Real Exchange Rate Misalignment in Latin America

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Abstract

This paper examines the degree of misalignment of the real exchange rate in Argentina, Brazil, Chile, Colombia, Mexico, Peru, Venezuela and the US over the period 1960-1998. We follow a model in which the equilibrium real exchange rate is the value consistent with both a balance of payments position where any current account imbalance is compensated by a sustainable flow of international capital (external equilibrium) and the efficient use of domestic resources (internal equilibrium). Using cointegration analysis, we find that for all the countries above there is a long-run relationship between the CPI-based real exchange rate, the stock of net foreign assets and the relative price of nontradable goods. We use an unobserved components model to estimate the equilibrium value of the real exchange rate and the degree of misaligment. Our results suggest that in 1998 the real exchange rate in Peru would be in equilibrium, in Chile close to equilibrium but with some room for a further appreciation. In Venezuela, the exchange rate would be overvalued by about 8 percent and in the US by about 16 percent. Finally, in Argentina, Brazil, Colombia and Mexico, the exchange rate would be overvalued by more than 20 percent.

1 Introduction

The real exchange rate (q) is one of the most important relative prices of the economy. Sustained deviations from its equilibrium level may lead to severe macroeconomic disequilibrium, whose correction "will generally require both demand management policies and a real exchange devaluation" (Edwards 1994). The success of a stabilization program is often seen as result of the proper management of the real exchange rate. The 1994 Mexican currency crisis has been blamed on a mismanaged exchange rate, that is, a policy that combined rather rigid nominal exchange rates with an expansionary monetary policy (Sachs and Tornell 1996, Edwards 1996). Other recent currency collapses, as those in East Asia (1997) and Brazil (1999) have also highlighted the importance of appropriate exchange rate management. More generally, analyzing the evidence provided by a sample of 93 countries in the period 1960-94, Goldfajn and Valdes (1996) conclude that when a currency has overappreciated by more than 25 percent, it is highly unlikely that the currency have a smooth return. In their sample, in 90 percent of the cases that arrived to such level of misalignment, the overappreciation ended abruptly in a collapse of the currency.

Assessing the degree of misalignment is not, however, straightforward. The most commonly used method relies on the theory of relative purchasing power parity (PPP). This theory maintains that changes in nominal effective exchange rates must compensate for the inflation differential between the country and its trading partners, implying that the equilibrium real exchange rate is constant. Measuring exchange rate misalignment according to relative purchasing power parity consists of, first, establishing (often in a *ad hoc* manner) a period when the the exchange rate was in equilibrium and, second, computing the difference between the actual real exchange rate in subsequent periods and the (constant) equilibrium (denoted $\bar{q}$); this difference is called "misalignment from parity."

The PPP approach to the study of misalignment is not acceptable given that exchange rates, as relative prices, change as its fundamental determinants change. This criticism is particularly important in periods of fiscal adjustment, structural reform, and international trade and capital openness given that the fundamental determinants of the real exchange rate are bound to change substantially under those circumstances. An exchange rate policy based on the PPP notion of equilibrium exchange rate may result in worsening external imbalances. Citing evidence provided by Aghevli, Khan, and

Montiel (1991), Montiel and Ostry (1991), and Calvo, Reinhart, and Vegh (1994), Faruqee (1995) points out that "efforts to stabilize an inappropriate target for the real exchange rate have sometimes lead to increased macroeconomic instability".

This paper models the equilibrium real exchange rate as the value or path consistent with both external balance, that is, a balance of payments position where any current account imbalance is compensated by a sustainable flow of international capital, and internal balance, that is, the efficient utilization of domestic capital and labor. The efficient use of domestic resources is obtained when the relative price of nontradable goods is at its equilibrium value, to which it converges gradually. The sustainable rate of capital flows is modeled following the stock-flow approach to balance of payments equilibrium presented in both the theoretical models of Mussa (1984) and Frenkel and Mussa (1985) and their empirical application presented in Faruqee (1995), MacDonald (1995a), Broner *et al*. (1998) and Alberola and Lopez (1999). According to this approach, the rate of sustainable capital flows is determined by the desired stock of foreign assets and liabilities among nations, given an adjustment process toward this desired stock. The real exchange rate moves to ensure both stock and flow market equilibrium, where the latter follows from the former. Under the stock-flow external balance approach, two levels of equilibrium can be distinguished: a short-run equilibrium consistent with flow equilibrium, and a long-run equilibrium consistent with stock equilibrium. By definition, actual values of the real exchange rate are identified with its short run equilibrium values, and the degree of misalignment is given by the difference between the actual and the long-run equilibrium $\bar{q}$. In what follows, the term "equilibrium" is applied only to the concept of long-run (stock) equilibrium.

According to the model presented below, the fundamental determinants of the equilibrium real exchange rate are factors that affect the net trading position of the home country in international markets and those that affect the propensity of the home country to be a net lender or borrower of capital. That is, the equilibrium real exchange rate is given by the interaction of permanent structural determinants of the current and capital accounts.

The most important factor affecting the country's net trading position are trend movements in the relative price of non-tradable goods, which to a large extent are caused by productivity-growth differentials between the tradable and non-tradable sectors (the Balassa-Samuelson effect); other factors affecting the net trading position are trend movements in the terms of trade and permanent changes in openness, whether induced by trade policy or natural market integration. On the capital account, the underlying propensity of a country to be net lender of capital is given by its saving behavior (determined by, for example, demographic factors through life-cycle effects and fiscal financing requirements in the absence of Ricardian equivalence) and by investment opportunities in the country (opportunities which can be permanently expanded by, for example, liberalization of the foreign investment regime, macroeconomic stabilization, and improvements in public infrastructure that augment private capital productivity).

The rest of the paper is structured as follows. Section 2 presents an illustrative model of exchange rate determination. Section 3 links the concepts of economic equilibrium and cointegration for the problem under analysis. Section 4 studies the econometric issues involved in the estimation of the unobserved long-run equilibrium. Section 5 describes the data and section 6 presents the empirical results. The paper is closed with some conclusions in section 7.

2 The Model

As noted above, our estimation of misalignment is based on a model that accounts for both the internal and the external dimension of the economy. The model use closely resembles the one presented by Alberola and Lopez (1999) in their estimation of misalignment for the Spanish Peseta. To start with, we define the (log) real exchange rate (q), taking as reference the CPI:

$$q = s + p - p^*, \tag{1}$$

where s is the (log) nominal exchange rate, defined as the price of the foreign currency in terms of the domestic currency and p, and p^* are the log of domestic and foreign price indices.[1] Hence, an increase in q indicates an appreciation of teh real echange rate.

Next, we express the domestic and foreign CPI indices as functions of three different types of goods, domestic traded, foreign traded, and non-traded goods[2] (superscripts T and N indicate traded and non traded respectively), so that for each country the CPI may be expressed as:

[1] In what follows, $*$ denotes a foreign variable

[2] Domestic and foreign traded goods are not perfect substitutes, and hence a price divergence may appear.

$$\begin{aligned} p &= (1-\alpha_N-\alpha_T)p_T+\alpha_N p_N+\alpha_T(p_T^*-s), \\ p^* &= (1-\alpha_N^*-\alpha_T^*)p_T^*+\alpha_N^* p_N^*+\alpha_T^*(p_T+s), \end{aligned} \tag{2}$$

where α_i and α_i^* (i=N,T) determine the shares of each good in the general index. Substituting these expressions in (1) and rearranging terms we get,

$$q=(1-\alpha_T-\alpha_T^*)[s+p_T-p_T^*]+[\alpha_N(p_N-p_T)-\alpha_N^*(p_N^*-p_T^*)]. \tag{3}$$

Equation (3) involves two different components in the determination of the real exchange rate: the evolution of tradable prices at home and abroad, expressed in a common currency, and the evolution of sectoral prices between countries, weighted by the corresponding share of nontradables in consumption. These terms will be denoted by q_X and q_I, respectively,

$$\begin{aligned} q_X &= (p_T+s-p_T^*), \\ q_I &= [\alpha_N(p_N-p_T)-\alpha_N^*(p_N^*-p_T^*)], \end{aligned} \tag{4}$$

and they are associated to the external and internal dimension of the economy: q_X determines external competitiveness and therefore is associated to the evolution of the current account, and q_I influences the allocation of resources between sectors and hence, it is related to the internal equilibrium in the economy.

The equilibrium real exchange rate ($\bar{q}$) implies both internal and external equilibrium, so that it will be attained when both q_X and q_I are equilibrium: $\bar{q}_X$ and $\bar{q}_I$:

$$\bar{q}=(1-\alpha_T-\alpha_T^*)\bar{q}_X+\bar{q}_I. \tag{5}$$

2.1 The external equilibrium real exchange rate

Excess saving over investment is reflected in a current account surplus, which implies an accumulation of net foreign assets (f). The current account balance (b) may be expressed as the trade balance (x) plus interest payments (or receipts) on the stock of net foreign assets:

$$b = x + r^* f, \tag{6}$$

where r^* is the real foreign interest rate. Assuming that an appreciation of the external real exchange rate ($q_X > 0$) worsens the competitiveness of domestic products and the trade balance position, we can rewrite q_X, $x = -\gamma q_X$ ($\gamma > 0$), which allows expressing (6) as:

$$b = -\gamma q_X + r^* f. \tag{7}$$

Following Mussa (1984), the current account balance adjusts to the difference between the current level (f) and the target level ($\overline{f}$) of net foreign assets that home residents would like to hold, so that a current account surplus reflects a net foreign asset position below the desired level:

$$b = \eta[\overline{f} - f]. \tag{8}$$

From these expressions it follows that:

$$q_X = \frac{\eta}{\gamma}[\overline{f} - f] + \frac{r^*}{\gamma} f. \tag{9}$$

In the long run, $\overline{f} = f$ and the equilibrium external exchange rate is given by:

$$\bar{q}_X = \frac{r^*}{\gamma}\overline{f}. \tag{10}$$

Note from (8) that in the long run, when agents net foreign asset positions are at their desired level, the current account balance is zero. This implies that the (equilibrium) external exchange rate is such as to generate a trade balance surplus equal to the flow of interest payments derived from the net foreign asset position.

2.2 The internal equilibrium real exchange rate

As noted above, the different behavior of sectoral relative prices between countries determines the evolution of the internal real exchange rate; in turn, sectoral relative prices are related to the evolution of sectoral productivity. We can illustrate the previous notions with a simple model with two production factors, labor (L) and capital (K) which are fully employed in the production of tradables and non-tradables. Output in each sector is determined by a Cobb-Douglas production technology:

$$
\begin{aligned}
Y_T &= A_T L_T^{\theta} K_T^{1-\theta}, \\
Y_N &= A_N L_N^{\delta} K_N^{1-\delta},
\end{aligned} \tag{11}
$$

where θ and δ represent the labor intensity of production in each sector. Labor is assumed to be perfectly mobile between sectors, implying nominal wage equalization, $W_T = W_N = W$. Finally, labor is paid the value of its marginal product $\partial Y_i / \partial L_i = W/P_i$. Under Cobb-Douglas technology it is easy to show that the ratio of marginal productivities is proportional to the ratio of average productivities:

$$
\frac{\partial Y_T / \partial L_T}{\partial Y_N / \partial L_N} = \frac{\theta Y_T / L_T}{\delta Y_N / L_N}. \tag{12}
$$

It immediately follows that the sectoral price differential is equal to the level of sectoral productivity differentials, plus a constant term, represented by relative labor intensity. Expressing this result in logs, where y_i is the log of average productivity, we can write:

$$
\bar{p}_N - \bar{p}_T = log(\theta/\delta) + [y_T - y_N]. \tag{13}
$$

An implication of these features is that the ratio of prices of non-traded goods to traded goods is higher in countries with higher productivity levels in the traded sector. Then, neglecting constant terms, the internal equilibrium exchange rate may be expressed as

$$
\bar{q}_I = [\alpha_N(\bar{p}_N - \bar{p}_T) - \alpha_N^*(\bar{p}_N^* - \bar{p}_T^*)] = \alpha_N(y_T - y_N) - \alpha_N^*(y_T^* - y_N^*), \tag{14}
$$

or under the assumption that $\alpha_N = \alpha_N^*$ (i.e. the share of traded goods is the same in the domestic and foreign price index),

$$
\bar{q}_I = \alpha_N[(\bar{p}_N - \bar{p}_T) - (\bar{p}_N^* - \bar{p}_T^*)] = \alpha_N[(y_T - y_N) - (y_T^* - y_N^*)]. \tag{15}
$$

Finally, denoting

$$
n = (p_N - p_T) - (p_N^* - p_T^*) = (y_T - y_N) - (y_T^* - y_N^*),
$$

we may write the following expression for the equilibrium:

$$\bar{q}_I = \alpha_N \bar{n}.$$

3 Cointegration and Economic Equilibrium

In this section we link the concept of economic equilibrium to those of integration and cointegration in time series econometrics. Let's start from the equilibrium notion for the real exchange rate ($\bar{q}$) derived from the theory of relative purchasing power parity (PPP),

$$\bar{q} = \mu. \tag{16}$$

Obviously, in practice one is not to expect that the real exchange rate be equal to its equilibrium value at every time period. The real exchange rate (q_t) would be given by the following empirical model

$$q_t = \mu + v_t, \tag{17}$$

where the element v_t captures all the stochastic properties of the real exchange rate at time t. One would expect that on average the real exchange rate be equal to its equilibrium value μ, that is,

$$E(q_t) = \mu, \tag{18}$$

where $E(.)$ is the expectations operator. Secondly, one would expect that there is a bounded limit to the deviations of q_t from μ, that is,

$$\mathrm{var}(q_t) = \sigma^2 < \infty. \tag{19}$$

This condition also ensures that when q_t at a given period is far from its equilibrium value μ there will be a tendency for q_t to approach μ in the next period.

We notice here that if v_t follows a stationary process, I(0) in short, then it will satisfy conditions (18) and (19). As explained above, when those conditions are met, it makes sense to consider μ as the equilibrium value of q.

However, if v_t is better described by the following process

$$v_t = v_{t-1} + \eta_t,$$

where for simplicity η_t is white noise with zero mean and variance σ_η^2, then, it is clear that although

$$E(q_t) = \mu, \tag{20}$$

it is also the case that

$$\text{var}(q_t) = t\sigma_\eta^2. \tag{21}$$

From (21) it follows that as t increases the variance of q_t increases without bound, which in turn implies that q_t may drift away from μ without bound. In other words, as time goes on any value of q_t would be feasible, and therefore, there is no room to talk about equilibrium.

Variables that are not stationary in levels but are stationary in first differences are known as *integrated* of order 1, I(1) in short. They have the characteristic of not returning to an equilibrium or mean value. Therefore, a simple test of whether PPP is an appropriate theory would be a test of whether q is better described by an I(0) process or by an I(1) process.

In the empirical part of the paper, we will initially test for the PPP theory. As explained later we find that there is little evidence to reject the hypothesis that q is well represented by an I(1) process, thus pointing towards a failure of PPP. Clearly, this claim does not imply that there is not an equilibrium value for the real exchange rate, but instead that this equilibrium may be time varying.

Assume for example the hypothesis highlighted by the model of the previous section,

$$\bar{q}_t = \beta_1 \overline{f}_t + \beta_2 \overline{n}_t \tag{22}$$

where the bar indicates the fundamental of long-run equilibrium values of f and n. Assume also that although v_t above is I(1), one could express it as

$$v_t = \beta_1 f_t + \beta_2 n_t + u_t. \tag{23}$$

Neglecting the constant term μ in (17), the actual real exchange rate would then follow

$$q_t = \beta_1 f_t + \beta_2 n_t + u_t. \tag{24}$$

Again if u_t is I(0) then q will fluctuate around $\beta_1 f_t + \beta_2 n_t$, and we could accept as a sensible hypothesis that the equilibrium exchange rate is given by f and n. In such a case we would say that q, f and n are *cointegrated* with cointegration vector $[1 \ \ -\beta_1 \ \ -\beta_2]$. If on the contrary, u_t is I(1) then q might shift apart without bound from the linear combination given by f and n. In such a case we would say that q, f and n are not cointegrated and that our equilibrium hypothesis fails and must be replaced.

An additional comment refers to the empirical estimation of $\bar{q}_t$, since in practice policy makers may find interesting to asses the difference between the equilibrium value $\bar{q}_t$ and the observed value q_t. If we denote the estimate of $\bar{q}_t$ by $\widehat{\bar{q}}_t$ one could be tempted to use (24) and compute

$$\widehat{\bar{q}}_t = \beta_1 f_t + \beta_2 n_t. \tag{25}$$

Observe, however that this estimate of the equilibrium real exchange rate would be based on the assumption that the observed values of both f and n are the long-run values $\overline{f}_t$ and $\overline{n}_t$, something not very appealing from an empirical point of view. A more plausible assumption is that

$$\begin{aligned} f_t &= \overline{f}_t + \hat{f}_t, \\ n_t &= \overline{n}_t + \hat{n}_t, \end{aligned} \tag{26}$$

where both $\hat{f}_t$ and $\hat{n}_t$ are zero mean I(0) processes, and therefore, we would assume that f_t and n_t would fluctuate around the long-run values but we would not force them to be at those values permanently. Otherwise from (25) and (26) we would obtain

$$\begin{aligned} \widehat{\bar{q}}_t &= \beta_1 f_t + \beta_2 n_t \\ &= \beta_1 \overline{f}_t + \beta_2 \overline{n}_t + \beta_1 \hat{f}_t + \beta_2 \hat{n}_t \\ &= \bar{q}_t + \hat{q}_t \end{aligned} \tag{27}$$

where

$$\hat{q}_t = \beta_1 \hat{f}_t + \beta_2 \hat{n}_t. \tag{28}$$

In other words, one would obtain an estimate of the equilibrium exchange rate that would fluctuate around the actual value $\bar{q}$ and clearly, the assessment of the degree of misalignment could be misleading. Below we will take into account this point in order to compute the estimates of $\bar{q}_t$.

We want to finish this section with a warning. If PPP holds and one finds that the real exchange rate is overvalued by say 10 percent, one would expect the real exchange rate to fall in the near future by this 10 percent. Time varying equilibria add the problem of future developments in the determinants of $\bar{q}$ (in our case f and n). For example, a consistent finding would be that a currency at time t is undervalued (and thus one would expect it to appreciate); in $t+1$ the observed real exchange rate remains unchanged and yet one finds that in $t+1$ is overvalued. A possible reason for this finding is that the long-run value of the controlling variables has changed. Therefore, with a time-varying equilibrium one would have to infer not only the likelihood of a movement due to the misalignment at time t, but also the possibility of changes in the long-run equilibrium values at time $t+1$. In consequence, the degree of misalignment at a given time period may give only relative information on the misalignment in the next period. By the same token, a currency which is showing a sustained appreciation (depreciation) could still be undervalued (overvalued).

4 Estimation and Inference

In this section we review the econometric methodology used for the identification and estimation of the exchange rate long-run equilibrium and corresponding misalignemnt. As noted in the previous section, a necessary condition for the existence of a long run equilibrium between the real effective exchange rate, the stock of net foreign assets, and the relative price of non-tradable goods is the existence of a cointegration vector linking the lon-run dynamics of the series. In addition, finding that the real exchange rate is well represented by an integrated proccess of order 1, (I(1)), would imply that the empirical evidence rejects the PPP theory. Since integration and cointegration techniques have been widely explored in the econometrics literature, we will just concentrate on the estimation of the equilibrium ($\bar{q}$) and disequilibrium components ($\hat{q}$) on the basis of the observed variables.

An additional theoretical issue in this section refers to the estimation of the time varying equilibrium real exchange rate. As noted in the previous section, using the cointegration vector and the observed values of the explanatory variables may lead to misleading results since the estimate is likely to differ from the actual value $\bar{q}$ due to the presence of transitory components in both f and n. The situation studied here is analogous to the decomposition of economic time series into permanent and transitory components. The permanent components would capture the long-run behavior of the system, whereas the transitory components would capture the temporary deviations of the observed variables from the long-run or fundamental values.

The natural question that now arises is how estimate these unobserved components. Unfortunately, there is not a unique decomposition between permanent and transitory components (see Maravall (1993) for the theoretical issues involved in the identification of permanent and transitory components. Also see, among others, Quah (1992), Kasa (1992) and Gonzalo and Granger (1995) for different decompositions). Notice that since different decompositions rely on different econometric restrictions the results are likely to differ among them.

Here we follow Gonzalo and Granger (1995) decomposition since unlike other approaches, it allows to clearly isolate shocks to the transitory (or misaligment) component from shocks to the permanet (or equilibrium) component. In fact, the basic identifying restrictions of their decomposition are that the transitory components do not Granger-cause the permanent components in the long run and that the permanent components are a linear combination of contemporaneous observable variables. In other words, the first restriction implies that a change in the transitory component today, will not affect the fundamental or long-run values of the variables. The second restriction makes the permanent component observable and assumes that the contemporaneous observations contain all the necessary information to extract the permanent component.

Specifically assume that $x_t = [q_t \; f_t \; n_t]$ admits the following representation:

$$\Delta x_t = \Delta D_1 x_{t-1} + ... + \Delta D_{p-1} x_{t-p+1} + \Pi x_{t-p} + e_t, \tag{29}$$

where e_t is a vector white noise process with zero mean and variance Σ. Moreover, assume the existence of a cointegration vector (i.e. an indication of a long-run equilibrium among the three variables under analysis). In this case, Π would be of rank 1 and can be written as the product of two rectangular matrices α (the matrix of loading factors) and β (the matrix of cointegration vectors) of order 3×1 such that $\Pi = \alpha\beta'$.

Given the matrices of loading factors α and of cointegrating vectors β, one can always define the orthogonal complements $\alpha_\perp$ and $\beta_\perp$ as the eigenvectors associated with the unit eigenvalues of the matrices $(I - \alpha(\alpha'\alpha)^{-1}\alpha')$ and $(I - \beta(\beta'\beta)^{-1}\beta')$ respectively. Observe that $\alpha'_\perp\alpha$=0 and $\beta'_\perp\beta$=0. With this notation it is possible to write

$$x_t = \beta_\perp(\alpha'_\perp\beta_\perp)^{-1}\alpha_\perp x_t + \alpha(\beta'\alpha)^{-1}\beta' x_t, \tag{30}$$

where the permanent and transitory components are captured by the terms $\beta_\perp(\alpha'_\perp\beta_\perp)^{-1}\alpha_\perp x_t$ and $\alpha(\beta'\alpha)^{-1}\beta' x_t$ respectively. Gonzalo and Granger show that the transitory components defined in this way will not have any effect on the long-run value of the variables captured by the permanent components.

In other words, the (3×1) vector $\beta_\perp(\alpha'_\perp\beta_\perp)^{-1}\alpha_\perp x_t$ will capture the long-run equilibrium values of the three variables in x_t whereas the vector $\alpha(\beta'\alpha)^{-1}\beta' x_t$ will capture the disequilibrium values.

5 The Data

We estimate equilibrium real exchange rates for a sample of seven Latin American countries, namely, Argentina, Brazil, Chile, Colombia, Mexico, Peru, and Venezuela and the US. In the estimation process, we use average annual data for the period 1960 to 1996. We also use preliminary figures of the relevant variables for 1997 and 1998 in order to obtain a preliminary estimate of the degree of misalignment at those dates.

Real Exchange Rate (q):

For the real exchange rate, we use a CPI-based index of the real effective exchange rate. Then q was constructed as follows,

$$q = \frac{(CPI/e)}{\Pi_i(CPI_i/e_i)^{\delta_i}} \tag{31}$$

where CPI is the domestic consumer price index, e is the domestic-currency price of one U.S. dollar, CPI_i and e_i are the corresponding series of the home country's trading partners, and δ_i are the respective trade shares. According to this definition, an increase in q means a real appreciation of the domestic currency. Following common practice, we use the natural logarithm of q in the estimation process.

Relative Price of Nontradable Goods (n):

We use a comparative index of the relative price of nontradable versus tradable goods. Especifically, this comparative index consits of the domestic ratio of the consumer price index (CPI) to the whole sale price index (WPI) relative to the corresponding ratio of the home country's trading partners.

The ratio of CPI to WPI is an increasing function of the relative price of nontradable goods given their larger share (mainly services) in the consumer price index. The n series was constructed as follows:

$$n = \frac{(CPI/WPI)}{\Pi_i (CPI_i/WPI_i)^{\delta_i}} \tag{32}$$

We use the natural logarithm of n in the estimation process.

Observe however, that using this variable one might expect to find a parameter β_2 close to 1 in the estimated regressions. To better understand this point, notice that rewriting p in terms of the non-traded price index and the wholesale price index (denoted p_w), which includes both domestic and foreign traded goods, we get

$$p = \alpha_N p_N + (1 - \alpha_N) p_w,$$

and after rearranging

$$p - p_w = \alpha_N (p_N - p_w).$$

In this regard, if the wholesale price indices mostly reflect domestically produced traded goods (i.e. if $p_w = p_T$ and $p_w^* = p_T^*$), it will follow that $(p - p_w) - (p^* - p_w^*) = \alpha_N n = q_I$.

Net Foreign Assets (NA):

The change in the net foreign asset position (NA) for each country is obtained by adding up the current account balances (CAB). However, to obtain the stock of NA at a given time period we need a value of initial assets, which is not available but for Venezuela and the US. Instead, we estimate it for the remaining countries using the following reasoning. Net foreign income at time t (NI_t) is given by

$$\begin{aligned} NI_t = i_t NA_t &= i_t (NA_0 + \sum_{s=1}^{t} CAB_s) \\ &= i_t NA_0 + i_t (\sum_{s=1}^{t} CAB_s) \\ &= i_t NA_0 + i_t ACAB_t, \end{aligned} \tag{33}$$

where i_t is the average effective interest rate paid or received on NA at time t. Equation (33) is the basis to estimate the initial value NA_0. If i_t was observed, then one could obtain immediately the value of NA_0. Unfortunately, i_t is not observed and therefore, we will try to jointly estimate i_t and NA_0 by imposing some restrictions. Our first restriction is that $i_t = i$ in a given period t. Clearly, for the estimation results to make sense one would expect that this restriction is satisfied, something that during the late 1970s and 1980s is not realistic. Thus, the span where our restriction could be acceptable is very limited (the 1960s) and, consequently, the results of the estimation would not be efficient (accurate). An additional problem is that the sample of NI does not cover the whole decade of the 1960s for all the countries. The first observation of NI corresponds to 1965 for Argentina and Chile, 1966 for Brazil, 1967 for Mexico, 1968 for Colombia and Venezuela, and 1969 for Peru. Thus if we attempted the estimation on a country by country basis, even if we span up to 1972, we would be using sample sizes that would range from 4 to 8 observations. We try to overcome this problem by imposing an additional restriction: the interest rate for all the countries in our sample is the same. This allow us to estimate a panel of 7 countries with fixed effects; the starting date for each country is the first available observation for NI and the final date 1972. Formally, we estimate

$$NI_{tj} = \gamma_j + \beta ACAB_{tj} + \eta_{tj}, \tag{34}$$

where t is a time index, j is a country index, and η_{tj} is an error term. Observe that $\beta = i$ and $NA_{0j} = \gamma_j/\beta$. Thus an estimate of NA_{0j} may be obtained by replacing the unknown parameters with consistent estimates.

Table 1 contains the results of the OLS estimation of (34). All the estimates are significant, and the values are sensible. Moreover, the estimated interest rate (7 percent) seems acceptable. The R^2 of the regression is .86. GLS and IV estimation of the same model, produced basically unchanged results but the R^2 was lower in the latter cases. Thus we proceed to compute the stock of net of foreign assets, using as initial condition $\widehat{NA}_{0j}$. In the empirical application below, in order to control for the size of the economy, we will use the ratio of NA to the GNP and will denote this ratio by f.

6 Results

Tables 2 to 9 report the results of the Johansen tests for the 8 countries under analysis in this paper as well as the results of the stationarity tests for each of the variables. We also test exclusion restrictions for each of the variables in the cointegration vector. Observe that stationarity of q would imply that the PPP holds. Observe also that the rejection of the existence of at least a cointegration vector leads to the rejection of the PPP.

Each table reports the number of lags used in the VAR estimation. With these orders for the VARs none of the residuals present problems of serial correlation. The tables also report the value of the eigenvalues used in the calculation of the tests, the Trace test and the λ-max test together with the corresponding five and ten percent critical values.

The main results are the following. For all the countries there is evidence of the presence of one and only one cointegration vector. The coefficients of all the cointegration vectors have the right sign and the magnitudes are sensible, although changes in f affect in different ways to different countries. For example, while a change of ten percent in the long run value of f leads to a change of twenty percent in the values of q in Argentina and around twenty seven percent in Colombia, it leads to a change of five percent in Brazil, about seven percent in Peru and Chile and less than three percent in Mexico, Venezuela and the US. Thus, the most sensitive countries to changes in the value of f are Argentina and Colombia with changes of around 2 to 1 with respect to f, whereas the other countries present changes of less than 1 to 1. Notice also that for Mexico the exclusion test is not able to reject the null hypothesis of a zero value for the parameter of f.

Next we proceed to the estimation of the misalignment $q - \bar{q}$. Figures 1 to 8 plot the estimated misalignment (values above the 0 line indicate an overvaluation whereas values below zero an under valuation) for the different countries in our sample. We also present 95 percent confidence bands for the estimated deviations from the equilibrium. The appendix gives details on the computation of these bands.

Inspection of these figures suggests that in 1998 there were only two real exchange rates below their equilibirum values (i.e. undervalued). For Chile we estimate the undervaluation at 9 percent (s.e. 4.8) and for Peru at 3 percent (s.e. 4.8). However, judging from 95 percent confidence bands, the Chilean currency might be undervalued by as much as 19 percent or instead overvalued by about 1 percent. For Peru, the same band would cover a range going from an undervaluation of 18 percent to an overvaluation of about 6 percent.

For the rest of the countries, in 1998 we estimate an overvaluation that rages from 8 percent in Venezuela to 26 percent in Colombia. Observe also that the point estimate for the US dollar in 1998 inicate an overvaluation of about 16 percent, with a 95 percent confidence band of (6, 26). Specifically, we find that the Argentinian Peso would be overvalued by about 24 percent, the Brazilian Real by about 26 percent, and the Mexican Peso by about 22 percent. Although for those currencies presenting an overvaluation by more than 20 percent the accuracy of the estimates differ largerly (the s.e. range from 2.74 for Mexico to 11.30 for Brazil), they are all singficantly different from zero. Table 10 summarizes the results presented in this section.

7 Conclusions

The main objective of this paper is to assess the degree of real exchange rate misalignment in, respectively, Argentina, Brazil, Colombia, Mexico, Peru, Venezuela and the US in the period from 1960 to 1998. This is done by estimating a path for the (long-run) equilibrium real exchange rate based on the cointegrating relationship it has with its fundamental determinants. We follow a model in which the equilibrium real exchange rate is the value consistent with both a balance of payments position where any current account imbalance is compensated by a sustainable flow of international capital (external equilibrium) and the efficient use of domestic resources (internal equilibrium). The rate of sustainable capital flows is in turn determined by the desired stock of foreign assets and liabilities among nations, given an adjustment process towards this desired stock. The efficient use of domestic resources is obtained when the relative price of nontradable goods is at its equilibrium value, to which it converges gradually. Guided by this model, we use as fundamental determinants of the equilibrium real exchange rate the stock of net foreign assets and the relative price of nontradable goods.

We find that, for all countries, the real exchange rate exhibits a unit root, which constitutes evidence against the theory of relative purchasing power parity. Furthermore, we find that for all countries, there exists a single cointegrating relationship between the real exchange rate and its fundamental determinants. Under the assumption that movements in the transitory components of the variables in the model do not affect their long-run components, we use the cointegrating relationship to estimate (long-run) equilibrium values for the real exchange rate.

Regarding the degree of misalignment in 1998, our results suggest that in Chile the real exchange rate would be undervalued by about 9 percent, in Peru the real exchange rate would be basically in equilibrium; in Venezuela the exchange rate would be slightly overvalued (less than 10 percent); in the US overvalued by 10 to 20 percent and in the remaining countries by more than 20 percent.

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Appendix

To derive the asymptotic distribution of $\hat{C}_t$,

$$\hat{C}_t = \hat{\alpha}(\hat{\beta}'\hat{\alpha})^{-1}\hat{\beta}'x_t,$$

observe that conditional on x_t the only source of variation could arise from $\hat{\alpha}$ and $\hat{\beta}$.

Next notice that a first order expansion of $\hat{C}_t$ around α and β yields

$$\hat{C}_t - C_t = \partial C_t/\partial\alpha'(\hat{\alpha}-\alpha) + \partial C_t/\partial\beta'(\hat{\beta}-\beta) + O_p(T^{-1})$$

and

$$T^{1/2}(\hat{C}_t - C_t) = \partial C_t/\partial\alpha' T^{1/2}(\hat{\alpha}-\alpha) + \partial C_t/\partial\beta' T^{1/2}(\hat{\beta}-\beta) + O_p(T^{-1/2}).$$

Notice also that since $\hat{\beta}$ is T consistent,

$$T^{1/2}(\hat{\beta}-\beta) \xrightarrow{p} 0,$$

and therefore we can write,

$$T^{1/2}(\hat{C}_t - C_t) = \partial C_t/\partial\alpha' T^{1/2}(\hat{\alpha}-\alpha) + o_p(1).$$

Thus, all the variation of $\hat{C}_t$ arises from $\hat{\alpha}$. Tedious but straightforward matrix algebra yields

$$\partial C_t/\partial\alpha' = -C_t(\beta'\alpha)^{-1}\beta' + (\bar{\alpha}'C_t \otimes I_N) = Z,$$

where $\bar{\alpha} = \alpha(\alpha'\alpha)^{-1}$, $\otimes$ is the Kronecker product and I_N is an identity matrix of order N. We therefore, can write

$$T^{1/2}(\hat{C}_t - C_t) = ZT^{1/2}(\hat{\alpha}-\alpha) + o_p(1),$$

or

$$T^{1/2}(\hat{C}_t - C_t) = ZZ_1T^{1/2}(\hat{\Pi}-\Pi) + o_p(1),$$

where $Z_1 = (\bar{\beta}' \otimes I_N)$, with $\bar{\beta} = \beta(\beta'\beta)^{-1}$. The asymptotic distribution of $T^{1/2}(\hat{\Pi}-\Pi)$ is known to be Normal with variance Σ_π (see Lutkepohl (1993) for the form of Σ_π). This implies that $\hat{C}_t$ will also be asymptotically normal and therefore,

$$T^{1/2}(\hat{C}_t - C_t) \overset{a}{\sim} N(0, ZZ_1\Sigma_\pi Z_1'Z').$$

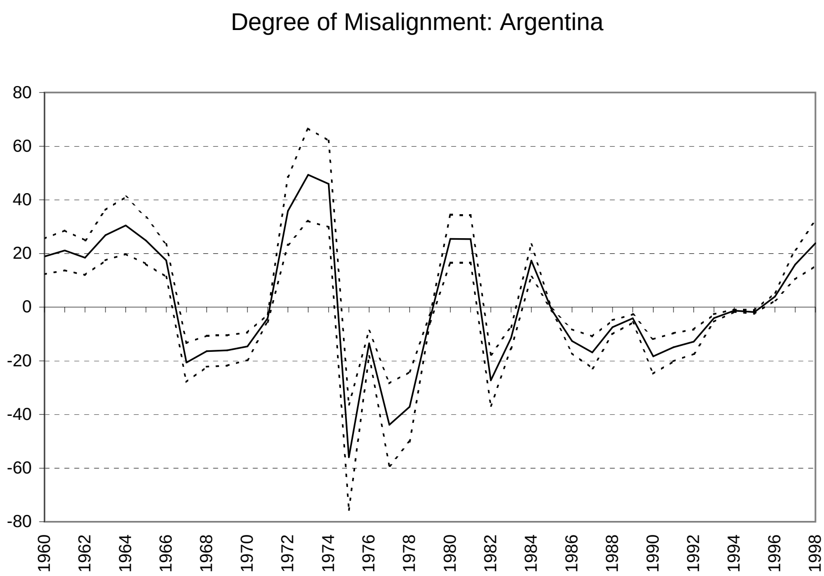

Figure 1: REER Misalignment in Argentina. Dashed lines show 95% confidence band.

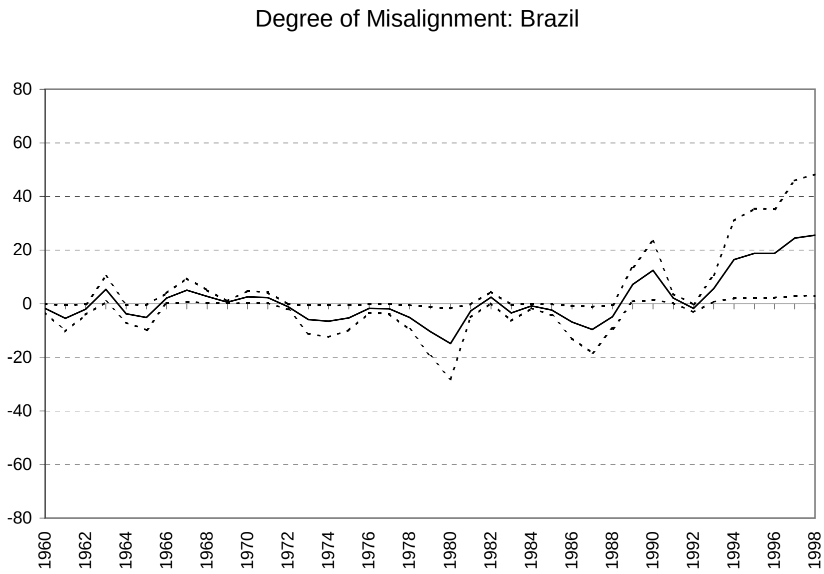

Figure 2: REER Misalignment in Brazil. Dashed lines show 95% confidence band.

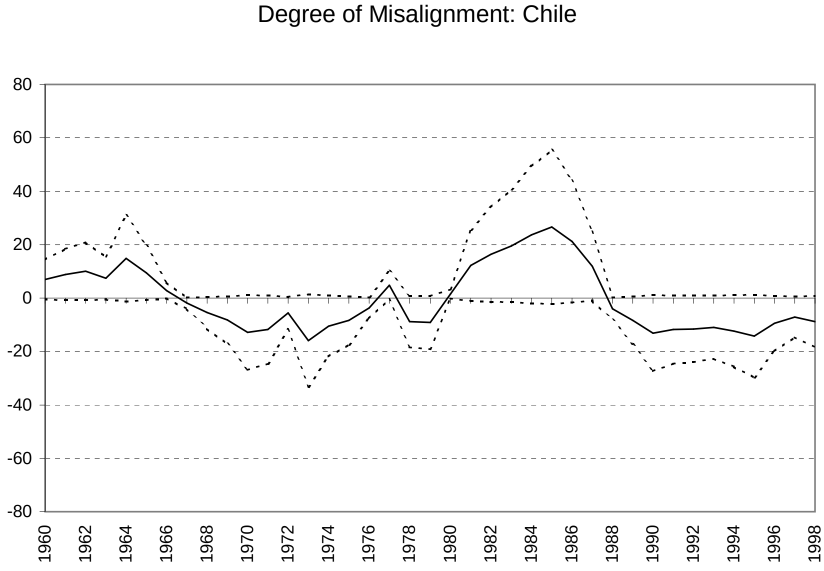

Figure 3: REER Misalignment in Chile. Dashed lines show 95% confidence band.

Table 1: Net Foreign Asset Estimation

COUNTRY	$\hat{\gamma}_j$	t-st	$\hat{\beta}$	t-st	$\hat{NA}_{0j}$	$t-st$
ARGENTINA	-265.9	-8.9	.068	5.0	-3853.3	-4.6
BRAZIL	-338.7	-8.3	.068	5.0	-4913.4	-3.4
CHILE	-146.9	-4.9	.068	5.0	-2130.9	-3.2
COLOMBIA	-109.0	-2.8	.068	5.0	-1581.6	-2.2
MEXICO	-300.1	-6.0	.068	5.0	-4352.6	-2.9
PERU	-149.9	-3.6	.068	5.0	-2174.5	-2.9

Table 2: Johansen Cointegration Tests

ARGENTINA, VAR(3)							
	λ_i	Trace-test	λ_{max}-test	5% cv T	5% cv λ	10% cv T	10% cv λ
$r \leq 2$	.01	.42	.42	8.18	8.18	6.50	6.50
$r \leq 1$	.15	5.87	5.45	17.95	14.90	15.66	12.91
$r = 0$	.46	26.98	21.10^a	31.52	21.07	28.71	18.90
(a) Significance at 5%. (b) Significance at 10%							
q=2.09f+.79n							
Stationarity Tests (cv 5.99) q:27.23. f:37.06. n:40.08.							
Exclusion Tests (cv 3.84) q:32.90. f:20.44. n:24.74.							

Table 3: Johansen Cointegration Tests

BRAZIL, VAR(2)							
	λ_i	Trace-test	λ_{max}-test	5% cv T	5% cv λ	10% cv T	10% cv λ
$r \leq 2$	.07	2.40	2.40	8.18	8.18	6.50	6.50
$r \leq 1$	.17	8.92	6.51	17.95	14.90	15.66	12.91
$r = 0$	.44	28.99^b	20.07^b	31.52	21.07	28.71	18.90
(a) Significance at 5%. (b) Significance at 10%							
q=.53 f+.85n							
Stationarity Tests (cv 5.99) q:33.65. f:33.95. n:36.93.							
Exclusion Tests (cv 3.84) q:27.49. f:3.29. n:21.65.							

Table 4: Johansen Cointegration Tests

CHILE, VAR(3)							
	λ_i	Trace-test	λ_{max}-test	5% cv T	5% cv λ	10% cv T	10% cv λ
$r \leq 2$	.07	2.26	2.26	8.18	8.18	6.50	6.50
$r \leq 1$	.28	13.49	11.23	17.95	14.90	15.66	12.91
$r = 0$	.50	37.31^a	23.81^a	31.52	21.07	28.71	18.90
(a) Significance at 5%. (b) Significance at 10%							
q=.67f+.65n							
Stationarity Tests (cv 5.99) q:46.54. f:35.34. n:46.60.							
Exclusion Tests (cv 3.84) q:11.94. f:23.29. n:5.23.							

Table 5: Johansen Cointegration Tests

COLOMBIA, VAR(2)							
	λ_i	Trace-test	λ_{max}-test	5% cv T	5% cv λ	10% cv T	10% cv λ
$r \leq 2$	.05	1.99	1.99	8.18	8.18	6.50	6.50
$r \leq 1$	.13	4.94	4.94	17.95	14.90	15.66	12.91
$r = 0$	.50	31.64^a	24.70^a	31.52	21.07	28.71	18.90
(a) Significance at 5%. (b) Significance at 10%							
q=2.77f+1.00n							
Stationarity Tests (cv 5.99) q:42.96. f:29.82. n:46.27.							
Exclusion Tests (cv 3.84) q:24.57. f:40.56. n:11.27.							

Table 6: Johansen Cointegration Tests

MEXICO, VAR(2)							
	λ_i	Trace-test	λ_{max}-test	5% cv T	5% cv λ	10% cv T	10% cv λ
$r \leq 2$	.00	.02	.02	8.18	8.18	6.50	6.50
$r \leq 1$	.25	10.03	10.08	17.95	14.90	15.66	12.91
$r = 0$	.52	35.97^a	25.44^a	31.52	21.07	28.71	18.90
(a) Significance at 5%. (b) Significance at 10%							
q=.06f+1.58n							
Stationarity Tests (cv 5.99) q:41.54. f:52.79. n:46.23.							
Exclusion Tests (cv 3.84) q:28.79. f:.07. n:25.61.							

Table 7: Johansen Cointegration Tests

PERU, VAR(1)							
	λ_i	Trace-test	λ_{max}-test	5% cv T	5% cv λ	10% cv T	10% cv λ
$r \leq 2$	.01	.58	.58	8.18	8.18	6.50	6.50
$r \leq 1$	.22	9.25	9.25	17.95	14.90	15.66	12.91
$r = 0$	.47	32.41^a	22.57^a	31.52	21.07	28.71	18.90
(a) Significance at 5%. (b) Significance at 10%							
q=.74f+1.01n							
Stationarity Tests (cv 5.99) q:34.34. f:17.25. n:40.99.							
Exclusion Tests (cv 3.84) q:17.03. f:18.69. n:15.32.							

Table 8: Johansen Cointegration Tests

VENEZUELA, VAR(2)							
	λ_i	Trace-test	λ_{max}-test	5% cv T	5% cv λ	10% cv T	10% cv λ
$r \leq 2$	.07	2.81	2.81	8.18	8.18	6.50	6.50
$r \leq 1$	.10	6.66	3.84	17.95	14.90	15.66	12.91
$r = 0$	.44	27.47	20.81^b	31.52	21.07	28.71	18.90
(a) Significance at 5%. (b) Significance at 10%							
q=.17f+2.86n							
Stationarity Tests (cv 5.99) q:36.06. f:35.61. n:35.57.							
Exclusion Tests (cv 3.84) q:32.24. f:14.26. n:35.47.							

Table 9: Johansen Cointegration Tests

US, VAR(2)							
	λ_i	Trace-test	λ_{max}-test	5% cv T	5% cv λ	10% cv T	10% cv λ
$r \leq 2$	.05	1.97	1.97	8.18	8.18	6.50	6.50
$r \leq 1$	.12	6.55	4.58	17.95	14.90	15.66	12.91
$r = 0$	.55	34.75^a	28.20^a	31.52	21.07	28.71	18.90
(a) Significance at 5%. (b) Significance at 10%							
q=.23f+1.58n							
Stationarity Tests (cv 5.99) q:44.32. f:52.24. n:49.54.							
Exclusion Tests (cv 3.84) q:49.53. f:22.63. n:34.73.							

Table 10: Results Summary Table

Country	Misalignment %				Accuracy	Misalignment Characteristics
	95	96	97	98		
Argentina	-2	4	16	24	High	Large swings Large Overappreciation in 1998
Brazil	19	19	24	25	Medium	Many swings Large Overappreciation
Chile	-14	-9	-7	-8	Medium	Polonged Transitions $\bar{q}$ leads q
Colombia	-17	-6	16	26	Medium	$\bar{q}$ leads q
Mexico	-10	5	23	21	Medium	Important since 80s Large Overappreciation in 1998
Peru	-2	-1	-5	-3	Low	Prolonged Transitions
Venezuela	21	11	12	8	Medium	Important since 80s
US	-7	-1	7	16	Medium	Overappreciation in the early 80s and late 90s

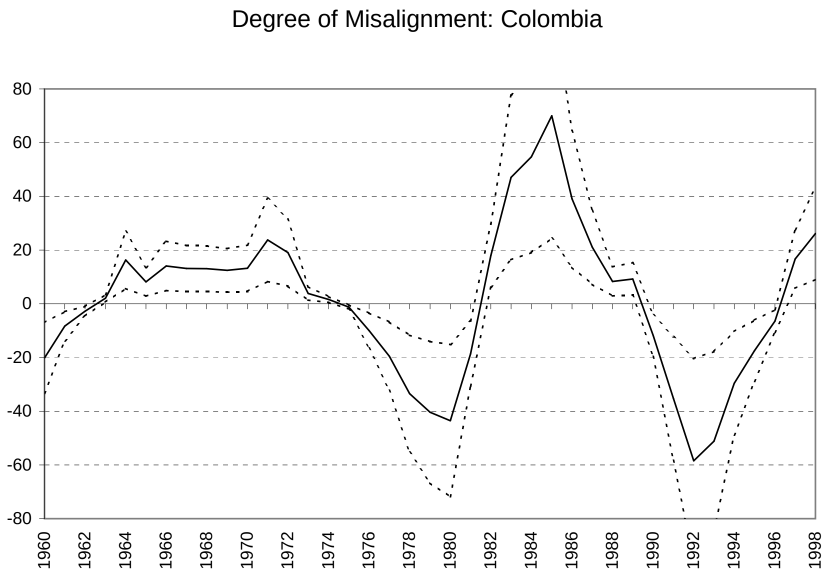

Figure 4: REER Misalignment in Colombia. Dashed lines show 95% confidence band.

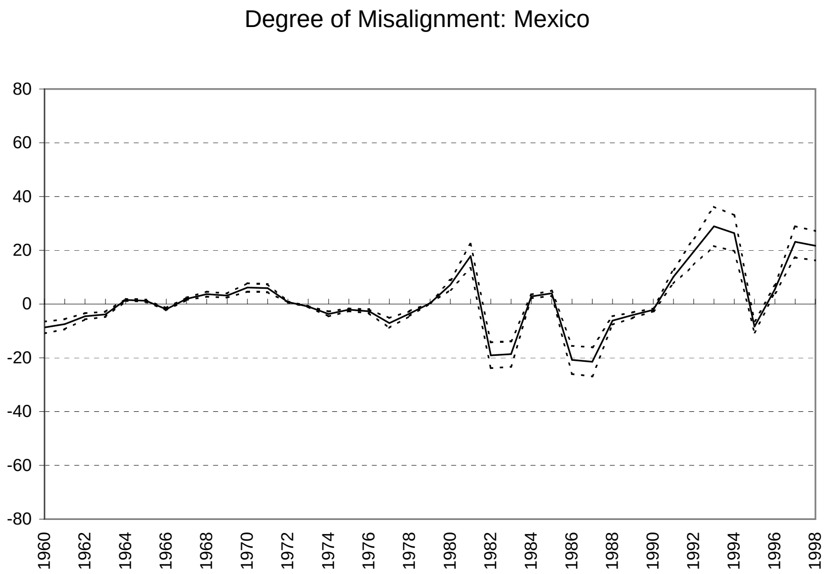

Figure 5: REER Misalignment in Mexico. Dashed lines show 95% confidence band.

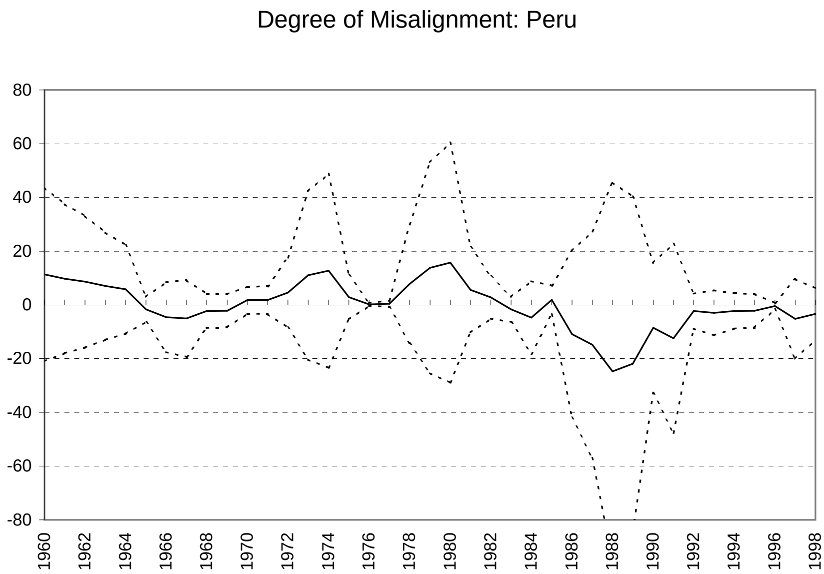

Figure 6: REER Misalignment in Peru. Dashed lines show 95% confidence band.

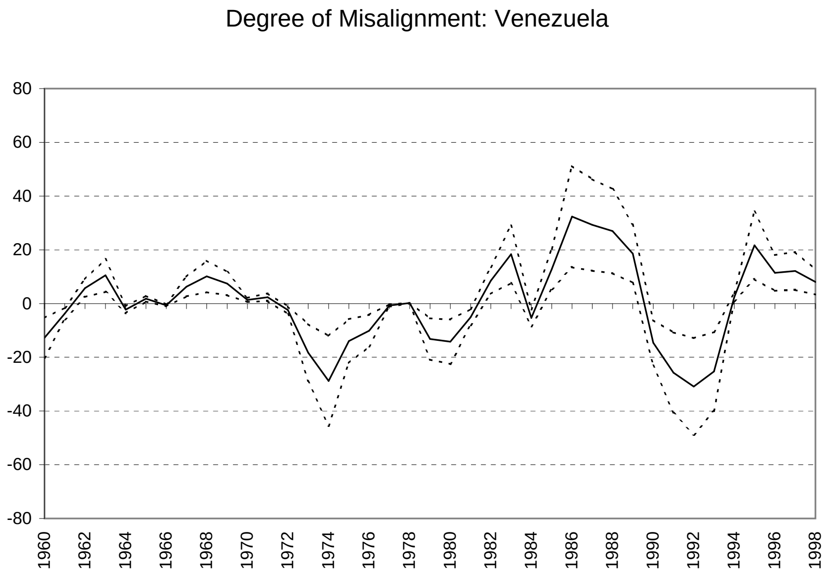

Figure 7: REER Misalignment in Venezuela. Dashed lines show 95% confidence band.

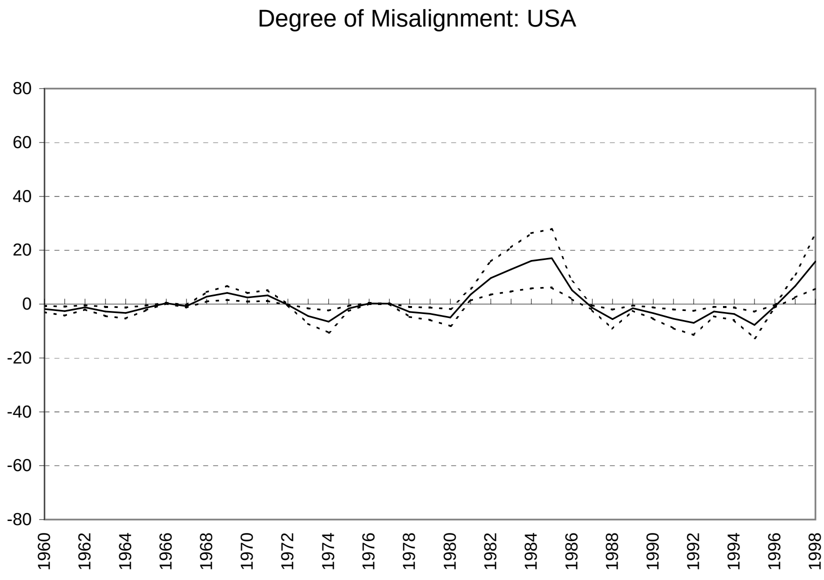

Figure 8: REER Misalignment in USA. Dashed lines show 95% confidence band.