

Economic fundamentals and the behavior of the real effective exchange rate of the Cyprus pound *

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Abstract

This paper investigates whether the real effective exchange rate of the Cyprus pound is misaligned by generating measures of the equilibrium rate using the behavioral equilibrium exchange rate (BEER) approach. Several measures of the equilibrium exchange rate were derived and used to check for the existence of exchange rate misalignment. The results suggest that, during the 1990s, the actual real effective exchange rate and the various equilibrium measures generated move closely together and there is no evidence of any significant and persistent misalignment. However, the empirical evidence suggests persistent overvaluation during the 1980s.

Keywords: Equilibrium exchange rates, Cyprus pound.

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1. Introduction

An inescapable fact of economic life is that exchange rates fluctuate. Economists are often asked to assess the nature and causes of these fluctuations and determine whether a particular exchange rate is overvalued or undervalued. Evaluation of such exchange rate misalignments necessarily requires the establishment of the equilibrium value of an exchange rate. A number of different approaches exist in the literature for calculating the equilibrium real exchange rate, ranging from the traditional purchasing power parity (PPP) theory (see Rogoff (1996) and Taylor and Taylor (2004) for a recent survey) to more recent approaches such as the internal-external balance (IEB) approach (also known as the macroeconomic balance approach). Popular variants of the IEB approach include the fundamental equilibrium exchange rate (FEER) approach of Williamson (1983,1994) (see also Wren-Lewis (1992) and Driver and Wren-Lewis (1999)); the natural real exchange rate (NATREX) approach of Stein (1994, 1999); and the approach used by the International Monetary Fund (IMF) (see, for example, Isard and Faruquee (1998) and Faruquee, Isard and Masson (1999)). Another recent and very popular approach is the behavioral equilibrium exchange rate (BEER) approach advocated by Clark and MacDonald (1999).

The key insight of the IMF approach is to recognize that the equilibrium current account can be viewed as the difference between desired saving and investment at full employment. Such an approach has been employed by the IMF (1998) to ascertain whether the real effective exchange rate of the Cyprus pound is misaligned. The general approach of the IMF study is to estimate the current account that is likely to emerge in the medium term under prevailing exchange rates and with domestic and foreign outputs at their potential levels (the underlying current account) and to

compare this with the equilibrium current account (defined as the current account that is compatible with savings and investment fundamentals at full employment). When the two current account balances differ it is assumed that the real exchange rate will adjust so as to move the underlying current account to its equilibrium level. The resulting adjustment in the real exchange rate is an indication of the degree of over- or undervaluation of the Cyprus pound. Based on this approach the IMF study has concluded that *'the 1997 real effective exchange rate of the Cyprus pound is broadly in line with present savings and investment fundamentals'* (IMF (1998), p.21).

To the best of our knowledge the IMF (1998) study (and subsequent updates of it) is the only work which has been done to ascertain whether the Cyprus pound real effective exchange rate is misaligned. The aim of the current paper is to fill this gap in the literature. This paper models the equilibrium real effective exchange rate of the Cyprus pound as time-varying, being determined by a set of economic fundamentals, using the behavioral equilibrium exchange rate approach advocated by Clark and MacDonald (1999). Such an approach is particularly appropriate in assessing whether a movement of the actual real exchange rate represents a misalignment or whether the equilibrium exchange rate itself has shifted given changes in economic fundamentals.

Although the Cyprus pound exchange rate was pegged to some currency anchor¹ for the period under investigation (1980Q1-2000Q3), the real effective exchange rate was changing, reflecting both changes in relative prices and changes in the nominal effective exchange rate (due to changes in the exchange rates outside the pegged

¹ A detailed description of exchange rate policy in Cyprus can be found in Kyriacou (2002).

arrangement and also due to changes in the pegged exchange rate itself within the fluctuation bands).² In fact, the nominal effective exchange rate was rising throughout the sample period (see Figure 1). Figure 1 also shows that the Cyprus pound real effective exchange rate was not very volatile but it seems to have exhibited a gradual depreciation from 1980-1990 and a gradual appreciation during the rest of the sample period. It is, therefore, important to understand the economic fundamentals that drive this important measure of competitiveness of the Cyprus economy. The estimation of the equilibrium real effective exchange rate can also shed light on possible exchange rate misalignments. As a new member of the European Union, Cyprus is planning to eventually adopt the Euro. If Cyprus joins at an inappropriate rate, this will create problems. For example, an undervalued exchange rate will lead to inflationary pressures, whereas an overvalued exchange rate may lead to lower exports with a negative impact on the rate of economic growth.

INSERT FIGURE 1 HERE

The paper is organized as follows. Section 2 discusses the BEER approach that will be used to estimate the equilibrium real effective exchange rate of the Cyprus pound. Section 3 presents and discusses the empirical results and the final section summarizes and concludes.

² As Gylfason (2002) argues, irrespective of nominal exchange rate arrangements, the real exchange rate always floats.

2. The BEER approach: Theory and empirical formulation

As already indicated in the previous section, a number of different approaches have been used in the literature for modeling equilibrium exchange rates and uncovering misalignments. A detailed overview of the various approaches can be found in MacDonald (2000) and MacDonald and Stein (1999).

Since a variant of the IEB approach has been used in the case of Cyprus (see IMF (1998)) and measures based on PPP are generally unreliable, this study aims to estimate the equilibrium value of the Cyprus pound real exchange rate using the behavioral equilibrium exchange rate approach advocated by Clark and MacDonald (1999) (see also Mark (1999), Chinn (1999), Alberola et al (1999), Alberola et al (2002), MacDonald (2002), Lane and Milesi-Ferretti (2002), and Paya *et al* (2003)).³ The exposition of the BEER approach in this section draws heavily on Clark and MacDonald (1999) and MacDonald (2002). These studies exploit the uncovered interest parity condition:

$$E_t(\Delta s_{t+k}) = -(i_t - i_t^*) \quad (1)$$

where s_t is the foreign currency price of a unit of domestic currency (so that an increase indicates an appreciation), i_t is the nominal interest rate at home (a * indicates the corresponding foreign variable), Δ is the first difference operator, E_t is the conditional expectations operator and $(t+k)$ defines the maturity horizon of the bonds. Equation (1) can be converted in real terms by subtracting the expected inflation differential from both sides of the equation. After rearrangement this gives:

³ For an interesting analysis that combines the FEER and BEER methodologies, see Égert and Lahreche-Revil (2003).

$$q_t = E_t(q_{t+k}) + (r_t - r_t^*) + e_t \quad (2)$$

where q_t is the *ex ante* real exchange rate, r_t the *ex ante* real interest rate and e_t is an error term. It is customary to assume in this approach that the unobserved component ($E_t(q_{t+k})$) represents the influence of economic fundamentals other than interest rates. Thus, the current equilibrium exchange rate comprises both components: the systematic component, \hat{q} ($=E_t(q_{t+k})$, determined by economic fundamentals) and the real interest rate differential.

The economic fundamentals that can introduce a systematic variability in the real exchange rate have been discussed extensively in the literature (see for example, the various papers cited above and the following discussion). In the case of Cyprus, \hat{q} is a function of the following fundamentals:⁴

$$\hat{q} = f(PNT, TOT, NFA, POIL, FBAL) \quad (3)$$

where PNT is the relative price of nontraded to traded goods in Cyprus relative to the equivalent (trade-weighted) foreign ratio; TOT is the terms of trade of Cyprus relative to the equivalent (trade-weighted) foreign variable; NFA is the net foreign asset position of Cyprus relative to Cyprus's GDP; $POIL$ is the real price of oil; and $FBAL$ is the fiscal balance of Cyprus as a proportion of GDP minus the equivalent (trade-weighted) foreign ratio. Thus, in the empirical analysis, the equilibrium real effective

⁴ The economic fundamentals employed in this study have been used extensively in the literature. In particular, the specification is based on MacDonald (1999) and Clark and MacDonald (1999) since the BEER approach has been popularized by them. Many other studies have used all or a subset of the variables used in this paper (see, for example, Alberola et al (1999), Hansen and Roeger (2000), and Paya *et al* (2003)).

exchange rate of Cyprus is assumed to be a function of these variables and the real interest rate differential (*RID*). The empirical measurement of all the variables is discussed in section 3.1. In the remainder of this section we discuss the likely theoretical effect of these variables on the real effective exchange rate.

An increase in the *relative price of nontraded goods (PNT)* in Cyprus relative to its trading partners will lead to an appreciation of the real effective exchange rate (defined as ep/p^* , where e is the nominal effective exchange rate (defined as the foreign currency price of a unit of domestic currency) and p and p^* are the overall price levels in the home and foreign country, respectively). This is because the prices of nontraded goods (or, more precisely, services) are included in the overall price levels, thus, leading to an appreciation of the real exchange rate (even though traded goods prices are equalized through international trade). The relative price of nontraded goods can be viewed as a proxy for the well known Balassa-Samuelson effect (Balassa (1964), Samuelson (1964)). This is based on the idea that productivity advances influence mainly the traded goods sector and to a lesser extent the nontraded goods sector. Assuming that prices are linked to wages, wages are linked to productivity, and wages are linked across the nontraded and traded sectors, then productivity growth in the tradables sector will raise real wages in both sectors and increase the relative price of nontraded goods (since nontraded goods production is more labor-intensive, consisting mainly of services). Thus, the overall price level of a fast growing (high productivity) economy will rise faster than that of a slow growing country (even though international trade may equalize the prices of traded goods). Fast growing countries, therefore, should experience an appreciation of their overall real exchange rate relative to the real exchange rate defined for traded goods prices.

Although the relative price of nontraded goods has been used extensively in the literature as a proxy for the Balassa-Samuelson effect, it is important to note that it also captures other factors such as demand effects (e.g. due to income changes) and also changes in factor endowments as suggested by Bhagwati (1984) (see discussion in section 3.1 for more details).

An improvement in the *terms of trade (TOT)* will have a positive impact on the current account that will require a real appreciation of the exchange rate. Another way of looking at this is that an improvement in the terms of trade will generate a positive wealth effect leading to an increase in aggregate demand and the relative price of nontradables and, therefore, to an appreciation of the real effective exchange rate (Paya *et al* (2003)).

Net foreign assets (NFA) are influenced by the determinants of savings and investment and, in particular, demographics and structural fiscal balances (Clark and MacDonald (1999)). The relationship between the fiscal balance and NFA can be explained in terms of the implications of portfolio balance models which postulate that in the long-run the current account is balanced so that any interest earnings on NFA are offset by a corresponding trade imbalance (MacDonald (1999)). Hence, if a fiscal contraction is permanent it will raise national saving leading to an increase in NFA (since countries which save more than their trade partners will tend to accumulate more foreign assets) and an appreciation of the real effective exchange rate (Paya *et al* (2003)). This is because an increase in NFA will lead to a future inflow of investment income, thus, causing a real exchange rate appreciation (and a trade imbalance). An alternative mechanism is that an increase in NFA will increase

aggregate demand leading to an increase in the relative price of nontradables and an appreciation of the real exchange rate (MacDonald and Ricci (2004)). However, empirical evidence suggests that the sign of NFA is ambiguous. In fact, even on theoretical grounds the sign of NFA may be positive or negative (see Égert, Halpern and MacDonald (2004) for a recent discussion). To an extent, the negative effect may also be explained as follows: an improvement in the fiscal balance (that causes an increase in national saving and NFA) will lower the domestic interest rate causing a real exchange rate depreciation (MacDonald (1999)). Furthermore, the fiscal contraction reduces aggregate demand and causes the relative price of nontraded goods to fall, leading to a depreciation of the real effective exchange rate. However, as MacDonald and Ricci (2004) argue, in the context of a portfolio balance model, the current account surplus resulting from the real depreciation will have to be eliminated in the long-run by a real appreciation that leads to a current account deficit that offsets the positive NFA. Thus, in the short to medium-run the effect of NFA on the real exchange rate may be negative but in the long-run it will be positive. For the same reasons outlined above, the effect of an improvement in the *fiscal balance (FBAL)* will have (as in the case of NFA) an ambiguous effect on the real effective exchange rate.

The effect of an increase in the *real price of oil (POIL)* on the real exchange rate is relatively straightforward. An increase in the real price of oil will have a negative effect on the current account of an oil importing country like Cyprus, causing the real exchange rate to depreciate. Finally, an increase in the *real interest rate differential (RID)* in favor of Cyprus will lead to an appreciation of the real exchange rate since it may reflect higher capital productivity, leading to a capital inflow. As MacDonald and

Ricci (2004) argue, the effect of the RID may represent several factors all pointing to a positive relationship with the real exchange rate. For example, an increase in aggregate demand (that puts an upward pressure on the real interest rate) would raise the relative price of nontradables and lead to a real exchange rate appreciation.

To summarize, the real effective exchange rate of the Cyprus pound will be estimated as a function of the following variables (with the signs below the variable names denoting the partial derivatives):

$$q = f(PNT, TOT, NFA, POIL, FBAL, RID) \quad (4)$$

$\begin{matrix} + & + & +/- & - & +/- & + \end{matrix}$

To generate the equilibrium real effective exchange rate of the Cyprus pound the paper simply substitutes the actual values of the fundamentals into the estimated relationship based on equation (4). The estimated equilibrium real exchange rate is then compared to the actual exchange rate and the difference between the two indicates the extent of exchange rate misalignment. Clark and MacDonald (1999) describe this as a measure of *current misalignment* since the equilibrium rate is calculated using the current (actual) values of the economic fundamentals. It is, however, possible that the actual values of the economic fundamentals themselves may depart from their sustainable or desirable levels. As a consequence, Clark and MacDonald (1999) propose a second measure of misalignment (termed *total misalignment*) given by the difference between the actual real exchange rate and the equilibrium rate estimated using the sustainable or long-run values of the economic fundamentals. There are various ways of deriving the long-run values of the economic fundamentals such as the Hodrick-Prescott (1980) filter, the Beveridge-Nelson decomposition and the permanent equilibrium exchange rate (PEER) approach used

by Clark and MacDonald (2000). In this paper the second measure of the equilibrium real exchange rate is estimated by smoothing all economic fundamentals using the Hodrick and Prescott (1980) filter and then substituting these smoothed series into the estimated long-run relationship. This method effectively takes the cyclical (short-run) components out of the data, thus, resulting in the sustainable (long-run) values of the economic fundamentals.

3. Empirical results

3.1 Data sources and construction of variables

The study uses quarterly data for the period 1980Q1-2000Q3. In what follows we explain how each variable was defined and the data sources used.

LREER: This variable is the real effective exchange rate of the Cyprus pound calculated by the International Monetary Fund (IMF) and expressed in (natural) logarithmic form. It is defined in terms of foreign currency per one unit of domestic currency, so that an increase indicates a real effective appreciation. It was obtained from the International Financial Statistics (IFS) of the IMF (IFS code rec).

LPNT: This variable is the relative price of nontraded to traded goods in Cyprus relative to the corresponding (trade-weighted) foreign ratio and can be considered as a proxy for the Balassa-Samuelson effect.⁵ It is defined as:

⁵ In the literature one of two variables is usually used to proxy the Balassa-Samuelson effect: the relative price of nontradables or a direct measure of sectoral productivity. For reasons given below, this paper focuses on the former, in line with many other studies (see for example, Clark and MacDonald (1999), Alberola *et al* (1999), Hansen and Roeger (2000), and Paya *et al* (2003)). A problem of using a measure of productivity as a proxy for the Balassa-Samuelson effect is that productivity data are

$$BS = \frac{\left(\frac{cpi}{wpi}\right)_{Cyprus}}{\prod_{i=1}^n \left(\frac{cpi}{wpi}\right)_i^{w_i}}$$

where the numerator is the ratio of Cyprus's consumer price index (CPI) to Cyprus's wholesale price index (WPI) and the denominator is the equivalent foreign (trade-weighted) ratio.⁶ This variable is also expressed in logarithmic form. For some of the

usually available at annual frequency. There is the additional problem of choosing one of the many alternative productivity measures that one can use (see for example, Maeso-Fernandez, Osbat and Schnatz (2004) for a brief discussion). Furthermore, given that both supply and demand factors affect the relative price of nontraded goods, the latter may be a more appropriate variable to use. In addition, the use of the relative price of nontraded goods may be more appropriate since changes in this variable may come from changes in factor endowments as suggested by Bhagwati (1984), who argued that as a country develops, it adopts more capital intensive techniques that lead to an increase in the wage-interest rate ratio and, therefore, to an increase in the relative price of (labor-intensive) nontraded goods. Thus, even though the relative price of nontraded goods may not be an ideal proxy for the Balassa-Samuelson effect, it is an important variable influencing the real exchange rate. For a critique of the use of such a variable (and, in particular, of the CPI/WPI ratio) as a proxy for the Balassa-Samuelson effect see Égert, Halpern and MacDonald (2004).

⁶ All trade-weighted foreign variables used in the construction of variables LPNT and LTOT were geometric averages. The most important trading partners and competitors of Cyprus were used according to weights (w_i) calculated by the IMF (and supplied to the authors). These weights are used by the IMF in constructing the real effective exchange rate of the Cyprus pound. The main trade partners and competitors of

foreign countries the producer rather than the wholesale price index was used due to data availability. All the data used to construct this variable were taken from the IFS (code 63 for the WPI and 64 for the CPI). In the case of Cyprus's WPI (code 63), the data was taken from the 2004 IFS CDRROM which contains data for this variable for the entire sample period.⁷

LTOT: This variable captures the terms of trade and is defined as the terms of trade of Cyprus relative to the effective foreign (trade-weighted) terms of trade. It is defined as:

$$TOT = \frac{\left(\frac{p_x}{p_m} \right)_{Cyprus}}{\prod_{i=1}^n \left(\frac{P_x}{P_m} \right)_i^{w_i}}$$

where the numerator is the terms of trade of Cyprus (defined as export prices (p_x) divided by import prices (p_m)) and the denominator is the effective (trade-weighted) foreign variable. All data used for the foreign countries were obtained from the IFS (code 74 for the export prices and 75 for import prices). In the case of Cyprus, however, data for export and import prices (as defined for the foreign countries) were not available in IFS (or elsewhere) for most of our sample period. We have used instead data published by the Statistical Service of Cyprus in its Monthly Economic Indicators to proxy these variables. More specifically, the export price used was the

Cyprus were: Austria, Belgium, Finland, France, Germany, Greece, Italy, Japan, Korea, The Netherlands, Norway, Singapore, Spain, Sweden, Switzerland, Turkey, UK, USA and Taiwan. In those cases where no data were available for a particular country, that country was excluded and the weights recalculated.

⁷ In the first draft of the paper, due to data unavailability, Cyprus's WPI reflected the combination of series codes 63 and 63A (WPI for home goods).

price index of manufacturing production destined for the export market. The import price used was the CPI of imported goods. A measure of Cyprus's terms of trade was subsequently calculated by dividing the export price measure by the import price.

NFA: This variable is the stock of net foreign assets of Cyprus obtained from the IFS (code 31N) and expressed as a proportion of Cyprus's Gross Domestic Product (GDP) obtained from the same source (code 99b).⁸ The annual GDP data were expressed in quarterly form using the cubic splines interpolation method.⁹

LPOIL: This variable is the real price of oil expressed in logarithmic form. The price of oil (in US\$) was obtained from the IFS (code 00176aazzf). It was then expressed in Cyprus pounds using the bilateral exchange rate (IFS code rh) and deflated by Cyprus's wholesale price index.

RID: This variable is the real interest rate differential. It is defined as the real interest rate of Cyprus minus the effective foreign (trade-weighted) real interest rate. The latter was an arithmetic average. The real interest rate of Cyprus was calculated as the nominal interest rate minus an (annualized) eight-quarter, centered moving average of the quarterly inflation rates (calculated using the CPI). The real interest rates of the foreign countries were calculated in a similar way. The nominal interest rates used were the short-run Treasury bill rates taken from the IFS (code 60c).

⁸ It is generally recognized that it is difficult to measure NFA. This variable should reflect the international investment position of a country. No such data were available in the case of Cyprus for most of the period under investigation. Furthermore, the current account balance (whose cumulative summation can be used as a measure of the stock of NFA) was not used since it was only available with annual frequency. Thus, the paper used the IFS series 31N as a proxy for Cyprus's stock of NFA.

⁹ We are grateful to Costas Xiouros for assistance in constructing this variable.

FBAL: This variable captures the effect of the fiscal balance and was calculated as the Cyprus fiscal balance as a proportion of GDP minus the equivalent (trade-weighted) foreign ratio. The latter was an arithmetic average. Data on GDP and fiscal balances of the partner countries were taken from the IFS (codes 99b and 80ZF, respectively). The quarterly GDP of Cyprus was constructed as explained for the NFA variable. Data on the fiscal balance of Cyprus were taken from the Monthly Economic Indicators published by the Statistical Service of Cyprus.

3.2 Equilibrium exchange rates

All variables entering the BEER model have been tested for unit roots using both versions of the Augmented Dickey-Fuller (1979, 1981) (ADF) test: the first included only an intercept in the ADF regression and the second included both an intercept and a linear trend. The appropriate lag length of the autoregression in the ADF test was chosen based on the Schwarz Bayesian Criterion (SBC). The ADF test results are presented in Table 1.

INSERT TABLE 1 HERE

The variables LREER, LPNT, LPOIL, LTOT, FBAL and RID were found to be I(1). The ADF test without a trend suggested that NFA was I(1) but the ADF test with a trend included in the ADF regression was unclear; suggesting that the variable might possibly be I(0).¹⁰ However, the autocorrelation function of NFA and formal Phillips-

¹⁰ Choosing the appropriate lag length with the Akaike Information criterion using a maximum lag order of 6 for the augmentation of the ADF test suggests that NFA is I(1).

Perron (1988) tests clearly suggest that NFA is non-stationary. The analysis, therefore, proceeded based on the finding that all variables are unit root processes.

The Johansen (1988; 1991) procedure was used to test for the existence of a valid long-run relationship. This procedure is now well known and is not discussed here. Before testing for cointegration it is important to determine the lag length of the vector autoregression (VAR) to be used. This was achieved by estimating unrestricted VARs and the lag length was chosen based on the Schwarz Bayesian Criterion (SBC) and the Akaike Information criterion (AIC). However, these two information criteria suggested different appropriate lag orders (with the SBC selecting order 1 and the AIC selecting 4 or 6 depending on whether the unrestricted VAR was estimated using a maximum order of 4 or 6). Re-estimating the VAR with a lag order of 1 and checking the diagnostic tests of the individual equations in the VAR suggests that some of them fail some of the usual tests including serial correlation. We, therefore, proceed to the cointegration analysis with the conclusion that the appropriate lag length to be used is two.¹¹

¹¹ Diagnostic testing of the individual equations in the VAR of order 2 suggests that they pass the usual battery of tests (serial correlation, functional form, normality, heteroscedasticity and autoregressive conditional heteroscedasticity (see Notes of Table 3 for more details on the actual tests used)) with the following exceptions (at the 95% level): normality in the equations of LTOT, NFA, LPOIL and RID; and functional form in the equations of LTOT and RID. Increasing the lag length of the VAR did not solve most of these problems and in certain cases caused additional econometric problems.

The second step in the analysis involves choosing the appropriate specification of the deterministic components in the VAR. Rather than assuming the nature of the deterministic components, VARs were estimated with three different specifications: (a) restricted intercepts and no trends in the VAR, (b) unrestricted intercepts and no trends and (c) unrestricted intercepts and restricted trends (see Pesaran and Pesaran (1997) for more details). The choice of the appropriate specification was based on the Pantula principle (Johansen (1992)). The Pantula principle chooses both the correct specification of the deterministic components and also the order of the cointegration rank (r). We have also included three seasonal dummies which is a usual specification with quarterly data. Based on the Pantula principle, Johansen's *trace statistic* shows that there is one cointegrating vector (under all specifications of deterministic components) and the appropriate specification is restricted intercepts and no trends in the VAR. This conclusion holds at both the 95% and 90% significance levels. The *maximal eigenvalue statistic* of Johansen also suggests that $r=1$ for the first two specifications of deterministic components in the VAR but suggests that $r=0$ in the case of unrestricted intercepts and restricted trends. We proceed on the finding that there exists one cointegrating vector. The cointegration results are presented in Table 2.¹²

INSERT TABLE 2 HERE

¹² We have also tested for cointegration without seasonal dummies in the specification. In this case, both of Johansen's statistics clearly show that there is one cointegrating vector (at the 95% level) and the correct specification is restricted intercepts and no trends in the VAR. Thus, the finding reported in the main text is fairly robust.

Having established cointegration among the I(1) variables and the existence of one cointegrating vector, an autoregressive distributed lag (ARDL) model was estimated using the levels of all the variables in order to obtain the cointegrating vector.¹³ For example, in the case of two variables (y and x) the ARDL model takes the following form:

$$y_t = \alpha + \sum_{i=1}^p \beta_i y_{t-i} + \sum_{i=0}^q \gamma_i x_{t-i} + \varepsilon_t$$

In our case, of course, the ARDL model includes all variables described in section 3.1. A ‘general-to-specific’ methodology was applied, with the original model estimated with four lags for each variable and a more parsimonious model was obtained by sequentially deleting insignificant variables. The results of the parsimonious model (ARDL1) are now reported in column 2 of Table 3 and the plot of actual and fitted values is presented in Figure 2.

INSERT TABLE 3 and FIGURE 2 HERE

¹³ Caporale and Chui (1999) have also used a similar approach, in that they have tested for cointegration using the Johansen approach and then estimated the long-run relationship using an ARDL model.

It is clear that the model passes all the usual diagnostic tests. From the results presented in column 2 of Table 3, the long-run cointegrating relationship that defines the equilibrium real exchange rate (ERER1) is given as (standard errors in parentheses):¹⁴

$$\mathbf{ERER1} = \mathbf{4.149} + \mathbf{0.972} \mathbf{LTOT} - \mathbf{0.162} \mathbf{LPOIL} - \mathbf{0.013} \mathbf{RID} + \mathbf{1.38} \mathbf{FBAL}$$

$$\mathbf{(0.229)} \quad \mathbf{(0.294)} \quad \mathbf{(0.089)} \quad \mathbf{(0.009)} \quad \mathbf{(0.769)}$$

All of the variables in the cointegrating vector are statistically significant (at either the 95% or 90% levels) and correctly signed, with the exception of RID whose coefficient is small, incorrectly signed and statistically insignificant at conventional significant levels. Thus, increases in the terms of trade or improvements in the fiscal balance will lead to an appreciation of the real exchange rate. On the other hand, an increase in the real oil price will lead to a depreciation of the real exchange rate of Cyprus (an oil importing nation). The variables LPNT and NFA were statistically insignificant and were dropped from the estimated model.¹⁵

¹⁴ From the results reported in Table 3, the long-run coefficient (*LR*) for each variable

was obtained as: $LR = \frac{\sum_i \gamma_i}{\left(1 - \sum_i \beta_i\right)}$, where γ_i refers to the coefficients of current and

lagged values of each explanatory variable and β_i to the coefficients of lagged values of the dependent variable.

¹⁵ ARDL models were also estimated using the ARDL option in Microfit 4.1 (see Pesaran and Pesaran (1997)). Under this option, the appropriate order of the ARDL model is chosen on the basis of model selection criteria (such as AIC and SBC). A very similar long-run relationship (not reported) was obtained using this option (and basing model selection on the AIC). Furthermore, the ARDL models estimated in this

To generate the equilibrium real effective exchange rate of the Cyprus pound we simply substituted the actual values of the fundamentals into the estimated long-run relationship. Figure 3 plots the equilibrium and the actual real effective exchange rates (ERER1 and LREER, respectively).

INSERT FIGURE 3 HERE

The difference between the two indicates the extent of *current* exchange rate misalignment. As can be seen from Figure 3, the long-run trend behavior of the actual real exchange rate is similar to that of the equilibrium real exchange rate. However, Figure 3 suggests that the equilibrium exchange rate is more volatile than the actual rate. To a large extent this may reflect the variability of the cyclical components of the economic fundamentals entering the BEER model.

As discussed in section 2, Clark and MacDonald (1999) have argued that the current values of the economic fundamentals themselves may depart from sustainable or desirable levels. Thus, they proposed a second measure of misalignment (*total misalignment*) given by the difference between the actual real exchange rate and the equilibrium rate estimated using the sustainable or long-run values of the economic fundamentals. To calculate the equilibrium real exchange rate using the long-run values of the fundamentals, the paper first removed the cyclical components from all the time series using the Hodrick-Prescott (1980) filter and then substituted these smoothed series into the estimated cointegrating vector. Figure 4 plots the actual real exchange rate with the equilibrium rate (ERERTREN1) based on the smoothed series

way suggest that the lagged dependent variable is an important factor influencing the real exchange rate. This is consistent with the results presented in Table 3. This is, of course, not surprising given the unit root behavior of the real effective exchange rate.

of the fundamentals, whereas Figure 5 presents the percentage misalignment of the actual real exchange rate from the equilibrium rate (defined as $MIS1=(LREER-ERERTREN1)*100$).

INSERT FIGURES 4 AND 5 HERE

The main conclusion that can be drawn from Figure 4 is that the actual real effective exchange rate was overvalued during the 1980s but during the second half of the sample (1990-2000) it is broadly in line with the equilibrium rate. As can be seen from Figure 5, the percentage misalignment of the actual rate from the equilibrium rate is very small (ranging from -4% to +6.5%) during the 1990s. Thus, we can conclude that economic fundamentals play an important role in determining the long-run behavior of the real effective exchange rate of the Cyprus pound.¹⁶

¹⁶ We have also estimated an unrestricted error correction model (UECM) and derived the long-run equilibrium relationship based on the results. The UECM is a simple reparameterisation of the ARDL model and, thus, expected to generate (at least theoretically and in large samples) the same long-run relationship. In small samples, however, the results are expected to be somewhat different. In the case of two variables (y and x), the UECM takes the following form:

$$\Delta y_t = \alpha + \sum_{i=1}^p \beta_i \Delta y_{t-i} + \sum_{i=0}^q \gamma_i \Delta x_{t-i} + \phi y_{t-1} + \theta x_{t-1} + \varepsilon_t$$

where Δ is the first-difference operator. In our case, of course, the UECM included all variables described in section 3.1. In estimating the UECM we have followed a ‘general-to-specific’ approach with a maximum lag of 4, and the results of the parsimonious model are reported in Table 4. The model passes all the usual diagnostic tests. From the results presented in Table 4, the long-run coefficients (LR) are

INSERT TABLE 4 HERE

Engle and Granger (1987) suggest that if data are non-stationary but cointegrated, a useful econometric model for studying the short-run adjustment process is an error correction model (ECM). Thus, we have estimated an error correction model using a ‘general-to-specific’ methodology with a maximum lag of 4 for each variable. The error correction term (ECT) (lagged one period) included in the ECM was based on the estimated long-run relationship and was defined as: $ECT1 = LREER - ERER1$. In the case of two variables (y and x) such an ECM takes the following form:

$$\Delta y_t = \alpha + \sum_{i=1}^p \beta_i \Delta y_{t-i} + \sum_{i=0}^q \gamma_i \Delta x_{t-i} + \delta ECT_{t-1} + \varepsilon_t$$

where Δ is the first-difference operator. In our ECM, of course, we have included all variables described in section 3.1. The results of the ECM (not reported) showed that the coefficient of the error correction term was -0.10 (t-stat. = -5.17). Thus, the ECT1 was correctly signed (i.e. negative) and statistically significant (confirming that the variables are cointegrated), and suggesting moderate adjustment to the long-run

estimated as: $LR = -(\theta/\phi)$, where θ is the coefficient of each lagged explanatory variable in level form (e.g. $LTOT(-1)$) and ϕ is the coefficient of $LREER(-1)$). The resulting long-run relationship that defines the equilibrium real exchange rate was very similar to that obtained from the ARDL model (as expected). It is given as: $ERER3 = 4.12 + 1.03 LTOT - 0.17 LPOIL - 0.014 RID + 1.9 FBAL$. All coefficients are statistically significant at either the 95% or 90% levels. The plots of the actual and equilibrium real exchange rates and the conclusions regarding misalignments were also very similar and are not repeated here.

equilibrium. In terms of other variables that explain changes in the real effective exchange rate in the short-run we have: the relative price of nontraded goods with positive effect (but insignificant at conventional levels), the terms of trade and net foreign assets with positive effect, and the real price of oil, fiscal balance and the real interest rate differential with negative effect.

Although the model presented in column 2 of Table 3 passes the usual battery of diagnostic tests, a plot of the residuals indicates the existence of 5 outliers (defined to be those which are greater than two times the standard error of the regression). These outliers were in 1993Q3, 1994Q2, 1997Q3, 1997Q4 and 1999Q1. It is well known that even in the case of well specified models, the existence of outliers can affect the estimated coefficients. We have, thus, re-estimated the ARDL model by including five dummy variables to capture the effect of outliers. The results of this model (ARDL2) are presented in column 3 of Table 3. It is clear that the model passes all the usual diagnostic tests. The plot of actual and fitted values is similar to the original model and is not reported here for space considerations. The long-run relationship calculated from the results presented in column 3 of Table 3, that defines the equilibrium real exchange rate (ERER2), is given as (standard errors in brackets):

$$\mathbf{ERER2 = 3.855 + 1.219 LTOT - 0.277 LPOIL - 0.02 RID + 1.254 FBAL}$$

$$\mathbf{(0.342) \quad (0.379) \quad (0.133) \quad (0.011) \quad (0.758)}$$

All the long-run coefficients are statistically significant (at either the 95% or 90% levels) and, with the exception of RID, correctly signed.¹⁷ Figure 6 presents the actual

¹⁷ The finding that the coefficient of RID is very small and incorrectly signed may be due to the fact that the nominal interest rate in Cyprus was fairly constant over the sample period and also due to the existence of restrictions on capital flows.

real exchange rate and the equilibrium rate (ERER2) calculated from the long-run relationship using the current values of the economic fundamentals, whereas Figure 7 presents the equilibrium exchange rate (ERERTREN2) calculated using the Hodrick-Prescott filtered values of the fundamentals. Figure 8 presents the percentage misalignment of the actual real exchange rate from the equilibrium rate (defined as $MIS2=(LREER-ERERTREN2)*100$). Even though the estimated long-run relationship derived from ARDL2 is somewhat different than the one derived from ARDL1, the conclusions (regarding exchange rate misalignments) that can be drawn from Figures 6-8 are very similar to the ones presented earlier. In summary, the main finding of the analysis presented in this section is that the Cyprus pound real effective exchange rate was overvalued in the 1980s (but with the extent of misalignment decreasing throughout that period), but during the 1990s it was consistent with economic fundamentals. The misalignment in the latter period was small, ranging from -5% to +6%.

INSERT FIGURES 6, 7 AND 8 HERE

As in the case of the first long-run relationship, we have estimated an error correction model in this case as well. The error correction term (lagged one period) included in the ECM was based on the estimated long-run relationship and was defined as: $ECT2 = LREER - ERER2$. This ECM also included the five dummy variables explained earlier. The results of the ECM (not reported) showed that the coefficient of the error correction term was -0.06 (t-stat. = -5.8). Thus, once again, the ECT2 was correctly signed and statistically significant, and suggesting slow adjustment to the long-run equilibrium. In terms of other variables that explain changes in the real effective exchange rate in the short-run we have: the terms of trade and net foreign assets with

positive effect, and the real price of oil, fiscal balance and the real interest rate differential with negative effect.

As has been discussed earlier, an IMF (1998) study concluded that the real effective exchange rate of the Cyprus pound in 1997 was consistent with economic fundamentals. Using a different methodology the results of this study confirm the finding of the IMF, since in 1997 the actual exchange rate was very similar to the equilibrium value estimated using the economic fundamentals. Furthermore, the present study shows that the same conclusion applies for most of the period from 1990 to 2000. However, this study also shows that the real effective exchange rate of the Cyprus pound was significantly overvalued during the 1980s.¹⁸

¹⁸ We have also estimated a static OLS regression with the current levels of all variables (including a constant and a time trend). The equilibrium exchange rates generated based on these results suggest that there is no serious misalignment as the actual and equilibrium real exchange rates move closely together throughout the sample period. However, these results are not presented since: (i) a residual-based cointegration test (in the sense of Engle and Granger (1987)) cannot be applied since no critical values are available given the number of regressors in the model; (ii) the model fails many diagnostic tests (as expected); (iii) the bias of the static OLS estimator is quite large in small samples; and (iv) statistical inference is quite difficult since the *t*-values follow non-standard distributions.

4. Conclusions

Economists often talk about exchange rate misalignments and overvalued and undervalued exchange rates. Misalignment of the actual exchange rate necessarily implies the existence of some ‘equilibrium’ value of the real exchange rate. This paper estimated the equilibrium value of the real effective exchange rate of the Cyprus pound using the behavioral equilibrium exchange rate approach advocated by Clark and MacDonald (1999). This approach is based on the idea that the equilibrium value of the real exchange rate is determined by a set of economic fundamentals. Various measures of the equilibrium exchange rate were derived and used to check for the existence of both current and total misalignment. Overall, the results suggest that during the 1990s, the actual and the various equilibrium measures generated move closely together and there is no evidence of any permanent divergence between the two. In other words, the evidence suggests that the actual real effective exchange rate of the Cyprus pound is consistent with (and is driven by) the economic fundamentals of the country. The estimated misalignment during the 1990s was small, ranging from -5% to +6%. However, this paper also provides evidence that the real exchange rate was overvalued during the 1980s (although the magnitude of this overvaluation was decreasing throughout that period).

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TABLES

Table 1: Augmented Dickey-Fuller unit root tests

Variable	L		ΔL	
	t_{μ}	t_{τ}	t_{μ}	t_{τ}
LREER	-2.14 (0)	-1.57 (0)	-6.97 (0)	-7.01 (0)
LPNT	-2.02 (1)	-2.24 (1)	-15.72 (0)	-15.6 (0)
LTOT	-1.36 (0)	-1.03 (0)	-8.1 (0)	-8.2 (0)
NFA	-0.74 (2)	-4.26 (2)	-11.25 (1)	-11.24 (1)
LPOIL	-2.23 (3)	-2.32 (3)	-4.75 (3)	-4.98 (3)
RID	-2.04 (0)	-2.29 (0)	-8.25 (0)	-8.24 (0)
FBAL	-2.49(3)	-2.4 (3)	-13.56 (2)	-13.5 (2)

Notes (Table 1): L and ΔL denote the level and first difference of the series, respectively. t_{μ} is the ADF t-ratio with a constant but no trend and t_{τ} is the ADF t-ratio with a constant and a trend included in the ADF regression. The order of augmentation of the ADF tests (given in brackets) was selected by the Schwarz Bayesian Criterion (SBC) using a maximum order of 4. Similar conclusions were obtained with a maximum order of 6. The 5% critical values are -2.9 for the t_{μ} test and -3.47 for the t_{τ} test.

Table 2: Cointegration test results

Null	λ_{\max}	Trace	λ_{\max} 95% Critical value	Trace 95% Critical value
Restricted intercepts and no trends in VAR				
r=0	50.3	139.84	46.47	132.45
r≤1	28.29	89.54	40.53	102.56
r≤2	23.5	61.25	34.4	75.98
Unrestricted intercepts and no trends in VAR				
r=0	45.96	124.79	45.63	124.62
r≤1	24.35	78.82	39.83	95.87
r≤2	21.19	54.47	33.64	70.49
Unrestricted intercepts and restricted trends in VAR				
r=0	45.98	158.2	49.32	147.27
r≤1	38.82	112.2	43.61	115.85
r≤2	23.44	73.4	37.86	87.17

Notes (Table 2): The lag length of the VAR was two. λ_{\max} and Trace are Johansen's maximal eigenvalue and trace statistics, respectively. r indicates the number of cointegrating vectors. The critical values are those given by Microfit 4.1 (see Pesaran and Pesaran (1997) for more details). In testing for cointegration we have also included three seasonal dummies which is a usual specification with quarterly data. If no seasonal dummies are included, then both of Johansen's statistics clearly show that there is one cointegrating vector at the 95% level. Although we have seven variables we report only the results up to $r \leq 2$ to save space.

Table 3: Results of parsimonious Autoregressive Distributed Lag (ARDL) models

Dependent variable is LREER Estimation from 1981Q1-2000Q3		
	ARDL 1	ARDL 2
Constant	0.329 (2.29)	0.233 (2.05)
LTOT (-1)	0.143 (4.17)	0.153 (5.53)
LTOT (-3)	-0.066 (2.1)	-0.079 (3.17)
LPOIL	-0.013 (2.82)	-0.017 (4.46)
RID (-3)	-0.005 (2.94)	-0.005 (3.51)
RID (-4)	0.004 (2.32)	0.0034 (2.61)
FBAL (-2)	0.064 (2.26)	0.056 (2.5)
FBAL (-4)	0.046 (1.6)	0.02 (0.85)
LREER (-1)	0.921 (29.57)	0.94 (38.26)
DV1	--	-0.024 (3.12)
DV2	--	0.027 (3.57)
DV3	--	-0.02 (2.73)
DV4	--	0.022 (2.96)
DV5	--	-0.025 (3.23)
DIAGNOSTIC TESTS		
Adjusted R ²	0.977	0.986
F-statistic	F(8, 70)=[0.000]	F(13, 65)=[0.000]
SER	0.0092	0.0072
Durbin's h-statistic	[0.130]	[0.385]
Serial correlation	F(4, 66)=[0.172]	F(4, 61)=[0.736]
	F(8,62)=[0.291]	F(8,57)=[0.637]
Functional Form	F(1, 69)=[0.683]	F(1, 64)=[0.085]
Normality	χ^2 (2)=[0.469]	χ^2 (2)=[0.802]
Heteroscedasticity	F(1, 77)=[0.145]	F(1, 77)=[0.563]
ARCH	F(4, 66)=[0.176]	F(4, 61)=[0.630]
	F(8,62)=[0.178]	F(8,57)=[0.690]

Notes (Table 3): Values in brackets are absolute *t-ratios* and values in square brackets are *p-values*. SER is the standard error of the regression. Serial Correlation is the F version of Godfrey's (1978a, 1978b) Lagrange multiplier test of (no) residual serial correlation (see also Harvey, 1981); Functional Form is Ramsey's (1969) RESET test for (correct) functional form specification; Normality is the Bera and Jarque (1981) test for normality; Heteroscedasticity is White's (1980) test for homoscedasticity; and ARCH is Engle's (1982) test for (no) autoregressive conditional heteroscedasticity (see Pesaran and Pesaran (1997) for more details).

Table 4: Results of the parsimonious unrestricted error correction model (UECM)

Dependent variable is DLREER Estimation from 1981Q2-2000Q3			
	Coefficient (absolute <i>t</i> -ratio)	DIAGNOSTIC TESTS	
Constant	0.385 (2.68)	Adjusted R ²	0.46
DLPNT	0.127 (1.56)	F-statistic	F(16, 61)=[0.000]
DLTOT (-1)	0.074 (1.82)	SER	0.008
DLTOT (-2)	0.134 (3.27)	Serial correl. (4)	F(4, 57)=[0.472]
DNFA (-4)	0.043 (2.95)	Serial correl. (8)	F(8,53)=[0.072]
DLPOIL	-0.034 (4.32)	Functional Form	F(1, 60)=[0.887]
DLPOIL (-4)	-0.028 (3.49)	Normality	χ^2 (2)=[0.141]
DRID (-3)	-0.003 (2.09)	Heteroscedasticity	F(1, 76)=[0.325]
DFBAL (-1)	-0.175 (3.62)	ARCH (4)	F(4, 57)=[0.525]
DFBAL (-2)	-0.115 (3.07)	ARCH (8)	F(8,53)=[0.687]
DFBAL (-3)	-0.088 (3)		
DLREER (-3)	-0.146 (1.48)		
LREER (-1)	-0.093 (3)		
LTOT (-1)	0.096 (3.57)		
LPOIL (-1)	-0.016 (2.9)		
RID (-1)	-0.001 (2.19)		
FBAL (-1)	0.178 (3.25)		

Notes (Table 4): See Notes of Table 3. The letter D in front of the name of a variable indicates first differences. [A more parsimonious model, that excluded DLPNT and DLTOT(-1), resulted in a similar long-run equilibrium relationship.]

FIGURES

Figure 1: The nominal (NEER) and real (REER) effective exchange rate indices of the Cyprus pound (not in logarithmic form)

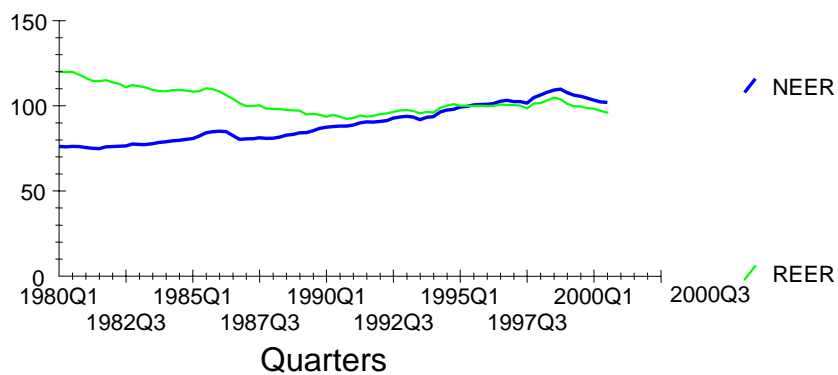


Figure 2: Plot of actual and fitted values of the ARDL1 model

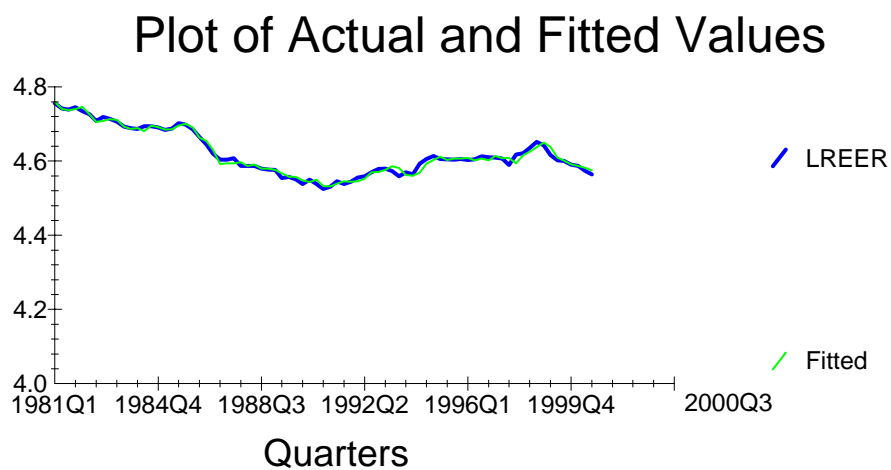


Figure 3: Plot of the (logarithm of the) actual (LREER) and equilibrium real exchange rate (ERER1)

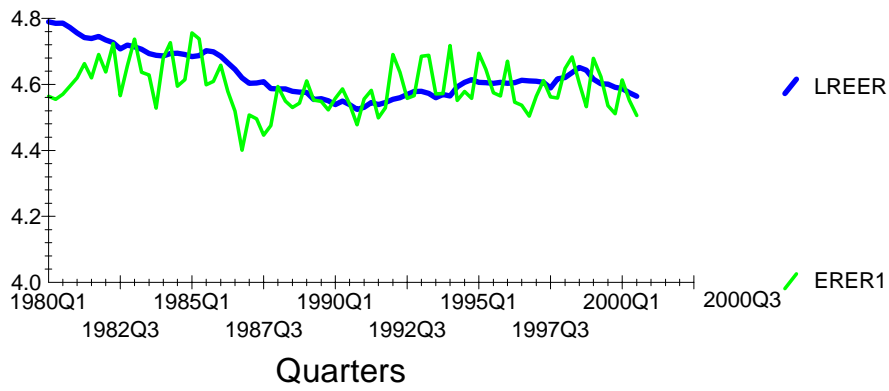


Figure 4: Plot of the actual (LREER) and equilibrium real exchange rate (ERERTREN1) generated using the Hodrick-Prescott filtered values of the fundamentals

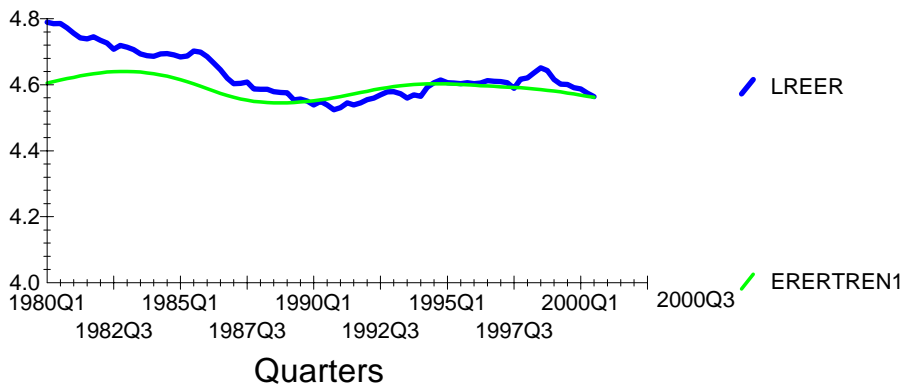


Figure 5: Percentage Misalignment (MIS1) between LREER and ERERTREN1

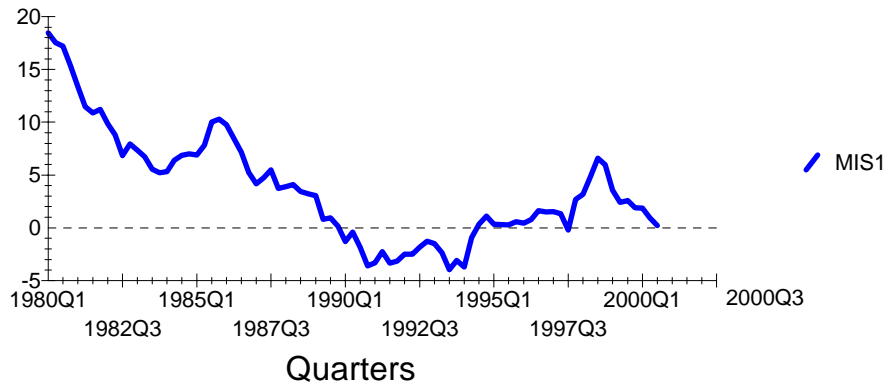


Figure 6: Plot of the (logarithm of the) actual (LREER) and equilibrium real exchange rate (ERER2)

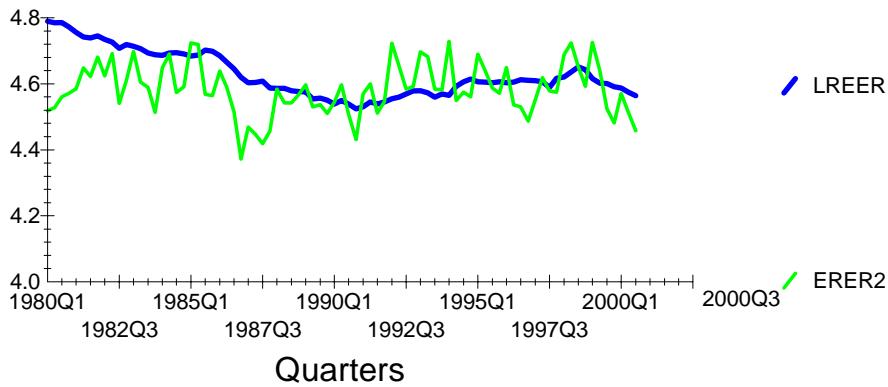


Figure 7: Plot of the actual (LREER) and equilibrium real exchange rate (ERERTREN2) generated using the Hodrick-Prescott filtered values of the fundamentals

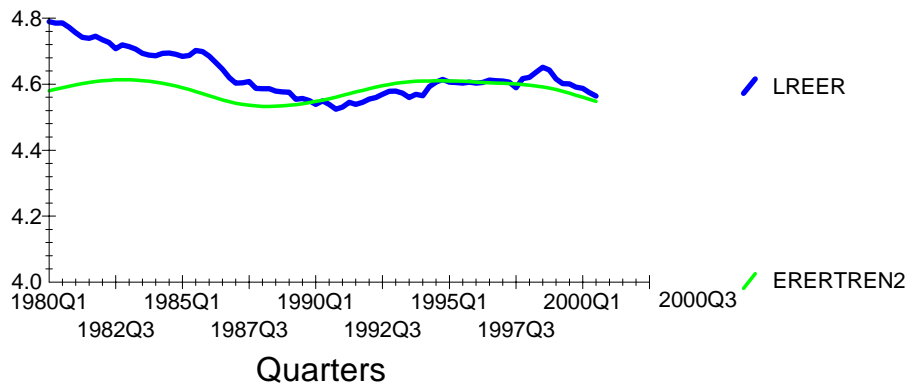


Figure 8: Percentage Misalignment (MIS2) between LREER and ERERTREN2

