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Illustrative Results From ORANI-INT:

An Intertemporal CGE Model of the Australian Economy

by

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Abstract

The purpose of this paper is to demonstrate how comparative-dynamic simulations may be conducted using ORANI-INT, an intertemporal CGE model of the Australian economy. The role of the intertemporal mechanisms in the model are highlighted via a detailed analysis of the results of several illustrative experiments. At this early stage of ORANI-INT's development, the purpose of these experiments is not to shed light on actual policy issues but rather to investigate the properties of the model itself.

The experiments analysed in this paper have in common a permanent expansion in government expenditure. The effects of such a shock are examined under alternative specifications of the investment theory. Also, the effects of announcing such a policy in advance of its implementation are compared to the case where the shock is implemented without warning.

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ILLUSTRATIVE RESULTS FROM ORANI-INT: AN INTERTEMPORAL CGE MODEL OF THE AUSTRALIAN ECONOMY

BY

Michael MALAKELLIS*

1. Introduction

Comparative-static CGE models are well suited to dealing with issues concerning the effects of policy changes on the composition of the economy at a particular point in time. However, they are not well suited to dealing with issues involving the allocation of resources over time. As with any single-period model, comparative-static CGE models offer little guidance on the question of whether policy changes should be implemented immediately or according to pre-announced plans.

The purpose of this paper is to demonstrate how comparative-dynamic simulations may be conducted using ORANI-INT, an intertemporal CGE model of the Australian economy. The role of the intertemporal mechanisms in the model are highlighted via a detailed analysis of the results of several illustrative experiments. At this early stage of ORANI-INT's development, the purpose of these experiments is not to shed light on actual policy issues but rather to investigate the properties of the model itself.

The experiments analysed in this paper have in common a permanent expansion in government expenditure. The effects of such a shock are examined under alternative specifications of the investment theory. Also, the effects of announcing such a policy in advance of its implementation are compared to the case where the shock is implemented without warning.

The remainder of this paper is organised as follows: section 2 summarises the theoretical structure of ORANI-INT, the data used and the method by which the model is solved. In section 3 ORANI-INT is used to analyse the impacts on the economy of a permanent 10 per cent increase in real government expenditure. Several experiments are conducted with a view to highlighting the role that capital gains and prior knowledge of the shock have on the results. Finally, section 4 provides some concluding comments.

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2. Summary of ORANI-INT

ORANI is a large-scale comparative-static CGE model of the Australian economy (see Dixon, Parmenter, Sutton and Vincent (1982)). The theoretical structure of ORANI is strictly neo-classical; optimising behaviour on the part of producers (i.e., cost minimisation) and consumers (i.e., utility maximisation) is assumed in the context of competitive markets. ORANI-INT is a multi-period elaboration of ORANI. In the following sections the key features of ORANI-INT are summarised with emphasis on the intertemporal aspects of the model. The model is described more fully in Malakellis (1992(a)).

2.1 Multi-period elaboration of ORANI

ORANI-INT is presented schematically in Figure 1. The model consists of a sequence of T identical single-period CGE sub-models, each of which represents the economy at a different point in time. Each static CGE sub-model is a 13 sector aggregation of ORANI with the equations governing sectoral investment removed. Both aggregate investment and aggregate consumption are exogenous in ORANI. The sequence of ORANI models accounts for the bulk of the equations in ORANI-INT. The equations within each of these sub-models are atemporal since they interrelate variables in a single time period only. The remaining equations are intertemporal in that they express relationships among variables at different points in time. The purpose of the intertemporal equations is to link the sequence of ORANI models across time. Intertemporal optimising behaviour on the part of investors and households provide these links. Implicit in the specification of the model is the assumption that agents have model consistent expectations.

As depicted in Figure 1 the ORANI sub-models are linked through time via both forward (F) and backward (B) linkages. For investment, the backward linkages are provided by the capital accumulation equations whilst the forward linkages are provided by the specification of forward-looking rates of return. In ORANI-INT only one representative household is modelled and capital is assumed to be sector-specific. This means that the model incorporates 14 independent types of forward-looking behaviour; of these, 13 relate to the planning of sectoral investment whilst the other relates to the planning of consumption. There are also 14 accumulation identities modelled; again, 13 of these relate to the accumulation of sectoral capital stocks and the final one relates to the accumulation of foreign debt.

Two sets of boundary conditions complete the model. The initial conditions reflect the state of the economy as described by the latest available data whilst the terminal conditions reflect assumptions about the long-run tendencies of the economy.

$$\overset{*}{\Lambda}_{j,t} = \frac{\Lambda_{j,t}}{\prod_{u=1}^{t} [1 + RR_{j,u}]^{L_u}}. \qquad t=1, \ldots, T \quad j=1, \ldots, J$$

The numerator and denominator on the RHS of equation (2.25) may be multiplied by $P_{j,t}$, the price of sector j's output to convert the respective marginal physical products into value terms. That is,

$$[\Pi_{j,t-1} - \overset{*}{\Lambda}_{j,t-1}]\,[1 + RR_{j,t}]^{L_t} - [\Pi_{j,t} - \overset{*}{\Lambda}_{j,t}]\,(1 - \delta_j)^{L_t} = \frac{L_t\, MRPK_{j,t}\, W_{j,t}}{MRPF_{j,t}}\ ; \qquad j=1, \ldots, J \quad t=1, \ldots, T \qquad (A10)$$

where,

$$MRPK_{j,t} = P_{j,t}\,\frac{\partial f}{\partial K_{j,t}}(K_{j,t}, F_{j,t})$$

and

$$MRPF_{j,t} = P_{j,t}\,\frac{\partial f}{\partial F_{j,t}}(K_{j,t}, F_{j,t}) .$$

The variables MRPK and MRPF denote the marginal revenue products of capital and "other" factors respectively.

Apart from capital, all other factors are hired for a single period at exogenous prices. The firm will hire "other" factors up to the point where their marginal revenue and price are equated. That is,

$$MRPF_{j,t} = W_{j,t} \qquad j=1, \ldots, J . \quad t=1, \ldots, T \qquad (A11)$$

Using (A11), equation (A10) may be re-written as:

$$[\Pi_{j,t-1} - \overset{*}{\Lambda}_{j,t-1}]\,[1 + RR_{j,t}]^{L_t} = L_t\, MRPK_{j,t} + [\Pi_{j,t} - \overset{*}{\Lambda}_{j,t}]\,(1 - \delta_j)^{L_t} \qquad j=1, \ldots, J . \quad t=1, \ldots, T \qquad (A12)$$

Assuming that L_t, the length of period t, is one year for all t, expression (A12) may be simplified as follows

$$MRPK_{j,t+1} = \theta_{j,t}\, RR_{j,t+1} + \theta_{j,t+1}\,\delta_j - [\,\theta_{j,t+1} - \theta_{j,t}] \qquad j=1, \ldots, J \quad t=1, \ldots, T \qquad (A13)$$

where $\theta_{j,t} = \Pi_{j,t} - \overset{*}{\Lambda}_{j,t}$.

The assumption of a one period gestation lag in the investment process means that if sector j wants additional capital services in period t+1 it must create sufficient capital in period t. The value that sector j places on having an additional unit of capital in period t is $\theta_{j,t}$. The cost of obtaining this capital is

Condition (A2) implies that either (i) the marginal condition on investment holds as an equality and investment is nonnegative, or (ii) the marginal condition holds as an inequality and investment is zero. It is convenient to transform the marginal condition on investment into an equality as follows

$$\frac{\Pi_{j,t}\, L_t}{\prod_{u=1}^{t} [1 + RR_{j,u}]^{L_u}} - L_t\, \Gamma_{j,t} - \Lambda_{j,t} = 0 \qquad t=1, \ldots, T \quad j=1, \ldots, J \qquad (A5)$$

where $\Lambda_{j,t}$ is a slack variable. Since $\Lambda_{j,t} = \frac{\partial L}{\partial I_{j,t}}$, $\Lambda_{j,t} = 0$ when $I_{j,t} \geq 0$. Conversely, when $\Lambda_{j,t} > 0$, $I_{j,t} = 0$.

The equilibrium conditions for sectoral capital stocks (A3) may be solved using the values of the Lagrange multipliers from (A4) and (A5). From equation (A5),

$$\Gamma_{j,t} = \frac{\Pi_{j,t}}{\prod_{u=1}^{t} [1 + RR_{j,u}]^{L_u}} - \Lambda_{j,t} \qquad t=1, \ldots, T \quad j=1, \ldots, J \qquad (A6)$$

and

$$\Gamma_{j,t-1} = \frac{\Pi_{j,t-1}}{\prod_{u=1}^{t-1} [1 + RR_{j,u}]^{L_u}} - \Lambda_{j,t-1} \qquad t=1, \ldots, T \quad j=1, \ldots, J \qquad (A7)$$

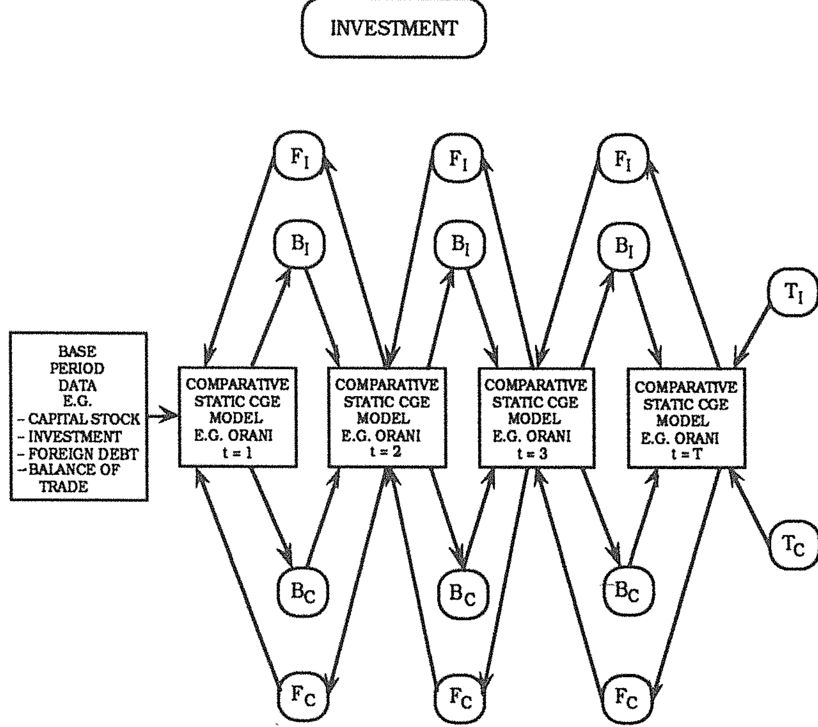
Similarly, using equation (2.3.20)

$$\Xi_{j,t} = \frac{L_t\, W_{j,t}}{\prod_{u=1}^{t} [1 + RR_{j,u}]^{L_u} \frac{\partial f}{\partial F_{j,t}} (K_{j,t}, F_{j,t})} \,. \qquad t=1, \ldots, T \quad j=1, \ldots, J \qquad (A8)$$

Substituting equations (A6) — (A8) into (A3), making appropriate cancellations and rearranging gives:

$$[\Pi_{j,t-1} - \mathring{\Lambda}_{j,t-1}]\, [1 + RR_{j,t}]^{L_t} - [\Pi_{j,t} - \mathring{\Lambda}_{j,t}]\, (1 - \delta_j)^{L_t} = \frac{L_t \frac{\partial f}{\partial K_{j,t}} (K_{j,t}, F_{j,t})\, W_{j,t}}{\frac{\partial f}{\partial F_{j,t}} (K_{j,t}, F_{j,t})} \qquad j=1, \ldots, J \quad t=1, \ldots, T \qquad (A9)$$

where



Key: F_I – current investment decisions depend on future returns.

B_I – current stock of capital depends on the stock of capital and investment expenditure in the previous period.

T_I – terminal capital stocks.

F_C – current consumption depends on future prices and income.

B_C – current debt position depends on the stock of debt and accumulation of debt in the previous period.

T_C – terminal debt.

Figure 1
Schematic Representation of an Intertemporal CGE Model

2.2 Treatment of consumption

The intertemporal consumption model used in ORANI-INT is a discrete time elaboration of Lluch's (1973) Extended Linear Expenditure System (ELES). The ELES uses a Klein-Rubin utility function which is additively separable across time. Under this specification, the consumer's optimisation problem may be treated in two parts. First, the consumer must decide how to allocate lifetime disposable income (which in the absence of bequests is equivalent to lifetime expenditure) across time. Having decided on its aggregate expenditure level in each period, the household must then decide how to distribute this expenditure among commodities. Note that the former decision is intertemporal in nature whilst the latter is atemporal.

The intertemporal problem for the representative (hereafter denoted by ^) household is to choose the levels of total expenditure, $\hat{C}_t$ (t = 1, ..., T) to maximise

$$P\hat{V}U = \sum_{t=1}^{T} \left[\frac{\hat{U}_t L_t}{\prod_{k=1}^{t} [1 + RHO]^{L_k}} \right] . \qquad (2.2.1)$$

where $P\hat{V}U$ is the present value of the utility stream, $\hat{U}_t$ is an the value of Klein-Rubin utility at time t, $R\hat{H}O$ is the pure time preference rate and L is the length of time (in years) between the start of adjacent periods.

The present value of the utility stream given by equation (2.2.1) is maximised subject to the following budget constraint which holds over the plan terminating in T:

$$\sum_{t=1}^{T} \left[\frac{\hat{C}_t L_t}{\prod_{k=1}^{t} [1 + I_k^d]^{L_k}} \right] = \hat{\Omega} , \qquad (2.2.2)$$

where $\hat{\Omega}$, the present value of the consumption stream, is exogenous to the household and I^d is the domestic market rate of interest faced by the representative household.

The first-order conditions implied by the above intertemporal optimisation problem are:

$$\frac{\hat{S}_t}{\hat{S}_{t+1}} = \frac{M\hat{U}C_t}{M\hat{U}C_{t+1}} = \frac{[1 + RHO]}{[1 + I_{t+1}^d]} \qquad t=0, ..., T \qquad (2.2.3)$$

where $\hat{S}_t$ is the above subsistence (supernumerary) expenditure in period t and $M\hat{U}C_t$ is the marginal utility of consumption in period t. Given the Klein-Rubin form of the indirect utility function in equation (2.2.1), the marginal utility of consumption in period t is a function of supernumerary (above subsistence)

Appendix A

The Lagrangian function is formed by combining the firm's objective function given by equation (2.3.10) with the constraints (2.3.11) - (2.3.16) as follows:

$$\mathcal{L}_j = \sum_{t=1}^{T} \left\{ \frac{L_t}{\prod_{u=1}^{t} [1 + RR_{j,u}]^{L_u}} (W_{j,t} \cdot F_{j,t} + \Pi_{j,t} I_{j,t}) \right.$$
$$+ \Gamma_{j,t} (K_{j,t+1} - K_{j,t} (1-\delta_j)^{L_t} - L_t I_{j,t})$$
$$\left. + \Xi_{j,t} (\overline{Q}_{j,t} - f(K_{j,t}, F_{j,t})) + ENDC \right\} \qquad j=1, ..., J \qquad (A1)$$

where ENDC represents the endpoint conditions (2.3.14) - (2.3.16) and their associated Lagrangian multipliers.

Partially differentiating expression (A1) with respect to $I_{j,t}$, $K_{j,t}$ and $F_{j,t}$ for t = 1,...,T gives:

$$\frac{\partial \mathcal{L}}{\partial I_{j,t}} = \frac{\Pi_{j,t} L_t}{\prod_{u=1}^{t} [1 + RR_{j,u}]^{L_u}} - L_t \Gamma_{j,t} \geq 0 ; \quad I_{j,t} \geq 0 ; \quad I_{j,t} \frac{\partial L}{\partial I_{j,t}} = 0 \qquad t=1, ..., L \quad j=1, ..., J \qquad (A2)$$

$$\frac{\partial \mathcal{L}}{\partial K_{j,t}} = \Gamma_{j,t-1} - \Gamma_{j,t} (1-\delta_j)^{L_t} - \Xi_{j,t} \frac{\partial f}{\partial K_{j,t}} (K_{j,t}, F_{j,t}) = 0 \qquad t=1, ..., T \quad j=1, ..., J \qquad (A3)$$

$$\frac{\partial \mathcal{L}}{\partial F_{j,t}} = \frac{L_t W_{j,t}}{\prod_{u=1}^{t} [1 + RR_{j,u}]^{L_u}} - \Xi_{j,t} \frac{\partial f}{\partial F_{j,t}} (K_{j,t}, F_{j,t}) = 0 \qquad t=1, ..., T \quad j=1, ..., J \qquad (A4)$$

Here, Γ and Ξ denote sequences of Lagrange multipliers and all other variables are as previously defined. The remaining first order conditions are obtained by partially differentiating (A1) with respect to the Lagrangian multipliers. This process gives back the constraints (2.3.14) - (2.3.16).

stocks in year 13 favours sectors (most importantly the *Construction* Sector (5)) with lower investment to capital ratios.

4. Conclusion

The illustrative experiments presented in this paper demonstrate that ORANI-INT is amendable to addressing a wide range of issues concerning the composition of the economy at particular points in time as well as the transition of the economy through time.

To date, experiments conducted with ORANI-INT have been motivated by the desire to investigate the properties of the model. The experiments analysed in this paper focus on the model's investment theory. Before the model is used for serious policy analysis the consumption theory modelled must also be scrutinised.

The experiments reported in this paper indicate that the incorporation of very simple forward-looking investment behaviour via the modelling of capital gains makes very large differences to the results produced by the model. The anticipation effects induced by this type of forward-looking behaviour are quite significant.

Whether the investment responses produced by ORANI-INT are plausible is a matter for future research. To this end, three key areas should be addressed:

(a) Treatment of Expectations: currently, all agents are assumed to have model-consistent expectations. Alternative views on how agents form their expectations must be investigated.

(b) Costs of Adjustment: much of the recent literature on investment behaviour recognises adjustment costs explicitly. Observed lags in investment behaviour are often rationalised in terms of adjustment costs. More work is required in identifying the exact sources and magnitudes of such costs before they can be convincingly incorporated into the CGE framework.

(c) Investment Technology: the investment technology specified in this model is overly restrictive in terms of length of the gestation period and does not allow for lumpiness in the capital creation process.

It is hoped that the insights gained from the illustrative simulations will assist in future developments of the model by highlighting weaknesses (and possibly implementation errors) in the model's theory and/or data. The experience gained in interpreting the results of relatively simple experiments will also be of benefit when more realistic but more complicated experiments are attempted.

expenditure in that period. Equation (2.2.3) implies that if the pure time preference rate exceeds the market rate of interest, the marginal utility of consumption in the current period will rise relative to that in the next period. In this case the representative household will transfer expenditures from the next period to the current one. The opposite will be true if the market rate of interest exceeds the time preference rate.

2.3 Treatment of investment

In ORANI-INT producers minimise the present value of their expected future cost stream taking the time path of output as given. In order to calculate this present value an appropriate discount factor is required.

Capital markets are assumed to be competitive so that producers will only choose to invest in fixed capital if the rate of return on that investment is at least as high (after allowing for any risk differential) as the rate of return on any alternative investment option (including bonds). Investment in fixed capital involves the purchase of an asset which yields a diminishing stream of capital services beginning. In equilibrium, the rates of return on all assets (net of any risk factors) will be equal.

This assumption is captured by the following arbitrage condition which holds at all time points and relates sectoral rates of return RR, to the safe domestic bond rate B^d, and a sector specific risk factor:

$$RR_{j,t} = B_t^D + Risk_{j,t} \qquad t=0, \dots, T \quad j=1, \dots, J \qquad (2.3.8)$$

Assuming uncovered interest parity,

$$B_t^D = [1 + B_t^F] \frac{\Phi_{t+1}}{\Phi_t} - 1 \qquad t=0, \dots, T \qquad (2.3.9)$$

where B^F is the exogenously given foreign safe bond rate and Φ is the exchange rate ($Australian/$foreign).

Producers are competitive, taking the time paths of all prices as given. Thus the typical producer in the jth sector takes the time paths of the sectoral rate of return, the asset price of capital Π, and the prices of all other factors W, as given. The producer then chooses the paths of factor inputs (e.g. labour and capital) and gross investment I, to minimise the present value of the expected future stream of costs PVC, given by:

$$PVC_j = \sum_{t=1}^{T} \left\{ \frac{L_t}{\prod_{u=1}^{t} (1 + RR_{j,u})^{L_u}} \right\} [\bar{W}_{j,t} \bullet F_{j,t} + \bar{\Pi}_{j,t} I_{j,t}] \qquad j=1, \dots, J \qquad (2.3.10)$$

subject to the following constraints:

$$K_{j,t+1} = K_{j,t}(1 - \delta_j)^{L_t} + L_t I_{j,t} \qquad j=1, ..., J \quad t=0, ..., T \qquad (2.3.11)$$

$$\overline{Q}_{j,t} = f(K_{j,t}, F_{j,t}) \qquad j=1, ..., J \quad t=1, ..., T \qquad (2.3.12)$$

$$I_{j,t} \geq 0 \qquad j=1, ..., J \quad t=0, ..., T \qquad (2.3.13)$$

$$K_{j,0} = \overline{K}_{j,0} \ , \qquad j=1, ..., J \qquad (2.3.14)$$

$$I_{j,0} = \overline{I}_{j,0} \ , \qquad j=1, ..., J \qquad (2.3.15)$$

and

$$I_{j,T} = \overline{I}_{j,T} \ . \qquad j=1, ..., J \qquad (2.3.16)$$

Here, $L \Leftrightarrow$ length of time in years between the start of adjacent periods,

$F \Leftrightarrow$ vector of factor inputs other than capital,

$\delta \Leftrightarrow$ the rate of depreciation,

$Q \Leftrightarrow$ the level of output,

$K \Leftrightarrow$ the stock of capital,

$f \Leftrightarrow$ production function,

and all other variables are as previously defined. The • operator takes the inner product of two vectors having the same number of components and superscript bars indicate that variables are exogenous.

Apart from the non-negativity constraint on investment (2.3.13), all other constraints are assumed to hold as equalities.

Equation (2.3.11) is the accumulation relationship between capital stocks and investment. This formulation assumes that sector j's capital stock at time point t+1 ($K_{j,t+1}$) is equal to the depreciated level of the capital stock inherited from the previous period plus any investment ($L_t I_{j,t}$) undertaken between time points t and t+1. Implicit in equation (2.3.11) is the assumption of a one-period gestation lag.[1]

[1] In this context, the term gestation lag refers to the interval between the point in time when the decision to invest is made and the point in time when a productive unit of capital comes on stream. In this implementation of the model, it is assumed for simplicity that the length of the gestation lag for all sectors is one period. Note that this assumption implies that the model results are affected by the choice of values for

economy absorbing over 40 per cent of total imports as intermediate inputs to its production process.

Although not evident from Table 9, a second factor behind this result is that aggregate investment in year 11 is relatively less import intensive than it is in year 10. The *Construction* sector (5) whose investment process is relatively import intensive does a lot less investment in year 11 than it does in year 10. Alternatively, the investment process of the *Ownership of Dwellings* sector (9) is not very import intensive and it does a lot more investing in year 11 than it does in year 9.

3.3.3 *Results over the duration of shock*

Charts 5 and 6 show that after year 11 the paths of the depicted variables tend to converge monotonically to their long-run values. The rather flat trajectories of these paths indicates that the values of the variables in year 10 do not significantly over- or under-shoot their long-run values.

The investment price deflator overshoots its long-run value in year 10 by a small margin then falls at a progressively slower rate towards it long-run value. The path of the investment price deflator implies that the magnitudes of the capital losses peak in year 10 then gradually diminish. With sectoral capital stocks held constant (and sectoral rates of return allowed to vary) in year 10, the capital losses observed in this period are of no consequence. In year 10 the rental price of capital in each sector adjusts to ensure that the market clearing conditions are preserved. Beyond year 11 however, the capital losses allow the rental price of capital deflator to fall, sharply at first then more gradually, to its long-run value. Since the demand for capital is inversely related to its rental price, the path of aggregate capital stocks mirrors the path of the rental price of capital deflator.

Aggregate investment in year 10 is below its long-run value because the demand for capital in year 11 falls (see sub-section 3.2.3). The fall in investment in year 10 is rather subdued relative to the fall in aggregate capital stock in year 11. The reason for this is that the fall in capital stocks in year 11 is heavily biased to the *Agriculture, Forestry, Fishing and Hunting* (1) and *Manufacturing* (3) sectors which have relatively high investment to capital ratios. The path of aggregate investment follows the path (not depicted) of the rate of growth in aggregate capital stocks. Hence, in year 12 when aggregate capital stocks fall by less than they did in year 11 (i.e., the annual rate of growth in aggregate capital stocks is positive) aggregate investment is positive. From year 12 the path of aggregate investment begins to fall as the rate of growth in capital stocks starts to fall. The sensitivity of aggregate investment in year 12 to the change in capital stocks in year 13 is much greater than in the previous year. The reason for this is that relative to year 12, the composition of the decrease in aggregate capital

3.3.2 *Results coinciding with the commencement of shock*

The economy is unable to expand its productive capacity in year 10 because sectoral capital stocks are held constant as is aggregate employment and agricultural land. As was the case in year 1 in the experiment in which the government shock was anticipated, any increase in domestic absorption must be accommodated largely by a deterioration in the trade balance.

The small decrease in aggregate investment in year 10 results from the decrease in demand for capital stocks in year 11. In combination, the 10 per cent increase in government expenditure and the 0.07 per cent decrease in real aggregate investment lead to an increase in real domestic absorption of about 1.95 per cent (the shares of government expenditure and investment in domestic absorption are about 20 and 22 per cent respectively). Domestic prices rise leading to a deterioration in the trade balance of A$3.46 billion (which is equivalent to about 1.9 per cent of base GDP in year 10). This is achieved by a 10. 37 per cent decrease in exports and 2. 85 per cent increase in imports. As Table 9 shows, the *Public Administration and Defence* (sector 10) and *Community Services* (sector 11) sectors expand largely at the expense of the traded goods sectors (i.e., Sectors 1-3).

In year 11 the investment price deflator rises by 3.01 per cent whilst the rental price of capital deflator rises by 4.09 per cent. This wedge between the two deflators indicates the presence of capital losses in year 11. Aggregate capital stocks will therefore increase by less in year 11 than they will in the long-run when capital losses are negligible. The fact that aggregate capital stocks actually fall in year 11 is somewhat surprising given that the average real cost of using capital falls in this year (i.e., rental price of capital deflator rises by 4.09 per cent whilst the average price received by producers rises by 4.51 per cent).

The fall in the real cost of using capital in year 11 is quite modest and is more than offset by the sectoral bias of the increase in domestic absorption. As Table 9 shows, the activity levels of the relatively capital intensive traded-goods sectors (sectors 1-3) fall quite significantly. In addition, the 0.87 per cent decrease in the activity level of the *Ownership of Dwellings* sector (9) is important because this sector is 100 per cent capital intensive and possess close to 30 per cent of the economy's total capital stocks.

The increase in real domestic absorption is slightly higher in year 11 than it is in year 10 because of the bigger contributions made by aggregate real investment. Given that the investment process is relatively import intensive and that the trade balance deteriorates by more in year 11 than it does in year 10 it is surprising that import volumes rise by less in year 11 than they do in year 10 (i.e., 1.91 per cent compared with 2.85 per cent). This result is explained largely by the poor performance of the *Manufacturing* sector (3) in year 11 relative to year 10. The *Manufacturing* sector is by far the most intensive user of imports in the

The constraint represented by equation (2.3.12) specifies the production technology available to producers and the path of output which must be produced. Equation (2.3.14) and (2.3.15) are initial conditions relating to capital stocks and investment respectively. Finally, terminal period investment flows are given by equation (2.3.16).

The equilibrium conditions which emerge from the above producer's cost minimisation problem are derived in appendix A. The equilibrium conditions for sectoral capital stocks are given by:

$$MRPK_{j,t+1} = \theta_{j,t}\, RR_{j,t+1} + \theta_{j,t+1}\, \delta_j - [\, \theta_{j,t+1} - \theta_{j,t}] \quad j=1, \ldots, J \quad t=0, \ldots, T \qquad (2.3.17)$$

where $\theta_{j,t} = \Pi_{j,t} - \Lambda^{*}_{j,t}$ and MRPK denotes the marginal revenue product of capital. The value that sector j places on having an additional unit of capital services in period t is $\theta_{j,t}$. The cost of obtaining it is given by $\Pi_{j,t}$. Thus, $\Lambda^{*}_{j,t}$ is the difference between the value that sector j places on having an additional unit of capital services and the cost of obtaining it.

In the case where the nonnegativity constraints on investment are never binding the value to the firm of an additional unit of capital services is always equal to its cost. In this case, equation (2.3.17) may be written as

$$MRPK_{j,t+1} = \Pi_{j,t}\, RR_{j,t+1} + \Pi_{j,t+1}\, \delta_j - [\, \Pi_{j,t+1} - \Pi_{j,t}] \quad j=1, \ldots, J \quad t=0, \ldots, T \qquad (2.3.18)$$

Equation (2.3.18) implies that the stock of capital held by the firm will be such that the marginal revenue product of an additional unit of capital services will be equal to its marginal cost. The marginal cost of a unit of capital services in period t+1 is given by the RHS of equation (2.3.18). The first term, $\Pi_{j,t}\, RR_{j,t+1}$, is the opportunity cost of funds tied up in the ownership of the capital services producing asset. The opportunity cost component is calculated on the basis that investment costs are incurred in period t for capital which comes on stream in period t+1. The second term, $\Pi_{j,t+1}\, \delta_j$, is the depreciation costs associated with the usage of the capital for one period. Finally, the term in square brackets in equation (2.3.18) captures capital gains/losses.

3. *An Application of ORANI-INT*

3.1 *Description of Experiments*

In the three experiments reported below, ORANI-INT is solved over a thirty year time horizon. In all experiments real government expenditure is assumed to increase by 10 per cent in each of years 10 through to 30.

L_t. Consistent behaviour over time then requires that L_t is in fact uniform over t. For L_t to vary the theory would have to be generalised to allow for gestation lags of more or less than one period.

In the first experiment the shock to government expenditure is anticipated 10 years in advance. In the second experiment all forward-looking behaviour in ORANI-INT is suppressed. The only links between the periods allowed in this experiment are provided by the sectoral capital accumulation relations which are backward-looking. The final experiment reported allows forward-looking investment behaviour but agents are surprised by the shock to government expenditure.

3.1.1 *Closure of the model*

ORANI-INT has many more variables than it has equations and therefore some variables must be exogenously specified. The economic environment in which a particular experiment is analysed depends on the choice of exogenous variables.

The amount of capital that sectors have at their disposal in year 1 is fixed by decisions taken in the past. Year 1 is therefore characterised by a short-run equilibrium in which sectoral capital stocks are held fixed and sectoral rates of return are allowed to vary. Beyond year one however, sectoral capital stocks are allowed to vary whilst sectoral rates of return are required to equalise via the imposition of an arbitrage condition. Investment is endogenous in all periods except the last. A terminal condition which requires the rate of growth of investment in the terminal year to be equal to that in the penultimate year is exogenously imposed.

For many variables ORANI-INT has no formal theory and typically, the values of these variables are specified exogenously. This group of variables includes technical change, consumer tastes, indirect taxes, subsidies, risk factors, foreign demand conditions, foreign price of imports, foreign interest rates, transfers overseas, population, government expenditure, supply of agricultural land and exports of those commodities for which Australia is assumed to be a price-taker.

In these experiments aggregate employment of labour is assumed to be fixed in all periods with the real wage adjusting to clear the labour market. To simplify the experiments and help isolate the implications of the investment theory modelled, the equations governing the distribution of household expenditure over time are disabled. Accordingly, aggregate real consumption is set exogenously in each year.

The treatment of exports in ORANI-INT distinguishes between those commodities for which Australia is a price-taker (non-traditional exports) and those whose world price is influenced by Australian sales (traditional exports). The commodities associated with the first three sectors listed in Table 2 (i.e., *Agriculture, Forestry, Fishing and Hunting* (sector 1), *Mining* (sector 2), and *Manufacturing* (sector 3)) are treated as traditional exports with their foreign

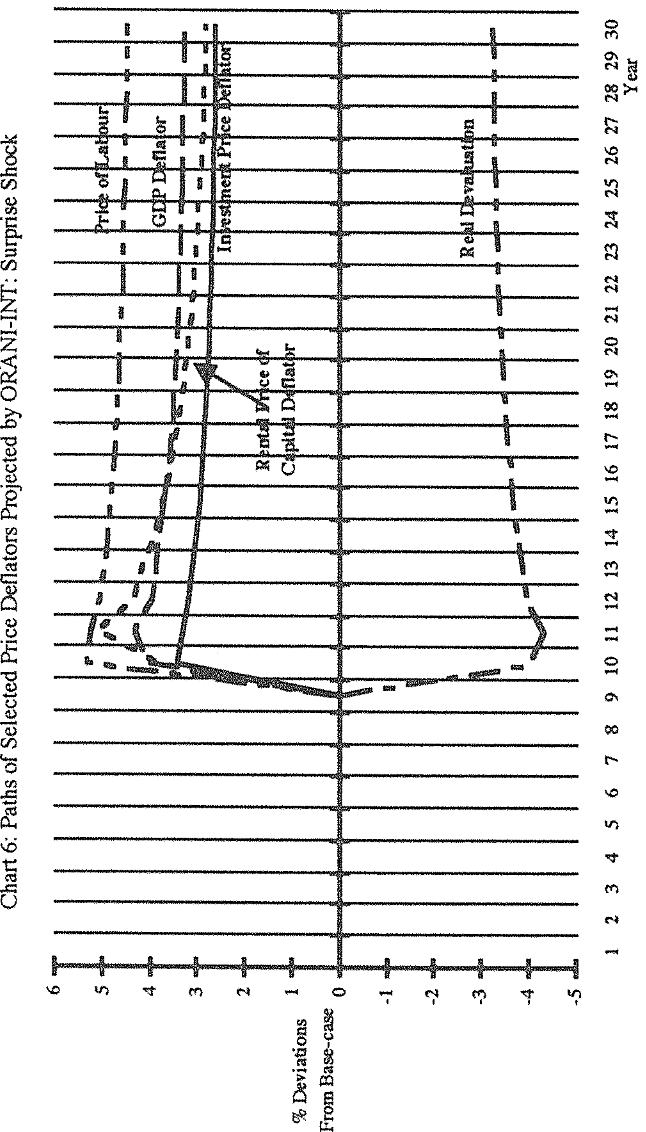
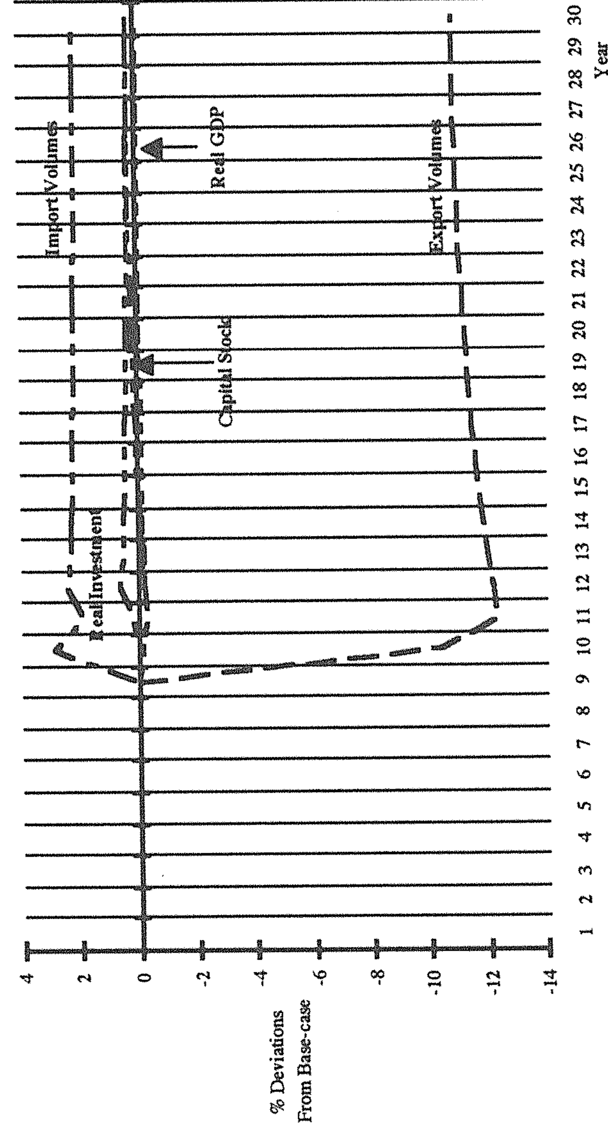


Chart 6: Paths of Selected Price Deflators Projected by ORANI-INT: Surprise Shock

Chart 5: Paths of Selected Macroeconomic Variables Projected by ORANI-INT: Surprise Shock



currency prices and sales overseas endogenously determined. The commodities associated with the remaining ten sectors are treated as non-traditional exports. The foreign currency price of these commodities are held constant as are sales of these commodities overseas. An endogenous export subsidy ensures that the exogenously specified sales of non-traditional exports are achieved.

Investment behaviour in ORANI-INT is distinguished on the basis of the degree of government involvement. The activities of two sectors in ORANI-INT (i.e., *Public Administration and Defence* (sector 10) and *Community Services* (sector 11)) are dominated by the government. Investment in these sectors is exogenous because the investment theory outlined in section 2.3 is considered inappropriate.

A special feature of the closure of ORANI-INT adopted for these experiments is the treatment of the Mining commodity. The Mining commodity has a very high import substitution elasticity as well as a relatively low foreign demand elasticity. This combination of parameters results from the aggregation of the ORANI database. The Mining commodity in ORANI-INT is an amalgam of five ORANI commodities which have quite different characteristics. The high import substitution elasticity attributed to the Mining commodity reflects the contribution made by the extremely high import substitution elasticity assigned to the Oil, Gas and Brown Coal commodity in ORANI. Similarly, the low export demand elasticity of the Mining commodity reflects the characteristics of the Ferrous Metal Ores and Non-Ferrous Metal Ores commodities in ORANI. To control the volatile output responses of the Mining sector an endogenously determined subsidy to this sector allows the share of domestic to total supply of the Mining commodity to be fixed. This strategy is analogous to that adopted in ORANI-F (see Parmenter (1988)) to control the domestic market share of the Oil, Gas and Brown Coal commodity.

To tie down the absolute price level ORANI-INT also requires the specification of a numeraire sequence. This is achieved by exogenously specifying the time path of the nominal exchange rate.

3.1.2 Base scenario used

To construct the base case solution a 13 sector aggregation of the 1980-81 ORANI database is used (corresponding with the ASIC divisions used by the ABS in the Australian National Accounts). Since simulations are to be conducted over a 30 year time horizon, the base case must also extend over this length of time. Accordingly the aggregated ORANI database was replicated 30 times. Appropriate shocks were administered to the exogenous variables so that a base case which satisfied all the non-linear equations of the model and in which all real variables converged towards steady growth of 2.5 percent per annum (and all prices converged to zero growth) was obtained. Note that the base case does not exhibit balanced growth in all periods. The values of variables in the first year of the base case reflect the state of the economy as given by the 1980-81 data. The base case

converges to balanced growth of 2.5 per cen per annum asymptotically. Technical details about the construction of the base case can be obtained in Malakellis (1992(a) and 1992(b)).

A selection of results from the base simulation are presented in Tables 1 and 2. The results should be interpreted as annual percentage growth rates. In the case of stocks such as capital the results in column t indicate the percent increase in the stock between the start of year t and the start of year t+1. For flows such as investment, it is the year on year percentage increase in the amount of the flow.

Overall, the tables show that the real variables tend to converge towards steady growth of 2.5 percent per annum and prices tend to converge to zero growth. In the early periods a degree of structural change is occurring in the economy. The structural changes observed in the early periods of the base case solution reflect the adjustments that sectors must make in order to re-configure their investment to capital ratios in a way which is consistent with both the arbitrage condition and the growth of the rest of the economy.

The percentage growth rates of sectoral capital stocks in year 1 are presented in the column headed "Initial Net Investment to Capital Ratio" in Table 3. Since the amount of capital that sectors have at their disposal in period 1 is fixed by decisions taken in the past, the growth of sectoral capital stocks in year 1 reflects the net investment to capital ratios in period 0 (i.e., the period to which the aggregated ORANI database pertains).

Ignoring sector 13 which does not possess any capital stock, the initial rates of growth in the capital stocks of three of the remaining sectors (i.e., *Agriculture, Forestry, Fishing and Hunting* (1), *Public Administration and Defence* (10), and *Community Services* (11)) is less than the long-run equilibrium growth rate of 2.5 per cent per annum to which the economy is tending. These sectors tend to re-adjust their investment/capital ratios up. Capital stocks in the other sectors are initially growing faster than 2.5 per cent per annum and the tendency for these sectors is to decrease their investment/capital ratios.

The structural changes implied above are compounded by the imposition of an arbitrage condition in period 2 which requires sectoral rates of return to equal 3 per cent, the exogenously specified world interest rate. The column headed "Rates of Return" in Table 3 shows the degree of disequilibrium in sectoral rates of return in the aggregated ORANI database. Two sectors, *Construction* (5) and *Recreation, Personal and Other Services* (12) have rates of return which are equal to the equilibrium rate. The *Manufacturing* (3) and *Agriculture, Forestry, Fishing and Hunting* (1) sectors have rates of return below the equilibrium rate whilst the rates of return in the remaining sectors are above 3 per cent. Sectors with rates of return higher than the equilibrium rate tend to increase their capital stock by

Table 8: Projections by ORANI-INT of the Percentage Deviations from Base of Selected Macroeconomic Variables: Surprise Shock

VARIABLE / YEAR	9	10	11	12	13	14	15	16	18	20	22	24	26	28	30
1. Change in the Trade Balance (a)	0.00	-3.46	-3.79	-4.01	-4.03	-4.08	-4.13	-4.20	-4.34	-4.50	-4.69	-4.89	-5.11	-5.35	-5.60
2. Export Volumes	0.00	-10.37	-12.39	-12.22	-12.04	-11.87	-11.73	-11.61	-11.41	-11.27	-11.16	-11.09	-11.03	-10.98	-10.94
3. Import Volumes	0.00	2.85	1.91	2.42	2.29	2.28	2.24	2.22	2.18	2.15	2.13	2.11	2.09	2.08	2.07
4. Real GDP at Market Prices	0.00	-0.14	-0.26	-0.22	-0.20	-0.18	-0.16	-0.15	-0.13	-0.11	-0.10	-0.09	-0.08	-0.08	-0.08
5. Aggregate Real Investment	0.00	-0.07	0.17	0.63	0.53	0.50	0.47	0.44	0.40	0.36	0.33	0.31	0.28	0.26	0.23
6. Aggregate Capital Stocks	0.00	0.00	-0.32	-0.24	-0.16	-0.09	-0.03	0.02	0.10	0.16	0.20	0.23	0.25	0.27	0.27
7. Real Government Expenditure (b)	0.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00
8. Investment Price Deflator	0.00	3.10	3.01	2.95	2.90	2.85	2.81	2.78	2.72	2.69	2.66	2.64	2.62	2.61	2.60
9. Rental Price of Capital Deflator	0.00	3.49	4.09	3.68	3.57	3.44	3.34	3.25	3.10	3.00	2.92	2.87	2.83	2.80	2.78
10. GDP Deflator	0.00	3.73	3.86	3.68	3.63	3.56	3.51	3.47	3.40	3.35	3.31	3.29	3.27	3.25	3.24
11. Factor Cost Deflator	0.00	4.37	4.51	4.31	4.24	4.17	4.11	4.06	3.98	3.93	3.88	3.85	3.83	3.81	3.80
12. Price of labour	0.00	5.00	4.94	4.82	4.77	4.72	4.68	4.65	4.59	4.55	4.53	4.50	4.49	4.47	4.46
13. Real GDP at Factor Cost	0.00	0.00	-0.10	-0.07	-0.05	-0.03	-0.01	0.01	0.03	0.05	0.06	0.07	0.08	0.08	0.08

NOTES: (a) Trade Balance results are reported as ordinary (rather than percentage) changes and measured in Billions of base period $A.
(b) Real Government Expenditure is exogenous and the values in Table 8 indicate the shocks administered.

Table 9: Projections by ORANI-INT of the Percentage Deviations from Base of Sectoral Activity Levels: Surprise Shock

SECTOR / YEAR	9	10	11	12	13	14	15	16	18	20	22	24	26	28	30
1. Agric., Forest., Fishing, Hunting	0.00	-5.00	-7.22	-7.09	-7.00	-6.89	-6.80	-6.72	-6.60	-6.51	-6.44	-6.39	-6.35	-6.32	-6.30
2. Mining	0.00	-2.56	-2.49	-2.34	-2.33	-2.29	-2.27	-2.25	-2.21	-2.19	-2.17	-2.16	-2.15	-2.14	-2.14
3. Manufacturing	0.00	-3.70	-4.34	-4.06	-4.04	-3.98	-3.94	-3.90	-3.84	-3.80	-3.76	-3.74	-3.73	-3.71	-3.71
4. Electricity, Gas and Water	0.00	0.38	0.29	0.39	0.40	0.42	0.44	0.45	0.48	0.49	0.51	0.52	0.52	0.53	0.53
5. Construction	0.00	-0.39	2.60	1.49	1.65	1.58	1.56	1.54	1.50	1.47	1.45	1.43	1.41	1.39	1.37
6. Wholesale and Retail Trade	0.00	-0.37	-0.65	-0.49	-0.51	-0.50	-0.50	-0.50	-0.50	-0.50	-0.49	-0.49	-0.49	-0.50	-0.50
7. Transport and Storage	0.00	0.74	0.77	0.82	0.83	0.84	0.85	0.86	0.87	0.88	0.89	0.89	0.90	0.90	0.90
8. Finance, Prop. and Bus. Services	0.00	0.14	0.48	0.45	0.47	0.48	0.49	0.49	0.50	0.51	0.51	0.52	0.52	0.52	0.52
9. Ownership of Dwellings	0.00	0.00	-0.87	-0.39	-0.40	-0.34	-0.30	-0.27	-0.21	-0.17	-0.15	-0.13	-0.11	-0.10	-0.10
10. Public Admin. and Defence	0.00	8.93	8.94	8.94	8.94	8.94	8.94	8.94	8.94	8.94	8.94	8.94	8.94	8.94	8.94
11. Community Services	0.00	6.05	6.12	6.08	6.08	6.08	6.07	6.07	6.07	6.06	6.06	6.06	6.06	6.06	6.06
12. Rec., Pers. and Other Services	0.00	0.42	0.59	0.57	0.57	0.57	0.58	0.58	0.58	0.58	0.58	0.58	0.58	0.58	0.58
13. Non-competing Imports	0.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00

The above explanation holds equally for ORANI-INT. The rate of decline in the real cost of using capital in year 10 is particularly strong in ORANI-INT because of the presence of capital gains whose growth peaks in year 10. The fact that the rate of growth in aggregate investment in year 9 is negative in ORANI-INT suggests that the compositional effect is much stronger in this model than it is in ORANI-DYN. Because investors in ORANI-INT react to the presence of capital gains, the rate of growth in aggregate investment, and hence aggregate absorption, in the years prior to year 9 is stronger than that projected by ORANI-DYN. However, the rate of growth in domestic absorption in year 10 is significantly less in ORANI-INT than it is in ORANI-DYN because the rate of decline in aggregate investment in that year in the former model almost outweighs the growth in government expenditure. It follows that the growth in domestic absorption in year 10 is more labour intensive in ORANI-INT than it is in ORANI-DYN.

3.3 *Results of a Surprise, Permanent 10 per cent Increase in Real Government Expenditure*

In this experiment agents learn about the increase in government expenditure in year 10. Prior to year 10 there is no change in the economy. Since sectoral capital stocks in year 10 depend on investment undertaken in previous years they cannot change. Year 10 in this experiment therefore represents the short-run situation in which sectoral capital stocks are held fixed and sectoral rates of return are allowed to vary. The characterisation of year 10 in this experiment is analogous to that of year 1 in the experiment in which the shock to government expenditure was anticipated.

A selection of results obtained from this experiment are reported in Tables 8 and 9 and depicted in Charts 5 and 6. In contrast to the results obtained from the experiment in which the shock to government was anticipated, the results from this experiment exhibit very little dynamic variation.

3.3.1 *Long-run results*

As expected the long-run results obtained from this experiment are very similar to the long-run results obtained in the previous two experiments. Since the mechanisms which generate the results are identical in the three experiments the analysis here will be brief.

In this experiment, the permanent increase in government expenditure is accommodated in the long-run by a slightly smaller increase in capital stocks than is the case in ORANI-DYN (i.e., 0.27 per cent compared with 0.32 per cent) and consequently, a slightly bigger deterioration in the trade balance (i.e., A$5.6 billion compared with A$5.59 billion). The slight differences in the two sets of results reflect the presence of very small capital losses which persist in this experiment.

Table 1: Base-case Projections of the Percentage Growth Rates of Selected Macroeconomic Variables

VARIABLE / YEAR	1	2	3	4	5	6	8	10	12	14	16	18	20	25	30
1. Real GDP at Market Prices	3.02	3.04	2.85	2.78	2.73	2.68	2.62	2.58	2.56	2.54	2.53	2.52	2.51	2.50	2.50
2. Aggregate Real Consumption	4.88	2.96	2.94	2.85	2.78	2.73	2.65	2.60	2.57	2.55	2.53	2.52	2.51	2.50	2.50
3. Aggregate Real Investment	-1.88	5.75	1.81	1.76	1.85	1.96	2.12	2.24	2.32	2.38	2.42	2.44	2.46	2.48	2.48
4. Export Volumes	1.38	2.32	4.20	3.99	3.72	3.50	3.17	2.95	2.80	2.70	2.64	2.59	2.56	2.52	2.51
5. Import Volumes	0.06	5.31	2.41	2.32	2.29	2.33	2.39	2.42	2.45	2.47	2.48	2.48	2.49	2.49	2.50
6. Real Government Expenditure	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50
7. Aggregate Capital Stocks	4.41	4.01	3.68	3.44	3.27	3.13	2.92	2.78	2.69	2.63	2.59	2.56	2.54	2.51	2.50
8. Investment Price Deflator	0.38	-0.60	-0.48	-0.39	-0.32	-0.26	-0.17	-0.12	-0.08	-0.05	-0.04	-0.02	-0.02	-0.01	0.00
9. GDP Deflator	0.55	-0.81	-0.62	-0.52	-0.41	-0.34	-0.23	-0.15	-0.10	-0.07	-0.05	-0.03	-0.02	-0.01	0.00

Table 2: Base-case Projections of the Percentage Growth Rates in Sectoral Activity Levels

SECTOR / YEAR	1	2	3	4	5	6	8	10	12	14	16	18	20	25	30
1. Agric., Forest., Fishing, Hunting	1.05	2.50	3.67	3.51	3.31	3.17	2.95	2.80	2.71	2.64	2.59	2.56	2.54	2.52	2.51
2. Mining	4.33	-0.18	2.78	2.80	2.73	2.69	2.63	2.59	2.56	2.54	2.53	2.52	2.51	2.50	2.50
3. Manufacturing	1.48	4.27	3.17	3.03	2.91	2.84	2.73	2.65	2.60	2.57	2.55	2.53	2.52	2.51	2.50
4. Electricity, Gas and Water	3.35	2.87	2.90	2.89	2.81	2.76	2.67	2.62	2.58	2.55	2.54	2.52	2.52	2.51	2.50
5. Construction	5.56	0.15	1.60	1.65	1.93	2.00	2.15	2.26	2.34	2.39	2.42	2.45	2.46	2.49	2.48
6. Wholesale and Retail Trade	2.82	4.17	2.81	2.72	2.65	2.63	2.58	2.56	2.54	2.53	2.52	2.51	2.51	2.50	2.50
7. Transport and Storage	2.99	3.56	2.71	2.71	2.66	2.64	2.59	2.56	2.54	2.53	2.52	2.51	2.51	2.50	2.50
8. Finance, Prop. and Bus. Services	3.53	3.54	2.66	2.68	2.65	2.62	2.58	2.56	2.54	2.52	2.52	2.51	2.51	2.50	2.50
9. Ownership of Dwellings	3.88	2.62	3.84	3.53	3.29	3.16	2.94	2.80	2.70	2.63	2.59	2.56	2.54	2.51	2.51
10. Public Admin. and Defence	2.60	2.57	2.53	2.52	2.52	2.51	2.51	2.51	2.50	2.50	2.50	2.50	2.50	2.50	2.50
11. Community Services	3.44	2.79	2.60	2.59	2.57	2.56	2.54	2.53	2.52	2.51	2.51	2.51	2.50	2.50	2.50
12. Rec., Pers. and Other Services	4.57	2.87	2.90	2.80	2.74	2.69	2.63	2.59	2.56	2.54	2.53	2.52	2.51	2.50	2.50
13. Non-competing Imports	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50

doing more investment and *vice-versa* for sectors with rates of return below the equilibrium rate.

Table 3: Additional Sectoral Details

VARIABLE / SECTOR	Initial Net Investment to Capital Ratio	Initial Rate of Return per cent
1. Agric., Forest., Fishing, Hunting	-0.002	2.60
2. Mining	0.096	8.20
3. Manufacturing	0.036	2.60
4. Electricity, Gas and Water	0.031	3.10
5. Construction	0.033	3.00
6. Wholesale and Retail Trade	0.059	3.70
7. Transport and Storage	0.042	4.20
8. Finance, Prop.and Bus. Services	0.081	8.80
9. Ownership of Dwellings	0.039	3.20
10. Public Admin. and Defence	-0.013	3.40
11. Community Services	0.019	3.40
12. Rec., Pers. and Other Services	0.033	3.00
13. Non-competing Imports	n.a	n.a

3.2 *Results of a Permanent 10 per cent Increase in Real Government Expenditure Anticipated Ten Years in Advance*

Projections of selected macroeconomic variables obtained from the experiment consisting of a 10 per cent increase in real government expenditure which is anticipated 10 years in advance are presented in Table 4. The time paths of the same variables are depicted in Charts 1 and 2. There are two notable features in these results. The first is that even though the shock to government expenditure does not commence until year 10, agents react to it prior to its implementation. The second notable feature is that the economy becomes more capital intensive even though the expansion in government expenditure favours labour intensive sectors.

With aggregate real consumption held constant in each year, forward-looking behaviour in this experiment is confined to investors only via the modelling of capital gains/losses in the equilibrium conditions for sectoral capital demands. To isolate the effects that capital gains/losses have on the results in Table 4, an identical experiment (i.e., same closure and same shocks) to that described above is performed using ORANI-DYN, a modified version of ORANI-INT, in which the equilibrium conditions for sectoral capital demands do not incorporate capital gains/losses. The linearised equilibrium conditions for sectoral capital demands in ORANI-DYN equate the percentage change in the

hence the change in the composition of production tends to place relatively more pressure on labour rather than capital resources.

The backward input-output linkage effect accounts only partly for the pre-shock results of ORANI-INT. In ORANI-INT increases in investment via backward input-output linkages generate capital gains which lead to further increases in the demand for capital and hence investment. ORANI-INT for example, projects that real investment in the first year will increase by about 2.1 per cent whilst ORANI-DYN projected a 0.1 per cent increase only.

A notable feature of the pre-shock results in both models is the fact that the *rate of growth* of aggregate investment peaks two years prior to the implementation of the shock. In both models the rate of growth in aggregate investment is positive and increasing in all years prior to year 9. In the case of ORANI-DYN, the rate of growth in aggregate investment in year 9 is positive but less than that observed in year 8. In ORANI-INT on the other hand, the rate of growth in aggregate investment in year 9 is actually negative.

To explain these results it is convenient to use deviations from base in the rates of growth of the relevant variables rather than percentage deviations from base.

In ORANI-DYN the decline in the real cost of using capital is greatest in year 10. The fact that the rate of growth in aggregate capital stocks peaks in year 9 rather than year 10 (hence the rate of growth in aggregate investment peaking in year 8) indicates the presence of significant compositional effects. In the special case of a single sector neoclassical model in which supplies of all factors of production except capital are fixed, and in which the rate of return on capital is also fixed, the demand for capital is a function of the real cost of using it only. In a multi-sectoral model however, compositional effects of the type discussed in sub-section 3.2.1 also influence the aggregate demand for capital.

In year 10 the growth in domestic absorption is almost entirely due to the growth in government expenditure. Prior to year 10 however, the growth in domestic absorption is attributable entirely to growth in aggregate investment. The growth in domestic absorption in year 10 favours sectors which are far more labour intensive (e.g., *Public Administration and Defence* (10) and *Community Services* (11)) than those favoured by the growth in domestic absorption in year 9 (e.g., *Construction* (5)). The change in the composition of aggregate absorption tends to work against the stimulatory effect of the decline in the real cost of using capital in year 10 and hence dampen the rate of growth in the demand for capital. In year 9 however, this compositional effect tends to reinforce the stimulatory effect of the decline in the real cost of using capital and therefore accelerate the growth in the demand for capital.

$$i_t - k_t = \frac{K_{t+1}}{I_t}\,(k_{t+1} - k_t)\ , \qquad t=0, \ldots, T. \qquad (3.2.4)$$

where lower case representations denote percentage changes in the variables previously defined. Since $\frac{K_{t+1}}{I_t} > 0$, if $k_{t+1} > k_t$ then $i_t > k_t$ and and vice versa. In the long-run (steady state) $i_{ss} = k_{ss}$. Thus if $i_t < k_t$ and $k_t > k_{ss}$ then $i_t < i_{ss}$. With capital stocks falling over the interval between years 10 and 30 the above reasoning explains why investment is below, but asymptoting towards, its long-run value over this interval.

The increase in real investment over this interval however, is quite modest and the increase in real domestic absorption is not sufficient to generate persistent capital gains of the size observed in year 10.

3.2.4 *Pre-shock (anticipation) effects*

The pre-shock results obtained from ORANI-DYN are attributable solely to the assumption of a one period gestation lag in the capital creation process. The increase in capital required in year 10 to accommodate the increase in government expenditure means that an appropriate investment program must be undertaken in the previous year (i.e., year 9). The increase in investment in year 9 also induces an increase in the demand for capital in year 9. In turn, the increase in the demand for capital in year 9 requires an increase in investment in year 8. This backward input-output linkage effect continues (in attenuated form) back to the first year.

Table 5 shows that the main beneficiary of the increase in investment in the pre-shock periods is the *Construction* sector (5) which supplies about 60 per cent of the economy's total requirements of inputs for capital creation.

In the first year of the simulation aggregate employment and sectoral capital stocks are held fixed. With real consumption and government expenditure also held fixed in the first year the increase in investment in year 1 must be accommodated fully by a deterioration in the trade balance. The required deterioration in the trade balance is brought about by an increase in domestic prices which induces an appreciation of the real exchange rate

The contraction of the traded-goods sectors, *Agriculture, Forestry, Fishing and Hunting* (1) and *Manufacturing* (3), allows labour, which is fixed in aggregate but mobile between sectors, to be released to the sectors stimulated by the increase in investment (particularly *Construction* (5)).

Despite the aggregate labour to capital ratio being held constant the results indicate that the price of labour rises relative to the average rental price of capital. This relative factor price movement emanates from the change in the composition of domestic production away from exports towards investment. The capital creation process is more labour intensive than is the production of exports and

Table 4: Projections by ORANI-INT of the Percentage Deviations from Base of Selected Macroeconomic Variables: Anticipated Shock

VARIABLE / YEAR	1	3	6	8	9	10	11	12	14	17	20	23	26	28	30
1. Change in the Trade Balance (a)	-0.63	-0.75	-1.13	-1.69	-1.54	-1.64	-2.05	-2.33	-2.83	-3.46	-3.99	-4.47	-4.94	-5.25	-5.57
2. Export Volumes	-1.76	-2.24	-2.83	-3.67	-4.20	-5.60	-6.41	-7.14	-8.25	-9.33	-9.98	-10.37	-10.61	-10.73	-10.82
3. Import Volumes	1.27	1.20	1.86	2.88	1.75	0.78	1.29	1.37	1.59	1.79	1.91	1.99	2.05	2.08	2.11
4. Real GDP at Market Prices	0.02	0.12	0.35	0.57	0.62	0.62	0.52	0.43	0.28	0.14	0.06	0.01	-0.01	-0.02	-0.03
5. Aggregate Real Investment	2.08	2.73	4.71	7.09	6.90	-1.52	-1.00	-0.84	-0.51	-0.18	0.02	0.16	0.27	0.33	0.41
6. Aggregate Capital Stocks	0.00	0.34	1.10	1.81	2.19	2.74	2.36	2.03	1.53	1.04	0.75	0.59	0.50	0.46	0.45
7. Real Government Expenditure (b)	0.00	0.00	0.00	0.00	0.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00
8. Investment Price Deflator	0.59	0.55	0.66	0.83	0.95	1.21	1.43	1.62	1.90	2.18	2.35	2.45	2.51	2.54	2.56
9. Rental Price of Capital Deflator	0.72	0.57	0.16	-0.12	-0.19	-1.12	-0.65	-0.08	0.74	1.55	2.03	2.31	2.47	2.54	2.59
10. GDP Deflator	0.64	0.68	0.80	1.01	1.15	1.49	1.71	1.96	2.33	2.70	2.91	3.04	3.12	3.16	3.19
11. Factor Cost Deflator	0.76	0.80	0.94	1.19	1.36	1.75	2.01	2.31	2.74	3.16	3.42	3.57	3.66	3.70	3.74
12. Price of labour	0.81	0.94	1.34	1.84	2.12	3.13	3.32	3.51	3.79	4.06	4.23	4.33	4.39	4.43	4.46
13. Real GDP at Factor Cost	0.00	0.10	0.34	0.55	0.67	0.83	0.72	0.62	0.47	0.32	0.23	0.18	0.15	0.14	0.14

NOTES: (a) Trade Balance results are reported as ordinary (rather than percentage) changes and measured in Billions of base period $A.
(b) Real Government Expenditure is exogenous and the values in Table 4 indicate the shocks administered.

Table 5: Projections by ORANI-INT of the Percentage Deviations from Base of Sectoral Activity Levels: Anticipated Shock

SECTOR / YEAR	1	3	6	8	9	10	11	12	14	17	20	23	26	28	30
1. Agric., Forest., Fishing, Hunting	-0.78	-1.19	-1.39	-1.73	-2.14	-2.80	-3.28	-3.77	-4.50	-5.22	-5.65	-5.91	-6.07	-6.14	-6.20
2. Mining	0.02	0.04	0.25	0.31	-0.01	-1.18	-1.27	-1.41	-1.62	-1.82	-1.94	-2.01	-2.05	-2.07	-2.08
3. Manufacturing	-0.14	-0.16	0.05	0.33	-0.23	-2.09	-2.22	-2.48	-2.83	-3.17	-3.38	-3.50	-3.57	-3.60	-3.62
4. Electricity, Gas and Water	-0.03	0.00	0.14	0.29	0.21	1.23	1.16	1.05	0.90	0.76	0.67	0.62	0.59	0.58	0.57
5. Construction	0.50	1.87	3.29	4.45	8.05	0.70	0.17	0.47	0.73	1.01	1.18	1.29	1.38	1.43	1.50
6. Wholesale and Retail Trade	0.23	0.22	0.41	0.68	0.28	-0.50	-0.42	-0.44	-0.46	-0.47	-0.48	-0.48	-0.48	-0.48	-0.47
7. Transport and Storage	0.03	0.08	0.23	0.40	0.28	1.27	1.23	1.18	1.10	1.02	0.98	0.95	0.94	0.93	0.93
8. Finance, Prop. and Bus. Services	0.11	0.29	0.58	0.89	0.96	0.84	0.76	0.73	0.67	0.61	0.58	0.57	0.56	0.56	0.56
9. Ownership of Dwellings	0.00	-0.02	0.27	0.53	0.64	1.29	1.30	1.04	0.72	0.40	0.21	0.10	0.04	0.01	0.00
10. Public Admin. and Defence	0.00	0.01	0.03	0.04	0.05	8.98	8.97	8.97	8.96	8.96	8.95	8.95	8.95	8.95	8.95
11. Community Services	-0.03	-0.04	-0.09	-0.14	-0.16	5.99	5.98	6.00	6.01	6.03	6.04	6.05	6.05	6.05	6.05
12. Rec., Pers. and Other Services	-0.04	-0.03	-0.04	-0.05	-0.11	0.64	0.62	0.62	0.61	0.60	0.59	0.59	0.58	0.58	0.58
13. Non-competing Imports	0.00	0.00	0.00	0.00	0.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00

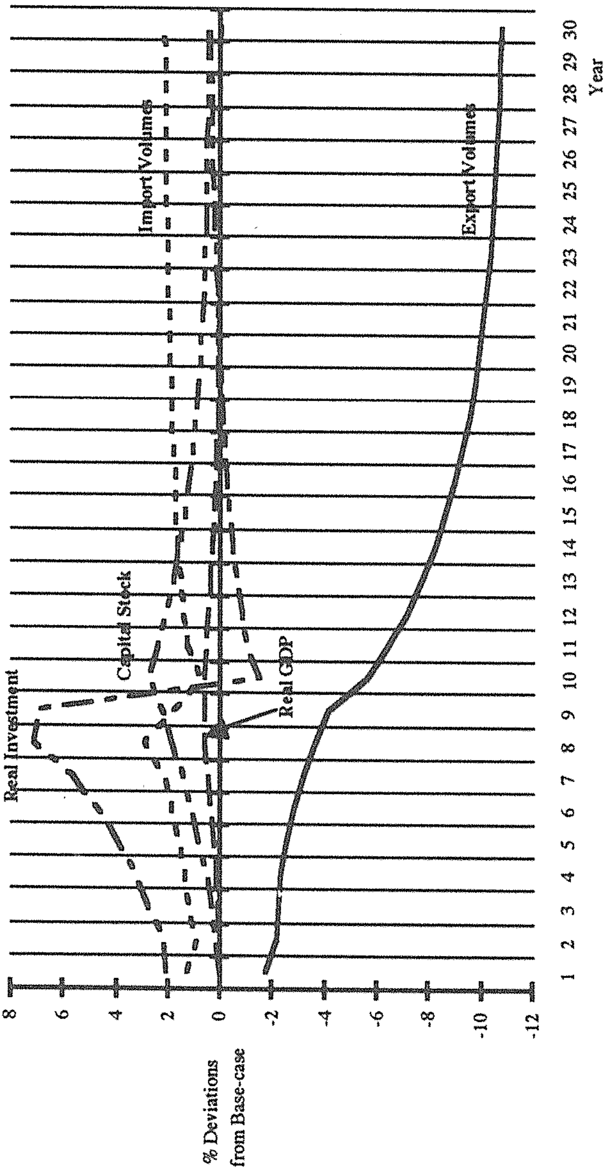


Chart 1: Paths of Selected Macroeconomic Variables Projected by ORANI-INT: Anticipated Shock

3.2.3 *Results over the duration of shock*

ORANI-DYN predicts that the economy will reach its new long-run equilibrium growth path in year 10. The explanation of the long-run results in sub-section 3.2.1 therefore applies to all years in the interval between years 10 and 30. An important feature of the ORANI-DYN results is that the resources attracted into the government sector in year 10 via an appreciation of the real exchange rate can be maintained there permanently without any further exchange rate adjustments. Appreciation of the real exchange rate in year 10 implies that capital gains will occur in that year. However, since investors in ORANI-DYN do not respond to the presence of capital gains there is no mechanism in the model which allows the stock of capital and the rate of investment in year 10 to deviate from their long-run values.

In contrast, Chart 2 shows that in the case of ORANI-INT the real exchange rate continues to appreciate (albeit at an increasingly slower rate) beyond year 10. The reason for this persistent appreciation of the real exchange rate is that despite the absence of any additional shocks to the economy, real domestic absorption rises over the interval between years 10 and 30 because real investment rises over this interval.

In ORANI-INT the persistent appreciation of the real exchange rate generates capital gains over the interval between years 10 and 30. Since investors in ORANI-INT respond to the presence of capital gains the stock of capital and rate of investment over this interval will differ from their long-run values. The magnitude of the capital gains decreases gradually from their highest value in year 10 to negligible values in year 30. Capital gains of the same order of magnitude as those observed in year 10 cannot persist beyond that year because real domestic absorption does not continue to increase at the same rate as that observed in year 10.

With investors trading off capital gains for rentals, the declining value of the capital gains beyond year 10 is mirrored by an off-setting rise in the rental price of capital. Therefore, the path of capital stocks follows very closely the pattern set by the capital gains. Capital stocks overshoot their long-run value by the greatest margin in year 10. Beyond year 10 capital stocks gradually asymptote to their long-run values.

The fact that capital stocks in year 11 fall relative to year 10 implies that investment in period 10 is below its long-run equilibrium value. This result follows from the capital accumulation relationship. Aggregate investment in year t, I_t, is given by

$$I_t = K_{t+1} - K_t(1-\delta) . \qquad t=0, \ldots, T. \qquad (3.2.3)$$

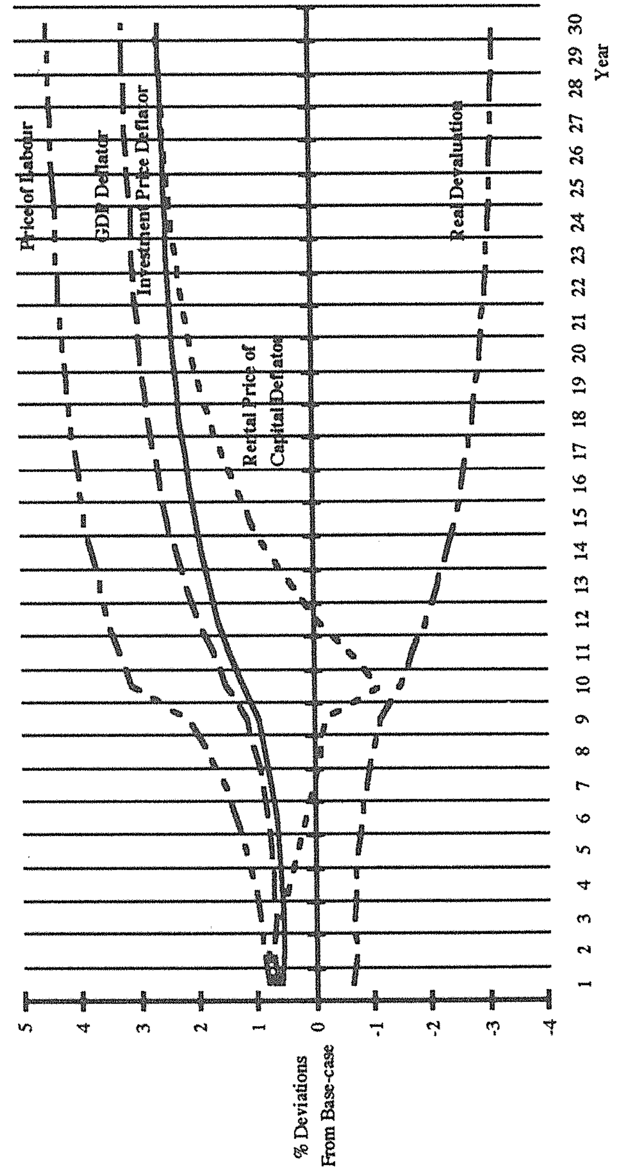
where K is aggregate capital stock and δ is the rate of depreciation. In its linearised form, expression (3.2.3) can be rearranged and written as

The construction cost of capital might be expected to rise by more in year 10 than year 9 (and hence the capital gain) simply because there is no shock in year 9. However, because of the investment technology assumed, this may not be true. It is assumed that there is a one-period gestation lag in the capital creation process so that the increase in demand for capital in year 10 requires an appropriate investment program to be undertaken in the previous period. Similarly, the demand for capital in year 11 determines the rate of investment in year 10.

The impacts on the economy of an increase in aggregate real investment will be qualitatively similar to the impacts of an increase in government expenditure as both have the effect of increasing domestic absorption. The real appreciation of the exchange rate required to accommodate the increase in domestic absorption in year 10 is greater than that required in year 9. The reason for this is two-fold: first, the increase in real domestic absorption is slightly less in year 9 than it is in year 10. In year 10 real consumption is at its base case value, real investment falls by 1.5 per cent and government expenditure is exogenously increased by 10 per cent. The share of investment in domestic absorption is about 22 per cent and the corresponding share of government expenditure is about 20 per cent. Real domestic absorption in year 10 therefore rises by about 1.7 per cent. In year 9, real consumption and government expenditure are held constant whilst real investment rises by about 7 per cent. The shares of investment and government expenditure in domestic absorption in year 9 are about the same as in year 10 hence, real domestic absorption in year 9 rises by about 1.5 per cent.

The second reason for the more rapid appreciation of the real exchange rate in year 10 has to do with the composition of the increase in domestic absorption. The increase in domestic absorption in year 10 is mainly due to an increase in government expenditure whilst the increase in domestic absorption in year 9 is due to an increase in investment. The investment process is more import intensive than is government expenditure. The direct and indirect import requirements resulting from a $1 increase in domestic absorption due to investment is 91 cents whilst the same increase in domestic absorption via government expenditure requires 40 cents worth of imports only. This means that an increase in investment places less pressure on the demand for domestic resources than does an equivalent (in terms of domestic absorption) increase in government expenditure. The required deterioration in the balance of trade can therefore be achieved with less real appreciation in the case of an increase in domestic absorption brought about by an increase in investment.

Chart 2: Paths of Selected Price Deflators Projected by ORANI-INT: Anticipated Shock



rental price of sector-specific capital with the percentage change in the cost of obtaining it. That is,

$$mrpk_{j,t} = \pi_{j,t} \qquad j=1, ..., J \quad t=0, ..., T \qquad (3.2.1)$$

A selection of results from ORANI-DYN[2] are shown in Tables 6 and 7 and illustrated in Charts 3 and 4. Notably, the long-run results (i.e., year 30) obtained from ORANI-DYN and ORANI-INT are very similar. However, unlike ORANI-INT which tends to converge to its new equilibrium growth path in year 30, ORANI-DYN reaches its new long-run equilibrium growth path in year 10, the same year in which the permanent 10 per cent increase in government expenditure is implemented. Another interesting feature of the ORANI-DYN results is their rather subdued nature in the years leading up to the implementation of the shock (i.e., prior to year 10).

To analyse the results obtained from ORANI-INT and ORANI-DYN it is convenient to divide the 30 year time horizon adopted in the experiments into four sub-intervals. For each of the four sub-intervals the results of ORANI-DYN are explained first and then the more complicated ORANI-INT results are tackled.

Since the results of both models are almost identical in the long-run (i.e., year 30) this sub-interval is discussed first. The second sub-interval analysed includes year 10, the year in which the government shock is initially implemented, as well as the years immediately prior and after (i.e., years 9 and 11). Next, the transition from year 10 to the long-run is discussed. Finally, anticipation effects are examined with reference to the results pertaining to the pre-shock years.

3.2.1 *Long-run results*

Differences between the results obtained from ORANI-DYN and ORANI-INT can be attributed solely to the effects of capital gains/losses. In the long-run, capital gains in ORANI-INT are very small since the model is converging to its new long-run equilibrium growth path in which the dynamic variables exhibit stable behaviour – that is, to a state in which all real variables are growing at a common rate and all nominal variables are stationary. It is not surprising therefore that the long-run results of the two models are similar and that the mechanisms which generate the results are identical.

2 In Table 6 the rental price of capital deflator is often rising faster than the investment price deflator. Whilst the rental price and the asset price of capital may move together at the sectoral level, their weights in the respective aggregate deflators differ. Movements in the rental price deflator and the investment price deflator are particularly sensitive to the capital prices in the *Construction* sector (5) which has a weight of about 0.30 in the former deflator but only 0.18 in the latter.

In this experiment the change in the rate of return is exogenously set to zero and the non-negativity constraints on investment are never binding. From equation (2.3.18) in section 2.3 therefore, the linearised equilibrium conditions for sectoral capital demands may be expressed as:

$$mrpk_{j,t+1} = -\frac{\Pi_{j,t}}{MRPK_{j,t+1}}(1 + RR_{j,t})\,[\pi_{j,t+1} - \pi_{j,t}] + \pi_{j,t+1} \qquad t=1, ..., J \quad t=0, ..., T. \qquad (3.2.2)$$

where lower-case representations denote percentage changes in the variables previously defined. Equation (3.2.2) implies that in the absence of capital gains/losses (i.e., where $\pi_{j,t} = \pi_{j,t+1}$) the percentage change in the rental value of a machine in period t+1 will be equal to the percentage change in the cost of constructing that machine. This situation prevails in the long-run when the economy reaches its new steady-state. When $\pi_{j,t} \neq \pi_{j,t+1}$ a capital gain or loss accrues to agents investing in period t. The presence of a capital gain means that investors are willing to accept a lower rental price for their capital and hence demand for capital will tend, *ceterus paribus*, to increase (*vice-versa* in the case of a capital loss).

The year 10 results show that GDP at market prices rose by about 0.6 per cent despite the fact that aggregate investment expenditure and export volumes fell by 1.5 per cent and 5.6 per cent respectively, and import volumes increased by 0.8 per cent. The increase in government expenditure in year 10 therefore, is accommodated partially by crowding-out private investment and the balance of trade and partially by an increase in productive capacity. Aggregate capital stocks increase by 2.7 per cent as the increase in government expenditure induces the economy to become more capital intensive. The mechanism which generates the increase in the capital intensity of the economy is analogous to that given in the explanation of the long-run results in section 3.2.1. The average rental price of capital in year 10 falls by 1.1 per cent whilst the average price of output received by producers, as represented by the factor cost deflator, rises by about 1.75 per cent. This means that the real cost of using capital falls in year 10.

In the explanation of the long-run results the fall in the real cost of using capital was attributed to the relatively high import intensity of the capital creation process. The explanation of the fall in the real cost of using capital in year 10 is not as straight-forward because of the presence of capital gains. The results in Table 4 show that the average rental price of capital decreases by 1.1 per cent in year 10 whilst the average cost of constructing capital (given by the investment price deflator) rises by 0.9 per cent in year 9. From equation (3.2.2) these results imply that investors expect capital gains in year 10. The results in Table 4 confirm this expectation with the investment price deflator in year 9 rising by less than in year 10 (i.e., 0.9 per cent compared with 2 per cent).

The fact that capital stocks and real GDP at factor cost expand suggests that the price effect dominates the compositional effect. That is, the increase in the employment of capital due to the reduction in the real cost of using capital outweighs the reduction in the use of capital due to the bias of the demand shock towards the labour intensive sectors of the economy.

Despite both models projecting an increase in real GDP at factor cost, real GDP at market prices falls by 0.03 per cent in ORANI-INT and by 0.06 per cent in ORANI-DYN. This result can be explained by the decrease in real net indirect taxes. For reasons discussed below, an increase in government expenditure induces an increase in some ad-valorem subsidies. These subsidies put wedges between the market prices and the prices received by producers. The real incomes accruing to producers (measured by real GDP at factor cost) include the contributions of the increase in the subsidy rates. Market prices do not include the subsidies so that the real value of output measured by real GDP at market prices will be less than the real income accruing to producers.

There are two reasons for the decrease in real net indirect taxes: the first relates to the special treatment of the *Mining* sector discussed in section 3.1.1 and the second, also discussed in section 3.1.1, relates to the modelling of export sales by the non-traditional export sectors. With domestic costs rising as a result of the increase in government expenditure, the price of the imported Mining commodity falls relative to the domestically produced commodity. To ensure that the market share of the domestically supplied Mining commodity does not shrink, the domestic Mining commodity must be subsidised. In the case of the non-traditional export sectors it is assumed that the world price and sales of non-traditional exports are fixed. To ensure that the market for non-traditional exports clears, any increase in domestic costs must be offset by an increase in subsidies.

3.2.2 *Results coinciding with the commencement of shock*

The results obtained from ORANI-DYN indicate that the economy reaches its new long-run equilibrium growth path in the same year (i.e., year 10) that the permanent 10 per cent increase in real government expenditure is initiated. All necessary adjustments in the economy are made in the pre-shock years. It follows that the explanation of the year 30 results in sub-section 3.2.1 also applies to the year 10 results produced by ORANI-DYN.

In contrast, the results in Table 4 and Charts 1 and 2 which are produced by ORANI-INT show that the variables diverge from their long-run values by the greatest margin in year 10. In this sub-interval, the modelling of capital gains/losses in the equilibrium conditions for sectoral capital demands makes a big difference to the results produced by the two models.

Table 6: Projections by ORANI-DYN of the Percentage Deviations from Base of Selected Macroeconomic Variables: "Anticipated" Shock

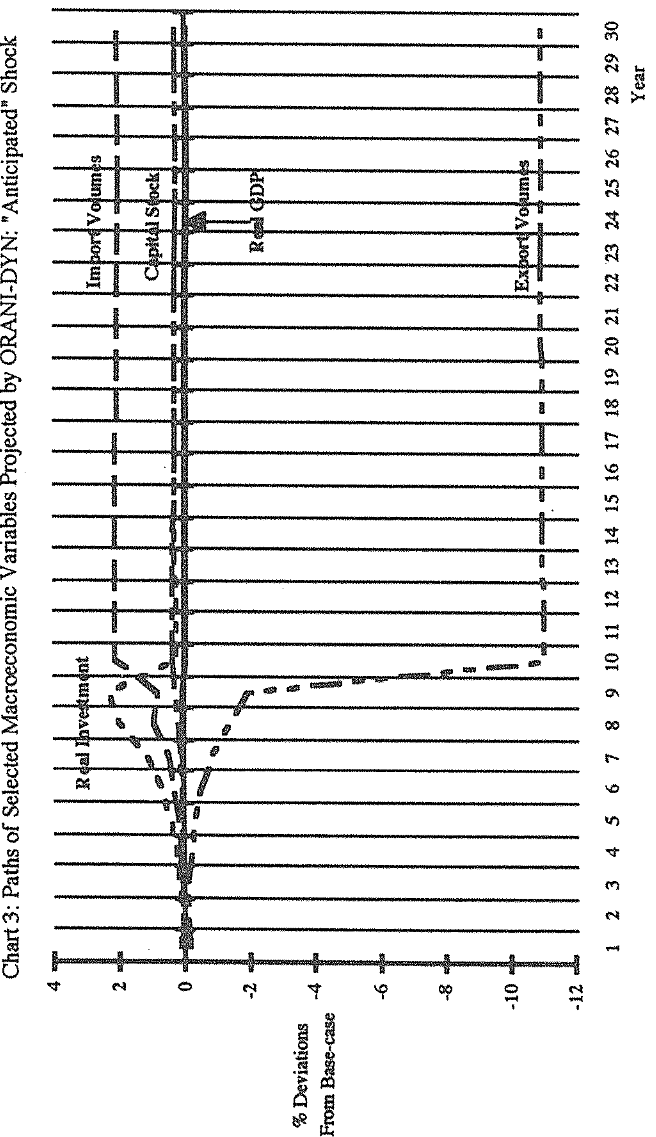
VARIABLE / YEAR	1	3	6	8	9	10	11	12	14	17	20	23	26	28	30
1. Change in the Trade Balance (a)	-0.04	-0.04	-0.20	-0.61	-0.70	-3.41	-3.50	-3.59	-3.77	-4.06	-4.37	-4.70	-5.06	-5.32	-5.59
2. Export Volumes	-0.14	-0.12	-0.52	-1.42	-1.91	-11.03	-11.01	-10.99	-10.96	-10.94	-10.92	-10.91	-10.91	-10.91	-10.91
3. Import Volumes	0.07	0.07	0.31	0.95	0.81	2.14	2.13	2.12	2.11	2.10	2.09	2.08	2.08	2.08	2.08
4. Real GDP at Market Prices	0.00	0.01	0.03	0.08	0.09	-0.05	-0.06	-0.06	-0.06	-0.06	-0.06	-0.06	-0.06	-0.06	-0.06
5. Aggregate Real Investment	0.14	0.16	0.69	1.99	2.31	0.27	0.27	0.27	0.28	0.28	0.28	0.28	0.28	0.28	0.28
6. Aggregate Capital Stocks	0.00	0.02	0.08	0.21	0.31	0.35	0.35	0.34	0.34	0.33	0.33	0.33	0.33	0.32	0.32
7. Real Government Expenditure (b)	0.00	0.00	0.00	0.00	0.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00
8. Investment Price Deflator	0.05	0.03	0.13	0.35	0.49	2.64	2.63	2.62	2.61	2.60	2.59	2.59	2.59	2.59	2.59
9. Rental Price of Capital Deflator	0.06	0.03	0.13	0.35	0.50	2.78	2.77	2.76	2.75	2.74	2.73	2.73	2.73	2.73	2.72
10. GDP Deflator	0.05	0.04	0.16	0.43	0.60	3.29	3.28	3.27	3.25	3.24	3.23	3.23	3.23	3.22	3.22
11. Factor Cost Deflator	0.06	0.04	0.18	0.50	0.71	3.85	3.84	3.83	3.81	3.80	3.79	3.78	3.78	3.78	3.78
12. Price of labour	0.07	0.05	0.22	0.59	0.84	4.54	4.52	4.51	4.49	4.48	4.47	4.46	4.46	4.46	4.46
13. Real GDP at Factor Cost	0.00	0.01	0.02	0.06	0.10	0.11	0.11	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10

NOTES: **(a)** Trade Balance results are reported as ordinary (rather than percentage) changes and measured in Billions of base period $A.
(b) Real Government Expenditure is exogenous and the values in Table 6 indicate the shocks administered.

Table 7: Projections by ORANI-DYN of the Percentage Deviations from Base of Sectoral Activity Levels: "Anticipated" Shock

SECTOR / YEAR	1	3	6	8	9	10	11	12	14	17	20	23	26	28	30
1. Agric., Forest., Fishing, Hunting	-0.06	-0.07	-0.29	-0.80	-1.43	-6.30	-6.30	-6.29	-6.28	-6.28	-6.27	-6.27	-6.27	-6.27	-6.27
2. Mining	0.00	0.01	0.02	-0.06	-0.30	-2.12	-2.12	-2.12	-2.12	-2.12	-2.12	-2.12	-2.12	-2.12	-2.12
3. Manufacturing	-0.02	-0.01	-0.02	-0.02	-0.21	-3.69	-3.69	-3.68	-3.68	-3.68	-3.68	-3.68	-3.68	-3.68	-3.68
4. Electricity, Gas and Water	0.00	0.00	0.00	0.01	-0.03	0.55	0.55	0.55	0.55	0.54	0.54	0.54	0.54	0.54	0.54
5. Construction	0.08	0.09	0.41	1.02	2.64	1.39	1.39	1.39	1.40	1.40	1.40	1.40	1.41	1.41	1.41
6. Wholesale and Retail Trade	0.01	0.01	0.06	0.21	0.14	-0.49	-0.49	-0.49	-0.49	-0.49	-0.49	-0.49	-0.49	-0.49	-0.49
7. Transport and Storage	0.00	0.01	0.02	0.08	0.05	0.91	0.91	0.91	0.91	0.91	0.91	0.91	0.91	0.91	0.91
8. Finance, Prop. and Bus. Services	0.01	0.02	0.07	0.18	0.18	0.53	0.53	0.53	0.53	0.53	0.53	0.53	0.53	0.53	0.53
9. Ownership of Dwellings	0.00	0.00	0.00	-0.01	-0.01	-0.07	-0.07	-0.07	-0.07	-0.07	-0.07	-0.07	-0.07	-0.07	-0.07
10. Public Admin. and Defence	0.00	0.00	0.00	0.01	0.01	8.95	8.95	8.95	8.95	8.95	8.95	8.94	8.94	8.94	8.94
11. Community Services	0.00	0.00	-0.01	-0.03	-0.04	6.06	6.06	6.06	6.06	6.06	6.06	6.06	6.06	6.06	6.06
12. Rec., Pers. and Other Services	0.00	0.00	-0.01	-0.01	-0.04	0.58	0.58	0.58	0.58	0.58	0.58	0.58	0.58	0.58	0.58
13. Non-competing Imports	0.00	0.00	0.00	0.00	0.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00

Chart 3: Paths of Selected Macroeconomic Variables Projected by ORANI-DYN: "Anticipated" Shock



using capital implies that p0 = pk and therefore, that p0 $(1 - S_k) = S_l w$. Since $(1 - S_k) = S_l$, p0 = w. With the real cost of using both factors fixed, producers have no incentive to alter their labour-capital ratios.

Under these conditions if the increase in demand favours a particular sector of the economy, say the non-traded sector, then in the absence of any relative factor price movements this sector will wish to increase its use of both labour and capital by the same proportion as the increase in demand for its output. A real appreciation of the exchange rate will signal the traded goods sector to release resources (specifically labour) to the non-traded goods sector. In this example the real appreciation is not allowed to affect relative factor prices but it does imply an increase in the domestic price level. The rise in domestic prices results in a contraction in the traded goods sector as export sales are lost and imports replace domestic outputs. Again, since relative factor prices have not changed the traded goods sector will wish to decrease its holding of both labour and capital by the same proportion as the decrease in the demand for their outputs.

With aggregate labour held fixed, the increased usage of labour by the non-traded sector must be matched by an equal decrease in the usage of labour by the traded sector. With both sectors wishing to maintain their labour-capital ratios constant this implies that the non-traded sector increases its use of capital whilst the traded goods sector decreases its use of capital. Whether the aggregate level of capital stock changes depends on the relative factor intensities of the two sectors. If both sectors have identical labour-capital ratios then an increase in demand under these conditions will have no net effect on output – the expansion in the non-traded sector will be exactly offset by the contraction in the traded goods sector (i.e., complete crowding-out). If the non-traded sector is relatively capital intensive however, the increase in demand will result in an increase in aggregate output. The opposite will be true if the non-traded sector is relatively labour intensive.

In ORANI-INT (and ORANI-DYN) an increase in government expenditure favours the non-traded sectors of the economy which are very labour intensive. A $1 increase in government expenditure requires, directly and indirectly, about 71¢ worth of labour. The government purchases about 28 per cent of its total requirements from the *Public Administration and Defence* sector (10) and about 43 per cent from the *Community Services sector* (11). These two sectors, which Tables 5 and 7 show benefit most from the expansion in government expenditure, are the most labour intensive sectors in the economy with labour costs accounting for about 99 per cent of total factor costs in the *Public Administration and Defence* sector (10) and about 97 per cent in the *Community Services* sector (11).

import requirements resulting from a $1 increase in investment expenditure however, is about 20 cents. Since import prices are assumed to be independent of domestic conditions an increase in domestic demand which increases domestic costs allows the real cost of using capital to fall.

The increase in real government expenditure requires resources to be drawn away from the rest of the economy and re-directed towards the government sector. The mechanism which signals the rest of the economy to release resources is the real exchange rate. An appreciation of the real exchange rate induces a contraction in the traded goods sectors of the economy as export sales are lost and imports are substituted for the relatively more expensive domestic commodities.

The nominal exchange rate is held constant as are foreign prices so that a real appreciation of the exchange rate is brought about by an increase in the domestic price level. The assumption of zero pure profits in all activities implies that the average price received by producers for their output is reflected by the factor cost deflator. In the case of ORANI-INT, Table 4 shows that the average rental price of capital rose by about 2.59 per cent whilst the average output price received by the typical producer rose by 3.74 per cent. Table 6 shows that the real cost of using capital is projected to fall by slightly less in ORANI-DYN. The factor cost deflator rises by 3.78 per cent whilst the rental price of capital rises by 2.72 per cent.

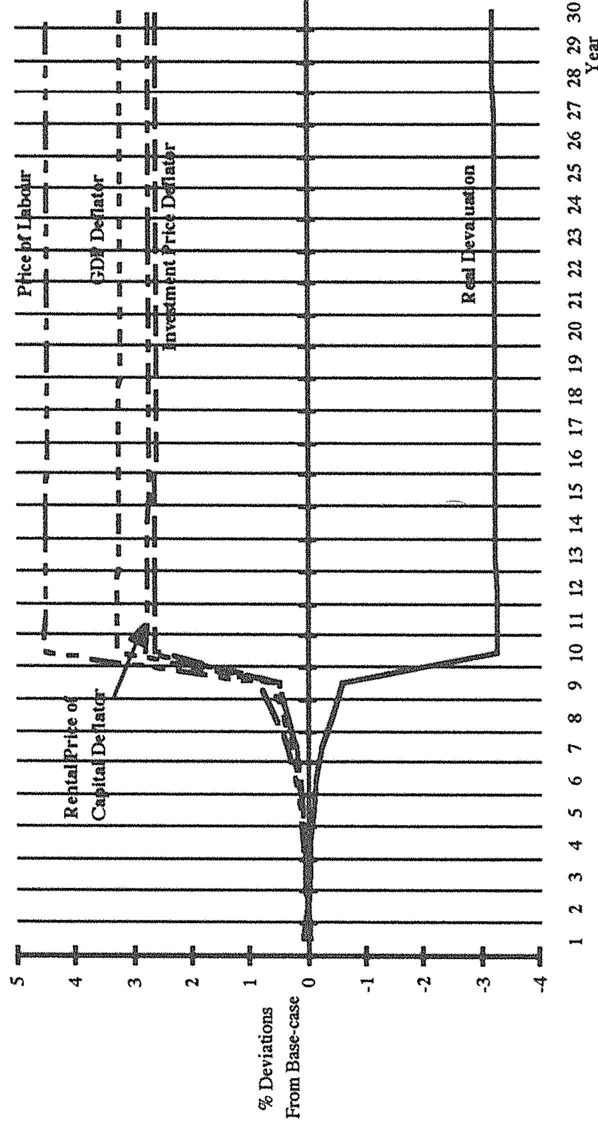
The results of both models imply that in aggregate, the real cost of using capital is falling so that the typical producer will want to become more capital intensive. Note that the decrease in the real cost of using capital allows the real cost of employing labour to rise despite the fact that aggregate employment is held constant.

Even if the real cost of *using* capital was fixed however, (i.e., the rental price of capital and the output price moved together) there would still be scope for the equilibrium level of capital stock to change in response to a demand shock. To simplify the exposition, consider an economy consisting of two productive sectors: one sector produces a traded good whilst the other produces a non-traded good. Assume that labour and capital are the only inputs to the production process. Capital is sector specific whilst labour is homogeneous and fixed in aggregate. With constant returns to scale production technology and zero pure profits assumed, holding the cost of using capital constant implies that the cost of employing labour will also be constant. That is, for each sector

$$p0 = S_l w + S_k pk$$

where p0 is the percentage change in the price of output, w and pk are the percentage changes in the price of labour and capital respectively and S_l and S_k are the shares of labour and capital in total factor costs. Fixing the cost of

Chart 4: Paths of Selected Price Deflators Projected by ORANI-DYN: "Anticipated" Shock



In both models, aggregate output is a function of the endowments of the primary factors land, labour and capital. With aggregate labour and land endowments held constant, aggregate output depends on the capital stock only. The increase in government expenditure may be accommodated by crowding-out some other component of aggregate demand and/or by increasing the economy's productive capacity via an increase in the stock of capital. Since the rate of return on capital is held constant, we might expect that the demand for capital, and hence investment, will be constant also. If this was the case, any expansion in government expenditure would, given that real consumption expenditure is fixed, be fully absorbed by a deterioration in the balance of trade.

The results in Tables 4 and 6 show that the increase in government expenditure is accommodated largely by a deterioration in the balance of trade and partly by an increase in the economy's productive capacity. ORANI-INT projects that the trade balance will deteriorate by A$5.57 billion – which is equivalent to about 1.8 per cent of base level GDP in the terminal year. Export volumes are projected to contract by 10.82 per cent whilst import volumes increase by 2.11 per cent. The deterioration in the trade balance is accompanied by a small expansion in the economy's productive capacity. Aggregate capital stocks increase by 0.45 per cent and with aggregate employment and agricultural land held fixed, this translates into a 0.14 per cent increase in productive capacity (here measured by real GDP at factor cost).

ORANI-DYN on the other hand projects that the increase in government expenditure will be accommodated by a slightly smaller increase in the economy's productive capacity and a slightly bigger deterioration in the trade balance. The trade balance deteriorates by A$5.59 billion whilst aggregate capital stocks increase by 0.32 per cent and real GDP at factor cost rises by 0.1 per cent.

The differences in the long-run results projected by the two models are accounted for by the small capital gains which persist in ORANI-INT. As is explained in more detail in section 3.2.2, the rental price of capital is inversely related to capital gains. ORANI-DYN projects that the average rental price of capital, as measured by the rental price of capital deflator, in year 30 will rise by 2.72 per cent (see Table 6). Because of the small capital gains, ORANI-INT projects a slightly lower increase in the average rental price of capital (i.e., 2.59 per cent). The smaller increase in the average rental price of capital in ORANI-INT explains the slightly higher increase in aggregate capital stocks and consequently, the smaller deterioration in the trade balance in this model.

Tables 5 and 7 show that the three traded-goods sectors (i.e., *Agriculture, Forestry, Fishing and Hunting* (1), *Mining* (2) and *Manufacturing* (3)) bear the brunt of the deterioration in the trade balance. The decline in the activity levels of the *Agriculture, Forestry, Fishing and Hunting* (1) and *Manufacturing* (3) sectors is due largely to their exposure to foreign demand conditions. Whilst the loss of export sales is the main reason for the contraction in these two sectors, it is not the sole reason. Both sectors lose domestic sales (particularly sales of intermediate inputs) because they face strong competition from foreign substitutes. Domestic users tend to substitute the imported commodities for the relatively more expensive domestic ones.

Despite the fact that the mining commodity is highly tradeable, tying the growth of domestic output of the Mining commodity to the growth of imports (see section 3.1.1) of this commodity means that there will be little scope for relative price effects. The decrease in the activity level of the Mining sector is due largely to the decrease in the activity levels of sectors, most significantly *Manufacturing*, which use the Mining commodity as an intermediate input.

Two questions emerge from the macro results presented above. First, given that the rate of return on capital is held constant, why does the aggregate capital stock expand? Second, why does real GDP (at market prices) fall despite the increase in the capital stock?

Producers will alter their factor input ratios only if the real cost of employing a particular factor changes. With aggregate labour stocks and agricultural land held constant, aggregate capital stocks will vary if the real cost of capital changes. Despite the fact that the rate of return on capital is fixed the real cost of *using* capital is able to vary. *Suppliers* and *users* of capital do not respond to the same real cost of capital. In the absence of any capital gains (as is the case in the long run when the economy is converging to a new intertemporal equilibrium growth path) suppliers of capital are concerned with movements in the rental price of capital relative to movements in the cost of constructing capital (asset price of capital). In this case holding the rate of return on capital constant means that the rental price of capital will move in line with the cost of constructing capital. An implication of this assumption is that capital is abundantly available at the given rate of return and that the equilibrium level of capital stock will be demand determined.

An increase in the employment of capital is possible if the real cost of *using* capital falls. Users of capital are concerned with movements in the rental price of capital relative to movements in the price of their output. The assumption of zero pure profits in all activities means that output prices will move with production costs. Similarly, movements in the asset price of capital reflect movements in the cost of constructing that capital. For a particular sector therefore, it is likely that movements in the cost of producing a unit of output will differ from movements in the cost of producing a unit of capital.

One key reason for the difference in the cost structures of current and capital outputs is that the latter process is typically more import intensive. In the absence of relative price movements, a $1 increase in final demand requires, directly and indirectly, about 16 cents worth of imports. The direct and indirect