THE IMPACT OF REAL AND NOMINAL SHOCKS ON AUSTRALIAN REAL EXCHANGE RATES

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ABSTRACT

This paper examines the behaviour of the real Australian dollar exchange rates against the US dollar and Japanese yen over the last two decades. It is argued that country differences in relative productivity growth in the traded goods sectors can help explain movements in the real rates. Using time series techniques together with restrictions derived from standard models of real exchange rate determination, the importance of real and nominal shocks to the real exchange rates are analysed. Both types of shocks are found to be important in explaining short-run deviations from Purchasing Power Parity, with the nominal shocks being more important for the rate against the US dollar than the rate against the yen.

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1. INTRODUCTION

There is a vast literature examining the Purchasing Power Parity (PPP) hypothesis.[1] The latest battery of tests centre on testing for a unit root in real exchange rates. Essentially, these tests ask the following question: should a positive innovation in the real exchange rate *today* lead one to revise upward one's forecast for all future horizons? The answer to this question must surely be *it depends*. Specifically, it depends upon the nature of the shock. Most models of exchange rate determination predict that a monetary shock will have no long run effect on the real exchange rate, although sticky prices may result in some short run effect. In contrast, models of exchange rate determination which are equipped to analyse the impact of structural shocks, predict that such factors as changes in relative productivities can permanently alter real exchange rates.

Theory clearly suggests that the nature of the real exchange rate response depends critically upon the type the shock. The real exchange rate will, however, exhibit a unit root if there are *any* shocks with permanent effects. Thus, while the finding that a unit root exists is informative, it provides no evidence on the relative importance of the permanent shocks. One way to examine this issue is to explicitly allow for shocks from different sources. This is the approach taken in this paper. A standard model of exchange rate determination is used to provide the restrictions needed to identify the two types of shocks most frequently discussed in models of the real exchange rate, namely real and monetary shocks. This approach helps provide answers to two questions of interest. First, how important are real versus monetary shocks in deviations from PPP? Second, how does price sluggishness influence real exchange rate and unemployment dynamics in response to real and monetary shocks.

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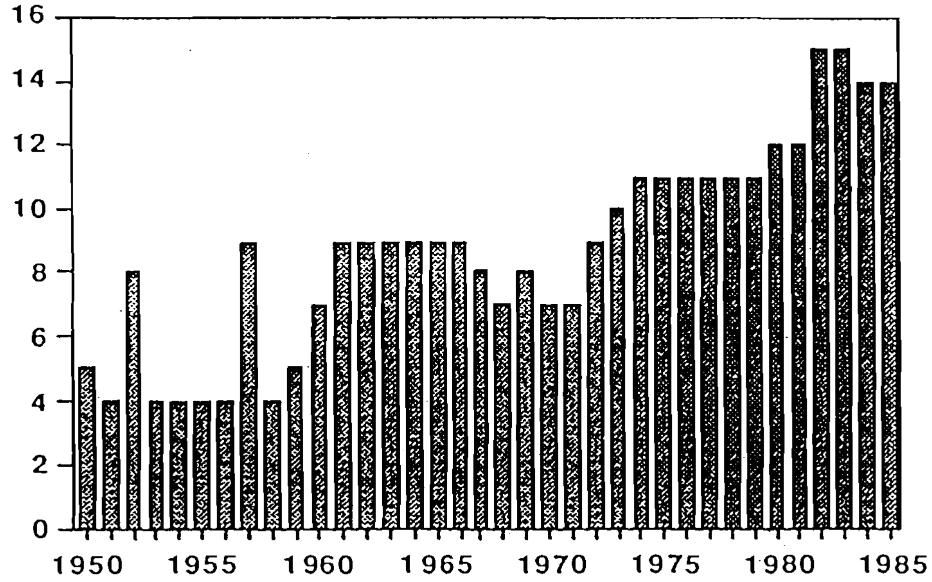
[1] See Dornbusch (1988) for a comprehensive review of the Purchasing Power Parity literature.

Huizinga (1987) in a study of real exchange rates finds a degree of mean reversion in most bilateral real rates. In a world characterised by both real and monetary shocks such a pattern might well be expected. In related work, Mark (1990) examines deviations from PPP for a range of currencies and concludes that Keynesian models suggest that shocks to real exchange rates are due principally to exogenous shifts in aggregate demand, while equilibrium models suggest that monetary factors have been more important. Daniel (1986) finds important roles for both price stickiness and real shocks in real exchange rate changes. These studies do not explicitly identify the various shocks with theoretically derived restrictions, nor do they examine the relative importance of the various shocks at different forecast horizons.

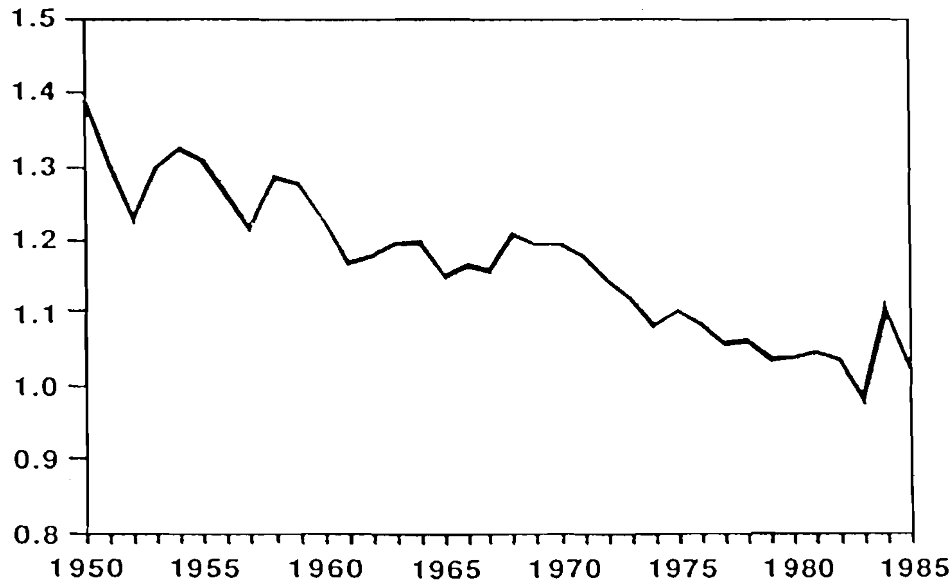
The paper begins with an examination of the long run. In doing so, questions concerning monetary factors and the extent of short-run wage and price flexibility recede into the background with real shocks providing the principal explanation for changes in real exchange rates. Provided prices and wages are flexible in the long run most models predict long-run monetary neutrality. They also predict that both monetary and real shocks have no long-term effect on the unemployment rate. In contrast, in the short run, price rigidities play a potentially important role in exchange rate and unemployment dynamics in response to both types of shocks.

The analysis is focused on Australian dollar real exchange rates. They provide a particularly interesting case to study. Since the Second World War Australia's terms of trade have shown secular decline and have been significantly more volatile than those of most other OECD nations. Australia's productivity performance, measured by growth in per-capita income, has also been poor relative to that of other members of the OECD. Graph 1(a) shows Australia's rank amongst 22 OECD nations in terms of Summers and Heston's (1988) internationally comparable measures of income per capita. Australia's income per capita relative to that of the average of 22 other OECD countries is shown in Graph 1(b). Australia's performance has clearly been inferior to that of the OECD as a whole. In 1950 its per capita income was 5th highest in the world. By 1985 it had fallen to 14th highest. Gruen (1986) using Summers and Heston's data up until 1977 suggested that Australia's relative decline may have slowed by the mid 1970s. The results in these graphs suggest that this has not been the case. Gruen identifies low rates of capital formation, product and labour market rigidities, protection from world

Graph 1(a): Australia's Rank in Income per Capita
Amongst OECD Countries



Graph 1(b): Australian Income per Capita
Relative to OECD Average



markets and rent seeking by the major actors in the economy as principal causes of this poor productivity performance.

While recent studies on longer-run changes in Australia's real exchange rate have focussed on the terms of trade (McKenzie (1986) and Blundell-Wignall and Gregory (1990)) little attention has been given to the importance of this relatively poor productivity performance. Relative productivity decline is more gradual than the sometimes sudden and dramatic changes in the terms of trade. This more gradual change makes its role in real exchange determination less immediately apparent, yet models of the real exchange rate suggest that it is an important factor. Empirical work by Hsieh (1982) shows that changes in Japanese and German real exchange rates are well described by a simple relative productivities model. More recently, work by Marston (1990) and Bergstrand (1991) also supports the relative productivities model. Section 2 examines Australian dollar real exchange rates and Australia's relative productivity performance over the period from 1970 to 1990. The focus is on the Australian dollar/US dollar (AUD/USD) and the Australian dollar/Japanese yen (AUD/YEN) exchange rates.

In the following section attention turns to shorter-run exchange rate dynamics. The joint behaviour of the real exchange rate and unemployment rates is used, together with long-run restrictions on the effect of various shocks, to examine the relative importance of these shocks in deviations from PPP in both the short run and the long run. The approach is adopted from Blanchard and Quah (1989). They examine the relative importance of supply and demand shocks in USA real GDP and unemployment dynamics.

Shocks from three sources are identified. All three shocks are assumed to be uncorrelated and to have no long-run effect on either countries' unemployment rate. The first shock is permitted to alter permanently the real bilateral exchange rate. The second and third types of shocks are, however, not permitted to have any long-run impact on the real exchange rate. As in Blanchard and Quah (1989) the shocks are defined by the identification restrictions imposed, but using the exchange rate determination model in Mussa (1984), each has an economic meaning. The two disturbances that are not permitted to alter the real exchange rate can be thought of as nominal shocks, one originating in each country. The shock which is allowed to alter permanently the real bilateral exchange rate can be interpreted as a real shock, say a shock to relative productivities or to the terms of trade. Section 3 of the paper discusses the identification of each of the three shocks. This is followed in Section 4 by the presentation of the results. Finally, Section 5 concludes and summarises.

2. REAL EXCHANGE RATES AND PRODUCTIVITY GROWTH

This section examines changes in the AUD/USD and AUD/YEN real exchange rates over the previous two decades. It begins with an examination of the changes. Discussion of a simple model of real exchange rates follows. The model is then used to interpret the observed changes.

The real exchange rate (R) is defined by:

$$R \equiv \frac{EP}{P^*} \tag{1}$$

where P (P^*) is the domestic (foreign) price level and E is the spot exchange rate, defined as the foreign currency cost of one unit of domestic currency. An increase in R represents a real appreciation. To construct an empirical measure of R a price index must be chosen. Three indices have commonly been used: the Consumer Price Index (CPI), the Wholesale Price Index (WPI) and the GDP deflator. Given that these three price indices are based on different baskets of goods, they should only yield the same results if there are no sector specific price shocks. McKenzie's (1986) study of Australia's effective real exchange rate found little difference in the CPI and WPI based measures. Here, bilateral real exchange rates are calculated using both the CPI and WPI.[2] The results are shown in Graphs 2 and 3. In the case of the AUD/YEN rate the two measures lead to quite different results.

Graph 2 presents the AUD/USD real exchange rate for the period from 1970 to 1990. It shows that while the net change in the real exchange rate over the period in not greatly influenced by the choice of price index there was a long period in the 1970s and the early 1980s when the CPI based measure showed considerably greater appreciation of the AUD than did the WPI based

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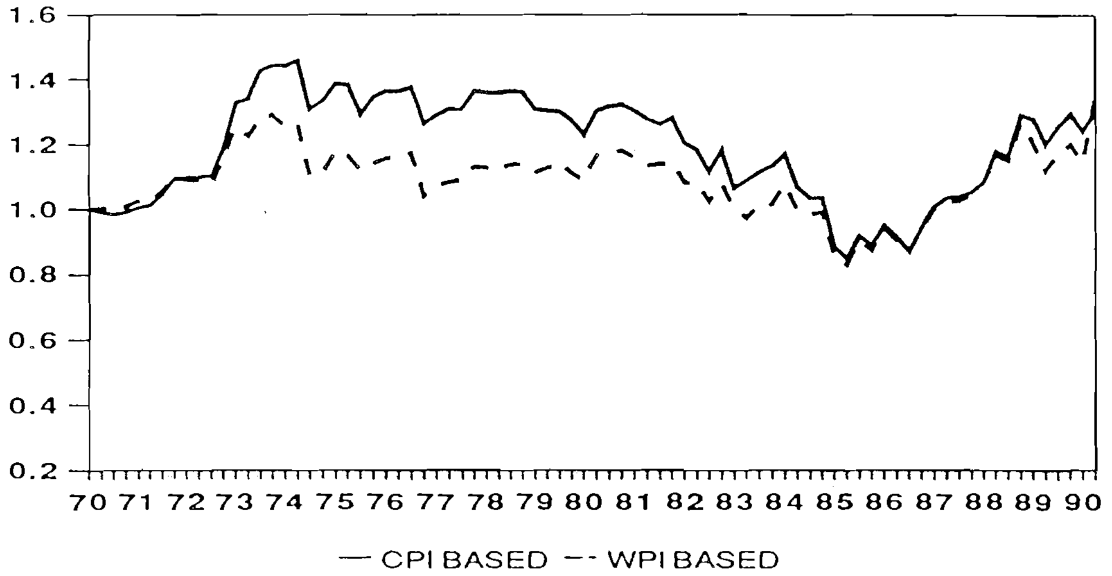
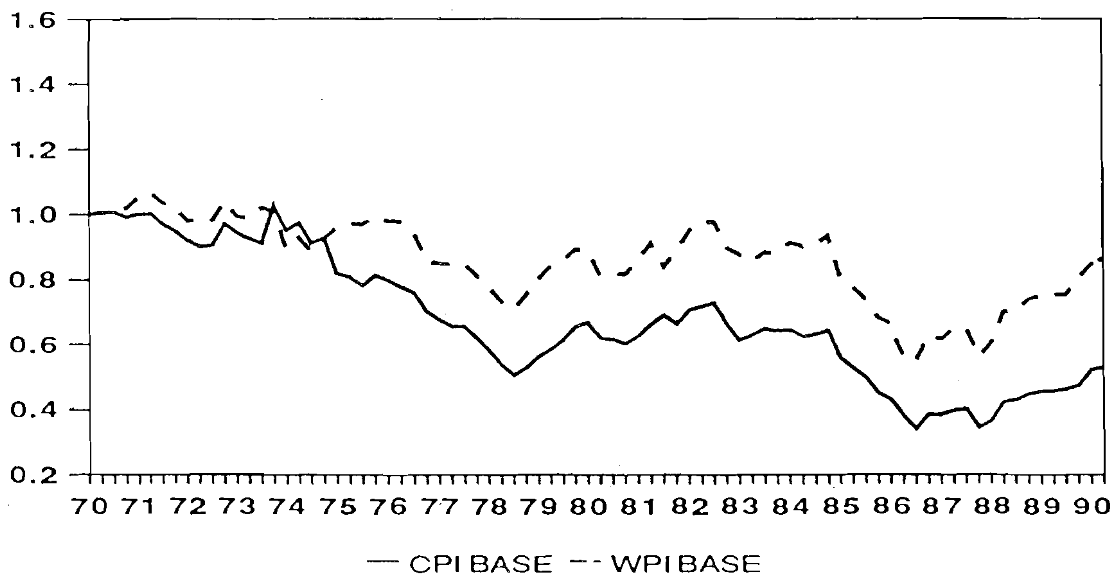
[2] The exchange rate, price indices, and the terms of trade data used in this section are from the IMF's International Financial Statistics.

Graph 2: AUD/USD Real Exchange Rate



Graph 3: AUD/YEN Real Exchange Rate



measure. Using either measure suggests that there has been some real appreciation against the USD since 1970. However, if 1973 had been chosen as the initial date the two measures would yield conflicting results; the CPI suggesting some real depreciation, the WPI some real appreciation.

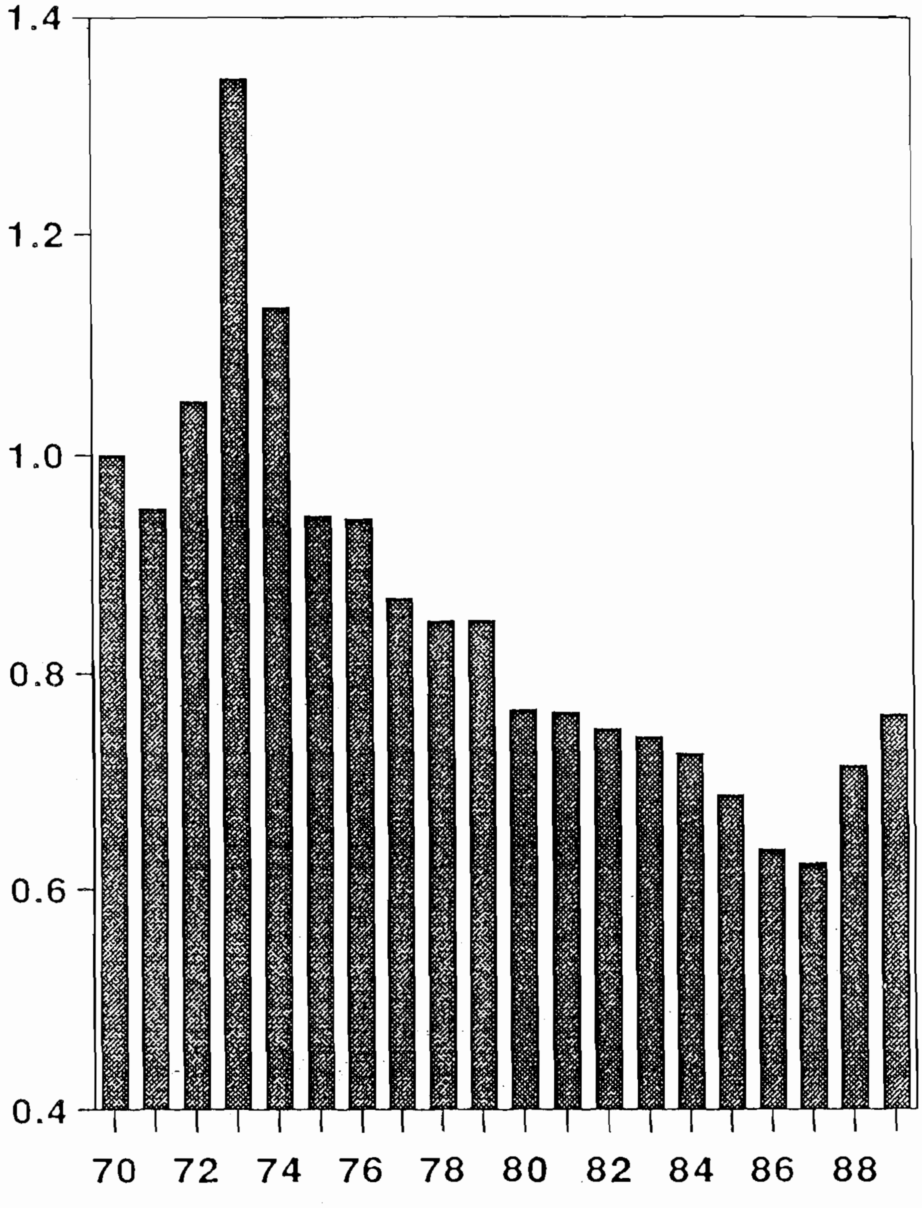
Graph 4 shows Australia's terms of trade over the last 20 years. As McKenzie notes, major changes in Australia's real exchange rate have often been associated with terms of trade changes. Three phases can be clearly distinguished from the graph: the rapid terms of trade improvement in 1973, the period of secular deterioration of the terms of trade between 1974 and 1987 and the period since 1987 which has been characterised by an improvement in the terms of trade. Each of these three periods are associated with changes in the AUD/USD exchange rate in the direction expected.

Graph 3 shows the AUD/YEN real exchange rate. It is clear from this graph that there has been secular real depreciation of the Australian dollar against the yen. The extent of this depreciation is, however, quite sensitive to the choice of price index. The CPI based measure shows a real depreciation of almost 45 per cent while the WPI based measure shows a depreciation of less than 15 per cent. The evidence presented below attributes this large disparity to differences in the rate of change in relative prices within Australia and Japan. The CPI has a much larger weight on non-tradeables than does the WPI. With Japanese non-tradeables prices increasing much faster than the prices of tradeables, the Japanese CPI has increased much faster than the WPI. This has resulted in a more significant real appreciation of the Japanese yen using the CPI based measure. The impact of changes in the terms of trade can also be seen in the AUD/YEN real exchange rate. Their effect is, however, much less pronounced than for the AUD/USD rate.

The principal models of real exchange rate determination generally yield one of two interpretations of the real exchange rate. In one class of models the real exchange rate is given by the terms of trade while in the other it is given by the price of non-tradeables relative to tradeables. These measures of the real exchange rate are equivalent to the above empirically used measure only under a number of relatively strict assumptions.

The real exchange rate is identified with the terms of trade if all goods are assumed tradeable and there are no impediments to trade. This definition of

Graph 4: Australia's Terms of Trade



R falls out of standard two commodity, two country models of international trade. In the Ricardian model of trade, in which there is a continuum of goods, the equivalent definition of the real exchange rate is given by relative wages in the two countries (see Dornbusch, Fischer and Samuelson (1977)).

In the second set of models non-traded goods are introduced while the terms of trade are assumed exogenous and fixed. Given the fixed terms of trade, the prices of importables and exportables can be aggregated into a single price index, known as the prices of tradeables. The domestic and foreign prices indices are thus given by:

$$\begin{aligned} P &\equiv P_T^{\,1-\alpha} \, P_N^{\,\alpha} \\ P^* &\equiv P_T^{*\,1-\alpha} \, P_N^{*\,\alpha} \end{aligned} \tag{2}$$

where P_T is the price of tradeables and P_N is the price of non-tradeables. Starred (*) variables refer to the foreign country. Substituting (2) into (1) the real exchange rate can be expressed as:

$$R \equiv \frac{\left[\dfrac{P_N}{P_T}\right]^{\alpha} P_T \, E}{\left[\dfrac{P_N^*}{P_T^*}\right]^{\alpha} P_T^*} \tag{3}$$

If the Law of One Price holds then $P_T E = P_T^*$. The real exchange rate is thus the relative price of non-traded goods at home divided by the relative price of non-tradeables abroad. An increase in the home price of non-traded goods represents a real appreciation of the domestic currency.

A critical aspect of this interpretation of the real exchange rate is the assumption that the terms of trade are exogenous. At a first approximation it is a reasonable assumption for Australia. Australia's share of world trade is small and her trading structure is highly specialised. In 1987 Australia accounted for 1.12 per cent of world trade. Its specialised trade structure is evidenced in its low level of intra-industry trade. In 1987 such trade accounted for just 12 per cent of trade. This compares with an average of 37 per cent for the entire OECD.[3] Developments in trade theory over recent years suggest that the low level of intra-industry trade reflects little trade in differentiated products where market power is strongest. While Australia may enjoy some market power in some of its primary commodity export markets, the exogenous terms of trade remains a reasonable assumption.

The above model is a not a complete model of exchange rates as the factors determining prices have not been specified. To tie down the relative prices the dependent economy model developed by Salter (1959) and Swan (1960,1963) is used.[4] The set-up is standard. There are two sectors: traded and non-traded. Goods in each sector are produced using labour and capital with constant returns to scale. Labour is mobile across sectors but capital is sector specific. Diminishing returns to labour are assumed. Factor returns and the price of non-tradeables are flexible ensuring a continuous full employment equilibrium. Equilibrium is defined by simultaneous domestic and external balance.

Within the context of this structure consider the effect of a productivity improvement in the home country's traded goods sector. At initial prices, the productivity shock increases demand for labour in the traded goods sector. This forces up the wage in terms of non-traded goods prices and causes output and employment to fall in the non-traded goods sector. Labour thus moves from the non-traded to the traded goods sector. At constant prices this results in excess demand for non-traded goods. To re-establish equilibrium the price of non-traded goods must increase relative to that of traded goods. That is, the real exchange rate must appreciate. Assuming no productivity growth in either country's non-traded goods sector, changes in the real exchange rate reflect differences in relative productivity growth in the two countries' traded goods sectors.

So far the terms of trade have been assumed exogenous and held constant. Suppose now that there is an exogenous increase in the demand for the home country's exports which increases their price. On the demand side this has

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[3] The intra-industry trade shares are calculated using SITC 3 digit bilateral trade data. See Lowe (1991) for additional details.

[4] Dornbusch (1980) provides a clear description of this model.

both an income and substitution effect on the market for non-traded goods. Higher export income increases the demand for non-tradeables (assuming a positive income elasticity) while the higher prices of exportables leads to some substitution in consumption toward non-traded goods. On the supply side there is substitution away from non-traded goods. These developments result in an excess demand for non-traded goods. To re-establish equilibrium the relative price of non-traded goods must increase; the real exchange rate must appreciate.

Bringing the data to this simple model of real exchange rate determination is not a straightforward task. Debate exists over what constitutes tradeable and non-tradeable goods and how to measure the appropriate price indices.[5] Data limitations invariably constrain the choices made. In this paper the OECD Intersectoral Database is used. This database reports output and employment data for 10 different sectors for 14 OECD countries[6] over the period 1960 to 1985. Unfortunately, complete data exist for all countries only for the years 1970 through 1985.

Output of the agricultural, mining and manufacturing sectors is classified as output of the tradeable goods sector while the output of the remaining seven sectors[7] is classified as non-tradeable. To construct a measure of labour productivity, output in constant 1980 prices is divided by total employment.[8]

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[5] See Goldstein and Officer (1979) for a discussion of these issues.

[6] The countries are USA, Japan, Canada, Germany, France, United Kingdom, Italy, Australia, Netherlands, Belgium, Denmark, Norway, Sweden and Finland.

[7] These sectors are (i) Electricity, gas and water, (ii) Construction, (iii) Wholesale, retail trade, restaurants and hotels, (iv) Transportation, storage and communication, (v) Finance, insurance and real estate, (vi) Community, social and personal services and (vii) Producers of government services. Data do not exist for the mining sectors of Belgium, France, Italy and the United Kingdom and for the finance, insurance and real estate sectors for Italy and the Netherlands.

[8] This measure of sectoral productivity has a number of problems. The classification system is far from perfect. Even if it were possible to distinguish between tradable and non-tradeable goods at a high level of disaggregation, international comparable data exist only at the one digit level of classification. This inevitably leads to some misclassification. For example, some financial services have increasingly become tradeable "goods" in recent years, yet are classified as non-tradeable. Such problems suggest that the results should not be taken as exact measurement of productivity performance in the different sectors but

Price indices for the non-traded and traded goods sectors are constructed by dividing the current value of output by the value of output in 1980 prices. Price indices and labour productivity indices have also been calculated for the manufacturing sector. In most countries these closely mirror those of the tradeable goods sector. In countries such as Australia, where manufacturing output makes up a smaller than average share of the output of the tradeables sector, potentially large differences can exist in productivity growth in the manufacturing sector and the traded goods sector more generally.

Table 1 presents changes in relative prices and the growth of labour productivity between 1970 and 1985 for the different sectors. Data are reported for Australia, the USA and Japan. For purposes of comparison, data for the average of the other eleven countries are also reported. Before the results for Australia are examined two general points can be made. First, productivity growth has been considerably faster in the traded goods sector than in the non-traded goods sector. For the 14 countries the average increase in productivity in the traded goods sector over the 15 years has been 85 per cent. This compares with a figure of 21 per cent for the non-traded goods sector. The second point is that there has been a general increase in the relative price of non-tradeables. In light of the productivity numbers this is hardly surprising. As expected the changes in relative prices are highly correlated with changes in relative productivities. For the fourteen countries the correlation coefficient between productivity growth in manufacturing relative to non-traded goods and the relative price of manufactured goods in terms of non-traded goods is -0.83. For the entire traded goods sector the correlation is -0.30.

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rather should be interpreted as showing broad trends. A second problem is that total employment is used in the denominator. When the number of hours worked, or the extent of labour hoarding differs across either time or industry, total employment does not provide an accurate measure of labour input. However, given that our interest is in long term trends, these issues are likely to be unimportant.

Table 1: Productivity Growth and Relative Price Changes (1970-85)

	AUSTRALIA	USA	JAPAN	OTHER
RELATIVE PRICES (% Δ)				
P_N / P_T	+15	+20	+74	+19
P_N / P_M	+20	+37	+85	+29
PRODUCTIVITY GROWTH (%)				
Traded Goods (G_T)	60	44	158	84
Manufactures (G_M)	48	56	147	65
Non-Traded Goods (G_N)	16	4	42	21
$\frac{G_{T,AUS}}{G_{N,AUS}} \Big/ \frac{G_{T,FOR}}{G_{N,FOR}}$		0.99	0.76	0.93
$\frac{G_{M,AUS}}{G_{N,AUS}} \Big/ \frac{G_{M,FOR}}{G_{N,FOR}}$		0.85	0.74	0.96

NOTES

1. N subscripts refer to non-traded goods, T subscripts to traded goods and M subscripts to the manufacturing sector.
2. OTHER is a simple average of the data for the other eleven countries for which data is available.

Australian productivity performance in the non-traded goods sector has been broadly in line with the experience of most other OECD nations. It is less obvious that this has been the case in the manufacturing sector and the traded goods sector more generally. Productivity growth in the Australian manufacturing sector has been amongst the slowest of the 14 countries. Over the 15 years productivity in the Australian manufacturing sector increased 48 per cent. This compares with an average for the other 13 countries of 71 per cent. While faster productivity growth in the mining and agricultural sectors helped improve the performance of the entire traded goods sector, productivity growth in that sector has also been slower than average.

The simple real exchange rate model discussed above suggested that productivity growth in the traded goods sector relative to that in the non-traded goods sector was an important determinant of real exchange rate changes. The last block of Table 1 shows productivity growth in Australia's traded goods sector relative to that in the non-traded goods sector compared to that of the foreign country. A number less than one indicates that Australia's productivity growth in the traded goods sector relative to the non-traded goods sector has been slower than that of the foreign country. The comparison with the USA shows relative productivity growth in the traded goods sector to have been the same in Australia as in the USA. Relative productivity growth in manufacturing has, however, been faster in the USA. The results also suggest that productivity growth in the traded goods sector relative to that in the non-traded goods sector has been slower in Australia than the average for other OECD countries. Australia's performance has been particularly poor compared to that of Japan's. This is true both for the manufacturing sector and the entire traded goods sector.

While relative productivity performance has limited power in explaining short run exchange rate movements such changes are likely to help explain longer term changes. Unfortunately, insufficient data exists to test this proposition formally. Nevertheless, differences in the performance of the Australian dollar against the US dollar on the one hand and the yen on the other appear to be attributable to differences in relative productivity growth in the traded goods sector. If Australian productivity growth remains inferior to that of much of the OECD, then, in the absence of some sustained terms of trade improvement, the Australian dollar real exchange rates should be expected to depreciate in the medium and long term. This is especially the case for measures of the real exchange rate which are based on price indices which give a relatively high weight to non-traded goods.

3. REAL EXCHANGE RATE DYNAMICS IN RESPONSE TO REAL AND NOMINAL SHOCKS: THEORY AND IDENTIFICATION

In the previous section, questions of price flexibility were ignored as they should make little difference to net exchange rate changes over periods of decades. In the short run, however, price rigidities can have important implications for exchange rate and unemployment dynamics. There is considerable evidence that many prices are sticky in the short run.[9] Substantial research effort has recently been devoted to understanding the causes of these rigidities and their implications for output and employment, particularly in a closed economy (for a survey of this literature see Blanchard and Fischer (1989)).

The seminal work on the implications of price stickiness in an open economy is that of Dornbusch (1976). His model is essentially monetary in nature with its central focus being on the impact of monetary shocks on the exchange rate and output (and thus indirectly on unemployment). Given sticky prices in the short run, an increase in the money supply results in an immediate *real* depreciation. This real depreciation is the result of the nominal depreciation needed to sustain money market equilibrium. With an increase in money and with sticky prices, real balances increase and interest rates fall. To equalise the return on domestic and foreign assets the nominal exchange rate must thus be expected to appreciate. In a perfect foresight equilibrium this expectation is realised. The initial nominal depreciation followed by the appreciation implies that the nominal exchange rate initially overshoots its new equilibrium value. After the initial real depreciation, an increasing price level and the nominal appreciation work to restore the original level of the real exchange rate.[10] During the exchange rate adjustment process, the depreciated real exchange rate and lower interest rates stimulate demand and

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[9] For evidence on specific prices see Cecchetti (1986) and Kashyap (1988). For more general but less direct evidence see Gali (1989) and Fahrer (1990).

[10] Nominal exchange rate overshooting is not a necessary implication of this model. If the output elasticity with respect to the real exchange rate and the money demand elasticity with respect to output are both large the demand for money may increase sufficiently so that interest rates actually increase in the short run. In such a case the initial nominal depreciation would be followed by further depreciation. The real exchange rate would, however, follow much the same pattern as before: an initial depreciation followed by real appreciation to reestablish the original equilibrium.

reduce unemployment. This creates inflationary pressures which gradually erode the decline in unemployment. In the new equilibrium, unemployment returns to its level in the initial equilibrium.

So far two types of models of exchange rate determination have been discussed: a real model in Section 2 and the above monetary model. Mussa (1984) combines these two approaches to derive a model which is capable of answering questions concerning the dynamic impact of both nominal and real shocks on the exchange rate and unemployment when price adjustment is sluggish.

The real side of the model is simple. There is no modelling of production technologies or factor markets. All real shocks operate through shift parameters in the excess demand functions for domestic and foreign goods. Changes in these parameters lead to changes in relative prices and thus the real exchange rate. The domestic money price of domestic goods is assumed sticky. Equilibrium is defined as that combination of the real exchange rate and domestic residents holdings of foreign bonds which is consistent with rational expectations of a constant exchange rate and constant asset holdings.

The model delivers real exchange rate and unemployment responses to monetary shocks very similar to those in the Dornbusch model. Changes in the equilibrium price of non-traded goods have the same equilibrium effects on the real exchange rate as in the dependent economy model. However, in the face of sluggish adjustment in the prices of non-traded goods, the short run dynamics differ from those in the long run. Mussa shows that if the conditions guaranteeing *overshooting* of the nominal exchange rate in response to a nominal shock are satisfied then the real exchange rate will *undershoot* in response to the real shock. If the price of non-tradeables is below its long run equilibrium level, output (and thus implicitly employment) will be above its equilibrium level. Real shocks such as a favourable productivity shock in the traded goods sector or an increase in the real price of exports leads to excess demand for non-traded goods at constant prices and thus to a short-run fall in unemployment. As the price of non-traded goods gradually adjusts unemployment returns to its natural level.

To summarise, this model of real exchange rate determination makes a number of predictions about the response of the economy to various shocks.

Specifically, nominal shocks are neutral in the long run but alter the real exchange rate and unemployment in the short run. In contrast, sustained real shocks have a permanent effect on the real exchange rate. As is the case with nominal shocks, price sluggishness allows these real shocks to have an effect on unemployment in the short run but not in the long run. These restrictions are used to examine the relative importance and dynamic effects of shocks to the two Australian dollar real exchange rates.

Consider three types of uncorrelated shocks.[11] The first shock is permitted to have a long-run effect on the real exchange rate and assumed to have no long-run employment effect. This is interpreted as a real shock. The second and third shocks are constrained to have no long-run effect on the real exchange rate and as with the first shock are assumed to have no long-run employment effects. These two shocks are interpreted as nominal shocks, one originating in each country. The assumption on the long-run employment effects of the various shocks ensure that the unemployment rates are stationary. The only additional restriction that is imposed on the nominal shocks is that the Australian nominal shock has no instantaneous effect on foreign unemployment. Given the small size of the Australian economy and the lags in the international transmission of shocks this assumption is reasonable.

Define the vector $X' \equiv (\Delta R, U, U^*)$ where R is the real exchange rate, U the Australian unemployment rate and U^* the foreign unemployment rate. Given the above assumptions X has a vector Wold moving-average representation given by:

$$X(t) = v(t) + C(1)v(t-1) + C(2)v(t-2) + \ldots\ldots$$

$$= \sum_{j=0}^{\infty} C(j)v(t-j) \qquad (4)$$

$$\text{and } Evv' = \Omega$$

[11] The dimensionality of the system is intentionally kept low. Adding additional variables increases the number of restrictions needed for identification making it difficult to identify systems with more than three variables. There is clearly more than one type of real shock. Above we have discussed both productivity and terms of trade shocks. Blanchard and Quah (1989) provide necessary and sufficient conditions for the interpretation of the shocks to be valid when there are multiple real and nominal shocks. They show that correct identification is possible if and only if the individual lag responses of the different shocks within a certain class (e.g. real shocks) are sufficiently similar. While there is no way to verify whether this condition holds the Mussa model does predict similar responses to the two principal real shocks.

where $C(j)$ is a 3x3 matrix and v is a 3x1 vector of innovations.

Further, define the vector of economic shocks as $\varepsilon \equiv (\varepsilon_r, \varepsilon_a, \varepsilon_f)$ where ε_r is the real shock, ε_a is the Australian nominal shock and ε_f is the foreign nominal shock. Given the orthogonality/normalisation conditions, $E\varepsilon\varepsilon' = I$. The assumptions made above concerning these shocks imply that X follows a stationary process given by:

$$\begin{aligned} X(t) &= A(0)\varepsilon(t) + A(1)\varepsilon(t-1) + A(2)\varepsilon(t-2) + \ldots\ldots \\ &= \sum_{j=0}^{\infty} A(j)\varepsilon(t-j) \\ & \qquad\qquad\qquad\qquad and\ E\varepsilon\varepsilon' = I \end{aligned} \tag{5}$$

The impact effect of shock i on the level of the real exchange rate is given by $A_{1i}(0)$[12] while the long-run effect is given by $\Sigma_{j=0}^{\infty} A_{1i}(j) = 0$. In contrast, the long run effect of the ith shock on the Australian unemployment rate is simply $A_{2i}(\infty)$. Our interest is in estimating the sequence of matrices $\{A(j)\}$.

The assumptions made above imply certain restrictions on the elements of $A(j)$. The assumption that the long-run effect of an Australian nominal shock on the real exchange rate is zero translates into the restriction that $\Sigma_{j=0}^{\infty} A_{12}(j) = 0$. Similarly, the equivalent assumption for the foreign nominal shock implies that $\Sigma_{j=0}^{\infty} A_{13}(j) = 0$. Finally, the assumption that a nominal shock in Australia has no contemporaneous effect on foreign unemployment implies that $A_{32}(0) = 0$.

To recover the elements of $A(j)$, note that the vector of innovations in the Wold decomposition (v) and the vector of economic shocks (ε) are related by the following:

$$v = A(0)\varepsilon \tag{6}$$

and that

$$A(j) = C(j)\ A(0) \tag{7}$$

The elements of the sequence of matrices $\{C(j)\}$ can be obtained by estimating and then inverting the vector autoregression of $(\Delta R, U, U^*)$. Thus, given (7) the

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12 The first subscript refers to the row of the matrix denoted by A, while the second refers to the column of the matrix.

sequence of matrices *{A(j)}* can be obtained by identifying the elements of *A(0)*. This matrix has 9 elements and thus 9 restrictions are needed for identification.

From (4), (5), and (6) note that :

$$E vv' = EA(0)\varepsilon\varepsilon'A(0)' = A(0)A(0)' = \Omega \tag{8}$$

Equation (8) provides 6 non-linear restrictions on the elements of *A(0)* as Ω has 6 unique elements. Above it was noted that the long-run restrictions on the impact of the nominal shocks on the real exchange rate imply restrictions on the sum of the $A_{12}(j)$ elements and on the sum of the $A_{13}(j)$ elements. Using (7) these restrictions translate into the following restrictions on *A(0)*:

$$A_{12}(0)\sum_{j=0}^{\infty} C_{11}(j) + A_{22}(0)\sum_{j=0}^{\infty} C_{12}(j) + A_{32}(0)\sum_{j=0}^{\infty} C_{13}(j) = 0 \tag{9}$$

$$A_{13}(0)\sum_{j=0}^{\infty} C_{11}(j) + A_{23}(0)\sum_{j=0}^{\infty} C_{12}(j) + A_{33}(0)\sum_{j=0}^{\infty} C_{13}(j) = 0 \tag{10}$$

Finally, recall that the restriction that the Australian nominal shock has no effect on contemporaneous foreign unemployment implies that $A_{32}(0) = 0$. These nine restrictions allow the identification of *A(0)* and thus *A(j)*.[13]

To obtain the sequence of matrices *C(j)* a VAR system consisting of changes in the real exchange rate and the two countries' unemployment rates is estimated using monthly data. Twelve lags are used in the VAR. Separate systems are estimated for the AUD/USD and the AUD/YEN exchange rates.

In order to obtain some measure of the dispersion of the point estimates of the elements of *A(j)* matrices Efron's (1979) bootstrap procedure is used. A pseudo history for each of the three variables is created by randomly drawing (with replacement) N disturbances from the residuals of the vector autoregression and then adding these residuals to the predicted values from the vector autoregression. With this "new" data set the *A(j)* matrices are re-estimated. This procedure is repeated 500 times and the standard deviation

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[13] These restrictions do not provide an unique solution for $A_{12}(0)$ and $A_{22}(0)$ as both $\{A_{12}(0),-A_{22}(0)\}$ and $\{-A_{12}(0),A_{22}(0)\}$ are solutions. This failure of uniqueness is, however, unimportant as the sign of *all* elements in any *column* of *A(0)* can be changed without altering the results. A column sign change simply alters the interpretation of the shock from a positive to a negative shock (or visa versa).

of each element of the $A(j)$ matrices is calculated. These standard deviations are reported in the Appendix for selected lags.

4. RESULTS

In order to maximise the available degrees of freedom and to observe short run dynamics monthly data is used. While the preferred measure of the real exchange rate is that using the CPI, Australia does not publish the CPI monthly. Various producer price indices are, however, published on a monthly basis. Below, the producer price index for machinery and equipment is used. Of the available indices this one appears to most closely track the CPI. For the USA and Japan the CPI is used. Unemployment data is seasonally adjusted. All data in this section are taken from the OECD Main Economic Indicators.

There is an active debate over whether or not the exchange rate regime matters for real exchange rate determination. While real exchange rate variability has been greater under the floating regime than under the fixed rate system, one school of thought attributes this to increased volatility in the underlying determinants of real exchange rates.[14] The position taken here is that prices are not instantly adjustable and thus the short-run behaviour of real exchange rates may differ under fixed and flexible exchange rates.

Australia's exchange rate system has undergone considerable change since 1970. At various times the Australian dollar has been fixed in terms of the sterling (prior to December 1971), the US dollar (December 1971 to September 1974) and a trade weighted basket of currencies (September 1974 to November 1976). Between November 1976 and December 1983 the Australian dollar was set on a daily basis in terms of a trade-weighted basket of currencies. Subsequently, the Australian dollar was floated. With an eye to these changes and the desire to maximise the number of available observations January 1977 is chosen as the starting date for the analysis. The sample period runs until July 1990 making a total of 150 useable observations.

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[14] Mussa (1986) provides a detailed review of the evidence concerning nominal exchange rate neutrality. He notes that while there are many theoretical models which embody the neutrality hypothesis there is little convincing empirical evidence to support it.

For completeness we begin with the results of testing the null hypotheses that each of the series used in this paper have a unit root. Two tests are used: the Phillips-Perron Z(α) (1988) test and the augmented Dickey-Fuller test. The results are reported in Table 2. For both tests a constant is included in the regression. The results are not sensitive to its exclusion or to the inclusion of a time trend. These tests, however, should be interpreted with a deal of caution, as their power depends on the sample length in years. While there are a reasonable number of observations data is only available for eleven years. For a further discussion of these issues see the review in Campbell and Perron (1991).

At standard significance levels it is not possible to reject the null hypothesis that the two real exchange rates have unit roots. This tends to support the view that there are shocks to the real exchange rate which have permanent effects. The hypothesis that *changes* in the real exchange rates have unit roots is overwhelmingly rejected. The assumption that changes in the real exchange rate are stationary thus seems appropriate. These results are not sensitive to the test employed or to the number of lags used. Similar results for a number of currencies are reported in Adler and Lehmann (1983) and Abuaf and Jorion (1990).[15]

The results for the unemployment rates are more problematic. In all three cases it is not possible to reject the null hypothesis that the unemployment rate has a unit root. This is surprising in light of previous work on the stationarity of the unemployment rate. In the seminal study on unit roots, Nelson and Plosser (1982) found that the USA unemployment rate was the only stationary variable of the 14 macro variables examined. Perron (1989), in his recent work, does not even test the unit root hypothesis for unemployment arguing that "there is general agreement that it is stationary". Campbell and Perron (1991) also argue that the seasonal adjustment procedure often creates a bias toward non-rejection of the unit root hypothesis. The results in the above table, are therefore viewed not as a rejection of the stationarity assumption, but as indicative of a lack of power of the tests using

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[15] Abuaf and Jorion (1990), however, argue that using a multivariate approach results in considerably weaker support for the unit root hypothesis. Tests for a unit root in *nominal* exchange rates almost universally fail to reject the unit root null. For tests using daily data see Baille and Bollerslev (1989) and for tests using weekly data see Corbae and Ouliaris (1986) and Meese and Singleton (1982).

Table 2: Tests of the Unit Root Hypothesis

VARIABLE	PHILLIPS-PERRON Z(α)			AUGMENTED DICKEY-FULLER		
	Lags Used in Spectral Density			Number of Lags		
	6	12	24	3	6	12
AUD/USD	4.52	4.81	5.00	1.70	1.49	1.65
Δ AUD/USD	138.4*	138.5*	137.1*	7.68*	5.23*	3.57*
AUD/YEN	3.45	3.75	3.79	1.72	1.65	1.46
Δ AUD/YEN	162.1*	178.1*	179.4*	5.79*	3.99*	3.42*
Aust. Unemploy.	4.65	5.86	6.19	1.99	2.29	1.58
US Unemploy.	2.75	3.97	4.30	1.37	1.93	1.50
Japan Unemploy.	6.61	7.21	9.44	1.60	1.32	1.25
Critical Values:						
5%		13.9			2.89	
10%		11.1			2.58	

* indicates that the unit root null is rejected at the 5 per cent level.
The entries for the Phillips-Perron test are the Z(α) statistic and for the augmented Dickey-Fuller they are the "t-statistic" for the test that $\beta=0$ (see below).
The Phillips-Perron test is based on estimating the following equation and testing $H_0 : \alpha=1$:

$$Y_t = const. + \alpha Y_{t-1} + v_t$$

To test H_0, the Z(α) statistic is formed as follows:

$$Z(\alpha) = T(\hat{\alpha}-1) - \frac{\frac{1}{2}(\hat{\sigma}^2_{Tl} - \hat{s}^2)}{T^{-2}\Sigma(y_t - \bar{y})^2}$$

where is an $\hat{\sigma}^2_{Tl}$ estimate of the spectral density at frequency zero of v and $s^2 = T^{-1}\Sigma v_t^2$. To estimate the spectral density at frequency zero the Newey-West (1987) estimator is used. Slight modifications of the test statistic are required when the constant is excluded or a time trend is added.
The augmented Dickey-Fuller test is conducted by estimating the following equation and then testing $H_0 : \beta=0$.

$$\Delta y_t = const. + \beta y_{t-1} + \sum_{j=1}^{p-1} \beta_j \Delta y_{t-j} + v_t$$

The distributions of both the Phillips-Perron and augmented Dickey-Fuller test are given in Fuller (1976) (Tables 8.5.2 and 8.5.1 respectively).

monthly data over the period used in this study. While this interpretation may leave one who is hostile to the stationarity assumption unconvinced, the assumption that shocks which have a permanent effect on the unemployment rate have been unimportant over the sample period examined in this paper, appears reasonable. If the unemployment rate is in fact non-stationary, then the techniques used in this paper are inappropriate as the Wold moving average representation of X as defined does not exist.

The dynamic responses of the system to the various shocks are examined first followed by an examination of the variance decompositions.

(a) Dynamics

The dynamic responses are broadly consistent with those suggested by the Dornbusch/Mussa model. Real shocks which temporarily reduce domestic unemployment are associated with a permanent real appreciation with the long-run effect being greater than the short-run effect. Nominal shocks which cause a temporary fall in unemployment lead to a temporary real depreciation. There also is evidence of an important international transmission of nominal disturbances in Japan and the United States to Australia. Unfortunately, the bootstrap standard errors are large in a number of cases making strong inferences difficult. Rather than clutter the figures these standard errors are reported in the Appendix for selected lags.

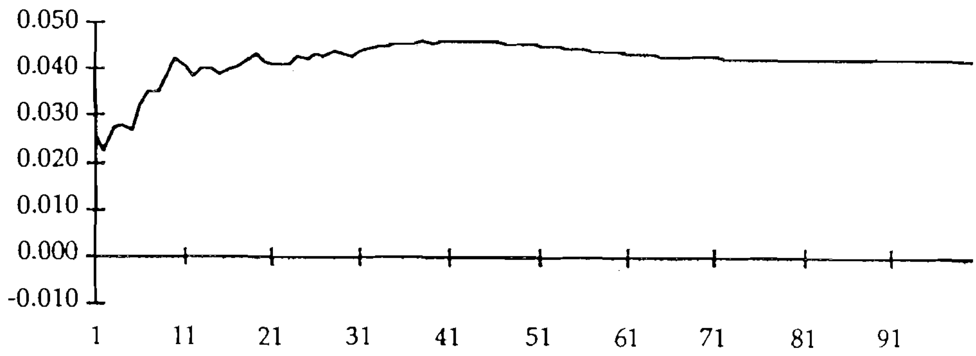
The dynamic responses of the three variables to the real shocks are shown in Figure 1 for the case where the Japan is the foreign country and Figure 2 for the case where the USA is the foreign country. In these and subsequent figures the horizontal axis is time in months.

Consider Figure 1 first. As predicted by the Mussa model, the impact effect of a real shock is smaller than the long run equilibrium effect. The impact of the real shock reaches a maximum after some 36 months, although most of the appreciation is completed within 10 months. The final long run effect is approximately 1.6 times the size of the impact effect.

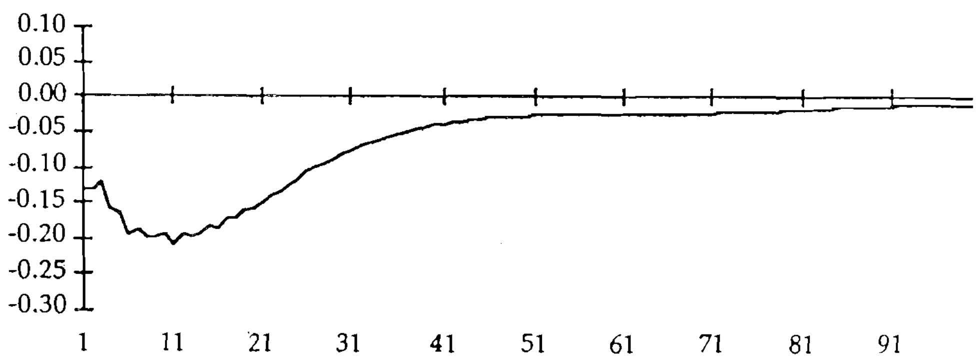
The shock which permanently appreciates the real AUD/YEN rate reduces unemployment in Australia. This is consistent with the impact of productivity shocks in the traded goods sector reducing unemployment temporarily. The

Figure 1: Responses to Real Shock

AUD/YEN RESPONSE TO REAL SHOCK



AUSTRALIAN UNEMPLOYMENT RESPONSE TO REAL SHOCK



JAPANESE UNEMPLOYMENT RESPONSE TO REAL SHOCK

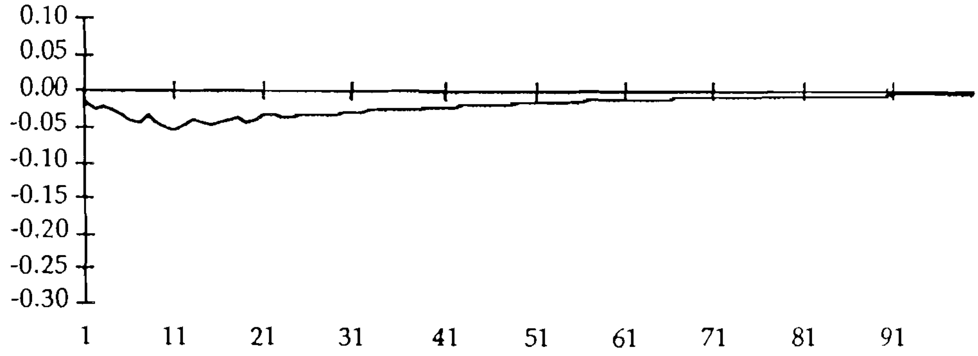
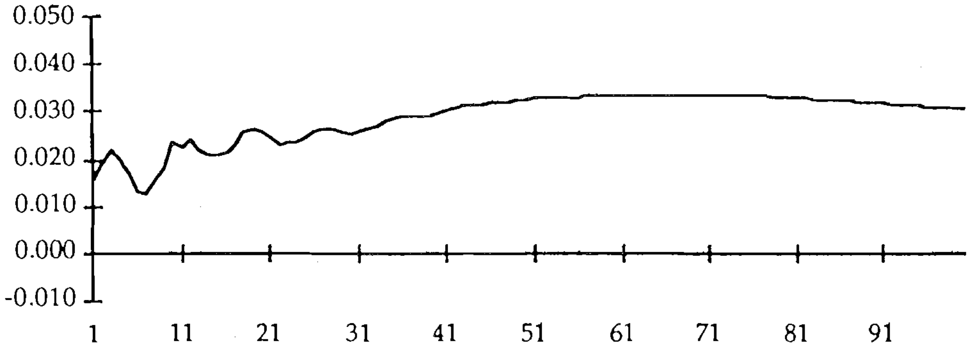
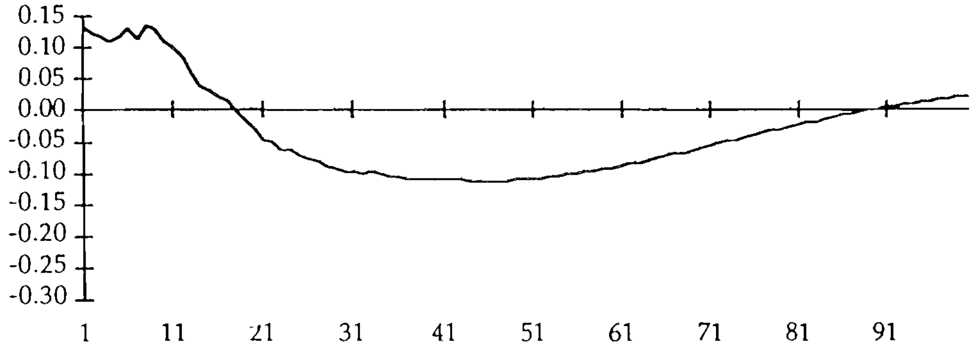


Figure 2: Responses to Real Shock

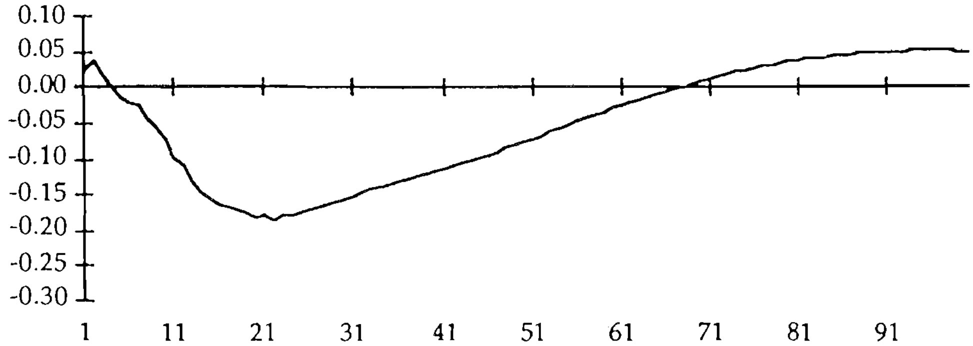
AUD/USD RESPONSE TO REAL SHOCK



AUSTRALIAN UNEMPLOYMENT RESPONSE TO REAL SHOCK



USA UNEMPLOYMENT RESPONSE TO REAL SHOCK



maximum employment effect is reached after 6 months. It is sustained around this maximum level for a further 12 months, after which the favourable employment effects of the shock gradually disappear as wages and prices are bid up. After four years the Australian employment response has disappeared. The assumption that there is no long-run employment effect does not appear to be violated.

Japanese unemployment also falls in response to a real exchange rate shock which depreciates the Yen against the Australian dollar. The effect is, however, extremely small.

We now examine the results when the US dollar is the foreign currency. As is the case with the AUD/YEN, the long-run response of the AUD/USD to the real shock is considerably greater than the impact effect. After 48 months the change in the level of the real exchange rate is 1.8 times the initial change. Little additional change takes place after this time.

In contrast to the results for the AUD/YEN rate, Australian unemployment initially increases in response to the real shock which appreciates the AUD/USD real exchange rate. The increase in unemployment is, however, unwound over the next 12-18 months. Unemployment continues to fall out to 36 months after which it gradually returns to its level before the real shock. Two possible explanations for the initial increase in unemployment exist. The first is that at least in the short run there is real wage rigidity in terms of Australia's exports to the USA. There is, however, little evidence that nominal wages increase instantaneously in response to a change in traded goods or export prices. The second explanation is that provided by Blanchard and Quah (1989) who noted a similar response in USA unemployment following a productivity shock which permanently increases output. They argue that nominal rigidities can explain why in response to a productivity shock aggregate demand does not initially increase to match the increase in output needed to maintain output constant. In the medium term real rigidities act to reduce unemployment.

A difficulty with this rationalisation of the results is that when Japan was used as the foreign country we saw a somewhat different response pattern for Australian unemployment. While the declining unemployment after the initial effect is characteristic of both cases the impact effects are different. One would expect that the same factors would be at work in the two cases and thus the responses would be similar.

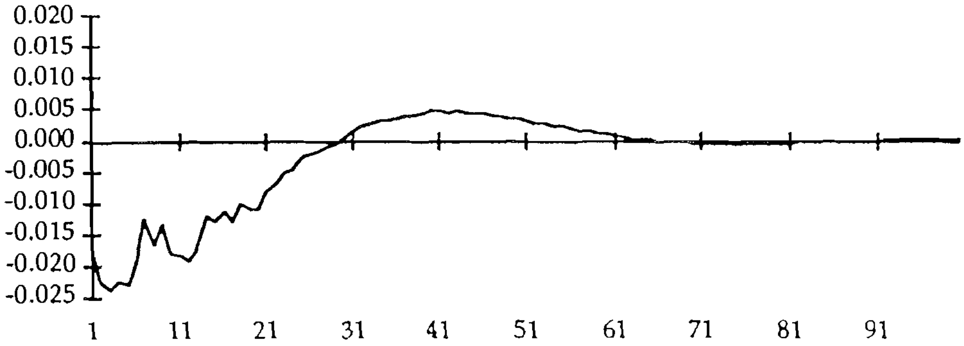
This lack of similarity in the results for the AUD/USD and AUD/YEN suggests the need to look again at the assumptions underlying the estimation technique. One of the key assumptions is that the disturbances are uncorrelated at all leads and lags. This assumption does not restrict the channels through which the various disturbances effect unemployment and the real exchange rate; however, it is critical that the same underlying data generating process operated through the entire period. Macfarlane and Tease (1989) argue that for *some* of the floating period the relationship between the exchange rate and interest rates was dominated by a policy reaction function from the exchange rate to interest rates. For example, on occasions when the exchange rate depreciated, the authorities tightened monetary policy. If the deprecation was the result of a real shock in the first place then an induced monetary policy response makes the orthogonality assumption questionable. More importantly Macfarlane and Tease (1989) suggest that the policy reaction function may have changed over time thus altering the data generating process. Given that the exchange rate against the US dollar has typically been the primary focus of attention it seems reasonable to assume that any policy reaction function is heavily weighted towards the US dollar. This clouds the interpretation of the results achieved using the AUD/USD rate and may well be responsible for the different results achieved using the two exchange rates.

In response to the real shock which causes a permanent depreciation of the US dollar against the Australian dollar, United States unemployment falls considerably. The effect reaches a maximum after about 18 months and has all but disappeared after 4 years. Above we have assumed that prices in terms of domestic goods were sticky. If instead wages and prices are sticky in terms of tradeables, a negative productivity shock in the US tradeables goods sector would depreciate the US dollar and would cause unemployment to fall as the wage in terms of non-tradeables falls.

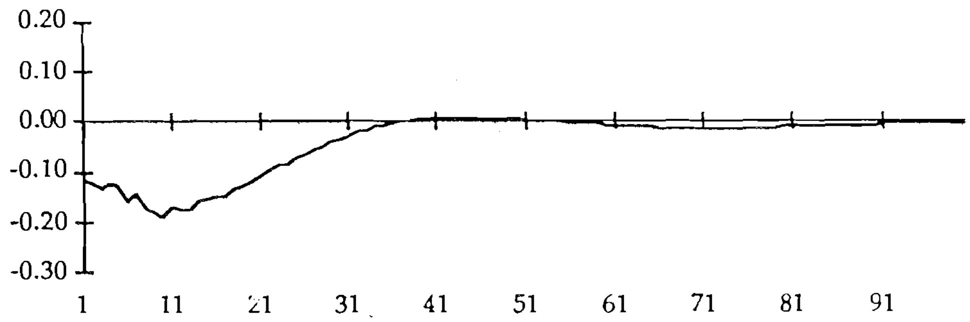
The dynamic responses to the Australian and foreign nominal shocks are shown in Figure 3 for the case in which Japan is the foreign country and Figure 4 for the case in which the USA is the foreign country. First consider Figure 3. The Australian nominal shock has the traditional hump-shaped effect on domestic unemployment. The effect peaks after about 9 months and

Figure 3: Responses to Nominal Shocks

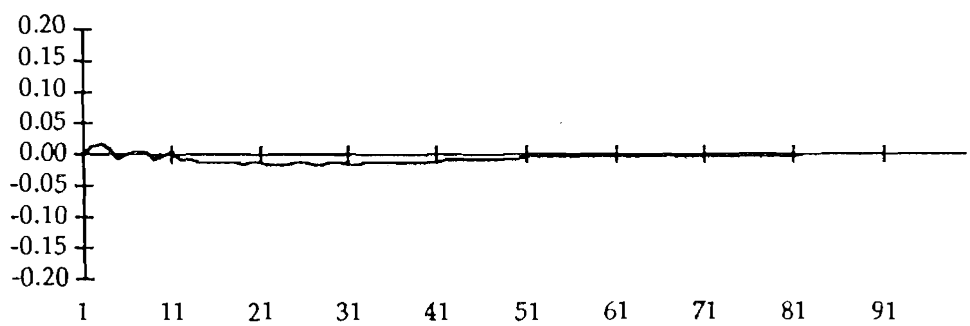
AUD/YEN RESPONSE TO AUSTRALIAN NOMINAL SHOCK



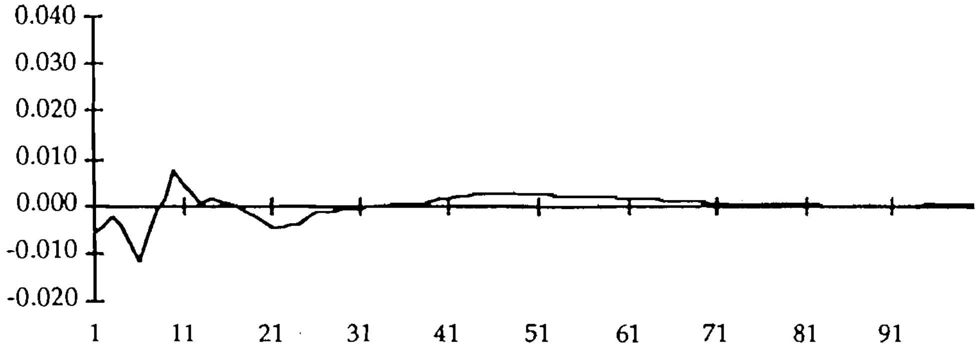
AUSTRALIAN UNEMPLOYMENT RESPONSE TO AUSTRALIAN NOMINAL SHOCK



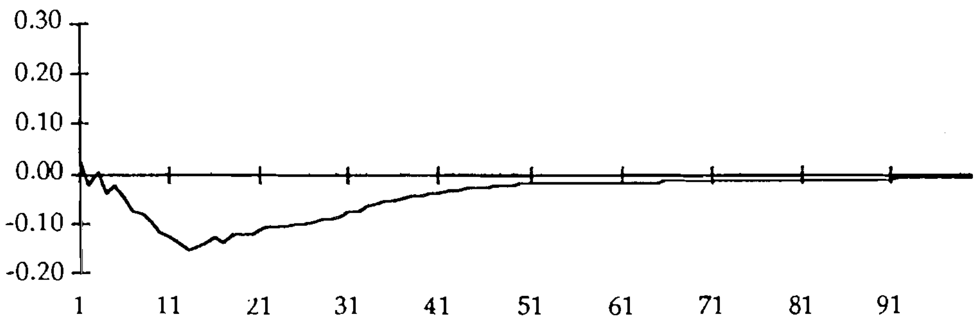
JAPANESE UNEMPLOYMENT RESPONSE TO AUSTRALIAN NOMINAL SHOCK



AUD/YEN RESPONSE TO JAPANESE NOMINAL SHOCK



AUSTRALIAN UNEMPLOYMENT RESPONSE TO JAPANESE NOMINAL SHOCK



JAPANESE UNEMPLOYMENT RESPONSE TO JAPANESE NOMINAL SHOCK

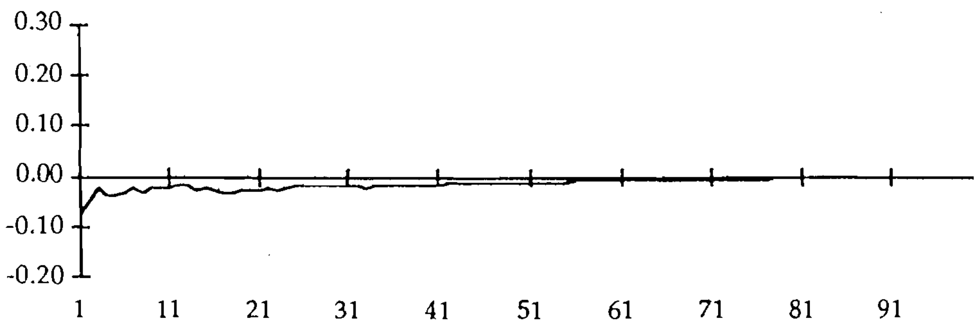
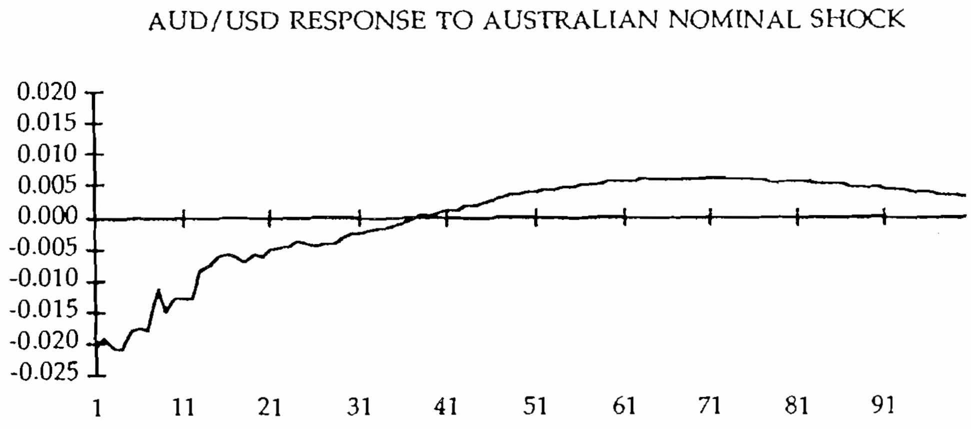
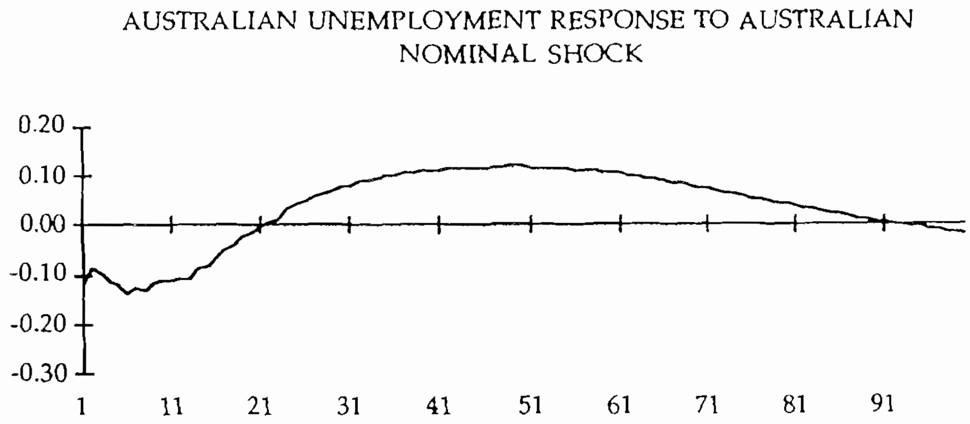
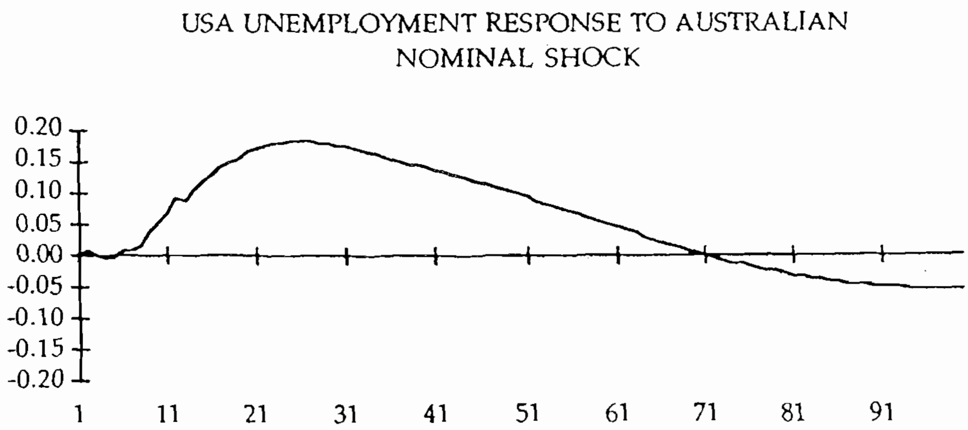


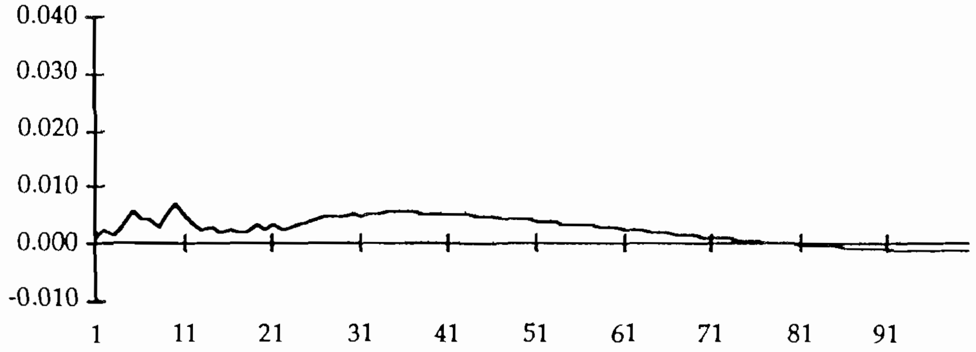
Figure 4: Responses to Nominal Shocks



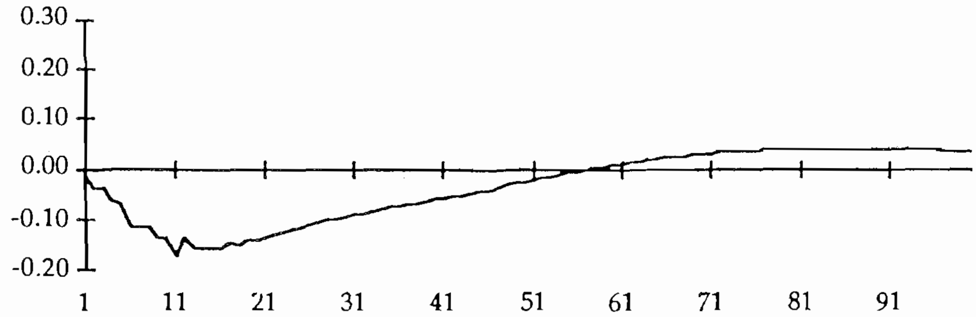




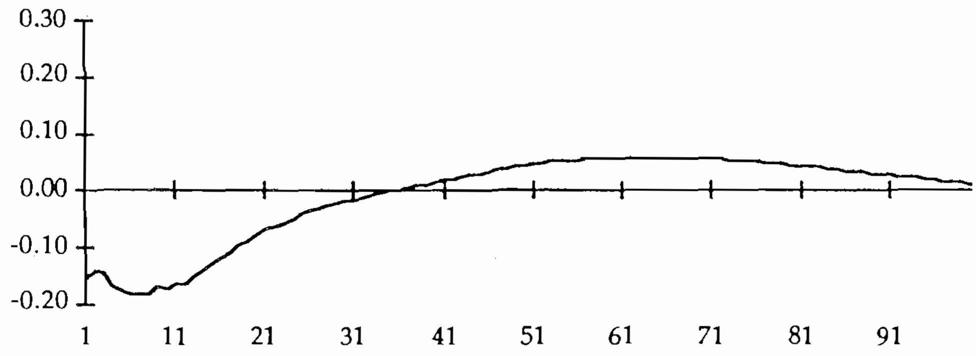
AUD/USD RESPONSE TO USA NOMINAL SHOCK



AUSTRALIAN UNEMPLOYMENT RESPONSE TO USA NOMINAL SHOCK



USA UNEMPLOYMENT RESPONSE TO USA NOMINAL SHOCK



has vanished after 3 years. These results are similar to those for demand shocks in Blanchard and Quah's decomposition of USA unemployment and output dynamics. As they note, this pattern is consistent with the traditional view of the dynamic effect of aggregate demand on employment in which movements in aggregate demand build up until adjustment in wages leads the economy back to the full employment equilibrium.

Recall that the Dornbusch/Mussa model predicts that a nominal shock which reduces unemployment causes an immediate real depreciation. This prediction appears to be borne out in the data. The depreciation is gradually worked off over time. After five years the real exchange rate has returned to its initial level, although after 2 years most of the real depreciation has been reversed. There does, however, appear to be some overshooting of the real exchange rate on its way back to its initial level. As expected, Australian nominal shocks have essentially no effect on Japanese unemployment. Of the three shocks, the Japanese nominal shock has the strongest effect on Japanese unemployment. The effect is, however, relatively small. The effect of expansionary Japanese monetary policy on Australian unemployment is also initially very small. It, however, increases over time to reach its maximum effect at the 12 month horizon. Substantially lower unemployment in Australia is sustained for 3 years, suggesting a strong international transmission of Japanese shocks to Australia.

Turning to the AUD/USD rate we see a broadly similar response to the Australian nominal shock that we saw for the AUD/YEN rate. Most of the real depreciation is worked off within two years and there is some suggestion that the real rate overshoots on its way back to its initial level. The favourable employment consequences of the shock last for some 12-18 months after which unemployment appears to be slightly above its equilibrium level for a period of time. The most troubling aspects of the results is the response of US unemployment to the Australian nominal shock. One would expect there to be little, if any, response of US unemployment to this shock. For the first 6 months this is indeed the case, however, the US response gradually increases to be quite sizeable after 2 years. While the effect is larger than expected, an analysis of the variance decompositions for US unemployment shows the Australian nominal shock to account for a relatively small share of the variance.

There again appears to be an important international transmission of shocks with favourable employment consequences in the foreign country to Australia. While the initial effect is small, the impact grows steadily for 12 months and is sustained for a further 12-18 months.

(b) Variance Decompositions

An assessment of the relative importance of the three shocks at various horizons can be gained by examining the proportion of the variance of the forecast error at the relevant horizon which is accounted for by each of the shocks. Define the k month ahead forecast error in the level of the real exchange rate as the difference between the actual value and its forecast from (4), k months earlier. This forecast error has three components: real shocks over the last k periods, Australian nominal shocks over the last k periods and foreign nominal shocks over the last k periods. The variance decompositions for the real exchange rates and the Australian unemployment rates are presented in Tables 3 and 4 respectively. The numbers in parenthesis are standard deviations calculated using the bootstrap technique discussed in Section 3.

We first examine the variance decompositions for the real exchange rates. Recall that by construction the percentage share of the variance accounted for by the real shock must go to 100 per cent as the forecast horizon goes to infinity. However, at short horizons, the importance of the real shock is allowed to, and in fact does, differ across the two currencies. For the AUD/YEN rate, 65 per cent of the variance at the one month horizon is accounted for by the real shock. This compares with a figure of 37 per cent for the US dollar. The foreign shock accounts for a very small share of the variance for both currencies. This leaves the Australian nominal shock to account for much more of the short-run variance of the AUD/USD rate than it does for the variance of the AUD/YEN rate. While nominal shocks play a smaller role in explaining the variance as the forecast horizon increases, they maintain an important role out to at least 2 years. At the 12 month horizon the share of the forecast error variance of the AUD/Australian nominal shock is still 44 per cent. At the two year horizon this share has fallen to 26 per cent. After five years it accounts for less than 10 per cent. At all horizons the nominal shock is less important in understanding dynamics of the AUD/YEN rate than it is for the AUD/USD rate. Unlike the decompositions for the real

Table 3: Variance Decompositions for Real Exchange Rates

HORIZON (months)	PERCENTAGE OF VARIANCE DUE TO:					
	REAL SHOCK		AUSTRALIAN NOMINAL SHOCK		FOREIGN NOMINAL SHOCK	
	Foreign Country		Foreign Country		Foreign Country	
	USA	*JAPAN*	*USA*	*JAPAN*	*USA*	*JAPAN*
1	**36.6** (22.8)	**64.9** (24.4)	**63.2** (22.5)	**31.6** (27.4)	**0.2** (0.3)	**3.4** (16.4)
2	**42.4** (27.2)	**56.8** (23.9)	**57.0** (25.6)	**40.4** (26.1)	**0.6** (1.6)	**2.8** (16.3)
3	**46.4** (28.1)	**57.0** (23.7)	**53.4** (25.8)	**41.2** (25.3)	**0.4** (2.3)	**1.8** (16.4)
6	**44.6** (27.0)	**59.1** (22.6)	**53.8** (25.6)	**37.2** (21.6)	**1.5** (1.4)	**3.7** (15.7)
12	**53.8** (17.8)	**73.3** (20.5)	**43.8** (17.4)	**24.5** (16.5)	**2.4** (0.4)	**2.2** (17.1)
24	**72.0** (9.0)	**84.1** (17.6)	**26.2** (9.0)	**14.7** (10.7)	**1.9** (0.2)	**1.2** (14.5)
60	**89.0** (2.2)	**94.0** (11.8)	**8.9** (1.8)	**5.5** (5.1)	**2.0** (0.4)	**0.5** (8.8)
150	**95.0** (1.6)	**97.5** (5.6)	**4.2** (1.2)	**2.3** (2.1)	**0.8** (0.4)	**0.2** (4.3)

Table 4: Variance Decompositions for Australian Unemployment

HORIZON (months)	PERCENTAGE OF VARIANCE DUE TO:					
	REAL SHOCK		AUSTRALIAN NOMINAL SHOCK		FOREIGN NOMINAL SHOCK	
	Foreign Country		Foreign Country		Foreign Country	
	USA	*JAPAN*	*USA*	*JAPAN*	*USA*	*JAPAN*
1	**55.5** (38.3)	**53.2** (25.5)	**44.1** (27.7)	**43.8** (27.4)	**0.4** (4.5)	**3.0** (11.8)
2	**58.2** (34.8)	**53.0** (24.4)	**38.8** (25.8)	**44.7** (26.0)	**2.9** (4.7)	**2.2** (10.9)
3	**57.9** (31.3)	**50.5** (23.9)	**38.2** (22.5)	**48.1** (25.0)	**3.9** (1.2)	**1.5** (10.6)
6	**46.4** (25.2)	**55.7** (24.3)	**40.1** (20.8)	**42.0** (23.7)	**13.5** (1.2)	**2.3** (12.0)
12	**35.8** (28.6)	**50.7** (24.0)	**34.4** (13.1)	**38.9** (21.2)	**27.8** (0.7)	**10.3** (14.6)
24	**24.5** (17.7)	**48.3** (24.4)	**25.5** (7.6)	**33.8** (19.6)	**50.0** (5.0)	**17.9** (17.1)
60	**33.9** (23.4)	**48.3** (23.9)	**34.7** (12.8)	**30.5** (18.9)	**31.3** (3.2)	**21.2** (17.0)
150	**34.0** (22.8)	**48.4** (23.9)	**37.2** (11.9)	**30.3** (18.9)	**28.9** (3.6)	**21.3** (17.1)

exchange rates, the estimation technique does not impose any restrictions on the variance decompositions for the unemployment rate. In both the cases when the USA and Japan are taken as the foreign country, the Australian nominal shocks accounts for just over 40 per cent of the variance at the one month horizon. At this short horizon, real shocks account for a slightly higher share of the variance (56 per cent in the case of the USA and 53 per cent in the Japanese case). The foreign nominal shock has relatively little role at the shortest horizons. Its importance, however, increases with the passage of time, reflecting the lag in the international transmission of the disturbance. After 2 years the United States nominal shock accounts for 50 per cent of the variance of the forecast error of the Australian unemployment rate. The comparable figure when Japan is taken as the foreign country is 18 per cent.

5. CONCLUSIONS AND SUMMARY

Unit root tests of real exchange rates examine the issue of whether or not there are shocks which have permanent effects. In this paper the focus is on two Australian dollar real exchange rates and it is shown that they are characterised by unit roots. In light of models of real exchange rate determination any other result would have been surprising. The more interesting question addressed in this paper is how important are the shocks which have permanent effects relative to those which have just temporary effects. To answer this question a technique developed by Blanchard and Quah (1990) is used, together with restrictions on exchange rate and unemployment dynamics suggested by some standard models of exchange rate determination. Important roles for both types of shocks are found.

The paper begins with an examination of the links between productivity growth and long-run real exchange rate changes. It is argued that productivity growth in Australia's traded goods sector has been very slow compared to that of Japan and roughly comparable to that in the United States. These differences have been reflected in differential rates of change in the relative price of non-tradeables to tradeables in the three countries. It is argued that Australia's productivity growth relative to Japan on the one hand, and the United States on the other, can help explain the difference in the behaviour of the two real exchange rates over the last two decades.

In the second part of the paper the focus turns to an explicit consideration of two types of shocks: those with temporary effects on the real exchange rate and those with permanent effects. Using a model of the real exchange rate these shocks are given a economic interpretation. The "permanent" shock is considered a real shock and the "temporary" shock a nominal shock.

In general, the dynamic responses are similar to those suggested by the model. Positive nominal shocks lead to a substantial temporary real depreciation and a fall in Australian unemployment. Positive real shocks show a similar unemployment response and real appreciation with some short-run undershooting of the real exchange rate. The variance decompositions show that for the AUD/YEN rate, real shocks account for the bulk of the forecast error variance at all horizons. In contrast, Australian nominal shocks account for over half of the short-run forecast error variance for the AUD/USD rate. While the importance of this shock falls as the forecast horizon lengthens, it remains relatively important for some time: at the 2 year horizon it is still accounting for a quarter of the variance.

The results support the view that both real and monetary factors are important in understanding real exchange rate behaviour, especially in the short run. While real exchange rates have a unit root, shocks which have a temporary effect also play an important role. These results, however, must be interpreted with some caution. First, the exchange rate regime during the period of study has not been a completely clean float. Prior to December 1983 the exchange rate was set by a daily adjustable peg against a trade weighted basket of currencies. Since December 1983 it has been floating, but with periods of sizeable foreign exchange market intervention. No account has been made for these deviations from a clean float. Additionally, the difference in some of the results achieved using the AUD/USD and AUD/YEN rates suggest that estimation technique may not be capturing the complete dynamics of the AUD/USD rate. Second, the pseudo standard errors are relatively large making it difficult to quantify the observed effects with any great degree of precision. The results might thus be best interpreted as suggestive rather than definitive. Thirdly, the same caveats that Blanchard and Quah make concerning the low dimensionality of the system and the possibility that unemployment does in fact have a unit root apply here. Finally, the bilateral rates have been examined individually. It may be more appropriate to examine them in one system. Unfortunately, doing so increases the number of identifying restrictions needed beyond that supplied by the model. Notwithstanding these caveats, the results do suggest that moving beyond the standard unit root tests offers additional insight into the behaviour of real exchange rates.

APPENDIX

The following tables provide point estimates of the elements of A{j} for selected lags together with "bootstrap standard deviations".

EFFECT OF REAL SHOCK ON:

j	Real Exchange Rate $\sum_{i=0}^{j} A_{11}(i)$	S.D.	Australian Unemployment $A_{21}(j)$	S.D.	Japanese Unemployment $A_{31}(j)$	S.D.
0	0.0256	0.0072	-0.1314	0.0743	-0.0121	0.0450
1	0.0224	0.0072	-0.1320	0.0584	-0.0249	0.0205
2	0.0276	0.0075	-0.1192	0.0728	-0.0218	0.0221
6	0.0325	0.0081	-0.1932	0.1041	-0.0376	0.0235
12	0.0386	0.0100	-0.1926	0.1246	-0.0464	0.0231
24	0.0427	0.0121	-0.1224	0.0703	-0.0353	0.0181
60	0.0438	0.0140	-0.0248	0.0158	-0.0100	0.0033
150	0.0423	0.0131	-0.0018	0.0150	-0.0006	0.0004

EFFECT OF AUSTRALIAN NOMINAL SHOCK ON:

j	Real Exchange Rate $\sum_{i=0}^{j} A_{12}(i)$	S.D.	Australian Unemployment $A_{22}(j)$	S.D.	Japanese Unemployment $A_{32}(j)$	S.D.
0	-0.0179	0.0095	-0.1193	0.0581	-0.0000	0.0000
1	-0.0225	0.0095	-0.1225	0.0344	0.0148	0.0091
2	-0.0238	0.0090	-0.1318	0.0386	0.0173	0.0089
6	-0.0193	0.0087	-0.1563	0.0517	-0.0014	0.0113
12	-0.0194	0.0087	-0.1748	0.0548	-0.0081	0.0111
24	-0.0046	0.0070	-0.0838	0.0345	-0.0146	0.0086
60	0.0009	0.0017	-0.0065	0.0121	-0.0030	0.0024
150	0.0000	0.0000	-0.0008	0.0010	-0.0002	0.0003

EFFECT OF FOREIGN NOMINAL SHOCK ON:

j	Real Exchange Rate $\sum_{i=0}^{j} A_{13}(i)$	S.D.	Australian Unemployment $A_{23}(j)$	S.D.	Japanese Unemployment $A_{33}(j)$	S.D.
0	-0.0059	0.0108	0.0312	0.0771	-0.0730	0.0161
1	-0.0047	0.0105	-0.0211	0.0468	-0.0541	0.0102
2	-0.0023	0.0104	0.0017	0.0571	-0.0217	0.0103
6	-0.0115	0.0104	-0.0488	0.0747	-0.0311	0.0129
12	0.0024	0.0091	-0.1382	0.0777	-0.0149	0.0133
24	-0.0039	0.0084	-0.1027	0.0403	-0.0232	0.0105
60	-0.0099	0.0019	-0.0146	0.0152	-0.0075	0.0037
150	-0.0006	0.0000	-0.0013	0.0011	-0.0004	0.0003

EFFECT OF REAL SHOCK ON:

j	Real Exchange Rate $\sum_{i=0}^{j} A_{11}(i)$	S.D.	Australian Unemployment $A_{21}(j)$	S.D.	USA Unemployment $A_{31}(j)$	S.D.
0	0.0156	0.0057	0.1355	0.0624	0.0253	0.0741
1	0.0186	0.0061	0.1222	0.0417	0.0397	0.0531
2	0.0218	0.0062	0.1188	0.0472	0.0195	0.0572
6	0.0128	0.0060	0.1296	0.0584	-0.0216	0.0631
12	0.0242	0.0072	0.0829	0.0594	-0.1087	0.0786
24	0.0237	0.0089	-0.0656	0.0577	-0.1777	0.0898
60	0.0337	0.0159	-0.0916	0.0440	-0.0296	0.0409
150	0.0281	0.0173	0.0115	0.0160	-0.0097	0.0182

EFFECT OF AUSTRALIAN NOMINAL SHOCK ON:

j	Real Exchange Rate $\sum_{i=0}^{j} A_{12}(i)$	S.D.	Australian Unemployment $A_{22}(j)$	S.D.	USA Unemployment $A_{32}(j)$	S.D.
0	-0.0205	0.0067	0.1209	0.0566	0.0000	0.0000
1	-0.0194	0.0066	0.0871	0.0394	-0.0076	0.0204
2	-0.0210	0.0068	0.0952	0.0387	0.0008	0.0244
6	-0.0177	0.0057	0.1398	0.0458	-0.0074	0.0375
12	-0.0129	0.0064	0.1091	0.0440	-0.0931	0.0624
24	-0.0039	0.0054	-0.0311	0.0378	-0.1774	0.0590
60	0.0056	0.0032	-0.1063	0.0282	-0.0503	0.0202
150	0.0000	0.0000	0.0166	0.0108	-0.0066	0.0144

EFFECT OF FOREIGN NOMINAL SHOCK ON:

j	Real Exchange Rate $\sum_{i=0}^{j} A_{13}(i)$	S.D.	Australian Unemployment $A_{23}(j)$	S.D.	USA Unemployment $A_{33}(j)$	S.D.
0	0.0012	0.0061	-0.0119	0.0553	-0.1567	0.0234
1	0.0025	0.0060	-0.0392	0.0379	-0.1390	0.0222
2	0.0015	0.0060	-0.0393	0.0380	-0.1461	0.0234
6	0.0044	0.0051	-0.1176	0.0450	-0.1802	0.0291
12	0.0033	0.0052	-0.1388	0.0349	-0.1616	0.0471
24	0.0034	0.0038	-0.1190	0.0315	-0.0469	0.0547
60	0.0027	0.0026	0.0075	0.0298	0.0583	0.0232
150	0.0000	0.0000	-0.0122	0.0105	-0.0158	0.0094

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