

Long-run equilibrium real exchange rates and oil prices

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Abstract

Using cointegration and causality tests, this paper demonstrates that the nonstationary behavior of US dollar real exchange rates, over the post-Bretton Woods era, is due to the nonstationary behavior of real oil prices. © 1998 Elsevier Science S.A.

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1. Introduction

There is a growing consensus that US dollar real exchange rates are nonstationary over the post-Bretton Woods sample period. There are two explanations for this nonstationarity. The first is the lack of power of standard unit root tests. Researchers using long data samples tend to reject the null of nonstationarity, suggesting that a sample of roughly twenty-one years is not long enough. An alternative explanation is that there were more real shocks over this period, and that the long samples are dominated by relatively more tranquil periods. Under this hypothesis, there was something different about this period, which made real exchange rate behavior appear nonstationary. The purpose of this paper is to investigate this hypothesis by focusing on oil prices as an important source of post-Bretton Woods real shocks.

Since real exchange rates are computed with price indices, comprising different commodities with different weights, real exchange rates are relative prices. Therefore, real shocks can have long-run effects on real exchange rates even if all markets function perfectly in the long run. This study focuses on real exchange rates measured with producer price indices. Since countries differ in the extent to which oil is an output included in the producer price index, nonstationary oil price changes should be reflected in nonstationary real exchange rate changes. In particular, when the relative price of oil increases, the relative price of the output bundle of commodities of an oil producing country should rise, compared with that of non-oil producing countries. This creates an increase in the oil producer's real exchange rate.¹

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¹Amano and van Norden (1995) focus on the effect of oil prices on a country's terms of trade.

There is also considerable empirical evidence on the importance of oil price changes in affecting relative prices. Examples include: Bomberger and Makinen (1993); Burbidge and Harrison (1984); Corbae and Ouliaris (1988); Zhou (1995); Amano and van Norden (1995) and Chinn and Johnston (1996).² Additionally, real oil prices appear nonstationary over the post-Bretton Woods sample period, and stationary over longer sample periods.³ If oil prices do have long-run effects on real US dollar exchange rates, then the fact that oil prices and real exchange rates appear stationary over long samples and nonstationary in the post-Bretton Woods period is consistent.

This paper examines the contribution of real oil price behavior to the nonstationary behavior of monthly real US dollar producer price exchange rates for sixteen OECD countries⁴ over the post-Bretton Woods period. We show that most of these real exchange rates and real oil prices are cointegrated with the direction of causality running from real oil prices to real exchange rates. Therefore, oil price behavior appears to be responsible for the nonstationary behavior of US dollar real exchange rates over the post-Bretton Woods period.

2. Empirical evidence

2.1. Data

The data set contains real exchange rates for 16 OECD countries and for the real price of oil. Data are from International Financial Statistics and are monthly from 1973:01–1996:02 for all countries except Italy and Switzerland, where samples end at 1993:11, 1993:06, and Belgium where the sample is 1980:01–1996:03. The exchange rate is defined as the foreign currency price of the US dollar, implying that the dollar appreciates as the exchange rate rises. Real bilateral exchange rates are constructed using producer price indices. The United Arab Emirates price of oil, quoted in US dollars, is chosen as representative of the general movement in oil prices over the period. To obtain the real oil price, relevant to each country, the US dollar price of oil was converted to domestic prices using the US dollar exchange rate, and then deflated by the domestic producer price index. All data are converted to natural logarithms. Prior to testing for cointegration, all real exchange rate and real oil price series are shown to be integrated of order one, using conventional augmented Dickey–Fuller tests.⁵

²It is not obvious that a panel approach, as in Chinn and Johnston (1996), should imply cointegration between real exchange rates and oil prices since an oil price increase should have different effects in different countries.

³Pindyck and Rubinfeld (1991) p. 463 cite evidence that real oil prices were stationary over the horizon 1870–1987.

⁴Omissions include France and New Zealand. France experiences a break in the method of calculation of its producer price index series, making this series inappropriate for this purpose. New Zealand does not have monthly data.

⁵Results are available from the authors upon request. Also, given the measure of the real oil price, it is necessary to rule out a special case. If the cointegrating vector were $[1, 1]$, then cointegration would imply stationarity of the real US dollar price of oil, and would yield no inferences on the determinants of the nonstationary behavior of real exchange rates. This case can always be ruled out. Dickey–Fuller tests indicate nonstationarity of the real US dollar oil price, and the second element of the cointegrating vector is always less than .5, with the first element normalized to unity.

2.2. Engel–Granger cointegration tests

The Engel–Granger two step procedure is the simplest cointegration test for a bivariate model. The first step is a static OLS regression. The second is a test for stationarity of the residuals, using a Dickey–Fuller test, with the critical values adjusted to account for the fact that the cointegrating coefficients have been estimated. For consistency of the parameter estimates, the right hand side variable should be weakly exogenous with respect to the cointegrating parameters. We assume that the real oil price is weakly exogenous and test for this subsequently. Letting e_t be the real exchange rate, and letting p_t be the real price of oil, the cointegrating regression can be expressed as:

$$e_t = \beta_0 + \beta_1 p_t + \epsilon_t. \quad (1)$$

Augmented Dickey–Fuller tests for stationarity of the residual from this regression for the sixteen US dollar exchange rates are contained in Table 1. The lag lengths for each test are chosen by beginning with 25 lags and using F -tests to eliminate the most distant lags.⁶

Critical values are taken from MacKinnon (1991). The null of no cointegration can be rejected at the 10% level for thirteen of the sixteen real exchange rates, and at the 5% level for three of the real exchange rates. Therefore, for all but three of the real exchange rates, there is evidence that real

Table 1

Bivariate cointegration tests between real exchange rate and real price of oil

Country	Selected lags	Test statistic
Australia	0	−3.069*
Austria	11	−3.414**
Belgium	6	−3.244*
Canada	11	−2.782
Denmark	11	−3.286*
Finland	11	−3.490**
Germany	11	−3.515**
Ireland	13	−2.847
Italy	11	−3.241*
Japan	11	−3.339*
Netherlands	11	−3.283*
Norway	11	−3.303*
Spain	2	−2.723
Sweden	11	−3.115*
Switzerland	11	−3.263*
United Kingdom	11	−3.064*

Critical values: −3.36 (5 percent level), −3.06 (10 percent level).

*denotes significance at 10 percent level,

** at 5 percent level. Selected lag lengths are according to Ng and Perron, 1995.

⁶This method is suggested by Ng and Perron (1995).

exchange rates and real oil prices are cointegrated. The absence of cointegration for Canada, Ireland, and Spain suggests that some factor other than oil prices is responsible for the nonstationary behavior of these real exchange rates.

2.3. Error correction model

To test the direction of causality, it is necessary to specify an error correction model. The error correction model for the two variable system is given by:

$$\Delta e_t = \eta_1 + \sum_{i=1}^{k-1} \gamma_{11i} \Delta e_{t-i} + \sum_{i=1}^{k-1} \gamma_{12i} \Delta p_{t-i} + \alpha_1 (e_t - \beta_0 - \beta_1 p_t), \quad (2)$$

$$\Delta p_t = \eta_2 + \sum_{i=1}^{k-1} \gamma_{21i} \Delta e_{t-i} + \sum_{i=1}^{k-1} \gamma_{22i} \Delta p_{t-i} + \alpha_2 (e_t - \beta_0 - \beta_1 p_t), \quad (3)$$

where β_0 and β_1 are estimated by OLS from Eq. (1), k takes on the same value as before for each country, and η_1 and η_2 are constants.

Johansen (1992) shows that if a variable is weakly exogenous for the purpose of estimating the elements of the cointegrating vector, then the corresponding element of α will be zero. Therefore, weak exogeneity of the real exchange rate (real oil price) can be tested by testing the null that $\alpha_1 = 0$ ($\alpha_2 = 0$). The coefficient has a standard t distribution since all the variables in the regression are stationary. The p values are contained in Table 2. The results show that errors from the cointegrating vector significantly affect the change in the real exchange rate (reject the null that $\alpha_1 = 0$), and that they do not significantly affect the change in the real price of oil (fail to reject the null that $\alpha_2 = 0$).

Table 2
Weak exogeneity tests: p Values

Country	α_1	α_2
Australia	0.001	0.320
Austria	0.005	0.550
Belgium	0.0001	0.244
Canada	0.003	0.748
Denmark	0.005	0.522
Finland	0.002	0.617
Germany	0.005	0.452
Ireland	0.001	0.103
Italy	0.016	0.347
Japan	0.033	0.111
Netherlands	0.007	0.438
Norway	0.005	0.578
Spain	0.018	0.753
Sweden	0.004	0.797
Switzerland	0.004	0.903
United Kingdom	0.031	0.157

Therefore, oil prices are weakly exogenous since they do not respond to errors in the cointegrating vector. Only the real exchange rate adjusts to eliminate errors in the cointegrating vector.⁷

2.4. Long-run equilibrium real exchange rates

Estimates of the cointegrating vector (Eq. (1)) can be used to provide estimates of long-run equilibrium real exchange rates, given real oil prices.⁸ However, although the estimates of β_1 in Eq. (1) are consistent, there is evidence that small sample bias can be significant (Banerjee et al., 1993). This bias can be reduced by estimating β_1 directly in the dynamic error correction model, given by Eq. (2). These estimates are used to graph the long-run equilibrium values for each of the sixteen exchange rates.⁹ In all cases, an increase in the real price of oil appreciates the real US dollar exchange rate. Plots of real exchange rates and of long-run equilibrium real exchange rates are presented for Germany, Japan, and the UK (Figs. 1–3). Other plots are similar and are available from the authors upon request.¹⁰ It is important to recognize that since the exchange rates investigated are all US dollar rates, that these sixteen examples are not independent.

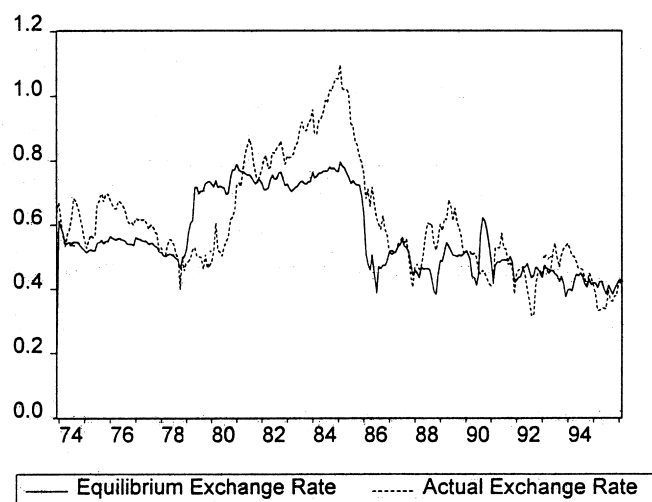


Fig. 1. Equilibrium and actual real exchange rate for Germany (73:12–96:02)

⁷This is an alternative test for cointegration. In the absence of cointegration, both α_1 and α_2 would be zero. Rejection of the null that $\alpha_1 = 0$ in all cases is evidence in favor of cointegration in all cases.

⁸The long-run equilibrium component is very close to Beveridge and Nelson (1981) concept of the permanent component because decomposition of the real oil price into a permanent and a temporary component implies that oil price movements are almost entirely permanent.

⁹Since Eq. (2) does not provide an estimate of the constant, these estimates are taken from Eq. (1). Monte Carlo experiments have focused on the bias in the slope coefficient and have not explicitly addressed bias in the estimate of the constant.

¹⁰Estimates of slope coefficients (β_1) are also available from the authors. For Germany, Japan, and the UK, they are .426, .349, and .389, respectively. The largest is for the Netherlands at .454, and the smallest is for Canada at .105.

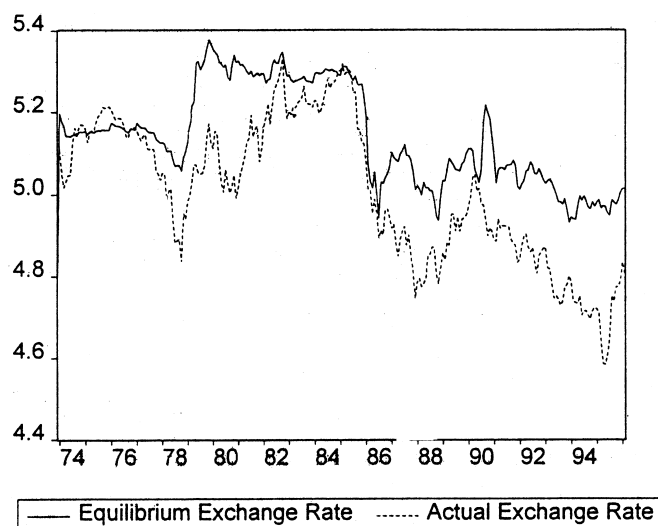


Fig. 2. Equilibrium and actual real exchange rate for Japan (73:12–96:02).

Note how well the overall trends in long-run equilibrium real exchange rates track actual real exchange rates. Yet, there are long swings of the actual real exchange rate about its equilibrium level. The “dazzling dollar” is clearly evident in the late 1970’s and early 1980’s, as the oil price increase in 1978 appreciated the equilibrium value of the dollar against all three currencies. Actual real exchange rates seemed to take time to catch up. For the UK, the real exchange rate initially went in the wrong direction, and for Germany and Japan the real exchange rates eventually overshoot their equilibrium values. This period of dollar strength was followed by a sharp depreciation of both equilibrium and actual real exchange rates with the fall in the price of oil in 1986. After this, equilibrium real exchange rates are more stable. The German actual rate tracks relatively closely, while rates for the UK and Japan continue to show large swings.

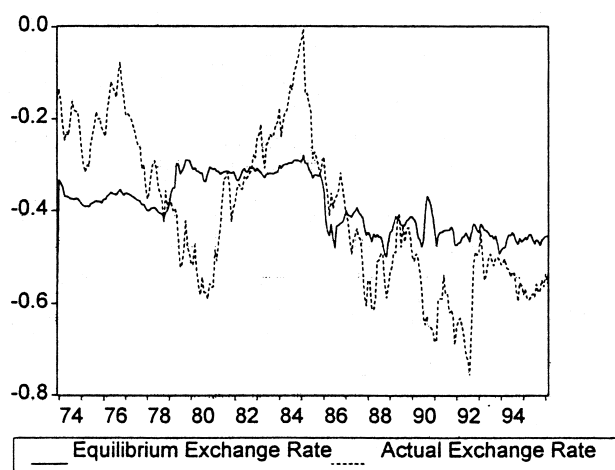


Fig. 3. Equilibrium exchange rate and actual exchange rate for United Kingdom (73:12–96:02).

Engel and Hamilton (1990) studied long swings in the nominal value of the dollar relative to the British pound, the French franc, and the German mark. Given a measure of the equilibrium value of the real exchange rate, we are able to document long swings in real values relative to equilibrium, suggesting misalignment relative to long-run equilibrium values. Additionally, some of this misalignment seems due to the unprecedentedly large oil price increase in 1978. The result that the large oil price decrease in 1986 did not cause similar misalignment could be due to learning how to adjust in a world with large oil shocks.

3. Conclusion

This paper has shown that real US dollar producer price exchange rates for most of the industrial countries and the real price of oil are cointegrated over the post-Bretton Woods period. The results imply that the nonstationarity attributed to US dollar real exchange rates over this period is due to the nonstationarity in the real price of oil. This interpretation is consistent with other papers in which real US dollar exchange rates appear stationary over long samples because oil prices also appear stationary over long samples.

Interpreting the cointegrating vector as the long-run equilibrium real exchange rate reveals that real exchange rates showed relatively long swings away from their equilibrium paths following the 1978 oil price increase. However, the 1986 oil price decrease did not cause similar misalignment in Germany and Japan, suggesting that the world was learning to adapt to a new regime of large oil shocks.

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