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How misaligned is the Australian real exchange rate?

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Abstract
This paper uses quarterly data from September 1981 to December 2000 to quantify the extent to which the Australian real exchange rate is misaligned relative to its long-run equilibrium value. Our modelling suggest, that as of December 2000, the real exchange rate was seven percent below its equilibrium value; this figure is modest in comparison to purchasing power parity indicators that suggest considerably greater misalignment. Furthermore, once short-run dynamics are accounted for, even this anomaly disappears.

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Key words: Exchange rates, misalignments, Australia

Introduction

The recent fall in the Australian exchange rate, particularly the bilateral rate to the US$, has raised questions on the sustainable value of the exchange rate and the extent and likelihood of further falls. More importantly, the recent fall in the $A has raised concerns about the efficacy of markets in determining the exchange rate. Several commentators, the Australian Treasurer included, have suggested that the currency is well below its equilibrium value; a proposition not supported by the markets, given the absence of any significant bounce back in the exchange rate.[1] Here, we explore the degree to which the Australian real exchange rate is misaligned given its economic fundamentals including the strong historical links between the real exchange rate to the terms of trade.

Over the last 30 years, the Australian trade weighted real exchange rate (RTWI) and the nominal A$ to US$ bilateral exchange rates have closely tracked movements in the terms of trade. A time plot of the exchange rates on a monthly basis from January 1970 to February 2001, confirming the above, is provided as Figure 1. This picture shows a definite negative time trend in the movement of the two exchange rates. The large and statistically significant impact of movements in terms of trade on the nominal and real exchange rates have been well documented (see for example Blundell-Wignal and Gregory, 1990; and Gruen and Wilkinson, 1994; and, Aruman and Dungey, 2001). The close correlation of these two exchange rates is the result of the methods used to construct the two series and the limited capacity of Australian exporters to change their pattern of trade in response to changes in export prices; the last being true even in the

[1] Feedback and momentum inherent in exchange rate movements may constrain any (small) individual player to take a stance against the trends in the market.

long run. The strength of this relationship between terms of trade and the exchange rate may be slowly weakening; here we use this relationship to gauge the extent of misalignment of the exchange rate relative to the fundamentals.

The objective of this paper is to quantify the extent of misalignment of the real trade-weighted exchange rate to its long- and short-run equilibrium values. To do so, we need to know the equilibrium value of the real exchange rate against which the observed values are benchmarked. We quantify this equilibrium value using available time series data on the variables constituting the fundamentals that underpin the real exchange rate. The equilibrium real exchange rate is modelled as being dependent on these fundamentals and any deviation of the actual from the predicted value is interpreted as the extent of misalignment. The limited availability of data on the price of imports enables the use of this methodology on quarterly data from September 1981 to December 2000.

Our estimates suggest that the real trade weighted exchange rate was 7 percent below its equilibrium value as of December 2000. According to the estimates, this overshooting was by no means unusual since the real exchange rate overshot by a similar magnitude in September 1986, and June 1995. Furthermore, the real exchange rate has overshot in the opposite direction several times; the last by a similar amount was in June 1999. The recent overshooting is of little surprise, but the magnitude of this misalignment is very different from those suggested by several commentators.[2] If our analysis is correct, there

[2] The *Economist*, for example, via its big-mac index claims that the $A as of April 2001 was under-valued by 40 percent. The most under-valued currency according to the big-mac index was the Philippine peso at 54 percent below parity. Amongst the industrial countries the New Zealand dollar, at 43 percent below parity, was the only currency more under-valued than its Australian counterpart.

is little room for a bounce back in the trade weighted real exchange rate, but this does not preclude opportunities for significant adjustments in bilateral nominal rates.

The rest of the paper is organised as follows. Next we present a short survey of the literature on the determinants of the real exchange rate. Section 3 develops the analytical framework employed to model equilibrium values of the real exchange rate. Section 4 describes the data used for the analysis while section 5 presents the empirical findings. Conclusions and suggestions for further work bring this paper to a close.

Determinants of the real exchange rate

The recent literature on exchange rate misalignment has been mostly confined to developing countries, though the earlier work on asset price bubbles was much concerned with the USA. Here, we use the developing country literature to gauge the extent to which the Australian dollar is misaligned, given its dramatic fall over the recent past. Quantifying the extent of misalignment of the exchange rate is not a trivial task given that distinguishing between equilibrium and disequilibrium movements in the exchange rate is considered as one of the greatest challenges in macro-economics (Edwards, 1988).

We make the important assumption that the real exchange rate is determined by its fundamentals. This assumption is put to test by the ability of our estimated model to account for the movements in the real exchange rate. We assume that all behavioural relationships are homogeneous of degree 0; consequently, no nominal variables appear in the estimates. The above two assumptions imply that any nominal shocks, at most, have only transitory effects on the real exchange rate as a result of frictions and nominal rigidities such as those in prices, wages, and asset adjustment. These short-run dynamics may impact on real variables and are incorporated in one of the models.

According to Dornbusch (1974, 1980), the equilibrium real exchange rate is the relative price of tradables to nontradable goods at which income equates expenditure and both the tradable and nontradable goods markets are in equilibrium. This definition of the long-run sustainable real exchange rate does not distinguish between transitory and permanent changes in the equilibrium real exchange rate. It constrains the current account to equilibrate in the long run. Exchange rate misalignment, therefore, is the sustained departure of the actual real exchange rate from its long-run sustainable equilibrium level. The above definition enables the equilibrium exchange rate to evolve over time in accordance with fundamentals.

The fundamentals that determine the value of the equilibrium exchange rate comprise potentially an inexhaustible set, but here we concentrate on a small subset including trade taxes, international prices, and productivity that have proved to be the most salient. Equilibrium constitutes simultaneous clearing of the domestic non-tradable goods markets and satisfaction of the inter-temporal budget constraint on the external account. The latter imposition implies that the discounted-value of current account balances is zero. Four implications naturally follow from the above, including: first, the equilibrium exchange rate will move as the underlying fundamentals shift; second, there is a path of the equilibrium exchange rate over time; third, this path is affected by the current and expected values; and fourth, options for borrowing and lending together with inter-temporal substitution in consumption and production will all impact on the future values of the real exchange rate (see Edwards, 1988 for a detailed discussion on the above).

The analytical framework[3]

We motivate our modelling framework using a simple two goods – traded and non-traded – structure under the small country assumption. Let the real exchange rate (RER) be defined as the domestic relative price of non-traded to traded goods. i.e.,

$$RER = e = \frac{P_N}{EP_T^W} \qquad (1),$$

where E is the nominal exchange rate, P_N is the domestic price of the non-traded good, and P_T^W is the exogenous world price of traded good as a result of the small country assumption. Note that in the above formulation, a rise in the value of e is a real appreciation.

The long-run equilibrium exchange rate is defined as that which prevails when the economy is in internal and external balance. Internal balance holds when the markets for labour and non-traded goods clear such that the following equation is satisfied.

$$y_N(e) = c_N + g_N = (1-\theta)ec + g_N\,,\ \partial y_N / \partial e > 0 \qquad (2)$$

where y_N is the supply of non-traded good under full employment, c_N and g_N are total private and government spending, in terms of traded goods, on non-traded goods and θ is the share of total private spending on traded goods.

[3] Much of this and the following section draws on Baffes *et al* (1999) and Hinkle and Montiel (1999).

External balance is considered by first looking at the current account balance that is given by the following equation:

$$\dot{f} = b + rf = y_T(e) - (g_T + \theta c) + rf \;,\; \partial y_T / \partial e < 0 \qquad (3);$$

where f is net foreign assets and b the trade balance, all measured in traded goods, and r the yield on foreign assets. The current account balance, b, is the difference between domestic production and the sum of government and private expenditure on traded goods. We take the long-run stock equilibrium approach in defining external equilibrium to hold when the net creditor position of the country in world financial markets has reached a steady-state equilibrium.[4] We now solve for the combinations of private spending and the real exchange rate that are consistent with the above notion of external balance. Fiscal balance holds at each point in time in this model, with any required adjustments – as in the nominal exchange rate or the rate of inflation – taking 'place behind the scenes' (Baffes *et al*, 1999: 409).

The equilibrium exchange rate is obtained by setting the right-hand side of equation (3) to zero and combining this with equation (2) to give:

$$e^* = e^*(\underset{+}{g_N}, \underset{-}{g_T}, \underset{+}{r^* f^*}) \qquad (4)$$

where "*" denotes steady state values of endogenous variables and the signs below being the corresponding partial derivatives of e^*. For given government expenditure, interest

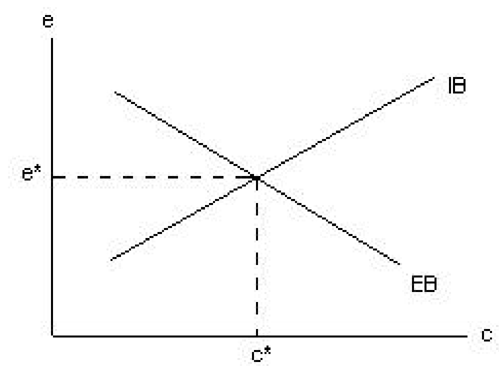
[4] See Khan and Lizondo (1987), Edwards (1989), and Rodriguez (1994) for the case for such a consideration.

rates, and net foreign asset position, c* and e* ensure simultaneous internal and external balance as shown in Figure 2 below.

Letting the nominal interest rate be tied down by the long-run rate of time preference and domestic inflation within the traded goods sector, the final expression for the equilibrium exchange rate takes the form:

$$e^* = e^*(g_N, g_T, r_W, p_T) \qquad (5)$$

Figure 2: Internal (IB) and external balance (EB)



Note: A rise in e is a real appreciation; EB is drawn for steady-state values of the current account.

where r_W is the world real interest rate and p_T the rate of inflation in the domestic relative price of traded goods. Equation (5) shows that the real exchange rate consistent with internal and external balance is a function of the listed macroeconomic fundamentals comprising the right-hand side variables. This equilibrium rate varies over time given time-variant fundamentals; this is in sharp contrast to the purchasing power parity (PPP) approach that imposes the given fundamentals for the benchmark period, creating a single equilibrium exchange rate. In the case where all of the fundamentals are stationary variables, the above two approaches give identical estimates for the long-run equilibrium exchange rate. Hence, when all of the variables are stationary, the PPP definition of the real exchange rate may be used in place of the internal terms-of-trade definition as given by e^* in equation (5) above.

The sub-set of fundamentals in equation (5) can easily be expanded, depending on the specific context. For example, changes in the internal and external terms of trade would constitute one of the primary determinants of the real exchange rate (see de Brouwer 1999, Gruen and Wilkinson, 1994, and Blundell-Wignall and Gregory, 1990). Furthermore, letting the country face an upward sloping supply curve for external funds implies that the trade balance is endogenously determined at each moment in time by the savings and portfolio decisions of the households. This now links the stock equilibrium concept of external balance with the flow approach to defining external balance.[5] Incorporating the above two factors into equation (5) provides us with the basic estimating model for the equilibrium real exchange rate. ie

$$e^* = e^*(p_X^W, p_M^W, g_N, g_T, b, \tau) \qquad (6)$$

where p^W denotes world prices, subscripts X and M denote exports and imports, respectively, b (= $-rf$) is the trade surplus, and τ captures the domestic stance of trade policy. This set of fundamentals is by no means an exhaustive list and therefore may be expanded, for example by including productivity and trade policy differentials. This augmentation has been done in the empirics as part of the sensitivity tests; such additions are at a cost to the available data and the simplicity of the model.

[5] Baffes *et al* (1999) impose a credit ceiling to generate such a link.

The empirics

We first discuss in detail the empirical implementation of the model in equation (6). This discussion then leads to the data needed for estimation of the proposed model. The results of the estimates, model diagnostics, and a discussion of the results are presented last.

The empirical model

The estimated model assumes a log-linear form for equation (6) in estimating the unobserved equilibrium real exchange rate, given data on the actual value and for the fundamentals. The estimated equation takes the stochastic form

$$\ln e_t{*} = \boldsymbol{b}' F_t^{\,P} + \boldsymbol{w}_t \qquad (7)$$

where $e*$ is the equilibrium real exchange rate, $\boldsymbol{b}$ is the vector of long-run parameters of interest, F^P is the vector of permanent values for the fundamentals, and ω is a zero-mean stationary variable; the last ensures that the conditional expectation of the equilibrium exchange rate is the weighted sum of the fundamentals.

We further impose the restriction that the steady state is dynamically stable such that any perturbations that cause the exchange rate to diverge from its equilibrium value are short-lived. This assumption implies that the real exchange rate converges to its equilibrium value, permitting the transformation of equation (7) into the general error-correction model, i.e.,

$$\Delta \ln e_t = \alpha(\ln e_{t-1} - \beta' F_{t-1}) + \sum_{j=1}^{p} \mu_j \Delta \ln e_{t-j} + \sum_{j=0}^{p} \gamma' \Delta F_{t-j} + \nu_j \tag{8}$$

where the variables are as defined before and ν is once again assumed to be independent and identically distributed, mean-zero, stationary random variable. Baffes *et al* (1999: 417) note that should all the variables be integrated of order 0 or 1, equation (8) gives a long-run equilibrium that is stable for $-2<\alpha<0$. The authors also note that the above equation "embodies the central insight of the single-equation approach: that the equilibrium real exchange rate can be identified econometrically as that unobserved function of the fundamentals towards which the real exchange rate gravitates over time" (page 417).

Equations (7) and (8) are estimated to gauge the degree of exchange rate misalignment next.

The data

The data used for this analysis is discussed briefly here with variable names and data sources detailed in Appendix I. The real exchange rate used here is the real trade weighted index (rtwi) for the Australian dollar sourced from Aruman and Dungey (2001). This variable has been defined such that an increase in its value corresponds to a real appreciation. Labour productivity is measured in terms of output per hour of labour input. The data did not allow separation of government expenditure into traded and non-traded components; hence we used total government expenditure. We also used the investment share in total output to proxy demand for traded commodities, given the high import content of investments. Several trade policy measures are available; here we used total trade as a share of GDP – a measure of openness – given its popularity of use in the literature. Note that our resource gap measure constituting the current account balance as a proportion of GDP has the potential to be correlated with the measure for openness; this issue is addressed by estimating unrestricted forms of the model where the share of exports and imports are entered independently.

The time series properties of the data were examined. The Dickey-Fuller test was unable to reject the null hypothesis of stationarity for all of the variables. Hence, we proceed on the assumption of stationarity and subject the residuals to tests of the same; the rationale being that even if one or more of the variables are non-stationary, the stationarity of the residuals implies that the real exchange rate and its fundamentals are cointegrated.[6] These results together with the mean and standard deviation of the variables used in the models are reported in table 1. For the September-1981 to December-2000 period, the real trade weighted index (rtwi) index that was set at 100 as of March 1995, had a mean of 112 with a standard deviation of 13; its value as of December 2000 of 91 was with-in two standard deviation from the mean. Similarly, the terms of trade for the corresponding period had a mean of 0.88 and a standard deviation of 0.07; the December 2000 figure of 0.85 was well thing one standard deviation of the mean (see figure 3).

Parameter estimates

Two methods are used to estimate the models specified in equations (7) and (8). The first involves estimating the static regression – the long-run model given in equation (7) –

[6] The finding of stationarity is in accord with the claims of Blundell-Wignal and Gregory (1990: 249) of a stable long-run relationship between the real exchange rate and terms of trade.

using OLS. We test the residuals for stationarity in case the maintained hypothesis of all the variables being I(0) fails. The estimates of β from the static regression when the variables in F^P are cointegrated are super consistent; this being true even in the absence of weak exogeneity (see footnote 11). The OLS estimates for the parameters of the error-correction specification are consistent, providing estimates of the adjustment speed, α. The residuals from the static model, lagged one period, are then used to estimate equation (8). Finally, the flexible form of the ECM as given in equation (8) is estimated. The results of the estimate for the static model are provided in table 2 while those for the ECM are reported in table 3. The use of contemporaneous values for the fundamentals in determining the unobserved equilibrium exchange rate raises questions of pre-determinedness. To address this concern, we employ instrumental variable estimation with higher lags of the fundamentals as instruments to achieve consistent estimates of the parameters.

The unit root test applied on the residuals supports stationarity in all of the estimates. The estimate of α supports the stability restriction.[7] Model 1 uses the ratio of price of exports to the price of imports to construct the terms of trade variable; this implies restricting the coefficients on the export and import price indices to be equal.[8] Such a restriction is rejected by the data. This observation of the effects of export price shocks being markedly different from those of import price shocks is consistent with similar

[7] Note that to obtain α, 1 has to be subtracted from the estimated adjustment parameter given that the Bewley transform of the ECM has been estimated.

[8] We note that the parameter estimate is insignificantly different from 1; this fact survives several specifications indicating that the real exchange rate movements are nearly perfectly correlated with movements in the terms of trade. This result is consistent with the findings of Blundell-Wignall and

findings for New Zealand (see Wells and Evans, 1985) and supported by the large theoretical literature on the macroeconomic effects of higher energy prices (see Bruno and Sachs, 1982). We therefore use the unrestricted form in modelling the degree of misalignment of the real exchange rate.

Exchange rate misalignment is interpreted as the gap between e and e^*, constituting the error term from model 2. Given the logarithmic form, the magnitude of the error can be interpreted as the percent deviation of the actual real exchange rate from the predicted (equilibrium) value. The extent of misalignment is conditional on the fundamentals and by assumption is necessarily a temporary phenomenon. The DW statistics suggest serial correlation of the error terms; this is to be expected given nominal rigidities in the market place and the absence of short-run dynamics in the static model.

Figure 4a provides a time plot of the actual and fitted values while figure 4b maps out the time path of the error terms where the latter are interpreted as the extent of exchange rate misalignment. On the basis of the static model, the Australian real exchange rate was 7 percent below its equilibrium value in the December quarter of 2000. Such misalignment is not unique to this period since misalignments of similar magnitude took place in the September quarter of 1986 and the June quarter of 1995. Misalignments in the opposite direction are just as common as shown by figure 4b. Restricting the beginning of the sample period from March 1984 since when the currency has been floating and entering exports and imports, as shares in GDP, separately does not alter the qualitative findings.

Gregory (1990) and Gruen and Wilkinson (1994) even when the sample periods considered are very different.

Here we concentrate on the IV estimates for the unrestricted ECM, reported in the last column of table 3, since it provides better diagnostics than the rest even though the residuals from the left-hand column provide the same qualitative conclusions.[9] With the exception of the coefficient on openness, all of the parameter estimates strongly corroborate the theoretical model. The fitted values for the logarithm of the real exchange rate closely match actual values as shown in figures 5a &b. The positive coefficients for RESGDP suggests that an increase in net capital in-flows, inducing a decrease in the resource balance, raises domestic absorption and shifts the composition of potential output towards non-traded goods. The unit elasticity of the real exchange rate with respect to the resource balance implies a one-for-one relationship between percentage increases in the resource gap and appreciation of the real exchange.

Shocks to the terms of trade have the expected qualitative effects; the surprise here is that the magnitude of this impact is not the same for import as export prices. The reasons for this anomaly is beyond the purview of this paper, though this observation is consistent with those made by Hinkle and Montiel (1999, chapter 1) in the context of developing countries and Wells and Evans (1985) for New Zealand. The coefficient on the openness variable is consistently positive, suggesting that trade liberalisation has, all-else-equal, had an appreciating effect on the equilibrium real exchange rate.[10] The coefficient on the error correction term less 1 provides the point estimate of α, which measures the speed of

[9] As part of the tests for robustness of the reported findings, alternative specification using the terms of trade and exports and imports as a proportion of GDP was used to estimate the long-run and short-run models both for the full sample and for the period of the float. The results are reported in appendix, tables A1 and A2. The qualitative findings remain unaffected from these changed specification to the model.

adjustment. The point estimate of 0.41 suggests that a 10 percent misalignment in RER is reduced to 4 percent in one quarter. Such adjustments have indeed been the norm except for the three occasions shown in figure 5b, of which December 2000 was not one. This last observation suggests that once short-run dynamics are taken into account, the recent overshooting of the Australian real exchange rate is nothing extraordinary.

The behaviour of the real exchange rate (see figure 5b) shows periods of instability. One such period was centred around June 1986, the other between March 1998 and June 1999. It would be of interest to investigate any unusual interventions in these periods. The distribution of the error terms – call it misalignments after short-run dynamics have been accounted for – appear normal as shown by figure 6. This observation lends considerable credence to the market efficiency hypothesis, except for the two periods noted above.

Conclusions

According to the estimates reported here, the real exchange rate was below its equilibrium value as of December 2000 by seven percent. This is small relative to the magnitudes of misalignment suggested by simple purchasing power parity estimates. Given that the extent of this overshooting is not unprecedented, the above findings lend considerable support to the efficacy of exchange rate markets. The only disconcerting observation is that at the tail end of the period of study, the misalignments – after short-run dynamics were accounted for – exceeded the 95 percent confidence band suggesting that some unusual factors could have been in play then.

[10] This result is contrary to expectation.

We used a single equation regression model to gauge the level of the real equilibrium exchange rate. The gap between this unobserved variable and the observed real exchange rate is interpreted as the extent of misalignment. The diagnostics from the models suggest that the estimates are acceptable on statistical considerations. There are several qualifications that need to be taken into account in interpreting these results, however. For example, the single equation methodology ignores the processes that drive the formation of the particular fundamentals[11] and conditions on the current values and lagged values of a subset of the fundamentals. Furthermore, we have made the small country assumption, which is obviously not valid for some of the export commodities, including wool. It therefore remains an interesting research question to test the robustness of the above findings in the context of a more realistic global model that incorporates inter temporal budgetary constraints, allows for capital flows, and incorporates short-term nominal rigidities in the markets.[12]

Despite the above reservations, the fit of the predicted and actual values from the model, together with the favourable diagnostics, provide strong support to the proposition that the real exchange rate has overshot, but to within levels seen before. The estimates suggest that a bounce back in the real exchange rate of modest magnitudes can be anticipated unless the terms-of-trade, import prices in particular, turn for the worse. The estimates also provide indications of the sensitivity of the real exchange rate to the

[11] All that is required for efficient estimation and inference is weak exogeneity implying that there are no cross-equation restrictions between the model in equation (7) and the larger system that jointly determines all of the fundamentals. For forecasting and simulations, we would need strong exogeneity in that there is no feedback from the real exchange rate to the fundamentals. For completeness, super exogeneity would be necessary for β to be constant as the fundamentals shift as a defence against the Lucas critique (See Baffes, et al (1999:422)).
[12] McKibbin and Vines (2000) present one such possibility.

resource gap, an issue of concern in the current budgetary climate, given the forthcoming Commonwealth elections. The issues that remain to be explored include an investigation into the reasons for the anomalous behaviour between March 1998 and June 1999.

Table 1: Stationarity and some other basic statistics

	DF (without time trend)	Mean	St. Deviation
log (RER)	-1.52	4.71	0.12
log(TOT)	-1.60	0.89	0.073
log(P^X)	-1.24	4.47	0.15
log(P^M)	-2.03	4.60	0.20
Open	-0.17	0.32	0.062
RESGDP	-1.54	-0.019	0.013

DF refers to Dickey-Fuller stationarity statistics. There are 78 quarterly observations from September 1981 to December 2000. The 95 percent critical values for the DF-statistic is –2.8986.

Figure 1: Australian exchange rates, actual relative to period mean (Jan 70 to Dec '00).

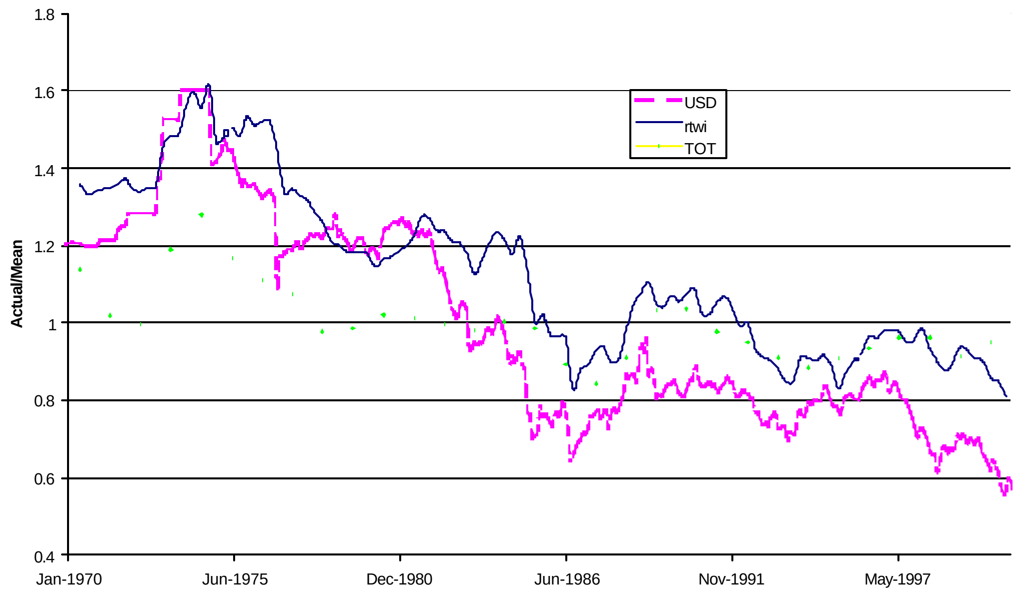


Figure 3: Time plot of RTWI and Terms of Trade (TOT) Sep 1981 to Dec 2000.

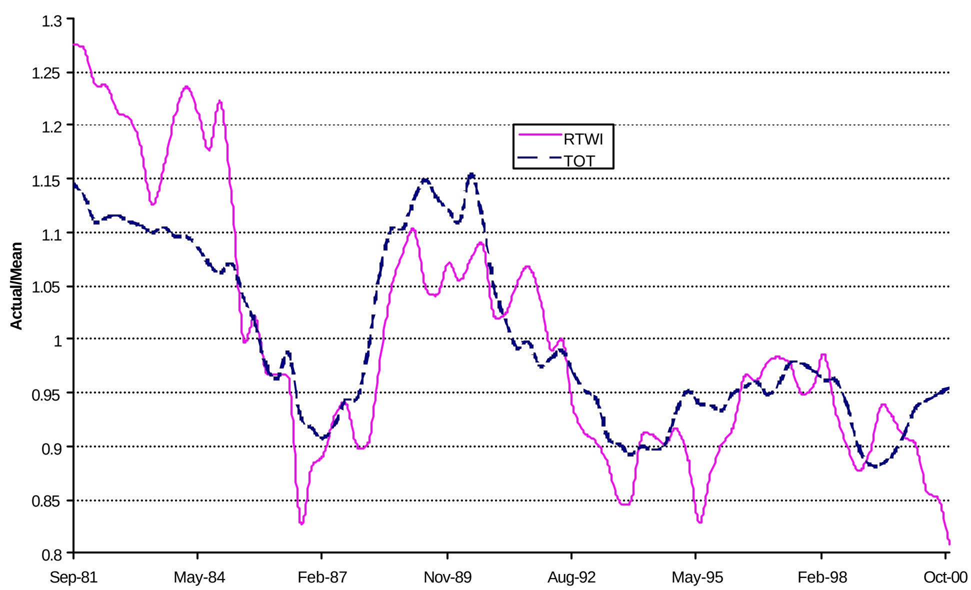


Table 2: Long-run parameter estimates using import and export prices individually, and the composite terms of trade index.

	Model 1	Model 2
Constant	4.95 (126.37)	7.11 (42.42)
log(TOT)	0.97 (6.36)	
log(P^X)		0.77 (8.93)
log(P^M)		-1.33 (-14.85)
RESGDP	-0.84 (-1.11)	1.26 (2.81)
Open	-0.41 (-2.54)	0.83 (6.37)
Number of observations	78	78
Adjusted R^2	0.75	0.92
DW	0.41	0.66
DF	-2.69	-3.72
Serial correlation (χ^2, df = 12)	52.49 [0.00]	40.61 [0.00]

Note: 95 percent critical value for DF statistic is –4.61. Terms of trade has been used as a single variable in model 1 while export and import prices are used separately in the second model. t-statistics given in parenthesis while p-values provided in brackets. The dependent variable is log (RER).

Figure 4a: Actual and fitted values for log (RER) from the long-run model

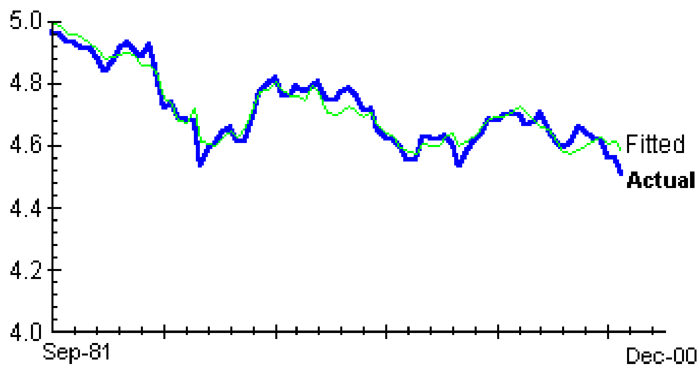


Figure 4b: Residuals from the long-run model and two standard-error bands

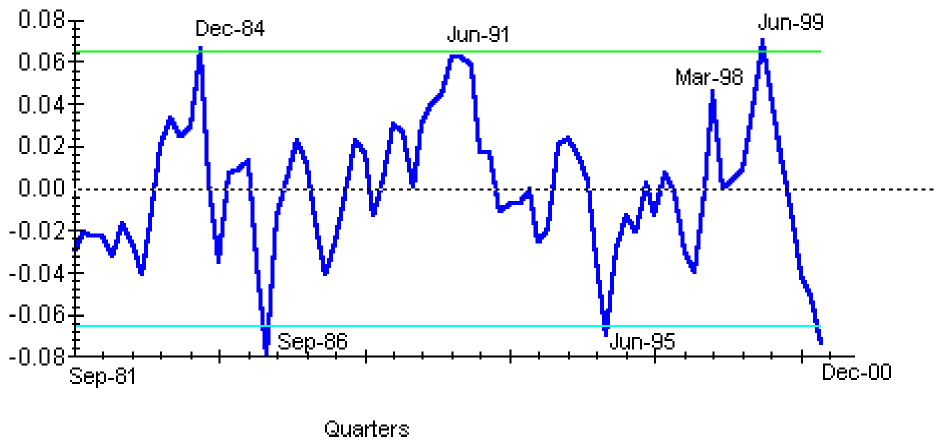


Table 3: ECM parameter estimates using import and export prices individually.

	Two-step ECM		Unrestricted ECM	
	OLS	IV	OLS	IV
Constant	7.03 (77.85)	7.19 (48.62)	2.64 (5.59)	3.03 (2.57)
Error (Model 1) $_{t-1}$	0.61 (9.31)	0.59 (3.41)	–	–
log(RER)$_{t-1}$	–	–	0.61 (9.31)	0.59 (3.41)
log(P^X) $_{t-1}$	0.80 (17.62)	0.92 (8.83)	0.32 (4.64)	0.47 (3.38)
log(P^M) $_{t-1}$	-1.33 (-28.41)	-1.49 (-13.03)	-0.51 (-5.16)	-0.72 (-3.43)
RESGDP $_{t-1}$	1.04 (4.37)	1.73 (3.14)	0.27 (1.08)	1.00 (1.96)
Open $_{t-1}$	0.76 (11.06)	0.94 (7.30)	0.25 (2.86)	0.46 (3.05)
Δlog(P^X)	0.13 (1.25)	0.64 (1.01)	0.13 (1.24)	0.64 (1.01)
Δlog(P^M)	-1.26 (-11.82)	-1.75 (-2.23)	-1.25 (-11.82)	-1.76 (-2.23)
ΔRESGDP	0.27 (0.46)	2.67 (1.49)	0.28 (0.47)	2.67 (1.48)
Δ (Open)	1.00 (1.78)	1.81 (0.82)	1.00 (1.77)	1.81 (0.81)
Number of observations	77	75	77	75
Serial correlation (χ^2, df = 12)	17.71 [0.13]	12.42 [0.41]	17. 71 [0.13]	12.42 [0.41]
Functional form (χ^2, df = 1)	0.60 [0.44]	0.15 [0.70]	0.59 [0.44]	0.15 [0.70]
Normality (χ^2, df = 2)	11.26 [0.004]	1.52 [0.46]	11.26 [0.004]	1.52 [0.46]

Note: t-statistics given in parenthesis while p-values quoted in brackets. The dependent variable is log (RER). Note that the Bewley transform, results for which are reported above, distort the error terms invalidating the R^2 measure and hence its absence from the above table.

Figure 5a: Actual and fitted values from IV estimates of unrestricted ECM

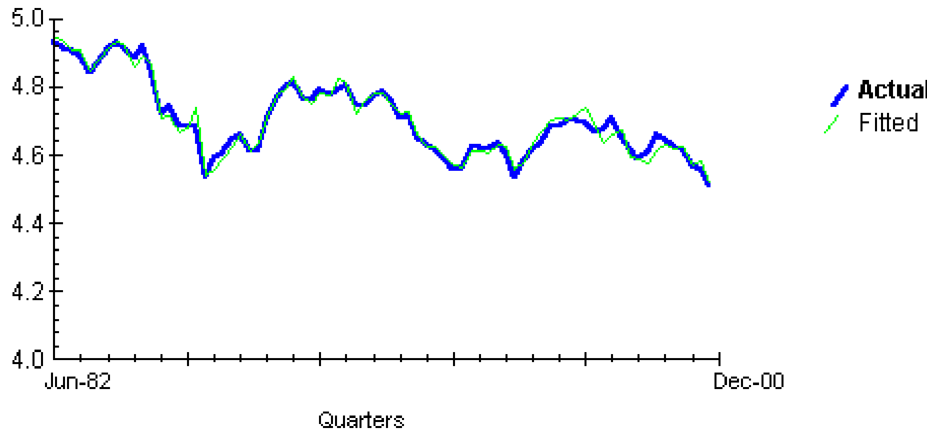


Figure 5b: Residuals from the IV estimate for the unrestricted ECM and two standard-error bands

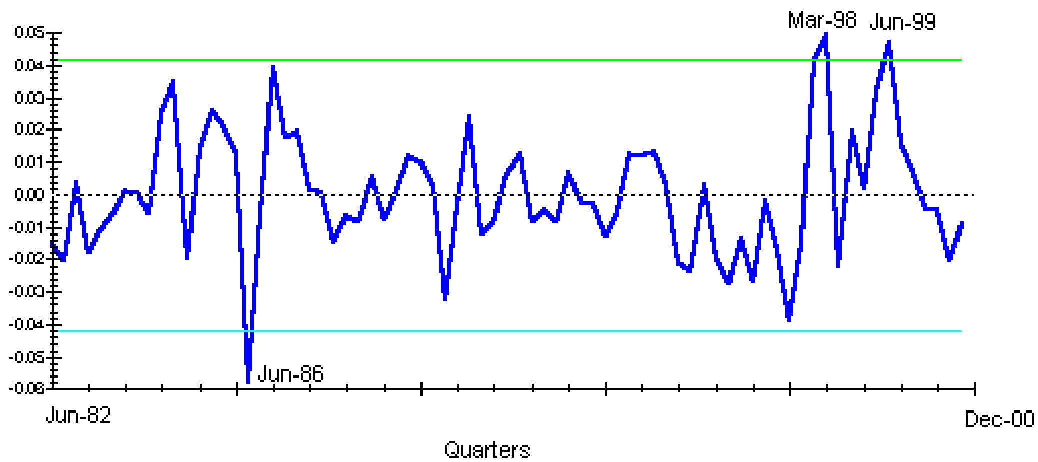


Figure 6: Histogram of residuals and the normal density function

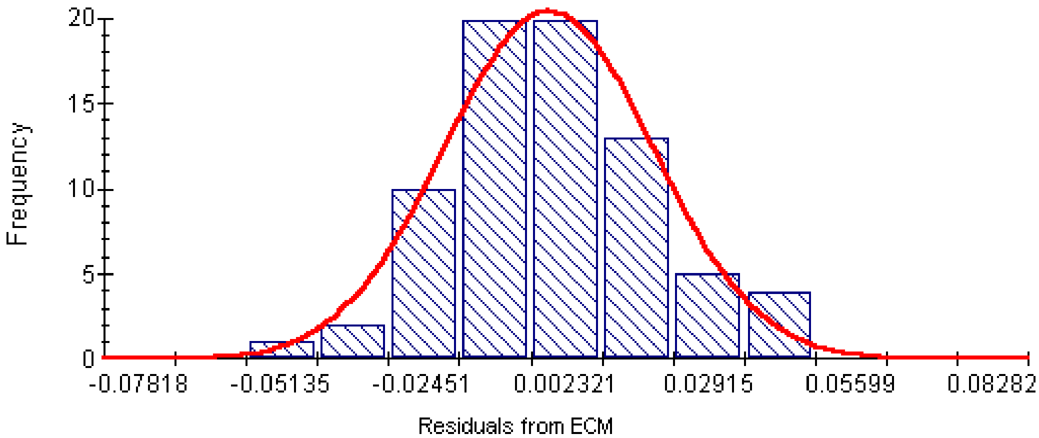


Table A1: Long-run parameter estimates using the composite terms of trade index, import and export ratios for the full sample and that for the period of the float.

	Full sample	From 1984 to 2000
Constant	4.95 (126.37)	4.87 (116.45)
log(TOT)	0.98 (6.36)	0.91 (6.21)
Exports/GDP	-1.24 (-1.48)	-0.40 (-0.49)
Imports/GDP	0.43 (0.62)	0.013 (0.019)
Number of observations	78	68
Adjusted R^2	0.76	0.63
Serial correlation (χ^2, df = 12)	52.49 [0.00]	41.35 [0.00]
Functional form (χ^2, df = 1)	2.15 [0.14]	0.47 [0.49]
Normality (χ^2, df = 2)	2.55 [0.28]	0.75 [0.69]

Note: Terms of trade has been used as a single variable, the sample period is restricted to the period of the float in the estimates reported in the last right-hand column. t-statistics given in parenthesis while p-values provided in brackets. The dependent variable is log (RER).

Table A2: ECM parameter estimates using terms of trade and exports and imports as ratios of GDP.

Dependent variable	*ln(RER)*		*Dln(RER)*
	OLS	IV	OLS
Constant	1.22 (3.34)	1.41 (2.23)	1.22 (3.35)
ln(RER)$_{t-1}$	0.75 (10.21)	0.71 (5.53)	-0.25 (-3.31)
ln(P^X/P^M)$_{t-1}$	0.30 (2.60)	0.27 (1.12)	0.30 (2.60)
(Exports/GDP)$_{t-1}$	0.21 (0.41)	-1.19 (-0.12))	0.21 (0.42)
(Imports/GDP)$_{t-1}$	-0.41 (-0.98)	-0.10 (-0.087))	-0.42 (-0.98)
$\Delta(P^X/P^M)$	0.65 (3.21)	-0.49 (-0.36)	0.65 (3.21)
Δ(Exports/GDP)	1.61 (0.83)	8.99 (0.85)	1.61 (0.83)
Δ(Exports/GDP)	2.98 (2.31)	8.99 (0.85)	2.98 (2.31)
Number of observations	77	75	77
Adj. R^2	0.91	0.82	0.28
Serial correlation (χ^2, df = 12)	11.22 [0.51]	9.94 [0.62]	11.22 [0.51]
Functional form (χ^2, df = 1)	3.68 [0.06]	0.21 [0.64]	2.10 [0.15]
Normality (χ^2, df = 2)	3.79 [0.15]	27.19 [0.00]	3.79 [0.15]

Note: t-statistics given in parenthesis while p-values quoted in brackets. Note that estimates from the Bewley transform are reported in the first two columns while that for the standard ECM is reported in the last column.

Data Appendix

Variable definitions and sources of data are as follows.

Real Exchange Rate (RER). This is the ratio of foreign trade weighted index of wholesale prices expressed in $A converted at the relevant official exchange rate to home country consumer price index (CPI). This data was sourced from the Reserve Bank of Australia via Aruman and Dungey (2001). The data is available on a quarterly basis from June 1970 to December 2000.

Price of Exports (P^X). This is the price index for exports sourced from the Australian Bureau of Statistics (ABS) publication with catalogue number 6405.0. The complete time series extends from September 1974 to December 2000.

Price of Imports (P^M). This is the price index for imports sourced from the Australian Bureau of Statistics (ABS) publication with catalogue number 6414.0. The complete time series extends from September 1981 to December 2000; hence the span of our analysis in this paper.

Terms of Trade (TOT). The terms of trade is defined as the ratio of P^X to P^M.

Resource Balance to GDP Ratio (RESGDP). This is derived as follows: The value of exports less the value of imports divided by GDP all at constant prices. The data on exports and imports is drawn from the Australian Bureau of Statistics (ABS) publication with catalogue number 5206.0.

Openness (OPEN). The index for openness is the ratio of total trade to GDP all at constant prices. The data on constant price GDP, exports, and imports are all drawn from the Australian Bureau of Statistics (ABS) publication with catalogue number 5206.0.

Productivity, measured as GDP per hour worked and investment share, both sourced from ABS cat# 5206.0, were also used in the sensitivity analysis of our empirical findings.

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