WP/00/144

IMF Working Paper

Filtering the BEER: A Permanent and Transitory Decomposition

Peter B. Clark and Ronald MacDonald

INTERNATIONAL MONETARY FUND

 WP/00/144

IMF Working Paper

Research Department

Filtering the BEER: A Permanent and Transitory Decomposition

Prepared by Peter B. Clark and Ronald MacDonald

August 2000

Abstract

In this paper we extend the BEER (Behavioral Equilibrium Exchange Rate) approach which identifies an estimated equilibrium relationship between the real exchange rate and economic fundamentals. Here the economic fundamentals are decomposed using Johansen cointegration methods into transitory and permanent components, with the latter used to estimate the Permanent Equilibrium Exchange Rate, or PEER, for the U.S. and Canadian dollars and the pound sterling. The BEER and the PEER move closely together for the U.S. and Canadian dollars and generally track the actual exchange rate. By contrast, for the pound sterling the BEER and the PEER diverge sharply, with the latter following the actual exchange rate quite closely.

JEL Classification Numbers: F31, F32, F41

Keywords: Real exchange rates, equilibrium exchange rates.

Author's E-Mail Address: Pclark1@imf.org; r.r.macdonald@strath.ac.uk

Contents Page

I. Introduction

As the exchange rates of many industrial and developing countries have shown substantial fluctuations over the past 25 years, there has been considerable interest in exploring the factors that may be able to account for these movements. In particular, the substantial changes in the nominal and real exchange value of the U.S. dollar, the yen and the pound sterling have raised questions as to whether exchange rates are driven in a systematic fashion by fundamental economic forces or are more a reflection of the perhaps irrational whims of market participants.[1] In attempting to answer this question, one strand of analysis has tried to identify a relatively small set of economic variables that can be used to explain these movements and to ascertain the extent to which exchange rates are misaligned, i.e., can be said to depart from economic fundamentals.

Some of the recent contributions to this literature have gone under the rubric of "equilibrium exchange rates," such as contained in Baffes et. al (1999), MacDonald and Stein (1999), and Williamson (1994). Two main approaches have been developed to assess the degree to which exchange rates are consistent with economic fundamentals. One is the macroeconomic balance approach which calculates the real exchange rate that is consistent with the economy operating at capacity output and a sustainable current account position. This method has been popularized by Williamson (1994), who referred to the exchange rate computed in this manner as the Fundamental Equilibrium Exchange Rate (FEER). A recent extension and refinement of this methodology is contained in Isard and Faruqee (1998). An alternative approach involves the direct econometric analysis of a model of the behavior of the real exchange rate, which can be called the Behavioral Equilibrium Exchange Rate (BEER). The BEER approach produces a measure of misalignment that is different from the FEER, as it relates to the deviation between the actual exchange rate and the value given by the estimated equilibrium relationship between the real exchange rate and economic fundamentals.

In an earlier paper, Clark and MacDonald (1999) used the multivariate cointegration methods of Johansen (1995) to construct estimates of the BEER for the real effective exchange rates of the U.S. dollar, the German mark, and the Japanese yen. The estimated BEERs were then compared to FEERs as tools for assessing misalignments in exchange rates. We noted that the direct application of the behavioral approach yielded a measure of *current misalignment*, namely, the difference between the actual value of the exchange rate and the estimated level of the exchange rate given by the current values of all the economic fundamentals. As the current values of these determinants may depart from sustainable or long-run levels, as emphasized in the FEER approach, it is also useful to calculate the *total*

[1]This topic is the focus of a recent Controversy (1999) section of the *Economic Journal* on Exchange Rates and Fundamentals.

misalignment, which is the difference between the actual exchange rate and that given by the sustainable or long-run values of the economic fundamentals.[2] As an illustration of this type of calculation we used the Hodrick-Prescott (H-P) filter to obtain smoothed series for the economic fundamentals to generate long-run trend values for the real effective exchange rates of the U.S. dollar, the German mark, and the Japanese yen.

As it is generated from variables that are highly persistent, and indeed often non-stationary, the measured BEER is itself likely to be a highly persistent series. Using the methods of Beveridge and Nelson (1981), a number of papers (see, for example, Huizinga (1987) and Clarida and Gali (1994)) have in fact interpreted the persistent, or permanent, component of the real exchange rate as a measure of equilibrium. Recently, Gonzalo and Granger (1995) have shown how the Johansen cointegration method can be used to extract the permanent component from a vector of variables which exhibit cointegration, thereby producing a measure of equilibrium which is close in spirit to the BEER. In this paper we use the method of Gonzalo and Granger to estimate the permanent components of the economic fundamentals and the real effective exchange rates of the U.S. dollar, the Canadian dollar, and the pound sterling. We refer to these measures as the Permanent Equilibrium Exchange Rate, or PEER. Thus the PEER may be thought of as one way of calibrating the BEER at equilibrium values, which is similar in spirit to the use of the H-P filter described above. As the approach used to extract the permanent component involves the cointegration methods used by Clark and MacDonald (1999) to estimate a BEER, a natural question to ask is: how similar are the BEER and PEER estimates? To the extent that the BEER is a persistent series, as noted above, it would be expected that there are similarities between the two.

Aside from this comparison, we also argue that there may be advantages in supplementing a BEER analysis with a PEER-based approach to modeling equilibrium exchange rates. First, the latter approach produces estimates of the permanent and transitory components of all of the variables and this may be useful in circumstances where the BEER and PEER are very different. Given the way the PEER is measured, any difference between it and the BEER must be due to the way the latter measure incorporates any transitory elements. Clearly, it is likely to be important for policy purposes to assess the extent to which a currency misalignment is due to significant transitory elements. Second, as a by-product of the permanent-transitory decomposition, it is possible to identify which variables are the main contributors of any system wide non-stationarity (the common trends) and which variables, in turn, are affected by these common trends. For example, is it the net foreign asset position which is the key driving variable in a particular exchange rate system, or is it some combination of the underlying variables which drive the system? A third advantage of our approach, although one which is not pursued here, is that it is possible to analyze an exchange rate relationship in isolation, using a common factor analysis, and then go on in the second stage to analyze the joint interaction of this common factor with the common factors(s) from, say, other currency systems. Given that currencies, and indeed other asset

[2]For a recent application of this approach, see Lim (2000).

prices, are interrelated, this may be a useful exercise. The common factor approach facilitates this type of analysis because instead of analyzing the complete currency systems simultaneously, all that is required is to estimate the interactions of the common factors. A final advantage of our approach is that because the common factors are derived from a vector error correction model (VECM), the problem with unit roots/non-stationarity does not arise and hypothesis testing on linear combinations of the common factors can be conducted using standard chi-squared tests.

The remainder of the paper is as follows. In the next section we provide a brief overview of the BEER approach to defining an equilibrium exchange rate. The following section then describes the methodology used to decompose a vector which exhibits cointegration into permanent and transitory components. The next section then uses this decomposition to yield estimates of the total misalignment of three currencies: the U.S. and Canadian dollars and the U.K. pound. The last section provides some concluding comments.

II. The BEER Approach

A. The Model

The model we apply is the same as that used in an earlier paper (Clark and MacDonald (1999)). The starting point is the familiar uncovered interest parity (UIP) condition;[3]

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

where s_t is the foreign currency price of a unit of home currency, an i_t denotes a nominal interest rate, Δ is the first difference operator, E_t is the conditional expectations operator, t+k defines the maturity horizon of the bonds, and a * denotes a foreign variable. Equation (1) can be converted into a relationship between real variables by subtracting the expected inflation differential, $E_t(\Delta p_{t+k} - \Delta p_{t+k}^*)$, from both sides of the equation. After rearrangement this gives:

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

where $r_t = i_t - E_t(\Delta p_{t+k})$ is the *ex ante* real interest rate, $q_t = s_t - E_t(\Delta p_{t+k})$, is the *ex ante* real exchange rate, and e_t is a disturbance term. Expression (2) describes the current equilibrium exchange rate as determined by two components, the expectation of the real exchange rate in period t+k and the real interest differential with maturity t+k.

---

[3]Our operationalisation of the short-run real exchange rate equation follows Isard (1983), Meese and Rogoff (1988), Edison and Pauls (1993), Baxter (1994) and MacDonald (1997).

The use of the uncovered interest parity relationship may appear suspect, as many researchers, e.g., Meese and Rogoff (1988), Campbell and Clarida (1987), Froot (1990), and Edison and Pauls (1993), have failed to uncover a systematic, robust relationship between exchange rates and interest rates. However, some recent research provides greater support for UIP. For example, Flood and Taylor (1997) and Meredith and Chinn (1998) find that looking at longer time horizons, namely, from three years up to ten years, reveals a quite strong and consistent relationship between the change in the nominal exchange rate and the level of the interest differential across a range of currencies. MacDonald (1997), Edison and Melick (1999) and MacDonald and Nagayasu (1999) confirm that the finding of Meredith and Chinn also holds for the real uncovered interest differential. Thus there is greater support than a few years ago for using UIP as our point of departure in modeling real exchange rates.

We assume that the unobservable expectation of the exchange rate, $E_t(q_{t+k})$, is the "long-run" equilibrium exchange rate, $\bar{q}_t$. The current equilibrium rate is defined as $q_t^{'}$ to distinguish it from the actual rate q_t:[4]

$$q_t^{'} = \bar{q}_t + (r_t - r_t^*) \tag{3}$$

In summary, therefore, our approach posits that the current equilibrium exchange rate given by (3) comprises two components: the systematic component, $\bar{q}_t$, and the real interest differential.

The factors likely to introduce systematic variability into $\bar{q}_t$ have been discussed elsewhere in some detail (see Faruqee, (1995), MacDonald (1997) and Stein (1999)) and are not considered here in any depth. Suffice to say that for our purposes the long-run equilibrium rate is assumed to be a function of two key variables:

$$\bar{q}_t = f(\overset{-}{tnt}_t, \overset{+}{nfa}_t) \tag{4}$$

where *tnt* is the Balassa-Samuelson effect, i.e., the relative price of nontraded to traded goods, and *nfa* is net foreign assets, and the signs above the right-hand side variables denote the partial derivatives.[5] As in the internal-external balance approach to modeling the real exchange rate, we see *nfa* being driven by the determinants of national savings and

---

[4]It is straightforward to modify (3) to include a risk premium – see Meese and Rogoff (1988). However in our empirical work the risk premium always proved to be insignificant and therefore it is not included here.

[5]The importance of net foreign assets as a determinant of real exchange rates has recently been highlighted in Lane and Milesi-Ferretti (2000).

investment and, in particular, demographics and structural fiscal balances.[6] The definitions of the three variables entering (4) are described below.

As real interest rates appear in equation (3), which describes the current equilibrium exchange rate, we have not included them as a determinant of the long-run equilibrium rate, $\bar{q}_t$. However, some models of the equilibrium exchange rate (such as that of Stein (1999)) would ascribe to real interest rates an influence on the systematic component of the real exchange rate through productivity and thrift channels. The reason for separating real interest rates from $\bar{q}_t$ in equation (3) is that they are normally thought to reflect business cycle developments rather than the longer-run systematic trends (see MacDonald and Swagel (2000)). However, as the equation we estimate is a reduced form, it may be that real interest rates do have their effect through the systematic component of the real exchange rate. Indeed, our permanent and transitory decomposition of the data allows us to determine which effect dominates for our currency systems. As will be seen below, this is especially the case for the U.K. pound.

B. Data Sources and Definitions[7]

The real effective exchange rates analyzed in this paper are the U.S. and Canadian dollars and the pound sterling. The sample period is from 1960-1997 and the data are annual. The definitions of the variables and sources of the data are given below.

Real effective exchange rate: *q*

This is a multilateral CPI-based real effective exchange rate (REER) of the currency of the domestic economy relative to its G-7 partner countries. It is defined in terms of foreign currency per unit of domestic currency, so that that an increase in q is a real effective appreciation. The methodology is described in Zanello and Desruelle (1997). This variable is expressed in logs: *lq*

The basic data for the weights come from the I.M.F.'s Information Notice System (INS). In the INS system, for each "home" country there are 146 partner countries that have some positive weight. To reduce the number of partner countries, the INS uses a threshold of one percent. Those partners with weights of less than one percent for a home country are eliminated and the remaining partner country weights are renormalized to sum to unity. Typically, this leaves home countries with between one dozen and two dozen partners for the calculation of the weights. The REERs in this paper are constructed in a parallel fashion,

---

[6]For a recent analysis that derives this relationship from internal and external balance considerations, see Alberola, et al (1999).

[7]The authors are indebted to Jeff Gable for constructing the data set used in this paper.

with partner countries limited to the G-7 only. Typically, about 40 percent (36 percent for the U.S., 43 percent for Germany) of a G-7 country's partner weights come from non-G-7 partners.

To assess the degree to which our narrower set of trading partners affects our REER calculations, correlations were calculated between our G-7-only REERs and those REERs calculated by the INS using the one-percent cutoff for inclusion of partners. With exchange rates measured as annual percent changes, the correlation coefficient between the two exchange rate measures was at least 0.97 for the three currencies in our sample, indicating that our calculated exchange rates are very close to the CPI-based REERs published by the IMF.

Relative price of nontraded to traded goods: *tnt*

The relative price of nontraded to traded goods is defined as the ratio of the domestic consumer price index (CPI) to the domestic wholesale or producer price index (PPI) relative to the corresponding weighted average of partner country ratios, using the same weights as described above. This variable is expressed in logs: *ltnt*
Source: CPI, IMF *World Economic Outlook* database; PPI, IMF Unit Labor Cost database.

Net foreign assets: *nfa*

This variable is the stock of net foreign assets, defined as total foreign assets (less official gold holding) minus total liabilities to foreigners. In the empirical analysis below, the stock of net foreign assets is scaled by dividing by the nominal value of GDP, which is denoted by *nfa*.
Source: Masson, Kremers, and Horne (1993) for data from 1960-1990. Data from 1991-1997 obtained from the same publications cited in the source for this variable.

Real interest rates: r, r*

The domestic real interest rate, r, is defined as the average annual nominal long-term (ten-year) government bond yield minus the change in the CPI from the previous year. The foreign interest rate, r^*, is a weighted average of partner G-7 real interest rates computed in the same manner.
Source: IMF *World Economic Outlook* database.

Hence our specification of the overall, or gross vector, x, is:

$$x_t' = [lq_t, (r_t - r_t^*), ltnt_t, nfa_t] \tag{5}$$

Figure 1. The Real Exchange Rate and Fundamentals: United States

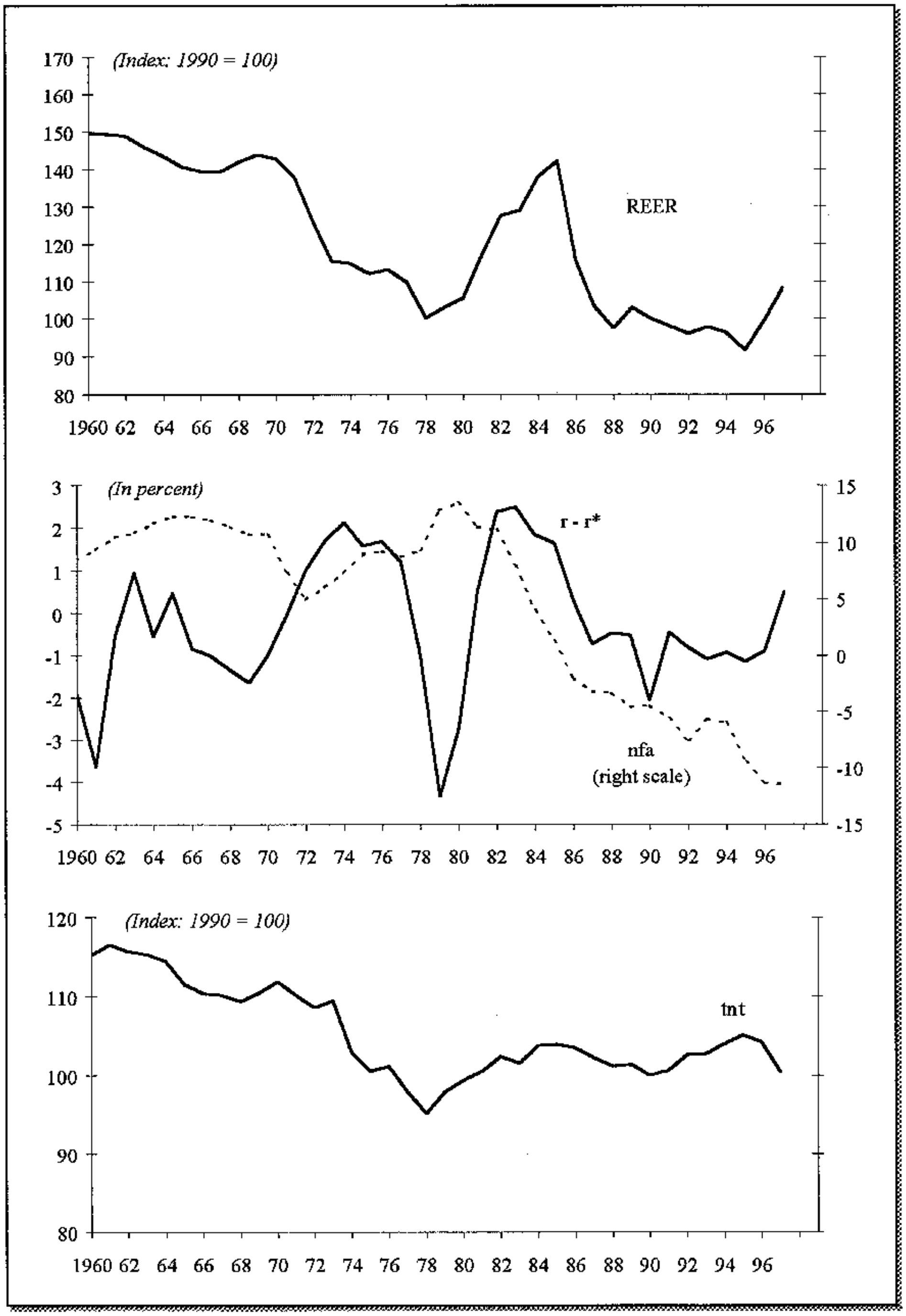


Figure 1. (continued) The Real Exchange Rate and Fundamentals: Canada

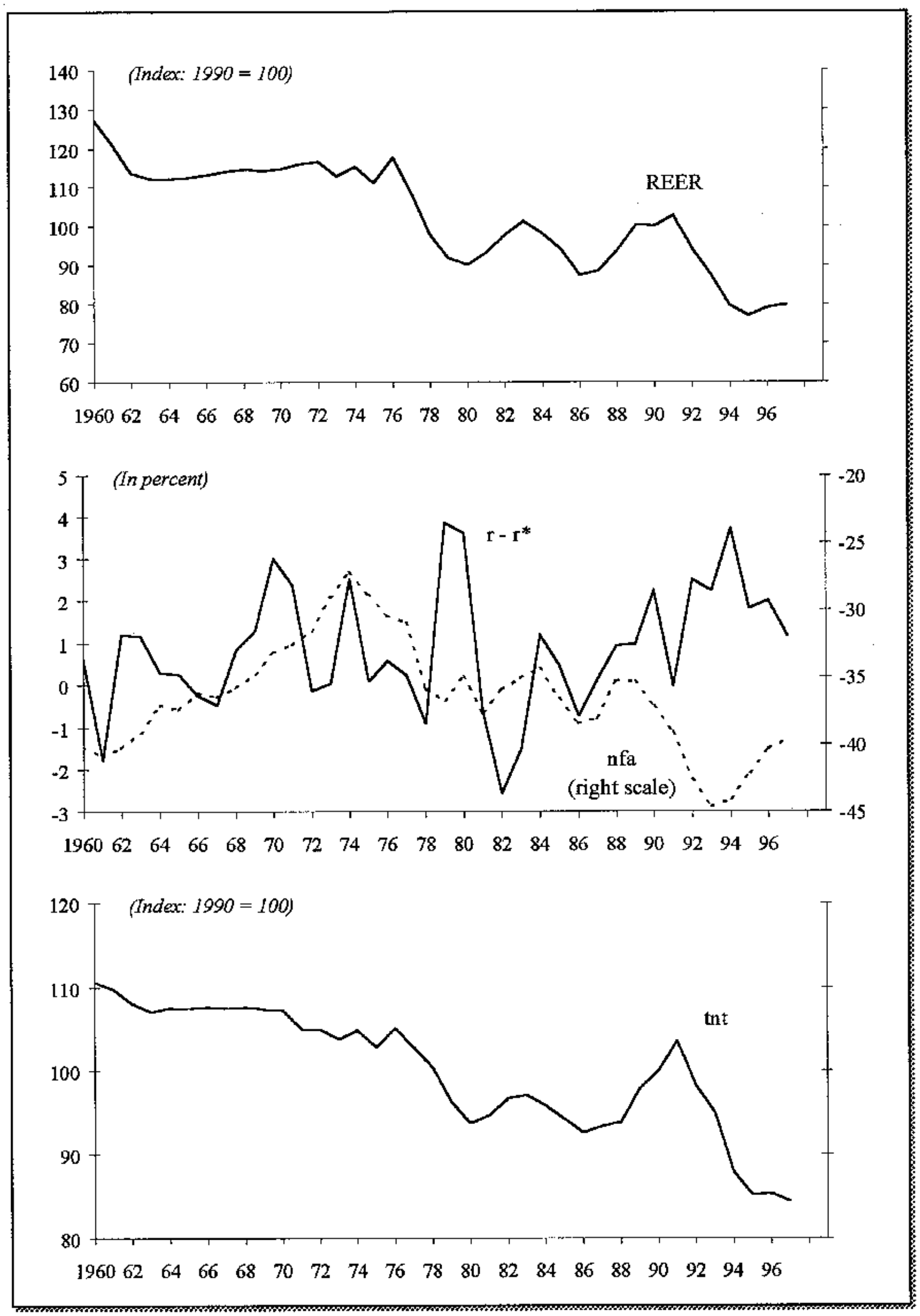
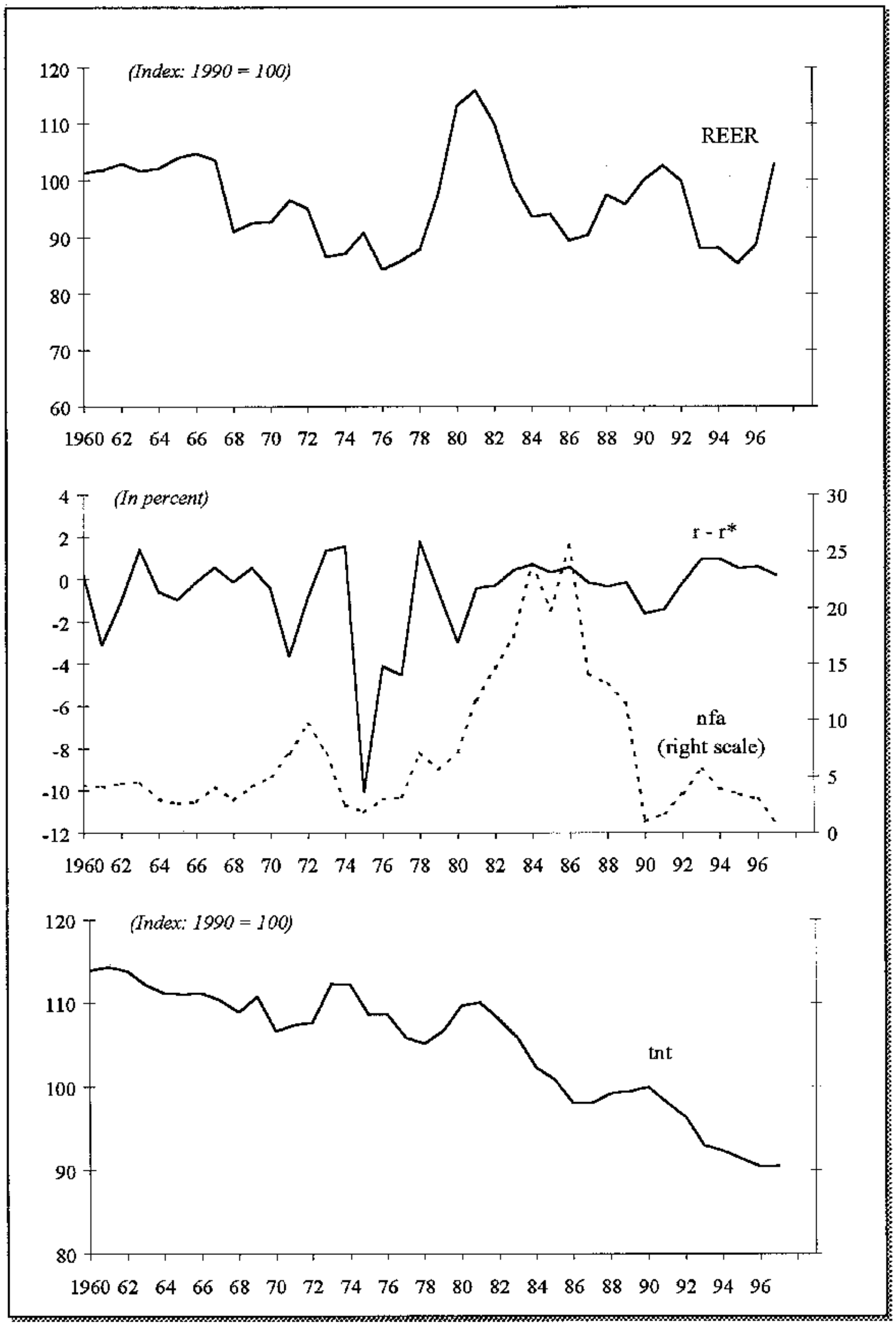


Figure 1. (concluded) The Real Exchange Rate and Fundamentals: United Kingdom



C. The Behavior of the Three Exchange Rates

Figure 1 plots the real effective exchange rate for the United States, Canada, and the United Kingdom, as well as the three explanatory variables. Looking first at the U.S. dollar, there appear to be five distinct periods: a depreciation from 1960 to 1978, a fairly sharp appreciation from 1978 to 1985 followed by a sharp depreciation to 1988, a period of fairly limited movement from 1988 to 1995, and a real appreciation from 1995 to 1997. The first period of depreciation appears to be associated only with the gradual downward trend in the relative price of non-traded to traded goods, whereas the following sharp appreciation may reflect the substantial rise in the U.S. real interest rate relative its G-7 partners. The subsequent reversal in interest rates and declining net foreign assets can perhaps in part account for the depreciation from 1985 to 1988, and the appreciation at the end of the sample period appears to be associated with a rise in the interest differential in favor of the United States. This is of course a very impressionistic description of the relationships between the explanatory factors and the real exchange rate compared with the statistical analysis presented below, which shows the net effect of all three factors together.

Turning to the Canadian dollar, there is a general trend of depreciation over most of the sample period which may reflect the downward trend in the relative price of non-traded to traded goods. The behavior of the other two variables over this period does not reveal any obvious association with the real value of the Canadian dollar, but the statistical analysis below indicates that they are important explanatory variables. It is noteworthy that the real interest rate differential shows sharp year-to-year movements, which may reflect an attempt by the Bank of Canada to affect the value of the Canadian dollar through changes in monetary policy, in which case one would not see a positive bivariate association between the interest rate differential and the exchange rate.

The real value of the pound shows no clear trend over the period, with beginning and ending values the same. Moreover, there is no obvious association between the three explanatory variables and the real value of the pound. Nonetheless, as shown below, the ability of the model to capture major movements in the pound is as impressive as for the other two currencies, the major difference being that is the PEER, not the BEER, which provides the explanatory power in the case of the pound.

III. A Permanent and Transitory Decomposition Using the VECM Representation

The recent literature on the decomposition of series into their permanent and transitory components has as its starting point the paper by Beveridge and Nelson (1995). In this literature the permanent component of a series is normally interpreted as an I(1) process while the transitory component is stationary, or I(0). The original work of Beveridge and Nelson involved both univariate and multivariate decompositions of the series. Since the sum of an I(1) and I(0) series is also I(1), one important issue that has to be addressed in this type of analysis is how the two components are identified. Often this involves assuming that the permanent component follows a random walk or that the two components are orthogonal at all leads and lags (see, for example, Quah (1989)). Here, however, we follow Gonzalo and Granger (1995) and use the identification implicit in the cointegration of the series. In particular, Stock and Watson (1988) have demonstrated that if cointegration exists amongst a number of variables, then the vector will also have a common trend, or factor, decomposition. Gonzalo and Granger demonstrate that the common factor can be estimated if it is assumed to be a linear combination of the series in question and if it is further assumed that the residuals from this model do not have a permanent effect on the original series. The former assumption makes the common factor observable, while the second permits identification. As Gonzalo and Granger show, the linear combination may be estimated from a VECM, and as this approach takes care of any non-stationarity, it facilitates statistical inference on the common factor.

In this paper we use the methods of Johansen (1995) to extract all the necessary information from the VECM. Briefly, this approach involves the following. Define an (nx1) vector of variables, consisting of the variables specified in (5), and the associated definitional equations (these terms may be I(1) or I(0)), and assume that it has a vector autoregressive representation of the form:

$$\mathrm{x}_t = \eta + \sum_{i=1}^{p} \Pi_i \mathrm{x}_t + \varepsilon_t, \qquad (6)$$

where η is a (nx1) vector of deterministic terms, and ε is a (nx1) vector of white noise disturbances, with mean zero and covariance matrix Ξ. Expression (6) may be reparameterised into the vector error correction mechanism (VECM) as:

$$\Delta \mathrm{x}_t = \eta + \sum_{i=1}^{p-1} \Phi_i \Delta \mathrm{x}_{t-i} + \Pi \mathrm{x}_{t-1} + \varepsilon_t \qquad (7)$$

where Δ denotes the first difference operator, Φ_i is a (nxn) coefficient matrix (equal to $-\sum_{j=i+1}^{p} \Pi_j$), Π is a (nxn) matrix (equal to $\sum_{i=1}^{p} \Pi_i - I$) whose rank determines the number of cointegrating vectors. If Π is of either full rank, n, or zero rank, $\Pi=0$, there will be no cointegration amongst the elements in the long-run relationship (in these instances it will be appropriate to estimate the model in, respectively, levels or first differences). If, however, Π is of reduced rank, r (where $r<n$), then there will exist (nxr) matrices α and β such that $\Pi=\alpha\beta'$ where β is the matrix whose columns are the linearly independent cointegrating vectors and the α matrix is interpreted as the adjustment matrix, indicating the speed with which the system responds to last period's deviation from the equilibrium level of the exchange rate.

Hence the existence of the VECM model, relative to say a VAR in first differences, depends upon the existence of cointegration.[8]

We test for the existence of cointegration amongst the variables contained in x_t using the Trace test as proposed by Johansen (1995). For the hypothesis that there are at most r distinct cointegrating vectors, this has the form:

$$TR = T\sum_{i=r+1}^{N}\ln(1-\hat{\lambda}_i), \tag{8}$$

where $\hat{\lambda}_{r+1},.....,\hat{\lambda}_N$ are the N-r smallest squared canonical correlations between x_{t-k} and Δx_t series (where all of the variables entering x_t are assumed I(1)), corrected for the effect of the lagged differences of the x_t process.[9]

For our purposes, it will prove useful to present the moving average representation of equation (7). Johansen (1995) has demonstrated that equation (7) has a vector moving average representation of the following form:

$$\mathrm{x}_t = C\sum_{i=1}^{t}\varepsilon_i + C\eta + C(L)(\varepsilon_t + \eta), \tag{9}$$

where

$$C = \beta_\perp(\alpha_\perp'(I - \sum_{1}^{k-1}\Phi_i)\beta_\perp)^{-1}\alpha_\perp'$$

where $\alpha_\perp$ and $\beta_\perp$ denote the orthogonal complements to α and β (that is, $\alpha'\alpha_\perp = 0$ and $\beta'\beta_\perp = 0$) and $\alpha_\perp$ determines the vectors defining the space of the common stochastic trends, and therefore should be informative about the key 'driving' variable(s) in each of the systems. The $\beta_\perp$ vector gives the loadings associated with $\alpha_\perp$, i.e., the series which are driven by the common trends. Thus the C matrix measures the combined effects of these two orthogonal components.

If the vector x is of reduced rank, r, then Gonzalo and Granger (1995) have demonstrated that the elements of x can be explained in terms of a smaller number (n-r) of I(1) variables called common factors, f_t, plus some I(0) components, the transitory elements, $\tilde{x}_t$:

---

[8]The so-called Granger representation theorem (see Engle and Granger (1987)) implies that if there exists cointegration amongst a group of variables there must also exist an error correction representation.

[9]For details of how to extract the λ's see Johansen (1988), and Johansen and Juselius (1992).

$$x_t = A_1 f_t + \tilde{x}_t. \tag{10}$$

The identification of the common factors may be achieved in the following way. If it is assumed that the common factors, f_t, are linear combinations of the variables x_t:

$$f_t = B_1 x_t, \tag{11}$$

and if $A_1 f_t$ and $\tilde{x}_t$ form a permanent-transitory decomposition of x_t, then from the VECM representation (7) the only linear combination of x_t such that $\tilde{x}_t$ has no long-run impact on x_t is:

$$f_t = \alpha'_\perp x_t. \tag{12}$$

As Gonzalo and Granger point out, these are the linear combinations of Δx_t which have the 'common feature' of not containing the levels of the error correction term in them. This identification of the common factors enables Gonzalo and Granger to obtain the following permanent-transitory decomposition of x_t:

$$x_t = A_1 \alpha'_\perp x_t + A_2 \beta' x_t, \tag{13}$$

where, of terms not previously defined, $A_1 = \beta_\perp (\alpha'_\perp \beta_\perp)^{-1}$ and $A_2 = \alpha(\beta' \alpha)^{-1}$. It is straightforward to demonstrate that the common factor, f_t, corresponds to the common trend in the analysis of Stock and Watson (1988). This has the advantage that it is straightforward to estimate and also that hypotheses on the common trends can be tested.

IV. Estimation Results

The Johansen cointegration methodology used below presupposes that at least some (although not necessary all) of the variables entering the x_t vector are non-stationary. As a check on this, we used the multivariate stationarity test of Johansen (1995). This tests the null hypothesis of stationarity against the alternative of non-stationarity, subject to the chosen cointegrating rank which as we shall see below is one in each system. The results, along with the X^2 *(5)* critical value, are reported in Table 1. These results clearly indicate that all of the variables in each of the systems are non-stationary.[10]

[10]In the estimated equation below, *q* and *tnt* are expressed in logs and are represented in Table 1 as *lq* and *ltnt,* respectively.

Table 1. Multivariate Stationarity Tests

Country	*lq*	*(r-r*)*	*ltnt*	*nfa*	X^2 *(5)*
U.S.	24.42	15.54	20.90	27.88	11.07
Canada	40.28	29.79	40.48	40.75	11.07
U.K.	27.86	21.59	34.41	34.26	11.07

A. The U. S. Dollar

We first consider the results for the United States. The lag length, *p*, in the underlying VAR system (6) was set equal to two and the Pantula principle, of jointly testing the rank and deterministic specification, was used to specify the VECM. For the United States, and indeed all of the other systems, this resulted in the constant term being constrained to lie in the long-run relationship. Table 2 reports a number of residual diagnostics from the estimated U.S. system and this confirms that the estimated VAR is well specified.

Table 2. Multivariate Diagnostics – U.S. Dollar

LB (9)	**LM (1)**	**LM (4)**	**NM (10)**
134.92	14.04	8.80	4.28
(0.24)	(0.60)	(0.92)	(0.83)

The LB, LM and NM statistics are multivariate residual diagnostic tests: LB(9) is the Hoskings multivariate Ljung-Box statistic, LM(1) and (4) are multivariate Godfrey (1988) LM-type statistics for first- and fourth-order autocorrelation, and NM(10) is a Doornik and Hansen (1994) multivariate normality test. Numbers in parenthesis are p-values and indicate an absence of serial correlation and normally distributed errors.

The estimated values of the Trace statistics for the U.S. system are reported in Table 3.

Table 3. Significance of U.S. Cointegrating Vectors

H_0:r	Trace	Trace 95
0	62.93	53.12
1	37.66	34.91
2	15.25	19.96
3	4.23	9.24

On the basis of the Trace statistics there is clear evidence of one significant cointegrating vector and perhaps two. However, a visual inspection of the second vector indicated some non-stationarity and this was reinforced by an analysis of the roots of the companion matrix. We therefore focus solely on the first vector, which, normalized on the exchange rate, produces the following equation, with standard errors in parenthesis:

$$lq_t = \underset{(0.62)}{1.592}(r - r^*) + \underset{(0.16)}{2.030}\,ltnt + \underset{(0.12)}{1.107}\,nfa + \underset{(0.012)}{4.618} \tag{14}$$

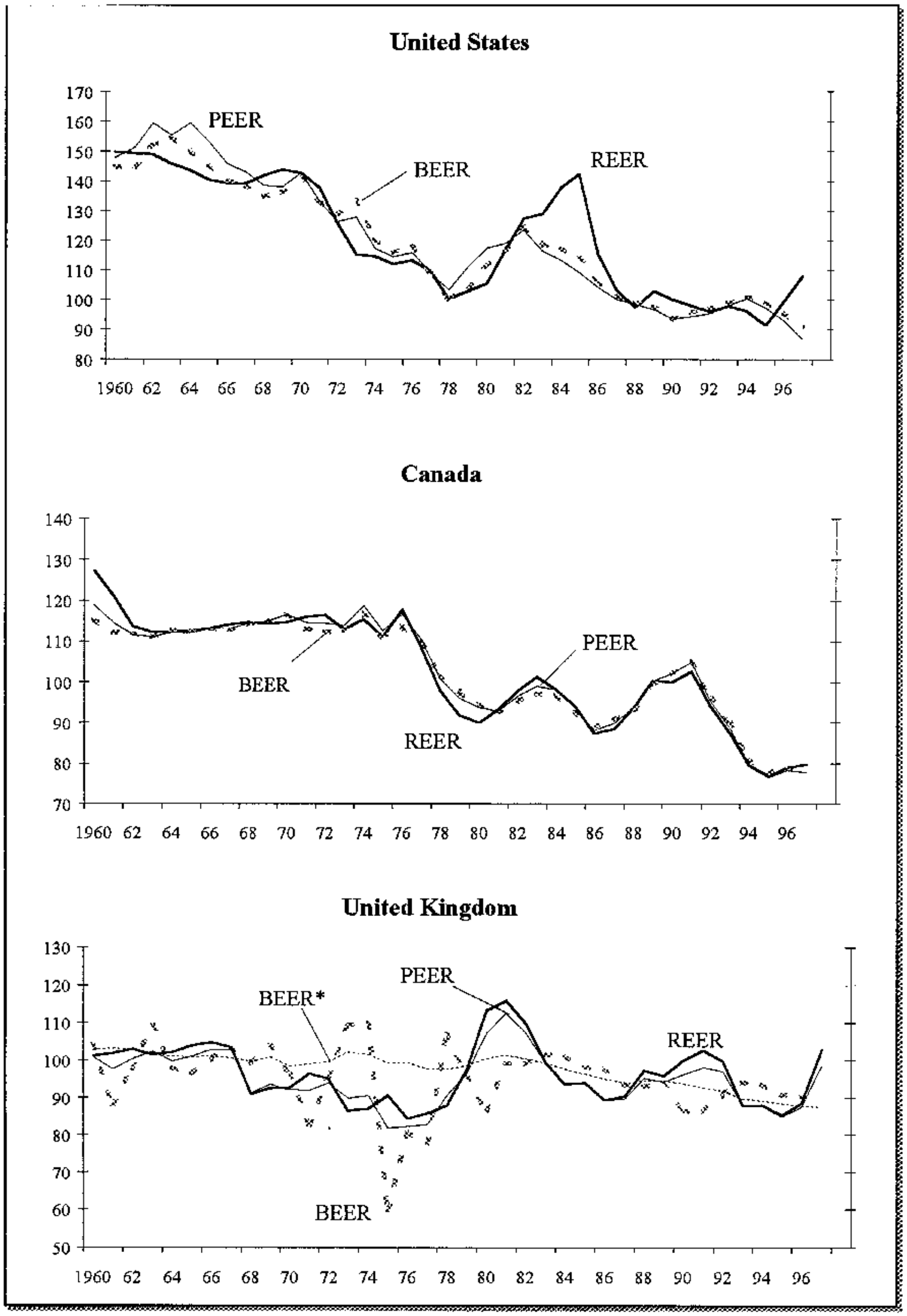
All of the coefficients have the correct sign and are of a plausible magnitude. On the basis of the Fisher standard errors, all of the variables are statistically significant. The alpha, or adjustment, matrix associated with this equation is reported in Table 4.

Table 4. U.S. Alpha Adjustment Matrix

Variable	Alpha1	t-alpha
Δlq	-0.669	-3.988
Δ(r-r*)	-0.022	-0.508
$\Delta ltnt$	0.119	1.881
Δnfa	-0.094	1.864

The significantly negative alpha coefficient in the exchange rate equation indicates that the exchange rate moves to close the gap of a disequilibrium by approximately 70 percent per annum. This means that most of the adjustment to a shock to the real exchange rate will be offset after two years. This result reinforces the usefulness of conditioning a real exchange rate on an appropriate set of fundamentals, as half-life estimates recovered from regressions which condition the real exchange rate solely on lagged real exchange rates are about 20 years for the recent floating period (see MacDonald (1995)). It is noteworthy that significant adjustment to the exchange rate disequilibrium does not occur in the other equations.

Figure 2. BEER and PEER Compared with the REER
(Index 1990 = 100)



The top panel in Figure 2 shows the estimated BEER calculated from equation (14), together with the actual real exchange rate for the sample period from 1960 to 1997 as well as the PEER, which has been constructed from the common factor representation (13). The close relationship between the BEER and the PEER series for the U.S. dollar is quite striking, which indicates that the BEER has only a small transitory component. However, it can be seen that the BEER implies that a somewhat greater proportion of the dollar appreciation in the 1980s was an equilibrium phenomenon. Given the similarity of the BEER and PEER, our discussion of the U.S. dollar below simply focuses on the PEER.

It is noteworthy that from the beginning of the sample to the end of the 1970s, the trend path of the U.S. dollar real exchange rate (REER) is mirrored quite closely in the PEER, although there are periods, such as 1963-64 and 1972-74, when transitory components are important. The period 72-74 corresponds to the breakdown of the Bretton Woods system when there was a general recognition that the dollar was overvalued. The largest discrepancy between the estimated PEER and the REER in this period is in 1973, when the latter depreciated sharply and the PEER rose somewhat. As can be seen in Figure 1, the increase in the PEER appears to be accounted for by a rise in relative U.S. interest rates. Thus for 1973, it would appear that the model is giving the wrong signal regarding the appropriate valuation of the U.S. dollar.

By contrast, the top panel in Figure 2 shows that in the period 1983-85 the REER substantially exceeds the estimated PEER by about 20 percent, and thus corresponds to the widely-held view that the U.S. dollar was overvalued during this period. Transitory factors drove the actual exchange rate far above the value suggested by the permanent components of economic fundamentals identified in the model.[11] Once these transitory factors had dissipated, the real value of the dollar returned to its equilibrium level given by the PEER. Similarly, at the end of the sample period economic fundamentals in the model indicate that the dollar should have weakened, whereas it strengthened instead, probably on account of cyclical factors not captured by the model.

In constructing the PEER we have made use of the moving average representation of the VECM. This representation is of particular interest since it yields information on which variables drive the common stochastic trends, measured by $\alpha_\perp'\sum_{i=1}^{t}\varepsilon_i$, and which variables are most affected by the common trends, as measured by the $\beta_\perp$ weights. Since the U.S. system contains four I(1) variables, and one stationary relationship implied by the significant cointegrating vector, we can infer that there must be three common trends. For the U.S. system, the alpha and beta orthogonal components are reported in Tables 5 and 6, respectively. These tables should be read in the following way. In Table 5 the row headings

[11]This is a common finding in papers that provide empirical estimates of the behavior of the U.S. dollar. See, for example, Faruqee (1995), Kramer (1996), MacDonald (1997), and Stein and Allen (1995).

indicate the three common trends, while the column headings indicate the contributions of the variables to the trends. Reading across a row, the cell with the largest absolute number indicates that the shock to the variable in the column heading makes the largest contribution to the trend in the row heading. In Table 6 the column headings indicate the weights attached to the common trends and the rows indicate how the weights are distributed amongst the variables. Reading down a column we see how a particular common trend gets distributed amongst the variables in the row headings. Alternatively, reading across a row information is obtained on which trend has the largest effect on a particular variable. Since there are currently no significance levels available for these numbers, they should be regarded as informative rather than definitive.

The results in Table 5 indicate that the first and second common trends appear to correspond to unanticipated shocks to the net foreign asset and Balassa-Samuelson terms, respectively, while the third is driven by the long-run real interest differential.

Table 5. Alpha Orthogonal Components for the U.S. System

Variable	lq_t	$r_t - r_t^*$	$ltnt_t$	nfa_t
$\alpha_\perp^1$	0.003	-0.002	-0.608	-0.794
$\alpha_\perp^2$	-0.220	-0.045	-0.774	0.592
$\alpha_\perp^3$	0.041	-0.998	0.030	-0.020

Table 6 indicates that the real exchange rate appears to be driven by the first common trend, with the Balassa-Samuelson variable and net foreign assets driven by the second. Both the exchange rate and the real interest differential are driven by the third common trend.

Table 6. Beta Orthogonal Components for the U.S. System

Variable	$\beta_{\perp}^{1}$	$\beta_{\perp}^{2}$	$\beta_{\perp}^{3}$
lq_t	-3.263	-0.270	-1.105
r_t-r_t^*	-0.463	-0.131	-1.118
$ltnt_t$	-0.570	-0.822	0.309
nfa_t	-1.237	1.451	0.042

Further insight into the driving variables in our systems may be obtained by calculating the *C* matrix from equation (9). This measures the combined effects of the alpha and beta orthogonal components and gives an indication if a shock to a particular variable has a permanent effect on the other variables in the system. The estimated *C* matrix for the United States is reported in Table 7. The t-ratios in parenthesis are based on the asymptotic standard errors suggested by Paruolo (1997). These results reinforce the message from Tables 5 and 6: shocks to net foreign assets and the Balassa-Samuelson effect have a significant cumulative impact on the real exchange rate and are correctly signed.

Table 7. The Estimates of the Long-run Impact Matrix for the U.S. System

Variable	$\Sigma\varepsilon_{lq}$	$\Sigma\varepsilon_{r\text{-}r^*}$	$\Sigma\varepsilon_{ltnt}$	$\Sigma\varepsilon_{nfa}$
lq_t	0.004	1.123	**2.159**	**3.454**
	(0.01)	(1.47)	(2.42)	(2.50)
r_t-r_t^*	-0.019	**1.123**	**0.349**	0.3131
	(0.22)	(5.40)	(2.02)	(1.17)
$ltnt_t$	0.192	-0.271	**0.992**	-0.041
	(1.38)	(0.81)	(3.56)	(0.09)
nfa_t	-0.321	-0.104	-0.371	**1.840**
	(1.71)	(0.23)	(0.98)	(3.14)

B. The Canadian Dollar

The VAR specification for the Canadian system is the same as that for the U.S. system, namely, two lags and the constant restricted to the cointegrating space. The residual diagnostics for the Canadian system are reported in Table 8 and indicate an absence of serial correlation and that the errors are normally distributed.

Table 8. Multivariate Diagnostics – Canadian Dollar

LB (9)	LM (1)	LM (4)	NM(10)
157.25	25.84	7.28	6.85
(0.02)	(0.06)	(0.97)	(0.55)

The estimated values of the Trace statistics for the Canadian system, which are reported in Table 9, also indicate that there is a single unique cointegrating vector for the Canadian dollar. Normalizing this vector on the real exchange rate produces the following equation:

$$lq_t = \underset{(0.31)}{0.532}(r - r^*) + \underset{(0.06)}{1.489}\, ltnt + \underset{(0.09)}{0.633}\, nfa + \underset{(0.04)}{4.849}. \tag{15}$$

Table 9. Significance of Canadian Cointegrating Vectors

H_0:r	Trace	Trace 95
0	56.96	53.12
1	26.65	34.91
2	8.50	19.96
3	1.48	9.24

The results are similar to those for the U.S. dollar, as all of the variables enter with the correct sign and all are statistically significant. The alpha matrix associated with equation (15) is reported in Table 10.

Table 10. Canadian Alpha Adjustment Matrix

Variable	*alpha1*	*t-alpha1*
Δlq	-0.605	-2.307
Δr-r*	0.158	1.429
Δltnt	-0.035	-0.232
Δnfa	0.132	1.137

Similar to the findings above for the U.S. dollar, the real exchange rate adjusts significantly to the error correction term. The adjustment speed is also approximately the same as in the case of the U.S. exchange rate and suggests that adjustment is essentially complete within two years.

The BEER and PEER implied by equation (15) are plotted in the middle panel of Figure 2. We note that again, as in the case of the U.S. dollar, there is a very close correspondence between these two measures of the equilibrium exchange rate. Further, there is also a very tight link between the estimated PEER and the actual exchange rate; in fact, it is much tighter than in the case of the U.S. dollar. The most significant difference is at the very beginning of the period when the Canadian dollar was significantly above the value indicated by the PEER. This may reflect the large capital inflows in the late 1950s that strengthened the Canadian dollar and contributed to a current account deficit. The economic fundamentals that explain the PEER can account for only a small fraction of the higher value of the Canadian dollar. In 1961 the Canadian Government took measures to counter what it viewed as an overvalued exchange rate, including exchange market intervention and expansionary monetary and fiscal policies. These measures had the desired effect of changing market sentiment, and the exchange rate weakened during the second half of 1961 and into 1962. On May 2, 1961 the currency was pegged at 92.5 U.S. cents, which compares with an average value of 102.7 U.S. cents from 1952-1960.[12] Thus the empirical results here suggest that the Canadian dollar moved toward its equilibrium value when it depreciated and was then pegged in the early 1960s.

The results from the moving average representation for the Canadian dollar are reported in Tables 11 and 12. The first common trend appears to correspond to unanticipated shocks to the net foreign asset term, the second to the Balassa-Samuelson effect, and the third

[12]For a discussion of the factors affecting the value of the Canadian dollar during this period and the exchange rate policy of the government, see Yeager (1966).

to the long-run real interest differential. This pattern is similar to the U.S. dollar system, indicating a degree of commonality between the two systems.

Table 11. Alpha Orthogonal Components for the Canadian System

Variable	lq_t	$r_t - r_t^*$	$ltnt_t$	nfa_t
$\alpha_{\perp}^1$	-0.209	0.014	-0.011	-0.978
$\alpha_{\perp}^2$	0.023	-0.131	-0.991	0.005
$\alpha_{\perp}^3$	-0.250	-0.960	0.121	0.038

As shown in Table 12, the variables which adjust most to the first two trends are the real exchange rate, the Balassa-Samuelson effect and *nfa*; real interest rate appear to be affected most by the third trend.

Table 12. Beta Orthogonal Components for the Canadian System

Variable	$\beta_{\perp}^1$	$\beta_{\perp}^2$	$\beta_{\perp}^3$
lq_t	-1.929	-1.070	0.026
$r_t - r_t^*$	0.138	0.026	-0.739
$ltnt_t$	-0.822	-1.092	0.284
nfa_t	-1.230	0.856	-0.006

The estimated *C* matrix for the Canadian dollar is reported in Table 13. As in the U.S.-based system, we note that the cumulative *nfa* term is significant for the real exchange rate and also for the Balassa-Samuelson effect. The latter result seems perverse, although it may simply reflect the way we have measured the Balassa-Samuelson effect.

Table 13. The Estimates of the Long-run Impact Matrix for the Canadian System

Variable	$\Sigma\varepsilon_{lq}$	$\Sigma\varepsilon_{r-r^*}$	$\Sigma\varepsilon_{ltnt}$	$\Sigma\varepsilon_{nfa}$
lq_t	0.371	0.088	1.085	**1.882**
	(0.64)	(0.19)	(0.91)	(2.98)
r_t-r_t^*	0.156	**0.708**	-0.117	-0.163
	(1.25)	(7.26)	(0.45)	(-1.18)
$ltnt_t$	0.075	-0.141	1.125	**0.809**
	(0.21)	(0.52)	(1.58)	(2.11)
nfa_t	0.278	-0.124	-0.835	**1.206**
	(1.02)	(0.58)	(1.49)	(4.01)

C. The Pound Sterling

For the pound sterling system three lags were required to produce well-behaved residual diagnostics and these are reported in Table 14. The diagnostics indicate an absence of serial correlation, although the NM(10) statistic is marginally significant, suggesting that there is some evidence of non-normality in the residuals, which seems to arise from heteroscedasticity in the real interest rate equation.

Table 14. Multivariate Diagnostics – U.K. Pound

LB (9)	LM(1)	LM(4)	NM(10)
129.412	24.63	16.47	17.38
(0.01)	(0.08)	(0.42)	(0.03)

The estimated values of the Trace statistics for the U.K. system are reported in Table 15. These indicate that, as for the other two currencies, there is a single cointegrating vector for the pound sterling.

Table 15. Significance of U.K. Cointegrating Vectors		
H_0:r	**Trace**	**Trace 95**
0	70.26	53.12
1	24.23	34.91
2	11.47	19.96
3	2.68	9.24

Normalizing the significant cointegrating vector on the real exchange rate we obtain:

$$lq_t = \underset{(0.55)}{5.038}(r - r^*) + \underset{(0.13)}{0.678}\,ltnt + \underset{(0.12)}{0.030}\,nfa + \underset{(0.02)}{4.549} \tag{16}$$

All variables enter (16) with the correct sign and all are statistically significant apart from the *nfa* term. In the light of the discussion to follow, it is worth noting that the coefficient on the relative interest rate term is much larger for the U.K. system than in the other systems. The alpha matrix associated with equation (16) is reported in Table 16.

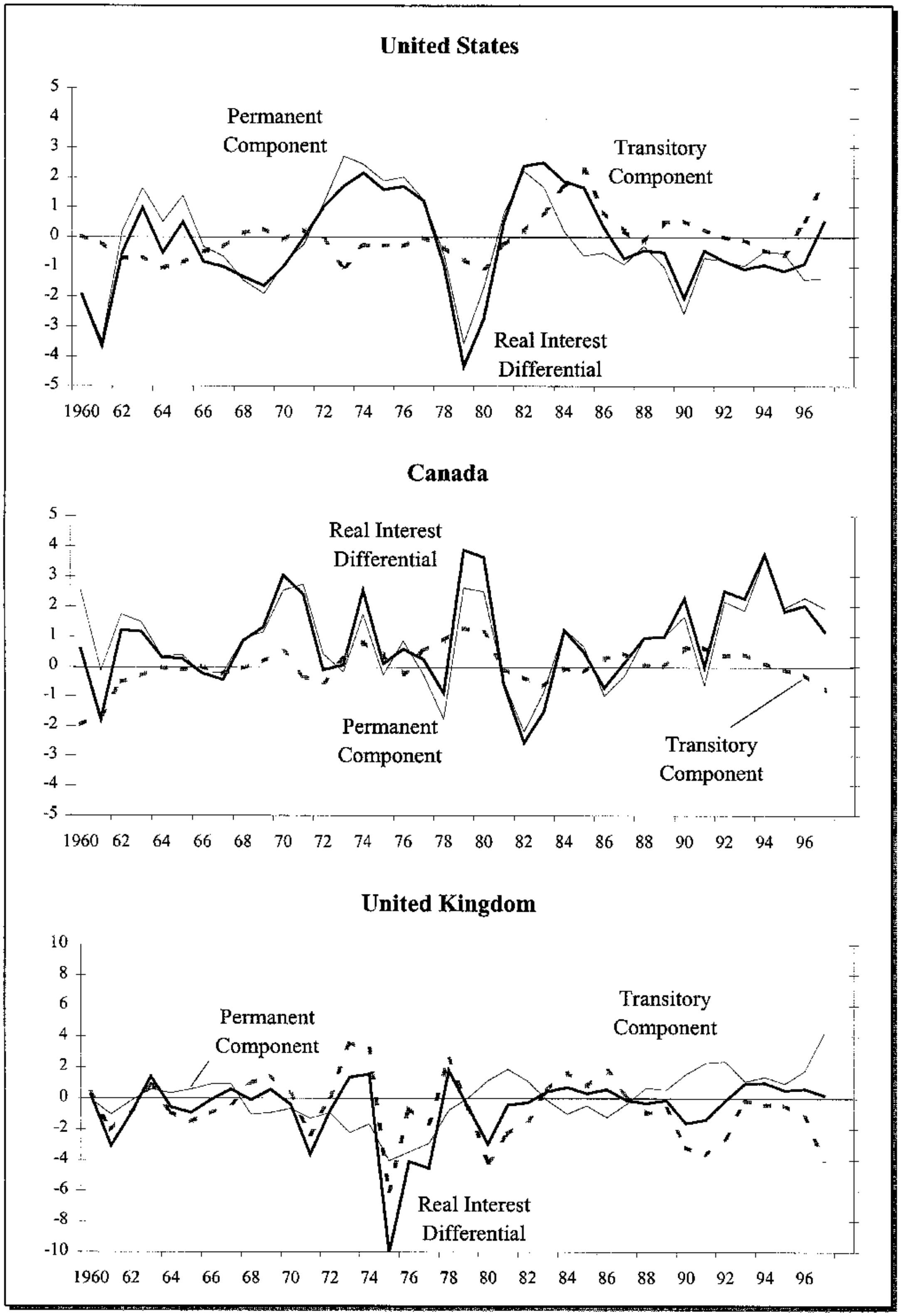
Table 16. U.K. Alpha Adjustment Matrix Variable		
	alpha1	**t-alpha1**
Δlq	-0.460	-3.653
$\Delta(r\text{-}r^*)$	0.238	5.541
$\Delta ltnt$	-0.117	-3.008
Δnfa	0.237	3.118

As in the other two systems, the real exchange rate adjusts significantly to the exchange rate disequilibrium. However, in contrast to the other systems, all of the other variables are also significantly reacting to the error correction term, suggesting that adjustment to equilibrium is not so transparent in the U.K. system.

The BEER and PEER implied by (16) are plotted in the bottom panel of Figure 2. The picture here is quite distinct from that given in the other panels of Figure 2, as the BEER and PEER are very different, with the former being much more volatile than the actual rate in the period up to the early 1980's. This volatility is driven by the volatility of real interest rates that was an important feature of this period. What explains this difference between the BEER and PEER? As we argued above, one advantage of estimating the PEER is that we have access to the permanent and transitory components of all of the variables in our systems. In contrast to the United States and Canada, for the United Kingdom there is a much closer correlation between the actual and the transitory components of the real interest differential than between the actual and the permanent component. For example, the correlation between the actual and the transitory component for the U.K. real interest rate is 0.69, while for the United States it is only 0.06. This is underscored by an examination of Figure 3, where we have graphed the permanent and transitory components of the real interest differentials against the actual values for all three countries.

Figure 3. Transitory and Permanent Components of the Real Interest Differential

(In percent)



We believe that one advantage of the PEER decomposition is that it clarifies the extent to which a misalignment implied by the BEER is permanent or transitory. Referring back to our discussion in Section II, it would seem that as the real interest differential for Canada and the United States is driven in large measure by the permanent component, it should perhaps be thought of having its affect on the real exchange rate through $\bar{q}_t$. For the United Kingdom, however, the prominence of the transitory component in the real interest differential suggests it is more closely associated with business cycle developments and therefore its influence on the real exchange rate should be separate from $\bar{q}_t$. However, it turns out that the permanent component of the real interest differential follows closely the real exchange rate and would therefore be part of $\bar{q}_t$.

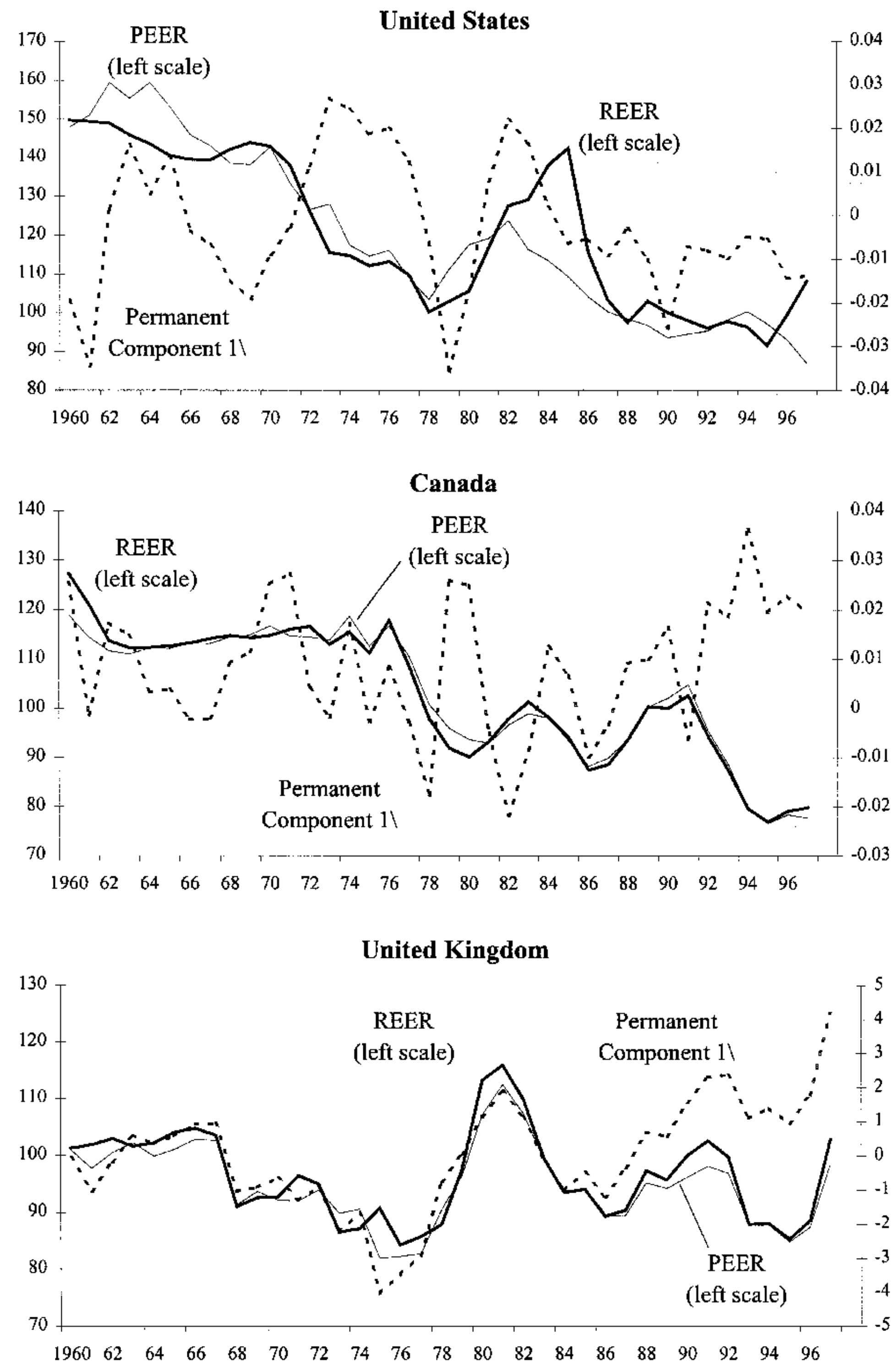
The pronounced volatility of real interest rates in the mid-1970s corresponds to the almost hyperinflationary environment of that period, combined with rising nominal interest rates which did not quite catch up with the inflationary spiral until the late 1970's. We believe that the U.K. BEER is of interest in itself since, for one thing, it clearly illustrates how different the monetary environment has been for the United Kingdom compared to the United States and Canada. However, given the importance of interest rate volatility for the United Kingdom, it may be instructive to produce a BEER which is neutral with respect to interest rate effects; that is, a BEER which is based only the $\bar{q}_t$ component of $q_t^{'}$ in equation (3). This is shown as BEER* in the bottom panel of Figure 2. We note that its profile is much smoother than the BEER and the REER for the United Kingdom.[13]

More generally, it is clear from Figure 2 that the BEER provides a generally poor explanation of the behavior of the pound, as compared with the remarkably good fit for both the U.S. and Canadian dollars. One reason for this may be that the real effective value of the pound shows no clear trend, starting and ending the sample period at an index value of 100, whereas the estimated BEER does have a downward trend, reflecting the unit root characteristics of the three explanatory variables. By contrast, the PEER provides a remarkably good explanation for the real value of the pound, capturing well the devaluation in 1967, the substantial appreciation in the late 1970s, and the sharp appreciation in 1997. As noted above, this would appear to reflect the importance of the permanent component of the real interest differential in explaining the behavior of the pound, which is clearly evident in Figure 4. By contrast, in the United States and Canada, the permanent component of the real interest differential is much less closely related to the PEER and the REER.

---

[13]BEER* in Figure 2 is constructed on the basis that the real interest rate observed in the first year of the sample remains constant throughout the sample.

Figure 4. REER, PEER, and the Permanent Component of the Real Interest Differential



1\ Permanent component of real interest differential (right scale).

The set of results from the moving average representation for the United Kingdom are reported in Tables 17 to 19. The first common trend appears to correspond to the real interest differential, the second is driven by *nfa* and *lq* while the third is driven by the Balassa-Samuelson effect.

Table 17. Alpha Orthogonal Components for the U.K. System

Variable	lq_t	r_t-r_t^*	$ltnt_t$	nfa_t
$\alpha_{\perp}^1$	0.213	0.881	0.190	-0.377
$\alpha_{\perp}^2$	-0.574	-0.237	0.375	-0.688
$\alpha_{\perp}^3$	-0.017	-0.005	-0.884	-0.466

The real exchange rate has the largest loading on all three common trends, although the second gets a large loading into *nfa* and the third a relatively large loading into the Balassa-Samuelson term. This is a rather different pattern from that contained in the U.S. and Canadian systems, where no single variable is strongly affected by all three common trends.

Table 18. Beta Orthogonal Components for the U.K. System

Variable	$\beta_{\perp}^1$	$\beta_{\perp}^2$	$\beta_{\perp}^3$
lq_t	1.777	-1.128	1.336
r_t-r_t^*	0.278	-0.224	0.385
$ltnt_t$	0.595	0.046	-0.869
nfa_t	-0.843	-0.998	-0.398

The estimates of the *C* matrix reported in Table 19 confirm the importance of real interest rates for the U.K. real exchange rate and that the real exchange rate, in turn, is important for the real interest differential, although the coefficient on the latter is much smaller.

Table 19. The Estimates of the Long-run Impact Matrix for the U.K. System

Variable	$\Sigma\varepsilon_{lq}$	$\Sigma\varepsilon_{r\text{-}r^*}$	$\Sigma\varepsilon_{ltnt}$	$\Sigma\varepsilon$ ***nfa***
lq_t	**1.002**	**1.827**	-1.267	-0.518
	(2.98)	(3.11)	(1.27)	(0.77)
$r_t\text{-}r_t^*$	**0.181**	**0.296**	**-0.372**	-0.130
	(3.01)	(2.81)	(2.07)	(-1.08)
$ltnt_t$	0.115	**0.518**	**0.899**	0.150
	(0.92)	(2.36)	(2.41)	(0.59)
$lnfa_t$	0.401	-0.504	-0.183	**1.190**
	(1.68)	(1.21)	(0.26)	(2.50)

In contrast to the other two systems, we note that shocks to net foreign assets do not have a cumulative effect on the pound. Consistent with what we said above, shocks to the real interest rate differential have a significantly positive cumulative effect on the real exchange rate and also on the *ltnt* term. We interpret this as a demand side influence on the relative price of traded to non-traded goods.

V. Concluding Comments

This paper has provided an extension of the BEER approach to exchange rate analysis by providing a decomposition of the BEER into its permanent and transitory components. The BEER approach to identifying equilibrium exchange rates involves estimating an equilibrium relationship between the real exchange rate and economic fundamentals. In an earlier paper (Clark and MacDonald (1999)), we noted that in analyzing exchange rate behavior and making judgements about exchange rate sustainability, it is important to ascertain whether the economic fundamentals themselves are at their equilibrium values. In this paper the explicit calculation of the permanent components of the real effective exchange rates of the U.S. and Canadian dollars and the U.K. pound (and the related transitory components) provides one method of calibrating fundamentals at their "equilibrium" values. Does such a calibration, which produces the PEER, yield a measure of equilibrium which is distinct from that provided by the BEER?

For the U.S. and Canadian dollars, we found that the BEER and the PEER move very closely together, implying that the current values of the economic variables driving the BEER have only a very small transitory component. Moreover, both the BEER and the PEER track the actual values of these two real exchange rates extremely well, with the exception of the 1983-85 period for the U.S. dollar, which shows clearly that the highly appreciated value of the U.S. dollar during this period was a transitory phenomenon. By contrast, in the case of the U.K. pound, the BEER and the PEER diverge sharply, with the latter generally following the movements of the actual real value of the pound, thereby illustrating the value of the permanent-transitory decomposition. Moreover, much of the volatility of the pound appears to be driven by fluctuations in the permanent component of the real interest rate differential. There is a much higher correlation between the actual and the transitory component of U.K. interest rates compared to U.S. interest rates, for example, which would appear to account for the poor fit of the BEER with the real value of the pound.

The permanent-transitory decomposition adopted here has a number of additional advantages. One of these is that it is possible to identify which variables are the main contributors of system-wide non-stationarity (the common trends) and which variables in turn are affected by these common trends. Moreover, this approach yields information on the combined effects of the permanent and transitory components and gives an indication if a shock to a particular variable has a permanent effect on the other variables in the system. It is noteworthy that net foreign assets have a long-run impact on the real value of the U.S. and Canadian dollars; by contrast, the only variable that has a significant long-run effect on the U.K. pound is the real interest differential. Finally, it should be noted that this approach lends itself to extending the analysis to common factors across currency systems, as such systems and relevant interest rates are obviously interrelated. This extension is left for further work.

REFERENCES

Alberola, E., Susana G. Cervero, Humberto Lopez, and Angel Ubide, 1999, "Global Equilibrium Exchange Rates: Euro, Dollar, "Ins," "Outs," and Other Major Currencies in a Panel Cointegration Framework," IMF Working Paper 99/175 (Washington: International Monetary Fund).

Baffes, J., I.A. Elbadawi, and S.A. O'Connell, 1999, "Single-Equation Estimation of the Equilibrium Real Exchange Rate," Chapter 10 in *Estimating Equilibrium Exchange Rates in Developing Countries*, L.E. Hinkle and P.J. Montiel (eds.), (Washington: World Bank).

Beveridge, S., and Charles R. Nelson, 1981, "A New Approach to Decomposition of Economic time Series into Permanent and Transitory Components with Particular Attention to Measurement of the 'Business Cycle'," *Journal of Monetary Economics* , Vol. 7, pp. 151–174.

Baxter, M., 1994, "Real Exchange Rates and Real Interest Rate Differentials: Have We Missed the Business-Cycle Relationship?," *Journal of Monetary Economics*, Vol. 33, pp. 5–37.

Campbell, J.Y. and R.H. Clarida, 1987, "The Dollar and Real Interest Rates," in A Meltzer and K. Brunner (eds.), *Carnegie-Rochester Conference Series on Public Policy*, Vol. 24, Amsterdam: North Holland.

Clarida, R. and J. Gali, 1995, "Sources of Real Exchange Rate Fluctuations: How Important are Nominal Shocks?," in *Carnegie-Rochester Series on Public Policy*, Vol. 41, pp. 1 –56.

Clark, P.B., and R. MacDonald, 1999, "Exchange Rates and Economic Fundamentals: A Methodological Comparison of BEERs and FEERs," Chapter 10 in *Equilibrium Exchange Rates*, R. MacDonald, and J.L. Stein (eds.), Kluwer Academic Publishers, London, U.K.

"Controversy: Exchange Rate Fundamentals," 1999, *The Economic Journal*, Vol. 109, No. 459, November, pp. F652–F691.

Doornik, John and Henrik Hansen, 1994, "A Practical Test of Multivariate Normality," unpublished paper, (Oxford: Nuffield College).

Edison, H.J., and W.R. Melick, 1999, "Alternative Approaches to Real Exchange Rates: Three Up and One Down," *International Journal of Finance and Economics*, Vol. 4, pp. 93–111.

Edison, Hali and Dianne Pauls, 1993, "A Re-assessment of the Relationship Between Real Exchange Rates and Real Interest Rates: 1974–1990," *Journal of Monetary Economics*, Vol. 31, pp. 165–188.

Engle, Robert and Clive Granger, 1987, "Cointegration and Error Correction: Representation, Estimation and Testing," *Econometrica*, Vol. 55, pp. 251–76.

Faruqee, Hamid, 1995, "Long-Run Determinants of the Real Exchange Rate: A Stock-Flow Equilibrium Approach," *Staff Papers*, International Monetary Fund, Vol. 42, pp. 80–107.

Flood, R.P, and M.P. Taylor, 1996, "Exchange Rate Economics: What's Wrong with the Conventional Macro Approach?," in J. Frankel, et al. (eds.), *The Microstructure of Foreign Exchange Markets*, University of Chicago Press, Chicago and London

Froot, K.A., 1990, "Short Rates and Expected Asset Returns," NBER Working Paper No. 3247, January.

Godfrey, L.G., 1988, *Misspecification Tests in Econometrics*, (Cambridge, Mass.: Cambridge University Press).

Gonzalo, J., and C. Granger, 1995, "Estimation of Common Long-Memory Components in Cointegrated Systems," *Journal of Business and Economic Statistics*, Vol. 13, pp. 27–35.

Huizinga, John, 1987, "An Empirical Investigation of the Long-Run Behaviour of Real Exchange Rates," in *Carnegie-Rochester Conference Series on Public Policy*, Vol. 27, pp. 149–214.

Isard, Peter, 1983, "An Accounting Framework and Some Issues for Modeling How Exchange Rates Respond to the News," in J. Frenkel (ed.), *Exchange Rates and International Macroeconomics*, (Chicago: Chicago University Press).

Isard, P., and H. Faruqee, 1998, "Exchange Rate Assessment: Extensions of the Macroeconomic Balance Approach," IMF Occasional Paper No. 167 (Washington: International Monetary Fund).

Johansen, Soren, 1988, "Statistical Analysis of Cointegrating Vectors," *Journal of Economic Dynamics and Control*, Vol. 12, pp. 231–254.

Johansen, S. and K. Juselius, 1992, "Maximum Likelihood Estimation and Inference on Cointegration - With Applications to the Demand for Money," *Oxford Bulletin of Economics and Statistics*, Vol. 52, pp. 169–210.

Johansen, Soren, 1995, *Likelihood-Based Inference in Cointegrated Vector Autoregressive Models,* (Oxford: Oxford University Press).

Kramer, Charles, 1996, "The Real Effective Value of the U.S. Dollar, the Fiscal Deficit, and Long-Run Balance of Payments Equilibrium: An Empirical Note," (Washington: International Monetary Fund), unpublished.

Lane, Philip, and Gian Maria Milesi-Ferretti, 2000, "The Transfer Problem Revisited: Net Foreign Assets and Real Exchange Rates," unpublished paper, Trinity College Dublin and International Monetary Fund.

Lim, Guay-Cheng, 2000, "Misalignment and Managed Exchange Rates: An Application to the Thai Baht," IMF Working Paper 00/63 (Washington: International Monetary Fund).

MacDonald, Ronald, 1995, "Asset Market and Balance of Payments Characteristics: An Eclectic Exchange Rate Model for the Dollar, Mark and Yen," IMF Working Paper 95/55 (Washington: International Monetary Fund).

MacDonald, Ronald, 1997, "What Determines Real Exchange Rates: The Long and Short of It," IMF Working Paper 97/21 (Washington: International Monetary Fund).

MacDonald R. and J. Nagayasu, 1999, "The Long-Run Relationship Between Real Exchange Rates and Real Interest Differentials: A Panel Study", IMF Working Paper 99/37 (Washington: International Monetary Fund), forthcoming in *IMF Staff Papers.*

MacDonald, R., and P. Swagel, 2000, "Real Exchange Rates and the Business Cycle," IMF Working Paper, forthcoming (Washington: International Monetary Fund).

MacDonald, Ronald and J.L. Stein (eds.), 1999, *Equilibrium Exchange Rates,* Kluwer Academic Publishers, London, U.K.

Masson, P., Jeroen Kremers, and Jocelyn Horne, 1993, "Net Foreign Assets and International Adjustments: the United States, Japan, and Germany," IMF Working Paper 93/33 (Washington: International Monetary Fund).

Meese, Richard, and Kenneth Rogoff, 1988, "Was it Real? The Exchange Rate-Interest Differential Relation over the Modern Floating-Rate Period," *The Journal of Finance,* Vol. 43, No. 4.

Meredith, Guy, and Menzie D. Chin, 1998, "Long-Horizon Uncovered Interest Rate Parity," NBER Working Paper No. 6797.

Paruolo, P., 1997, "Asymptotic Inference on the Moving Average Impact in Cointegrated I(1) VAR Systems," *Econometric Theory,* Vol. 13, 79–118.

Quah, D., 1989, "The Relative Importance of Permanent and Transitory Components: Identification and Some Theoretical Bounds," working paper, MIT.

Stein, J.L., 1999, "the Evolution of the Real Value of the U.S. Dollar Relative to the G7 Currencies," Chapter 3 in Ronald MacDonald and J.L. Stein (eds.), *Equilibrium Exchange Rates*, Kluwer Academic Publishers, London, U.K.

Stein, J.L. and P.R. Allen, 1995, *Fundamental Determinants of Exchange Rates*, Clarendon Press, Oxford, U.K.

Stock, J.H., and M.W. Watson, 1988, "Testing for Common Trends," *Journal of the American Statistical Association*, Vol. 83, pp. 1097–1107.

Williamson, John (ed.), 1994, *Estimating Equilibrium Exchange Rates,* (Washington: Institute for International Economics).

Zanello, Allessandro, and Dominique Desruelle, 1997, "Primer on the IMF's Information Notice System," IMF Working Paper 97/71 (Washington: International Monetary Fund).

Yeager, Leland B., 1966, *International Monetary Relations: Theory, History, and Policy,* University of Virginia, Harper & Row, New York.