INFLUENCES ON THE
AUSTRALIAN REAL EXCHANGE RATE:
AN ANALYSIS USING THE AMPS MODEL

W.J. Martin, C.W. Murphy and D.T. Nguyen

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SUMMARY

The purpose of this paper is to examine quantitatively the dynamic effects on the real exchange rate of a range of important shocks, and to give some indication of the relative importance of these factors as sources of real exchange rate variability.

In section II, an overview is presented of the AMPS macroeconometric model which is used in the subsequent simulation analysis. To facilitate understanding of the process of exchange rate determination in the AMPS model, the section includes a discussion of some relevant theoretical models. It begins with a brief review of the Dornbusch model, with which the AMPS model shares three key features: forward-looking exchange rate expectations, sticky prices/wages and uncovered interest parity. This is followed by an examination of a more general theoretical framework in which the level of foreign debt affects private consumption (as is also the case in AMPS). As a result the current account occupies an explicit and central role in determining the equilibrium real exchange rate. Although this more general theoretical framework provides a basis for understanding exchange rate determination in the AMPS model, the latter incorporates a number of extensions and refinements. These are noted briefly.

In section III, simulations with the AMPS model are used to study the response of the real exchange rate to permanent but unanticipated changes in export demand, protection, wages behaviour and macroeconomic policy, including fiscal policy and monetary policy. An indication of the relative importance of particular shocks as sources of exchange rate variability is obtained by calculating the effects of shocks which are of typical magnitudes, as experienced historically. The results highlight the major historical roles of changes in export demand, monetary policy and wage behaviour as sources of real exchange rate variability. However, changes in protection policy and fiscal policy appear to have made relatively small contributions to real exchange rate variability.

The following are some of the specific findings regarding the dynamic effects of the shocks considered:
An increase in export demand induces a large, immediate appreciation of the nominal exchange rate, taking the real exchange rate close to its new long run equilibrium level.

An increase in the money supply induces a large immediate depreciation of the nominal and real exchange rates, but these large real depreciations are then steadily eroded by subsequent appreciation of the nominal exchange rate and a rising domestic price level. In the long run the real exchange rate returns to its level before the shock.

In the long run wage restraint results in a real depreciation brought about largely by deflation of the domestic price level. However, the adjustment process is characterised by marked cyclical fluctuations in the nominal (and hence the real) exchange rate.

The pattern of the response of the (nominal and real) exchange rate to a tariff cut is similar to that following a reduction in export demand. However, historically, changes in tariffs have been a much less important source of year-to-year variability in the real exchange rate.

Fiscal expansion has a relatively small effect on the long run equilibrium level of the real exchange rate because its main effect is to change the composition of demand (away from the private sector and in favour of the public sector) rather than to significantly disturb external balance. It is associated with a rather small real appreciation in both the short run and the long run.
INfluences on the Australian Real Exchange Rate: An Analysis Using the Amps Model

W.J. Martin, C.W. Murphy and D.T. Nguyen

1. Introduction

Major movements in the exchange rate and the current account balance have dominated economic policy discussions over the past two years. Between September 1984 and September 1986, the real effective exchange rate depreciated by more than 35 per cent, according to the BAE's measure (BAE 1986, p 370). Such a change in relative prices has marked implications for both the tradeable and non-tradeable sectors of the economy.

There is a long-standing tradition in Australian economics of using general equilibrium models to analyse the effects of both domestic policy (eg tariff cuts) and external shocks (eg shifts in export demand) on key economic variables including the real exchange rate. This tradition dates back to the dependent-economy model developed in the late 1950s (Salter 1959, Swan 1960) and extends to recent discussions of the Gregory thesis (Gregory 1976, Snape 1977, Stoeckel 1979) and the development and applications of the ORANI model (Dixon, Parmenter, Sutton and Vincent 1982).

As Turnovsky (1983) suggests, the structural changes in the economy upon which these analyses typically focus may be regarded as changes in long-run equilibrium values resulting from domestic or external shocks. While such comparative-static effects are obviously important, it would be very useful to be able to trace out the path traversed by the economy on the way to the new long-run equilibrium. This is particularly relevant in view of recent open-economy macroeconomic analyses (Dornbusch 1976a; Chalfant, Love, Raussers and Stamoulis 1986) which indicate that monetary shocks, although having no real effects in the long run, may cause significant and protracted deviations of the real exchange rate from its steady-state value and therefore exert considerable influence on the economy in the short-to-medium run.

In this paper, simulations of the Australian Medium-term Policy Simulation (AMPS) model are employed to examine the dynamic effects on the real exchange rate and other macro variables
of a range of domestic and external shocks. The plan of the paper is as follows. In the next
section, an overview is presented of the logic of the model in the context of modern theories of
exchange rate determination, and of the model's key features. In the third section, the simulation
experiments and the results obtained from the model are discussed. Some concluding remarks are
given in Section IV.

II. THE MODEL

The version of the AMPS macroeconometric model used in this paper was primarily the
responsibility of Chris Murphy who developed the model while working at the Australian
Treasury, the Office of the Economic Planning Advisory Council and, most recently, the Australian
National University. The model contains 22 stochastic equations, which are estimated on the basis
of half-yearly data covering the period from 1970 (2) to 1985 (1), and 67 identities and definitions.
As it has been described in detail elsewhere (see Murphy, Bright, Brooker, Geeves and Taplin,
1986) only a brief overview of its structure and characteristics is provided here. In the next sub-
section of the paper, the Dornbusch model, which provides an initial point of departure for model
specification, is outlined. This is followed by a discussion of the determination of the long-run,
equilibrium level of the real exchange rate in the AMPS model, and some key features of exchange
rate dynamics. Finally, some of the other features of the model are considered as background to
the discussion of simulation results in the next section.

The Dornbusch Model

Before discussing the AMPS model itself, it may be helpful to first review the main features
of one of the more influential recent models of exchange rate determination, the Dornbusch (1978b)
model. This well-known and relatively simple theoretical model encapsulates many of the major
features of exchange rate determination in AMPS, although AMPS contains a number of important
additional features, such as feedback from the current account (via foreign debt) to consumption, as
will be discussed later in this section.
One variant of the Dornbusch model can be represented as follows:

IS schedule: \[ y = a_1 y - a_2 x - a_3 (E + P - P^f) + a_4 \] \hspace{1cm} (1)

LM schedule: \[ M^* - P = b_1 y - b_2 x + b_3 \] \hspace{1cm} (2)

Price equation: \[ \dot{P} = c_1 (y - y^*) \] \hspace{1cm} (3)

UIP condition: \[ r = r^f - e \] \hspace{1cm} (4)

Regressive expectations: \[ e = d_1 (E^* - E) \] \hspace{1cm} (5)

where: \( y \) = real domestic output, in logs
\( y^* \) = full employment value of "y" in logs (exogenous)
\( P \) = price of domestic output, in logs
\( P^f \) = foreign price level, in logs (exogenous)
\( E \) = exchange rate (foreign-currency price of \$A), in logs
\( e \) = expected rate of exchange rate appreciation, i.e. the expected increase in "E"
\( E^* \) = long-run equilibrium value of "E", as determined by the model
\( r \) = domestic interest rate, expressed as a proportion
\( r^f \) = foreign interest rate, as a proportion (exogenous)
\( M^* \) = nominal money supply, in logs (exogenous)

The coefficients of the model are subscripted and defined to be positive. A dot over a variable indicates the derivative of that variable with respect to time.

Equation (1) is a statement of the familiar IS schedule, which corresponds to the condition for clearance of the market for domestic output. Equation (2) describes the LM schedule, representing equilibrium in the money market. Equation (3) postulates a Phillips Curve relationship between excess demand for domestic output and the inflation rate.

In the above simplified representation, the portfolios of domestic residents are assumed to be made up of domestic money, domestic bonds, and foreign bonds. The latter two assets are
considered perfect substitutes so that their expected rates of return are equalised, as indicated by equation (4), the uncovered interest parity condition.

In much of the recent theoretical literature, exchange rate expectations are assumed to be formed rationally. Under a strictly fixed exchange rate regime, this implies that the exchange rate is expected to be static. However, under a floating exchange rate regime, rational expectations involve market participants accurately anticipating future movements in the exchange rate, provided there are no unanticipated shocks to the economy in the interim. Any other approach would result in continuing forecast errors and opportunities for profitable speculation. Under a floating exchange rate, the rational expectations approach is closely related to another forward-looking approach, regressive expectations, under which the exchange rate is assumed to regress at a fixed rate towards its long-run equilibrium path. This is represented by equation (5) in which $E^*$ is the value of $E$ which would be consistent with steady-state equilibrium. Regressive expectations have been used in work by, for example, Dornbusch (1976a), Artus and Bismut (1986), and Frankel and Froot (1986).

It has been shown that, under particular circumstances, regressive expectations are equivalent to rational expectations (Dornbusch, 1976b). The following conditions are sufficient to ensure that equivalence. Firstly, the value of the regressive expectations parameter, $d_1$, must be consistent with the parameters of the model. Secondly, the model must contain only first order dynamics. Thirdly, the policy regime must remain constant. From simulations of the AMPS model by Murphy (1986) it appears that, even where a model contains higher order dynamics, regressive expectations may provide a useful approximation to rational expectations, at least for shocks to the demand for money. Regressive exchange rate expectations were used in the present analysis. Chris Murphy has recently undertaken further major model development work which includes the use of rational expectations for not only the expected exchange rate, but more generally in financial markets (Murphy 1988a). At the time of writing, only the fiscal and monetary policy shocks had been performed with the new Murphy model (Murphy 1988b). Although the results obtained for
those shocks differ in some respects from those presented here, the broad thrust of the conclusions is unchanged.

**The Equilibrium Exchange Rate**

In this subsection, it will be demonstrated that, under a set of fairly reasonable assumptions, the real exchange rate can be regarded as adjusting in the long run to ensure that the trade balance is zero. If the reader is prepared to accept this proposition, then this section can be skipped without loss of continuity.

The equilibrium real exchange rate (or index of competitiveness) in the Dornbusch model, \((E^*+P-P^f)\), adjusts to clear the domestic goods market. This can be seen as follows. In equilibrium, \(\dot{p} = \sigma = 0\), so that \(y = y^*\), \(r = r^f\), and \(E = E^*\). Using these conditions, equation (1) can be solved for \((E^*+P-P^f)\). It can thus be seen that the equilibrium values of \((E^*+P-P^f)\) must be such as to clear the market for domestic output. However, there is nothing in the foregoing which would ensure that the current account is balanced. Thus, in the above Dornbusch model, continuing current account surpluses (deficits) are possible, implying that the level of net foreign assets (or indebtedness) may grow indefinitely. In the terminology of Swan (1955), internal balance is required, but external balance is not.

External balance requires that the current account balance be zero in a stationary economy, so that the level of foreign debt remains constant; or that foreign debt grows at the same rate as GDP in a growing economy. The rationale for this condition is clear. In a stationary economy, a persistent current account deficit causes foreign debt to rise relative to GDP. In a growing economy, if foreign debt grows at a faster percentage rate than GDP, it will rise as a proportion of GDP. In turn, if foreign debt rises relative to GDP, then domestic consumption demand is likely to fall relative to GDP, indicating that equilibrium has not been achieved. Thus, a condition of long-run external balance might be incorporated into the above framework by including a link from the current account to real expenditure through changes in foreign debt and hence net worth, as in Dornbusch and Fischer (1980).
For a stationary economy model such as the version of the Dornbusch model presented earlier, the resulting equations for internal balance (the IS curve) and foreign net worth accumulation might take the form:

\[ y = a_5 \cdot y + a_6 \cdot r + a_7 \cdot (E + P - P^f) + a_8 \cdot (\ln A - P) + a_9 \]  \hspace{1cm} (6)

\[ \Lambda = A \cdot r + \text{Antilog}(P) \cdot \text{Antilog}(-x_1 \cdot (E + P - P^f)) + x_2 \]

\[ - \text{Antilog}(P^f \cdot E) \cdot \text{Antilog} \left[ m_1 \cdot y + m_2 \cdot (E + P - P^f) + m_3 \right] \]  \hspace{1cm} (7)

where \( A \) is the stock of net foreign net worth (assumed to be denominated in domestic currency), held by domestic residents; the first term in square brackets in (7) refers to the log of the volume of exports and the second to the log of the volume of imports. Equation (6) is merely equation (1) augmented with a wealth effect on the demand side. Equation (7) defines the change in foreign net worth over time as equal to interest receipts from foreign net worth plus the balance of trade. In equation (7), import demand has been specified as a function of output. This is consistent with an import pattern dominated by investment goods and intermediate inputs, as is the case in Australia.

In what follows, it will be convenient to deflate (7) by the domestic price level, \( \text{Antilog}(P) \):

\[ \Lambda / \text{Antilog}(P) = [r \cdot A / \text{Antilog}(P)] + \text{Antilog}(-x_1 \cdot (E + P - P^f)) + x_2 \]

\[ - \text{Antilog}((P^f \cdot E + P) + m_1 \cdot y + m_2 \cdot (E + P - P^f) + m_3) \]  \hspace{1cm} (7')

Replacing equation (1) by equations (6) and (7), and again setting \( \hat{p} = e = 0 \), one can derive the long-run solution of the new system, as follows. From (3) and (4), one obtains \( y = y^* \) and \( r = r^f \). Equations (6) and (7') can be solved simultaneously to determine the equilibrium values of \( (E + P - P^f) \) and \( A/P \). Thus, in this stationary economy model with a feedback effect from foreign debt to consumption, the equilibrium values of the real exchange rate and real foreign debt are jointly determined to ensure both internal and external balance, in contrast with the Dornbusch model, where the equilibrium real exchange rate is determined solely by the requirement of internal balance.
In a model of a growing, and net debtor, country (such as the AMPS model of the Australian economy) the current account will not balance in the long run. Rather, there will be a deficit of sufficient size to provide for growth in nominal foreign debt at the same rate as nominal GDP. This is described in equation (8) where \( n \) is the nominal growth rate of GDP in the long run.

\[
\dot{A} = A \cdot n \tag{8}
\]

Clearly, if the interest rate, \( r \), happened to equal \( n \) in the steady state, then \( r = n \) and then equations (7) and (8) combine to produce the condition that the trade account must balance in the steady state, as in equation (9).

\[
\frac{(\dot{A} - A \cdot r)}{\text{Antilog}(P)} = 0
\]

\[
= \text{Antilog}\{-x_1 \cdot (E+P \cdot P_i) + x_2 - \text{Antilog}\{(P_i \cdot E+P) + m_1 \cdot y - m_2 \cdot (E+P \cdot P_i) + m_3\}} \tag{9}
\]

From (3) one obtains \( y = y^* \) in the steady state, so the trade balance condition, equation (9), can be solved for the equilibrium value of \( (E+P \cdot P_i) \). Thus, under these assumptions, the equilibrium real exchange rate is determined by the requirement of trade (or external) balance, rather than by internal balance, as in the Dornbusch model. Further, given this solution for the real exchange rate, the real level of foreign debt is determined by the requirement of internal balance, equation (6). This has the important implication that any shock to demand, such as a fiscal expansion, will not affect the real exchange rate in the long run. An exogenous increase in government demand will, in the long run, "crowd out" the same amount of private consumption through an increase in private foreign debt.

Whether \( r \) is likely to equal \( n \) in the steady state is an important question if the trade balance condition is to be imposed on long run solutions of the model. Under the usual assumption that the nominal interest rate consists of a real interest rate and an inflation premium equal to the expected rate of inflation, the nominal interest rate will equal the nominal growth rate only if the real interest rate equals the real growth rate. In AMPS, uncovered interest parity is assumed so that the
domestic real interest rate will equal the foreign real interest rate in the long run. Thus \( r = \omega \) would require that the foreign real interest rate equals the domestic equilibrium real growth rate. This seems to be a reasonable approximation to the historical experience and is used in setting up the AMPS control solution for this paper. This assumption could be relaxed, but this would complicate the analysis without adding significant additional insights. Thus, in all of the simulations reported in this paper, the real exchange rate adjusts in the long run to ensure that the trade account balances.

**Exchange Rate Dynamics**

Combining equations (4) and (5), we can express the nominal exchange rate in terms of its long-run equilibrium value and the interest rate differential:

\[
E = E^* + (1/d_1)(r - r^f). \tag{10}
\]

This suggests that the response of \( E \) to an unanticipated shock is likely to consist of (a) an initial jump at the time the shock occurs, due partly to the market's immediate revision of the equilibrium value of \( E, E^* \), and partly to any immediate change in \( r \); and (b) subsequent adjustments along the transition path to the new equilibrium. The latter adjustments are driven by the evolution over time of the interest rate \( r \). (Recall that \( r^f \) is exogenous, and that in equilibrium \( e = 0 \) and hence \( r = r^f \).)

The real exchange rate, \( R = (E + P - P^f) \), can be decomposed in a similar fashion. Equation (10) can be rewritten as

\[
E + (P - P^f) - (P - P^f) = E^* + P^* - (1/d_1)(r - r^f)
\]

or:

\[
R = (E^* + P^* - P^f) + (1/d_1)(r - r^f) + (P - P^*) \tag{11}
\]

In order to focus on the domestic determinants of the real exchange rate, we shall assume that \( P^f \), which is exogenous, is also constant. This implies that the first term in brackets on the right
hand side of (11) is the long-run equilibrium value of the real exchange rate, $R^*$. Thus, the deviation of $R$ from $R^*$ consists of (a) the dynamic deviation of $E$ from its equilibrium; and (b) the dynamic deviation of $P$ from its equilibrium, $(P-P^*)$. Equation (11) shows clearly that both the nominal exchange rate and the price level represent sources of transitional dynamics in the real exchange rate.

**Particular Features of the AMPS Model**

The AMPS model contains the key structural features of the theoretical model described by equations (2)-(7). Specifically, prices and wages are sticky, uncovered interest parity is assumed, exchange rate expectations are forward looking (more precisely, they are regressive) and foreign debt affects consumption (since foreign debt is netted out of non-human wealth in the consumption function, which is formulated along the lines of Ando-Modigliani, 1963). However, as would be expected with a macroeconometric model, AMPS has a more elaborate structure than is contained in simple theoretical models such as this. AMPS is more disaggregated, has a much richer dynamic structure, contains some additional linkages, and has an endogenous treatment of full employment output. Some of these aspects of AMPS that are of particular relevance for this paper are discussed briefly below.

There are two important refinements in the IS schedule of the AMPS model which are not found in equation (6). First, unanticipated inflation has a major negative effect on private consumption expenditure, following Deaton (1977). Second, trade volumes adjust gradually, rather than instantaneously to changes in the real exchange rate. This second refinement also affects the AMPS equivalent of the balance of payments identity, equation (7).

The actual portfolio structure of the AMPS model is more elaborate than the Dornbusch model's portfolio structure as described in equations (2), (4) and (5). In addition to domestic money, domestic bonds and foreign bonds, wealth includes claims on real assets, namely business fixed capital, dwellings, and stocks of inventories. Also, equation (5) (and hence equation (10)) is augmented to cover the case where the expected rates of inflation in both domestic and foreign
economics are non-zero. As a result, real interest rates rather than nominal interest rates are equalised internationally in the long run.

In AMPS, the treatment of the real economy is considerably more subtle than that contained in equations (3) and (7). In the theoretical model only one good is produced domestically and full employment output is exogenous. In AMPS firms combine two factors (labour and capital) to produce two joint products: an export good and a good sold domestically. Further, in the long run, firms operate on this production function, both factors are paid their marginal products, and the marginal rate of transformation between the two products is equated with their relative price. Households supply labour to firms and consume three different goods: the good produced and sold domestically, an imported good and rental services. In the long run the labour supply is positively related to the real wage, and consumers allocate total consumption expenditure between the three consumption goods on the basis of utility maximisation. Further, in the long run, the unemployment rate equals the non-accelerating inflation rate of unemployment (NAIRU). Finally, foreigners substitute between Australian exports and exports from other countries. The AMPS model thus contains a complete, though aggregated, general equilibrium representation of the structure of the economy.

For the simulations reported below, we have employed a version of the AMPS model which is slightly different from that documented in Murphy et al (1986). The only differences are as follows. First, the public sector deficit equation (Murphy et al 1986, p. 139) is solved for the lump sum tax, rather than for the income tax. Second, the direct effect from real interest rate differentials to the price of domestic output (Murphy et al 1986, p. 124) is suppressed. Third, as explained above, in the control solution for the simulation experiments, the foreign real interest rate is set equal to the domestic equilibrium real growth rate.
III. SIMULATION EXPERIMENTS

Influences on the Australian Real Exchange Rate

In a recent study, McKenzie (1986) identified a number of influences on the long-run behaviour of the Australian real exchange rate, two of which are terms of trade developments, and changes in commercial policy (eg tariffs). These factors would be expected to have an impact on the steady-state value of the real exchange rate and, in general, of the nominal exchange rate. In turn, the latter effect is likely to induce, via expectations, an immediate effect on the value of the nominal exchange rate. In addition, adjustment to the new long-run equilibrium may involve deviations from the equilibrium level in both the nominal and real exchange rates.

A number of other factors might also be expected to influence the real exchange rate, either by creating dynamic deviations from equilibrium, or by changing the equilibrium level itself. Three policy variables are likely to be of particular importance: (i) monetary policy; (ii) fiscal policy; and (iii) wages policy. Five experiments relating to changes in these factors were conducted using perturbations of a magnitude within the general range of shocks experienced.1 Prior to the discussion of the results, the design of the simulation experiments is considered and the real exchange rate measure used is explained.

Design of the Simulation Experiments

Simulation experiments were conducted with the AMPS model to examine the effects of changes in the above-mentioned factors on the exchange rate and other relevant variables. In each case, the shock applied is initially unanticipated but, following its occurrence, is believed to be permanent. The default policy regime was specified so as to ensure that macroeconomic policy does not respond actively to changes in variables such as the exchange rate or the price level. More

1 Some investigation of a particular investment shock was reported in an earlier version of this paper. Because of the rather specific nature of the shock, and some concerns about the length of time required for the new equilibrium to be reached, this experiment has not been reported in this paper. The new version of the model (Murphy 1988b) has an improved treatment of this area and we intend to use it in the near future to consider an investment/productivity shock.
specifically, the budget deficit is postulated to be a constant proportion of the outstanding combined stock of domestic money and domestic government bonds, implying that this stock grows at a constant proportional rate. Moreover, the stocks of money and bonds also grow at this common fixed rate.

Results of the simulation experiments are reported in terms of the percentage deviations of the endogenous variables from what their levels would have been in the absence of the shock. To avoid the possibility that the results obtained are specific to the cyclical conditions prevailing at the time the shock is imposed, the model was first placed on an equilibrium growth path with: exogenous real prices set at their 1985(1) values, nominal prices growing at a steady rate of 6 percent per year, real magnitudes growing at the rate of population growth plus the rate of technical change as specified in Murphy et. al. (1986, p90); and the foreign real interest rate set equal to the real growth rate. This was achieved by first running the steady state version of the model with the projected exogenous data set to obtain a long-run equilibrium solution. The full dynamic version of the model was then simulated to check for consistency with the steady state version: the dynamic model should replicate the steady state results once placed on the equilibrium growth path.

The steady state version of the model was then subjected to a specific, sustained change in the exogenous variable or parameter under consideration, to assess the effect of the shock on the long-run equilibrium exchange rate (E* in equation (5)). This rate was then fed into the dynamic model as a newly fixed parameter, and the dynamic model run with the same shock applied to the exogenous variable set. The effects of the shock were then measured by calculating the proportional deviations of the endogenous variables from their values on the control time path.

**Measuring the Real Exchange Rate**

Before considering the simulation results, it is useful to clarify some issues concerning the measurement of the real exchange rate. In the simple theoretical model presented in the previous section, the real exchange rate variable, \( R = (E + P - P^f) \), has a clear interpretation as the price of
domestic output relative to the price of foreign output. Since these are the only two commodities appearing in the model, this variable summarises all the relative prices in the model.

In empirical models, such as AMPS, there are considerably more relative prices, and a number of alternative measures of the real exchange rate might be constructed, each being appropriate for a different purpose. For the purpose of summarising, from the perspective of the import-competing and export sectors, the macroeconomic effects of a wide variety of shocks, a commonly used method is to compare the domestic level of prices (or costs) with the foreign counterpart, both being expressed in the same currency. Thus $R$ is again defined as $(E + P - P^f)$, where $P$ now stands for some measure of the general price level in the domestic economy and $P^f$ is its foreign counterpart.

Alternative measures of $P$ which have often been adopted include the consumer price index (CPI), the GDP deflator, the consumption deflator, the manufacturing wholesale price index, and unit wage cost. The CPI is favoured in this study, partly in deference to conventional usage. An index of Australia’s real effective exchange rate, using the CPI, has been compiled and published by the BAE for a number of years (O’Mara, Campbell and Carland 1980; BAE 1986).

Indexes of the real exchange rate of the type just described have often been called competitiveness indexes. In what follows, the phrases "real exchange rate appreciation" and "deterioration in competitiveness" will be used interchangeably, as will the reverse descriptions of "real depreciation" and "improvement in competitiveness". A more detailed treatment of these issues is provided in another paper (Nguyen and Martin 1987).

Terms of Trade Developments

In the AMPS model, demand for Australian exports relative to world import demand is specified as a function of the price of Australian exports relative to the price of world imports (Murphy et al 1986, p128). The effect of a shift in the demand for Australian exports is most readily explored by changing the exogenous level of world demand for imports. The experiment was thus conducted by imposing a sustained increase of 0.05 in the logarithm of this variable.
This corresponds to a shift to the right of 5 percent in the long-run demand for all exports, including agricultural products. The effects of this shift on some key variables of the model are presented in Table 1.

As can be seen in Table 1, following the shock, the exchange rate appreciates immediately by virtually the full change of 4.84 percent in the long-run equilibrium rate. Between periods two and five, the nominal exchange rate appreciates slightly more, to a peak (not shown in the table) of 5.4 percent in period 5, and then gradually converges to the long-run rate. Thus, the adjustment path involves a degree of overshooting, although this is slight relative to the magnitude of the change in the equilibrium rate.

### Table 1

**Effects of a 5 Percent Increase in Export Demand**

(Percentage deviation from control path)

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>4</th>
<th>8</th>
<th>Long-run</th>
</tr>
</thead>
<tbody>
<tr>
<td>Y</td>
<td>0.70</td>
<td>0.50</td>
<td>-0.15</td>
<td>0.37</td>
<td>0.46</td>
</tr>
<tr>
<td>E</td>
<td>4.80</td>
<td>4.67</td>
<td>5.20</td>
<td>4.59</td>
<td>4.84</td>
</tr>
<tr>
<td>P</td>
<td>-0.84</td>
<td>-1.19</td>
<td>-0.92</td>
<td>-1.67</td>
<td>-1.52</td>
</tr>
<tr>
<td>R</td>
<td>3.95</td>
<td>3.47</td>
<td>4.29</td>
<td>2.93</td>
<td>3.32</td>
</tr>
<tr>
<td>R^b</td>
<td>-0.02</td>
<td>-0.09</td>
<td>0.20</td>
<td>-0.12</td>
<td>0</td>
</tr>
<tr>
<td>TSSH</td>
<td>0.79</td>
<td>0.67</td>
<td>-0.17</td>
<td>-0.14</td>
<td>0</td>
</tr>
<tr>
<td>TOT</td>
<td>4.73</td>
<td>5.88</td>
<td>5.58</td>
<td>2.84</td>
<td>3.84</td>
</tr>
<tr>
<td>PEX</td>
<td>-0.07</td>
<td>1.22</td>
<td>0.37</td>
<td>-1.76</td>
<td>-1.0</td>
</tr>
</tbody>
</table>

a. Variables appearing in the table are: Y = Gross Domestic Product at constant prices; E = Nominal exchange rate (Foreign currency price of $A); P = Consumer price index; R = real exchange rate, as defined in the previous section; r = Nominal rate of interest on 90 day commercial bills (Percent per year); TSSH = Trade surplus as a percentage of GDP; TOT = Terms of Trade, and PEX = Price of exports (Australian currency).

b. Percentage point deviations from control

In the long run, the increase in demand for exports must be offset in order to return the trade balance to zero. Writing the trade balance in foreign currency terms as: $T = P_x \times - P_m \times m$, where
P_x is the price of exports, P_m, the price of imports and x, m are the volumes of exports and imports, helps make clear the offsetting factors at work. The increase in export demand tends to improve the trade balance by increasing the foreign currency price of exports, P_x, by 3.8 percent. However, trade balance is largely restored by an increase in the volume of imports, m, of 4.0 percent, which is induced by the combined effects of currency appreciation and the income effect of the improvement in the terms of trade. The foreign currency price of imports, P_m, is unchanged since Australia is assumed to be a price taker in the market for imports. There is only a marginal increase of 0.2 percent in the supply of exports, x, as the positive effect of a higher foreign currency price on this supply is largely neutralised by exchange rate appreciation.

In the short run, the increase in demand for exports does move the trade balance into surplus. This is because, while the increase in the foreign currency price of exports occurs immediately, the currency appreciation takes about two years to have its full stimulating effect on import volumes. This lagged import response is also one reason why output rises by more in the short term than in the long term. The other major factor is that the temporary and unanticipated fall in inflation associated with currency appreciation gives a temporary stimulus to consumption demand.

Some indication of the importance of trade shocks as a source of real exchange rate variability can be obtained by examining the magnitude of shocks from this source. If the demand for imports can be represented as a random walk (with or without drift), then the best predictor of future levels of import demand will be its current value (adjusted for trend increases/decreases if needed). In this case, the standard deviation of changes in the variable provides an indication of the period to period variability in expected future levels of the variable.

Using the AMPS data set, the standard deviation of percentage changes in world import demand was estimated to be 5.5 percent. A shock of such magnitude would be associated with a peak change in the real exchange rate of 4.7 percent and a long-run change of 3.7 percent. Another potentially useful general indicator of the importance of trade shocks is the standard deviation of percentage changes in the terms of trade, which was 6.9 percent over the sample period, one percentage point above the peak effect (5.9 percent) resulting from the shock
considered in this paper. Both of these measures of changes were widely dispersed, with minimum values of -16 percent in each case and maximum values of +11 percent for world trade and +17 percent for the terms of trade. The size of these changes highlights the importance of trade shocks as sources of real exchange rate variability.

Changes in Commercial Policy

Changes in trade policy measures, such as tariff and quota protection and export taxes/subsidies, can be expected to have an impact on the equilibrium level of the real exchange rate. A reduction in tariff rates tends to induce domestic consumers to switch from domestic goods towards imports. Hence the long-run equilibrium real exchange rate must depreciate in order to preserve long-run equilibrium in the trade account.

An estimate of the effects of a change in the rate of protection was obtained by reducing the implicit tariff rate on imports of consumption goods by one percentage point from its initial level of 12.3 percent. (Since imports of investment goods are not usually subject to protective barriers, their price is not directly affected by the change in protection). The results of the simulation are presented for key variables in Table 2, and are consistent with the expectation that the tariff reduction would result in a depreciation of the nominal and real exchange rates. As with the export demand experiment, the immediate response of the nominal exchange rate is sufficient to bring both the nominal and real exchange rates very close to their new long-run equilibrium levels.

In the long run, the exchange rate depreciation increases the domestic currency price of exports, which induces an increase in the volume supplied. This increase in export volume results in a small decline in the foreign currency price of exports, but nevertheless the foreign currency value of exports increases. The trade account is balanced through an increase in the volume of total imports. Imports of non-investment goods increase in response to an improvement in their price competitiveness from the tariff cut, which is only partly offset by the currency depreciation. Imports of investment goods decline as the increase in their price resulting from currency depreciation raises the user cost of capital.
TABLE 2
Effects of a 1 Percentage Point Reduction in Protection on Imports Other Than Investment Goods
(Percentage deviation from control path)

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>4</th>
<th>8</th>
<th>Long-run</th>
</tr>
</thead>
<tbody>
<tr>
<td>Y</td>
<td>0.06</td>
<td>0.07</td>
<td>0.03</td>
<td>0.02</td>
<td>0</td>
</tr>
<tr>
<td>E</td>
<td>-0.69</td>
<td>-0.70</td>
<td>-0.66</td>
<td>-0.63</td>
<td>-0.72</td>
</tr>
<tr>
<td>P</td>
<td>-0.04</td>
<td>-0.06</td>
<td>-0.01</td>
<td>-0.04</td>
<td>-0.01</td>
</tr>
<tr>
<td>R</td>
<td>-0.73</td>
<td>-0.75</td>
<td>-0.67</td>
<td>-0.67</td>
<td>-0.73</td>
</tr>
<tr>
<td>r₂</td>
<td>0.02</td>
<td>0.01</td>
<td>0.03</td>
<td>0.05</td>
<td>0</td>
</tr>
<tr>
<td>TSSH</td>
<td>-0.10</td>
<td>-0.03</td>
<td>0</td>
<td>-0.04</td>
<td>0</td>
</tr>
<tr>
<td>TOT</td>
<td>-0.67</td>
<td>-0.47</td>
<td>-0.13</td>
<td>-0.27</td>
<td>-0.23</td>
</tr>
<tr>
<td>PEX</td>
<td>0.01</td>
<td>0.22</td>
<td>0.54</td>
<td>0.36</td>
<td>0.49</td>
</tr>
</tbody>
</table>

a. All variables are as defined in Table 1.
b. Percentage point deviations from control.

Clearly, changes in commercial policy tend to be considerably more gradual than shifts in export demand. Changes in the implicit rate of tariffs on imports had a standard deviation of 1.4 percent over the AMPS sample period. Based on the results given above, a shock of this size would result in a peak deviation of 1 percent in the real exchange rate. This would imply that changes in protection were likely to be much smaller sources of exchange rate variability than the trade shocks considered previously. However, secular changes in protection levels, such as that brought about by the reduction of manufacturing sector protection from 23 percent in 1970-71 to 16 percent in 1982-83 (Norton and Kennedy 1985, p 12) would probably account for more important longer term changes.

The shock considered in this section is an hypothetical, across-the-board, reduction of one percentage point in protection on all imports of non-investment goods. The magnitude of the effect of a reduction in the average protection rate brought about by reductions concentrated in particular
sectors might be quite different. In view of this, the results should be interpreted as providing only a qualitative indication of the nature and direction of macroeconomic responses to changes in protection policy.

Changes in the Money Supply

In the next simulation experiment, we consider an open-market operation, in which the monetary base, M, is increased by 5.0 per cent compared with the control case. This increase is exactly offset by a decrease in B, the net stock of government bonds, leaving wealth initially unchanged. The results of this experiment are summarised in Table 3.

<table>
<thead>
<tr>
<th>TABLE 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Effects of Increase of 5 percent in the Monetary Base^a</td>
</tr>
<tr>
<td>(Percentage deviation from control path)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Half year</th>
<th>1</th>
<th>2</th>
<th>4</th>
<th>8</th>
<th>Long-run</th>
</tr>
</thead>
<tbody>
<tr>
<td>Y</td>
<td>0.08</td>
<td>0.08</td>
<td>0.13</td>
<td>-0.10</td>
<td>0</td>
</tr>
<tr>
<td>E</td>
<td>-7.71</td>
<td>-8.63</td>
<td>-7.82</td>
<td>-5.12</td>
<td>-5.0</td>
</tr>
<tr>
<td>P</td>
<td>2.38</td>
<td>3.78</td>
<td>5.18</td>
<td>-5.22</td>
<td>5.0</td>
</tr>
<tr>
<td>R</td>
<td>-5.33</td>
<td>-4.85</td>
<td>-2.64</td>
<td>0.10</td>
<td>0</td>
</tr>
<tr>
<td>r^b</td>
<td>-1.34</td>
<td>-1.80</td>
<td>-1.40</td>
<td>-0.04</td>
<td>0</td>
</tr>
<tr>
<td>TSSH</td>
<td>-0.25</td>
<td>0.95</td>
<td>1.32</td>
<td>-0.07</td>
<td>0</td>
</tr>
<tr>
<td>TOT</td>
<td>-5.94</td>
<td>-3.43</td>
<td>0.26</td>
<td>0.19</td>
<td>0</td>
</tr>
<tr>
<td>PEX</td>
<td>1.77</td>
<td>5.20</td>
<td>8.18</td>
<td>5.31</td>
<td>5.0</td>
</tr>
</tbody>
</table>

a. All variables are defined in Table 1.

b. Percentage point deviations from control.

The monetary expansion necessitates a fall in the long-run equilibrium value of the domestic currency, a fall which is immediately recognised by the market. As a result, the domestic currency immediately depreciates. The depreciation in the first half-year is 7.7 per cent, compared with a 5.0 per cent depreciation required in the long run. Intuitively, the reasons for this overshooting can be seen as follows. The increase in the real money supply induces a fall in the interest rate. Given the
uncovered interest rate parity condition, this implies that the exchange rate must be at such a level as to generate expectations of a subsequent appreciation. In other words, the domestic currency must initially depreciate by more than is ultimately required.

In subsequent periods, as the price level rises further to reflect more fully the effect of the depreciation, the real money supply and the interest rate gradually return to their respective control values, and the exchange rate approaches its long-run equilibrium value with some minor oscillations. In the long run, the monetary expansion is "neutral", in that it is offset exactly by an increase in domestic prices and a matching depreciation, leaving the interest rate and all real variables unchanged.

In the short-to-medium run, however, the overshooting of the exchange rate and the lagged response by prices mean that there is a temporary but substantial improvement in the international competitiveness of domestic export and import-competing industries (while the nominal exchange rate overshoots its long run value by only 2.7 percentage points, the real exchange rate overshoots by a maximum of 5.3 percentage points). As can be seen in Table 3, this real depreciation persists for several years, thus helping to bring about an improvement in the trade account.

The emergence of a trade surplus stimulates aggregate demand. However, the large depreciation in the exchange rate causes an unanticipated inflation in consumption prices, which reduces consumption expenditure. Further, the rise in the price level reduces the real value of financial assets, and this wealth effect reduces consumption demand. These offsetting effects are quite strong, so that the net increase in output is rather small. The trade surpluses result in an increase in wealth and are a means by which real asset levels are restored to their equilibrium level.

While monetary policy shocks can obviously be a major source of variability in the real exchange rate, it is not straightforward to determine the extent to which they have induced, or are likely to induce, such variability. Under a fixed exchange rate regime, for instance, the money supply needs to adjust in order to maintain the fixed rate. Such adjustments in the money supply are not sources of variability in the nominal exchange rate, although they will be associated with
short-term changes in the real rate. Only under a clean float can the money supply be regarded as exogenous. In view of this, the historical range of variations in the real money supply can only give an indication of the order of magnitude of shocks which might be plausible. In the AMPS data set, the standard deviation of ex post percentage changes in the real base money stock was 2.9 percent, with a range from -4.2 to +6.4. The shock considered in this simulation resulted in a peak change in the real money supply of 2.6 percent, which clearly falls well within the range of historical experience.

Changes in Government Expenditure

The results of a simulated fiscal contraction are presented in Table 4. In this experiment, the level of government expenditure on goods produced by the domestic private sector is reduced by an amount equivalent to 1 per cent of GDP, and lump sum taxes are reduced by an equal amount.

In the long run, the fiscal expansion has only small effects on real output and the real exchange rate. In fact, for reasons explained in Section II, both of these variables would be unaffected in the long run if the increase in government demand had the same composition (imports, domestic goods and dwelling services) as private consumption. In this situation, the increase in government spending would merely "crowd out" private consumption as a consequence of a reduction in wealth associated with a rise in foreign debt.

Initially, there is a nominal exchange rate appreciation which is substantially larger than the long-run appreciation. This overshooting, which reflects a transient increase in interest rates, arises mainly because of the effect of the fiscal expansion on total expenditure and output. Of course, the effect on output is partly offset by declining net exports in response to the appreciation. Nevertheless, it takes some time for trade volumes to fully adjust, so that the net effect on output is initially dominated by the increase in government spending. The rise in output tends to increase the demand for money, thus causing the interest rate to rise. This means that, initially, the domestic currency must appreciate by more than the long-run change so as to create expectations of a later depreciation.
TABLE 4
Effects of an Increase of 1 Percent of GDP in Government

Purchases of Domestic Goods and Services a
(Percentage deviations from control path)

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>4</th>
<th>8</th>
<th>Long-run</th>
</tr>
</thead>
<tbody>
<tr>
<td>Y</td>
<td>0.56</td>
<td>0.12</td>
<td>-0.35</td>
<td>0.18</td>
<td>-0.09</td>
</tr>
<tr>
<td>E</td>
<td>1.97</td>
<td>2.44</td>
<td>3.00</td>
<td>1.62</td>
<td>1.28</td>
</tr>
<tr>
<td>P</td>
<td>-0.15</td>
<td>0.07</td>
<td>0.38</td>
<td>-0.33</td>
<td>0.14</td>
</tr>
<tr>
<td>R</td>
<td>1.82</td>
<td>2.51</td>
<td>3.38</td>
<td>1.29</td>
<td>1.42</td>
</tr>
<tr>
<td>r b</td>
<td>0.35</td>
<td>0.59</td>
<td>0.86</td>
<td>0.17</td>
<td>0</td>
</tr>
<tr>
<td>TSSH</td>
<td>0.11</td>
<td>-0.31</td>
<td>-0.53</td>
<td>-0.17</td>
<td>0</td>
</tr>
<tr>
<td>TOT</td>
<td>2.48</td>
<td>1.96</td>
<td>2.14</td>
<td>-0.29</td>
<td>0.58</td>
</tr>
<tr>
<td>PEX</td>
<td>0.51</td>
<td>-0.49</td>
<td>-0.86</td>
<td>-1.91</td>
<td>-0.70</td>
</tr>
</tbody>
</table>

a. All variables are defined in Table 1.
b. Percentage point deviations from control.

In the medium run, the substantial deterioration in competitiveness induces a trade deficit, which serves to increase foreign debt, to reduce private net wealth and hence to depress consumption. Both the reductions in net exports and in consumption tend to decrease the demand for money via their impact on aggregate demand, so that eventually the interest rate falls, and the domestic currency weakens. The real appreciation peaks at 3.4 per cent in the fourth half year after the shock.

In the Australian context, many commentators have associated fiscal expansions with a weakening of the domestic currency, in contrast with the transitory appreciations observed in the above experiment. A possible reason for this may have been an implicit expectation by these commentators that all budget deficits will ultimately be monetised, so that fiscal expansions would be tantamount to increasing the money supply. By contrast, it is assumed here that the rate of growth in the monetary base is a fixed parameter. The results are broadly consistent with recent U.S. experience which suggests that a fiscal expansion which is not accommodated by monetary
expansion would tend to raise the interest rate and strengthen the domestic currency in the short to medium term.

Over the AMPS sample period, the percentage share of government spending on goods and services in GDP varied considerably. The standard deviation of changes in this share (over the same period of the previous year) was 0.48 percent, just under half the size of the shock considered in this section, with a range from -1.2 to 1.5 per cent.

Changes in the Wage-Setting Environment

In the AMPS model, movements in the real wage rate are heavily influenced by the non-accelerating inflation rate of unemployment (NAIRU). If the NAIRU is reduced, adjustments are required to absorb the effective increase in the labour supply. The effects of a reduction of two percentage points in the NAIRU are summarised in Table 5.

As we shall see below, the long-run equilibrium exchange rate must depreciate. In the short run, the recognition of this required change leads to an immediate, overshooting depreciation. The fall in the NAIRU increases the ex-ante supply of labour and reduces nominal wages relative to the control case, and part of this flows through to prices. The reduction in prices increases real money balances and so interest rates fall. This requires an anticipation of future exchange rate appreciation, which implies that the domestic currency must over-depreciate initially.

The fall in interest rates is limited by upward pressures on aggregate demand, and the demand for money, arising from several sources. First, both the depreciation and the reduction in prices serve to increase competitiveness and net exports. Second, the unanticipated price deflation stimulates consumption expenditure. Third, the decline in interest rates encourages investment in housing and business capital. These demand-side effects continue and a damped price/activity cycle is a feature of the adjustment path.
TABLE 5

Effects of a Reduction of 2 Percentage Points in NAIRU a
(Percentage deviations from control)

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>4</th>
<th>8</th>
<th>Long-run</th>
</tr>
</thead>
<tbody>
<tr>
<td>Y</td>
<td>1.18</td>
<td>2.33</td>
<td>2.14</td>
<td>0.91</td>
<td>2.1</td>
</tr>
<tr>
<td>E</td>
<td>-1.45</td>
<td>-2.49</td>
<td>-2.86</td>
<td>0.73</td>
<td>-0.58</td>
</tr>
<tr>
<td>P</td>
<td>-1.23</td>
<td>-2.21</td>
<td>-1.33</td>
<td>-0.37</td>
<td>-1.62</td>
</tr>
<tr>
<td>R</td>
<td>-2.68</td>
<td>-4.70</td>
<td>-4.18</td>
<td>0.36</td>
<td>-2.20</td>
</tr>
<tr>
<td>r^b</td>
<td>-0.43</td>
<td>-0.95</td>
<td>-1.14</td>
<td>0.65</td>
<td>0</td>
</tr>
<tr>
<td>TSSH</td>
<td>-0.19</td>
<td>0.10</td>
<td>0.93</td>
<td>-0.62</td>
<td>0</td>
</tr>
<tr>
<td>TOT</td>
<td>-4.21</td>
<td>-6.56</td>
<td>-2.93</td>
<td>-0.68</td>
<td>-2.29</td>
</tr>
<tr>
<td>PEX</td>
<td>-2.76</td>
<td>-4.07</td>
<td>-0.07</td>
<td>-1.41</td>
<td>-1.70</td>
</tr>
</tbody>
</table>

a. All variables are defined in Table 1.
b. Percentage point deviations from control.

In the medium run (more specifically, in year two) the supply-side factors begin to become important. Lower producer real wages tend to increase desired output at any given level of capital, and to raise the return on capital. Over time, the resulting stimulus to investment leads to a greater capital stock relative to the control case. In turn, this raises labour demand, and real wages rise back toward their initial level.

Both the price level and the nominal exchange rate exhibit considerable damped cyclical variation during the adjustment process. The combined effect of these variations is a marked degree of variability in the real exchange rate. This variability arises both from the dynamics of price and activity adjustments, and of investment and asset accumulation.

In the long run, with the actual unemployment rate being driven down to the NAIRU, employment rises by 2 percent. Through uncovered interest rate parity, the domestic real interest rate remains fixed. As a result, the real rate of return on capital, as well as the real wage, are essentially unchanged. This implies that the capital stock rises by approximately the same proportion as employment, so that output increases more or less equi-proportionately. To absorb the increased supply of exports, the real exchange rate must depreciate because the export demand
curve is downward sloping. Most of this real depreciation comes in the form of a fall in the price level, the remainder being manifested in a slight nominal depreciation.

It is frequently been suggested that a wages policy which reduces the rate of growth in nominal wages would both improve Australia's trade balance and support its currency. In the context of the AMPS model, such a policy would be equivalent to the kind of shock which we have just considered. Our simulation results suggest that wages restraint, with no accommodation by monetary policy, would stimulate net exports, but would not strengthen the domestic currency, which would need to depreciate in both nominal and real terms to accommodate the resultant increase in domestic output. The conventional view of wage increases leading to depreciation (presumably in the near to medium term) may be based on the assumption that wage increases would subsequently be accommodated by monetary expansion. As Papell (1984) has demonstrated, the nature of monetary policy response can be expected to affect the dynamics of exchange rate response. However, the conclusion that the long-run effect should be a real devaluation would not be affected.

The NAIRU appears to have risen substantially over the period since 1970, with the estimated rate increasing from 2.7 percent to 8.5 percent over the sample period used in AMPS (Murphy et al 1986, p 79). (Note, however, that the measurement of the NAIRU is subject to considerable conceptual and practical difficulties, as Trivedi and Baker (1985) conclude). This increase in the NAIRU would, ceteris paribus, be expected to have caused some longer term currency appreciation. Over shorter periods, the considerable volatility evident in the growth rate of nominal wages can be expected to have been a source of some real exchange rate variability. The standard deviation of percentage changes in the producer real wage (the wage rate paid by firms deflated by the price of business sector output) was 2.2 percent over the AMPS sample period. This is reasonably close to the peak deviation from control (2.8 percent) of this variable resulting from the shock considered in this section, implying that this shock is well within the range of shocks experienced by the economy.
Review of Real Exchange Rate Effects

The time paths of the real exchange rate following the shocks considered in this section are depicted in Figures 1-5, which also show the new equilibrium, $R_1$, relative to the control level, $R_0$. The figures highlight the wide differences across the shocks, in the relative importance of changes in the equilibrium real exchange rate and dynamic deviations from this rate. At one extreme, the monetary and fiscal policy shocks cause little or no change in the equilibrium real exchange rate, but substantial deviations over a fairly long period. At the other extreme, for the export demand shock and the tariff shock, the response is dominated by changes in the equilibrium rate. The wages shock is an intermediate case, with both changes in the equilibrium level and dynamic deviations having important influences on real exchange rate behaviour; the adjustment path involves marked cyclical behaviour rather than persistent over or under-shooting.

In Table 6, the effects of particular shocks on the real exchange presented in the earlier tables have been scaled to make them comparable with the standard deviations of percentage changes in the relevant variable in the AMPS data set. In some cases, this involved scaling the effects by the ratio of the size of the simulated shock to the historical variability of the corresponding exogenous variable. However, the exogenous variable used for the wages shock is not directly observable, and the changes in the real money supply relevant to the money supply shock are only observable ex post. Therefore, the effects of these shocks were scaled in such a way as to make their largest single-period effects on the most relevant endogenous variable equal to the standard deviation of percentage changes in that variable. The particular magnitudes involved in these comparisons have been discussed together with the simulation results in earlier sub-sections of the paper.

It seems clear that changes in export demand have been a major exogenous source of real exchange rate variability. The response of the real exchange rate to a permanent change in export demand is dominated by the change in the long-run equilibrium rate.
Table 6

<table>
<thead>
<tr>
<th></th>
<th>Half-year</th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>1</td>
<td>2</td>
<td>4</td>
<td>8</td>
</tr>
<tr>
<td>Export demand increases (5.5%)</td>
<td>4.3</td>
<td>3.8</td>
<td>4.7</td>
<td>3.2</td>
<td>3.7</td>
</tr>
<tr>
<td>Tariff reduction (1.4%)</td>
<td>-1.0</td>
<td>-1.0</td>
<td>-0.9</td>
<td>-0.9</td>
<td>-1.0</td>
</tr>
<tr>
<td>Money supply increases (2.9%)</td>
<td>-5.9</td>
<td>-5.4</td>
<td>-2.9</td>
<td>0.1</td>
<td>0</td>
</tr>
<tr>
<td>Fiscal Expansion (0.48% GDP)</td>
<td>0.9</td>
<td>1.2</td>
<td>1.6</td>
<td>0.6</td>
<td>0.7</td>
</tr>
<tr>
<td>Wage restraint (2.2% fall)</td>
<td>-2.1</td>
<td>-3.7</td>
<td>-3.3</td>
<td>0.3</td>
<td>-1.7</td>
</tr>
</tbody>
</table>

Of the policy shocks, it appears that monetary policy changes could have had marked effects on the variability of real exchange rates, especially in the short run. From Table 6, fiscal policy would appear to be a much less important source of variability than money supply or wages shocks. Changes in wage policy would appear to have had important implications for the real exchange rate, partly because of the size of the shocks experienced, and partly because even a single, sustained change in wages policy would appear to induce a pattern of marked cyclical variations in the real exchange rate. Changes in rates of protection appear to have been a relatively minor source of year-to-year variability in real exchange rates.

Some Other Shocks

While the range of shocks considered in this paper is far from complete, it does include a number of the factors most often cited as key determinants of the Australian exchange rate. Further, the results provide a qualitative guide to the likely nature of the effects of some other shocks which have not been considered here. A change in the rate of increase of the money supply (and therefore the inflation rate) has some elements in common with the monetary shock discussed above. This is because the rise in the rate of inflation causes the nominal interest rate to increase and therefore the equilibrium demand for money to fall. The initial money supply is
therefore too high and a process of adjustment of real money balances and other real balances, similar to that occurring in the monetary expansion simulation considered above, is required to restore long-run equilibrium. The actual outcome for real variables would, however, differ because of factors such as non-neutrality of the tax system with respect to inflation and divergences between actual and long-run inflation along the adjustment path.

Changes in foreign real interest rates as a result of changes in foreign nominal interest rates or inflation rates will, like the money supply shock, disturb the equality of domestic and foreign real interest rates, which must hold in equilibrium, and have real effects during the transition phase (Murphy 1986). The long-run change in domestic real interest rates associated with such changes will, in addition, induce changes in the equilibrium capital stock, output supply and real exchange rate.

Another shock of potential interest is the effect of a change in the level of foreign prices. This shock has not been explicitly considered here since Murphy (1986) has shown that, in the present context, it has no effects on nominal or real variables other than the exchange rate. The rise in foreign nominal prices results in an immediate, equal appreciation which insulates all domestic variables from the shock.

A final class of shock which has not been considered is the effect of a change in anticipations about future policies or other exogenous variables. The exchange rate will typically jump at the time that these expectations are revised, and subsequent, anticipated adjustments will occur both before and after the actual change in the exogenous variable occurs (Wilson 1979; Gray and Turnovsky 1979; Turnovsky 1983). A full analysis of such shocks requires the use of fully rational expectations, rather than the regressive expectations assumed here and remains to be undertaken.

IV. CONCLUSIONS

The purpose of this paper was to examine the response of the real exchange rate to a number of important shocks. The AMPS macroeconomic model was used as the vehicle for the
analysis. The AMPS model shares many of the features of some of the more popular theoretical macroeconomic models of exchange rate determination, such as sticky prices and wages, forward looking exchange rate expectations, uncovered interest parity, and a link from foreign debt to consumption. At the same time, the long run equilibrium of its real sector is not dissimilar to traditional general equilibrium models. In the long run, the real exchange rate adjusts to ensure a balanced trade account (under certain assumptions regarding the foreign real interest rate).

Five different shocks were applied to the model and deviations calculated relative to a control steady-state solution. Each shock was permanent and was assumed to be unanticipated. An increase in export demand and an increase in tariffs lead to a similar pattern of response in the exchange rate: the exchange rate immediately appreciates, bringing the nominal and real exchange rates close to their new long run equilibrium levels. However, historically, export demand shocks have been a far more important source of year-to-year variability in the real exchange rate. An increase in money supply immediately induces a large depreciation of the exchange rate, but this large real depreciation is subsequently completely eroded by a rising domestic price level and a partial reversal of the initial depreciation of the nominal exchange rate. Wage restraint results in a real depreciation brought about by deflation of the domestic price level but the adjustment process is characterised by marked fluctuations in the nominal and real exchange rates. Fiscal expansion leads to a rather small real appreciation in both the short run and the long run. Its effects are more on the composition of demand.

We conclude that, over the last fifteen years, shocks to export demand, the money supply and wages have been important sources of variation in the real exchange rate, and changes in fiscal policy and tariffs have been relatively unimportant.

Two qualifications are in order. Firstly, a new round of model development work has recently been completed (see Murphy 1988a, 1988b) which has included the incorporation of full rational expectations in the financial sector and various improvements to the trade sector. This new version of the model is known as the Murphy model. It is likely to lead to some changes in the detail of the results reported in this paper, but the broad conclusions reported in this section are not
expected to change. Work is underway which will determine whether that expectation will be realised. Secondly, we have considered only five shocks in the context of a particular policy regime. Obviously other shocks may be important at particular times and responses under other policy regimes would also be of interest. Notwithstanding these qualifications, we believe our analysis should be of assistance in understanding recent and future variations in nominal and real exchange rates.
FIGURE 1.

EXPORT DEMAND SHOCK

[Graph showing time series data with labeled axes: Time (half-years), R_1, R_0]
REFERENCES


Murphy, C.W., Bright, I.A., Brooker, R.J., Geeves, W.D. and Taplin, B.K. (1986), *A Macroeconometric Model of the Australian Economy for Medium Term Policy Analysis*. 


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