# REAL AND NOMINAL DETERMINANTS OF REAL EXCHANGE RATES: THE EMPIRICAL EVIDENCE*

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CHAPTER 5

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## ABSTRACT

This paper corresponds to Chapter 5 of the forthcoming book Real Exchange Rates, Devaluation and Adjustment: Exchange Rate Policy in Developing Countries. This work investigates several aspects related to exchange rates in developing nations. Theoretical models of equilibrium and disequilibrium exchange rates are developed; the behavior of real exchange rates is investigated for a large cross section of countries; and the effectiveness of devaluation is assessed for a group of 39 developing nations.

# CHAPTER 5

## Real and Nominal Determinants of Real Exchange Rates: The Empirical Evidence

According to the theoretical models of Chapters 2 and 3, long run equilibrium RERs depend on real variables only -- the "fundamentals". In the short run, however, both real and nominal variables exercise an influence on actual RERs. In Chapter 3 it was argued that unsustainable macroeconomic policies will generate conditions of real exchange rate over-valuation that will usually end up in balance of payments crises and devaluations.

The cross country empirical evidence presented in Chapter 4 showed that RERs in LDCs have indeed exhibited a behavior significantly different from what the traditional Purchasing Power Parity theory has suggested; independently of whether multilateral official or bilateral parallel exchange rates were used, for all 33 countries analyzed, deviations from PPP differed significantly from white noise. The purpose of this chapter is to analyze empirically the relative importance of nominal and real variables in explaining RER movements in a number of developing countries. This analysis not only serves as a test of the main implications of the models of Chapters 2 and 3, but more importantly it sheds light on the crucial question of disentangling equilibrium from disequilibrium real exchange rates. Because only some countries have long enough time series of (at least some of the) "fundamentals" the analysis presented in this chapter is limited to a smaller number of countries than those analyzed in Chapter 4.

The chapter is organized in the following way: We start in Section 5.1 with two descriptive country "stories" -- Chile and Colombia -- where simple inspection allows us to illustrate how some major real structural changes have affected the equilibrium real exchange rate in these two countries. In Section 5.2 an empirical equation for RER dynamics is developed. Section 5.3 contains results from regression analyses using annual data for 12 countries. In these regressions an effort is made to isolate the roles of real factors, nominal exchange rate changes and monetary and fiscal policies. In order to capture some of the intertemporal implications of the theoretical models a distinction is made between temporary and permanent changes in the fundamentals. In Section 5.4 we use the results from the regression analysis to briefly analyze the way in which equilibrium RER evolved in some of these countries. Finally in Section 5.5 some conclusions are presented.

## 5.1 Changes in Fundamentals and Equilibrium Real Exchange Rates: Some Simple Illustrations

In this section we provide two simple illustrations on how structural changes in fundamentals can severely affect equilibrium RERs. The discussion is carried out at a fairly informal level, and serves as an introduction for the econometric analysis presented below. Although these examples -- Chile and Colombia -- are quite extreme they still provide a clear sense on the difficulties associated with disentangling equilibrium from disequilibrium real exchange rates movements.

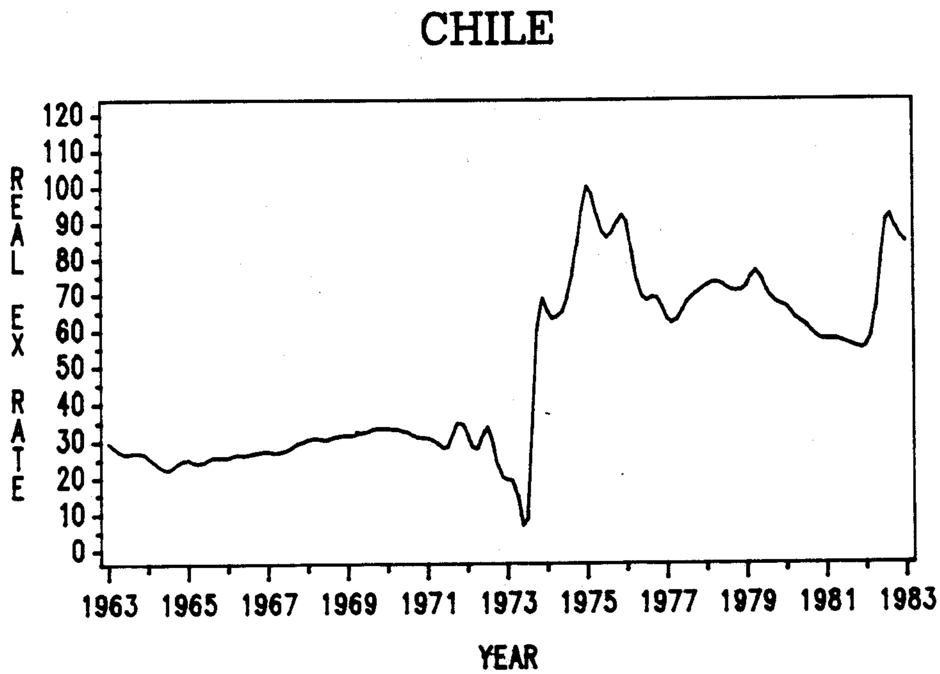
Chile: Figure 5.1 contains the evolution of the RER in Chile. As can be seen, between 1965 and 1970 there was a slow and steady real depreciation which broadly corresponds to the mild trade liberalization undertaken by the Frei administration. During this period a crawling peg nominal exchange rate helped to achieve and maintain this depreciating real exchange rate (see Corbo 1985). The period 1970-1973 corresponds to the socialist government of Dr. Salvador Allende, where expansive macropolicies and the massive imposition of exchange controls resulted in forces that appreciated the real rate by almost 50%. With respect to other "fundamentals", during this period the terms of trade fluctuated without exhibiting a definitive trend (Corbo 1985). This suggests, then, that during this period Chile's RER became severely overvalued.

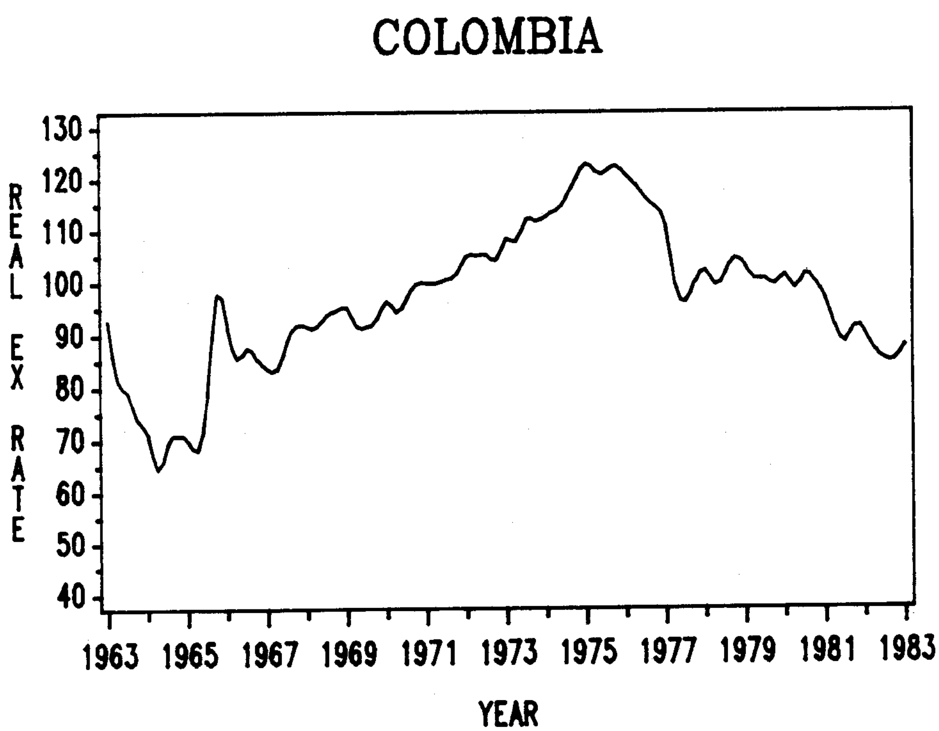
The years 1974-1984 correspond to the first decade of the Pinochet regime. The first thing that stands out from the diagram is that between the periods 1965-1973 and 1974-1984 there is a clear structural break in the real exchange rate behavior in Chile. Throughout 1974-84 in spite of broad fluctuations, the real exchange rate was at all times significantly higher than at any time during the previous ten years. Two main "real" events that greatly affected the behavior of "fundamentals" are behind the major real depreciation that took place between 1965-73 and 1979: First, there was a drastic liberalization of international trade which eliminated all quantitative restrictions and reduced import tariffs from an average of more than 100% to a uniform 10% level (Edwards and Edwards 1987); and second, there was a steep, and apparently permanent deterioration of Chile's terms of trade: during 1975-79 the average real price of Chile's main export, copper, was 41% below its 1965-73 average. This casual comparison of the pre- and post-1974 real exchange rate in Chile forcefully suggests that in Chile tariffs reductions and terms of trade worsening "required" a real depreciation to maintain external equilibrium. These indeed were the type of reactions which according to our discussions of Chapter 2, were more likely to occur.

Between mid-1979 and mid-1982 the by-now much discussed real appreciation of the Chilean peso took place (Corbo 1985, Edwards 1985a).

# REAL EXCHANGE RATE

## CHILE AND COLOMBIA




SOURCE: CONSTRUCTED FROM RAW DATA OBTAINED FROM THE I.F.S.

This appreciation can in principle be attributed to two interconnected factors related to both nominal and real variables: (1) between 1979 and 1981 capital controls were greatly relaxed, allowing a massive inflow of foreign funds. As suggested by the model of Chapter 2 the opening up of the capital account generated important forces towards an equilibrium real appreciation; (2) the fixing of the nominal exchange rate in June of 1979 as a way to bring down inflation also contributed to the observed real appreciation. Almost every observer of the Chilean scene has pointed out that this loss in competitiveness after mid-1979 was one of the main forces that generated the collapse of the Chilean economy in 1982-83. What is fascinating is to notice that although during this period the RER declined by 30%, it was still almost 70% higher than its peak during 1965-73! This, of course, provides a vivid illustration of how changes in fundamentals can greatly change the equilibrium value of the real exchange rate. A RER that would have been excessively "high" in the 1970s, before the tariff liberalization and structural worsening of the terms of trade, was fatally low in the early 1980s.

A regression analysis for Chile's real exchange rate using quarterly data for 1977-1982 confirms our discussion regarding the roles of capital flows and terms of trade. Unfortunately, the lack of a complete time series on import tariffs and other restrictions did not allow the incorporation of that variable (the numbers in parentheses are t-statistics).[1]

$$\log RER_t = \underset{(3.973)}{0.016} - \underset{(-3.521)}{0.076} \log(\text{Net Capital flows})_{t-1}$$

$$- \underset{(-1.935)}{0.218} \log(\text{terms of trade})_{t-1} + \underset{(1.250)}{0.271} \text{growth}_t + \underset{(0.194)}{0.005}(\text{devaluation dummy})$$

$$+ \underset{(7.889)}{0.964} \log RER_{t-1} \qquad DW = 1.753 \quad R^2 = 0.946 \qquad (5.1)$$

These results, then, support the view that an increase in net capital flows is associated with a real appreciation. Moreover, for the case of Chile, Morande (1986) has shown that the causality indeed went from capital flows to real exchange rate. The results in equation (5.1) also indicates that, as expected, a deterioration of the terms of trade -- that is a decline in log(terms of trade) -- will result in a real depreciation.

Colombia: Figure 5.2 contains the evolution of Colombia's multilateral real exchange rate. Between 1967 and 1975 Colombia embarked on a steady trade liberalization process, where quantitative import restrictions were slowly lowered and import tariffs were reduced (see Diaz Alejandro 1976). As can be seen from the figure, during this period a steady real depreciation took place. By 1975 Colombia's real multilateral exchange rate was 43% higher than in 1967. Throughout the period a very successful crawling nominal exchange rate policy was followed, where government authorities frequently devalued the nominal rate, using a set of indicators that included the price of coffee, domestic inflation, foreign inflation, and the level of protection (Urrutia 1981).

Between 1967 and 1975 the real price of coffee fluctuated somewhat. In late 1975, however, a major coffee "boom" which continued until 1979 took place. By 1977 the real price of coffee was 170% above its 1975 level. This period was also characterized by an escalation in illegal drug traffic, which resulted in massive inflows of (illegal) foreign funds. As can be seen from Figure 5.2, starting in late 1975, and as expected, a process of real appreciation of the Colombian currency began. This quasi-equilibrium real appreciation was partially accommodated by the authorities by slowing down the rate of devaluation of the crawl. However, given the temporary nature of the coffee "boom" -- it stemmed from a frost in Brazil which damaged most of that country's coffee trees -- the authorities tried to avoid some of the real appreciation by engaging in sterilization and other policies (see Edwards 1986c).

The Chile and Colombia "stories" presented above served a double purpose. First they have illustrated quite vividly that under some circumstances the analyst can detect broad movements in real exchange rates that have been associated to major structural changes in real fundamentals. Second, it has shown that understanding RER movements, and in particular disentangling changes induced by real and monetary shocks can indeed be very difficult. In the next two sections, results obtained from the estimation of a dynamic equation aimed at explaining real exchange rate movements are presented. The analysis is based on the models of Chapters 2 and 3. It uses annual data from 1965 to 1984 for a group of 12 LDCs, and its main purpose is to separate the effects of real from monetary induced movements of RERs.[2]

## 5.2 An Empirical Equation for Real Exchange Rate Dynamics

The theoretical models of Chapters 2 and 3 made the following basic points with respect to the dynamics of RER behavior: First, in the long run equilibrium real exchange rate movements depend on real variables only. Second, temporary and permanent changes in fundamentals will usually have different effects on the equilibrium RER. Third, under a predetermined nominal exchange rate regime inconsistent macroeconomic policies will generate, in the short run, real exchange rate misalignment. Fourth, if the system is let on its own, the convergence of the actual to the equilibrium RER will usually take some time. The speed at which this convergence will actually take place will depend on the model's parameters, and on the extent of capital mobility. Fifth, nominal devaluations will only have a lasting effect on the equilibrium real exchange rate if they are undertaken from a situation of real exchange rate misalignment and if they are accompanied by "appropriate" macroeconomic policies.[3] Nominal devaluations are neutral in the long run. In addition, the model of Chapter 2 provided a complete list of the relevant real "fundamentals" to be incorporated in the estimation of a RER equation.

The following equation for the dynamics of RER behavior captures the main implications of the theoretical analysis:[4]

$$\Delta \log e_t = \theta(\log e_t^* - \log e_{t-1}) - \lambda(Z_t - Z_t^*) + \phi(\log E_t - \log E_{t-1}) \quad (5.2)$$

where $e$ is the actual real exchange rate; $e^*$ is the equilibrium real exchange rate, in turn a function of the fundamentals; $Z_t$ is an index of macroeconomic policies (i.e., the rate of growth of domestic credit); $Z_{t-1}^*$ is the sustainable level of macroeconomic policies to be defined more precisely later; $E_t$ is the nominal exchange rate; $\theta$, $\lambda$ and $\phi$ are positive parameters that capture the most important dynamic aspects of the adjustment process.

Equation (5.2) establishes that actual movements of the real exchange rate respond to three forces. First, there will be an autonomous tendency for the actual real exchange rate to correct existing misalignments. This force is given by the partial adjustment term $\theta(\log e_t^* - \log e_{t-1})$. With all other things given this self-correcting process tends to take place, under pegged nominal rates, through reductions in the price of nontradable goods. The speed at which this self-adjustment takes place is captured in equation (5.2) by the parameter $\theta$. A value of $\theta$ of 1 means that in one period any deviation of $\log e$ from its long run equilibrium value will be completely eliminated. The smaller is $\theta$ (i.e., the closer it is to zero), the slower will be the speed at which real exchange rate misalignments will be corrected. Theoretically, the value of $\theta$ will depend on a number of institutional factors, including the extent of capital mobility and the existence of wage indexation rules. Since in most cases nominal prices and wages are (somewhat) inflexible downward this self-correcting process can be very slow and costly in terms of lost real output and increased unemployment.

According to equation (5.2) the second determinant of real exchange rate movements is related to macro-policies and is given by $-\lambda[Z_t-Z_t^*]$. This term states that if the macroeconomic policies are unsustainable in the medium to longer run and are inconsistent with a pegged rate (i.e., $Z_t > Z_t^*$), there will be pressures towards a real appreciation: that is if $(Z_t - Z_t^*) > 0$, with other things given, $\Delta\log e < 0$. Notice that if macroeconomic disequilibrium and/or $\lambda$ are large enough, these forces can easily dominate the self-correcting term, generating an increasing degree of overvaluation through time.

Finally, the third determinant of RER movements is related to nominal devaluations and is given by the term $\phi(\log E_t-\log E_{t-1})$. According to this, a nominal devaluation will have a positive effect on the real exchange rate on <u>impact</u>, generating a short-run real depreciation; the actual magnitude of this real depreciation will depend on parameter $\phi$, itself a function of the structural and institutional characteristics of the economy in question. The larger is $\phi$ the larger the instantaneous impact of the nominal devaluation on the real exchange rate. Typically, as discussed in Chapter 3, this impact coefficient will be smaller than one. An important property of equation (5.2) is that it captures the fact that, although nominal devaluations will have an effect on the real exchange rate in the short run, this effect will not necessarily last through time. In fact, whether the nominal devaluation will have any impact over the medium to longer run will depend on the other two terms of equation (5.2), or, more precisely, on the initial conditions captured by $(\log e^*_t - \log e_{t-1})$ and on the accompanying macropolicies, captured by $[Z_t - Z^*_t]$. As the model of Chapter 3 indicated, nominal devaluations will help the adjustment process only to the extent that the initial condition is one of disequilibrium and if they are accompanied by consistent macropolicies. An important characteristic of equation (5.2) is that by allowing three different forces to interact, we can, in principle, obtain estimated movements in the RER that resemble their observed fluctuations.

In order to estimate the equation for real exchange rate dynamics (5.2) it is first necessary to specify an empirical equation for the equilibrium real exchange rate $(\log e^*)$, and to define the macroeconomic disequilibrium term $(Z_t - Z^*_t)$. This is done below, where on the basis of the insights provided by the models of Chapters 2 and 3, an equation for $\log e^*$ is presented, and the empirical definitions of the indexes of macroeconomic disequilibrium are provided.

## The Equilibrium Real Exchange Rate

According to the model of equilibrium real exchange rates developed in Chapter 2, the most important "fundamentals" in determining the behavior of equilibrium RERs are: (1) external terms of trade; (2) level and composition of government consumption; (3) controls on capital flows; (4) exchange and trade controls (i.e., import tariffs); (5) technological progress and (6) capital accumulation. The simplest possible way of writing down the equilibrium real exchange rate is:[5]

$$\log e_t^* = \beta_0 + \beta_1 \log(TOT)_t + \beta_2 \log(GCN)_t + \beta_3 \log(CAPCONTROLS)_t + \beta_4 \log(EXCHCONTROLS)_t + \beta_5 \log(TECHPRO)_t + \beta_6 \log(INVGDP)_t + u_t \quad (5.3)$$

where the following notation has been used:

| | |
|---|---|
| e*: | equilibrium real exchange rate |
| TOT: | external terms of trade, defined at $(P_X^*/P_M^*)$ |
| GCN: | government consumption on nontradables |
| CAPCONTROLS: | measure of extent of controls over capital flows |
| EXCHCONTROLS: | index of the severity of trade restrictions and capital controls |
| TECHPRO: | measure of technological progress |
| INVGDP: | ratio of investment to GDP |
| u: | error term. |

Before actually estimating the RER equation, a number of issues related to the data have to be resolved. One of the more serious obstacles encountered refers to data availability. In fact, the only fundamentals for which we have reliable time series data are the external terms of trade (TOT), and the investment ratio. This means that in the estimation of the RER equation the other fundamentals either have to be omitted or, alternatively, proxies for them have to be found. In this investigation we followed the two approaches, estimating real exchange rate equations under alternative specifications that either omitted variables or used proxies for those which did not have data.

The following proxies were used: technological progress was proxied by the rate of growth of real GDP. This type of proxy has been used in a number of empirical investigations dealing with the Ricardo-Balassa effect. In the case of capital controls, it was not possible to find time series for an appropriate proxy. For this reason CAPCONTROL was replaced by the lagged ratio of net capital flows to GDP. As discussed in Chapter 2 changes in the extent of capital controls will also affect the flow of capital moving in and out of the country. In principle a hike in capital controls will reduce capital flows and vice-versa. It is expected, then, that an increase (decline) in capital inflows will appreciate (depreciate) the equilibrium real exchange rate. With respect to exchange and trade controls (EXCHCONTROLS) two proxies were used. First, we computed implicit import tariffs as the ratio of tariff revenues to imports. This proxy, however, has a number of limitations.[6] First it is only available for a few years for each country, and second it ignores the role of nontariff barriers. For this reason a more comprehensive proxy that captures the extent of controls in a broad sense was sought. The spread between the parallel and official rate in the foreign exchange market is a variable that captures in a broad sense the extent and severity of exchange controls, and was thus used as a proxy in the regressions reported here. It should be noted, however, that although the spread has all the characteristics of a good proxy for the extent of trade, exchange and capital controls, it may also capture other forces. In fact, according to the model in Chapter 3 the (actual) real exchange rate and the parallel market spread are jointly determined. Naturally, in the estimation, instruments have to be found for this variable. Finally, there are no data on government consumption on nontradables. For this reason GCN was proxied by the ratio of total government consumption over GDP(GCGDP). However, since this is admittedly not a very good proxy, the results obtained should be interpreted with care.

A limitation of equation (5.3) is that it does not provide an explicit distinction between permanent and temporary movements in the fundamentals.

However, this distinction turned out to be an important one in the theoretical analysis of ERERs. To the extent that intertemporal substitution is an important transmission channel from fundamentals to the ERER, we would expect that temporary shocks would play an important role in the observed movements of the ERER. In order to overcome this limitation, in some of the estimated equations the time series of the fundamentals were broken into a permanent component and a temporary (or cyclical) component. This decomposition was done following the methodology suggested by Beveridge and Nelson (1981).

Macroeconomic Policies

In the RER dynamics equation (5.2) the term $-\lambda(Z_t - Z_t^*)$ measures the role of macroeconomic policies in real exchange rate behavior. According to the model developed in Chapter 3, with other things given, if macroeconomic policies are "inconsistent" the RER will become overvalued. In the estimation the following components of $(Z_t - Z_t^*)$ were used:

(1) Excess supply for domestic credit (EXCRE) measured as the rate of growth of domestic credit minus the lagged rate of growth of real GDP:

$$EXCRE_t = (\text{dlog Domestic Credit}_t - \text{dlog GDP}_{t-1});$$

this assumes that the demand for domestic credit has a unitary elasticity with respect to real income.

(2) Also, we incorporated the ratio of fiscal deficit to lagged high powered money (DEH) as a measure of fiscal policies.

(3) Finally, instead of our measure for the excess supply of domestic credit in a number of equations we included the rate of growth of domestic credit (DCRE).

## 5.3 Econometric Results

After replacing the equation for $\log e_t^*$ and the expressions for $(Z_t - Z_t^*)$ into (5.2) we obtain an equation that can be estimated using conventional methods. For example, when EXCRE and DEH are the elements of the macroeconomics policies vector $(Z_t - Z_t^*)$ the equation to be estimated is:

$$\begin{aligned} \log e_t = \gamma_1 \log(TOT)_t + \gamma_2 \log(GCGDP)_t \\ \gamma_3 \log(CAPCONTROLS)_t + \gamma_4 \log(EXCHCONTROLS) \\ + \gamma_5 \log(TECHPRO)_t + \gamma_6 \log(INVGDP)_t + (1-\theta)\log e_{t-1} \\ - \lambda_1 EXCRE_t - \lambda_2 DEH_t + \phi NOMDEV_t + u_t \end{aligned} \quad (5.4)$$

where NOMDEV stands for nominal devaluation, and where the $\gamma$'s are combinations of the $\beta$'s and $\theta$.

Several versions of equation (5.4), including a number of equations that decomposed the "fundamentals" into temporary and permanent series, were estimated using pooled data for a group of 12 developing countries: Brazil, Colombia, El Salvador, Greece, India, Israel, Malaysia, Philippines, South Africa, Sri Lanka, Thailand and Yugoslavia. These countries were chosen because of data availability. They were the only ones with continuous time series for all the relevant variables (except the proxies for exchange and trade controls) for 1962 through 1984. The length of the series varied slightly from country-to-country. Throughout the period all of these countries had predetermined nominal exchange rate regimes -- either pegged or crawling. Moreover all of them, except El Salvador, experienced substantial nominal devaluations during the period under analysis. The decision to estimate these regressions using pooled data was based on the fact that there are very few time series observations for most of these variables. In order to test the robustness of the results, the group was broken into two subgroups: one included the middle income countries and the other the poorer countries.[7]

The estimation was performed using a fixed-effect procedure, with country specific dummy variables included in each regression.[8] Ordinary least squares and instrumental variables (IV) techniques were used.[9] Both indexes of bilateral and multilateral real exchange rates were employed as dependent variables.[10]

Table 5.1 contains a summary of the results obtained from IV estimation of a number of variants of the basic equation (5.4); here no distinction is made between temporary and permanent components of the fundamentals. Results obtained when these distinctions are made are discussed below. In this table the $\chi^2$ statistic tests for the significance of all the real variables as a group. The results are satisfactory and provide support to the view that short-run movements in real exchange rates respond both to real and nominal variables.

In all the regressions the measures of macroeconomic policy -- the excess supply of domestic credit (EXCRE), the fiscal deficit ratio (DEH) and the rate of growth of domestic credit (DCRE) -- affect negatively the RER, and in most of them significantly so. This indicates that as these policies became increasingly expansive in these countries -- higher deficits or increased excess supply for credit -- the real exchange rate appreciated. Naturally, starting from RER equilibrium, if other things, including the fundamentals remain constant this appreciation will reflect a mounting disequilibrium or RER overvaluation. For the excess supply for credit (EXCRE) the estimated coefficients ranged from -0.131 to -0.082. Although these coefficients appear somewhat small, they do imply that inconsistent domestic

TABLE 5.1

Real Exchange Rate Equations

(Instrumental Variables)

Equation No.

| Dependent Variable: | (5.4.1) RER | (5.4.2) RER | (5.4.3) RER | (5.4.4) REER | (5.4.5) REER | (5.4.6) REER |
|---|---|---|---|---|---|---|
| EXCRE | -- | -0.118 (-4.210) | -0.131 (-4.527) | -- | -- | -0.082 (-2.195) |
| DEH | -0.016 (-1.837) | -0.012 (-1.531) | -0.014 (-2.100) | -- | -0.004 (-0.321) | -0.016 (-1.934) |
| DCRE | -0.116 (-2.995) | -- | -- | -0.055 (-2.128) | -0.085 (-2.122) | -- |
| NOMDEV | 0.677 (13.436) | 0.573 (15.580) | 0.634 (17.908) | 0.536 (8.439) | 0.497 (10.612) | 0.489 (10.567) |
| log TOT | -0.057 (-2.283) | -0.022 (-1.217) | -0.038 (-1.826) | -0.043 (-2.371) | -0.271 (-0.955) | -0.007 (-0.727) |
| log GCGDP | 0.025 (0.909) | -0.018 (-1.968) | -0.030 (-1.528) | 0.054 (1.712) | -0.062 (-2.530) | -0.010 (-1.444) |
| log INVGNP | -- | 0.073 (1.304) | -- | -- | 0.148 (1.589) | -- |
| log EXCONT | -- | -0.162 (-5.795) | -- | -0.255 (-2.682) | -- | -0.167 (-4.798) |
| $CAPFLO_{-1}$ | -- | -- | -0.152 (-2.104) | -0.231 (-1.406) | -0.198 (-1.956) | -- |
| GROWTH | 0.146 (4.808) | 0.062 (0.541) | 0.474 (4.365) | 0.997 (2.257) | -- | 0.279 (1.934) |
| log $e_{t-1}$ | 0.941 (30.512) | 0.790 (23.518) | 0.900 (39.590) | 0.739 (8.947) | 0.896 (30.572) | 0.811 (20.152) |
| N | 226 | 201 | 207 | 226 | 207 | 213 |
| Root MSE | 0.047 | 0.048 | 0.049 | 0.073 | 0.061 | 0.069 |
| $R^2$ | 0.99 | 0.99 | 0.99 | 0.99 | 0.99 | 0.99 |
| $\chi^2$ | 51.4 | 49.2 | 53.7 | 52.1 | 49.7 | 54.3 |

Table 5.1 (cont.)

Notes: Numbers in parentheses are t-statistics. N is number of observations. MSE is the mean square error. $R^2$ is the coefficient of determination. All regressions included country-specific dummy variables. $\chi^2$ is a chi-square test for the joint significance of the real variables (the "fundamentals").

credit policies maintained for periods of 3 to 4 years can generate very substantial disequilibria. Consider, for example, the case of equation (5.4.3) with a coefficient for EXCRE of -0.131; if domestic credit grows at a rate of 25% per year and income at 2%, after three years there will be an accumulated real appreciation of approximately 7%. In this sense, the estimates for the coefficients of the macro variables strongly support the view that in these countries inconsistent macroeconomic policies resulted in growing pressures that eventually generated situations of real exchange rate disequilibrium.

The results in Table 5.1 show that real variables (the "fundamentals") have also influenced RER behavior in these countries. The $\chi^2$ statistics reported at the bottom of the table show that in all regressions the fundamentals as a group were significantly different from zero. In all regressions the coefficients of the (log of the) terms of trade is negative, and significant at conventional levels in a number of them. This negative sign gives support to the popular views discussed in Chapter 2 that suggest that improvements in the terms of trade -- an increase in log(TOT) -- will result in an equilibrium real appreciation. In a way, this result provides an empirical resolution to the undetermined theoretical response of ERER to terms of trade disturbances discussed in Chapter 2.

Due to the lack of data on the composition of government consumption, the ratio of government expenditures to GDP (log GCGDP) is the only real variable related to government behavior incorporated in the analysis. In four of the equations this coefficient was negative, and in a number of them it was statistically significant at the conventional levels. In those regressions where it was included the coefficient of the (log of the) investment ratio was positive, indicating that in these countries increases in investment resulted in equilibrium real depreciation. Recall that the model in Chapter 2 indicated that the effect of investment on the equilibrium RER would depend on factor intensities and, consequently on whether it took place in the tradables or nontradables good sectors.

The index proxying exchange and trade controls (the parallel market premium) was significantly negative in all the regressions where it was included, indicating that -- at least for these countries during this period -- a relaxation of the extent of impediments to international trade resulted in equilibrium real exchange rate depreciation. As was discussed at some length in Chapter 2 this has indeed been the contention of the policy literature on trade liberalization reforms. When this index was replaced by the ratio of the revenue from import tariffs to imports, the coefficient was still negative (see Edwards 1988).

With respect to (lagged) capital flows, the coefficient is negative and in most regressions significant. This indicates that when a country has to make a (net) transfer of resources to the rest of the world an equilibrium real depreciation will be required. This has important implications for the developing countries in the aftermath of the debt crisis. The coefficient of real growth, however, turned out to be positive in all regressions and significant in a number of them. To the extent that growth is considered to be a measure of technological progress this result seems to contradict the Ricardo-Balassa hypothesis discussed in Chapter 2. There are a number of reasons, however, why this estimated coefficient may not be negative as suggested in Chapter 2. First, growth is admittedly not a very good proxy for technological progress; and second, this coefficient may be picking up, in part, the effects of growth in the (flow) demand for credit on the behavior of RERs.

The estimated coefficients of nominal devaluation (NOMDEV) and lagged RERs provide the last two elements of analysis for the dynamics of RERs. The coefficient of NOMDEV is always significantly positive, ranging from 0.489 to 0.677. This indicates that even with all other things given, a nominal devaluation has been transferred in a less than one-to-one real devaluation in the first year. The size of this coefficient is, however, quite large, and provides evidence supporting the view that nominal devaluations can indeed be a quite powerful device to reestablish real exchange rate equilibrium. If, for instance, as in our prior example, the real exchange rate becomes overvalued by 7%, a nominal devaluation of approximately 12% will help regain equilibrium.[11] Naturally for the nominal devaluation to have a lasting effect, it is necessary that the sources of the original disequilibrium -- the positive EXCRE and DEH -- are eliminated. If this is not the case, soon after the devaluation the RER will again become overvalued.

The coefficients of lagged RER are quite high in all regressions. In a way this is not too surprising in light of the analysis of the time series properties of RERs discussed in Chapter 4.[12] From an economic perspective these high values for the coefficients imply that in the absence of other intervention, actual real exchange rates converge very slowly towards their long run equilibrium level.

Table 5.2 contains the estimated adjustment coefficients for two of the regressions. As can be seen in both cases the $\theta$ coefficient is in the neighborhood of 0.2, implying that with other things given in one year approximately one fifth of a given discrepancy between the (log of the) real exchange rate and its equilibrium value will be corrected. This slow endogenous adjustment provides a solid empirical support for the hypothesis

TABLE 5.2

Estimated Coefficients of Real Exchange Rate Dynamics Equations

(Selected Estimates)

$$\Delta \log e_t = \theta(\log e_t^* - \log e_{t-1}) - \lambda_1 \text{ EXCRE} - \lambda_2 \text{ DEH} + \phi \Delta \log E_t$$

| | (Eq. 5.4.2) RER | (Eq. 5.4.6) REER |
|---|---|---|
| $\theta$ | 0.210 | 0.189 |
| $\lambda_1$ | 0.118 | 0.082 |
| $\lambda_2$ | 0.012 | 0.016 |
| $\phi$ | 0.573 | 0.489 |

Source: Table 5.1.

that devaluation policies are helpful in speeding up the adjustment process (recall the theoretical analysis of Chapter 3.)

Permanent and Temporary Changes in Fundamentals

The results presented above did not distinguish between permanent and temporary changes in fundamentals. In order to investigate whether this distinction was empirically important the method suggested by Beveridge and Nelson (1981) was used to decompose the time series of the fundamentals into a "permanent" and a "temporary" component.[13] This method was applied to each country individually, and the resulting time series for permanent and temporary components were pooled for the 12 countries. The fundamentals decomposed were the terms of trade, the ratio of government consumption to GDP, the exchange controls proxy and the capital flows. In the Appendix to this chapter we report the estimated ARIMA models used to perform this decomposition.

Table 5.3 contains the results obtained from the IV estimation of two alternative equations that distinguished between permanent (P) and temporary (T) shocks to fundamentals. These results are quite interesting. First, they show that for the terms of trade (TOT) and exchange and trade controls (EXCONT) variables the distinction between temporary and permanent was relevant. For both of these variables only changes in the permanent component are significant; they also have the expected sign. Moreover, for these two variables tests for the equality of the permanent and temporary coefficients resulted in strong rejection of the null hypothesis. In the case of GCGDP the distinction between P and T appears to not be empirically important; the test for equality of coefficients indicates that the null hypothesis cannot be rejected. Notice, however, that in both equations the signs do not correspond to what was expected. The coefficients

TABLE 5.3

Temporary and Permanent Shocks to Fundamentals and

Real Exchange Rate Dynamics (Instrumental Variables)

| Dep. Var. | log TOT | | log GCGDP | | log EXCONT | | CAPFLO | |
|---|---|---|---|---|---|---|---|---|
| | P | T | P | T | P | T | P | T |
| REER | -0.060<br>(-1.980) | -0.201<br>(-1.499) | 0.093<br>(2.246) | 0.053<br>(0.852) | -0.303<br>(-3.667) | 0.139<br>(1.346) | -0.122<br>(-0.747) | 0.296<br>(1.214) |
| RER | -0.059<br>(-2.119) | -0.152<br>(-1.242) | 0.069<br>(1.838) | 0.057<br>(0.861) | -0.373<br>(-4.372) | 0.203<br>(1.640) | 0.099<br>(0.672) | 0.041<br>(0.179) |

| | Growth | EXCRE | DCRE | NOMDEV | log $e_{-1}$ | $R^2$ |
|---|---|---|---|---|---|---|
| REER | 0.083<br>(2.100) | - | -0.047<br>(-0.954) | 0.508<br>(8.227) | 0.698<br>(9.354) | 0.958 |
| RER | 0.045<br>(1.274) | -0.083<br>(-1.981) | - | 0.562<br>(9.424) | 0.607<br>(7.454) | 0.998 |

Notes: The number of observations was 221. P refers to the permanent component, while T refers to the temporary component. The proxy for technical progress (growth) was not decomposed since the theoretical model of Chapter 2 does not suggest that the distinction between permanent and temporary is important for that variable. The numbers in parentheses are t-statistics.

of the capital inflows variables turned out to be nonsignificant in all of the equations.

The coefficients of the macroeconomic variables have the correct signs but now the degree of significance is lower than in Table 5.1. An interesting characteristic of the results in Table 5.3 is that the coefficients of the lagged dependent variable are now quite a bit lower than in Table 5.1. However, the absolute value of this coefficient remains quite high, still indicating that if the system is left on its own the return of the actual real exchange rate to its long run equilibrium value may take a substantial amount of time.

In sum, the results reported in Table 5.3 indicate that at least for some of the fundamentals -- the terms of trade and exchange and trade controls -- the distinction between permanent and temporary changes is an important one. Also, the apparently small role played by temporary shocks seems to cast some doubt on the importance of the intertemporal channels developed in Chapter 2 for explaining the dynamic process of RER behavior.[14] These results, however, should be considered as tentative and preliminary. A more definitive analysis along these lines will require longer time series and the development of more powerful econometric techniques.

Nominal Devaluations and the Real Exchange Rate: Country Specific Estimates

The pooled estimates reported above indicate that, for these 12 countries as a group the nominal devaluations have had an important impact effect on the real exchange rate. In the longer run, however, devaluations are neutral. Table 5.4 presents, for 11 of the countries, the results obtained when the coefficients for NOMDEV was not restricted to be equal across countries.[15] As can be seen, the estimated value of this coefficient exhibits important differences across countries. These differences may be

TABLE 5.4

Impact Effect of a Nominal Devaluation on the

Real Exchange Rate by Country

| | NOMDEV |
|---|---|
| Brazil | 0.491<br>(7.426) |
| Colombia | 0.645<br>(3.000) |
| Greece | 0.659<br>(4.825) |
| India | 0.677<br>(3.764) |
| Israel | 0.466<br>(5.519) |
| Malaysia | 1.034<br>(3.353) |
| Philippines | 0.680<br>(5.902) |
| South Africa | 0.704<br>(4.789) |
| Sri Lanka | 1.039<br>(9.092) |
| Thailand | 0.763<br>(1.081) |
| Yugoslavia | 0.819<br>(11.295) |

NOTE: The numbers in parentheses are t-statistics.

capturing institutional characteristics of each of these countries which have not been explicitly incorporated into the analysis. Possibly the most important of those institutions refers to the labor markets, including the existence of indexation and other sources of wage rigidities.

Anticipated and Unanticipated Shocks

A limitation of the analysis up to now is that there has been no explicit distinction between expected and unexpected shocks. In order to get around this problem, and in particular to include the role of expectations, a number of steps were taken. First, series on expected and unexpected monetary variables were constructed and estimated domestic credit surprises were incorporated in the regression analysis.[16] The introduction of this measure of unanticipated policies did not affect our results, nor were its estimated coefficients significant. The following equation is an example of this type of regression, where DDCU refers to unexpected growth in domestic credit.

$$\log RER_t = \underset{(-1.726)}{-0.034} \log(GCGDP)_t - \underset{(-1.157)}{0.023} \log(TOT)_t + \underset{(4.417)}{0.450}(GROWTH)_t$$

$$- \underset{(-3.932)}{0.132} DDCRE_t - \underset{(2.376)}{0.017} DEH_t + \underset{(1.567)}{0.035} DDCU_t + \underset{(11.189)}{0.621} NOMDEV_t$$

$$+ \underset{(38.705)}{0.907} \log RER_{t-1} \qquad N = 220, \quad MSE = 0.053$$

The second procedure to analyze the role of innovations of nominal and real variables consisted on using quarterly data for a reduced number of countries -- those that had long enough series -- to estimate (for one country at a time) Vector Autoregressions (VARs). A limitation with this analysis, however is that for a number of the important variables, such as GDP, fiscal deficit, and government consumption, there are no quarterly data. The results obtained from these VARs should then be taken as being merely suggestive. The estimated correlation matrix of residuals from the VARs indicate that in general the role of innovations do not seem to have played an important role in explaining real exchange rate behavior in these countries.

The Parallel Market Spread

The model derived in Chapter 3 also provided a number of insights on the determination of the spread in the parallel market. Regressions performed for this group of 12 countries provide some support to the implications of the model. For instance, when an IV procedure was used the following result was obtained:

$$\begin{aligned} \text{Spread}_{tn} = & \underset{(1.090)}{0.123}\ \text{EXCRE}_{tn} - \underset{(-2.933)}{0.121}\ \log E_{t-1n} + \underset{(3.315)}{0.251}\ \log \text{GCGDP}_{tn} \\ & - \underset{(-4.615)}{0.198}\ \text{GROWTH}_{tn} + \underset{(3.221)}{0.230}\ \log \text{TOT}_{tn} \qquad R^2 = 0.741 \\ & \qquad N = 216 \end{aligned}$$

These results indicate that, with other things given, expansive macropolicies will result in a higher spread, while nominal devaluations will generate a reduction in the speed. These results, then, suggest that the model derived in Chapter 3 provides promising leads towards the understanding of parallel market behavior. More definitive analyses, however, should be sought to use monthly, or at most quarterly data. The reason, of course, is that parallel market spreads are very sensitive to developments in the monetary sector. By using annual data a significant quantity of information is being lost.

## 5.4 Estimated Equilibrium Real Exchange Rates

The real exchange rate equations reported above can be used to generate estimated series of long run equilibrium real exchange rates. In order to obtain these ERERs we have to consider a long run situation where the monetary sector is in equilibrium, and only the "fundamentals" influence the

ERER. In terms of our equations this means that we impose EXCRE = 0, DEH = 0, and DCRE = 0. Next we compute the estimated long run coefficients ($\hat{\beta}_i$s) for the equilibrium real exchange rate equation as $\hat{\gamma}_i/(1-\hat{\theta})$, where the $\hat{\gamma}_i$ are the estimated coefficients of the fundamentals in the RER equation (5.4), and where $\hat{\theta}$ is the estimated coefficient of the endogenous speed of adjustment in equation (5.2).

Once the long run coefficients for the equilibrium real exchange rate equation are computed, we can find the estimate of the long run equilibrium real exchange rate $\log \hat{e}_t^*$. In order to do this, however, we first have to decide what values of the fundamentals actually to use in this equation. Here there are several possible ways to proceed. The simplest, and not very satisfactory, solution is to use actual values of log TOT, log GCGDP, and so on. A problem with this, however, is that, as discussed in Chapter 2, the concept of ERER refers to sustainable values of the fundamentals, rather than to actual values. A second alternative is to arbitrarily choose values for these series of fundamentals, perhaps based on some historical pattern. A third alternative is to use some kind of averaging procedure to smooth the series of the RER fundamentals. In many ways this third procedure is closed to the theoretical concept of ERER.

There are at least two possible ways to "smooth" the series of the fundamentals before using them in the construction of series for ERER. One way consists on using the permanent component of the series obtained from the Beveridge-Nelson decomposition. A second method consists on constructing a moving average of the actual fundamentals. In this section this latter procedure was used; five years moving averages were computed in order to construct time series for the "sustainable" values of the ERER fundamentals.

Figure 5.3 contains the evolution of the estimated index of equilibrium real exchange rate for eight countries for the period 1965-80. In the computation of these indexes we used the estimated coefficients from equation (5.4.3) reported in Table 5.1. Naturally, instead of this equation any of the other reported in that table can be used to generate series of equilibrium real exchange rates. The most important characteristic of these indexes of ERERs is that they exhibit nontrivial variations throughout the 15 years. These movements, of course are a reflection of changing real structural conditions in these economies, and do not constitute a disequilibrium situation.[17]

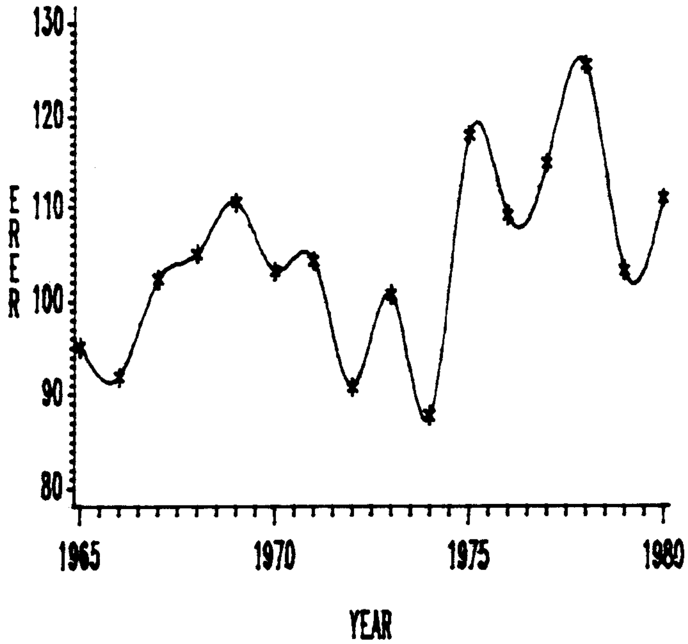
It is interesting to notice that in spite of the fact that the estimated ERERs depicted in Figure 5.3 move through time, the amplitude of these movements can only explain a small fraction of the observed RER variations for these countries during the years under study. This provides some preliminary evidence that suggests that, at least for these specific cases, the dominant force behind observed real exchange rate movements has been financial and macroeconomic instability, and not structural real changes.

## 5.5 Summary

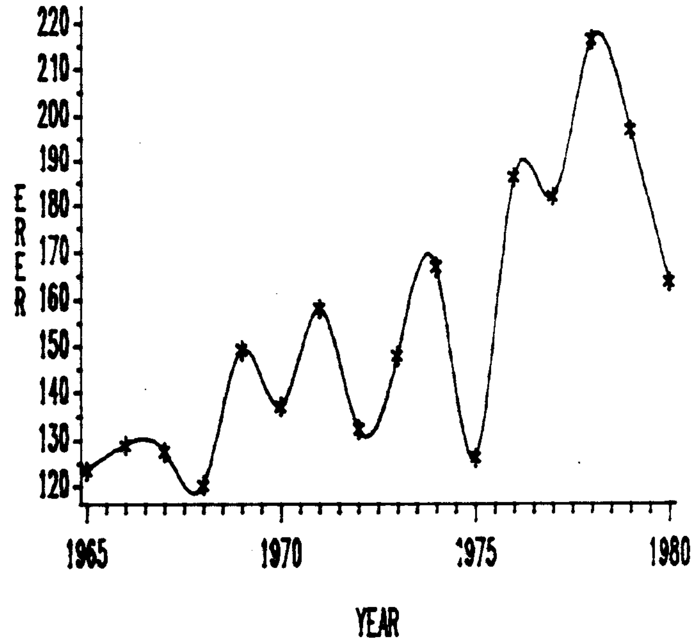
In this chapter we have empirically investigated the process of real exchange rate determination in a group of developing countries. In particular we have analyzed whether, as our theoretical models suggest, real exchange rate movements have historically responded to both real and nominal disturbances. In order to carry out the analysis an augmented partial adjustment equation for real exchange rate dynamics was postulated. This equation captures in a simple and yet powerful way the most important

# ESTIMATED EQUILIBRIUM REAL EXCHANGE RATES

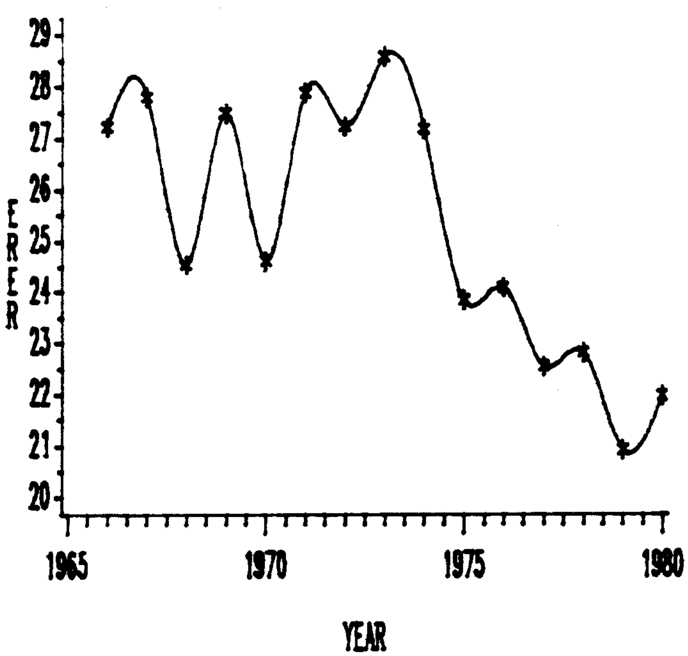
## INDIA



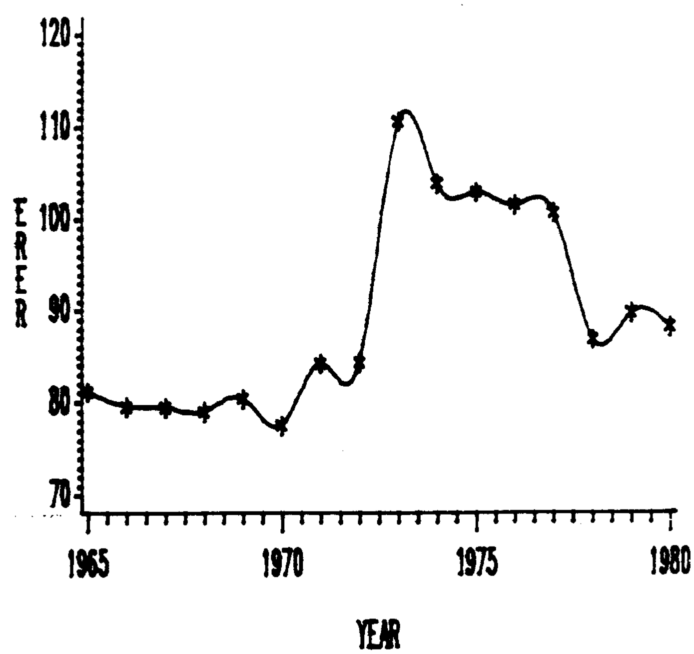

## MALAYSIA




## BRAZIL

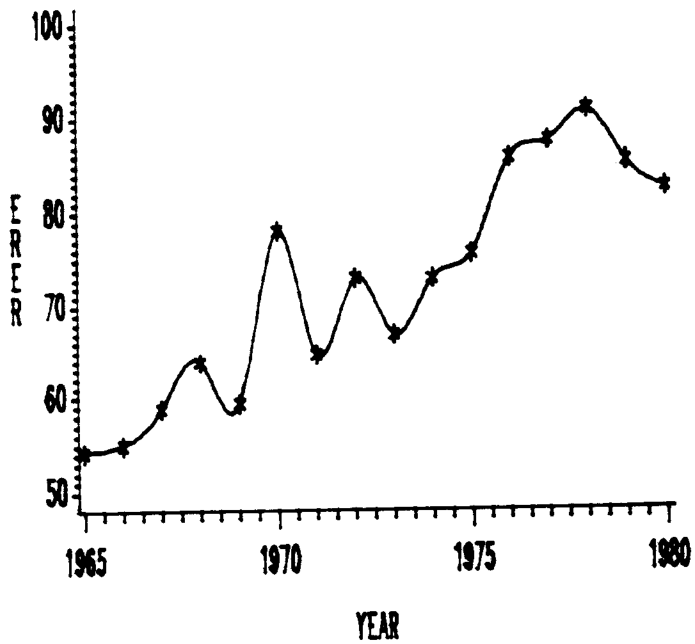



## PHILLIPINES

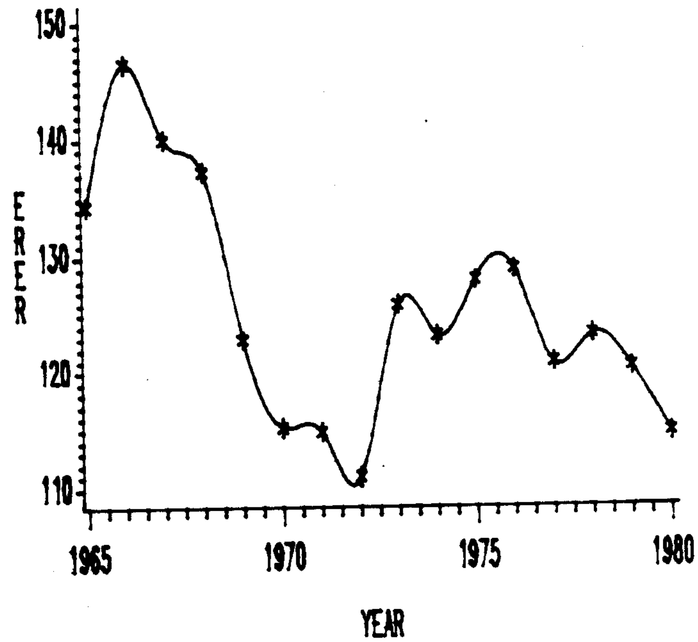


# ESTIMATED EQUILIBRIUM REAL EXCHANGE RATES

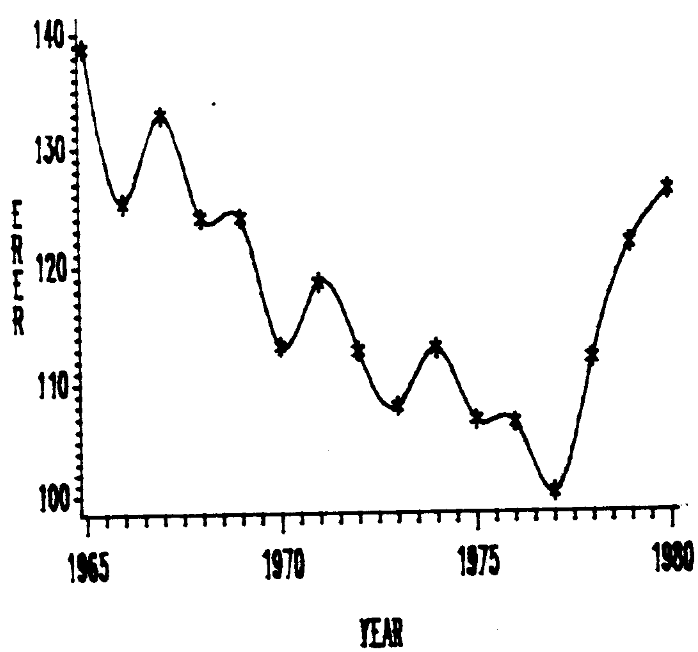
SRI LANKA



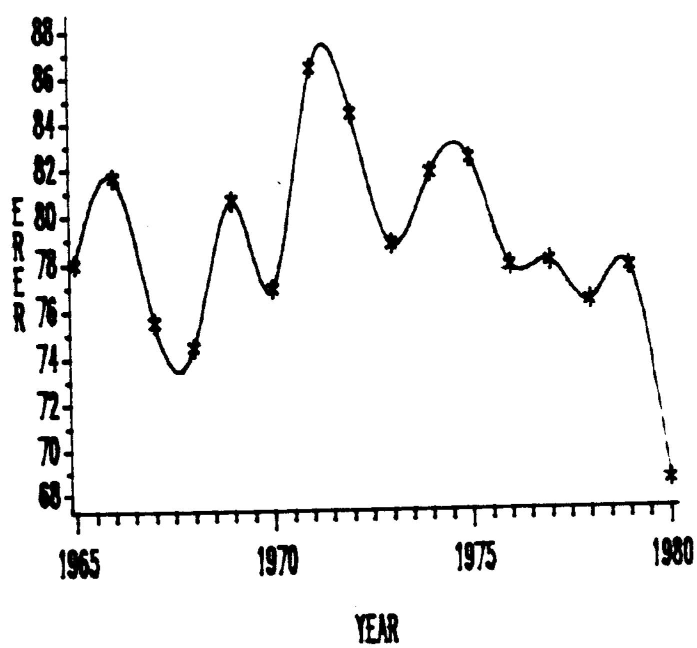

THAILAND




SOUTH AFRICA




YUGOSLAVIA



features of our theoretical analysis: (1) discrepancies between actual and equilibrium real exchange rates will tend to disappear slowly if left on their own; (2) nominal devaluations are neutral in the long run, but can be potentially helpful to speed up the restoration of real exchange rate equilibrium; (3) macroeconomic disequilibria affect the real exchange rate in the short run; (4) the long run equilibrium real exchange rate responds to changes in fundamentals; (5) temporary and permanent changes in the fundamentals will affect the equilibrium real exchange rate in different ways.

This dynamic equation was estimated using pooled data for a group of 12 countries. The estimation was done using two stage least squares on a fixed effect procedure with country and time specific fixed terms, and the results obtained provide support for the broad implications derived from the models of Chapters 2 and 3. In these countries short run real exchange rate movements have responded to both nominal and real disturbances. In particular expansive and inconsistent macroeconomic policies have inevitably generated forces towards real overvaluation. Moreover, our analysis suggests that, at least for these countries, macroeconomic instability has been the major force behind observed real exchange rate fluctuations.

The estimation also indicates that the autonomous forces that move the RER back to equilibrium operate fairly slowly, maintaining the country out of equilibrium for a long period of time. Also, these results show that if a country is indeed in disequilibrium nominal devaluations can greatly help to speed up the real exchange rate realignment. If, however, we start from a situation of equilibrium a nominal devaluation will be neutral. The estimated coefficients from the real exchange rate equations were used to generate a series of estimated long run real exchange rates. In Edwards

(1988?) the estimated series for equilibrium RER were used to construct indexes of real exchange rate misalignment for the group of developing countries. These indexes were then used to test whether there has been any relation between the extent of real exchange rate misalignment and economic performance. It was found that countries with persistent misalignment were systematically outperformed by those countries that manage to maintain their RERs closer to equilibrium.

# APPENDIX TO CHAPTER 5

In this Appendix ARIMA estimates of terms of trade, government consumption ratio, capital flows and parallel market premium for each individual country are reported. These estimates were then used to decompose these time series into permanent and temporary components according to the procedure suggested by Beveridge and Nelson (1981). Q(x) is the Box-Pierce statistic, which is distributed $\chi^2$ with x degrees of freedom. B is the lag operator, and n is the number of observations.

| | Estimated Process | Estimates | Q.n |
|---|---|---|---|
| A. log TOT | | | |
| Greece | ARIMA(2,1,0) | $(1+0.2217B+0.2235B^2)(1-B)X_t = \epsilon_t$<br>(1.28) (1.26) | Q(9)=6.4<br>n=35 |
| Yugoslavia | ARIMA(3,1,0) | $(1+0.3901B+0.2755B^2+0.2213B^3)(1-B)X_t = \epsilon_t$<br>(2.23) (1.50) (1.25) | Q(8)=5.6<br>n=35 |
| South Africa | ARIMA(2,1,0) | $(1-0.0925B+0.1123B^2)(1-B)X_t = \epsilon_t$<br>(0.53) (0.64) | Q(9)=4.4<br>n=36 |
| Brazil | ARIMA(2,1,0) | $(1-0.2127B+0.3335B^2)(1-B)X_t = \epsilon_t$<br>(0.99) (1.55) | Q(9)=7.5<br>n=23 |
| Colombia | ARIMA(3,1,0) | $(1-0.0658B+0.3074B^2-0.3002B^3)(1-B)X_t = \epsilon_t$<br>(0.35) (1.69) (1.57) | Q(8)=11.3<br>n=29 |
| El Salvador | ARIMA(3,1,0) | $(1-0.0739B+0.1462B^2-0.1108B^3)(1-B)X_t = \epsilon_t$<br>(0.38) (0.76) (0.56) | Q(8)=4.5<br>n=31 |
| Israel | ARIMA(3,1,0) | $(1+0.2951B+0.2956B^2+0.3365B^3)(1-B)X_t = \epsilon_t$<br>(0.16) (1.70) (1.83) | Q(8)=3.2<br>n=31 |
| Sri Lanka | ARIMA(3,1,0) | $(1-0.2059B+0.3446B^2+0.1853B^3)(1-B)X_t = \epsilon_t$<br>(1.18) (2.0) (1.02) | Q(8)=3.5<br>n=36 |
| India | ARIMA(3,1,0) | $(1-0.0453B+0.4629B^2+0.2925B^3)(1-B)X_t = \epsilon_t$<br>(0.24) (2.63) (1.48) | Q(8)=2.7<br>n=31 |

| | Estimated Process | Estimates | Q,n |
|---|---|---|---|
| Malaysia | ARIMA(2,1,0) | $(1+0.0296B+0.4156B^2)(1-B)X_t = \epsilon_t$<br>(0.16) (2.30) | Q(9)=5.4<br>n=29 |
| Philippines | ARIMA(2,1,0) | $(1+0.2065B+0.4196B^2)(1-B)X_t = \epsilon_t$<br>(1.32) (2.65) | Q(9)=9.4<br>n=37 |
| Thailand | ARIMA(2,1,0) | $(1-0.1926B+0.5282B^2)(1-B)X_t = \epsilon_t$<br>(1.21) (3.33) | Q(9)=9.3<br>n=32 |

B. <u>Capital Inflows Over GDP</u>

| | | | |
|---|---|---|---|
| Greece | ARMA(1,1) | $(1 + 0.3025B)X_t = (1 + 0.6416B)\epsilon_t$<br>(0.56) (1.50) | Q(9)=5.22<br>n=23 |
| Yugoslavia | ARMA(1,1) | $(1 + 0.5369B)X_t = (1 + 0.9910B)\epsilon_t$<br>(2.46) (14.14) | Q(9)=3.61<br>n=22 |
| South Africa | AR(3) | $(1 - 0.3972B + 0.3450B^2 + 0.1803B^3)X_t = \epsilon_t$<br>(1.76) (1.48) (0.78) | Q(8)=6.26<br>n=23 |
| Brazil | AR(1) | $(1 - 0.5185B)X_t = \epsilon_t$<br>(2.61) | Q(10)=16.42<br>n=22 |
| Colombia | AR(1) | $(1 - 0.4972B)X_t = \epsilon_t$<br>(2.63) | Q(10)=7.80<br>n=23 |
| El Salvador | AR(2) | $(1 + 0.2310B + 0.6486B^2)X_t = \epsilon_t$<br>(1.24) (3.46) | Q(9)=7.21<br>n=22 |
| Israel | AR(2) | $(1 - 0.4112B + 0.6572B^2)X_t = \epsilon_t$<br>(2.42) (3.84) | Q(9)=5.46<br>n=23 |
| Sri Lanka | AR(1) | $(1 - 0.4432B)X_t = \epsilon_t$<br>(2.13) | Q(10)=7.85<br>n=23 |
| India | AR(1) | $(1 - 0.7587B)X_t = \epsilon_t$<br>(5.12) | Q(10)=11.20<br>n=22 |
| Malaysia | AR(1) | $(1 - 0.4426B)X_t = \epsilon_t$<br>(2.26) | Q(10)=11.29<br>n=23 |
| Philippines | ARMA(1,1) | $(1 - 0.3711B)X_t = (1 + 0.5388B)\epsilon_t$<br>(1.35) (2.16) | Q(9)=10.35<br>n=23 |

| | Estimated Process | Estimates | Q,n |
|---|---|---|---|
| Thailand | AR(3) | $(1 - \underset{(2.16)}{0.4357}B + \underset{(2.92)}{0.6272}B^2 + \underset{(2.40)}{0.5561}B^3)X_t = \epsilon_t$ | Q(8)=7.51 n=23 |

C. log GCGDP

| | Estimated Process | Estimates | Q,n |
|---|---|---|---|
| Greece | ARIMA(1,1,0) | $(1 + \underset{(1.12)}{0.1861}B)(1-B)X_t = \epsilon_t$ | Q(10)=6.02 n=37 |
| Yugoslavia | AR(3) | $(1 - \underset{(2.99)}{0.6941}B + \underset{(1.44)}{0.3796}B^2 + \underset{(0.45)}{0.1069}B^3)X_t = \epsilon_t$ | Q(8)=2.91 n=24 |
| South Africa | ARIMA(3,1,0) | $(1+\underset{(0.11)}{0.0174}B+\underset{(1.63)}{0.2557}B^2+\underset{(2.25)}{0.3679}B^3)(1-B)X_t = \epsilon_t$ | Q(8)=4.63 n=37 |
| Brazil | ARIMA(3,1,0) | $(1+\underset{(0.25)}{0.0586}B-\underset{(1.40)}{0.3251}B^2-\underset{(0.23)}{0.0574}B^3)(1-B)X_t = \epsilon_t$ | Q(8)=1.47 n=22 |
| Colombia | ARIMA(3,1,0) | $(1-\underset{(1.36)}{0.2477}B+\underset{(0.78)}{0.1454}B^2+\underset{(0.68)}{0.1247}B^3)(1-B)X_t = \epsilon_t$ | Q(8)=22.82 n=34 |
| El Salvador | ARIMA(3,1,0) | $(1+\underset{(0.08)}{0.0151}B-\underset{(0.36)}{0.0683}B^2+\underset{(0.35)}{0.0683}B^3)(1-B)X_t = \epsilon_t$ | Q(8)=8.17 n=34 |
| Israel | ARIMA(1,1,0) | $(1 + \underset{(0.79)}{0.2141}B)(1-B)X_t = \epsilon_t$ | Q(4)=1.91 n=15 |
| Sri Lanka | ARIMA(1,1,0) | $(1 + \underset{(1.38)}{0.2382}B)(1-B)X_t = \epsilon_t$ | Q(10)=8.34 n=34 |
| India | ARIMA(3,1,0) | $(1+\underset{(1.29)}{0.2426}B+\underset{(0.85)}{0.3364}B^2-\underset{(0.12)}{0.2291}B^3)(1-B)X_t = \epsilon_t$ | Q(8)=6.27 n=33 |
| Malaysia | AR(1) | $(1 - \underset{(4.02)}{0.6057}B)X_t = \epsilon_t$ | Q(10)=7.86 n=31 |
| Philippines | ARIMA(1,1,0) | $(1 + \underset{(3.50)}{0.5153}B)(1-B)X_t = \epsilon_t$ | Q(10)=6.65 n=36 |
| Thailand | ARIMA(3,1,0) | $(1-\underset{(0.32)}{0.0581}B+\underset{(1.19)}{0.2084}B^2+\underset{(0.51)}{0.0918}B^3)(1-B)X_t = \epsilon_t$ | Q(8)=12.53 n=35 |

| | Estimated Process | Estimates | Q,n |
|---|---|---|---|
| D. Parallel Market Spread | | | |
| Greece | ARIMA(1,1,0) | $(1 - \underset{(1.13)}{0.2593}B)(1-B)X_t = \epsilon_t$ | Q(10)=8.08<br>n=21 |
| Yugoslavia | AR(1) | $(1 - \underset{(5.21)}{0.8776}B)X_t = \epsilon_t$ | Q(10)=11.74<br>n=14 |
| South Africa | ARIMA(2,1,0) | $(1 + \underset{(1.07)}{0.2411}B + \underset{(1.30)}{0.2940}B^2)(1-B)X_t = \epsilon_t$ | Q(9)=8.33<br>n=21 |
| Brazil | ARIMA(1,1,0) | $(1 + \underset{(1.91)}{0.414}B)(1-B)X_t = \epsilon_t$ | Q(10)=4.03<br>n=20 |
| Colombia | ARIMA(2,1,0) | $(1 + \underset{(1.96)}{0.4493}B + \underset{(1.40)}{0.3196}B^2)(1-B)X_t = \epsilon_t$ | Q(9)=5.68<br>n=21 |
| El Salvador | ARIMA(2,1,0) | $(1 - \underset{(0.98)}{0.2336}B + \underset{(1.31)}{0.3193}B^2)(1-B)X_t = \epsilon_t$ | Q(8)=6.68<br>n=21 |
| Israel | AR(3) | $(1 - \underset{(3.68)}{0.8401}B + \underset{(0.15)}{0.0149}B^2 + \underset{(1.13)}{0.2596}B^3)X_t = \epsilon_t$ | Q(8)=7.87<br>n=22 |
| Sri Lanka | ARIMA(2,1,0) | $(1 - \underset{(0.44)}{0.0961}B + \underset{(1.83)}{0.3987}B^2)(1-B)X_t = \epsilon_t$ | Q(8)=9.71<br>n=21 |
| India | ARIMA(2,1,0) | $(1 - \underset{(3.01)}{0.5129}B + \underset{(4.17)}{0.7251}B^2)(1-B)X_t = \epsilon_t$ | Q(9)=4.81<br>n=21 |
| Malaysia | AR(2) | $(1 - \underset{(1.88)}{0.4167}B - \underset{(1.16)}{0.2629}B^2)X_t = \epsilon_t$ | Q(9)=12.27<br>n=22 |
| Philippines | AR(1) | $(1 - \underset{(1.94)}{0.4907}B)X_t = \epsilon_t$ | Q(10)=3.49<br>n=22 |
| Thailand | AR(1) | $(1 - \underset{(1.29)}{0.2779}B)X_t = \epsilon_t$ | Q(10)=12.80<br>n=22 |

## Footnotes

[1]This regression was run using OLS. The devaluation dummy takes a value of 1 in June of 1979 and March 1982 and zero otherwise. For further details see Edwards and Edwards (1987).

[2]The length of the series varies from country-to-country depending on data availability. The earliest year is 1962 and the latest, 1985. Given the lack of appropriate series for all the important variables, a number of compromises had to be made during the estimation process. However, in spite of these shortcomings, the results are highly revealing, providing broad empirical support to the theoretical analysis of Part I of this book.

[3]Notice that theoretically, a devaluation that accompanies a trade liberalization with no macroeconomic disequilibrium, is still undertaken from a situation of misalignment. When the level of trade restrictions is reduced, the old RER will (under most cases) be below its new equilibrium level and, thus, overvalued.

[4]It should be stated at the outset that the empirical analysis reported here does not attempt to provide direct tests of the theories developed in Chapters 2 and 3, in the sense of testing a precise equation derived from those models. What this analysis does, however, is to use a dynamic equation for the real exchange rate to test the more salient implications of those theories. Since all economic models are extremely simplified representations of reality, strict testing of any model will always lead, if well done, to rejection of the theory.

[5]The investment ration term (INVGDP) has been included in order to capture the role of capital accumulation. Remember that most of the analysis in Chapters 2 and 3 proceeded under the assumption of no investment

(see, however, the last part of Section 2.3 in Chapter 2).

[6]The data on import tariff revenues were obtained from the IMF Yearbook on Government Finances.

[7]The results obtained from this analysis were less precise than those for the whole group. The main conclusions, however, were not altered in a significant way. Test statistics ($\chi^2$) used to test the appropriateness of pooling the two groups suggested that such a procedure was not always fully warranted. For this reason in a number of runs some of the parameters were allowed to differ across countries (see below).

[8]In a first run both country and time specific dummies were included. Tests for the significance of each group were then performed. The time specific variables were never significant, and, thus were dropped in the final estimation. When a random effect technique was used (the Fuller-Battesse procedure) the results obtained were not significantly different from those reported below. On deciding whether to use a fixed or a random effect methodology for estimating pooled models see Judge et al. (1980).

[9]In the IV estimation it is not trivial to choose the instruments. The reason, of course, is that equation (5.4) includes a lagged dependent variable. As a consequence, lagged endogenous variables are not adequate instruments. A serious, and well known, problem is that by ruling out lagged dependent variables we are left with instruments that are only poorly correlated with the endogenous variables. In the results reported here different sets of instruments were used. In a few regressions lagged dependent variables were also included. Most of the regressions, however, used the following instruments: $EXCRE_t$, $EXCRE_{t-1}$, $EXCRE_{t-2}$; time specific country dummies; logTOT, $logTOT_{t-1}$, $logTOT_{t-2}$, $logTOT_{t-3}$; DCRE, $DCRE_{t-1}$, $DCRE_{t-2}$ lagged, twice lagged and three times lagged real exchange rates; lagged,

twice lagged and three times lagged domestic credit innovations; DEH, $DEH_{t-1}$; NOMDEV, $NOMDEV_{t-1}$; $logGCGDP_t$, $logGCGDP_{t-1}$, $logGCGDP_{t-2}$; nominal exchange rate, lagged, twice lagged and three times lagged nominal exchange rate; country specific dummy variables; money surprises (as defined in Chapter 8); investment ratio; and output growth.

[10]The issue of stationarity of the real exchange rate series also has to be addressed before estimating equation (5.4). As shown in Chapter 4, due to the little power that the currently available tests have, the evidence regarding this issue is not completely clear.

[11]This is obtained using a coefficient of NOMDEV of 0.634, corresponding to equation (5.4.3). This result assumes that there have been no changes in fundamentals.

[12]Obviously, a relatively high value of lagged RER brings up the issue of possible non-stationarity of the real exchange rate. Our discussion of Chapter 4, however, indicates that it is not possible to accurately discriminate in a meaningful enough way on whether these series are stationary and mean revert slowly, or if they are nonstationary. In the analysis of that chapter however, we came to the conclusion that for the majority of the sample countries there is evidence that makes us comfortable rejecting the unit-root hypothesis. For nonstationary series, as seems to be the case of RERs in the developed countries, the implications of our theory can be tested using co-integration analysis (see Kaminsky 1987). Frequency domain techniques can also be used to analyze any differences between short and long run effects of different disturbances (Huizinga 1986).

[13]On easier ways to implement this method see Cuddington and Winters (1987) and Miller (1988).

[14]Naturally, this is by no means a definitive and direct test on the importance of intertemporal substitution in consumption. One possible way of performing such a test is by directly testing the restrictions embodied in the first order conditions of the theoretical intertemporal model. This approach has recently been persued by, among others, Eckstein and Leiderman (1988) within the context of intertemporal models of consumption and money.

[15]These coefficients were obtained from the estimation of a RER equation that included terms of trade (permanent and transitory), log GCGDP (permanent and transitory), technological progress, capital flows (permanent and transitory), DCRE, lagged dependent variable and country specific dummies. The estimation did not include El Salvador since the (official) nominal exchange rate did not change in that country during the period under study.

[16]These series were computed by first estimating domestic credit and money supply equations. The monetary surprises were computed as the innovations from these equations. The domestic credit and money equations were constructed with lagged, twice lagged, and thrice lagged dependent variables plus a fiscal deficit measure. On this procedure see, for example, Edwards (1986a).

[17]It is important to notice that although these estimated series provide important information regarding the behavior of equilibrium real exchange rates, they have a somewhat limited use to directly compute RER misalignments. The problem, of course, is that we have to "anchor" the actual RER at some point in the past. Only if we are willing to assume that the actual and equilibrium rates were equal some X years back can we talk about RER misalignment.

[18]For a list of the instruments used see footnote 7.