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Exchange Rates and Economic Fundamentals: A Methodological Comparison of BEERs and FEERs

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Abstract

This paper compares two approaches for examining the extent to which a country's actual real effective exchange rate is consistent with economic fundamentals: the FEER approach, which involves calculating the real exchange rate that equates the current account at full employment with sustainable net capital flows, and the BEER approach, which uses econometric methods to establish a behavioral link between the real rate and relevant economic variables. An exchange rate model is estimated for the G-3 currencies to provide illustrative comparisons of BEERs and FEERs.

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SUMMARY

This paper compares two approaches for assessing the extent to which a country's real effective exchange rate is consistent with economic fundamentals. One approach defines the Fundamental Equilibrium Exchange Rate (FEER) as that real exchange rate which is consistent with macroeconomic balance, which is identified as the rate that brings the current account into equality with the underlying or sustainable capital account, where the determinants of both the current and capital accounts have been set at their full employment values.

By contrast, the other approach involves the direct econometric analysis of a model of the behavior of the real effective exchange rate—consequently 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. However, the BEER approach also requires judging whether the economic fundamentals that determine exchange rate behavior are themselves at sustainable or equilibrium levels.

We illustrate the BEER approach with the estimation of equations for the real effective exchange rates for the German mark, the Japanese yen, and the U.S. dollar using cointegration methods. This has the novel feature of providing a meaningful interpretation of multiple cointegrating vectors: one that embodies four long-run determinants of the exchange rate (the terms of trade, relative price on nontraded to traded goods, the stock of net foreign assets, and a proxy for the risk premium) and another that involves the short-run effect of the interest rate differential. The estimated BEERs, including those generated with calibrated values of the explanatory variables using the Hodrick-Prescott filter, are used to shed light on the consistency of the three exchange rates with economic fundamentals, and are also compared with FEERs estimated by Williamson (1994).

I. Introduction

The analysis of exchange rate behavior has been a perennial topic in international monetary economics. One strand of this literature relates to the explanation of observed movements in nominal and real exchange rates in terms of relevant economic variables. A different strand focuses on assessing exchange rates relative to economic fundamentals and coming to a judgement as to whether a particular exchange rate is misaligned, i.e., over- or undervalued. One approach taken in this latter strand of research that has been developed by Williamson (1994) involves the calculation of what is called the Fundamental Equilibrium Exchange Rate (FEER). In this approach the equilibrium exchange rate is defined as the real effective exchange rate that is consistent with macroeconomic balance, which is generally interpreted as when the economy is operating at full employment and low inflation (internal balance) and a current account that is sustainable, i.e., that reflects underlying and desired net capital flows (external balance). This exchange rate concept is denoted as "fundamental" in that it abstracts from short-term factors and emphasizes instead determinants that are important over the medium term. An assessment of a country's exchange rate can be made by comparing its current level with the calculated FEER

One issue that arises in the application of the FEER approach is the extent to which it is informed by both the theoretical and empirical literature on exchange rate determination. The notion of equilibrium in the FEER calculation is that of consistency of the current account calibrated at full employment with sustainable capital flows. However, in many cases the calculation is made without incorporating the effects of variables that have been found to affect the actual behavior of exchange rates. The exchange rate under this approach remains unchanged as long as the positions of internal and external balance are undisturbed, but it is not clear whether the exchange rate will be in equilibrium in a behavioral sense, i.e., reflects the effect of factors that determine the exchange rate over the medium term. Thus it is useful to compare the FEER approach with one that involves the direct econometric analysis of the behavior of the real effective exchange rate, which can be called the BEER (Behavioral Equilibrium Exchange Rate) approach.

One obvious reason why one might prefer the FEER approach is that exchange rates have been volatile and unpredictable, and economists up until quite recently had considerable difficulty in explaining exchange rate movements, as noted in Meese and Rogoff ((1983) and (1984) and Frankel and Rose (1995). In particular, some modeling exercises that use data for a single currency have failed to establish a significant link between real exchange rates and economic fundamentals, such as real interest differentials.[2] However, there is now growing evidence that with longer or panel-data samples, appropriate econometric methods, and proper specification, the behavior of nominal and real exchange rates can be explained in terms of economic fundamentals in reduced-form econometric equations. [3]

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[2] See, for example, the studies by Meese and Rogoff (1988), Edison and Pauls (1993), and Coughlin and Koedijk (1990).

[3] The use of panel data sets to estimate real exchange rate relationships in the recent floating rate period has been exploited by Chinn (1996), Chinn and Johnson (1996), MacDonald
(continued...)

Thus it would appear useful to examine how statistical approaches to explaining the actual behavior of real exchange rates - the BEER approach - can be used to assess exchange rates in the manner in which the FEER approach has been used. The next section compares and contrasts these two approaches from this perspective. The subsequent section then develops a particular BEER equation for the real effective exchange rate for the U.S. dollar, the German mark, and the Japanese yen using cointegration methods. One of the novel features of our empirical implementation of the BEER approach is that we provide an economically meaningful interpretation of multiple cointegrating vectors. We then go on to illustrate how this approach might be used in assessing the exchange value of these currencies. The final section provides some concluding remarks.

II. A Comparison of FEERs and BEERS as Tools for assessing Exchange Rates

In this section we compare the two approaches. We first describe the FEER and focus on the extent to which it can be seen to embody a theory of exchange rate determination that provides predictions about the future evolution of the exchange rate. In addition, we discuss the normative aspects of the FEER. Whereas the FEER is a special-purpose modeling approach that is specifically designed to calculate the medium-term real effective value of a currency in order to assess the current value of the exchange rate, the BEER denotes a modeling strategy that attempts to explain the actual behavior of the exchange rate in terms of relevant economic variables. In the FEER approach the notion of equilibrium that is considered relevant for assessing current exchange rates is that of macroeconomic balance, whereas this concept is absent from the BEER approach, where the relevant notion of equilibrium is the value given by an appropriate set of explanatory variables. A theme of the paper is how the BEER approach can be adapted so as to provide meaningful assessments of exchange rate values along the lines of the FEER approach. Conversely, it raises the issue of whether this latter approach could usefully be extended or elaborated to incorporate some of the key behavioral relationships between exchange rates and their determinants.

A. The FEER Approach

The FEER concept is based on the notion of macroeconomic balance which has both an internal and external dimension.[4] Internal balance is identified as the level of output consistent with both full employment, in particular, the level of unemployment given by the

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[3](...continued)
(1996) and MacDonald, Marsh, and Nagayasu (1996). Time series data for this period have been used by MacDonald (1997a) to obtain plausible relationships between economic fundamentals and real effective exchange rates for the U.S. dollar, the Deutsche mark, and the Japanese yen.

[4]The literature on the FEER has grown considerably since Williamson (1985) first popularized the idea. See, for example, Williamson and Miller (1987), Wren-Lewis, et al., (1991), Wren-Lewis (1992), Clark, et al., (1994), Williamson (1994), Isard and Faruqee (1998), and Wren-Lewis and Driver (1997).

NAIRU, and a low and sustainable rate of inflation. External balance is characterized as the sustainable desired net flow of resources between countries when they are in internal balance. Because this approach aims at calculating exchange rates for a particular set of economic conditions, it abstracts from short-run cyclical conditions and temporary factors and focuses on "economic fundamentals," which are identified as those conditions or variables that are likely to persist over the medium term. These conditions are not necessarily those projected to occur in the future, but rather are desirable outcomes that may in fact never be realized. In this sense, the FEER exchange rate measure is a normative one, and indeed Williamson (1994, pp. 180-181) has characterized the FEER as the equilibrium exchange rate that would be consistent with "ideal economic conditions." This normative aspect by itself is not a criticism of the approach, as it simply reflects the objective of calibrating the exchange rate at a set of well-defined economic conditions. One could, of course, choose a different set of conditions at which to calculate the exchange rate, e.g., those most likely to prevail over the period of interest.

The core of the macroeconomic balance approach is the identity equating the current account (CA) to the (negative of) capital (KA) account:

$$CA \equiv -KA \tag{1}$$

Rather than specify the behavioral factors affecting the exchange rate, as in the BEER, most of the attention in the FEER approach is on the determinants of the current account, which is typically explained as a function of home and foreign aggregate output or demand, y_d and y_f, respectively, and the real effective exchange rate, q,[5] In many applications of the FEER approach, the equilibrium capital account over the medium term $(\overline{KA})$ is arrived at judgementally by taking into consideration a number of relevant economic factors.[6] Equation (1) can then be transformed into an equilibrium relationship between the current and capital accounts, where for illustrative purposes the current account is expressed as a linear function of its main determinants, which are set at their full employment levels:

$$CA = b_0 + b_1 q + b_2 \bar{y}_d + b_3 \bar{y}_f = -\overline{KA} \tag{2}$$

where $b_1 < 0, \quad b_2 < 0,$ and $b_3 > 0.$

Using the model of the current account on the left-hand side of equation (2), the exchange rate that is consistent with macroeconomic balance—the FEER—is the real effective exchange rate, q, which will bring the current account into equality with the "normal", "underlying" or "sustainable" capital account, where the determinants of the

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[5]It is recognized that the current account includes not only trade flows but also transfers and both factor and non-factor services. For a recent attempt to model these latter components of the current account, see Wren-Lewis and Driver (1997).

[6]Relevant examples are the partial equilibrium FEER calculations in Bayoumi *et al.* (1994), Williamson (1994) and Wren-Lewis and Driver (1997).

current account have been set at their full employment values. Solving equation (2) for q gives the FEER as:

$$FEER = (-\overline{KA} - b_0 - b_2\,\bar{y}_d - b_3\bar{y}_f) \;/\; b_1 \tag{3}$$

As emphasized by Wren-Lewis (1992), equation (3) shows that the FEER is a "*method of calculation* of a real exchange rate which is consistent with *medium-term macroeconomic equilibrium*."[7] In the words, given the parameters of a model of the current account, including in particular the sensitivity of current account flows to the real exchange rate, the FEER is calculated using an exogenously given estimate of sustainable net capital flows. As it is a method of calculation, the FEER approach *per se* does not embody a theory of exchange rate determination. Nonetheless, there is the implicit assumption that the *actual* real effective exchange rate, q, will converge over time to the FEER. Hence embedded in this approach is a medium-run current account theory of exchange rate determination. It is assumed that a divergence of q from the FEER will set in motion forces that will eventually eliminate this divergence, but as the approach characterizes only the equilibrium position, the nature of the adjustment forces is left unspecified.

This lack of focus on the dynamics of adjustment of the real exchange rate reflects the fact that the FEER approach is primarily designed as *a method of assessment* of the current value of a country's real exchange rate. A comparison of q_t with $FEER_t$ is used to estimate whether the current exchange rate is overvalued ($q_t > FEER_t$) or undervalued ($q_t < FEER_t$). Making the assessment requires estimating what the current account would be if (1) q_t were to persist over the medium term and (2) the country and its trading partners were at full employment levels of output. The projected current account, $\hat{CA}_t$, is compared with the exogenously given net capital account, $\overline{KA}$, and the FEER is the real exchange rate which will bring the current account at full employment into equality with $\overline{KA}$. By focusing explicitly on the current account, the FEER approach provides a transparent and systematic way for policymakers to base their assessments of exchange rates on their views regarding equilibrium or sustainable current account positions.[8]

It is clear from the above that a FEER calculation requires considerable parameter estimation and judgement involving: (1) a current account model, (2) estimates of potential output for the country concerned and its main trading partners and (3) an estimate or judgement regarding $\overline{KA}$. As the first two have been both the subject of extensive theoretical and empirical analysis and are analytically and conceptually fairly straightforward, they will not be discussed further here. The same cannot be said for the

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[7]Wren-Lewis (1992), p. 75. Emphasis in the original.

[8]It should be noted that as the FEER approach is a method of calculation, it lends itself to ensuring that there is multilateral consistency in computing effective exchange rate changes across countries as well as consistency between bilateral and effective exchange rates (the *n–1* exchange rate problem). This issue addressed in a comprehensive fashion in the FEER methodology developed in Isard and Faruqee (1998).

third required input to FEER analysis, $\overline{KA}$, as the determinants of equilibrium net capital flows are by no means well established. Williamson (1994), for example, relies on a host of factors, including investment needs as determined by debt cycle considerations, the effects of demographics on saving behavior, and judgements regarding sustainability and consistency, to arrive at current account targets in 1995 for 14 countries and regions. An even wider set of theoretical consideration is used to develop current account targets for 2001 as inputs for the FEER calculations of Wren-Lewis and Driver (1997).[9] In calculating what they refer to as "DEERs" (Desirable Equilibrium Exchange Rates) for the major industrial countries in 1970, Bayoumi *et al* (1994) assumed that the targeted current account surplus for each country was equal to 1 percent of GDP because it was the approximate stated objective of the U.S. Administration during the Smithsonian discussions of appropriate parities for the exchange rates for the major industrial countries.

This rather unsatisfactory state of affairs appears to have been remedied, at least in part, by the recent extension of FEER analysis in Faruqee, Isard, and Masson (1996). The key insight of their approach is to recognize that the equilibrium current account can be viewed as the difference between desired aggregate saving and investment at full employment. Thus the net capital account $(-\overline{KA})$ in equation (2) is replaced by $\overline{S} - \overline{I}$.

The full employment levels of saving and investment are estimated as behavioral functions of the output gap, the dependency ratio, and the fiscal deficit[10]. The FEER is then calculated as the real effective exchange rate that will generate a current account equal to $\overline{S} - \overline{I}$ when the other determinants of the current account are set at their full-employment levels. Thus equation (3) is used to calculate the FEER with $\overline{S} - \overline{I}$ substituted for $-\overline{KA}$.

This provides a transparent and plausible method for estimating the equilibrium current account that depends much less on judgement than other implementations of the FEER approach.

While this particular application of the FEER approach includes a number of variables that are plausible determinants of the net capital account, such as relative fiscal position and demographics, nowhere do rates of return or other factors affecting the relative attractiveness of assets denominated in different currencies play a role. The FEER model is basically recursive in that the current account determines the capital account without any feedback from the latter to the former.[11] In particular, neither saving nor investment is a function of the exchange rate. Thus there is no channel through which a shift in asset

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[9]See John Williamson and Molly Mahar, "Current Account Targets," an appendix in Wren-Lewis and Driver (1997).

[10]For an extensive analysis of the determinants of saving and investment that underlies this particular FEER application, see Debelle and Faruqee (1996).

[11] See Wren-Lewis (1992) for an excellent discussion of the implications of recursiveness in the FEER approach.

preferences that changes the real exchange rate can affect the current account in the medium term. If such shifts in asset preferences are associated with differential variations in the marginal productivity of capital across countries, then movements in S - I will be matched by corresponding changes in KA. Yet it is certainly possible for changes to occur in the capital account that are likely to persist over the medium term, for example, the dramatic increase in net capital flows from industrial countries to emerging markets and developing countries so far during the 1990s. It is reasonable to argue that capital flows of this kind would have persistent effects on real exchange rates and the current account. We shall return to the importance of the capital account in discussing below the application of the BEER approach to developing countries.

Finally, it should be pointed out that the FEER analysis described above has been developed solely in terms of flow equilibrium. It is in this sense that the analysis is a medium-run concept, as it does not take into account longer-run stock equilibrium considerations.[12] However, even over the medium run it is not clear that debt stocks can be ignored in the analysis of exchange rates, as they have been a factor in affecting risk premia in both industrial and developing countries. This is obviously the case where assets denominated in different currencies are imperfect substitutes, but it also applies where uncovered interest parity holds with a time-varying risk premium that depends on relative stocks of outstanding debt. Stock equilibrium of this type is employed in the illustrative BEER developed below.[13]

B. The BEER Approach

As noted above, a potential alternative to the FEER for assessing the current value of an exchange rate is the use of an estimated reduced-form equation that explains the behavior of the real effective exchange rate over the sample period.[14] Such a reduced-form expression is represented in general terms by equation (4):

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[12]Note , however, that the FEER analysis could be extended in this direction. Debelle and Faruqee (1996), for example, provide evidence that the current account is a function of the ratio of net foreign assets to GDP. Moreover, to the extent that net foreign assets in turn reflect factors affecting the capital account, the FEER analysis need not be recursive.

[13]Faruqee, Isard, and Masson (1996), point out that a stock equilibrium condition can be used as an alternative to $\bar{S} - \bar{I}$ as a way of defining external balance, namely, the current account that stabilizes the ratio of net foreign assets to GDP. As this approach depends on judgements regarding appropriate level or time path for this ratio that involve notions of desirability and sustainability, they prefer the less judgmental $\bar{S} - \bar{I}$ approach based on empirical evidence regarding the factors influencing S and I.

[14]The following discussion is based in part on Clark (1994) and Baffes, Elbadawi, and O'Connell (1997).

$$q_t = \beta_1' Z_{1t} + \beta_2' Z_{2t} + \tau' T_t + \varepsilon_t \tag{4}$$

where:

$Z_1 =$	a vector of economic fundamentals that are expected to have persistent effects over the long run.
$Z_2 =$	a vector of economic fundamentals that affect the real exchange rate over the medium term, which may, e.g., coincide with the business cycle.
$\beta_1, \beta_2 =$	vectors of reduced–form coefficients.
$T =$	a vector of transitory factors affecting the real exchange rate in the short run.
$\tau =$	vector of reduced-form coefficients.
$\varepsilon_t =$	random disturbance term.

In equation (4) the actual, observed real effective exchange rate is explained exhaustively in terms of a set of fundamental variables, Z_1 and Z_2, a set of variables that affect the exchange rate only in the short run, T, and a random error ε. It is useful to distinguish the *actual* value of the real exchange rate from the *current equilibrium* rate, q', which is the level of the exchange rate given by the current values of the two sets of economic fundamentals:

$$q_t' = \beta_1' Z_{1t} + \beta_2' Z_{2t} \tag{5}$$

Using this framework, it is natural to define the *current misalignment, cm_t*, as the difference between the actual real exchange rate and the real exchange rate given by the *current values* of all the economic fundamentals:

$$cm_t \equiv q_t - q_t' = q_t - \beta_1' Z_{1t} - \beta_2' Z_{2t} = \tau' T_t + \varepsilon_t \tag{6}$$

As the current values of the economic fundamentals themselves may depart from sustainable or desirable levels, as emphasized in the FEER approach, it is also useful to define the *total misalignment, tm_t*, as the difference between the actual real rate and the real rate given by the sustainable or long-run values of the economic fundamentals, which are denoted by $\bar{Z}_{1t}$ and $\bar{Z}_{2t}$:

$$tm_t = q_t - \beta_1' \bar{Z}_{1t} - \beta_2' \bar{Z}_{2t} \tag{7}$$

By adding and subtracting q_t' from the right–hand side of (7), the total misalignment can be decomposed into two components:

$$tm_t = (q_t - q_t') + [\beta_1'(Z_{1t} - \bar{Z}_{1t}) + \beta_2'(Z_{2t} - \bar{Z}_{2t})] \tag{8}$$

The first component is simply the current misalignment given by equation (6) above. The other component shows the effect of departures of the current fundamentals from their long-run or sustainable values. As $q_t - q_t^{'} = \tau' T_t + \varepsilon_t$, equation (8) can be written as:

$$tm_t = \tau' T_t + \varepsilon_t + [\beta_1^{'}(Z_{1t} - \bar{Z}_{1t}) + \beta_2^{'}(Z_{2t} - \bar{Z}_{2t})] \tag{9}$$

Thus in the BEER approach the total exchange–rate misalignment at any point in time can be decomposed into the effect of transitory factors, random disturbances, and the extent to which the economic fundamentals are away from their sustainable values. Whereas the FEER is exclusively a medium– to long–run concept, the BEER is more general in that it can in principle be used to explain cyclical movements in the real exchange rate. As will be seen below, approaches to estimating reduced-form exchange rate equations differ in their identification of short-run factors, T, the choice of medium–term and long–run fundamentals, Z_2, and Z_1, and the extent to which the fundamentals are calibrated at their long-run values, $\bar{Z}_2$ and $\bar{Z}_1$.

It is useful to start with approaches to estimating equilibrium exchange rates that derive a reduced-form equation implied by the macroeconomic balance approach. Two examples are Faruqee (1995) and Stein (1994, 1995) and Stein et. al. (1995). Both Faruqee and Stein take as their starting point the balance-of-payments equation which equates the current account with the capital account. In Stein's specification of what he calls the "natural real exchange rate," or NATREX, net capital flows are determined by the difference between national saving and investment, with the former a function of the rate of time preference, and the latter by the Tobin q ratio. In the NATREX, two basic variables—productivity and thrift—drive the capital account, which in turn influences the real exchange rate through changes in the current account. Moreover, the model has the desirable property of taking into account stock equilibrium conditions, so that the steady state is reached when the domestic capital stock and net foreign assets are at their long-term values. In the steady state, the real exchange rate, the capital stock, and the level of net foreign assets are all functions of the exogenous foreign and domestic productivity and thrift variables.

The distinction between current and capital accounts is also drawn sharply by Faruqee. In his illustrative model, the current account balance is the sum of the trade balance, which is a function of the real exchange rate and exogenous variables (X), and interest income received (or paid) on a country's net foreign asset (or debt) position, F:

$$CA = cq + X + rF \qquad c < 0, r = \text{domestic real interest rate} \tag{10}$$

Faruqee points out that a viable balance of payments position requires that the current account be financed by a desired or sustainable level of capital flows. In his model, he posits that the desired rate of net foreign asset accumulation (or decumulation), which corresponds to the desired rate of net national saving, is given by:

$$KA^d = d(r - r^*) + f(F^d - F), \qquad d < 0, f > 0 \tag{11}$$

where:

KA^d	=	desired net capital flow
r^*	=	world real interest rate
F^d	=	target or desired level of net foreign assets.

Combining equations (7) and (8) gives the full balance of payments equation:

$$cq + X + rF = d(r-r^*) + f(F^d-F). \tag{12}$$

This balance of payments equation requires that the desired excess of income over spending, the left–hand side of (12), be equal to the desired net change in claims on foreigners. In Faruqee's model, the actual real exchange rate can be solved as a function of the long-run value, $\bar{q}$ and the difference between the actual and the long-run stock equilibrium level of net foreign assets, $\bar{F}$:

$$q_t = \bar{q}_t + s(F_t - \bar{F}_t) \quad s>0. \tag{13}$$

The solution for $\bar{q}_t$ is given by:

$$\bar{q}_t = (r/c)\,\bar{F}_t + \frac{1}{c}\,\bar{X}_t \tag{14}$$

The NATREX model and that of Faruqee share a number of common features. First, the actual real exchange rate is a function of the difference between the actual and long-term desired level of net foreign assets, as shown in (13). This can be referred to as the short-run equilibrium level of the real exchange rate. Second, the long-run equilibrium level, as shown in equation (14), is a function both of factors affecting the capital account, $\bar{F}$, as well as those affecting the current account, $\bar{X}$. Thus, unlike the FEER approach , the model is not recursive, as the capital account has an impact on both the current and the long-run equilibrium exchange rate. Third, in both models the issue of a sustainable or desirable current account position does not arise. Agents are always at the desired positions, whether in the short run or long run. Basically, the real exchange rate and the real interest rate adjust so that the current account balance is willingly financed by wealth holders.

However, there are some significant differences in empirical implementation. Faruqee makes no attempt to deal with issues of internal or, as noted above, external balance. Using cointegration analysis, he estimates basically equation (14) using productivity growth differentials, the relative price of non-traded goods, and the terms of trade as variables determining the current account (the X variable), and treats the actual stock of net foreign assets as an exogenous variable. This approach has no normative elements, as it simply tries to explain the (annual average) real effective value of the yen and the U.S. dollar in terms of the economic fundamentals, and the fitted value of the real exchange rate from his estimating equation is referred to as the "trend" value, rather than equilibrium value.

Nonetheless, his results could be used to make assessments of the exchange rates of the U.S. dollar and yen. For example, the estimated trend value for the U.S. effective exchange rate in 1984 and 1985 is considerably below the actual value, indicating that the dollar was considerably overvalued during this period, i.e., not consistent with the fundamental economic variables explaining the behavior of the exchange rate. Interestingly, his quantitative estimates of misalignment (difference between estimated and actual values) for both the dollar and yen at the time of the breakup of Bretton Woods are broadly in line with the results reported in Bayoumi *et al.* (1994).

MacDonald (1995) uses the same theoretical structure as Faruqee to motivate empirical models of the nominal effective exchange rates of the German mark, Japanese yen and U.S. dollar for the post Bretton Woods period. Estimated cointegrating vectors are then used to generate measures of equilibrium exchange rates, and these show, inter alia, the extent of exchange rate misalignment of the U.S. dollar for the period 1980 to 1985, and the overvaluation of the German mark for the period coinciding with German reunification.

Kramer (1996) provides an extension of Faruqee's model which focuses on the relationship between the U.S. fiscal deficit and the real exchange value of the U.S. dollar. After accounting for the effect of net foreign assets, the terms of trade, and the relative price of traded to non-traded goods, he finds that the U.S. fiscal balance relative to its G-7 trading partners has a positive effect on the real value of the dollar. This is consistent with the long-run stock equilibrium view of the impact of fiscal policy: an improvement in the fiscal position (smaller deficit) lowers net foreign debt and improves the income component of the current account, thus requiring a real appreciation to restore the current account equilibrium. It is noteworthy that the fitted values of his model account for nearly all of the real appreciation of the dollar between 1980 and 1984, which appears to reflect the rather surprising fact that the *relative* U.S. fiscal position *improved* over this period.[15]

While both Faruqee and Kramer restrict themselves to explaining the actual behavior of the real value of the U.S. dollar, in one of his papers on the NATREX Stein (1995) attempts to estimate the degree of misalignment of the dollar when there is internal and external balance. Departures from internal and external balance are incorporated as disequilibrium terms in the reduced form exchange rate equation, rather than reflected in the economic fundamentals, which therefore by assumption do not have a cyclical component. Departures from internal balance are proxied by deviations of capacity utilization from its mean, and departures from external balance are assumed to be a function of the deviation of the U.S. real long-term rate from a weighted average of comparable interest rates in the

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[15]The data for the relative U.S. fiscal position that he reports show this to be the case. Moreover, the data used in this paper for the stock of U.S. government debt relative to the other G-7 countries also shows an improvement in the *relative* U.S. position over the 1980–1985 period. However, Hooper and Mann (1989), in their study of the U.S. external imbalance over this period, report data showing a clear *worsening* in the relative U.S. fiscal position. Thus there would appear to be a puzzle in estimating the contribution of U.S. fiscal policy to the appreciation of the dollar in 1980–1985.

other G-7 countries. The former measure appears quite plausible, whereas it is not clear how the latter relates to the concept of external balance in the FEER literature. In estimating the misalignment of the dollar Stein calculates the fitted value from the long-run relationship where the exchange rate is a function only of fundamentals. There are extremely large differences between actual and fitted values between 1977 and 1982, and between 1983 and 1986. In addition, the large appreciation of the dollar between 1980 and early 1985 is not captured by his model. Hence it is difficult to interpret to what extent Stein's approach provides reasonable estimates of the misalignment of the dollar. This highlights a general issue that arises in the application of BEERs in assessing exchange rates, namely, the extent to which the difference between the estimated BEER and the actual exchange rate reflects true misalignment or specification error, i.e., failure to capture the effect on the exchange rate of one or more fundamentals. This issue is discussed further below.

The use of BEERs for assessing the real exchange rates of developing countries has been much more extensive than in the case of industrial countries. Edwards (1989) provided an extensive theoretical and empirical analysis of the factors affecting the equilibrium real exchange rate (ERER). The concept of the ERER is similar to that of the FEER, except that the real exchange rate (RER) is defined in terms of the relative price of tradables to nontradables, as the prices of tradable goods are more or less given for developing countries. Edwards defines the ERER as that RER which results in the simultaneous attainment of internal and external equilibrium for given sustainable values of the relevant economic fundamentals explaining the RER. Internal balance is where unemployment is at its natural level, and external balance is where current and future current account balances are compatible with long-run sustainable capital flows.

The key methodological difference between the ERER and the FEER is that Edwards estimates a reduced-form equation for the RER and then uses the results to calculate the ERER by excluding the effects of transitory variables and using proxies for sustainable values of the economic variables by different smoothing procedures. However, it is by no means clear that these procedures result in a real exchange rate that corresponds to internal and external balance along the lines of the FEER approach. Nonetheless, Edwards reports that using this methodology, he finds that countries that maintained their RERs closer to the estimated ERERs systematically outperformed those countries subject to persistent misalignment.

Elbadawi (1994) develops a model of the long-run equilibrium real exchange rate in which the fundamentals include the terms of trade, a measure of openness (as a proxy for commercial policy), the sustainable level of net capital inflows relative to GDP, the share of government spending in GDP, and the rate of growth of exports. His empirical estimation is based on annual data spanning the period 1967-90 for Chile and Ghana, and 1967-88 for India. He finds that in all three countries the real exchange rate and all of the fundamentals identified in the model were nonstationary and cointegrated, and the signs of the coefficients in the cointegrating regressions are in accord with those predicted by the theoretical model. He then uses time-series techniques to estimate the permanent components of the fundamentals in each of the countries, and then substitutes these "permanent" values into the cointegrating equations to derive estimates of the long-run equilibrium real exchange rate over the sample in each country. The differences between these estimated long-run equilibrium rates and the actual real exchange rates are taken to represent estimates of misalignment, which in Elbadawi's view correspond extremely well to the episodic macroeconomic developments in these countries over the sample periods.

A major collection of papers edited by Hinkle and Montiel (1997) has recently appeared that focuses on estimating equilibrium exchange rates for developing countries. They cover a range of theoretical and empirical approaches, including partial equilibrium estimation techniques and structural general equilibrium models. One of the themes in the book is the difficulty in identifying the long-run sustainable values of the relevant predetermined, policy, and exogenous variables that are the economic fundamentals. By and large the authors therefore take a pragmatic approach and concentrate less on describing optimal or sustainable values for all the explanatory variables, but more on how particular values of these variables affect the equilibrium exchange rate. In this sense, the papers are much more in the BEER than the FEER tradition[16].

Finally, it is perhaps not surprising that exchange market participants have begun to explore the usefulness of the BEER approach for explaining and assessing exchange rates. Major work in this area has been published recently by Goldman Sachs (1996, 1997). While details of the methodology are not completely clear, the results reported to date for a wide range of currencies of advanced and developing countries appear to support the basic presumption of the BEER approach that real exchange rates are related in a systematic fashion to economic fundamentals.

III. The BEER and Econometric Methodology

A. General Approach

The starting point of our model of the long-run exchange rate is the familiar risk–adjusted interest parity condition:[17]

$$E_t[\Delta s_{t+k}] = -(i_t - i_t^*) + \pi_t \tag{15}$$

where s_t is the foreign currency price of a unit of home currency, i_t denotes a nominal interest rate, $\pi_t = \lambda_t + k$ is the risk premium that has a time–varying component, λ_t, Δ is the first difference operator, E_t is the conditional expectations operator, t+k defines the maturity

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[16]In terms of the BEER framework described above, the authors are more concerned with estimating the β parameters of the empirical model of exchange rate behavior than identifying the sustainable values of the economic fundamentals, i.e., the $\bar{Z}$.

[17]Our operationalisation of the short-run real exchange rate equation follows Isard (1983), Meese and Rogoff (1988), Edison and Pauls (1993), Coughlin and Koedijk (1990), Baxter (1994), and MacDonald (1997a).

horizon of the bonds, and other symbols have the same interpretation as before. Equation (15) may be converted into a real relationship by subtracting the expected inflation differential, $E_t(\Delta p_{t+k} - \Delta p^*_{t+k})$, from the exchange rate and interest differential. After rearrangement this gives:

$$q_t = E_t[q_{t+k}] + (r_t - r_t^*) - \pi_t \tag{16}$$

where $r_t = i_t - E_t(\Delta p_{t+k})$ is the *ex ante* real interest rate. Equation (16) describes the current equilibrium exchange rate as being determined by three components: the expectation of the real exchange rate in period t+k, the real interest differential with a maturity t+k, and the risk premium. The latter enters (16) with a negative sign indicating that a rise in the risk premium requires a depreciation of the real rate which, given the model structure, generates the expectation of an appreciation.[18] We assume that the time–varying component of the risk premium term is a function of the relative supply of domestic to foreign government debt:[19]

$$\lambda_t = g\,(\overset{+}{gdebt_t / gdebt_t^*}) \tag{17}$$

Thus an increase in the relative supply of outstanding domestic debt relative to foreign debt will increase the (domestic) risk premium, thereby requiring a depreciation of the current equilibrium real exchange rate[20].

To make this operational, we follow the exposition at the beginning of the previous section and assume that the unobservable expectation of the exchange rate, $E_t\,[q_{t+k}]$, is determined solely by the long-run economic fundamentals, Z_1. We denote the long–run equilibrium exchange rate as $\hat{q}_t$ and assume that $\hat{q}_t = E_t[q_{t+k}] = E_t[\beta_1' Z_{1t}] = \beta_1' Z_{1t}$.

The factors likely to introduce systematic variability into $\hat{q}_t$ have been discussed elsewhere in some detail, for example, Faruqee (1994) and MacDonald (1997a), 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 the three variables:

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[18]This assumption has been invoked by, for example, Meese and Rogoff (1988).

[19]This is obviously only one possible proxy for the risk premium. It was chosen because it is an observed variable of relevance for policy and because it appears to have affected exchange rates in several countries, e.g., Italy, as shown by Giorgianni (1997). Moreover, alternative proxies have not produced more precise results than the one used here. For discussion and analysis of the risk premium, see Charles Engel (1996), and Ronald MacDonald (1997b).

[20]For an empirical analysis of the effect of government debt on the foreign exchange risk premium, see Giorgianni (1997).

$$\hat{q}_t = f(\overset{+}{tot_t}, \overset{+}{tnt_t}, \overset{+}{nfa_t}) \tag{18}$$

where *tot* is the terms of trade, *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. As in the internal-external balance approach to modelling the real exchange rate, we see *nfa* being driven by the determinants of national savings and investment and, in particular, demographics and structural fiscal balances, as has been analyzed by Masson, Kremers, and Horne (1993).[21] Although we do not explicitly model the former, it may nevertheless be interpreted as "in the data" in the sense that it is what is left of *nfa* after we have adjusted *nfa* for fiscal imbalances. The empirical measurement of the three variables entering (18) is discussed in the next section.

Before proceeding with the econometric estimates, it is instructive to compare the FEER described above with the BEER implied by equations (15) - (18). The former is given by equation (3), which can be represented by the following general relationship:

$$FEER = f(-\overline{KA}, \bar{y}_d, \bar{y}_f) \tag{19}$$

Equations (15) - (18) imply the following general equation:

$$BEER = (r - r^*, gdebt/gdebt^*, tot, tnt, nfa) \tag{20}$$

One key difference is that the FEER is the real exchange rate associated with an independently specified equilibrium capital account together with both domestic and foreign output set at potential, whereas the BEER is estimated using actual values of the fundamental determinants of the real exchange rate. A proper comparison would therefore involve calculating the BEER with these determinants set at their full–employment values. One interpretation of such a comparison could involve matching the potential output variable of the FEER with the calibrated values of the relative price variables (*tot and tnt*) and the interest differential. Variation in the equilibrium capital account could be seen as captured by movements in the calibrated values of net foreign assets, relative government debt, and the interest differential. Looked at from this perspective on can see some similarities in the two models, but they are nonetheless quite different and are clearly not nested. Consequently, a formal test would have to rely on techniques for testing nonnested hypotheses, but these are not attempted here.

The econometric methods used to estimate our model are those of Johansen (1995). One advantage of the Johansen approach, in contrast to other methods, is that it not only provides a test for cointegration, but it also reveals the number of cointegrating

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[21]For empirical evidence on the link between net foreign assets and the real exchange rate, see Faruqee (1995), Gagnon (1996), and MacDonald (1997a)

relationships. While this makes the interpretation of conintegration more difficult, there are statistical procedures which allow one to identify the cointegrating vectors, and we use these procedures in this paper. An additional advantage of the Johansen approach is that it is based on a FIML algorithm and therefore has the potential to address problems of simultaneity

This approach involves the following. Define an (nx1) vector of variables, x_t, consisting of the variables specified in (16) and (17) which may be I(1) or I(0), and assume that it has a vector autoregressive representation of the form:

$$x_t = \eta + \sum_{i=1}^{p} \Pi x_t + \varepsilon_t, \tag{21}$$

where η is a (nx1) vector of deterministic variables, and ε is a (nx1) vector of white noise disturbances, with mean zero and covariance matrix Ξ. Expression (21) may be reparameterized into the vector error correction mechanism (VECM) representation as:

$$\Delta x_t = \eta + \sum_{i=1}^{p-1} \Phi_i \Delta x_{t-i} - \Pi x_{t-1} + \varepsilon_t \tag{22}$$

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, Π=0, there will be no cointegration amongst the elements in the long-run relationship. In these two cases 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.[22]

We test for the existence of cointegration amongst the variables contained in $\mathbf{x}_t$ 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:

$$TR = T \sum_{i=r+1}^{N} \ln(1 - \hat{\lambda}_i), \tag{23}$$

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

where $\hat{\lambda}_{r+1},\ldots\ldots,\hat{\lambda}_N$ are the N-r smallest squared canonical correlations between $\mathbf{x}_{t-k}$ and $\Delta\mathbf{x}_t$ series (where all of the variables entering $\mathbf{x}_t$ are assumed I(1)), corrected for the effect of the lagged differences of the $\mathbf{x}_t$ process. The method for extracting the λ's is described in Johansen (1988) and Johansen and Juselius (1991).

B. Data Sources and Definitions[23]

The sample period is from 1960–1996 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 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 an increase in q is a real effective appreciation. The weights are based on 1988–1990 trade data and include third–country market effects. The methodology is described in Zanello and Desruelle (1997). This variable is expressed in logs:***lq***
Source: IMF Information Notice System.

terms of trade: *tot*

The terms of trade for each country is defined as the ratio of the domestic export unit value to the import unit value relative to the equivalent effective foreign ratio, where the same trade weights as described above are used to calculate the weighted average or effective terms of trade of the partner G–7 countries. This variable is expressed in logs:***ltot***
Source: IMF *World Economic Outlook* database.

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 equivalent foreign effective (trade-weighted) ratio. 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, expressed as a ratio to GNP.
Source: Masson, Kremers, and Horne (1993) for data from 1960–1990. Data from 1991–1996 obtained from the same publications cited in the source for this variable.

relative stock of government debt: λ

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

This variable is the ratio of domestic government net financial liabilities (gnfl) to nominal GDP relative to the effective (trade-weighted) ratio of G–7 partner countries.
Source: gnfl, *OECD Analytical Database;* GDP, IMF *World Economic Outlook* database.

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:

$$x_t' = [(r_t - r_t^*), ltnt_t, ltot_t, nfa_t, \lambda_t]$$

C. Estimation Results

The Johansen cointegration method used below presupposes that at least some (although not necessarily all) of the variables entering the $\mathbf{x}_t$ vector are nonstationary. 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 cointegration rank (which, as we shall see below, is two for each system). The results are presented in Table 1 and indicate that all of the variables are non-stationary. The only variable which produces an estimated chi–squared statistic close to the 5 percent critical value is the Japanese real interest differential, which is stationary at the one percent level.

Table 1. Multivariate Stationarity Tests

Country	*lq*	*ltot*	*ltnt*	*nfa*	λ	$(r\text{-}r^*)$	x^2 *(5)*
U.S.	17.09	24.85	18.81	25.94	18.81	16.24	11.07
Germany	18.36	26.26	14.56	24.21	30.91	19.02	11.07
Japan	28.34	25.67	13.44	35.90	32.31	12.16	11.07

1. The United States dollar

We consider, first, the results for the U.S. dollar. In order to implement the Johansen method we have to specify a VAR system. Using the Pantula principle of jointly testing the rank and deterministic specification, we constrained the constant to lie in the long–run relationship and we set p, the lag length, to two years, as we are using annual data. That the estimated VAR is well specified is confirmed in Table 1, where we report a set of residual diagnostics from our estimated equations.

Table 2. Multivariate Diagnostics – U.S. Dollar			
LB (8)	**LM (1)**	**LM (4)**	**NM (12)**
268.25	28.46	34.57	14.20
(0.10)	(0.81)	(0.54)	(0.29)

The LB, LM and NM statistics are multivariate residual diagnostic tests: LB(8) is Hoskings multivariate Ljung-Box statistic, LM(1 and 4) are multivariate Godfrey (1988) LM-type statistics for first–and fourth–order autocorrelation, and NM(12) is a Doornik and Hansen (1994) multivariate normality test. Numbers in parenthesis are p-values and indicate normally distributed errors and the absence of serial correlation.

The estimated values of the Trace statistics are reported in Table 3.

Table 3. Significance of Cointegrating Vectors—U.S. dollar		
H_0:r	**Trace**	**Trace 99**
0	127.79	111.01
1	85.08	84.44
2	52.64	60.16
3	30.68	41.07
4	13.72	24.60
5	6.47	12.97

On the basis of the Trace test statistic and a 99 per cent significance level, there would appear to be up to two cointegrating vectors. As is now well known, the existence of multiple cointegrating vectors complicates the interpretation of equilibrium. Indeed, this is also the case in a single cointegrating vector context where it is unclear if the vector truly represents a structural relationship or a reduced form. In attempting to partition the two cointegrating vectors, we started by restricting the first vector to contain only elements driving $\hat{q}$, while the second vector contained the remaining elements from Z_2[24] However, restricting the cointegrating space in this way was statistically rejected and the source of this rejection was traced to constraining the risk premium to lie in the second vector. Including the time–varying risk premium in the first vector and defining the second vector to be the real interest differential, adjusted for a constant risk premium, was not statistically rejected and produced the following equilibrium relationships (with standard errors in parenthesis):

[24]For and interpretation of multiple cointegrating vectors in an exchange rate context, see La Cour and MacDonald (1997).

$$lq_t = \underset{(0.04)}{0.084} ltot + \underset{(0.33)}{2.7011} ltnt + \underset{(0.10)}{1.237} \text{nfa} - \underset{(0.01)}{0.0004} \lambda + \underset{(0.014)}{4.595} \tag{23}$$

$$r_t - r_t^* = \underset{(0.003)}{-0.014} \tag{24}$$

We note that all of the coefficients are correctly signed and all, apart from that on the relative debt term, which is our proxy for the time–varying risk premium, are statistically significant[25]. The $\chi(4)$ test of whether our chosen restricted vectors span the cointegrating space has an estimated value of 5.49 and a marginal significance level of 0.24; the restrictions are therefore easily satisfied at standard levels of significance. We interpret this finding as indicating that the risk premium should be modelled as a component of $\hat{q}$. The alpha matrix and associated t - ratios corresponding to equations (23) and (24) are reported in Table 4.

Table 4. Alpha Adjustment Matrix

Variable	alpha1	alpha2	t-alpha1	t-alpha2
Δlq	-0.374	-0.434	-2.262	-0.648
$\Delta ltot$	0.075	-0.714	0.182	-0.428
$\Delta ltnt$	0.205	-0.942	4.965	-5.641
Δr	-0.067	-0.021	-2.052	-0.159
$\Delta\lambda$	0.238	-0.934	4.370	-4.229
Δnfa	-0.077	0.314	-1.638	-1.654

The estimated values of the alpha coefficients seem to support our choice of the restricted cointegrating space, in the sense that the real exchange rate adjusts negatively to disequilibrium in the first cointegrating vector and this adjustment dominates the

[25]As an alternative proxy for the relative price of non–traded to traded goods, *tnt*, we used instead relative productivity (manufacturing output per hour) in the same specification. However, the empirical results were inferior to those for the U.S. dollar above as well as those presented below for the Japanese yen. As these results were not encouraging for these two countries, we did not proceed with the estimation using this variable for Germany. As we are implicitly assuming that both demand and supply factors can affect the relative price of nontraded to traded goods, rather than just supply factors aloe via the Balassa-Samuelson effect, the use of the relative price proxy may, in fact, be more appropriate than relative productivity.

comparable adjustment in the other equations. The t-ratio on the exchange rate error correction is also significant in the dynamic real interest rate equation. The most significant adjustments to real interest rate disequilibria occur in the dynamic risk premium and relative nontraded-traded goods price ratio equations.

In Figure 1 we report the estimated BEER calculated from (23) and (24) along with the actual real exchange rate in the sample 1960–1996.[26] It is noteworthy that the fundamentals can account for most of the movement in the dollar. In terms of the framework described above, Figure 1 shows the current equilibrium rate. Perhaps the most striking feature of the figure is the extent to which the dollar was misaligned in the period 1980-86, i.e., where the actual exchange rate exceeded the estimated equilibrium rate to a significant extent. It is useful to note that this finding is common to many examples of BEERs, for example, Faruqee (1994), Kramer (1996), MacDonald (1997a) and Stein (1995). Equation (6) shows that what we call a "current" misalignment reflects either some transitory factor or a random error term, e.g., a speculative bubble based, perhaps, on extrapolative expectations. The fitted values shown in Figure 1 are from the sum of the two cointegrating vectors given by equations (23) and (24), not from the estimated VAR that includes the short-run dynamics. Thus these fitted values are "equilibrium" levels in that they reflect the full adjustment of the real exchange rate to the set of identified fundamental economic variables, and the estimated level of the exchange rate is therefore consistent in a well-defined statistical sense with economic fundamentals. The unexplained movements in the actual exchange rates are a measure of exchange rate misalignment because they reflect exchange rate behavior that cannot be accounted for by fundamentals, but rather by unobserved transitory and random factors.

It could be argued that the measured "misalignment" in Figure 1 is a manifestation of specification error and the failure to account for all relevant economic fundamentals. While this possibility cannot be ruled out in principle, we would note that the diagnostics for the residuals from the underlying report VAR reported in Table 2 indicate normally distributed errors and an absence of serial correlation. The finding that the residuals are white noise suggests that we have not left out economic factors that affect the real exchange rate in a systematic fashion.This evidence is consistent with our interpretation of the measured misalignment as reflecting transitory and random factors that push the actual exchange rate temporarily away from the level given by the determinants in the cointegrating vectors.

As discussed above, the U.S. BEER plotted in Figure 1 reflects a *behavioral* equilibrium. However, as noted in the comparison of BEERs and FEERs, the economic

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[26]Our estimate of the BEER are calculated by setting all of the dynamics equal to zero, summing the two cointegrating vectors, and solving for the real exchange rate. This method for calculating the BEER involves the assumption that the ratio of the alpha terms on the second vector is equal to unity. As the ratio of the estimated alphas in the case of the U.S. dollar is indeed very close to one, this assumption generates a calculated BEER that is observationally equivalent to one based on actual alphas.

FIGURE 1. **US BEER**

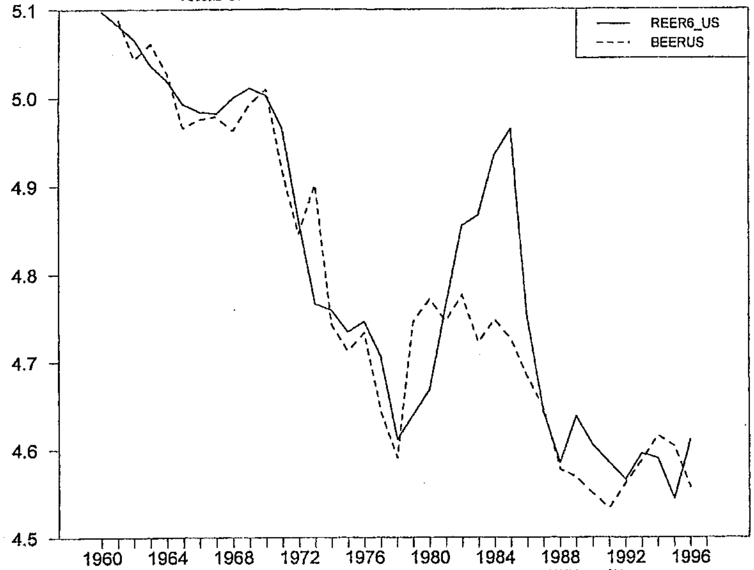


FIGURE 2. **US BEER, HP Filter Adjusted**

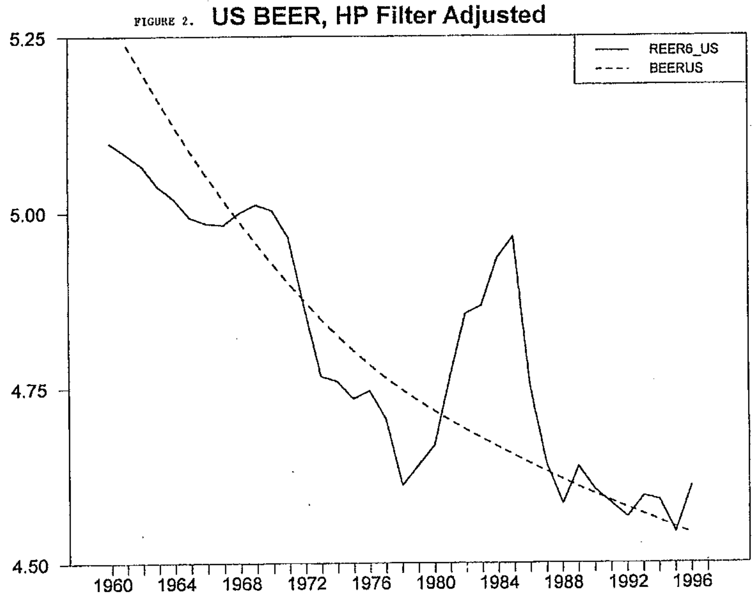
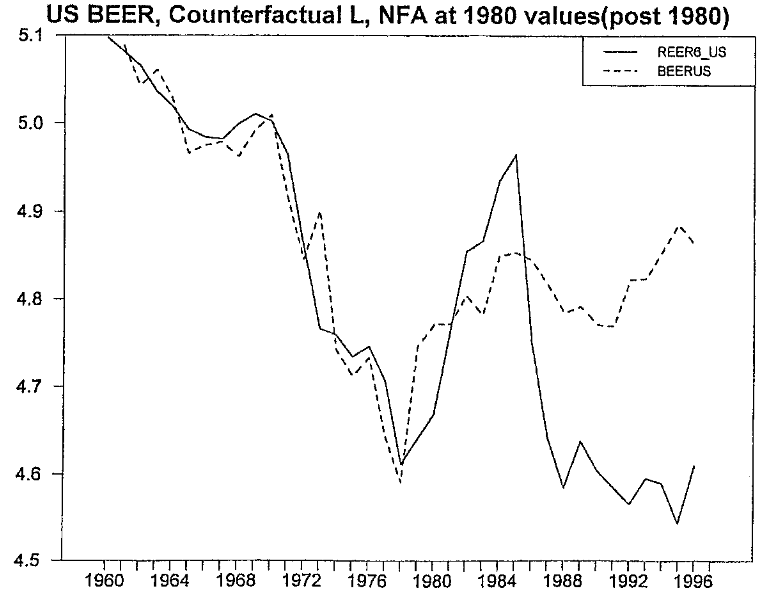


FIGURE 3.

US BEER, Counterfactual L, NFA at 1980 values(post 1980)



fundamentals may themselves not be at their long-run or "equilibrium" values. In particular, the FEER approach calibrates the economic fundamentals at values that correspond to internal and external balance. The BEER approach can also be implemented in the same manner by calibrating the variables in the cointegrating vectors at particular values, as shown in equation (9) above. This provides a measure of *total* misalignment, where the difference between the actual and fitted values incorporates the effects of departures of the economic fundamentals from their long-run, sustainable, or desired levels.

A particular example of such a calculated BEER is shown in Figure 2, where the economic fundamentals have been smoothed using the Hodrick-Prescott filter. Note that this is a mechanical procedure that does not correspond to the notion of internal balance where the economy is operating at potential output with low inflation[27]. Rather, this procedure calculates the BEER simply using the smoothed series for the explanatory variables. It shows that the long-run trend behavior of the dollar was characterized by a real depreciation over this period and that the sharp appreciation and subsequent depreciation from 1980 to 1987 was a major departure from this trend.

It is also instructive to examine what would have happened to the path of the real value of the U.S. dollar if the large deterioration in the U.S. fiscal deficit and U.S. net foreign assets did not take place following 1980. This is done by holding the relative debt stock variable and NFA constant at their 1980 values from 1981-1996. This kind of counterfactual is in the spirit of a FEER–type approach in the sense that the NFA position is set at a "sustainable" level. The effect is shown in Figure 3, most of which reflects the influence of NFA, as the coefficient of the relative debt stock is extremely small. As NFA/GDP declined from 13 ½ percent in 1980 to -11 percent in 1996, Figure 3 shows clearly that the real depreciation of the dollar over this period can be seen as an equilibrating response to the deterioration in the net foreign asset position of the United States.[28]

2. The German mark

The VAR specification for the German system was the same as the U.S. based system, namely, two lags and the constant restricted to the cointegrating space. The residual diagnostics for the German system are reported in Table 5 and again indicate normal errors and an absence of serial correlation.

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[27]In constructing this counterfactual simulation we assume that the estimated cointegrated vectors are immune form the Lucas critique.

[28]It should be noted that this counterfactual experiment is indeed a partial equilibrium calculation, as other explanatory variables, such as $r-r^*$, would presumably also be affected if NFA were unchanged. This counterfactual calculation and those described below should therefore be regarded as illustrative of the effects of particular variables on the real exchange rate, rather than as full general equilibrium experiments in which all endogenous variables change.

Table 5. Multivariate Diagnostics – German Mark

LB (8)	LM(1)	LM(4)	NM(12)
273.19	36.61	26.56	11.69
(0.07)	(0.44)	(0.87)	(0.47)

The estimated values of the Trace statistics for the German system are reported in Table 6.

Table 6. Significance of Cointegrating Vectors – German Mark

H_0:r	Trace	Trace95
0	135.22	111.01
1	94.87	84.45
2	62.15	60.16
3	36.19	41.07
4	13.40	24.60
5	3.58	12.97

The Trace tests indicate that there may be up to three significant vectors in the German system, although a plot of the third vector, which is only marginally significant, suggested some evidence of nonstationarity. We therefore concentrate on the first two significant cointegrating vectors and impose the same structure as used in our U.S. system. The two cointegrating vectors are:

$$lq_t = \underset{(0.15)}{0.062 ltot} + \underset{(0.45)}{5.215 ltnt} + \underset{(0.35)}{2.293 nfa} + \underset{(0.61)}{0.005\lambda} + \underset{(0.08)}{4.436} \tag{25}$$

$$r_t - r_t^* = \underset{(0.09)}{-0.025} \tag{26}$$

All of the variables enter with the correct sign apart from the time–varying risk premium term, which is statistically insignificant. The terms of trade variable is insignificant, while the Balassa-Samuelson proxy and *nfa* are both highly significant. The $\chi(4)$ test that our chosen restricted vectors span the cointegrating space has an estimated value of 10.21 and a marginal significance level of 0.04; the restrictions are therefore on the borderline of acceptance. The alpha matrix associated with equations (25) and (26) is reported in Table 7.

Table 7. Alpha Adjustment Matrix – German Mark

Variable	alpha1	alpha2	t-alpha1	t-alpha2
Δlq	-0.040	-0.102	-0.410	-0.154
$\Delta ltot$	0.220	1.945	1.138	1.498
$\Delta ltnt$	0.094	0.578	2.533	2.311
Δr	-0.064	-0.311	-2.689	-1.929
$\Delta\lambda$	0.306	3.197	2.578	4.008
Δnfa	0.069	0.415	-1.638	-1.654

As in the case of the U.S. system, the real exchange rate adjusts to disequilibria from both of the error correction terms and also the real interest differential adjusts to these disequilibria as well.

The BEER implied by (25) and (26) is plotted in Figure 4. We note that for the mark, in contrast the dollar, there are prolonged periods when the actual rate diverges from the BEER. For example, from 1973 through to 1979 the mark appears undervalued on the basis of our measure, while from 1991 to 1996 it appears overvalued. This could reflect the impact of German unification in appreciating the German mark, an effect which may not be captured by our model. However, Figure 5 shows that using smoothed values of the fundamentals obtained from the H–P filter, the German mark may have been overvalued in the period 1973–1979, perhaps indicating some overshooting in the years immediately following the breakdown of the Bretton Woods system. Figure 5 also indicates that using smoothed values of the fundamentals does not reproduce the appreciation of the mark from 1991-1996, which, as noted above, may be due to the impact of German unification. Hence it would seem implausible to identify the total misalignment in 1996, i.e., the gap between the actual and calculated values in Figure 5, as a misalignment that will generate a self–connecting depreciation.

In the case of Germany, a relevant counterfactual is to hold the relative debt stock and NFA fixed at their 1990 values to illustrate the effect of German unification. As shown in Figure 6, the model suggests that the mark would have appreciated strongly in the absence of unification because there would have been no deterioration in NFA. This is counter to the Mundell-Fleming interpretation of the appreciation which in fact took place, which stresses the higher interest rates associated with expansionary fiscal and contractionary monetary policies, rather than the stock equilibrium that is a feature of the model here.

3. The Japanese yen

The residual diagnostics for the Japanese VAR system (which, as in the U.S. and German cases, contains two lags and a restricted constant) are reported in Table 8 and they indicate normal errors and the absence of serial correlation.

FIGURE 4. German BEER

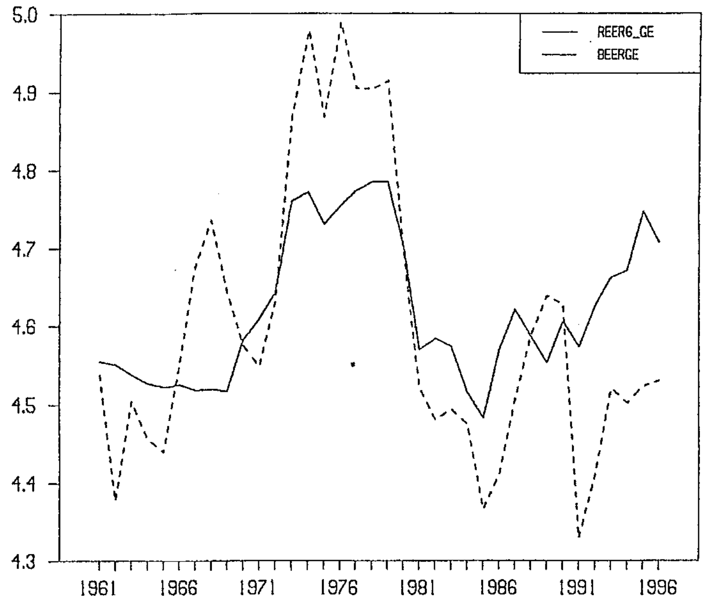

FIGURE 5. German BEER, HP Filter

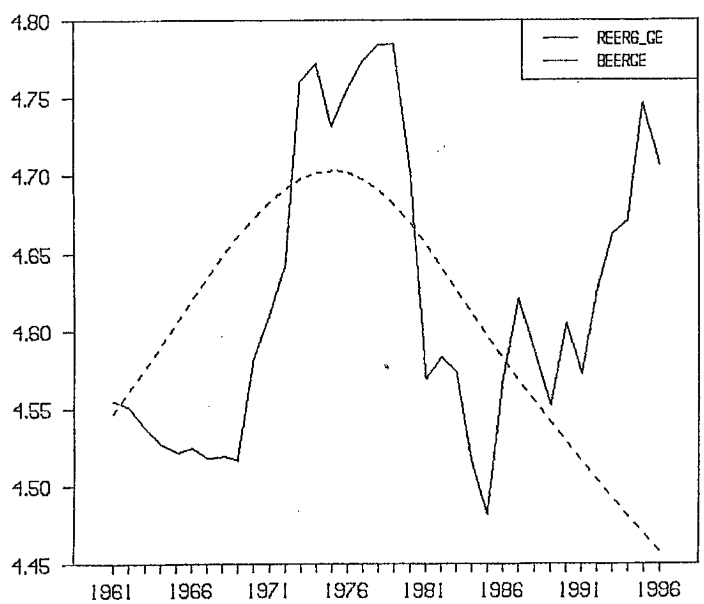

FIGURE 6. German BEER, L and NFA set at 1990 values (Post 1990)

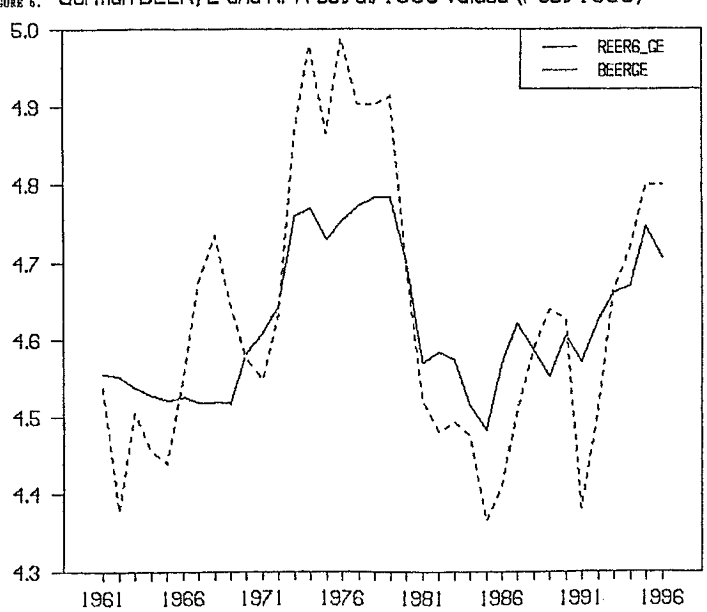

Table 8. Multivariate Diagnostics - Japanese Yen

LB (8)	LM(1)	LM(4)	NM(12)
236.92	26.09	32.33	12.96
(0.54)	(0.89)	(0.64)	(0.37)

The estimated values of the Trace statistics for the Japanese system are reported in Table 9.

Table 9. Significance of Cointegrating Vectors – Japanese Yen

H_0:r	Trace	Trace95
0	158.82	111.07
1	101.22	84.44
2	60.15	60.16
3	30.85	41.07
4	14.14	24.60
5	3.68	12.97

The statistics in Table 8 indicate that there are two significant cointegrating vectors. Imposing the same structure as used in our U.S. and German systems, we obtained the following two cointegrating vectors:

$$lq_t = \underset{(0.05)}{0.224} ltot + \underset{(0.27)}{1.876} ltnt + \underset{(0.79)}{1.596} nfa + \underset{(0.06)}{0.128} \lambda + \underset{(0.01)}{4.436} \tag{27}$$

$$r_t - r_t^* = \underset{(0.04)}{-0.025} \tag{28}$$

All of the variables enter with the correct sign apart from the time–varying risk premium term, and all are statistically significant. The magnitude of both the terms of trade and risk premium terms is greater here than in the case of the U.S. and Germany. The $\chi(4)$ test that our chosen restricted vectors span the cointegrating space has an estimated value of 10.80 and a marginal significance level of 0.03; as in the German case, the restrictions are on the borderline of acceptance. The alpha matrix associated with equations (27) and (28) is reported in Table 10.

Table 10. Alpha Adjustment Matrix – Japanese Yen

Variable	alpha1	alpha2	t-alpha1	t-alpha2
Δlq	-0.004	0.286	-0.043	0.371
$\Delta ltot$	-0.202	0.946	-0.759	0.439
$\Delta ltnt$	0.194	-0.687	2.533	2.311
Δr	-0.069	-0.385	-3.508	-2.414
$\Delta\lambda$	0.073	-1.293	1.602	-3.487
Δnfa	0.003	0.028	0.196	0.199

Again as in the other two systems, the real exchange rate adjusts to disequilibria from the first error correction term (although not the second) and the real interest differential adjusts to both disequilibria.

The BEER implied by (27) and (28) is plotted in Figure 7. The trend behaviour of the estimated BEER is similar to the trend in the actual exchange rate, but from 1960 to 1980 the fundamentals imply an equilibrium exchange rate that lies consistently below the actual rate. The HP filter applied to the fundamentals basically converts the BEER into a smooth upward trend, as shown in Figure 8, which again suggests that the yen was persistently overvalued relative to the trend values of the fundamentals over the first 20 years of the sample period. Finally, Figure 9 shows that holding the relative stock of debt and NFA at their 1986 values, i.e., before the period when there a substantial decline in the relative stock of debt, λ, and a regular increase in NFA, shows little impact on the exchange rate. The reason would appear to be offsetting effects; because λ has a large positive sign in the Japanese equation, holding λ fixed raises the real exchange, whereas holding NFA fixed at its 1986 value results in a real depreciation. Therefore the counterfactual value of the BEER is very close to the estimated value.

4. A Comparison of BEERs and FEERs

It is useful to compare the estimated BEERs above with estimates obtained using the FEER approach. This can be done by taking the FEERs provided in Table 14 in Williamson (1994) which are for 1990:Q1. The estimated BEERs are for the entire year 1990. For both sets of estimates the calculated overvaluation (+) or undervaluation (-1) was computed as the actual exchange rate minus the FEER or BEER as a percent of the actual exchange rate. The Williamson estimates are compared with three different BEER measures of misalignment: the current misalignment, *cm,* the total misalignment, *tm,* where the actual values of the fundamentals are replaced with their Hodrick-Prescott filtered values, and the BEERs generated by the counterfactual exercise. These estimates are reported in Table 11 below.

FIGURE 7. Japan BEER

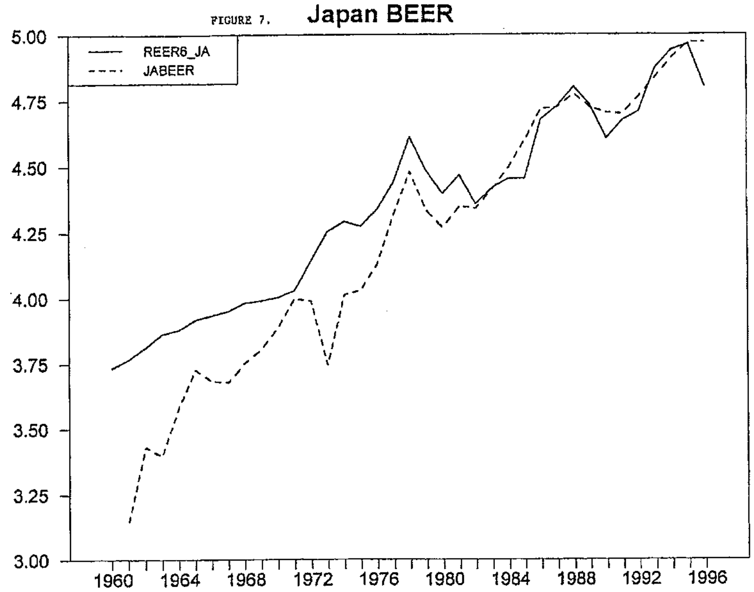

FIGURE 8. Japan BEER, HP Filter

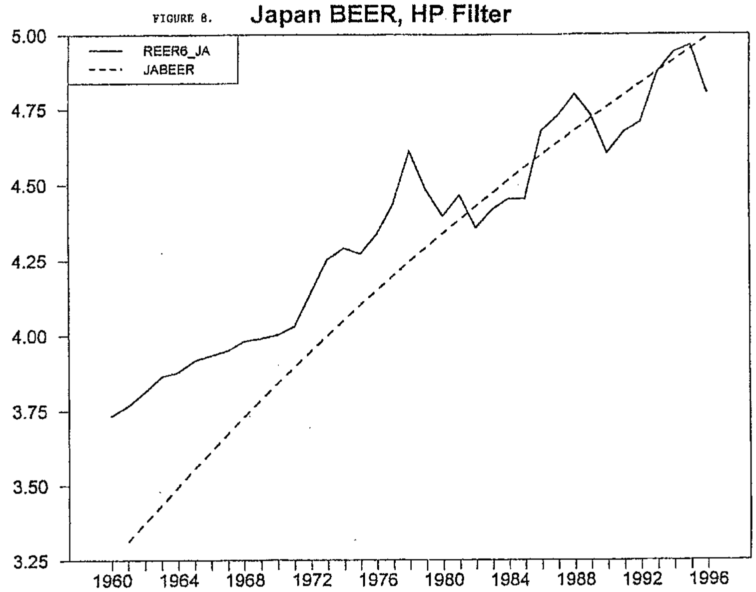

FIGURE 9. Japan BEER, L and NFA at 1986 Values (Post 1986)

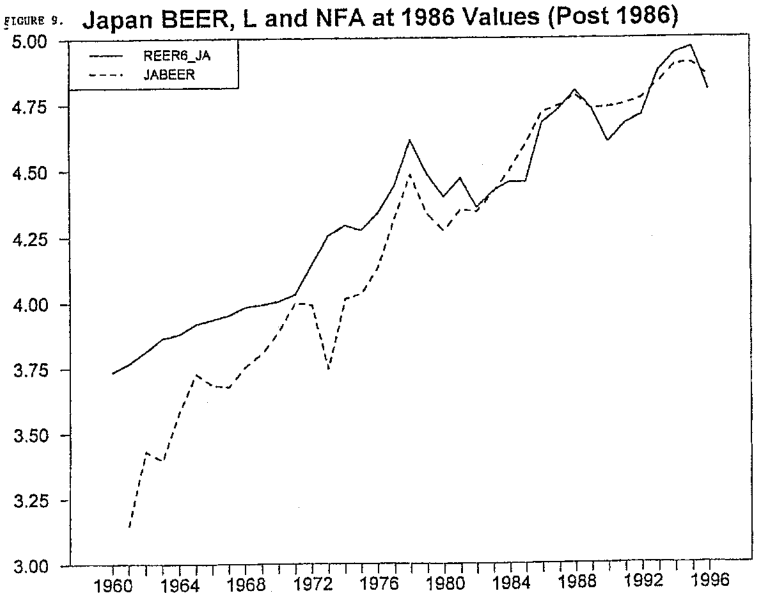

Table 11. Comparison of Williamson's FEERs with Estimated BEERs
(+ = overvaluation)

	U.S. Dollar	DM	Yen
FEER	9	-12	-21
BEER			
cm	7	-2	-10
tm	-1	8	-17
counterfactual	-18	-2	-14

For the U.S. dollar, the FEER and the BEER estimate using the current values of the fundamentals, *cm,* are very close, whereas the second BEER estimate shows that the actual real exchange rate was about in line with the H-P values of the fundamentals, as can be seen in Figure 2. It is perhaps remarkable that these two techniques give estimates of misalignments that are not that different. By contrast, the estimate of an undervaluation of 18 percent with the counterfactual is not really comparable to the other two BEERs and the FEER estimate, as it simply shows that the dollar would have been considerably stronger, using the BEER analysis, if the U.S net foreign asset position had not deteriorated since 1980.

For the DM, there are really only two comparisons, as the current misalignment and that generated by the counterfactual are the same, which reflects the fact that the latter began in 1990. These two BEER estimates indicate a small undervaluation, compared with the 12 percent undervaluation generated by the FEER. As noted above, there appear to be difficulties with the German estimates, and Figure 4 shows that if 1991, for example, had been used as the year for the comparison, the estimates using the two techniques could have been much different. In addition, Figure 5 shows that the BEER estimate of an *over*valuation of 8 percent in 1990 reflects a significant trend decline in the BEER that does not appear particularly plausible. Thus the comparison of the estimated BEERs with the FEER for the DM are not very revealing.

By constrast, the BEER estimates for the yen appear to be plausible, particularly over the second half of the sample. It is therefore reassuring that both techniques indicate considerable undervaluation of the yen in 1990. The similarity of the estimates appears to reflect the fact that the actual exchange value of the yen was relatively low. Consequently, as the BEER analysis shows a strong upward trend in the estimated equilibrium value of the yen, it is perhaps not surprising that the actual value is below the estimated equilibrium value. By the same token, as the estimated FEER is designed to reduce the Japanese current account surplus by ½ percent of GDP, the relatively low level of the yen in 1990 is found to be below the estimated equilibrium value.

Finally, it is useful to look again at the U.S. dollar and compare BEER estimates for 1984 with Williamson's FEER estimate for 1984:Q4, which is again taken fom Williamson (1994), Table 14. The latter shows a dollar overvaluation of 27 percent, which is very close to the *cm* estimate of 35 percent overvaluation. The estimated overvaluation in 1984 of the dollar using the BEER approach is clearly shown in Figures 1 and 2. Thus it is reassuring that the BEER technique supports, as does the FEER approach, the widespread view that the U.S. dollar was substantially overvalued in the first half of the 1990s.

The above–noted FEER comparisons are *ex post*. However, the FEER approach is often motivated in an *ex ante* sense; that is to say, it is used to say something about where the equilibrium exchange rate is likely to be at some point in the future. Is has been demonstrated in a number of papers (see, for example, MacDonald (1997a) and MacDonald and Marsh (1997)) that the kind of model used in this paper has good (in the sense of outperforming a martingale process) out–of–sample forecasting properties. We believe, therefore, that the model, along with some appropriate counterfactual assumptions, could also be used to calculate *ex ante* equilibrium rates in addition to the *ex post* rates presented above. Indeed, we believe that these rates are likely to be more appropriate than *ex ante* FEER calculations since they are based on a model which is known to produce well–founded future projections.

IV. CONCLUDING REMARKS

The reduced-form exchange rate equations described in the preceding section provide illustrative examples of BEERs. To the extent that this particular BEER can explain movements in the actual real effective exchange rate, q, the latter can be said to be in equilibrium in a behavioral sense, i.e., it reflects the economic fundamentals that have been found to be related to q in a well-defined statistical sense. The economic fundamentals can be viewed as the factors determining the exchange rate, and the economic behavior generating the observed outcome is consistent with the theory underpinning the model. The systematic relationship between q and its economic determinants is the basic equilibrium concept underlying the notion of the BEER.

The methodology of the BEER described above implies that a departure of the actual real exchange rate from the estimated BEER will not be sustainable, as the cointegrating vector of variables operates as an attractor that eventually brings the actual exchange rate back into line with the value consistent with the fundamentals. This equilibrating mechanism is seen, for example, in the adjustment of q to NFA: an increase in NFA generates a rise in the real exchange rate which will tend to counteract the change in net foreign assets by means of a deterioration in the trade balance, and vice versa for a decline in NFA. The overall mechanism of the return to equilibrium of the actual exchange rate is nicely illustrated by the appreciation of the U.S. dollar between 1980 and 1985. The model can explain only part of this appreciation, and the unexplained residual can be said to reflect a misalignment in that it does not reflect identifiable economic factors incorporated into the model, but rather unobserved transitory and random factors, as shown in equation (6) above. Thus, the highly appreciated value of the dollar in 1984 - 1986 can be said to be a disequilibrium phenomenon because the actual exchange rate eventually returned to the estimated BEER, which is generally close to the level of the actual exchange rate over the period 1987 - 1996.

This behavioral approach to identifying misalignments implies that the level of q is sustainable as long as the values of the economic fundamentals are also sustainable. But the method by itself does not identify which values of the variables, such as NFA and interest rates, are sustainable and likely to persist on their own accord. More specifically, the BEER approach does not directly involve considerations of internal and external balance, which are identified in the FEER approach as sustainable positions of macroeconomic equilibrium. However, as noted above, in principle the values of the fundamentals can be calibrated at those corresponding to full employment and low inflation, and thus made to be consistent with internal balance. By contrast, there is no obvious comparable calibration for external balance. This arises for two reasons. First, the model assumes uncovered interest parity and therefore there are no readily identifiable constraints on the financing of an external imbalance. Second, the model incorporates adjustment mechanisms generating equilibrating changes in the real exchange rate in response to changes in government debt levels and net foreign assets, so that external equilibrium is attained, at least in the long run.

Finally, in terms of our counterfactual experiments, the estimated BEERs were demonstrated to have sensible properties in that they produced counterfactuals which are in accordance with our economic priors. The particular examples used, which focused on NFA and the risk premium, were purely for illustrative purposes and are not intended to be the final word on the usefulness of the BEER approach for assessment purposes. Indeed, we believe that the model has a number of desirable properties in this regard. For example, the particular model presented in this paper is stock-flow consistent and is estimated using a systems estimator. It would therefore be feasible to apply the model in a rather more sophisticated manner than that employed here, depending on the particular requirements of the user. In particular, auxiliary equations linking stocks of government debt to fiscal imbalances, and fiscal imbalances to current account positions could easily be introduced and these, combined with equations tying down the sustainability of the flows (in terms of internal-external balance requirements) could produce a highly tractable system which had the normative elements of the FEER-based approach. However, we leave this particular application of the BEER on the agenda for future research.

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