DEVIATIONS FROM PURCHASING POWER PARITY : THE AUSTRALIAN CASE

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ABSTRACT

The hypothesis that deviations from PPP follow a random process is tested against two alternatives: that the real exchange rate reverts to a constant equilibrium level (long-run PPP); and that it reverts to an equilibrium level which is itself a function of shifts in commodity prices (long-run PPP doesn't hold, but for reasons that are predictable). The random walk hypothesis cannot be rejected if commodity prices are ignored or if the nominal exchange rate is fixed. It is consistently rejected when commodity prices are included and the exchange rate is floating.

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DEVIATIONS FROM PURCHASING POWER PARITY: THE AUSTRALIAN CASE

Adrian Blundell-Wignall and Marilyn Thomas

1. Introduction

In its simplest form the purchasing power parity (PPP) hypothesis states that, in equilibrium, international differences in the price of any bundle of goods will be constant when expressed in a common currency. That is, the real exchange rate will be constant. In Australia, the real exchange rate, which is the inflation-adjusted nominal exchange rate, has shown an overall downward trend from the early 1970s. There have also been persistent deviations from that trend.

Purchasing power parity is usually associated with the notion of balance of payments equilibrium. In a sustainable long-run equilibrium the current account will be a constant proportion of GDP (for example zero) and, in many economic models, there is a unique value of the real exchange rate associated with that level.

Shocks can drive the real exchange rate away from its equilibrium level. To bring about a return to equilibrium, the nominal exchange rate may adjust, relative price levels may adjust, or there may be some mix of adjustments. Since prices tend to be more "sticky" than nominal exchange rates, the nature of the adjustment process may differ between exchange rate regimes.

Adler and Lehmann (1983) demonstrated that for many countries, over both fixed and flexible exchange rate periods, deviations from PPP evolve in a random fashion.[1] They show that there is no systematic tendency for exchange rates

1. Specifically, they assume that deviations from PPP are a "martingale process". The expected value of the dependent variable at time t is the current value of the dependent variable. A random walk is a particular type of martingale that assumes independent and identically distributed errors. In fact, the econometric techniques employed by Adler and Lehmann make this latter assumption. Consequently, in the rest of this paper we shall refer to their model as the random walk model. Under the random walk hypothesis about deviations from PPP, changes in the real exchange rate should be serially independent.

in "real" (i.e. inflation-adjusted) terms to revert to a constant equilibrium level (PPP) following a deviation from parity. The issue is of interest because of its implications for balance of payments adjustment. If the real exchange rate has no tendency to revert to an equilibrium level, then equally there may be no tendency for the balance of payments to settle down at its equilibrium level.

An alternative explanation of deviations from PPP is that the equilibrium value of the real exchange rate itself might be changing in response to shifts in economic "fundamentals". In particular, a small economy with significant trade in commodities may be subject to sustained changes in its terms of trade consequent upon shifts in commodity prices. Such changes call for sustained shifts in the real exchange rate.

Such shifts in the real exchange are not a purely random process. They are partly predictable, given information about commodity price developments. Shocks may still drive the real exchange rate away from equilibrium. But there may be a tendency to revert back to an equilibrium level modified by any changes in the terms of trade during the intervening period.

In this paper, we derive a model of deviations from PPP that follow a random walk. We test the null hypothesis that the real exchange rate is best modelled as a random walk against two alternative hypotheses about the determinants of movements of the real exchange rate:

- that the real exchange rate tends towards a constant long-run equilibrium level (long-run PPP); and

- that the real exchange rate tends towards an equilibrium level which is itself a function of shifts in the terms of trade. (Long-run PPP does not hold, but for reasons that are at least partly predictable.)

The paper aims to provide evidence on whether movements of Australia's real exchange rate are a purely random process, or whether they are likely to revert to an equilibrium level - constant or variable. A secondary aim is to provide some insight into the role of the exchange rate regime in deciding this issue.

In the second section the behaviour of the real exchange rate in Australia from the early 1970s is examined. We distinguish between the periods before and after December 1983, when the Australian dollar was floated. In the third section a model is derived which is capable of explaining deviations from PPP as a random walk. Two alternative hypotheses against which the random walk model can be tested are considered: one ignores relative commodity price developments, while the other takes them into account. In the fourth section the random walk model is tested against the alternative hypotheses on Australian data, for the real bilateral exchange rate against the U.S. dollar and the real trade-weighted index. Quarterly and monthly observations and various lag lengths and sample periods are employed. In the fifth section some dynamics of commodity price influences on competitiveness under floating exchange rates are explored. Finally, in the sixth section, some concluding remarks are offered.

2. Deviations from PPP in Australia

The purpose of this section is to examine the historical behaviour of the real exchange rate against the U.S. dollar and in trade-weighted terms, from March 1970 to March 1987. This covers the period during which the Bretton Woods System was abandoned and most countries moved to floating exchange rates. During this period, two basic regimes can be identified for Australia:

- managed exchange rates from 1970 Q1 to 1983 Q4[2]; and
- floating exchange rates from 1984 Q1 to 1987 Q1.

Charts 1 and 2 show Australia's real exchange rate against the U.S. dollar and against a trade-weighted basket of currencies. The real exchange rate is the series compiled by Morgan Guaranty. It consists of the nominal exchange rate adjusted for relative movements of the wholesale manufacturing price index between Australia and the foreign country or countries. Each measure is

2. To 1974 Q3 the $A was fixed, but periodically adjusted, against the U.S. dollar; from 1974 Q4 to 1976 Q3, the $A was fixed, but periodically adjusted, against a trade-weighted basket of currencies; and from 1976 Q4 to 1983 Q4 the $A was a crawling peg against the U.S. dollar.

broken down into its component parts, the nominal exchange rate and the ratio of the two price indices. Table 1 shows the mean and variance of the real exchange rate, the relative price level and the nominal exchange rate.

These charts have a number of interesting features.

First, there is a trend decline in the ratio of world prices to domestic prices reflecting Australia's generally higher inflation rate over most of the period. There is a corresponding trend decline in Australia's nominal exchange rate. But the main source of short-term variation in the real exchange rate derives from movements of the nominal exchange rate, over both the managed and floating rate periods. In both periods, the variance of the real exchange rate and the nominal exchange rate exceeds that for relative price levels.

Second, as one would expect, the variance of the nominal exchange rates is higher in the floating rate period compared to the managed exchange rate era. Given the relative stability of price levels, this also implies that the real exchange rate has been more variable under floating rates.

Third, while the general statistical description applies both to the bilateral and effective exchange rate concepts, an important difference between them emerged mainly during the managed exchange rate period. From about 1980 to the end of 1983, Australia's real exchange rate vis-a-vis the trade-weighted basket rose quite sharply, before declining again in the floating exchange rate period. This pattern is not evident for the real exchange rate vis-a-vis the U.S. dollar. This implies that there were substantial increases in the real exchange rate vis-a-vis major trading partners other than the United States - notably Japan and countries of the EEC.

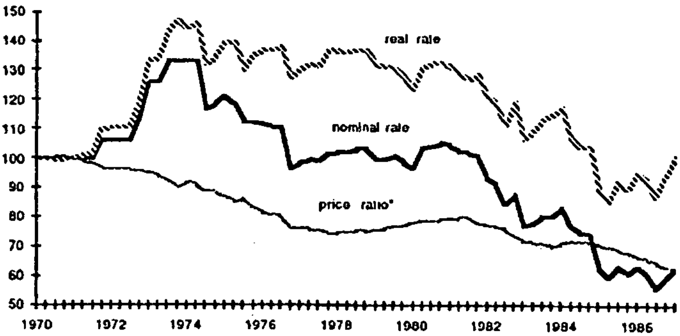
TABLE 1

BASIC STATISTICS ON PERCENTAGE CHANGES IN AUSTRALIA'S REAL EXCHANGE RATE

		1970(2)-1983(4)	1984(1)-1987(1)
Trade-weighted exchange rate			
Nominal rate:			
	mean	-0.004	-0.038
	variance	0.0010	0.0046
Real rate:			
	mean	0.001	-0.021
	variance	0.0008	0.0048
Price ratio:			
	mean	-0.004	-0.017
	variance	0.0002	0.0002
US$/$A exchange rate			
Nominal rate:			
	mean	-0.004	-0.017
	variance	0.0018	0.0047
Real rate:			
	mean	0.003	-0.010
	variance	0.0017	0.0050
Price ratio:			
	mean	-0.007	-0.009
	variance	0.0002	0.0001

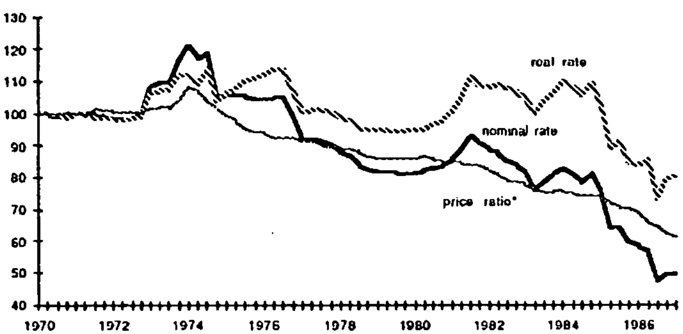
Note: Mean and variance are calculated for the quarterly percentage rate of change for each variable.

CHART 1: Movements in the US$/$A exchange rate



* This is the ratio of wholesale prices in the U.S. to those in Australia.

CHART 2: Movements in the effective exchange rate



*This is the ratio of a weighted average of consumer prices in the U.S., Japan West Germany and the U.K. to those in Australia.

3. The Models

(a) A random walk model of deviations from PPP

In this section we show that it is possible to derive a random walk model of deviations from PPP from conditions of asset market equilibrium, even though the ex-ante expectation is for the constant equilibrium level to prevail. Since Adler and Lehman's finding of widespread support for the random walk hypothesis is so surprising, it is important to illustrate the kind of theoretical assumptions that would justify testing it as a null hypothesis. Alternative hypotheses which suggest that the real exchange rate reverts to an equilibrium level are too well known to require further justification in this paper.

Let

i_t = the nominal interest rate from t to t+1,

π_t^e = expectation of the inflation rate from t to t+1, based on the information available at the end of time t-1,

π_t = actual inflation rate from t to t+1, measured by the wholesale manufacturing price index.,

s_t^e = the expectation of the percentage change in the exchange rate from t to t+1, based on the information available at the end of time t-1,

s_t = actual percentage change in the exchange rate from t to t+1,

I_{t-1} = information available at the end of time t-1.

An asterisk denotes a foreign country, and its absence the domestic country.

Using this notation, we begin with the simple equilibrium condition of the asset market approach to exchange rate determination. Perfect substitutability between assets denominated in different currencies is assumed (i.e. zero risk premium), so that the uncovered interest parity holds:

$$i_t = i_t^* + s_t^e \tag{1}$$

We postulate that rational expectations prevail in the spot exchange market, so that:

$$s_t = s_t^e + \mu_t, \quad E(\mu_t | I_{t-1}) = 0 \tag{2}$$

Subtracting $\pi_t^e - \pi_t^{*e}$ from both sides of (1) and re-arranging, we obtain:

$$(i_t - \pi_t^e) - (i_t^* - \pi_t^{*e}) = s_t^e - \pi_t^e + \pi_t^{*e} = 0 \tag{3}$$

This simply states that the expected real interest differential between assets (bonds) denominated in different currencies equals the expected change in the real exchange rate. We further postulate that inflation expectations within bond markets are also rational, so that actual inflation rates equal expected inflation rates plus random error terms:

$$\pi_t = \pi_t^e + \varepsilon_t; \quad \pi_t^* = \pi_t^{*e} + \varepsilon_t^* \tag{4}$$

where

$$E(\varepsilon_t | I_{t-1}) = 0, \quad E(\varepsilon_t^* | I_{t-1}^*) = 0 \text{ and}$$

$$I_{t-1} = I^*_{t-1}.$$

To arrive at a random walk model we also need to specify the ex-ante equilibrium condition for the real exchange rate with which our rationally expected inflation and exchange rate changes are consistent. We assume that a zero change is anticipated. PPP is expected to prevail at the existing real exchange rate and the real interest differential is expected to be zero. Ignoring real interest rates:

$$s_t^e - \pi_t^e + \pi_t^{*e} = 0 \tag{5}$$

By substituting (2) and (4) into (5) we obtain:

$$s_t - \pi_t + \pi_t^* = \mu_t - \varepsilon_t + \varepsilon_t^* \tag{6}$$

which is observable.

Following from the rational expectations assumption we have:

$$E(\mu_t - \varepsilon_t + \varepsilon_t^* \mid I_{t-1}) = 0$$

The ex-ante expectation that the real exchange rate will not change implies that the observed real exchange rate will follow a random walk process. There will be no systematic tendency to revert to PPP following a random deviation from parity.[3]

(b) The alternative hypotheses

The random walk model of deviations from PPP may be tested against the alternative hypothesis that there is a tendency to revert towards long-run PPP following a disturbance, as in Adler and Lehman. However, the argument that the equilibrium value of the real exchange rate is constant assumes that relative prices remain unchanged (apart from short-term cyclical fluctuations). This assumption may not be applicable to small open economies that specialise in commodity trade. Such countries may be subject to exogenous terms of trade shocks that are "permanent" - there may be trend movements, or persistent deviations from trend.

The maintenance of the equilibrium current account balance in the face of a permanent shift in the terms of trade calls for adjustments to the equilibrium real exchange rate[4]. A shift in the relative competitiveness of the bundle of goods in question is required to generate trade quantity offsets to the real gain or loss implied by the change in the terms of trade.

In this case the long-run equilibrium or "sustainable" level of the real exchange rate may not be constant, as implied by the PPP hypothesis. Shocks or innovations in the real exchange rate would revert to the

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3. Adler and Lehmann derive this model following different assumptions to those adopted here. In particular, they assume the real interest differential is constant. A non-zero real interest differential implies expectations of perpetual depreciation of the real exchange rate. This seems implausible without specific assumptions about trend movements in relative commodity prices.

4. See Spencer (1983) for a derivation of the extent of adjustment of PPP consequent upon a shift in the terms of trade.

terms-of-trade-modified equilibrium level. Taking account of such effects in the above model may mean that at least some of the movements in the real exchange rate may be predictable - contradicting the random walk hypothesis - given expectations about movements in commodity prices.

If the earlier model is modified to allow for terms of trade effects, equation (5) could be rewritten as:

$$s_t^e - \pi_t^e + \pi_t^{*e} = f(X_t^e) \tag{7}$$

where:

X_t^e = the expectation of the percentage change in the terms of trade from t to t+1 based on information available at the end of time t-1.

Making the further assumption that expectations about movements in the terms of trade (commodity prices) are rational:

$$X_t = X_t^e + \omega_t \tag{8}$$

Substituting (2), (4) and (7) into (8) and rearranging we obtain:

$$s_t - \pi_t + \pi_t^* - f(X_t) = \mu_t - \varepsilon_t + \varepsilon_t^* - \omega_t$$

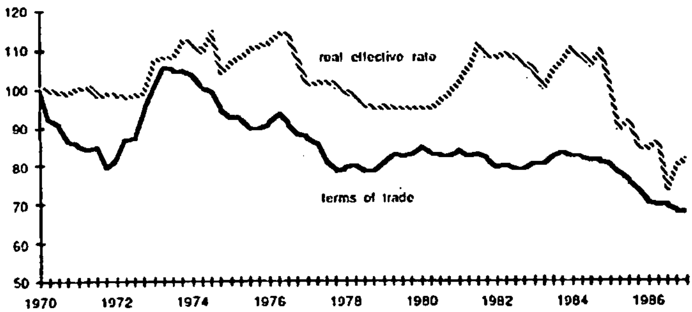
where

$$E\ (\mu_t - \varepsilon_t + \varepsilon_t^* - \omega_t \mid I_{t-1}) = 0 \tag{9}$$

This contradicts the random walk model of deviations from PPP in equation 6. At least some part of real exchange rate movements will be predictable, given information about the terms of trade.

Chart 3 shows Australia's real effective exchange rate together with our terms of trade. Both rose in the early 1970s and subsequently were subject to a trend decline. One exception to this general pattern is the period from about 1980 to the end of 1983, referred to earlier in relation to the trade-weighted nominal exchange rate. The real exchange rate rises strongly, in spite of a relatively flat profile for the terms of trade.

CHART 3: Movements in the real effective exchange rate and terms of trade



Nevertheless, there appears to be sufficient casual evidence to suggest that the terms of trade may be important in specifying an alternative to the random walk hypothesis. Consequently, we consider a more general alternative hypothesis than that adopted by Adler and Lehman: that there is a tendency for the real exchange rate to revert to an equilibrium level which may or may not be constant, depending on the importance of the terms of trade effect.

The percentage change in the real exchange rate in the random walk model (equation 6) represents the PPP innovation. Its conditional expectation given information available at the end of time t-1 is zero. This implies that in the regression model:[5]

$$Y_t = \sum_{i=1}^{n} b_i Y_{t-i} + \sum_{i=1}^{n} c_i X_{t-i} + \upsilon_t \tag{10}$$

the estimates of the b_i and c_i coefficients should be jointly insignificantly different from zero. Y_t is the percentage change in the real exchange rate from t to t+1 and υ_t is a random error at period t.

5. We assume for simplicity that there is a linear relationship between the expected change in the real exchange rate and the expected change in the terms of trade.

The null hypothesis that the random walk model of deviations from PPP is the true model, is tested against the alternative hypothesis that information about past changes in the real exchange rate and commodity prices are relevant for predicting innovations in PPP.

Adler and Lehman test the random walk model against the less general alternative hypothesis that the real exchange rate reverts to long-run PPP. This hypothesis predicts that real exchange rate changes should be positively serially correlated, because deviations from PPP are cumulative in the short-run and, in the long run, the real exchange rate tends to revert to a constant equilibrium.

In testing the random walk model against this alternative hypothesis they implicitly restrict the c_i coefficients to be zero, and test only whether the b_i coefficients are jointly insignificantly different from zero. If the set of b_i coefficients are jointly zero, then innovations to the real exchange rate in Adler and Lehman's regression model are serially uncorrelated. This would constitute evidence against the (less general) alternative hypothesis in favour of the random walk model.

A potential problem with this approach is that by restricting the c_i equal to zero, there may be a high probability of making a Type II error - failing to reject the null hypothesis when in fact it is false. Deviations from PPP may appear to be random, when in fact they arise partly because of changes in commodity prices, which are ignored in Adler and Lehman's regression model.

The modification considered in this paper is that in the long run the real exchange rate may revert to a level that is not constant, but changes with movements in the terms of trade or commodity prices.[6] The random walk model implies that successive increments to the real exchange rate are serially independent. If the random walk model is the true model, there should be no relationship between the real exchange rate and past movements of both itself and commodity prices. If there is no serial correlation then the null hypothesis that both the b_i and c_i coefficients, $i=1, \ldots, n$, in equation 10 are jointly insignificantly different from zero should not be rejected by the data.

6. The PPP alternative hypothesis is a special case of this more general regression model. The c_i coefficients would be jointly insignificantly different from zero, while this would not be the case for the b_i coefficients.

In the next section, we show that if we follow Adler and Lehman by restricting the c_i coefficients to zero, we too are unable to reject the random walk model of deviations from PPP on Australian data. However, we also show that if tested against the more general alternative the random walk model is rejected for some periods.

4. Testing the Models on Australian Data

The choice of lags in testing equation 10 is entirely arbitrary. However, in the effort to incorporate both short-run and long-run factors, models with lag lengths of 6 months, 12 months and 18 months are examined.

(a) Heteroskedasticity issues

We expect heteroskedasticity to be present in exchange rate data for Australia because of the changes in regime that have occurred - most notably the switch from a crawling peg to floating exchange rates. In the more general model, we are also aware of the problem of increasing variance of commodity prices in the lattor half of the floating exchange rate period.

Consequently, whon estimating the models, we tested for heteroskedasticity using a procedure developed by White (1980). The results are shown in Table 7. The null hypothesis of no heteroskedasticity is consistently rejected in the post float period when commodity prices are included in the model - but not otherwise.

Corrections for heteroskedasticity are made using the procedure developed by White. Tables 2 to 6 show estimation results for both the uncorrected and corrected models.

(b) Test statistics

The hypothesis that the parameters for the lagged explanatory variables are jointly insignificantly different from zero (no serial correlation) is tested using the F-statistic in the original model and the Wald statistic in the corrected model. The individual coefficients in each regression which are significant at the 95% level, according to their t-statistics, are also reported.

These tests assume independent and identically distributed errors - there should be no remaining autocorrelation in the error terms. We use the Breusch-Godfrey test to determine whether first-order autocorrelation exists in each model. Test results shown in Table 8 indicate that in general first order autocorrelation is not present.

The results for both models are presented in Tables 2 to 6, along with the marginal significance levels. The random walk model is rejected when the marginal significance level is greater than 0.99.

(c) The results

In Table 2 we present results for the case of the real exchange rate defined in terms of the U.S. dollar exchange rate, using quarterly data. Recall that we are testing the null hypothesis that the random walk model of deviations from PPP is the true model.

Over the full sample period, and both the managed and floating rate subperiods, it is difficult to reject the random walk hypothesis when the commodity price terms are excluded. The random walk hypothesis for the case of four lags is rejected when commodity prices are included over the floating rate period. Corrections for heteroskedasticity appear to be important to this finding.

Table 3 contains results for the same tests, but where the real exchange rate is defined in terms of a trade-weighted basket of currencies. The results are summarised as follows:

- over the full sample period the results are much the same as for the case of the U.S. dollar (i.e. the random walk model is not rejected by the data);
- over the sample period containing only managed exchange rate regimes the random walk hypotheses is again not rejected; and
- over the floating rate period the random walk model of deviations from PPP is rejected once terms of trade affects are taken into account. In this case the correction for heteroskedasticity appears to be crucial to the results.

The small number of quarterly observations during the floating rate period led to difficulties in placing much weight on our results. This motivated us to carry out tests for the real effective exchange rate using monthly observations. Since the terms of trade is not available on this basis, the Reserve Bank's index of commodity prices is used as a proxy for the terms of trade effect. This series is available only from July 1984. Consequently, only the model that ignores commodity price effects could be tested on monthly data over the full sample period (Table 4), and over the period of managed exchange rates (Table 5). In both of these cases the random walk hypothesis was not rejected by the monthly data.

The results for the post-float period using monthly data and the more general test of the random walk hypothesis (Table 6) are of more interest, and are summarised as follows:

- the random walk model of deviations from PPP is not rejected by the monthly data if commodity prices are ignored; but

- the random walk model is rejected by the monthly data over the period of floating exchange rates if commodity prices are included. Corrections for heteroskedasticity appear to be crucial for obtaining this result.

This latter finding provides evidence that behaviour of the real exchange rate since the float is not a random process - it may reflect movements in the equilibrium real exchange rate following from sustained changes in commodity prices.

5. A Digression on Competitiveness and Commodity Prices Under Floating Exchange Rates in Australia

The Australian dollar has sometimes been referred to as a commodity currency. The model of the real exchange rate underlying our test of PPP adds some weight to this view. Since the exchange rate was floated - and not before - the real exchange rate appears to be influenced by commodity price developments. To illustrate the predictive power of a model based solely on these considerations we simulate (dynamically) the monthly model of the real exchange rate from the beginning of 1985. The results are illustrated in Chart 4. The real exchange is predicted well, particularly in 1986 when the real exchange rate fell sharply by about 15 per cent in the middle of the year and subsequently rose again. Commodity prices (in foreign currency) fell 14 per cent from January to August 1986. From August 1986 until mid 1987 they rose by 30 per cent.

The dynamics of a commodity price shock are illustrated in Chart 5. A 10 per cent increase in commodity prices leads to an immediate real appreciation of about 8 per cent. The dynamics however are complicated, with fluctuations within the range of a 4 to 8 per cent appreciation during the first nine months. Subsequently, the appreciation settles down at around 5-1/2 per cent in the longer run.

CHART 4:
Dynamic simulation of the real exchange rate

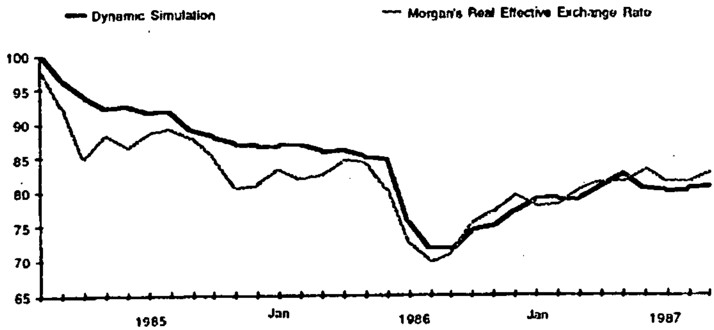
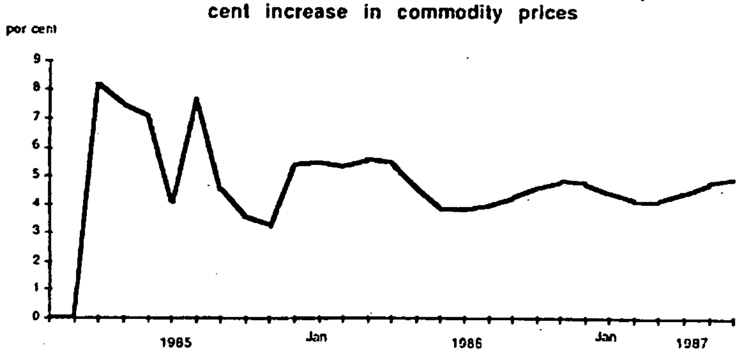


CHART 5:
Simulated real exchange rate response to a 10 per cent increase in commodity prices



6. Concluding Remarks

This paper has sought to examine three questions:

- is the general downward trend of the real exchange rate with persistent deviations from that trend, consistent with the hypothesis of random deviations from PPP - with no tendency to revert to a constant equilibrium level?

- does the inclusion of commodity prices matter? For small economies specialised in commodity trade there may be a tendency for the equilibrium real exchange rate to change in response to shifts in the terms of trade; and

- since relative prices are more "sticky" (with smooth longer-run behaviour) than exchange rates, does the issue of managed versus floating rates bear on the question of whether deviations from PPP display random behaviour?

When the real exchange rate is analysed independently of commodity price developments, it is difficult to reject the hypothesis that deviations from PPP follow a random process. However, when information about the terms of trade is also included in the analysis, this conclusion is modified. In particular, it depends on the particular exchange rate regime in operation. This can be interpreted as evidence that deviations from PPP may arise as the predictable equilibrium response to changes in relative commodity prices. The particular cases for which this is true are also of interest in providing evidence on whether appropriate real exchange rate adjustment is best facilitated under managed or floating exchange rate regimes.

Even when information about commodity prices is included, the random walk model of deviations from PPP is still difficult to reject when explaining the behaviour of the real exchange rate over the managed exchange rate period. However, it is possible to reject the random walk model of deviations from PPP if information about commodity prices is included (and adjustments for heteroskedasticity made) when explaining the behaviour of the real exchange rate over the floating rate period. (Whether defined in U.S. dollar or effective terms.)

In short the evidence is consistent with two propositions. First, when the exchange rate is not floating, PPP and commodity price considerations have no apparent systematic influence on the real exchange rate. Second, when the exchange rate for the Australian dollar is floating the behaviour of the real exchange rate is consistent with reversion to an equilibruim level modified by commodity price developments.

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APPENDIX A

DATA AND DETAILED RESULTS

Data used in the empirical analysis includes:

quarterly and monthly data for Australia's real effective exchange rate from 1970 to March 1987 in index form (1980-Q2 = 100), from Morgan Guaranty *World Financial Markets*. It is calculated as the nominal effective exchange rate adjusted for differential inflation measured by the wholesale manufacturing price index - a series which is partially estimated;

- end of quarter data for the bilateral exchange rate between the Australian and U.S. dollars;

- quarterly terms of trade data from March 1970 to March 1987 calculated as the unit value of exports divided by the unit value of imports; and

- monthly data for the Reserve Bank's rural commodity price index from July 1984 to March 1987. These last three series are from the Reserve Bank of Australia's research database.

Table 2

lag length (n)	test-statistics for $y_t = \sum_{i=1}^{n} b_i y_{t-i}$ using real US$/$A rate			test-statistics for $y_t = \sum_{i=1}^{n} b_i y_{t-i} + \sum_{i=1}^{n} c_i x_{t-i}$ using real US$/$A rate and the terms of trade					
				Uncorrected model			Corrected model		
	Significant coefficients	F	Marginal significance less than	Significant coefficients	F	Marginal significance less than	Significant coefficients	Wald	Marginal significance less than
				March 1970 - March 1987					
2	None	0.03	0.01 (A)	None	0.65	0.34 (A)			
4	None	0.29	0.08 (A)	None	0.58	0.19 (A)			
6	None	0.35	0.07 (A)	None	0.69	0.24 (A)			
				March 1970 - December 1983					
2	None	0.26	0.15 (A)	None	1.02	0.59 (A)			
4	None	0.31	0.09 (A)	None	0.75	0.34 (A)			
6	None	0.34	0.07 (A)	None	0.63	0.18 (A)			
				March 1984 - March 1987					
2	None	0.32	0.19 (A)	None	0.21	0.05 (A)	None	4.83	0.56 (A)
4	None	0.73	0.38 (A)	None	0.35	0.9 (A)	None	30.91	0.999 (R)

Note

(A) denotes acceptance of the null hypothesis that all the coefficients and the intercept are jointly zero, that is, the model follows a random walk;

(R) denotes rejection of the null hypothesis, implying the model does not follow a random walk.

5682R

lag length (n)	test-statistics for $y_t = \sum_{i=1}^{n} b_i y_{t-i}$ using real US$/$A rate			test-statistics for $y_t = \sum_{i=1}^{n} b_i y_{t-i} + \sum_{i=1}^{n} c_i X_{t-i}$ using real US$/$A rate and the terms of trade					
				Uncorrected model			Corrected model		
	Significant coefficients	F	Marginal significance less than	Significant coefficients	F	Marginal significance less than	Significant coefficients	Wald	Marginal significance less than
				March 1970 - March 1987					
2	None	0.35	0.21(A)	None	1.28	0.72(A)			
4	y_{t-3}	2.01	0.91(A)	y_{t-3}	1.66	0.88(A)			
6	y_{t-3}	1.76	0.89(A)	None	1.20	0.69(A)			
				March 1970 - December 1983					
2	None	0.07	0.03(A)	None	0.65	0.34(A)			
4	None	0.23	0.05(A)	None	0.50	0.24(A)			
6	None	0.18	0.01(A)	None	0.34	0.02(A)			
				March 1984 - March 1987					
2	None	0.80	0.48(A)	None	1.61	0.74(A)	X_{t-2}	39.57	0.999(R)
4	None	1.21	0.61(A)	None	1.51	0.63(A)	None	210.84	0.999(R)

Note

(A) denotes acceptance of the null hypothesis that all the coefficients and the intercept are jointly zero, that is, the model follows a random walk;

(R) denotes rejection of the null hypothesis, implying the model does not follow a random walk.

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Table 4: January 1970 - March 1987

lag length (n)	test-statistics for $y_t = \sum_{i=1}^{n} b_i y_{t-i}$ using real US$/$A rate		
	Significant coefficients	F	Marginal significance less than
6	y_{t-1}	2.94	$0.994^{(R)}$
12	y_{t-1}	1.76	$0.94^{(A)}$
18	y_{t-1}	1.76	$0.96^{(A)}$

Table 5: January 1970 - November 1983

lag length (n)	test-statistics for $y_t = \sum_{i=1}^{n} b_i' y_{t-i} + \sum_{i=1}^{n} c_i X_{t-i}$ using real US$/$A rate and the terms of trade		
	Significant coefficients	F	Marginal significance less than
6	None	0.57	$0.22^{(A)}$
12	None	0.52	$0.10^{(A)}$
18	None	0.59	$0.10^{(A)}$

Note

(A) denotes acceptance of the null hypothesis that all the coefficients and the intercept are jointly zero, that is, the model follows a random walk;

(R) denotes rejection of the null hypothesis, implying the model does not follow a random walk.

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Table 6: December 1983 - March 1987

lag length (n)	test-statistics for $y_t = \sum_{i=1}^{n} b_i y_{t-i}$ using real US$/$A rate			test-statistics for $y_t = \sum_{i=1}^{n} b_i y_{t-i} + \sum_{i=1}^{n} c_i X_{t-i}$ using real US$/$A rate and the terms of trade					
				Uncorrected model			Corrected model		
	Significant coefficients	F	Marginal significance less than	Significant coefficients	F	Marginal significance less than	Significant coefficients	Wald	Marginal significance less than
6	y_{t-3}	1.90	$0.90^{(A)}$	X_{t-1}	2.03	$0.89^{(A)}$	X_{t-1} X_{t-5} y_{t-1} y_{t-6}	62.51	$0.999^{(R)}$
12	None	0.94	$0.48^{(A)}$						
18	None	0.96	$0.47^{(A)}$						

Note

(A) denotes acceptance of the null hypothesis that all the coefficients and the intercept are jointly zero, that is, the model follows a random walk;

(R) denotes rejection of the null hypothesis, implying the model does not follow a random walk.

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Table 7: Results of White Test for Heteroskedasticity

Ho: no heteroskedasticity

Model	Lags (months)	Prob > Chi-Square 1970-Mar'87	1970-Dec'83	1984-Mar'87
effective(qly)				
without TOT	6	0.49	0.80	0.24
	12	0.37	0.60	0.26
	18	0.63	0.87	-
with TOT	6	0.74	0.98	0.10
	12	0.71	0.77	0.0001
	18	0.73	0.82	-
US bilateral (qly)				
without TOT	6	0.32	0.22	0.18
	12	0.61	0.37	0.05
	18	0.61	0.64	-
with TOT	6	0.64	0.37	0.01
	12	0.62	0.64	0.0001
	18	0.22	0.74	-
effective (mthly)				
without commodity prices	6	0.18	0.52	0.18
	12	0.09	0.82	0.19
	18	0.27	0.82	0.32
with commodity prices	6	-	-	0.0007

Note: Under Ho, it is assumed that the errors are independent of the regressors and that the model is correctly specified. The null hypothesis is rejected when the marginal significance level is less than that desired (e.g. 0.01, 0.05).

Table 8: Results of Breusch-Godfrey Test for First-Order Autocorrelation
H0: No First Order Autocorrelation

Model	Lags (months)	Prob > F 1970-Mar'87	1970-Dec'83	1984-Mar'87
effective (qly)				
without TOT	6	0.02	0.49	0.13
	12	0.20	0.03	0.38
	18	0.02	0.09	0.20
with TOT	6	0.54	0.06	0.16
	12	0.26	0.94	0.35
	18	0.05	0.62	-
US bilateral (qly)				
without TOT	6	0.27	0.71	0.49
	12	0.92	0.66	0.38
	18	0.08	0.23	0.57
with TOT	6	0.73	0.48	0.27
	12	0.75	0.36	0.42
	18	1.00	0.62	-
effective (mtly)				
without commodity prices	6	0.01	0.42	0.02
	12	0.06	0.07	0.31
	18	0.77	0.93	0.86
with commodity prices	6	-	-	0.012

Note: The null hypothesis is rejected when the marginal significance level is less than that desired (e.g. 0.01, 0.05).

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