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2. Introduction

During the 1970s and 1980s, resource-exporting economies experienced considerable volatility in the terms of trade. This volatility had adverse effects on their growth and development. The main purpose of this economic model is to study, empirically and theoretically, the macroeconomic consequences arising from terms-of-trade volatility, using the experience of the resource-exporting economy of Australia. The case of Australia is particularly interesting since it is a resource-rich country experiencing considerable terms-of-trade volatility. The Figure 11 depicts the long-term relationship in the world market of the price of export commodities. The Figure 21 shows that the volatility of the Australian terms-of-trade, which is the percentage change in the price of export commodities, is a good indicator of the volatility of the Australian economy, which is the percentage change in the Australian gross domestic product (GDP). The volatility of the Australian terms-of-trade is a good indicator of the volatility of the Australian economy, which is the percentage change in the Australian gross domestic product (GDP).

ABSTRACT

This paper is concerned with analysing, both empirically and theoretically, the macroeconomic consequences arising from terms-of-trade volatility for a resource producing and exporting economy, with emphasis placed upon the Australian experience. Using Australian quarterly data for the period 1975 to 1991, the existence of a long-term relationship between the terms of trade and nine key macroeconomic variables is empirically verified. These findings form the basis of the theoretical framework, which is simulated, using plausible parameter values, for terms-of-trade disturbances similar to that experienced by Australia during the 1980s. Comparisons with actual developments are then conducted.

1. Introduction

During the 1970s and 1980s, resource exporting economies experienced considerable volatility in the world price of their resources, and hence in their terms of trade. This paper proposes a new economic model to identify, empirically and theoretically, associated macroeconomic developments arising from such volatility, emphasising the experiences of one resource exporting economy in particular —Australia. The case of Australia is particularly interesting since its economy has recently experienced considerable terms of trade volatility (see Figure 1), largely reflecting developments in the world price of its primary export commodities (see Figure 2). It is well known that such volatility will exert a major influence upon the development of the Australian macroeconomy, where resource production accounted for 50 per cent of merchandise exports (41 per cent of total exports of goods and services) and 8-9 per cent of GDP in 1990. The nature of this relationship forms a major part of this paper, with resource sector developments likely to have had significant effects upon GDP, current account, trade account, inflation, exchange rate and the interest rate, to name but a few.

The paper proceeds as follows. Section 2 outlines the theoretical framework and describes the major distinguishing features of it, including the importance of long-term relationships between the major macrovariables. Due to the model's size and generality, however, it is not possible to generate analytically unambiguous results. This difficulty can be overcome through the use of a numerical simulation procedure. In Section 3, an empirical investigation is conducted into the existence of long-term relationships between the terms of trade, and that of a number of key macroeconomic variables

which form the basis of the theoretical framework. In Section 4, a numerical simulation procedure, using plausible parameter values, is applied to analysing potential developments of the macroeconomy arising from terms of trade disturbances similar to those which have occurred in Australia over the period December 1983 to September 1992. An interpretation of these results is presented. Section 5 compares and contrasts the simulation results of Section 4 with those which have actually occurred in Australia for the corresponding periods of time, thereby establishing, or otherwise, the explanatory potential of the theoretical model. Finally, in Section 6, a summary of the major conclusions derivable from this paper is presented.

2. Theoretical framework

In this section, a macroeconomic model, incorporating resource production and price, set in a deterministic framework and assuming economic agents possess rational expectations, is presented. This is equivalent to the case of perfect foresight. The theoretical foundations of the model can be found in the earlier contributions of Dornbusch (1976), later extended to incorporate resource production and price in Neary and van Wijnbergen (1983), Eastwood and Venables (1982), Buiter and Miller (1981) and Buiter and Purvis (1982). These models, however, emphasise the short-run adjustment process, and give erroneous results when compared to models emphasising the long run (Harvie (1993)). Harvie and Gower (1993) present a model in which capital stock and foreign asset stock accumulation are explicitly incorporated, and hence emphasise the long-run nature of the adjustment process. The empirical results presented in the following section suggest that, in the context of Australia at least, this is the appropriate approach, and is the one adopted.

The distinguishing characteristics of the Harvie and Gower model include the following. Economic agents are assumed to possess rational expectations, and, as just discussed, focus is placed upon the long-run nature of the adjustment process. Emphasis upon the long run is important in the context of dynamic macro models in which economic agents form their expectations rationally. Long-run equilibrium will influence the evolution of the economy over both the short and medium run, since dynamic stability requires the existence of a unique stable saddlepath ultimately leading to convergence to this long-run equilibrium.

As is well known in the literature, such a stable saddlepath requires the existence of jump (non-predetermined) and non-jump (predetermined) variables. Traditionally, financial variables have taken the role of jump variables, ensuring continual equilibrium in financial markets. Asset prices and rates of return, which guide short-run portfolio and allocation decisions, are assumed therefore to embody information about the longer-term evolution of the economy. In contrast non-financial variables, subject to the existence of contracts or costs of adjustment and hence quantity and price stickiness, are slow to adjust, resulting in disequilibrium in non-financial markets throughout the adjustment process.

The model assumes that the economy is a resource producer and net resource exporter. Its production generates an income and wealth effect (Buiter and Purvis (1982)) but also, due to the economy's presumed status as a resource exporter, a current account effect (Harvie and Gower (1993), Harvie (1991), Forsyth and Kay (1980)). Wealth, both financial and physical, plays a key role in the adjustment process, affecting the demand for both output and financial assets.

Finally emphasis is placed upon the demand and supply-side consequences of resource disturbances. Demand is affected

by the income, wealth and current account effects already mentioned, whilst the supply side is affected by capital stock accumulation and real wage consequences of resource related disturbances.

The equations of the model, with all variables being in logs with the exception of the domestic and world nominal interest rates, are as follows:

Product market equilibrium

- (1) $No = \Sigma 1y + \Sigma 2we + \Sigma 3(Dk + \Sigma 4k) + \Sigma 5g + \Sigma 6T$
- (2) $y = vNo + (1 - v)\alpha a + (1 - v - \alpha 2)Pres + (\alpha 1 - v)(e - w) - (1 - \alpha 1 - \alpha 2)p^*$
- (3) $yp = vNop + (1 - v)\alpha p + (1 - v - \alpha 2)Pres + (\alpha 1 - v)(e - w) - (1 - \alpha 1 - \alpha 2)p^*$
- (4) $Dk = \eta q$
- (5) $s = \lambda 1k - \lambda 2(w - p)$

Wage/price nexus

- (6) $p = \alpha 1w + \alpha 2(e + Pres) + (1 - \alpha 1 - \alpha 2)(e + p^*)$
- (7) $Dw = \phi 1 + \phi 2(No - s) + \phi 3\pi$
- (8) $\pi = Dm$

Equilibrium in asset markets

- (9) $m = p + \sigma 1y - \sigma 2r + \sigma 3we$
- (10) $De = r - r^*$
- (11) $R = \epsilon 1 + \epsilon 2y - \epsilon 3k$
- (12) $Dq = \delta 3^{-1}(q - \delta 1R + 2(r - \pi))$
- (13) $we = \gamma 1(f + e - p) + \gamma 2(m - p) + \gamma 3(k + q) + \gamma 4yp$

Overseas sector equilibrium

$$(14) \quad T = \mu_1(e + p^* - p) - \mu_2y + \mu_3y^*$$

$$(15) \quad Df = p_1T + p_2r^*f + p_3(one + Pres) - (1 - p_2 - p_3)(e - p)$$

$$(16) \quad one = -\tau_1or + \tau_2(oa - y)$$

Definition

$$(17) \quad c = e - w$$

$$(18) \quad l = m - w$$

Equilibrium in the model depends upon equilibrium in the product market, asset market and overseas sector. Equilibrium in the product market is discussed first. Total spending on non-resource output (No), equation 1, depends upon real income (y), domestic real wealth (w), domestic gross investment ($Dk + \Sigma 4k$), where k is the capital stock, D represents the differential operator and $\Sigma 4$ is the rate of depreciation, fiscal policy (g) and the non-resource trade balance (T). Such output can be either consumed domestically or exported, and is an imperfect substitute for the overseas non-resource imported good.

Real and permanent income definitions utilised are as those used by Buitier and Purvis, and shown here as equations (2) and (3). Real income depends upon non-resource output (No), resource production (oa) (assumed exogenous), the world price ($Pres$) of the resource expressed in overseas currency (exogenous), the real exchange rate, emphasised here as being ($e - w$), the nominal exchange rate (e) deflated by domestic wages (w), and the exogenously determined world price of the non-resource imported product (p^*).

Permanent income depends upon the permanent income value of non-resource output (Nop) (assumed exogenous),

permanent oil output (o_p) (assumed exogenous), the world price of the resource expressed in overseas currency (assumed exogenous), the real exchange rate as emphasised here, and the price of the non-resource imported product (assumed exogenous).

If the share of resource output in domestic real income $(1 - v)$ is larger than its share in domestic consumption (α_2), this economy will be a resource exporter. This case is emphasised throughout. Investment in the capital stock is captured by the partial adjustment hypothesis given by equation 4(a),

$$(4a) \quad Dk = \eta(k^* - k)$$

based upon costs of adjusting the physical capital stock (k) to the desired capital stock (k^*). The desired capital stock depends upon its market value as given by equation (4b):

$$(4b) \quad k^* = k + q$$

where q is Tobin's q , the ratio of the marginal market valuation of equity capital relative to the replacement cost of the capital. Substituting (4b) into (4a), equation (4) can be obtained. Net investment therefore adjusts positively to Tobin's q .

The supply (production) of non-resource output (s) is assumed to be endogenously determined, fluctuating in the long run, as well as the short run, by the production function given by equation (5). It depends upon the physical capital stock and the real wage ($w - p$).

Equations (6) - (8) identify the wage price nexus. Emphasis is placed upon the sticky, or slow, adjustment of nominal wages rather than prices. The consumer price level (p), equation (6), is a weighted average of domestic wages (w), the domestic currency cost of the resource ($e + p_{res}$), and the domestic

currency cost of the overseas imported non-resource good ($e + p^*$).

Nominal wage adjustment is generated by an expectations augmented Phillips curve, as given by equation (7). Adjusting to developments in productivity, wage fixing or bargaining processes (ϕ), excess demand for labour arising from current demand or spending on non-resource output being different from non-resource output supply ($N_o - s$) and inflationary expectations (π). Inflationary expectations are based upon developments in the monetary growth rate, as given by equation (8).

Asset market equilibrium is given by equations (9) - (13). The three non-money assets in the model (bonds, equities and foreign bonds) are assumed to be perfect substitutes, with arbitrage between them resulting in the same expected (instantaneous) rate of return. The common expected rate of return must be in turn consistent with agents being satisfied with the proportion of money in their portfolios.

Portfolio balance is characterised by a conventional LM equation, equation (9), incorporating domestic real wealth. Demand for real money balances is a function of real income (y) (representing a transactions demand), the domestic nominal interest rate (r) and domestic real wealth (w_e) (representing an asset demand for money).

Expected currency yields on the assets must be equalised. Of relevance here is the uncovered interest parity condition (equation 10). Deviations of the domestic nominal interest rate from the world nominal interest rate (r^*) result in instantaneous adjustment of the exchange rate, leading to offsetting expectations regarding the future adjustment of this variable. Hence the real return on foreign bonds, in domestic currency terms, is equivalent to $r^* + De - \pi$, which must equate continuously with the return on domestic bonds $r - \pi$.

These expected rates of return will be equated instantaneously, through arbitrage, with the expected real return on domestic equities. Domestic equities are assumed to be held only by domestic residents. The expected real return on holding equities is given by equation (12a).

$$(12a) \quad Dq/q + R/q$$

where q is the value (real) of these equities, and R the real profit stream derived from the capital services. The expected return depends upon the expected capital gain/loss from holding equity capital Dq/q , where $Dq = 0$ in steady state, plus the real profits stream derived from the capital services R relative to q . Real profit, as given by equation (11), is assumed to be an increasing function of real income and a decreasing function of the capital stock.

Continual and instantaneous arbitrage between domestic bonds, foreign bonds and equity capital implies

$$(12b) \quad Dq/q + (\epsilon_1 + \epsilon_2 y - \epsilon_3 k)/q = r - \pi = r^* + De - \pi$$

Ignoring $r^* + De - \pi$, and taking a log linear approximation, we can solve for q

$$(12c) \quad q = \delta_1 R - \delta_2 (r - \pi) + \delta_3 Dq$$

or re-arranging, and solving for Dq , we obtain equation 12.

Real domestic private sector wealth is given by equation (13). It consists of four components; domestic holdings of foreign assets (bonds) (f), expressed in domestic currency value and deflated by the domestic price level; holdings of real money balances; the real value of the domestic capital stock, assumed

to be entirely owned by agents in the domestic private sector, consisting of a physical quantity (k) multiplied by the real market value (q); permanent income arising from the permanent output equivalent of non-resource and resource output.

The overseas sector consists of the non-resource trade balance, the current account and the net export of resources. Equation (14) specifies the non-resource trade balance, which depends upon the real exchange rate ($e + p^* - p$), domestic real income and world real income (y^*).

Developments in the current account are given by

$$(15a) \quad Df + e - p = \rho_1 T + \rho_2 (r^*f + e - p) + \rho_3 (\text{one} + \text{Pres} + e - p)$$

where (one) represents the net export of resources. Rearranging (15a) and expressing this in terms of changes in foreign bond holdings, we can obtain equation (15). This indicates that the accumulation/deaccumulation of foreign bonds, as reflected in the current account balance, depends upon the non-resource trade balance (T), real foreign interest earnings (r^*f) and net resource exports ($\text{one} + \text{Pres}$). In long-run steady state, the current account balance must be zero, or else further wealth effects will arise requiring further macroeconomic adjustment.

Net resource exports are endogenously determined, being a function of domestic resource requirements (or) (exogenous) and the ratio of actual resource production (oa) to domestic real income (y). The higher the latter ratio, the larger will be domestic resource exports, as given by equation (16). Finally, equations (17) and (18) define two variables which are used extensively throughout the remainder of this paper, originally defined by Buiter and Miller (1980), the real exchange rate (c) and real money balances (l) respectively.

The size and generality of the model prevents the derivation

of analytically unambiguous results, thereby requiring for its solution, and analysis of dynamic adjustment, resort to a numerical simulation procedure. This is conducted below in Section 4.

3. Long term relationships between macroeconomic variables

While major economic theories and policy have been essentially based on the suitable selection of (for example, Tran Van Hoa et al (1983), Tran Van Hoa (1992b)) economic variables (modelling), and the assumption of the direction of causality between them (the structure of economic models), the early concept of causality, in the sense of Wiener, was proposed by Granger (1969), to investigate possible causation between economic variables. The concept is based on the cross-spectrum decomposition and, using current and lagged correlations amongst these variables, deals specifically with short-run fluctuations. Empirical applications of this Granger causality test have been extensive in the past two decades or so and involve many important areas of economics, such as money and income (Sims (1972)), wage and price inflation (Fels and Tran Van Hoa (1981)), to name a few.

The theory of cointegration (Granger (1981) and (1986), Engle and Granger (1987)) also deals with causation between economic variables, but is focussed particularly on long-term relationships. The basic idea of the theory is that 'causal or correlated' economic series may wander in the short run, but they will not drift apart in the long run or in the equilibrium. Thus, in the short run, the equilibrium error may not be zero, but in the long run, systematic differences between the causal or cointegrated variables should disappear.

The empirical tests of the above methods assume that the variables in the models must be statistically stationary in the

case of Granger-Wiener causality, and non-stationary or preferably $I(1)$ in the case of Engle-Granger cointegration. In addition, in applied economic work, it is well known that the reliability of the results of both the causality and cointegration methods depends not only on the correct information set used but also crucially on the usually unknown lag structure of these variables. In the particular case of the cointegration theory, the appropriate tests include cointegration regression analysis (Sargan and Bhargava (1983)), Dickey-Fuller and augmented Dickey-Fuller regression procedures, and restricted and unrestricted vector autoregressive methods (Engle and Granger (1987)). More recent developments of the cointegration theory include the maximum likelihood approach of Johansen (see for example Johansen (1991)) within the unified framework of vector autoregressive and error correction models, in which cointegrating vectors are simply obtained as eigenvectors. It can be verified that the eigenvector approach yields identical results to the OLS approach, in the case where the eigenvector is derived from the maximum characteristic root.

A comparative study of these alternative methods is not conducted, instead we make use of a simple but effective procedure (Pindyck and Rubinfeld (1991)) for a general time series representation, allowing for a linear and quadratic time trend of the variables in the level (Johansen (1991)) to test for unit roots, or random walks, amongst the variables of interest in our macroeconomic model (Tran Van Hoa, 1993). These include manufacturing production, current account, terms of trade, balance of trade, real profits, real wealth, capital stock, exchange rate, and GDP. We then apply the cointegration DW regression method (Sargan and Bhargava (1983), Granger (1986), Engle and Granger (1987)) to investigate the long-run relationships between the pivotal variable 'the terms of trade' and the rest of the variables.

In our study, the test of unit roots for a variable, say Y , consists simply of estimating the unrestricted regression equation (also known as the reduced form error correction model)

$$(3.1) \quad Y_t - Y_{t-1} = a_1 + a_2 T_t + (a_3 - 1)Y_{t-1} + a_4 DY_{t-1} + u_t$$

and the restricted regression equation with unit root (with $a_2=0$ and $a_3=1$)

$$(3.2) \quad Y_t - Y_{t-1} = a_1 + a_4 DY_{t-1} + u_t$$

In (3.1) and (3.2), T is a time trend, $DY_{t-1} = Y_{t-1} - Y_{t-2}$ an error correction term to capture higher order lag correlations, the a 's are the parameters to be estimated, and the u 's the error terms with white noise properties.

Using the resulting OLS estimated residual sums of squares from (3.1) and (3.2), an F statistic is computed and compared to the critical values of the distribution tabulated by Dickey and Fuller (1981) or any other subsequently tabulated critical values. The hypothesis of random walk for Y is rejected if the estimated F value is greater than the critical F value tabulated for an appropriate significance level.

In the case of bivariate (Y and X for example) models in which both Y and X are nonstationary and $I(1)$, the test of cointegration between Y and X is simply carried out by estimating by OLS the cointegrating regression equation (Sargan and Bhargava (1983), Granger (1986), Engle and Granger (1987),

$$(3.3) \quad Y_t = b_1 + b_2 X_t + e_t$$

and by testing whether the residuals (that is, the estimated e)

from this equation are stationary.

If Y and X are not cointegrated, then any linear combination of Y and X will not be stationary and the residuals e will be nonstationary. However for a series e to be a random walk $E(e_t - e_{t-1}) = 0$, the Durbin-Watson (DW) statistic must be zero. The test of cointegration between Y and X is therefore the test whether $DW = 0$ (Sargan and Bhargava (1983), Granger (1986), Engle and Granger (1987)).

Below, we test for stationarity of nine variables, which are the key variables in the theoretical model: manufacturing production, current account, terms of trade, balance of trade, real profits, real wages, capital stock, exchange rate, and GDP, and then test for the presence of a long term relationship between the terms of trade and the other variables. If the inclusion of the terms of trade alone is not sufficient to yield cointegration results, we make use of the simultaneity of the variables in our model to include other likely variables in the testing equations.

The raw data used to calculate manufacturing production, current account, terms of trade, balance of trade, real profits, real wealth, capital stock, exchange rate, and GDP are quarterly data in the form of the level and are available for the period 1975 to 1991. Each variable thus has a sampling size of 63 observations. These data are obtained from the DX database.

Making use of the general economic modelling approach proposed earlier (see Tran Van Hoa (1992a) and (1992c)), the variables in each of these models are expressed in terms of their percentage rates of quarterly change. In this case, the models provide approximations to a very general class of continuously differentiable functional forms, and they may be interpreted as econometric models of the Johansen-class and are fundamental in computable general equilibrium macroeconomic analysis. The parameters of these models are the elasticities that affect

the causation in a linear manner.

For the unit root tests, we use the augmented Dickey-Fuller procedure with a simple error correction term. For the cointegration tests, we adopt the cointegration DW regression on the grounds that (a) this is a simple procedure with fairly good results (Engle and Granger (1987)), and (b) this avoids the difficult and sometimes arbitrary decision on the selection of a suitable lag order for the variables.

The results of the unit root tests for nine key macroeconomic variables in our model are given in Table 1, and the results of the cointegration DW regression for eight macroeconomic variables are given Table 2.

From Table 1, we note that all nine macroeconomic variables—manufacturing production, current account, terms of trade, balance of trade, real profits, real wealth, capital stock, exchange rate, and GDP, as calculated as the rate of change in our model—are stationary or $I(0)$ and not characterised by the existence of unit roots. Since the variable expressed as the rate of change is equivalent, for small changes, to the difference in their logarithms, then this finding implies that our variables in their logarithmic transformations (or approximately, in the levels for the variables with negative values) are $I(1)$. Our findings thus provide empirical evidence to support the use of logarithmic transformations for our macroeconomic variables whenever appropriate in the application of the tests of the long term relationships.

From Table 2, we note that the pivotal variable 'terms of trade' has a pervasive long-term influence on all other macroeconomic variables in the model. This finding supports the main theoretical foundations of the model of a resource exporting economy described earlier.

4. Simulation scenario

This section presents, and interprets, the results derivable from a simulation assuming developments in the terms of trade, similar to that experienced by Australia over the period December 1983 to September 1992. The terms-of-trade fluctuations are assumed to have arisen from a change in the world price of the resource (Pres) with the world price of the non-traded good (p^*) remaining unchanged. The precise change in the resource price is contained in Figure 3, where it is assumed to decline, on impact, by 10 per cent from baseline with a further fall, to 20 per cent, below baseline in period 1. Period 2 sees the terms of trade recover to be 10 per cent below baseline, whilst in period 3 it has recovered back to its base level. Hence period 0 - 3 is characterised as being a period of time where a decline in the terms of trade is apparent, being most pronounced in period 1. Periods 3 to 7 see an improvement in the terms of trade from baseline, being 5, 10, 5 and then 0 per cent higher than baseline for periods 4, 5, 6 and 7 respectively. Hence, this period is characterised by an improvement in the terms of trade from its base level. Period 7 onwards is characterised by a decline in the terms of trade to a level 5 per cent below baseline, remaining at this level indefinitely thereafter.

The parameter values utilised to conduct the simulation are summarised in Table 3. They have the advantage of being both plausible and ensuring dynamic stability of the model.

The question now posed is how will the macroeconomy respond to such terms-of-trade volatility in the context of the theoretical model, and how well does this compare with macroeconomic developments actually observable for the Australian macroeconomy over equivalent periods of time? This section attempts to provide answers to the former

question, whilst the latter will be discussed in the following section.

For brevity, 11 key macroeconomic variables are given primary focus here. The adjustment process for each of these, in diagrammatic form, arising from the terms of trade shocks just identified is contained in Figures 4 and 5. The eleven macroeconomic variables discussed are - the foreign asset stock (f) (current account), trade balance (T), real exchange rate (c), non-resource output demand (N_o), output supply (s), real income (y), capital stock (k), interest rate (r), inflation (Dp), real wealth (we), and real wage growth ($Dw-Dp$). A number of other variables can also be identified, but are regarded as being of somewhat less interest.

In conducting a discussion of the adjustment process for each of these variables it is useful, for expository purposes, to break this down into three distinct periods:

Period I: a worsening of the terms of trade, time periods 0 - 3,

Period II: an improvement of the terms of trade, time periods 3 - 7,

Period III: a deterioration of the terms of trade leading to a permanent deterioration, time periods 7 onwards.

A summary of the long-run (equilibrium) change for each of the variables of the model, arising from developments in the price of the resource as specified, is contained in Table 4.

1. Terms-of-trade deterioration, time periods 0 - 3 (Period I)

External developments

An initial sharp downturn in the terms of trade, as specified here, produces a sizeable downturn in the stock of foreign assets, a reflection of current account deficits. This can be reconciled by the fall in the price of the resource itself, thereby reducing income from resource exports. A declining foreign asset stock itself contributes to a decline in foreign interest income from this source, however the non-resource trade balance improves contributing to an improvement in the current account balance. The improvement in the non-resource trade balance itself is due to a depreciation of the real exchange rate and a fall in real income.

Domestic demand/supply and real income

The demand for non-resource output experiences considerable volatility during this period, rising noticeably after the initial terms of trade deterioration, but is quickly reversed with an improvement in the terms of trade. The initial increase in demand occurs primarily from external developments, arising from the improved balance of trade. This is eventually reversed by the fall in real income, real wealth and reversal of the trade balance. Modest capital stock accumulation does not contribute much to alleviating this situation.

The supply (production) of non-resource output also exhibits some volatility, initially rising, falling and then rising again. Developments in the capital stock contribute to initially depressed and then rising production, with the initial decline in real wage growth contributing importantly to an increase in

production.

Real income falls during this period, due to the decline in the resource price and depreciation of the real exchange rate (see equation 2). These more than offsetting developments in non-resource output.

Others

The capital stock experiences an initial small decline and then recovery, reflecting lagged adjustment to the q ratio. The interest rate, after a slight initial rise, experiences a downturn, whilst inflation does likewise. Real wealth falls due to a decline in real money balances, permanent income and most importantly foreign asset stocks. These are offset somewhat by the slight increase in the physical capital stock, and, towards the end of the period, the rise in the q ratio. Real wage growth, as mentioned previously, decreases initially stimulating the supply of non-resource output, however this is eventually reversed having the opposite effect.

The simulation results suggest that, during this period, a deterioration in the terms of trade results in an overall decline in foreign asset stocks (current account deficits), a depreciation of the real exchange rate and improvement in the non-resource trade balance, a potential fall in the demand for non-resource output but increase in its supply as well as a fall in real income, an increase in the physical capital stock, fall in the interest rate, inflation, and real wealth, with a potential overall rise in real wage growth. These results will be later compared with actual developments in Australia, for the equivalent period of time, in the following section.

2. Terms of trade improvement, time periods 3-7 (Period II)

External developments

This period is characterised by a reversal of the loss of foreign asset stocks arising during the period of a worsening of the terms of trade, thereby implying an improved current account performance (essentially current account surpluses). Improved earnings from resource exports are important in this regard, however the exact opposite is happening with the non-resource trade balance which deteriorates. Two factors contribute towards this latter phenomenon, the recovery of real income, and hence increased demand for non-resource imports, and the appreciation of the real exchange rate after an initial depreciation during this period.

Domestic demand/supply and real income

Demand for non-resource output improves throughout this period from domestic sources due to the recovery in real income, wealth and rising investment in the capital stock, although external developments, as previously discussed, contribute to a deterioration in demand. The supply of non-resource output (production) remains buoyant, from the accumulation of capital stock and decline in real wage growth.

Real income shows a very strong recovery from the increase in the price of the resource, as well as from the appreciation of the real exchange rate and recovery of non-resource output.

Others

The capital stock noticeably improves, although declining

somewhat towards the end of this period. The interest rate rises back to its base level, with inflation also rising to be above its base level. There is also a strong recovery in real wealth, due primarily to the increase in real money balances and foreign asset stock, as well as capital stock, q ratio and permanent income. Real wage growth, as previously mentioned, adjusts in a downwards direction.

Overall this period is characterised by current account improvement (surpluses), an appreciation of the real exchange rate and deterioration in the non-resource trade balance, improving demand for non-resource output and real income, increasing capital stock (and rising non-resource output supply), a rising interest rate, rising inflation and wealth and an overall decline in real wage growth.

3. Terms of trade deterioration, time periods 7 onwards (Period III)

External developments

This third period is characterised by a further deterioration of the terms of trade, to a point where it falls to 5 per cent below its base level. It is a prolonged period initially experiencing a persistent decline in foreign asset stocks (current account deficits) with only a slight improvement towards the end. In long-run equilibrium foreign asset stocks have declined overall (see Table 4). The real exchange rate primarily depreciates throughout this period, contributing to an overall depreciation of the real exchange rate in long-run equilibrium. Likewise the non-resource trade balance improves almost continuously throughout this period, although it does deteriorate somewhat

towards the end of it reflecting developments in real income.

Domestic demand/supply and real income

Non-resource output demand exhibits a cyclical adjustment process to long-run steady state — initially declining, but then rising back to steady state equilibrium, where overall demand for such output will be lower than its base level. Such developments are reflective of changes in real income, wealth and the capital stock (investment) offsetting the improvement in the non-resource trade balance.

Non-resource production (supply) also exhibits a cyclical adjustment path to steady state, reflecting developments in the capital stock and real wages. Both of these are falling in the early stage of this period, tending to offset each other in terms of their impact upon output supply. A rising capital stock and rising real wage also tend to offset each other during the latter part of the adjustment process, with the former tending to dominate contributing to a modest recovery in output supply. In long-run steady state, non-resource production is lower, in line with lower non-resource output demand.

Real income, like non-resource production and demand, exhibits a cyclical adjustment process to equilibrium, initially falling and then rising. Overall, real income will be lower than its base level in final equilibrium. Contributory factors to this are the decline in the resource price itself, the depreciation of the real exchange rate and fall in non-resource demand.

Others

The capital stock also displays a cyclical adjustment process to long-run steady state, adjusting in a lagged fashion to the q ratio. In steady state the capital stock is lower in comparison to

its base level. The interest rate initially rises and then falls back to its base level, and inflation follows a similar path. Real wealth initially falls with a modest recovery towards the end of the adjustment period, reflecting fluctuations in real money balances, foreign asset stock, capital stock and permanent income which all display a similar adjustment profile.

In summary, this period is characterised by initial current account deficits and then small surpluses, an improved non-resource trade balance performance, a depreciating real exchange rate, a decline in real income and resource output, declining capital stock and rising and then falling interest rate, falling inflation and real wealth and growth of the real wage.

4. Actual developments in the Australian economy

In this section, actual developments in the Australian economy, corresponding to the equivalent time periods for the simulation scenario, are outlined and compared to the results derived from the simulation conducted in the previous section. Here actual developments in the following macro variables are given emphasis — current account, goods and services trade account, GDP, manufacturing production, interest rate, exchange rate and inflation. A diagrammatic summary of developments in these is contained in Figures 6-12. Period I corresponds to the actual period December 1983-March 1987, period II from March 1987-March 1989, whilst period III corresponds to March 1989-September 1992.

Current account (Figure 6)

Actual developments during period I (deterioration in the terms of trade) indicate a general deterioration in the current

account performance. Such was also derivable from the simulation scenario, being reflected in a deterioration in the foreign asset stock. Period II (improvement in the terms of trade) suggests that the current account initially improved before deteriorating further, with an overall deterioration apparent. The simulation results suggested that this period is characterised by an improvement in the current account balance (in fact surpluses since f is being increased). Hence other factors causing an actual deterioration in the current account must have been operative, such as that arising from the stronger than expected investment boom at this time contributing to a surge in imports of capital goods. Finally period III (further deterioration of the terms of trade) sees an initial further deterioration of the current account, similar to that for the simulation, but thereafter an improvement unlike that for the simulation. However, towards the end of this period, the current account balance shows signs of further deterioration.

Trade balance (Figure 7)

Actual developments in the trade balance suggest a slight initial deterioration but then improvement throughout period I. This is supported by the simulation results which, apart from the very end of this period, suggest an almost continual improvement in the trade balance.

Period II suggests that after initial stability in this balance, it deteriorates very substantially towards the end of it. This decline is very apparent. The simulation results likewise indicate a sharp down turn in the trade balance, although certainly not as sharp as that which actually occurred. Finally in period III, actual developments have shown a rapid recovery with only a slight deterioration to the end of the period

covered. This general adjustment process is quite similar to that identified by the simulation, in which the trade balance improves although this does take place over a longer period of time, at least initially, before deteriorating slightly as it adjusts to its long-run equilibrium.

GDP (Figure 8)

Actual developments in this during period I suggest a fairly rapid increase, slowing somewhat towards the end. The simulation results on the other hand suggest a downturn in real income. Period II sees a further sustained increase in actual GDP, and this likewise occurs for the simulation scenario.

Finally, period III in actual terms sees a levelling out of GDP, not surprisingly as the Australian economy entered its worst recession since the 1930's. The simulation results also suggest a deteriorating performance in terms of real income, with it declining sharply before rising to its long-run equilibrium level. Hence a deteriorating GDP performance occurs, although not as substantial as that indicated by the simulation results.

Manufacturing production (Figure 9)

Actual developments in non-resource production, as proxied here by manufacturing output, indicates that during period I such output increases noticeably initially, although slowing down towards the end of it. The simulation results, focussing upon output supply, suggest an increase, which goes into reverse before increasing again, with an overall increase apparent by the end of it. Period II sees a further increase in actual manufactured output, whilst the simulation result would suggest an initial increase but then decrease towards the end of the period. Overall, however, non-resource output

would be marginally higher. Finally, in period III, after a further actual increase, manufacturing production goes into a sizeable downturn, with a slight improvement observable by the end of the time period under consideration. This is again quite similar to the results derived from the simulation, although there is an initial sharp downturn before a gradual recovery to long-run equilibrium occurs.

Interest rate (Figure 10)

Actual developments in the interest rate show an initial increase, with a slight reversal towards the end of period I. Likewise the simulation result suggests a similar adjustment pattern, although the decline is more sustained. In period II the interest rate continues its decline initially, although this is reversed towards the end of it. The simulation results likewise indicate an initial decline and then sustained rise throughout the remainder of the period. Finally, in period III, actual developments in the interest rate show an initial slight rise, but then continually fall throughout the remainder of this period. This is again reasonably well captured in the simulation for this equivalent time period, although the size of the decline has turned out in practice to be much greater. This can be partially explained by the success of the fight against inflation, the wages accord being an important factor here, and the ability of the nominal interest rate to fall faster as a result.

Real exchange rate (Figure 11)

The exchange rate for Australia (Trade Weighted Index), with a fall representing a depreciation of the exchange rate, actually depreciated quite noticeably after the decline in the terms of trade. This is also very apparent for the real exchange rate from

the simulation scenario in period I. In period II, actual developments show an appreciation of the exchange rate after an initial depreciation, whilst the simulation results also suggest a similar adjustment process for the real exchange rate with an initial depreciation apparent before a sizeable appreciation. In period III, actual developments by September 1992 suggest that a further weakening of the exchange rate occurred, whilst this likewise occurred for the simulation scenario to long-run steady state. The simulation itself suggesting that this general depreciation is likely to arise over a prolonged period.

Inflation (Figure 12)

The final key macroeconomic variable identified is that of the rate of inflation. Actual developments during period I suggest that inflation initially declined before rising again towards the end of this period. The simulation results suggest the exact opposite result with inflation rising initially and then falling. Whilst this is somewhat puzzling a likely explanation for this discrepancy can be found from the existence of the Wages Accord operative at this time. This proved to be very successful in the fight against inflation, and particularly so the agreement arising after the initial decline in the terms of trade. In period II, a slight decline in actual inflation can be observed, however the simulation results again suggest the opposite with a strong rise occurring. Only in period III are actual developments and trend suggested from the simulation scenario reasonably consistent, with a decline in inflation occurring and anticipated. Overall, however, actual inflation falls quite noticeably throughout this volatile period of terms of trade adjustment, whilst the simulation results would suggest that inflation, over the long run would return to its base level.

5. Summary and conclusions

This paper developed a rational expectations macroeconomic model to analyse the adjustment process arising from a period of volatile terms of trade adjustment, and applied this specifically to the case of Australia. The objective of this was to identify whether such a model, and its underlying assumptions, could reasonably capture the adjustment process which this economy has undergone since December 1983. Empirical evidence suggested that the long-run nature of the theoretical framework is appropriate. A numerical simulation of it suggested that it can contribute to an understanding of the adjustment process which has occurred in Australia. Inevitably, there are exceptions to this, inflation being the obvious case. Here the simulation results did not track well developments in this variable, although as already mentioned the existence of the Wages Accord, the effect of which was not incorporated, and its success in reducing inflation is likely to have been a factor contributing to this discrepancy.

Whilst the contribution of terms-of-trade volatility to macroeconomic adjustment has been the focus of this paper, it must also be borne in mind that we have excluded any policy responses to this in deriving the simulation results. Incorporation of a policy response in generating simulation results from the model would present a very interesting extension to the paper.

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TABLE 1
**Tests for unit roots of key macrovariables in a resource
 exporting economy: Australia 1975 to 1991**

	(a3-1)	DW	F-value
Current account	-0.34 (3.2)	1.78	121.19
Terms of trade	-0.07 (1.5)	1.33	12.02
Real profits	-0.10 (1.4)	1.51	15.19
Balance of trade	-0.29 (2.9)	1.99	20.15
Real wage	-0.16 (2.4)	1.74	30.49
Capital stock	-1.01 (8.1)	2.30	54.22
Manufacturing production	-0.11 (1.8)	1.76	25.07
GDP	-0.10 (1.76)	1.65	24.05
Trade weighted index	-0.08 (1.1)	1.95	27.70

Notes. For the tests, see text. Columns 1 and 2 refer to Equation (1). t-values in brackets. The estimated F-ratios have 2 and 59 degrees of freedom. For a sample size of 50, the critical F value is 6.73 at the 5% significance level.

TABLE 2

Sargan-Bhargava Cointegration tests between key macrovariables in a resource exporting economy: Australia 1975-1991

Const	TOT	MAN	GDP	GOS	TWI	KQ	BOT	DW	R ²
Real profits									
1.07	-0.49	1.76						0.550	0.90
(2.0)	(4.6)	(22.3)							
Manufacturing production									
-2.41	0.27		0.65					0.509	0.90
(7.2)	(4.7)		(23.4)						
Real wage									
-2.81	0.09					0.60		1.156	0.92
(0.4)	(1.5)					(24.7)			
Capital stock									
-0.25	-0.21		1.17					1.84	0.95
(0.6)	(2.9)		(33.3)						
GDP									
5.00	0.34				-0.27			0.709	0.98
(26.6)	(7.9)				(50.8)				
Trade weighted index									
16.17	0.76					-3.01		1.70	0.96
(12.5)	(3.30)					(33.0)			
Balance of trade									
-2.21	0.03							0.593	0.06
(1.9)	(1.9)								
Current account									
-5.76	0.03							0.388	0.06
(3.1)	(1.9)								

Notes. For an example of bivariate models, refer to Equation (3) in the text. All variables except current account and balance of trade are in logs. The critical DW value for testing DW=0 in the case of 3-variable models is 0.367 at the 5% significance level. In the case of 2-variable models, it is 0.386. t-values in brackets.

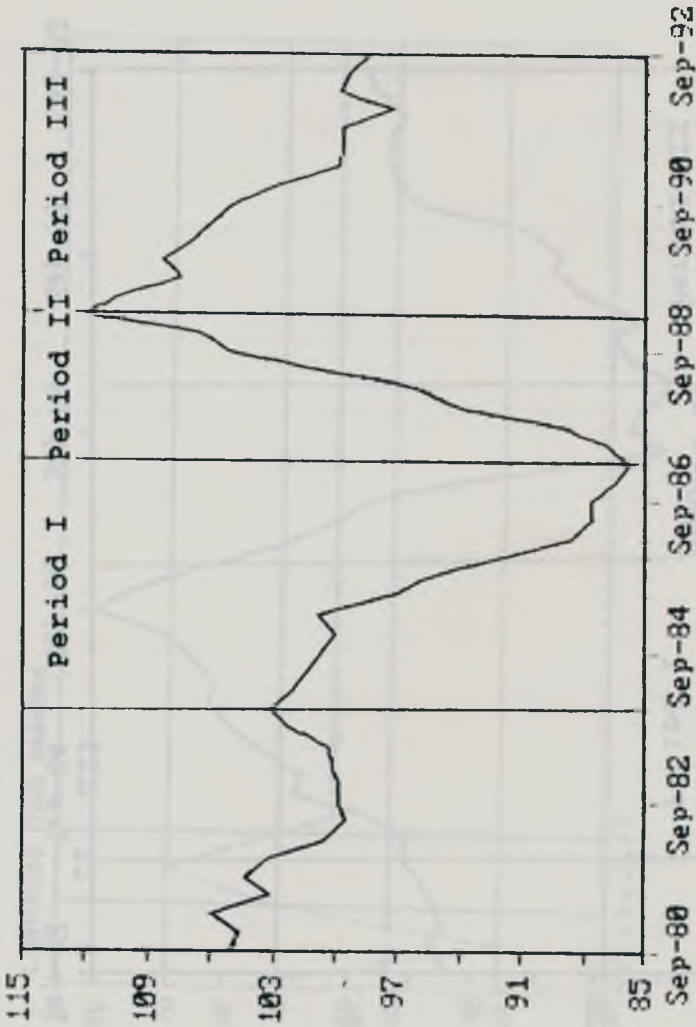
TABLE 3
Parameter values

$\Sigma 1 = 0.5$	$\eta = 0.7$	$\epsilon 1$ - exogenous	$\lambda 4 = 1.0$
$\Sigma 2 = 0.1$	$\lambda 1 = 0.5$	$\epsilon 2 = 0.5$	$\mu 1 = 0.5$
$\Sigma 3 = 0.5$	$\lambda 2 = 0.5$	$\epsilon 3 = 0.5$	$\mu 2 = 0.5$
$\Sigma 4 = 0.2$	$\phi 1$ - exogenous	$\delta 1 = 0.5$	$\mu 3 = 0.5$
$\Sigma 5 = 0.8$	$\phi 2 = 0.7$	$\delta 2 = 0.5$	$\rho 1 = 1.0$
$\Sigma 6 = 1.0$	$\phi 3 = 1.0$	$\delta 3 = 0.5$	$\rho 2 = 1.0$
$v = 0.8$	$\sigma 1 = 1.0$	$\lambda 1 = 1.0$	$\rho 3 = 1.0$
$\alpha 1 = 0.6$	$\sigma 2 = 0.5$	$\lambda 2 = 1.0$	$\tau 1 = 1.0$
$\alpha 2 = 0.1$	$\sigma 3 = 0.1$	$\lambda 3 = 1.0$	$\tau 2 = 0.5$

TABLE 4
Long-run equilibrium (% deviation from baseline)

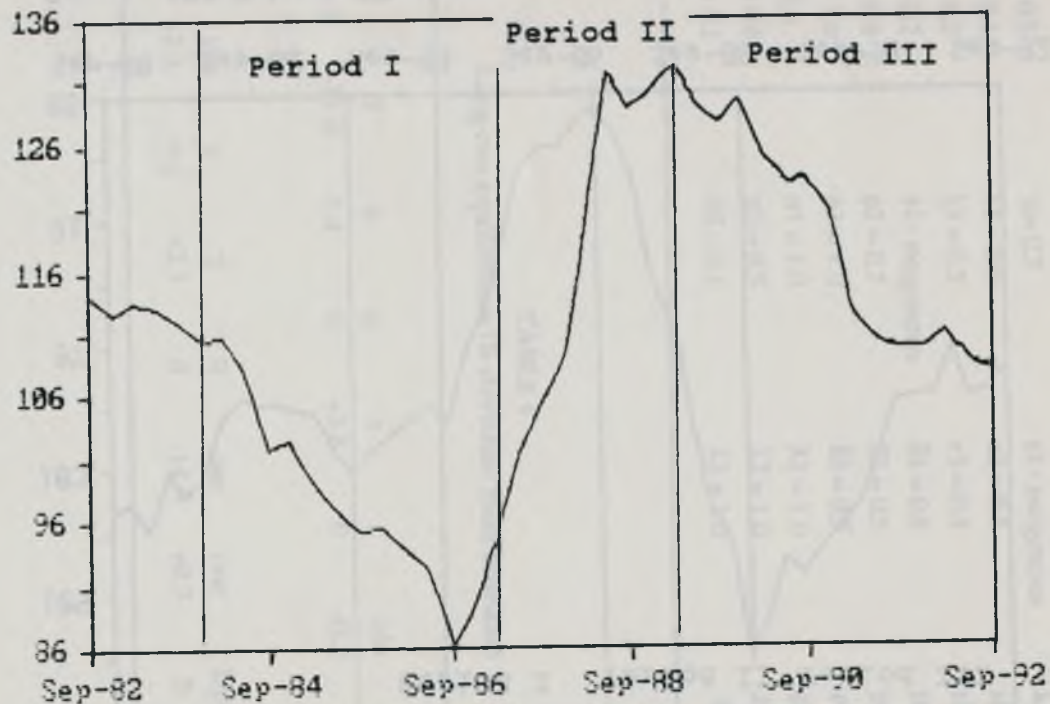
l	f	k	q	c	r	No	y
-1.8	-11.0	-1.4	0	+3.8	0	-0.2	-1.4
yp	s	T	R	we	one	Dp	
-1.3	-0.2	+2.1	0	-14.5	+0.7	0	

Figure 1 Terms of Trade: Goods (1984/85 = 100 sa)



Source: ABS, Balance of Payments

Figure 2 Index of Commodity Prices (\$US) (1984/85 = 100)



Source: RBA, Bulletin

Figure 3 Simulated resource price change

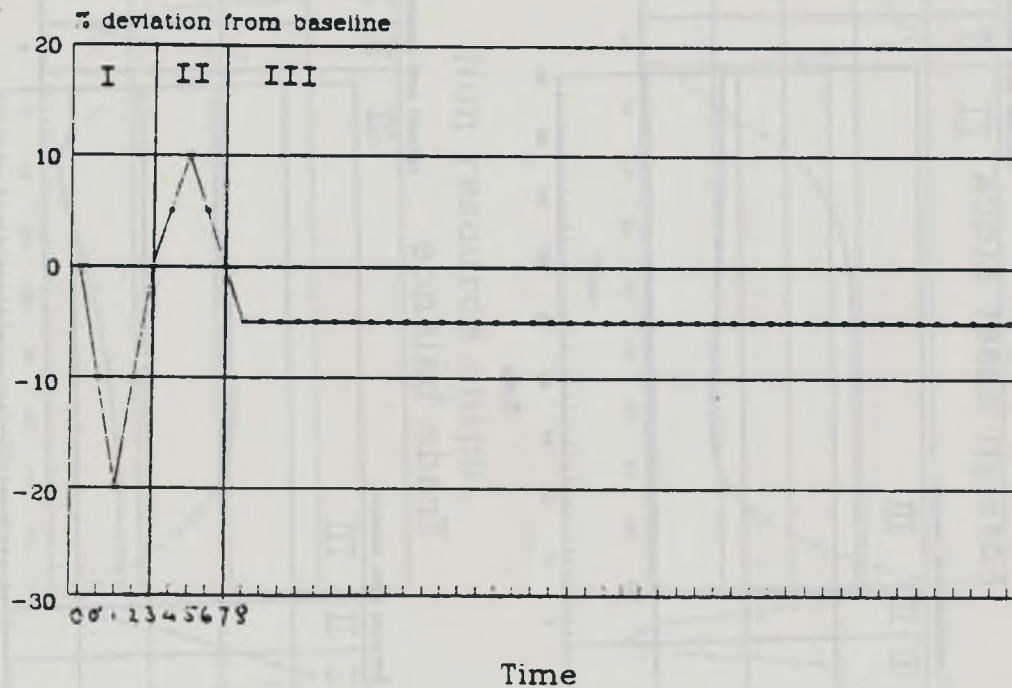


Figure 4 Simulation scenario results
(Foreign asset stock, trade balance, real exchange rate,
non-resource output demand, output supply)

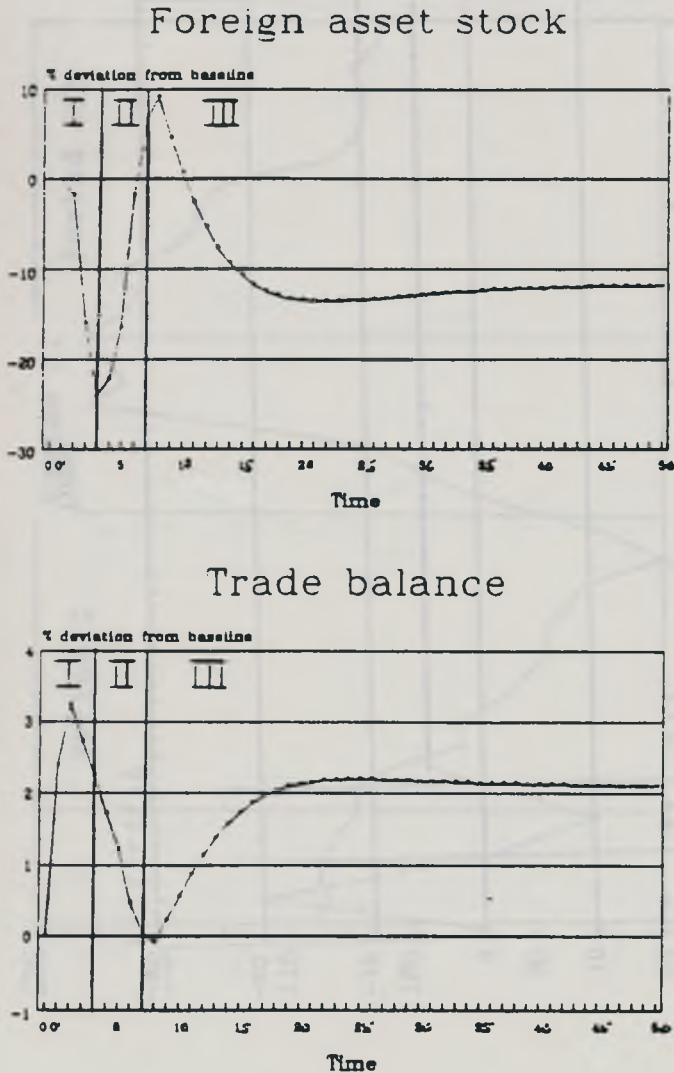


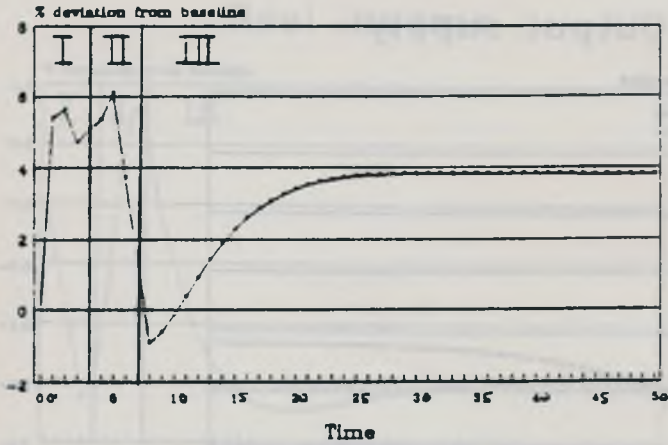
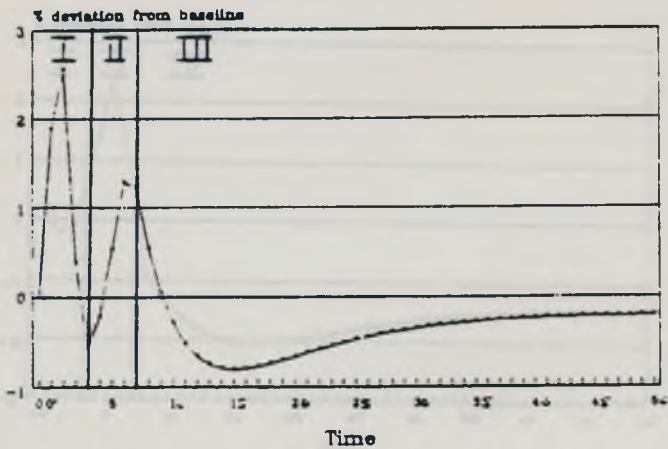
Figure 4 Simulation scenario results (continued)**Real exchange rate****Non resource output**

Figure 4 Simulation scenario results (continued)

Output supply

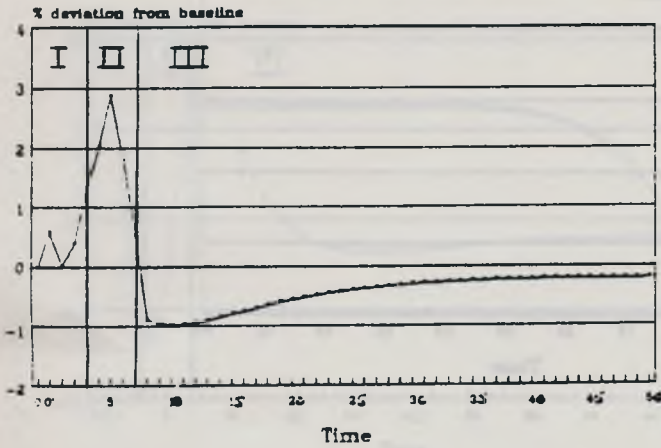
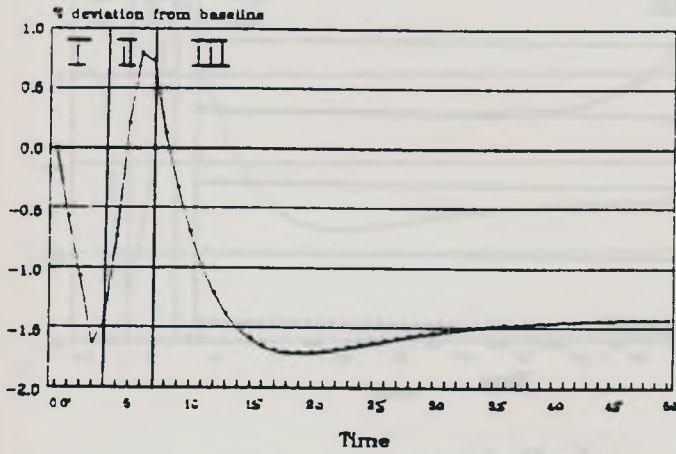


Figure 5 Simulation scenario results
(Real income, capital stock, interest rate, inflation,
real wealth, real wage growth)

Real income



Capital stock

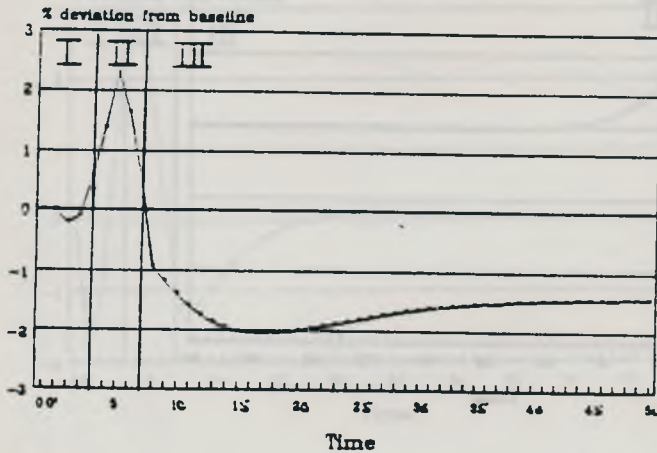
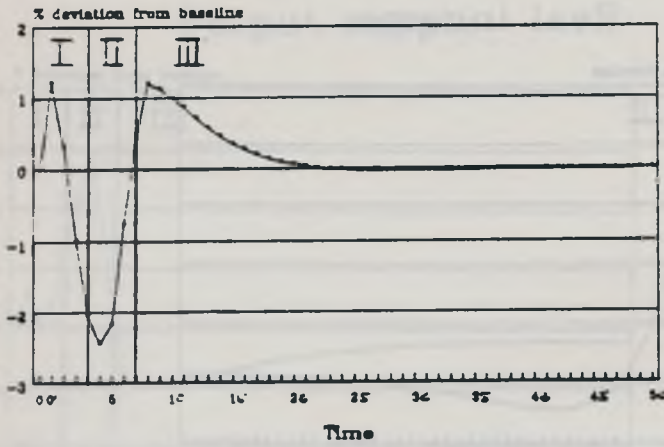


Figure 5 Simulation scenario results (continued)

Nominal interest rate



Inflation

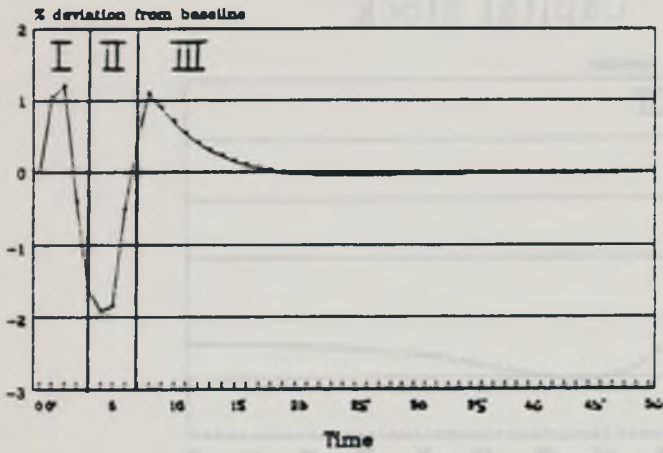
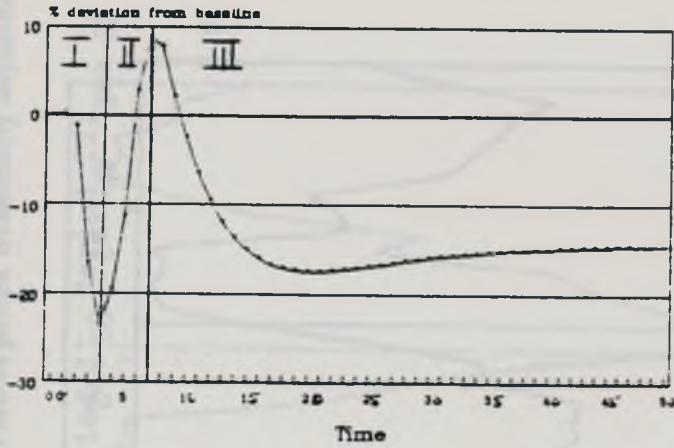


Figure 5 Simulation scenario results (continued)

Real wealth



Real wage growth

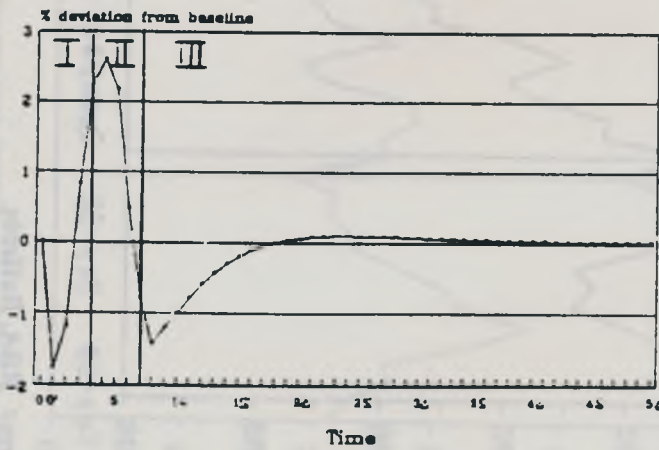
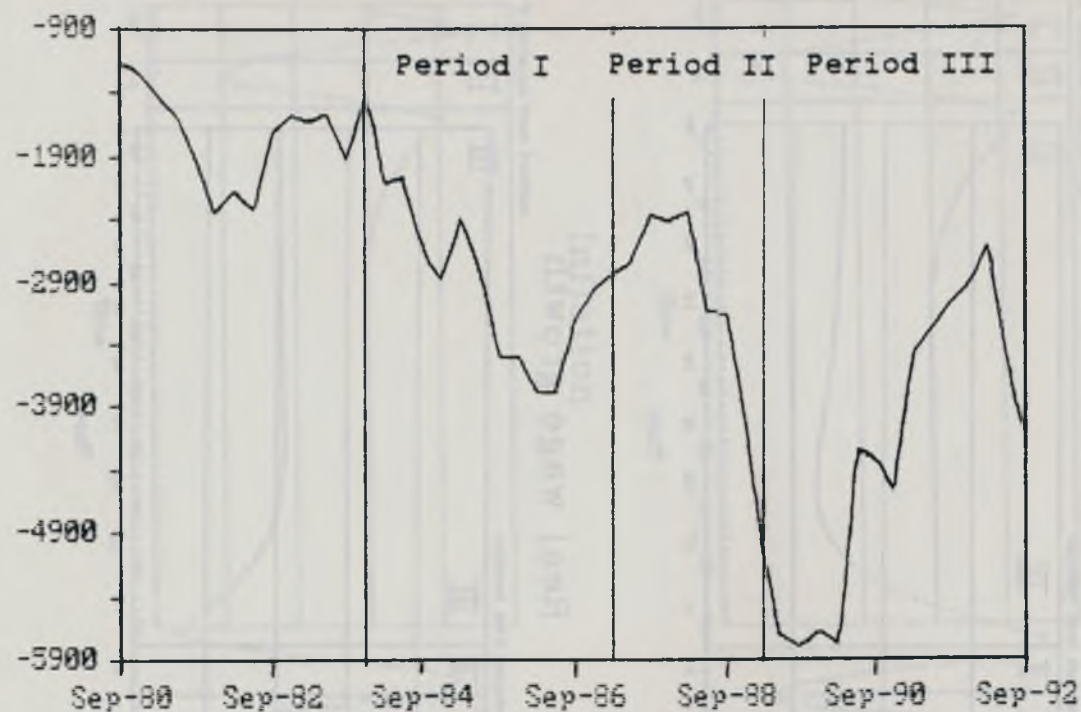
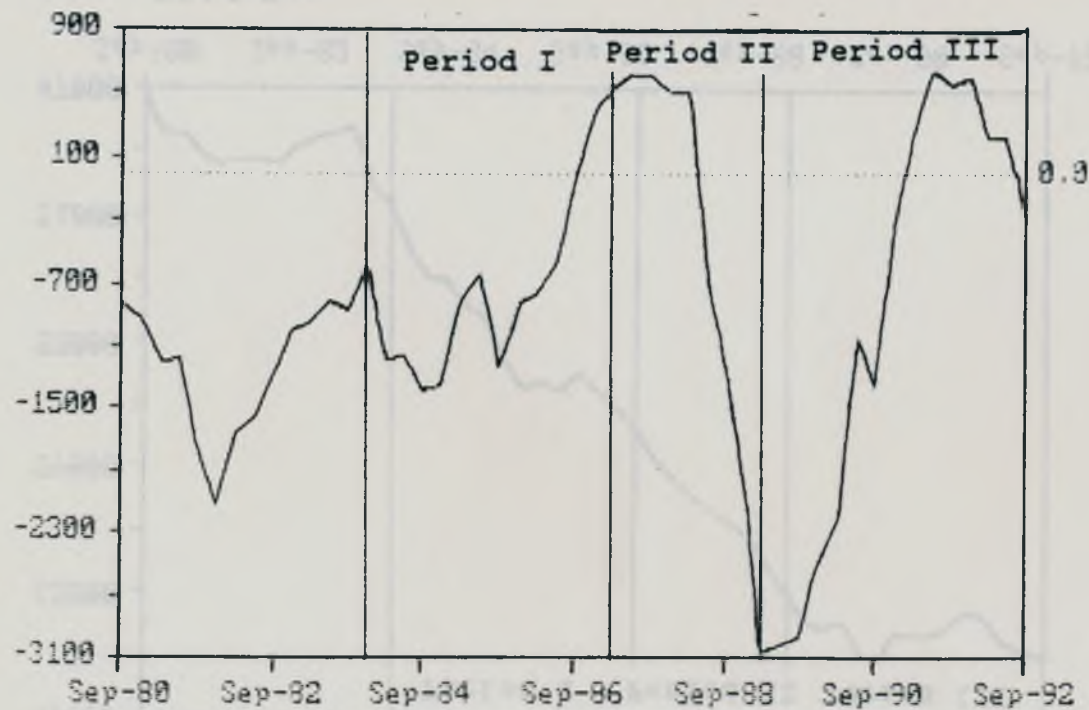


Figure 6 Current account balance: quarterly (\$M Seasonally adjusted)



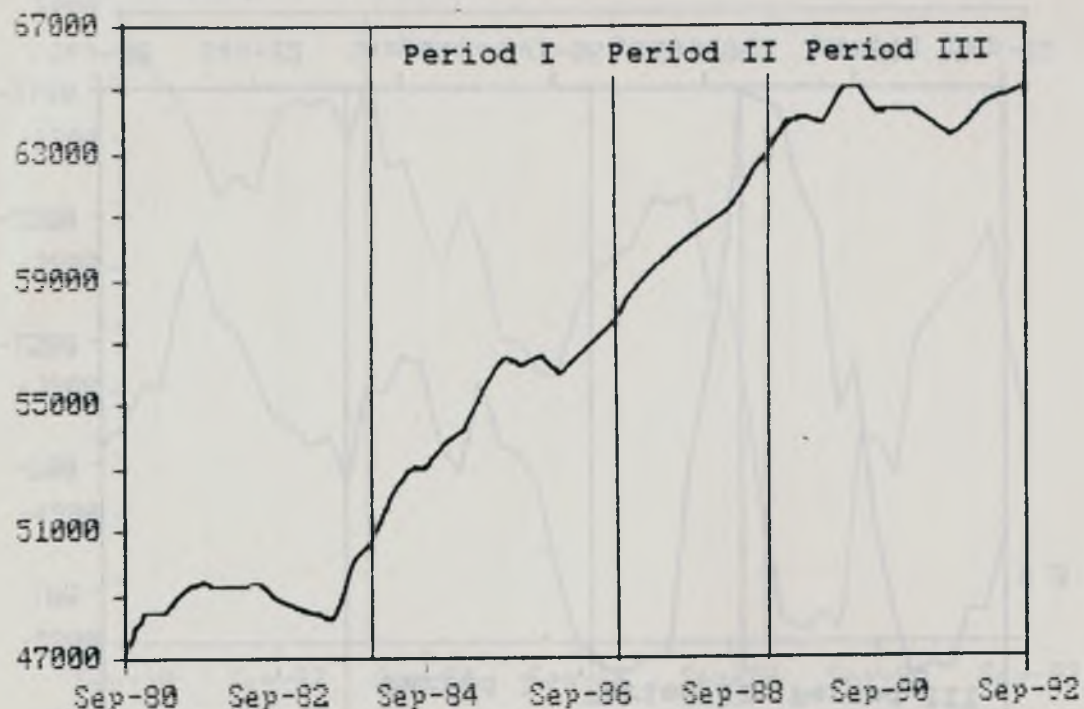
Source: RBA, Bulletin

Figure 7 Balance of goods and services (\$M 1984/85 prices Seasonally adjusted)



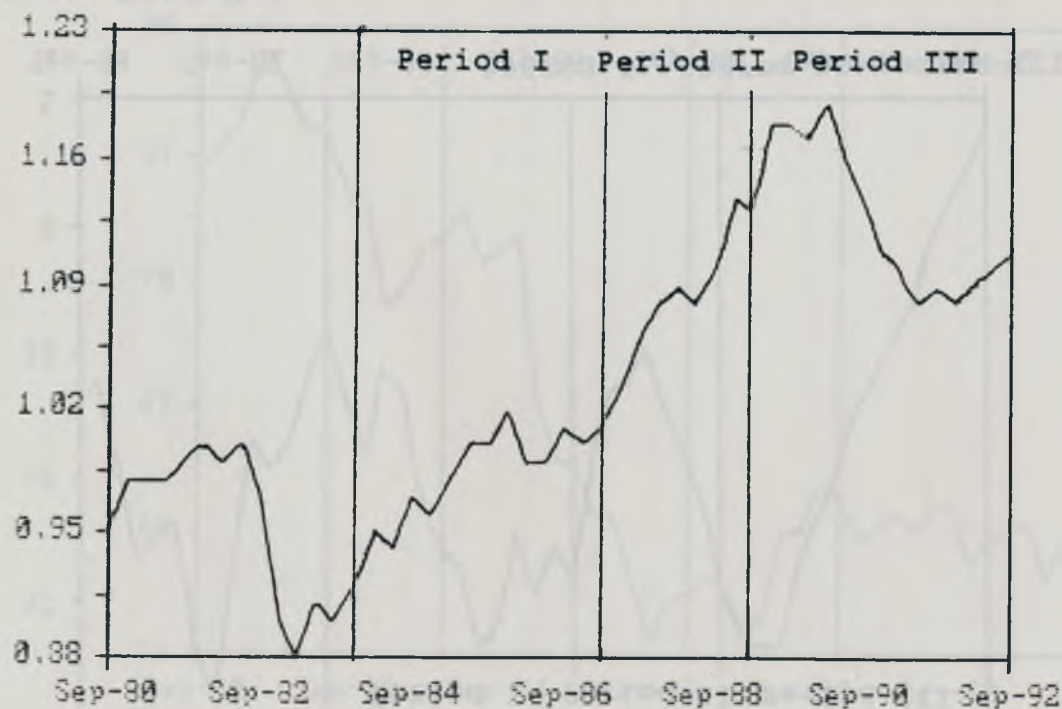
Source: ABS Balance of Payments

Figure 8 Expenditure on GDP: quarterly (\$M 1984/85 prices Seasonally adjusted)



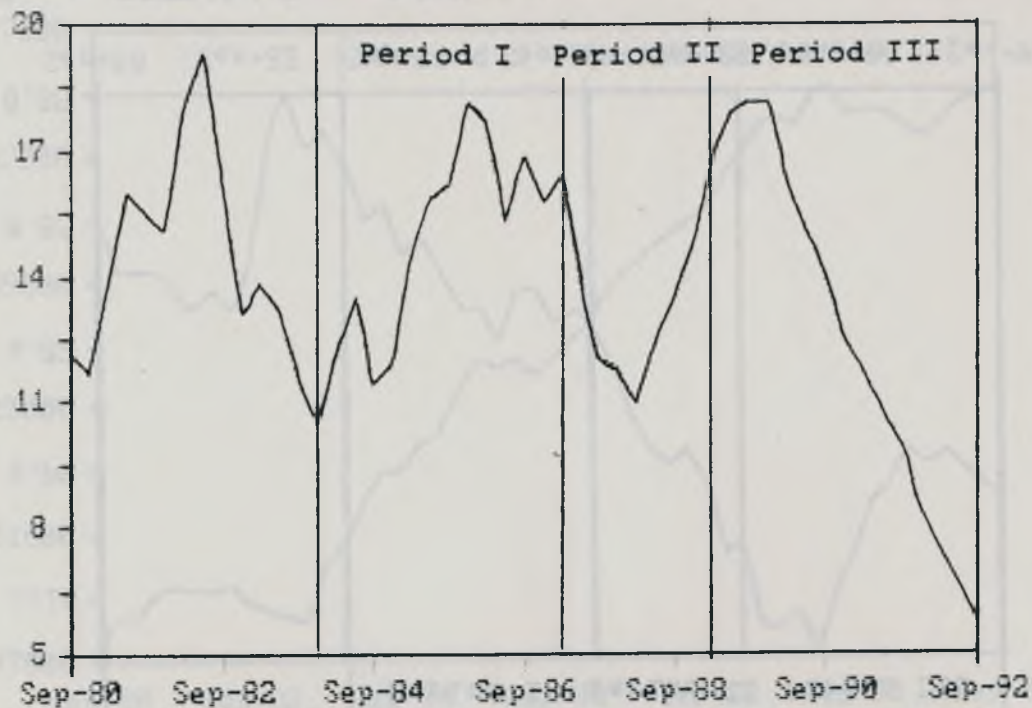
Source: RBA Bulletin

Figure 9 Real gross product: manufacturing (1985 = 100 Seasonally adjusted)



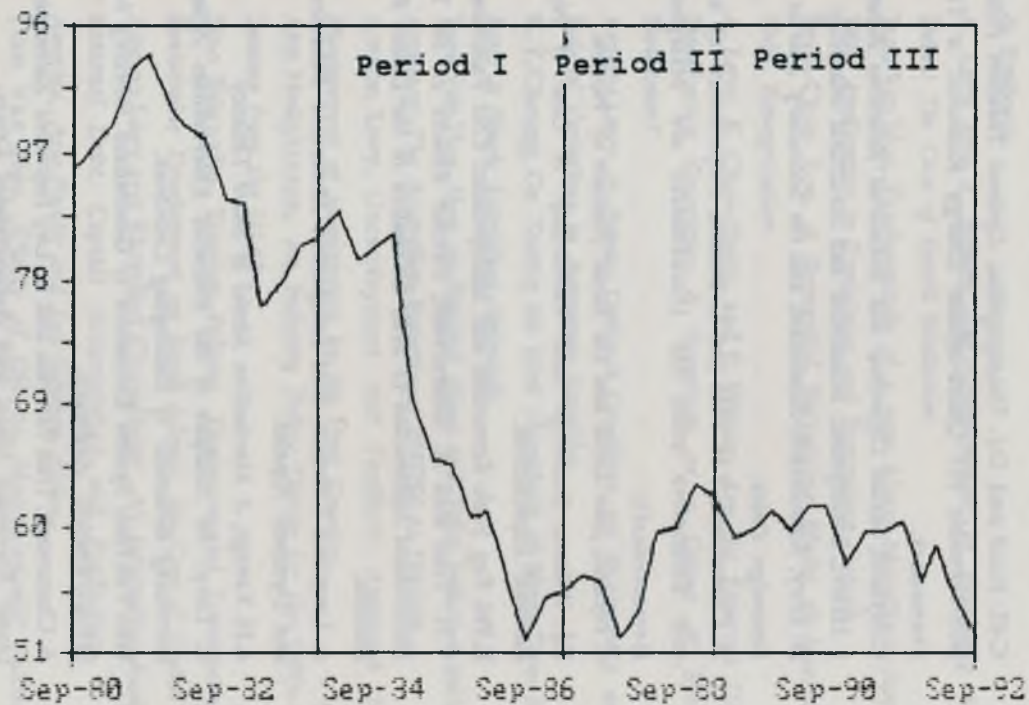
Source: OECD Main Economic Indicators

Figure 10 Interest rate: 90-day bill rate (% per annum)



Source: RBA Bulletin

Figure 11 Exchange rate: end of quarter: trade weighted index (May 1970 = 100)



Source: ABS Balance of Payments

APPENDIX

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