

# The Equilibrium Real Exchange Rate: Evidence from Turkey

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## Abstract

*This aim the paper is to scrutinize whether the equilibrium exchange rate framework could contribute to the understanding of misalignments in the real exchange rate in Turkey and whether this could be used as a guideline for policy interventions by the monetary authorities. Estimation results indicate the relevance of the equilibrium real exchange rate model for Turkey. (JEL C32, F31)*

## I. Introduction

The growth in the capital flows in 1990s was a mixed blessing for the developing countries; even though they were able to gain access to international capital to finance their borrowing requirements for faster growth, the volatile nature of the international capital flows led to fluctuations in the exchange rate markets and/or balance of payments crises. [1]

In such a volatile environment, economists are faced with the difficult task of identifying causes and real consequences of the fluctuations in the exchange rate markets. It is of considerable importance to have information about the causes of exchange rate changes since some changes require corrective intervention by the monetary authorities, whereas some others do not. The reason is that movements in the real exchange rate (RER), defined in the economic literature as the price ratio of tradable goods to non-tradable goods, may or may not signal a loss in the competitive stance for the economy. An appreciation of the real exchange rate, for instance, may be due to an improvement in the "fundamentals" such as an increase in the rate of productivity growth in the tradable goods sector of an economy and hence may be accompanied by an appreciation of the "equilibrium" real exchange rate (ERER). To the extent that the movements in RER are accompanied with movements in ERER, there is no need for policy intervention, however, when the real exchange rate movement is a significant departure from its equilibrium value, also referred to as a "misalignment", competitive stance of the economy may be jeopardized and may require "corrective action" by the authorities.

The analysis of the consequences of a real exchange rate movement, then, boils down to the determination of the unobserved equilibrium value of the RER. The recent theoretical and empirical literature on the determinants of the ERER in developing countries include Bartolini et al (1994), Edwards (1994), Elbadawi (1994), Guerguil and Kaufman (1998) and Chinn (1998). We follow Edwards (1994), and construct the ERER based on a theoretical model that features a sustainable long-run equilibrium in the nontraded goods and the external sector. The model recognizes the fact that the short-term and long-term determinants of the ERER may differ and more specifically only real factors determine the long-run behavior of the real exchange rate whereas both nominal and real factors influence the short-run behavior. The model is very similar to the Williamson's seminal work (Williamson 1985) except it is constructed for a small open economy, which is unable to influence its terms of trade. The construction of the ex-post ERER involves the estimation of the real exchange rate that preserves the internal and the external equilibria.

This paper applies the Johansen's full-information maximum-likelihood methodology of cointegrated systems (Johansen 1988) to estimate the ex-post ERER in an emerging market economy, Turkey, for the period 1987-1999. The estimation procedure is very convenient since it incorporates the cointegration relation to show how the "fundamentals" influence the real exchange rate in the long run and derives the ERER as well as the error correction mechanism to model the short-run adjustment process. [2]

## II. The Model

We consider a small, open economy model with three goods - exportables ( $X$ ), importables ( $M$ ) and nontradables ( $N$ ). The economy involves consumers. The country produces the nontradable and exportable goods and consumes the nontradable and importable goods. We assume that the country trades with a single country, which is sufficiently large.

The country has a floating exchange rate system, with  $E$  denoting the nominal exchange rate in all transactions. Let  $P_M$  and  $P_N$  be the prices of importables and nontradables respectively. The world price of exportables is normalized to unity ( $P_X^* = 1$ ), so the domestic price of exportables is  $P_X = EP_X^* = E$ . The world price of importables is denoted by  $P_M^*$ .

Define  $e_M$  and  $e_X$  as the domestic relative prices of importables and exportables with respect to nontradables, respectively:

$$e_M = \frac{P_M}{P_N} \quad (1)$$

and

$$e_X = \frac{P_X}{P_N} = \frac{E}{P_N} \quad (2)$$

Then the relative price of importables with respect to nontradables is

$$e_M^* = \frac{EP_M^*}{P_N} \quad (3)$$

The country imposes tariffs on the imports so that

$$P_M = EP_M^* + \tau \quad (4)$$

where  $\tau$  is the tariff rate.

The total output,  $Q$ , in the country is

$$Q = Q_X(e_X) + Q_N(e_X) \quad (5)$$

where  $Q_X' > 0$  and  $Q_N' < 0$ .

The private consumption,  $C$ , is given by

$$C = C_M(e_M) + C_N(e_M) \quad (6)$$

where  $C_M$  and  $C_N$  are consumption on importables and nontradables respectively,  $C'_M < 0$  and  $C'_N > 0$ .

We define the real exchange rate as the relative price of tradables to nontradables and denote it by  $e$ :

$$e = \alpha e_M^* + (1 - \alpha) e_X = \frac{E[\alpha P_M^* + (1 - \alpha)]}{P_N} \quad (7)$$

where  $\alpha \in (0, 1)$

The capital is perfectly mobile. The net foreign assets of the country are denoted by  $A$ . The country invests its net foreign assets at the international real interest rate  $r^*$ . The current account of the country in a given year is the sum of the net interest earnings on the net foreign assets and the trade surplus in foreign currency as the difference between output of exportables and total consumption of importables:

$$CA = r^* A + Q_X(e_X) - P_M^* C_M(e_M) \quad (8)$$

The change in the foreign currency reserves,  $R$ , of the country is then given by

$$\dot{R} = CA + KI \quad (9)$$

where  $KI$  is the net capital inflows.

In the short and medium run, there can be departures from  $\dot{R} = 0$ ; so that the country may gain or lose reserves. Current account is sustainable if the current account deficit plus the net capital inflows in the long run sum up to zero so that the official reserves of the country do not change.

We then say that the economy is in *external equilibrium* if the sum of the current account balance and the capital account balance equals to zero i.e.

$$Q_X(e_X) - P_M^* C_M(e_M) + r^* A + KI = 0 \quad (10)$$

On the other hand, the economy is in *internal equilibrium* if the domestic market for nontraded goods clears, i.e.

$$C_N(e_M) = Q_N(e_X) \quad (11)$$

A real exchange rate is then said to be in equilibrium if it leads to external and internal equilibria simultaneously.

From (10) and (11) it is possible to express the equilibrium exchange rate,  $e^*$ , as a function of  $P_M^*$ ,  $\tau$ ,  $r^*$ ,  $A$ , and  $KI$ :

$$e = \psi(P_M^*, \tau, r^*, A, KI) \quad (12)$$

We define terms of trade as the relative price of exports with respect to imports and denote by  $TOT = P_X^* / P_M^* = 1 / F_M^*$ .

### A. A Terms-of-Trade Improvement

Here we assume that  $E$  is flexible but the prices of nontradables,  $P_N$ , is fixed. An improvement in the terms of trade (due to a decrease in  $P_M^*$ ) leads to an increase in the nominal exchange rate  $E$ , and hence the relative prices of exportables with respect to nontradables,  $e_X$ . Then, the relative prices of importables with respect to nontradables,  $e_M$ , must decrease to restore the internal equilibrium. The consumption of nontradables and the output of nontradables both decrease, and the internal sector remains in equilibrium, though at a higher nominal exchange rate. Meanwhile, the output of the exportables increases due to depreciation in the value of the domestic currency. The consumption of importables increases due to a fall in import prices. Moreover, the private expenditure on importables also rises, and hence the external sector stays in equilibrium.

From (7), one can write

$$\frac{\partial e^*}{\partial P_M^*} = \alpha \frac{\partial e_M}{\partial P_M^*} + (1-\alpha) \frac{\partial e_X}{\partial P_M^*}$$

since  $\tau$  is constant. From (11) one can also write

$$\frac{\partial Q_N}{\partial P_M^*} = \frac{\partial C_N}{\partial P_M^*}$$

So, combining the last two equations we obtain  $\partial e^* / \partial P_M^* \geq 0$  if  $(1-\alpha)/\alpha \geq -Q'_N / C'_N$  and  $\partial e^* / \partial P_M^* < 0$  otherwise.

### B. A Tariff Decrease

A decrease in  $\tau$  decreases the domestic price of importables,  $P_M$ . This leads to an increase in the nominal exchange rate,  $E$ , and hence the relative prices of exportables with respect to nontradables,  $e_X$ . Then, the relative prices of importables with respect to nontradables,  $e_M$ , must decrease to restore the internal equilibrium. The adjustment in the internal and external sector exactly the same as in the case of a terms-of-trade improvement.

However, the effect on the equilibrium real exchange rate is now clear.

From (7), it follows that

$$\frac{\partial e^*}{\partial \tau} = -\alpha \frac{P_M^*}{P_N^2} \frac{\partial E}{\partial \tau} + (1-\alpha) \frac{1}{P_N} \frac{\partial E_N}{\partial \tau} < 0$$

Using the fact that  $\partial E / \partial \tau < 0$ , we have that  $\partial e^* / \partial \tau < 0$ , i.e., a decrease in tariffs leads to the depreciation of the equilibrium real exchange rate.

### C. Increase in Foreign Assets and Capital Flows

Increases in the interest earnings on the foreign assets of the country (if the country is a net creditor, that is,  $A > 0$ ) and increases in the net capital flow to the country will be shown to have the same effect on the equilibrium exchange rate. An exogenous rise in  $r^*A$  (assuming  $A > 0$ ) or  $KI$  (in absolute value) leads to a short-term improvement in the balance of payments account. Since the net change of the official reserves must be zero in equilibrium, the current account deficit is expected to rise.

So, equilibrium in the external sector implies a higher trade deficit and this is possible only with the change

in the nominal exchange rate and/or the nontradable prices. However, if only one of them adjusts the internal equilibrium cannot be attained, since we assume that the functional forms of  $Q_N$  and  $C_N$  are such that for each  $E$  there exists a unique level of  $P_N$ , and vice versa.

One can show that starting from an equilibrium situation, the only possible adjustment in  $P_N$  and  $E$ , in response to an increase in foreign assets or net capital flows, can be a simultaneous decrease. Furthermore, the decrease in  $E$  must be relatively high than that in  $P_N$  so that  $e_X$  must decrease, too. On the other hand,  $e_M$  rises. Therefore, the output of exportables,  $Q_N$  increases while the consumption of and hence expenditure on importables decreases. As a result, the trade surplus decreases and the equilibrium in the external sector is restored.

On the other hand, the consumption of nontradables increase at a higher  $e_M$  and a lower  $P_N$ . This increase is matched with an equal amount of increase in the output of nontradables due to a lower level of  $e_X$ . So, the internal equilibrium is also restored.

Let us define the variable  $B \in \{r^* A, KI\}$ . From (7), one can write

$$\frac{\partial e^*}{\partial B} = -\alpha \frac{\partial e_M}{\partial B} + (1-\alpha) \frac{\partial e_X}{\partial B} + \frac{\alpha \tau}{P_N^2} \frac{\partial P_N}{\partial B}$$

From (11) one can also write

$$\frac{\partial Q_N}{\partial B} = \frac{\partial C_N}{\partial B}$$

Combining these two equations and using  $\partial P_N / \partial B < 0$ ,  $\partial e_X / \partial B < 0$  and  $\partial e_M / \partial B > 0$ , we get that  $\partial e^* / \partial B < 0$  if  $(1-\alpha)/\alpha > -Q'_N / C'_N$ . That is to say, when  $\alpha$  is sufficiently low, an increase in the earnings on the net foreign assets or an increase in net capital flows leads to the appreciation of the equilibrium real exchange rate. If, on the other hand, the country is a net debtor a rise in the world real interest will result in the depreciation of the real equilibrium real exchange rate.

### III. Data

The quarterly data set considered in the estimations for the period 1987:1-1999:1 are obtained from the web site of the Central Bank of Turkey, the State Planning Organization, Federal Reserve Bank of St. Louis, Deutsche Bundesbank, and German Federal Statistical Office as well as the CD-ROM version of the International Financial Statistics prepared by the IMF. All series are seasonally unadjusted and, except for the interest rate and the capital account balance, are expressed in natural logarithms.

For the bilateral real exchange rate,  $RER$ , the nominal exchange rate giving the price of a United States dollar in domestic currency units, multiplied by the Wholesale Price Index, WPI, of the United States divided by the Consumer Price Index, CPI, of Turkey is used. [3] This definition of the bilateral real exchange rate is superior than other definitions in terms of direct correspondence to the theoretical definition given by the ratio of tradable goods to nontradable goods used in the model. The WPI is a more representative index of the internationally traded goods, whereas the CPI generally includes a large number of non-traded goods or

imported goods that may be subject to tariffs and additional taxes. The plots of the real exchange rate series are provided in Figure 1.

Two other different definitions of the real exchange rate were also used in the estimations. The first using the nominal exchange rate specifying the price of a Deutsche mark in Turkish Liras, and the wholesale price Index of Germany and the second using a basket exchange rate of the US dollar and Deutsche mark with weights 1 and 1.5, respectively. However the estimation results using *RER* were robust to these two different definitions, hence, only these results obtained using *RER* are reported. [4]

Next, variables that influence the equilibrium real exchange rate, given by the *reduced form equation* (12) are considered. The price of the exports relative to the price of the imports is the terms of trade variable, *TOT*. The plot of the terms of trade series is given in figure 2. The sum total value of exports and imports divided by the Gross Domestic Product. *OPEN*, is used as a proxy for the import tariffs. Notice that a reduction in the import tariffs is associated with an increase in *OPEN*, hence the theoretical analysis of a decrease in tariffs and its effects on the equilibrium real exchange rate will be observed with the reverse sign. The plot of the series provided in Figure 2 shows an improvement in the openness indicator for Turkey. Current account liberalization in the early 1980s and the ensuing liberalization in trade and financial markets account for this increase.

The international real interest rate, *R* is derived using the long-term U. S. Government Securities and the expected inflation rate, calculated under the assumption of perfect foresight using the U.S. CPI. The capital inflow variable, *KFLOW*, is the sum of the capital account balance and errors and the plot of this series is also given in Figure 2.

Additional variables that were not included in the discussions of the model were also considered. The financial liberalization in Turkey and the opening up of the capital account at the third quarter of 1989 is captured by *DLIBTUR*, which takes the value unity after the liberalization. The Turkish domestic financial crisis of 1994 is captured by the dummy variable *D94TUR*, which takes the value of unity at the first and the second quarter of 1994. Technological progress is proxied by *GGDP*, the growth in the real GDP.

We next analyse the time series properties of the data. Many macroeconomic variables are not stationary. It is important to identify the degree of integration of each variable in the model *prior* to the estimation since traditional estimation and inference procedures do not apply at the presence of nonstationary variables. The importance of the issue of nonstationarity arises due to the fact that even though the effects of shocks to variables that are stationary are temporary in nature -so that the series will converge to unconditional mean of the series- this is not true for nonstationary variables.

Previous empirical research on the real exchange rate revealed that major-country real exchange rates follow a random walk under floating exchange rate regimes.[5] If the real exchange rate variables turn out to be nonstationary, then they have a permanent component, implying that stationary variables in the system cannot be affecting the real exchange rate in the long run and hence cannot be considered "fundamental." Based on three different unit root tests, for the variables in concern we encounter the following results. The real exchange rate, terms of trade, openness indicator variable and the long-term real interest rate variables turn out to be nonstationary and the capital inflow and the growth in output variable, which is used to proxy productivity turns out to be stationary.[6]

#### IV. Empirical Methodology and Results

Because many macroeconomic variables contain unit roots and are nonstationary in nature, recent focus in the applied work has emphasized cointegration as the appropriate dynamic macroeconomic modeling of these variables. The intuition behind cointegration is that it allows us to capture the equilibrium relationships dictated by the economic theory between nonstationary variables within a stationary model. A search is made for a linear combination of such variables such that the combination is stationary. If such a stationary

combination exists, then the variables are said to be cointegrated, meaning even though they themselves are not stationary, they are bound by an equilibrium relationship. If the system has more than two nonstationary variables then the cointegrating, that is the long-run equilibrium, relationship among the variables may not be unique. Through the Vector Error Correction model, which is a restricted VAR that is designed for use with nonstationary series that are known to be cointegrated, one can restrict the long-run behavior of the nonstationary dependent variables to converge to their cointegrating relationships while allowing a wide range of short-run dynamics. [7]

The full information maximum likelihood system approach by Johansen (1988) is the most efficient among the other estimation procedures if the residuals from the estimated system are normally distributed, not serially correlated, unconditionally and conditionally homoskedastic.

The diagnostic tests do not reveal any problems for the application of the Johansen's procedure. We next test for the number of cointegrating relations in the system using the maximum likelihood system estimation method of Johansen. Based on the plots of the series, the information criteria, for all tests, the data is characterized with a linear trend and a cointegrating equation with an intercept but no trend. Based on the cointegration tests, we conclude that the variables *RER*, *TOT*, *OPEN* and *R* have a stable equilibrium relation even though the individual variables are individually nonstationary.

After establishing the result that there exists stable relationship between the real exchange and the other variables, we investigate whether any of the variables can be excluded from the cointegrating relation. The cointegrating relation gives the long-run equilibrium defining the behavior of the bilateral real exchange rate. We perform a step-wise exclusion test that has a chi-square distribution with one degree of freedom. Test results reject any exclusion of the variables entering into the equation defining the long-run equilibrium of the real exchange.

The cointegrating equation is as follows: [8]

$$rer = -0.913 \times TOT + 0.292 \times open + 0.034 \times R + 8.842$$

It should be noted that both the sign and the magnitude of the terms of trade fulfill the *a priori* postulates of the model. A 100% fall in the relative price of the importable goods appreciates the real exchange rate by 91.3%.

An increase in the *OPEN* variable is assumed to be arising from a decline in the tariff rates and hence is expected to lead to a depreciation of the equilibrium real exchange rate as explained in the model section. The sign of the *OPEN* is positive and consistent with the model.

An increase in the world interest rate is expected to appreciate the equilibrium real exchange rate if the country is a net creditor in the world markets. The result confirms our prior expectations since the equilibrium real exchange rate depreciates as a result of an increase in the long-term real interest rate due to the fact that Turkey is a net debtor in international financial markets.

Using the cointegrating equation, we first obtain the equilibrium values of the real exchange rate and then subtract these values from the observed real exchange rates to get the magnitude and duration of the misalignments. Figure 3 depicts the actual real exchange rate and the real exchange rate implied by the long-term equilibrium. The difference between the actual and the equilibrium is plotted in Figure 4.

Using the cointegrating term or the error correcting term (misalignment) obtained from the VEC estimation, and the assumption of weak exogeneity, the short-run analysis within the framework of error correction mechanism is given as follows:

$$\Delta \text{rer}_t = -0.390z_{t-1} + 0.208\Delta \text{rer}_{t-1} + 0.596\Delta \text{tot}_{t-1} + 0.075 - 0.110 \text{dlibtur} + 0.233 \text{d94tur} - 0.002 \text{ggdp} \\ + 7.93\text{E-}6 \text{kapflow}$$

where  $z_{t-1}$  term stands for the error correcting term which is one quarter lagged residual, and all variables are significant at 5% level. [9]

An analysis of the above result shows that the adjustment is quite prompt in Turkey. Two and a half months are required to eliminate 50% of the effects of an exogenous shock. [10] The productivity variable, *GGDP*, plays a significant role in the short run movements of the real exchange rate. Dummy variables are significant with signs confirming to the prior expectations. The liberalization dummy variable has a negative sign capturing the intervention by the monetary authority to increase the value of the TL vis-à-vis the US Dollar, the crisis dummy variable has a positive coefficient indicating the effect of the sharp devaluation during the crisis.

From Figure 4, we see that the real exchange rate vis-à-vis the US Dollar was relatively undervalued prior to 1990, and relatively undervalued following the crisis in 1994. In fact, the calculated annual average misalignment is 5.76% during 1996-1998. Annual averages for 1996, 1997, and 1998 are, respectively, 6.5%, 3.6%, and 7.6%.

## V. Conclusion

An attempt has been made to estimate the equilibrium real exchange rate for Turkey. The purpose was to analyze whether a contribution to the understanding of misalignments in the real exchange rate can be made and whether this could be used as a guideline for policy interventions by the monetary authorities.

The estimation results indicated the relevance of the equilibrium exchange rate model. Not only the sign and the magnitude of the estimated coefficients have verified the model postulates but also the estimation results correspond with the policy intervention and the targeting by the Turkish authorities. Therefore, we can conclude that the given framework of estimating currency misalignments can be used as a useful policy guide.

\*The authors would like to thank, without implicating, Dr. Fatih Ozatay and other participants of the Exchange Rate Dynamics in the Middle East session of the annual meeting of the MEEA in conjunction with ASSA, held in Boston January 7-9, 2000. Thanks are due to Refik Erzan, Gulbin Sahinbeyoglu, and Murat Ucer for their valuable comments, and Asli Savranoglu Alper for research assistance. The usual disclaimer applies. Financial support of Bogazici University Research Fund (Project Code No: 98HC102) is also gratefully acknowledged.

## Notes

[1] See Economic Report of the President (1999) chapter 6 for detailed discussion.

[2] See for example, e.g., Feyzioglu (1997) for an application of the estimation of the ERER to Finland.

[3] The base year of the Turkish CPI is adjusted to 1990=100 from 1987=100.

[4] See Arslaner and Erlat (1997) and Saygili et al. (1998) for a detailed discussion of measuring real exchange rate series for Turkey.

[5] Rogoff (1996), for example, refers to the "embarrassing resilience of the random walk model" for the real exchange rate.

[6] All the estimation and the test results are available from the authors upon request.

[7] The multivariate system is estimated, the number of cointegrating vectors are identified, inferences are drawn are described in detail in Johansen (1988 and 1991).

[8] The endogenous variables entering the VAR system are *RER*, *TOT*, *OPEN*, and *R*. The exogenous variables are a constant, *KAPFLOW*, three centered seasonal dummy variables and specific dummy variables discussed in the Data section.

[9] In order not to clutter the space, standard errors or t-statistics are not reported. All results are available from the author upon request.

[10] See, e.g., Elbadawi (1994) for a comparison of the amount of time required in eliminating exogenous shocks in Chile, Ghana, and India.

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Figure 1  
Real Exchange Rates  
Based on Alternative Definitions  
(1990=100)

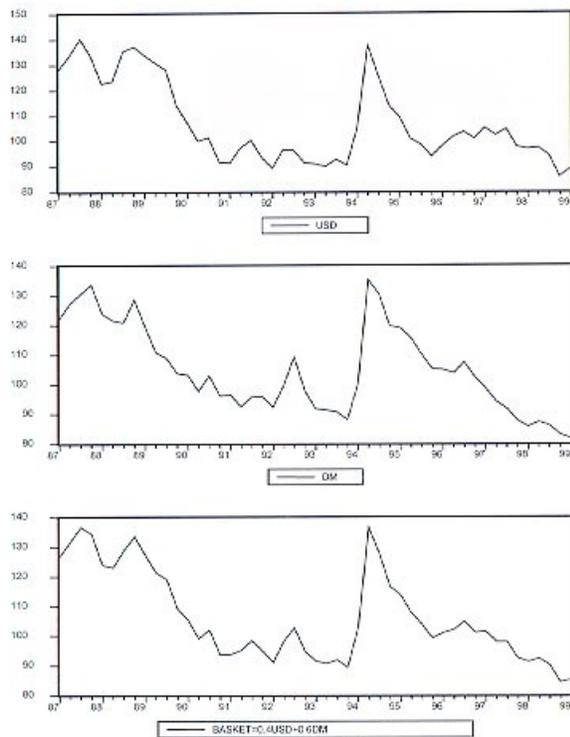


Figure 2  
Other Variables used in Estimations

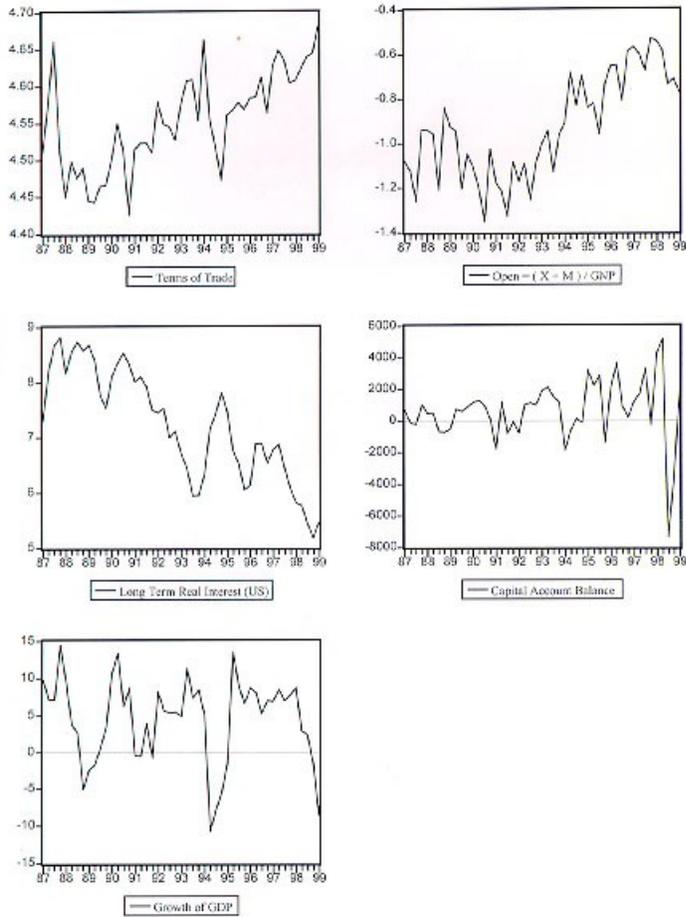


Figure 3  
Real Exchange Rate and the Estimated Equilibrium Exchange Rate  
(in USD)

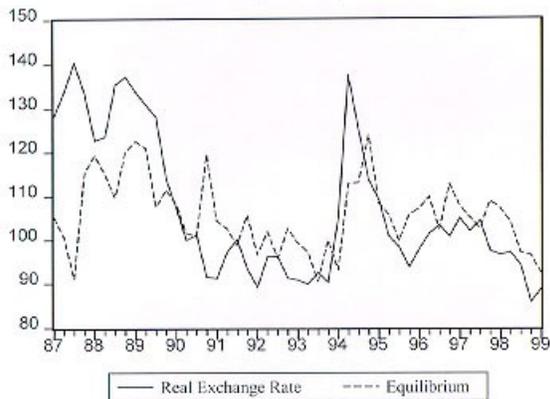


Figure 4  
Misalignments

