign assets by the private sector tend to increase during the transition, thereby leading to capital outflows and lower reserve accumulation by the central bank. The domestic money stock is thus falling during the transition.

If the degree of intertemporal substitution is sufficiently small, consumption will fall on impact and the real exchange rate will depreciate. This is the case characterized in the lower panel in Figure 4.4. Although the fall in consumption of traded goods and the expansion of output of these goods (resulting from the real depreciation) lead initially to an improvement in the trade balance, the reduction in interest income is large enough to generate a current account deficit. The net effect on the domestic interest rate is now unambiguously negative, since consumption falls. This tends to increase the demand for foreign bonds. Because both the world interest rate and the domestic interest rate fall, however, whether the net effect on real money balances and the demand for foreign bonds is positive or negative cannot be determined a priori. Thus, the economy may experience either capital inflows or capital outflows. If the reduction in the world interest rate is larger than the induced reduction in the domestic interest rate, holdings of foreign bonds will fall and the economy will experience capital inflows on impact. Real money balances in this case will rise. Despite the reduction in private expenditure on both categories of goods and the depreciation of the real exchange rate (which stimulates output of traded goods), the fall in interest income ensures that the current account remains in deficit. The domestic interest rate rises gradually toward its initial level, stimulating further capital inflows. With consumption falling and domestic interest rates increasing, real money balances tend to fall over time.

Consider now the case of a net debtor country ($\tilde{F} < 0$). The long-run effects of a permanent reduction in the world interest rate are again a reduction in consumption, a depreciation of the real exchange rate, and a reduction in total holdings of foreign assets – that is, an increase in foreign debt. The initial effect of the reduction in the cost of borrowing on world capital markets is an increase in private foreign indebtedness, which results in higher interest payments and a deterioration of the service account. To maintain external balance in the long run, the initial trade surplus (which is just equal, in absolute terms, to the initial deficit in the service account) must increase. Consumption must therefore fall. This leads to a depreciation of the real exchange rate, which in turn stimulates output of traded goods and further improves the trade balance. Because the nominal interest rate remains constant, real money balances – and thus official reserves – fall also. With foreign borrowing by private agents increasing, and net foreign assets held by the central bank falling, the economy's external debt unambiguously rises.

The impact effects of a permanent reduction in the world interest rate on private spending and relative prices, in contrast to the case where the economy is initially a net creditor, can be signed unambiguously. As illustrated in Figure 4.5, consumption increases, and the real exchange rate appreciates. This is because the wealth and intertemporal effects operate now in the same direction: the reduction in the world interest rate not only encourages agents to save less (and consume more) today, but it also lowers the debt burden and generates a positive wealth effect. Although the trade balance and the service account move in opposite directions (the former deteriorates, whereas the latter improves), the net effect is a current account deficit on impact; and if the degree of intertemporal substitution is sufficiently low, the domestic interest rate will rise on impact, and the economy will experience a capital inflow. Because of the permanent nature of the shock and the monotonic nature of the adjustment process, the current account remains in deficit throughout the transition period, with consumption falling toward its new, lower steady-state level, and the real exchange rate depreciating – with both effects contributing to a gradual reversal of the initial deterioration in the trade deficit. During the transition, with the domestic interest rate returning to its initial value, the economy experiences capital outflows.

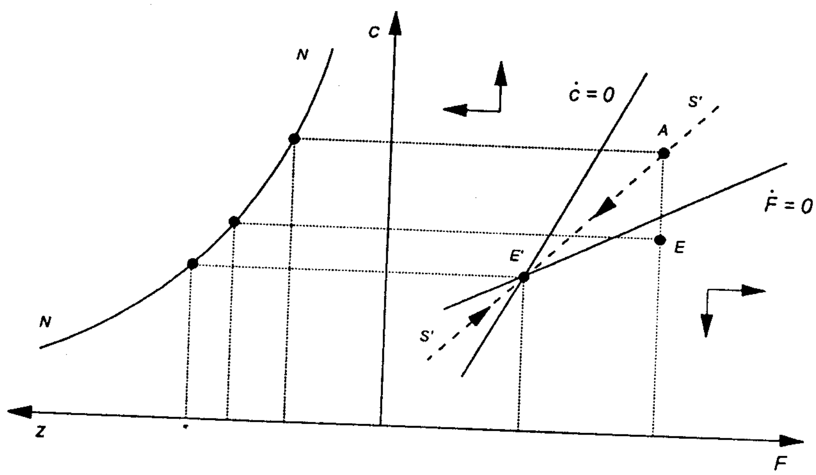


Figure 4.5. Reduction in the world interest rate (net debtor country).

4.3 Econometric analysis

As noted in the introduction, although the links between capital movements and the real exchange rate have been documented in several descriptive studies, there exist very few attempts to examine these links in a quantitative framework. This section presents an econometric analysis that may be useful in that regard. The analysis is based on a near-vector autoregression (near-VAR) model, which captures some of the key relationships emphasized in the analytical model described in the previous section.[11] We begin by presenting the methodology. We then examine variance decompositions and the dynamic response of the system to shocks.

4.3.1 *Methodology*

The specific variables that are included in our near-VAR model are a broad measure of capital inflows in proportion of aggregate output (denoted *ky*), changes in the uncovered interest rate differential (*idiff*), government expenditure as a proportion of aggregate output (*gy*), money base velocity (*veloc*), the change in the "world" interest rate (*iw*), and the temporary component of the real exchange rate (*lzc*), which is

[11] Some recent contributions to the analysis of the macroeconomic effects of capital inflows have used a VAR framework. See Abdel-Motaal (1995), and Morandé (1992). Hamilton (1994) provides a general discussion of VAR and near-VAR approaches.

denoted TCRER and whose derivation is explained later. The near-VAR approach allows us to treat the government spending–output ratio and changes in the world interest rate as block exogenous variables. The endogenous block consists therefore of capital flows, changes in the interest rate differential, TCRER, and velocity. Precise definitions of all variables are given in the appendix. In particular, the world interest rate is proxied by U.S. interest rates.

In line with the analytical model described in the previous section, where the *stock* demand for foreign assets is related to the *level* of the interest rate differential, we relate *changes* in the interest rate differential to capital *flows* in the empirical model.[12] Our empirical specification – whose statistical adequacy is established later – captures the key feature of our theoretical framework, namely, the view that capital movements respond not only to external factors (such as changes in world interest rates) but also to changes in domestic macroeconomic conditions, as captured by movements in domestic interest rates and fiscal policy. The addition of money base velocity plays the role of a "control" variable, which is meant to capture indirect effects of changes in the money supply on capital flows, through their effect on domestic interest rates.

The focus on the TCRER is motivated by two considerations. First, from a statistical point of view, the real exchange rate in the group of countries considered here is not stationary (as indicated by the unit root tests discussed later), while the other variables described earlier are stationary. Detrending the real exchange rate avoids mixing stationary and nonstationary variables in our econometric model. Moreover, the data for the countries in this study (as noted later) are available only for a time span of twelve years or less, whereas available statistical methods require much longer time series to provide reliable long-run inference. From an economic point of view, focusing on the TCRER is related to the assumption that, in line with the analytical framework described in the previous section, it is the stock of net foreign assets, rather than changes in this stock (capital flows), that affect the trend (or steady-state) value of the real exchange rate. The (stationary) temporary component can be interpreted as transitory deviations from the long-run path, resulting from short-term cyclical and speculative factors.[13]

[12] Our treatment of the link between interest rate differentials and the demand for foreign assets may ignore long-run information. In practice, however, given the short size of the sample and available techniques, we are skeptical that these data could be used to make informative long-run inferences.

[13] Note that the cyclical component does not necessarily represent "disequilibrium" movements but rather, as illustrated in the model here, transitional (equilibrium) adjustment

To decompose the real exchange rate into a nonstationary (trend) component and a stationary one, two commonly used techniques are implemented here. The first is the Beveridge-Nelson (BN) approach, the second the Hodrick-Prescott (HP) filter. To highlight the main features of these techniques, suppose that the observed variable x_t has no seasonal component and can be expressed as the sum of a trend x_t^* component and a cyclical component, x_t^c:

$$x_t = x_t^* + x_t^c. \tag{23}$$

At period t, the econometrician can observe x_t but cannot measure either x_t^* or x_t^c. The BN approach is motivated by the observation that many macroeconomic time series are well captured by ARIMA processes. Specifically, suppose that the series x_t follows an ARIMA(p, 1, q) process. Beveridge and Nelson (1981) showed that any such process can be represented in terms of a stochastic trend plus stationary component, where the former is a random walk (possibly with drift) and the latter is an ARIMA(p, 0, q) or, more compactly, ARMA(p, q) process.[14]

Formally, the model for $\{x_t\}_{t=0}^{T}$, where T is the sample size, can be written as

$$\Psi(L)(1-L)x_t = \mu + \Theta(L)\varepsilon_t, \tag{24}$$

where L is the lag operator, $\Psi(L) = \Sigma_{h=0}^{p}\phi_h L^h$, $\Theta(L) = \Sigma_{h=0}^{q}\theta_h L^h$, μ is a constant term, and ε_t is an i.i.d. error. Inverting $\Psi(L)$ gives $(1 - L)x_t = \gamma + B(L)\varepsilon_t$, where $\gamma = (\Sigma_{h=0}^{p}\phi_h)^{-1}\mu$, and $B(L) = \Psi(L)^{-1}\Theta(L)$. Recursively substituting for x_t and assuming that $x_0 = \varepsilon_\tau = 0$ (for $\tau \le 0$) yields

$$x_t = \gamma t + B(L)\sum_{\tau=1}^{t}\varepsilon_\tau,$$

which can be rewritten as (Blackburn and Ravn, 1991):

$$x_t = \gamma t + b\sum_{\tau=1}^{t}\varepsilon_\tau + G(L)\varepsilon_\tau, \tag{25}$$

where $b = \Sigma_{h=0}^{\infty}b_h$, $G(L) = \Sigma_{k=0}^{\infty}g_k L^k$, and $g_k = -\Sigma_{h=k+1}^{\infty}b_h$. The trend and cyclical components are given respectively by $x_t^* = \gamma t + b\Sigma_{\tau=1}^{t}\varepsilon_\tau$ and

to shocks to fundamentals. For an analysis (in an error-correction framework) of the effects of fundamentals on the real exchange rate, see Chinn (1996), Faruqee (1995), and Montiel (1996). The last-named study emphasizes the role of productivity differentials as well as relative stocks of foreign assets.

[14] See also Cuddington and Winters (1987) and Miller (1988). The BN technique has been used by, among others, Baxter (1994) in modeling real exchange rates.

$x_t^c = G(L)\varepsilon_t$. Thus, the trend component follows a random walk with drift. The equivalent representation is therefore

$$x_t^* - x_{t-1}^* = \gamma + b\varepsilon_t, \quad x_t^c = G(L)\varepsilon_t.$$

The second technique used here to define the cyclical component of the real exchange rate is the HP filter.[15] The technique consists essentially in specifying an adjustment rule whereby the trend component of the series x_t moves continuously and adjusts gradually. Formally, the unobserved component x_t^* is extracted by solving the following minimization problem:

$$\underset{x_t^*}{Min}\left[\sum_{t=1}^{T}\left(x_t - x_t^*\right)^2 + \lambda\sum_{t=2}^{T-1}\left[\left(x_{t+1}^* - x_t^*\right) - \left(x_t^* - x_{t-1}^*\right)\right]^2\right]. \tag{26}$$

Thus, the objective is to select the trend component that minimizes the sum of the squared deviations from the observed series, subject to the constraint that changes in x_t^* vary gradually over time. The Lagrange multiplier λ is a positive number that penalizes changes in the trend component. The larger the value of λ, the smoother is the resulting trend series.[16] By manipulating the first-order condition of the minimization problem (see King and Rebelo, 1993), a time domain representation of the HP filter can be developed in which the trend component x_t^* is represented by a two-sided symmetric moving-average expression of the observed series:

$$x_t^* = \sum_{h=-\infty}^{\infty} \alpha_{|h|} x_{t+h}, \tag{27}$$

where the parameters $\alpha_{|h|}$ depend on the value of the Lagrange multiplier λ.

Both of the foregoing decomposition techniques have their limitations. The difficulty with the BN approach results precisely from its flexibility: in practice, identifying the polynomials $\Psi(L)$ and $\Theta(L)$ requires considerable judgment, and choosing among alternative

[15] For a discussion of the properties of the HP filter and a comparison with other detrending methods, see Blackburn and Ravn (1991), King and Rebelo (1993), and Cogley and Nason (1995).

[16] In general, the choice of the value of λ depends on the degree of the assumed stickiness in the series under consideration. Here, we follow the usual practice of setting λ to 1,600 with quarterly time series. However, it should be noted that this choice is somewhat arbitrary; a more appropriate procedure would be to choose a value of λ using a data-dependent method.

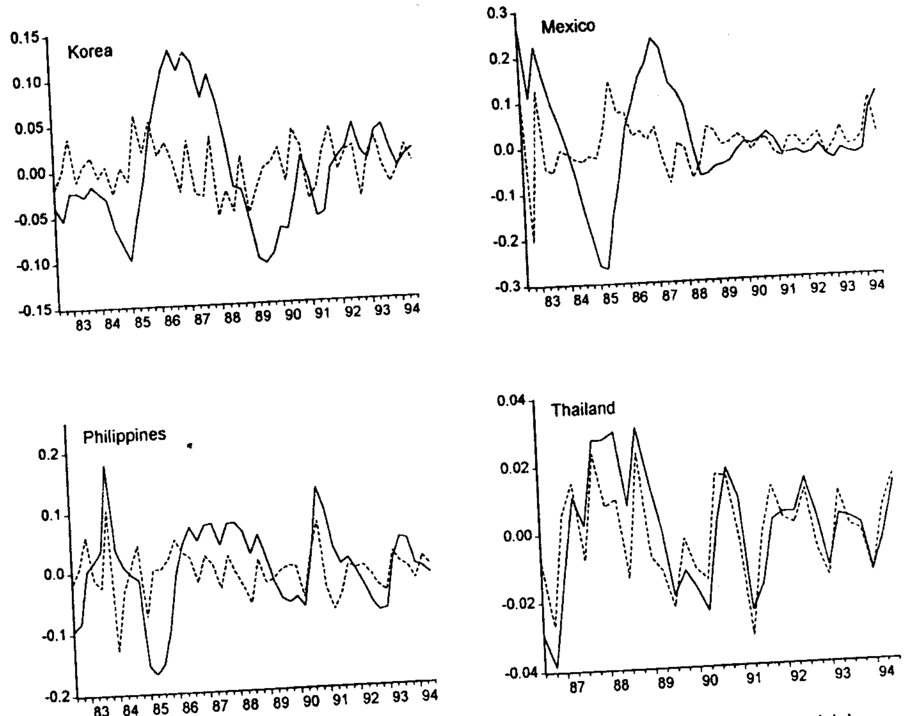


Figure 4.6. Temporary component of the real exchange rate. — = Hodrick-Prescott filter, - - - - = Beveridge-Nelson filter.

parameterizations can be arbitrary. The HP filter has also been the subject of criticism (see Stadler, 1994, pp. 1768–69). In particular, it has been argued that it removes potentially valuable information from time series (King and Rebelo, 1993), and that it may impart spurious cyclical patterns to the data (Cogley and Nason, 1995). Nevertheless, using both procedures here provides a way of testing the sensitivity and robustness of the econometric results to be described.

4.3.2 *Unit root tests and ARMA models*

Figure 4.6 shows the TCRERs derived by using both the BN and HP techniques. An ARMA process for the first differences of (the logarithm of) the real exchange rate was selected on the basis of conventional criteria, starting from an ARMA(2,2) to economize on degrees of freedom. The models selected were an ARMA(0,1) for Korea, ARMA(2,0) for Mexico, ARMA(2,2) for the Philippines, and ARMA(1,1) for Thailand. As shown in the figure the two series for Thailand are fairly similar throughout the sample period. For the other countries these series show similar movements of the TCRER during the 1990s. In the early part of the sample, however, these series show different movements of the TCRER. For example, the HP filter suggests that the TCRER depreciated from 1985 through 1987 for these other countries, whereas the BN filter suggests the reverse. Note further that the HP filter seems to identify a fairly regular cyclical movement for Korea and Mexico.

Prior to estimating the near-VAR model, each set of series was tested for stationarity. Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) unit root tests were employed (see Dickey and Rosanna, 1994). The results of these tests – based on a unit-root null versus a trend-stationary alternative – are reported in Appendix Table 4.A1. In general, both test statistics give similar results, although in a few cases differences exist and the significance level is not always large. In almost all cases, the results support the assumption that the "world" interest rate (proxied by the U.S. Treasury bill rate) is differenced stationary, whereas all the other variables are stationary in levels. Note that for Korea, there appears to be only weak evidence of stationarity of the TCRER obtained by the HP filter; this feature of the data is accounted for in the estimation of the near-VAR, as indicated later.

4.3.3 *Variance decompositions*

The near-VAR model (with seasonal dummies in each equation) was estimated using the two different measures of the TCRER discussed previously over the period from the first quarter of 1982 through the third quarter of 1994 for Korea, Mexico, and the Philippines, and from the third quarter of 1986 through the third quarter of 1994 for Thailand.[17] For consistency across countries and to conserve degrees of freedom, estimation for each country was performed with two lags.[18] The near-VAR model for Mexico includes a dummy variable (equal to one from the 1988 fourth quarter onward) to account for the stabilization program implemented in the late 1980s; this dummy is statistically significant. We

[17] Related to the weak evidence of stationarity of the TCRER obtained with the HP filter for Korea indicated previously, the near-VAR model estimated for that country proved unstable. To deal with this problem, a deterministic time trend was added to the model for Korea.

[18] Standard lag length tests (using Akaike's Information Criterion) suggested that for Korea, Mexico, and the Philippines two lags were appropriate, whereas for Thailand one lag was sufficient. However, for consistency, we used a uniform lag length.

also tried adding a dummy variable for NAFTA (one from the 1993 fourth quarter onward) but this variable was not statistically significant.

The statistical adequacy of the near-VAR models used in this study was tested with a multivariate generalization of the Granger causality test. This generalization is essentially a multivariate likelihood ratio test and the resulting test statistic is distributed as χ^2 with degrees of freedom equal to the number of regressors excluded in the null hypothesis. Specifically, we test the null hypothesis that *iw* and *gy* are jointly block exogenous against the alternative hypothesis that $i\omega$ and *gy* are part of the "endogenous" VAR system. The resulting χ^2 with 20 degrees of freedom (five variables with two lags each excluded from two equations) did not reject the null hypothesis at conventional levels of significance in any of the countries considered in this study.

The estimated models were used to perform "generalized" VAR analysis, as proposed by Koop, Pesaran, and Potter (1996). An attractive feature of this approach is that it does not suffer from the "compositional effect" inherent in standard VAR analysis. As is well known, variance decompositions and impulse response functions derived from standard VAR analysis depend on the ordering of the variables used to obtain the orthogonal shocks.[19] This dependence reflects the fact that changing the ordering changes the implicit linear combination of the VAR innovations used to obtain the orthogonal shock, that is, changing the ordering changes the "composition" of the orthogonal shock.

Generalized VAR analysis is based on rethinking what is to be "recovered" from the estimated VAR (or near-VAR) model. Specifically, consider impulse responses. Typically a VAR is subjected to an orthogonal shock, and the impulse responses trace out the dynamic response of the model to that shock. Note that implicitly these impulse responses compare the evolution of the model following the shock to a baseline model not subject to the shock. Generalized impulse responses (GIR) build upon this idea and propose to look instead at a "typical" historical shock. GIR compares the "average" dynamic responses of the model given a "typical" historical shock and the history of the model, compared with the "average" baseline model not subject to the shock, given the history of the model. Specifically, GIR compares the conditional expectation of a variable in the model given an arbitrary current shock υ_t and history ω_t, to the conditional expectation of that variable given history:

[19] Analysts conducting so-called atheoretical empirical investigations frequently note that their results are robust to the ordering used. However, robustness to different orderings does not guarantee that standard VAR analysis has succeeded in recovering economically meaningful shocks. For a detailed discussion of this issue, see Cooley and LeRoy (1985) and Keating (1996).

$$GIR(x_{t+k}, v_t, \omega_t) = E[X_{t+k}|v_t, w_t] - E[X_{t+k}|\omega_t].$$

For example, consider an economy where the real exchange depends only on fiscal policy and world interest rates. Suppose further that in this economy the data show that when a negative world interest rate shock is observed, the authorities respond with a contractionary fiscal shock. The GIR of the real exchange rate to a world interest rate shock in this economy would trace out, on average, the evolution of the real exchange rate to a typical world interest rate shock – given the historically observed fiscal shocks. It should be clear that since the GIR captures the historically observed information regarding shocks in the data, it does not pretend to recover the responses to a "pure" world interest rate shock.

Likewise, the generalized variance decompositions (GVD) measure does not pretend to measure the percentage of the variance attributed to "pure" shocks. Specifically, in our example, the percentage of the variance of the real exchange rate attributed to the typical world interest rate would also capture the historically observed information regarding shocks in the data. Note that, to the extent that historical shocks are in fact correlated, the GVD will typically not add up to 100 percent.

Table 4.2 presents the GVD of the TCRER at four-quarter intervals (up to sixteen quarters). At short forecasting horizons, the importance of composite shocks to the TCRER dominate movements of TCRER. Note, however, that composite shocks associated with *idiff* play a fairly substantive secondary role in Korea and Thailand at the four-quarter horizon, explaining somewhere in the order of 20 and 40 percent respectively. The evidence for Mexico and the Philippines on this issue is less clear and depends on the filter used to measure the TCRER. In particular, the evidence from the BN filter in both countries suggests that shocks associated with *idiff* play a substantive role in explaining movements of TCRER at the four-quarter horizon – 30 and 50 percent respectively in Mexico and the Philippines – but the evidence from the HP filter does not find this secondary role. With the notable exception of Korea,[20] at this forecasting horizon composite shocks associated with *gv* also appear to explain movements in the TCRER, but the magnitude of this effect is

[20] This contrasts with recent evidence on the importance of "pure fiscal" shocks in explaining real exchange rate movements in Korea. See Hoffmaister and Roldós (1996) for details. For Korea, the lack of importance of composite "fiscal" shocks in our findings could be associated with the fact that the large fiscal adjustments that occurred during the 1980s coincided with contractionary monetary shocks, as noted by Corbo and Nam (1992). Thus, the composite shock associated with *gv* would tend to reflect offsetting effects of fiscal and monetary policies.

Table 4.2 Generalized variance decomposition of TCRER

	HP filter						BN filter					
Quarters	*iw*	*idiff*	*lzc*	*ky*	*gy*	*veloc*	*iw*	*idiff*	*lzc*	*ky*	*gy*	*veloc*
Korea												
1	0.2	24.0	100.0	1.1	0.9	0.5	0.4	18.7	100.0	0.1	0.1	0.0
4	10.9	29.0	69.0	9.6	2.4	6.4	8.5	12.4	62.8	19.1	5.3	3.9
8	14.9	22.7	46.4	10.7	3.5	18.0	8.4	12.0	60.7	20.3	5.5	5.1
12	11.5	17.5	36.7	8.3	9.3	22.0	8.4	12.0	60.5	20.4	5.5	5.2
16	10.4	15.0	31.5	7.6	13.4	22.9	8.4	12.0	60.4	20.4	5.5	5.3
Mexico												
1	0.0	17.4	100.0	11.2	1.9	0.0	0.0	2.3	100.0	7.8	2.8	0.3
4	5.0	5.9	50.3	27.3	4.5	0.6	12.1	28.8	49.0	11.3	20.3	7.3
8	9.8	4.2	46.8	24.6	8.4	0.6	11.7	29.5	47.0	10.9	21.8	7.2
12	11.2	4.0	45.5	23.8	8.9	0.8	11.5	30.0	46.5	10.9	22.2	7.3
16	11.6	3.9	45.2	23.5	9.2	0.8	11.5	30.0	46.4	10.8	22.2	7.3
Philippines												
1	4.3	5.0	100.0	0.4	3.0	6.5	5.3	0.1	100.0	0.9	8.6	3.8
4	6.0	17.5	32.0	3.0	30.6	2.8	12.2	50.1	34.4	0.5	10.2	12.9
8	9.7	13.4	20.1	2.3	42.8	5.0	14.6	48.4	32.7	1.4	9.8	13.0
12	10.9	13.7	20.4	2.4	41.2	6.0	14.6	48.3	32.6	1.4	9.9	13.0
16	11.1	13.7	20.5	2.4	40.8	6.3	14.6	48.3	32.6	1.4	9.9	13.1
Thailand												
1	5.5	25.9	100.0	1.8	9.3	1.5	8.9	15.6	100.0	3.6	22.2	8.1
4	22.7	32.3	19.4	16.5	11.6	31.0	21.9	53.7	28.6	5.1	15.6	26.3
8	21.6	32.1	16.6	21.0	13.6	27.6	21.8	52.0	27.7	6.9	15.9	26.0
12	21.9	32.0	16.3	21.0	14.0	27.2	21.9	52.0	27.7	6.9	15.9	26.0
16	21.9	32.0	16.3	21.0	14.0	27.2	21.9	52.0	27.7	6.9	15.9	26.0

Notes: Based on the estimated near-VAR models discussed in the text. The percentage of the variance attributed to the historical shocks associated with each variable does not necessarily add up to 100.

filter dependent. Although in Thailand the effect of composite shoc[ks] associated with *gy* explain a fairly stable share of the movements of t[he] TCRER (15 and 10 percent respectively with the BN and HP filters), th[is] is not the case in Mexico or in the Philippines. In Mexico, these compo[s]ite shocks explain about 20 percent of the movements of the TCRER when measured with the BN filter but only about 5 percent when mea[sured] with the HP filter. In the Philippines, filter dependence is also evident: when the BN filter is used 10 percent of the movements of TCRER are explained by shocks associated with *gy* and 30 percent when the HP filter is used.

At sixteen quarters, the bulk of the movements of the TCRER are no longer associated with "own" composite shocks and suggest that the other composite shocks in the model play a role in explaining TCRER. Composite shocks associated with *iw* explain roughly about 10 percent of the movements of TCRER in Korea, Mexico, and the Philippines at this forecasting horizon, and in Thailand they appear to explain about 20 percent. Composite shocks associated with *idiff* explain about 15 and 40 percent of the movements of the TCRER in Korea and Thailand respectively, whereas these shocks explain somewhat less in Mexico and the Philippines when the HP filter is used to calculate the TCRER and explain more when the BN filter is used. Composite shocks associated with *ky* appear to explain about 10 percent of the movements of the TCRER in Korea, Mexico, and Thailand – with some filter dependence evident – but a negligible amount in the Philippines. Composite shocks associated with *gy* appear to explain between 10 and 15 percent of the movements of the TCRER in all countries (except in Korea and the Philippines where the BN filter suggests a small percentage). And finally, composite shocks associated with *veloc* explain about 15 percent of the movements of TCRER in Thailand, about 10 percent in Philippines, about 5 to 20 percent for Korea, and a smaller amount for Mexico.

Table 4.3 presents the GVD of *ky* at four-quarter intervals (up to sixteen quarters). Perhaps the most striking feature is the high degree of autonomy exhibited by these capital flows, that even after sixteen quarters the "own" composite shock still explains somewhere between 60 and 70 percent in all countries. Composite shocks associated with *iw*, *gy*, and *veloc* explain a much smaller amount of the movements in the TCRER at sixteen quarters, each accounting for roughly 10 percent.

4.3.4 *Dynamic response to shocks*

As discussed above, the transitional dynamics induced by a temporary change in any variable in the near-VAR model can be traced using GIRs.

Generalized variance decomposition of ky

Quarters	HP filter						BN filter					
	iw	*idiff*	*lzc*	*ky*	*gy*	*veloc*	*iw*	*idiff*	*lzc*	*ky*	*gy*	*veloc*
Korea												
1	0.4	6.0	1.1	100.0	17.8	2.2	0.0	2.0	0.1	100.0	20.6	0.6
4	2.5	7.5	6.5	84.4	15.8	5.6	3.6	3.0	3.4	85.2	18.8	3.0
8	3.1	7.2	6.2	74.9	15.2	12.0	3.7	2.8	3.7	78.4	17.8	8.6
12	2.9	6.5	6.4	64.7	16.7	15.5	3.9	2.6	3.6	74.3	16.2	11.9
16	3.3	6.3	7.0	57.0	18.2	17.0	4.0	2.4	3.5	72.1	15.1	13.6
Mexico												
1	6.6	3.8	11.2	100.0	0.6	2.4	6.8	1.9	7.8	100.0	0.2	1.6
4	11.0	6.4	8.4	73.2	9.8	7.3	11.8	6.7	5.3	70.6	12.8	3.0
8	13.7	6.2	9.3	69.9	10.5	7.0	22.4	7.1	4.9	61.8	15.9	2.6
12	13.9	6.2	9.5	69.1	10.8	6.9	22.4	7.1	4.9	61.5	16.3	2.6
16	13.9	6.2	9.6	68.9	10.8	6.9	22.4	7.1	4.9	61.4	16.4	2.6
Philippines												
1	3.1	5.5	0.4	100.0	0.4	3.6	3.4	4.1	0.9	100.0	0.4	4.2
4	2.9	4.7	2.4	83.6	5.4	11.5	3.4	3.6	2.0	85.7	4.9	9.3
8	6.1	8.1	4.0	72.3	7.9	16.5	5.3	8.0	2.2	75.4	7.9	14.6
12	6.2	8.2	5.4	69.0	10.1	17.2	5.3	9.0	2.3	72.1	9.5	16.6
16	6.3	8.3	5.7	68.2	10.4	17.6	5.3	9.5	2.3	70.5	10.2	17.7
Thailand												
1	0.7	6.4	1.8	100.0	0.8	0.7	2.1	1.4	3.6	100.0	1.3	8.1
4	3.5	13.7	3.7	63.2	13.9	6.1	12.6	15.1	16.1	61.0	13.6	7.8
8	5.1	13.8	3.7	60.5	16.3	6.2	13.0	15.0	16.2	58.3	14.6	9.0
12	5.1	13.9	3.7	60.4	16.3	6.3	13.1	15.0	16.1	58.1	14.8	9.0
16	5.1	13.9	3.7	60.3	16.3	6.3	13.2	15.0	16.1	58.1	14.8	9.0

Notes: Based on the estimated near-VAR models discussed in the text. The percentage of the variance attributed to the historical shocks associated with each variable does not necessarily add up to 100.

Here we examine shocks to government spending and the world interest rate.[21] We view these two experiments as particularly useful (in light of the discussion provided in section 4.2) to assess the effect of "pull" (internal) and "push" (external) factors.

4.3.4.1 World interest rate shock: GIRs and their one-standard error bands for the TCRER and capital inflows associated with a one-standard deviation reduction in the world interest rate *iw* are illustrated in Figures 4.7 and 4.8, for both measures of the TCRER.[22] Since the world interest rate variable enters in first-differenced form, this shock is tantamount to a permament shock to the level of the variable, and matches closely the experiment performed in the first part of the chapter. To save space, movements in the other variables of the system are not shown, although the behavior of the (change in) interest rate differentials is described here.

Consider first the behavior of capital inflows. The results obtained with the HP filter (Figure 4.7) suggest that a significant increase in capital inflows occurs on impact in the case of Korea and one quarter after the shock in the case of the Philippines; in the latter case, an increase in inflows also occurs in the fifth and sixth periods.[23] In both countries, the movement in inflows reflects a significant increase in (the change in) the interest rate differential between domestic and foreign assets, which improves the attractiveness of domestic assets. The results obtained with the BN decomposition (Figure 4.8) also suggest that capital inflows in Korea and the Philippines increase significantly on impact and in the first quarter after the shock – with no discernible effect in the subsequent periods in the case of Korea, despite a significant increase in the interest rate differential in the third quarter after the shock. They also indicate a significant increase in the interest rate differential in the Philippines after

[21] As noted earlier, these shocks correspond to "historically correct" composite shocks and should not be viewed as "pure structural" shocks. For example, the GIR function for a *iw* shock shows the evolution of the variables in the model to the typical historical *iw* shock that reflects the historical correlation of shocks to that variable with shocks to other variables in the model.

[22] In all figures the dotted lines for the GIRs show one standard error bands in each direction and are based on 1,000 Monte Carlo replications. In each replication we sample the near-VAR coefficients and the covariance matrix from their posterior distribution. From these replications we calculate the square root of the mean squared deviation from the impulse response in each direction. By construction these bands contain the impulse response function but are not necessarily symmetric. See Kloek and Van Dijk (1978) for details of the posterior distributions.

[23] Throughout this discussion a "significant" change means that the interval defined by the error bands does not contain the value zero.

two quarters, with capital inflows increasing significantly and showing some persistence.

For Thailand, the results with the HP filter indicate that capital inflows do not appear to be very responsive to the interest rate shock, although a slightly significant effect can be detected in the second quarter after the shock – mirroring a significant improvement in the interest rate differential at that period. The results obtained with the BN decomposition show a more significant effect in the second quarter (which again mirrors the movement in the interest rate differential) and a slight recovery in the third quarter. The response of capital movements in Mexico is somewhat counterintuitive: with both filtering methods, there is a significant reduction in capital inflows on impact (despite the fact that the interest rate differential shows no significant movement during that period). Results obtained with the BN filter indicate another fall between the third and sixth quarters. Those obtained with the HP filter, however, suggest a slightly positive effect in the first quarter after the shock.

Consider now the movements in the TCRER. In Korea and Mexico, both filtering methods indicate that there is no significant effect on the TCRER on impact. After one quarter, however, there is a slight real appreciation (which does not persist) in Mexico, whereas in Korea, two quarters after the shock, the TCRER depreciates, with the effect showing some persistence (notably with the HP filter) until the sixth quarter. The TCRER subsequently appreciates with the HP filter, but a comparison with the results obtained with the BN filter suggests that this effect is not robust. In both Thailand and the Philippines, the GIRs show a slight depreciation of the TCRER, followed by a statistically more significant appreciation in the first and second quarters after the shock. The response of the TCRER in both countries is more short-lived with the BN filter. For the Philippines, and in line with the drop in capital inflows noted earlier, the TCRER depreciates after the fourth quarter – a movement that displays some persistence over time.

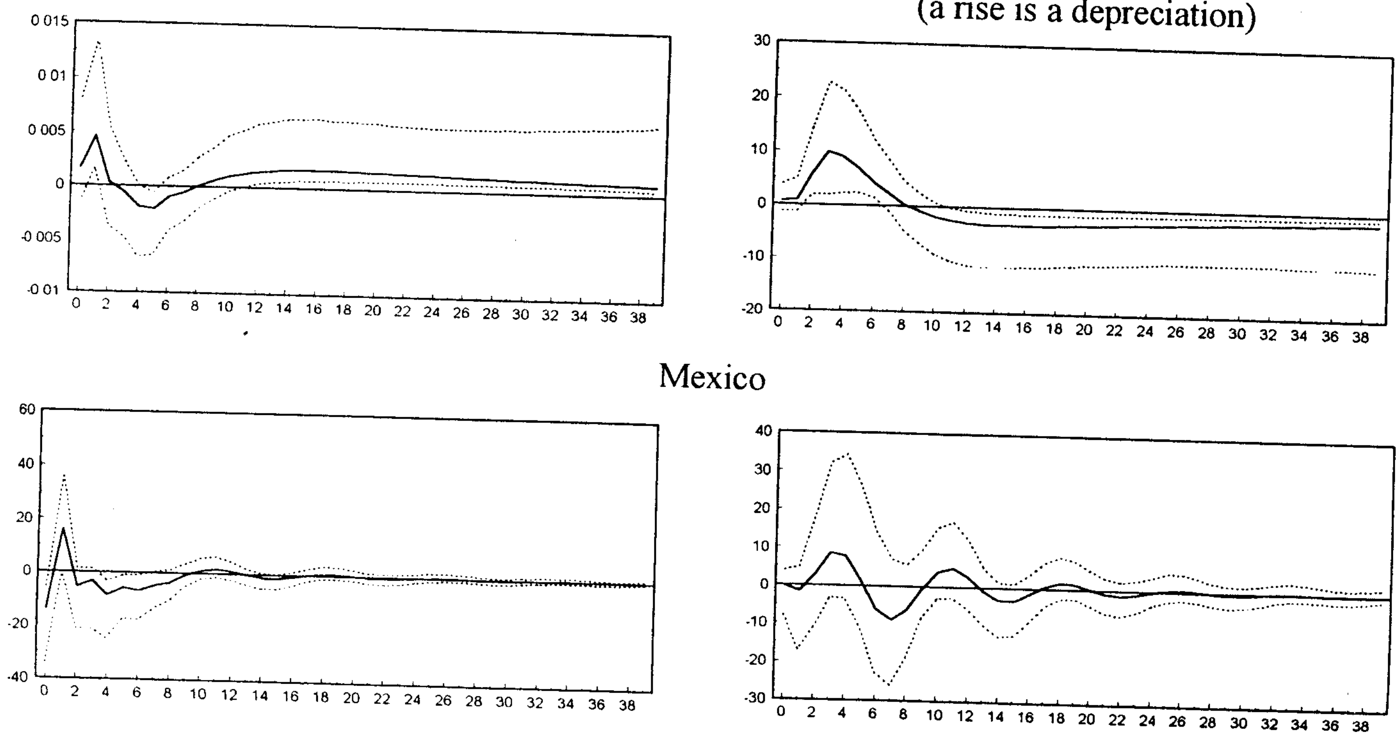
4.3.4.2 Government spending shock: Figures 4.9 and 4.10 illustrate the GIRs and their one standard error bands for the TCRER and capital inflows associated with a one standard deviation change in the government spending–output ratio *gy*.[24] Results obtained with both the HP and BN filters show very similar results for Korea, namely a significant

[24] Note that here, in contrast to the previous experiment, we are looking at a temporary rather than permanent shock; thus, a comparison of the empirical results and the theoretical predictions described earlier should focus on the short-term (impact) effects of the shock.

Capital Inflows

Korea

Temporary Component of the Real Exchange Rate (a rise is a depreciation)



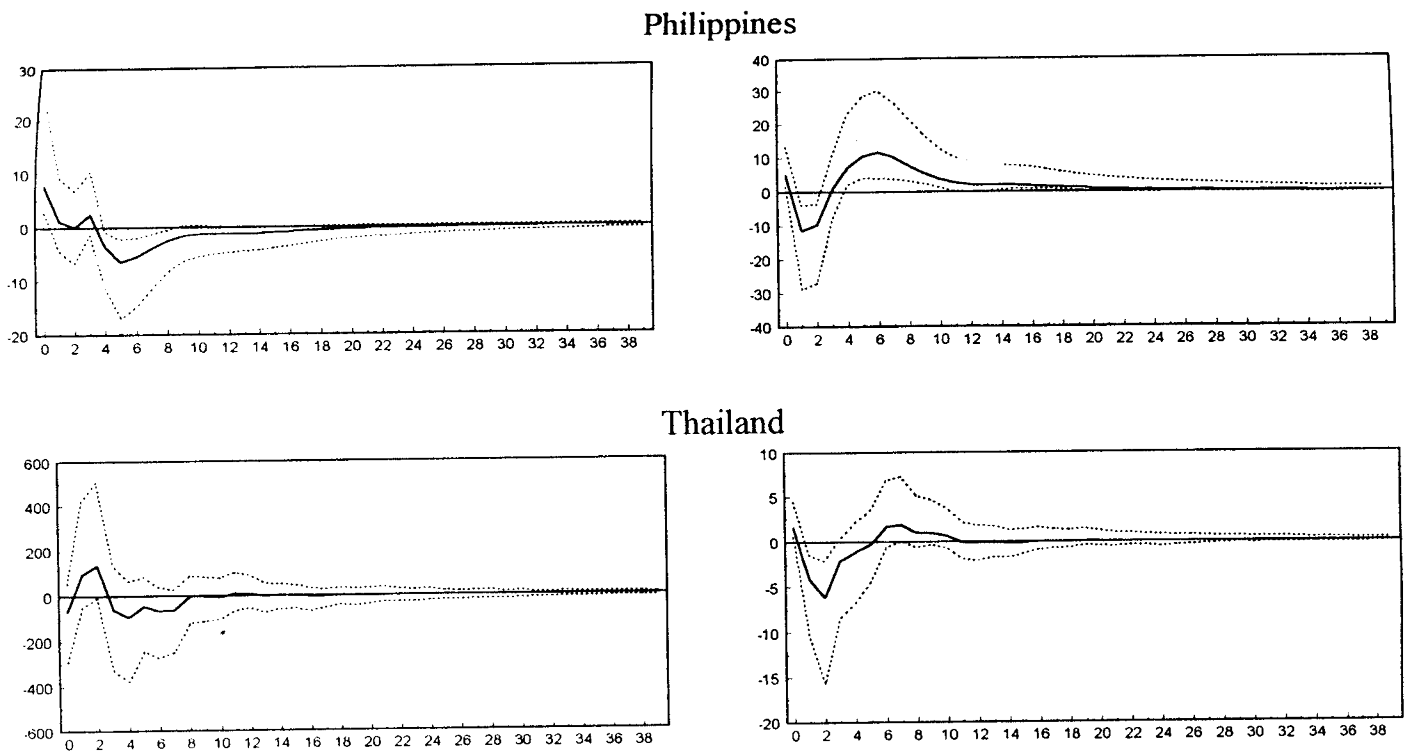
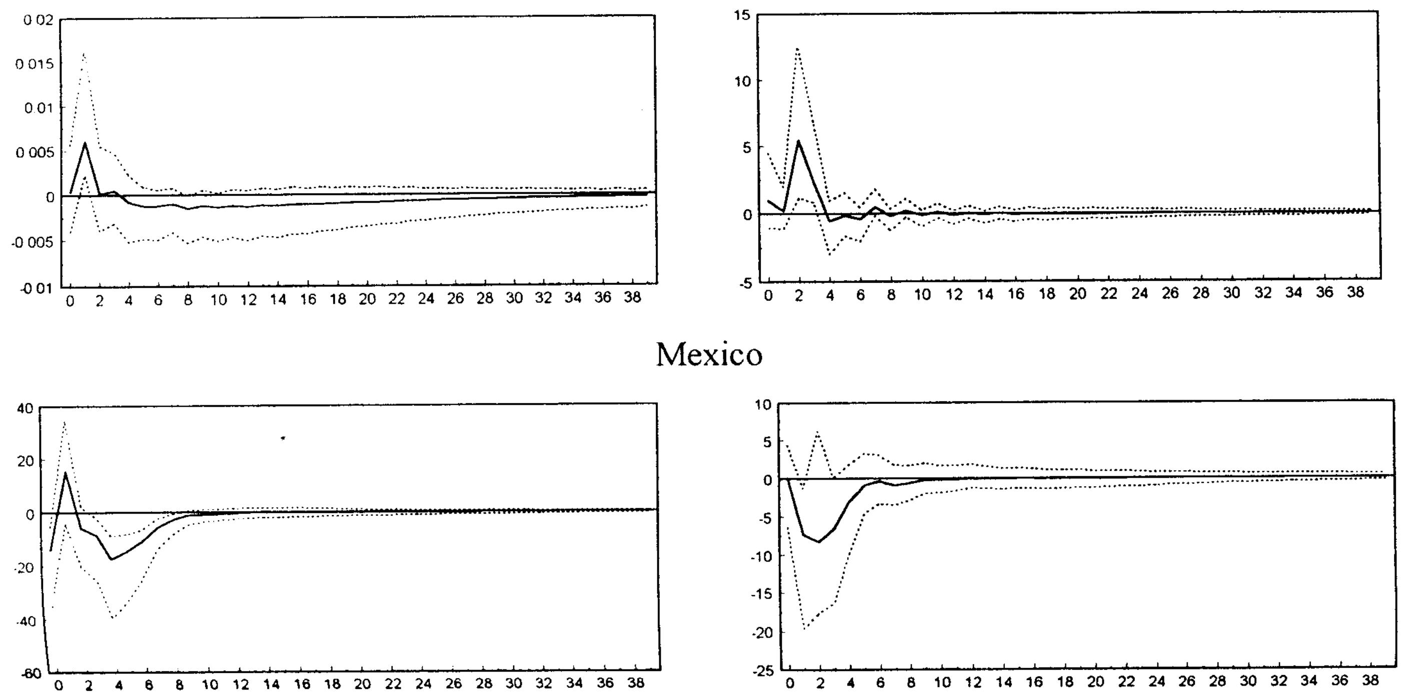


Figure 4.7. Generalized impulse responses to a fall in *iw*, HP filter.

Capital Inflows

Temporary Component
of the Real Exchange Rate
(a rise is a depreciation)

Korea



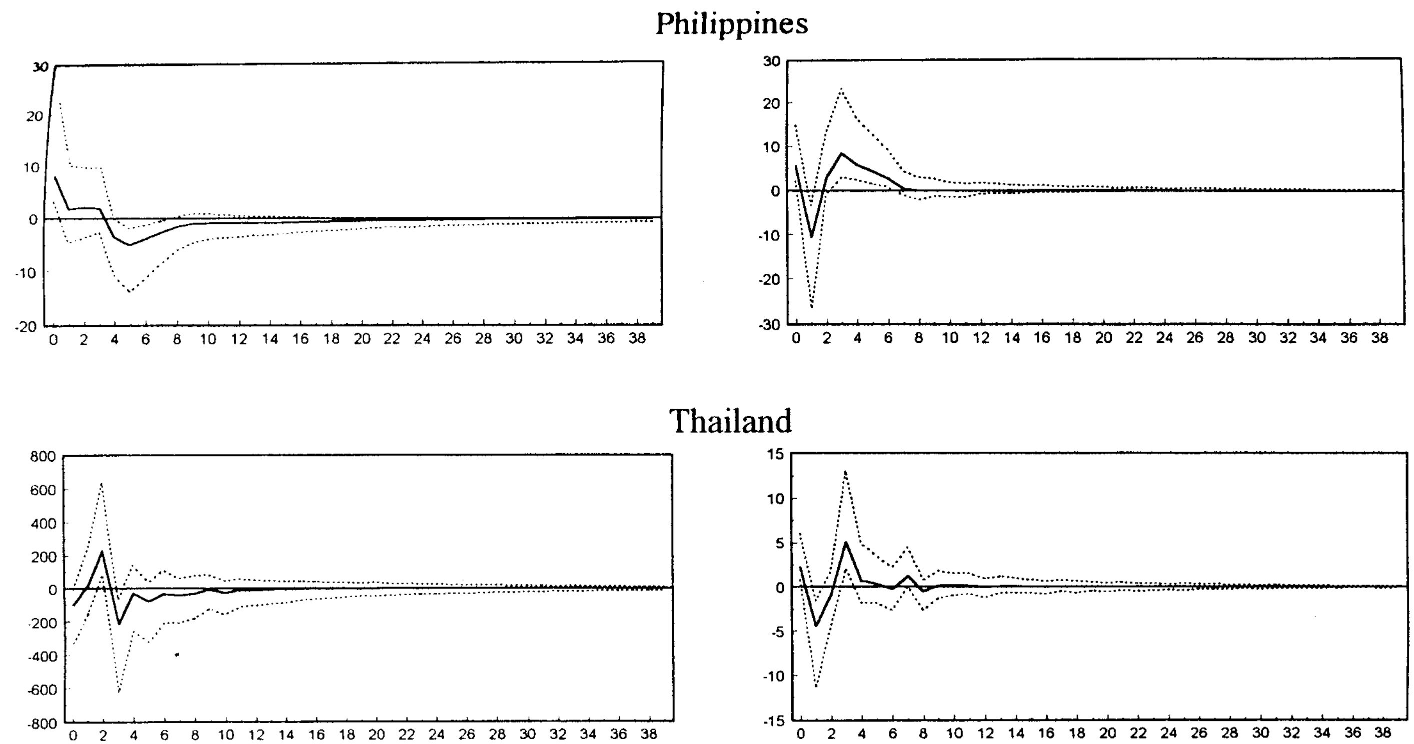
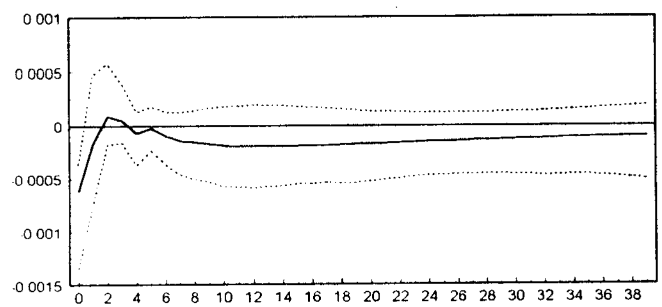


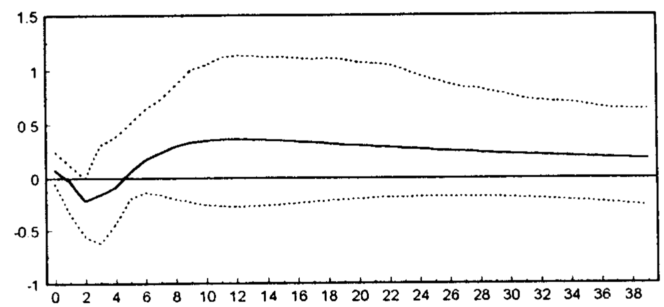
Figure 4.8. Generalized impulse responses to a fall in *iw*, BN filter.

Capital Inflows

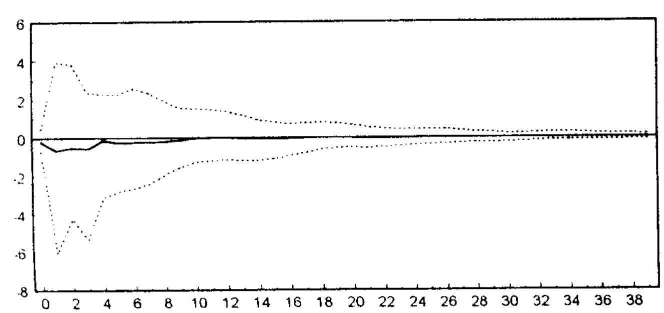
Temporary Component of the Real Exchange Rate (a rise is a depreciation)

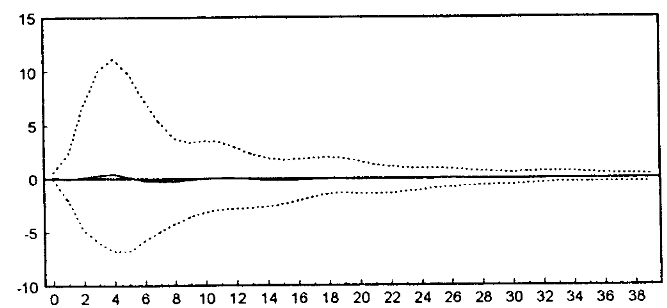
Korea



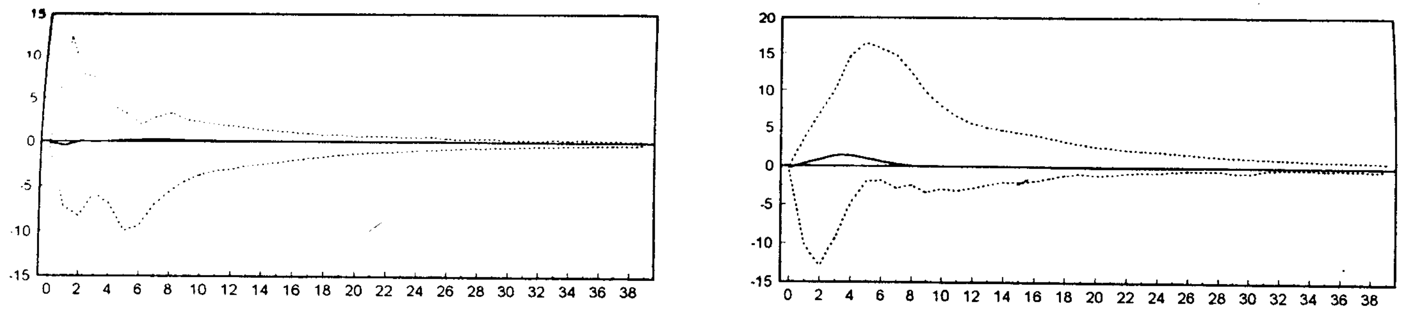


Mexico





Philippines



Thailand

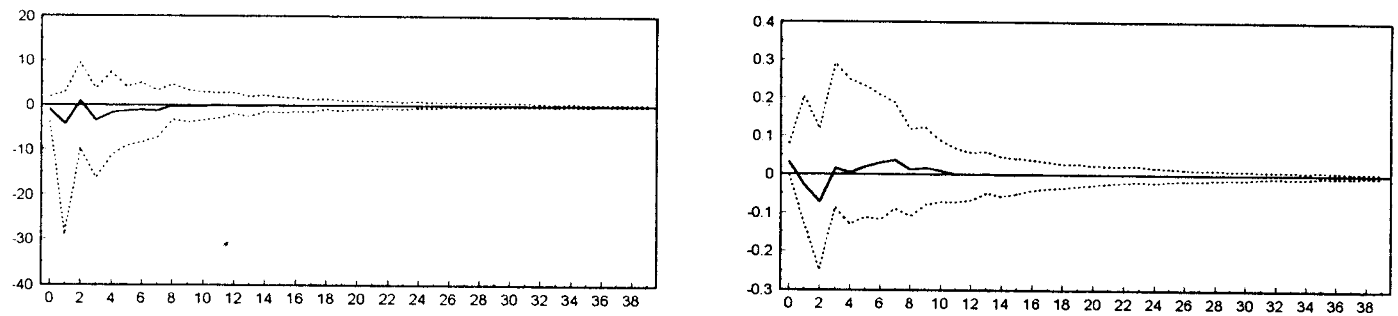


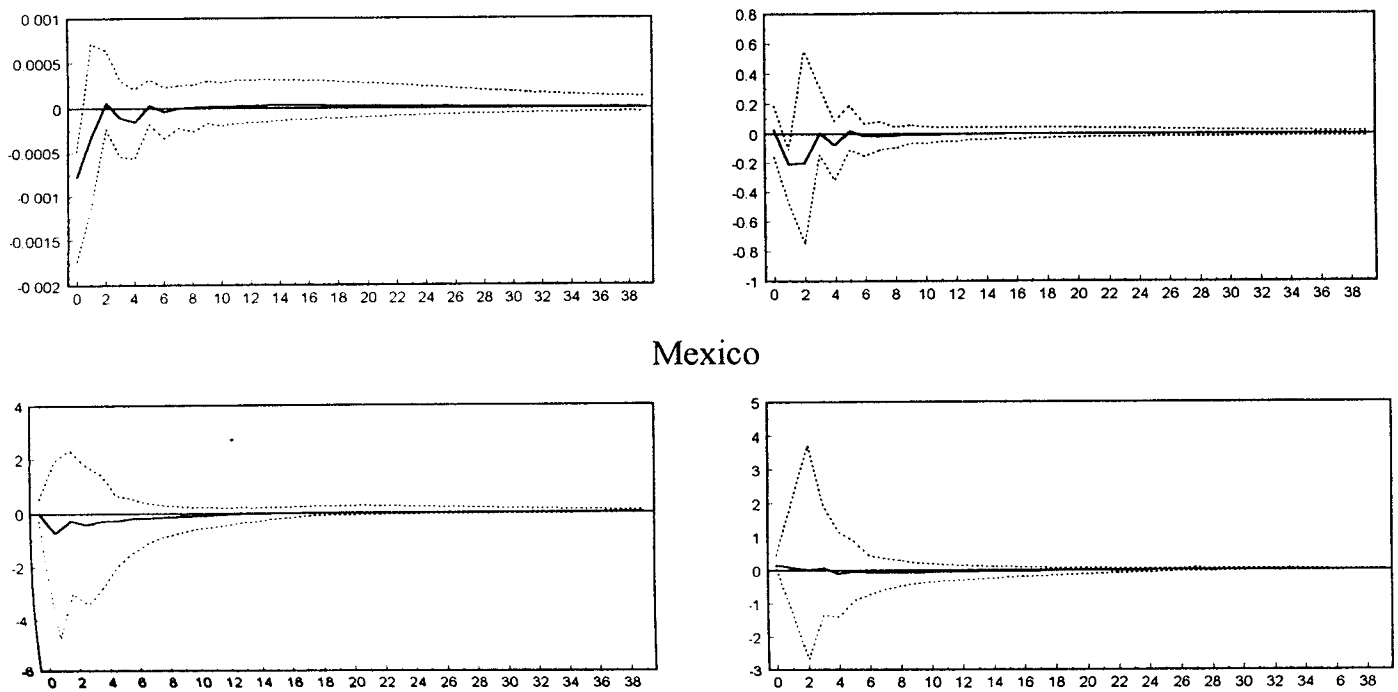
Figure 4.9. Generalized impulse responses to a rise in *gy*, HP filter.

Capital Inflows

Temporary Component of the Real Exchange Rate (a rise is a depreciation)

Korea

Mexico



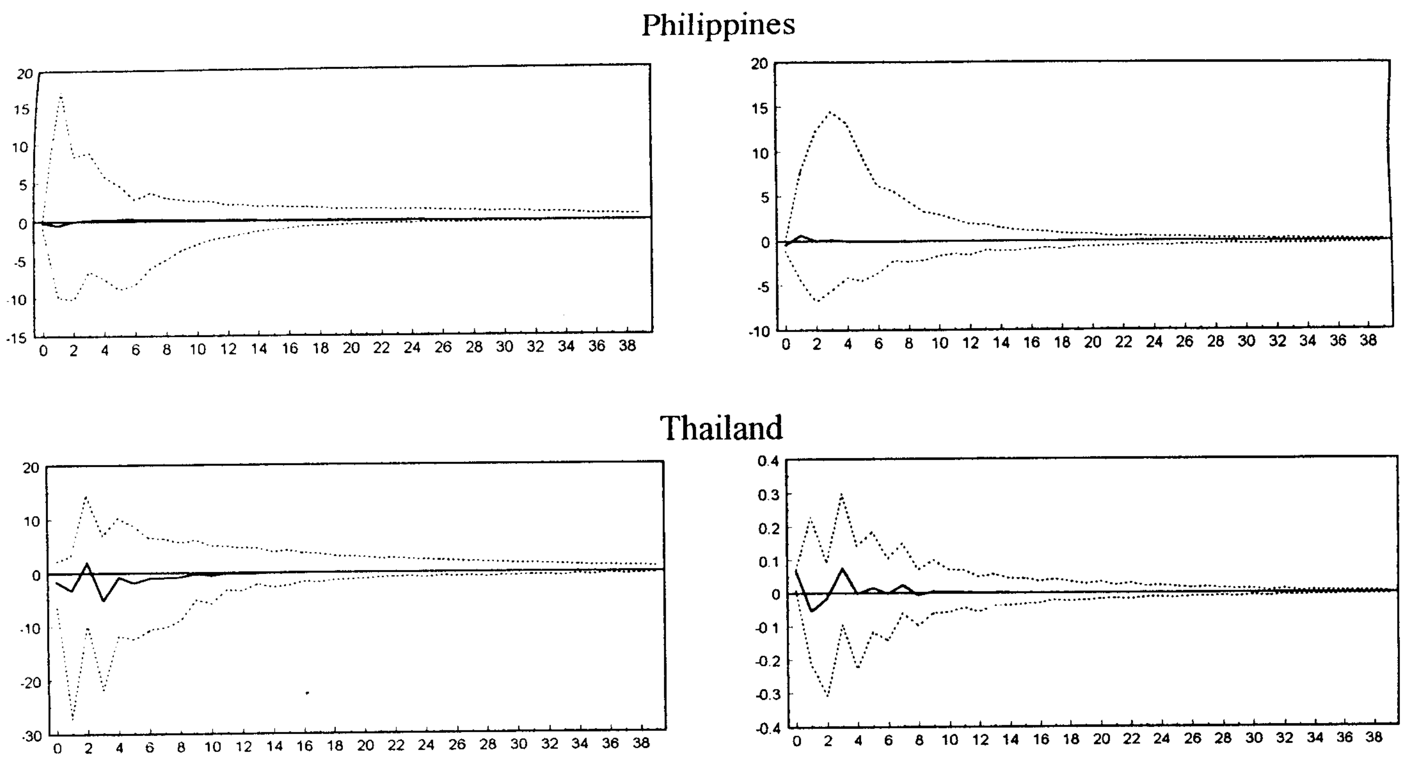


Figure 4.10. Generalized impulse responses to a rise in *gy*, BN filter.

reduction in capital inflows (which mirrors again a reduction in the interest rate differential) when the shock takes place, with little persistence over time. For all the other countries, the predictions obtained with the two filters are again consistent: there appears to be no statistically significant effect of an innovation in the government spending–output ratio on capital movements.

The response in the TCRER is statistically significant only in the case of Korea and Thailand, when looking at the results obtained with the BN filter. In Korea, the TCRER appreciates slightly after one quarter, whereas it depreciates slightly in Thailand. In both cases, the effect is short-lived.

To summarize, therefore, the GIRs suggest that a negative innovation in the (change in) world interest rate leads to a capital inflow in all Asian countries and an initial outflow followed by an inflow in the case of Mexico, with little persistence over time; a significant appreciation of the TCRER is observed (with a one-quarter lag) in the Philippines and Thailand, with some degree of persistence in both countries, whereas no discernible effect can be detected in the case of Mexico. In Korea, the TCRER depreciates significantly in the second quarter after the shock. A positive innovation in the government spending–output ratio has significant effects only in the case of Korea, leading to a reduction in capital inflows and a slight appreciation of the TCRER. Both effects are short-lived. With both types of shocks, movements in capital flows appear to be closely related to changes in the rate of return differential between domestic and foreign assets.

How do these quantitative results fare in light of the predictions of the analytical model described in the first part of the chapter? At the outset, it should be noted that the empirical model does not capture all the complexities involved in the theoretical model, and that by its very nature, a VAR-type methodology does not allow us to identify structural relationships and transmission mechanisms. Nevertheless, it is clear that the response of capital inflows and the real exchange rate in some of the Asian countries to changes in world interest rates is broadly consistent with the predictions of the model, as described in the net debtor case. The pattern of capital inflows in Mexico (an initial reduction followed by an increase) is somewhat more difficult to rationalize. It should be kept in mind, however, that our econometric model aims only at explaining short-term, *cyclical* movements in the real exchange rate; it cannot be excluded that capital inflows (or, more precisely, movements in the economy's stock of net foreign assets) induced by changes in world interest rates may have a significant effect on the *trend component* of the real exchange rate. Our approach, by design, does not account for some of the longer-run factors (such as productivity differentials) that might prove relevant to evaluate the existence of this type of effects.

Regarding the effects of the government spending–output ratio, both the existence (as in the case of Korea) and the absence (as is the case for the other countries) of a significant effect on capital inflows and the real exchange rate are consistent with the prediction of the analytical framework. As noted earlier, although private consumption is likely to fall on impact, thereby partly offsetting the increase in public expenditure on total absorption, the degree to which consumption falls determines the ultimate impact on the real exchange rate. One way of looking at the empirical results obtained here is therefore to view private spending as falling relatively little in Korea (thereby requiring a real appreciation to maintain equilibrium of the market for home goods), and falling by a more or less equal amount in the case of the other countries. The interpretation would thus be that private agents in Korea have a lower degree of intertemporal substitution (a stronger desire for consumption smoothing) than in the other countries considered here. Alternatively, it is possible that in Korea the increases in *gy* were viewed mostly as temporary, whereas in the other countries these shocks were mostly viewed as having more persistence. In this case, the GIR for Korea following a *gy* shock would reflect the perception that *gy* would not remain high and thus consumption would not tend to fall as much as otherwise. Of course, a direct test of these propositions, using a more structural approach than the one developed here, would be desirable in order to corroborate these assertions.

Four other factors, which are not captured in the analytical model presented earlier, may prove relevant in assessing the differences in the response of the TCRER to domestic and external shocks in the countries analyzed here: the composition of capital flows, the degree of sterilization, the intensity of capital controls, and the degree of flexibility in exchange rate policy.

1 As noted in the introduction, to the extent that capital inflows take the form of long-term flows, their short-term impact on the real exchange rate is likely to be more limited. However, in all the countries considered (particularly Korea and Thailand), the share of foreign direct investment in total flows remained fairly small during the period under study.
2 The existence of capital controls, to the extent that they are binding, would affect the link between capital flows and interest rate differentials – and thus the effect of the former variable on short-term fluctuations in the real exchange rate. In countries

such as Korea, for instance, the capital account was relatively closed in the early 1980s, and liberalization proceeded only at a gradual pace in the past fifteen years. Introducing in the quantitative model an index of the intensity of capital controls might improve the performance of the model – at least in the case of Korea.

3 As also noted in the introduction, and as documented by Corbo and Hernández (1996), these policies have differed quite markedly among Asian and Latin American countries – including those considered in this study. The use of money base velocity as a "control" variable helps to capture, albeit imperfectly, some of the effects of sterilization policy on money supply and (indirectly) domestic interest rates. The use of a more direct measure of the stance of intervention policy may be an important issue for future research.

4 Finally, the lack of evidence on the links between changes in the world interest rate, government spending, and the TCRER may reflect the fact that countries have allowed the nominal exchange rate to depreciate, in order to alleviate pressures on nontradable prices and the real exchange rate induced by capital inflows. Mexico, in particular, has followed at times a relatively flexible policy during the period under consideration.[25] Accounting for endogenous policy responses of this type would also enhance our understanding of the links between capital movements and changes in relative prices.

4.4 Summary and conclusions

The purpose of this chapter has been to examine the links between capital inflows and the real exchange rate in a fixed (or predetermined) exchange rate regime. The first part presented a brief analytical discussion of these linkages. Two types of experiments were discussed: an increase in government spending on home goods, and a reduction in world interest rates. This latter experiment is particularly interesting, since many economists have attributed a large role to the cyclical reduction in interest rates in the

[25] A dual exchange rate system was in force in Mexico between 1982 and November 1991, with a crawling peg operated for the official exchange rate during December 1982 and February 1988. The official exchange rate was kept fixed between February 1988 and January 1989, and a preannounced crawl was implemented during January 1989 to November 1991. The dual rate regime was then abolished and a preannounced crawling peg was put in place until December 1994.

United States in explaining the surge in capital inflows to developing countries in the early 1990s.[26] The analysis suggests that a permanent reduction in the world interest rate leads to a steady-state reduction in the economy's net stock of foreign assets and a real depreciation, regardless of whether the country considered is a net creditor or a net debtor in the initial steady state. On impact, however, whereas the real exchange rate always appreciates in the net debtor case, in the net creditor case it may either appreciate or depreciate – depending on the relative strength of wealth and intertemporal substitution effects.

The second part estimated a near-VAR model linking capital inflows, changes in ex post interest rate differentials, the government spending–output ratio, money base velocity, and the temporary component of the real exchange rate (TCRER). Because there is no obvious criterion for discriminating among alternative techniques for decomposing a time series between a trend and a temporary component, two alternative methods were used: the Hodrick-Prescott filter and the Beveridge-Nelson decomposition.

The near-VAR model was estimated for Korea, Mexico, the Philippines, and Thailand. Variance decompositions, based on a generalized approach proposed by Koop, Pesaran, and Potter (1996), suggest that only a small percentage of the movements of the temporary component of the real exchange rate is associated with "historically correct" shocks to capital flows. Regarding the importance of historical shocks to the government spending ratio, the variance decompositions suggest that they also play a small role in these movements in Mexico, the Philippines, and Thailand, but somewhat surprisingly not in Korea.

Generalized impulse response functions – based also on the Koop-Pesaran-Potter technique – indicate that a negative innovation in the (change in) world interest rates leads to a capital inflow in all Asian countries and to a "perverse" capital outflow in Mexico, with little persistence over time; a significant appreciation of the TCRER is observed (with a one-quarter lag) in the Philippines and Thailand, with some degree of persistence in both countries, whereas no discernible effect can be detected in the case of Mexico. In Korea, the TCRER depreciates significantly in the second quarter after the shock. A positive innovation in the government spending–output ratio has significant effects only in the case of Korea, leading to a reduction in capital inflows and a slight appreciation of the TCRER. Although both effects are statistically

[26] See Calvo, Leiderman, and Reinhart (1996), Fernández-Arias (1996), Fernández-Arias and Montiel (1996), and Frankel and Okongwu (1996).

significant (in the sense defined earlier), they are small and short-lived. With both types of shocks, movements in capital flows seem to mirror closely changes in interest rate differentials between domestic and foreign assets.

It is worth emphasizing that the econometric framework developed here aims only at capturing the short-run links between capital inflows, movements in the real exchange rate, and domestic and foreign shocks. It is also possible that, in addition to short-term (demand-type) effects, capital flows may also affect the long-run (trend component) of the real exchange rate – via their supply-side effects on, for instance, capital accumulation and productivity changes across sectors. These potential effects are also worth studying. Nevertheless, our results do suggest that the view according to which real appreciation follows systematically from capital inflows should be taken with care. Capital flows respond endogenously to perceived changes in relative rates of return between domestic and foreign assets; in turn, domestic rates of return are influenced by macroeconomic equilibrium conditions and the overall policy stance. In particular, policy inconsistencies (such as the combination of an expansionary fiscal policy with a relatively tight monetary policy) tend to generate equilibrium changes in asset prices and yields, which affect capital movements and may put upward pressure on the relative price of nontraded goods through wealth and income effects. The methodology described here, by taking into account the endogenous nature of capital flows, provides a useful framework for exploring their short-term macroeconomic effects.

Appendix: Data and unit root tests

The data used to estimate the VAR model are quarterly values for the period from the third quarter of 1982 to the third quarter of 1994 for Korea, Mexico, and the Philippines, and from the third quarter of 1986 to the third quarter of 1994 for Thailand. All data were obtained from the IMF's *International Financial Statistics (IFS)*, except the index of industrial output for Thailand, which was obtained from unpublished IMF material. z is (the inverse of) the IMF's real effective exchange rate, used to calculate the temporary component of the real exchange rate. ky is a broad measure of capital inflows measured in proportion of output, y. Capital inflows are calculated as the sum of net direct investment in the domestic country (*IFS* line 78*bed* minus line 78*bdd*), the net increase in portfolio liabilities (*IFS* line 78*bgd* minus line 78*bfd*), net increase in other investment liabilities (*IFS* line 78*bid* minus line 78*bhd*), and net errors and omissions (*IFS* line 78*cad*). y is GDP at current prices for

Appendix Table 4.A1. *Order of integration: Unit root test statistics*

		ADF test		
Country	Variable	k	Test statistic	PP test
Korea	*ky*	0	−4.557***	−4.848***
	idiff	0	−2.914	−3.208*
	lzc:HP	3	−2.731	−3.267*
	lzc:BN	0	−7.052***	−7.006***
	gy	2	−5.317***	−9.703***
	veloc	1	−2.270	−3.991**
Mexico	*ky*	0	−6.813***	−6.815***
	idiff	1	−5.403***	−7.818***
	lzc:HP	4	−4.827***	−2.697
	lzc:BN	0	−7.845***	−7.857***
	gy	0	−7.378***	−7.443***
	veloc	4	−1.746	−2.048
Philippines	*ky*	0	−5.878***	−5.835***
	idiff	0	−4.941***	−5.076***
	lzc:HP	4	−4.401***	−3.080
	lzc:BN	0	−6.405***	−8.585***
	gy	0	−4.839***	−4.931***
	veloc	0	−3.878**	−3.421*
Thailand	*ky*	0	−4.183***	−4.121***
	idiff	0	−5.211***	−5.263***
	lzc:HP	4	−3.703**	−2.823
	lzc:BN	1	−4.917***	−5.536***
	gy	1	−4.206**	−3.544**
	veloc	3	−0.633	−8.942***
U.S. Treasury-bill rate	level	3	−2.923	−3.054
	iw	1	−5.321***	−4.941***

Notes: Variables are as defined in the text. Estimation period begins in the third quarter of 1982 and ends in the third quarter of 1994, except for Thailand, for which estimation begins in the third quarter of 1986. k denotes the number of lags in the ADF test. *,**, and *** denote rejection of the null hypothesis of a unit root at the 10%, 5%, and 1% significance levels. Critical values are from MacKinnon (1991).

Korea, Mexico, and the Philippines; for Thailand, an index of nominal output was derived by multiplying the industrial output index by the consumer price level. *idiff* is the change in the quarterly interest rate differential, calculated as $(1 + i/100)^{1/4} - (1 + i^*/100)^{1/4}E_{+1}/E$, where i and i^* are the domestic and foreign interest rates (at annual rates), and E the average nominal exchange rate. i is the interest rate on three-month treasury bills for Mexico and the Philippines, and the interbank interest rate for Korea and Thailand. i^* is either the three-month U.S. Treasury bills rate (used for Mexico and the Philippines) or the federal funds rate (for Korea and Thailand).[27] E is the period average spot exchange rate of one U.S. dollar at time t to E units of domestic currency. We thus use the ex post (i.e., realized) domestic currency rate of return on foreign assets. *iw* is the change in $(1 + i^*/100)^{1/4}$. *gy* is the ratio of government expenditure at current prices to nominal GDP. Government spending is measured as the sum of expenditure plus lending minus repayment (*IFS* lines 82 and 83).

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