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# USING THE MURPHY MODEL TO PROVIDE SHORT-RUN MACROECONOMIC CLOSURE FOR ORANI

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## *ABSTRACT*

A macro model incorporating rational expectations in financial markets (the Murphy Model — MM) is used to endogenize the macroeconomic environment for a comprehensive general equilibrium model (ORANI). The interface exploits the existence of variables which are endogenous to both models, calibrating on a shock to government spending, which is the principal common exogeneity. The responses of the half-dozen doubly endogenous variables feature prominently in the calibration procedure, which minimizes any conflict between the stories told about these variables by the two models. Prospective benefits include: (1) to the numerous policy-oriented users of ORANI, a facility allowing the macroeconomic environment to be determined by a macrodynamic model such as MM; (2) to these users, reassurance that ORANI's short-run translates in calendar time to about two years; (3) to the clientele of a macro model, the possibility of much more detailed projections.

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# *Using the Murphy Model to Provide Short-run Macroeconomic Closure for ORANI*

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## *1. INTRODUCTION*

The core version of the ORANI model (Dixon, Parmenter, Sutton and Vincent, 1982) was built with a strong focus on the microeconomy. Users of ORANI in its standard short-run closure were required to provide their own scenario to describe the macroeconomic environment in which microeconomic events (such as a change in a tariff) were simulated. In particular, ORANI itself offered no guidance on the following:

(a) how much of any projected change in the real exchange rate would manifest itself as a changed price level, on the one hand, or as a change in the nominal exchange rate, on the other;

(b) how much of any change in the buoyancy of the labour market would show up in changed real wages and how much in changed employment;

(c) how much of any change in GDP would be realized as a change in expenditure, and how much as a change in the trade balance.

As noted by Cooper, McLaren and Powell (1985), there are at least two approaches available for providing ORANI with a macroeconomic closure. In the *extended Walrasian paradigm*, the general equilibrium model is formulated as an

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intertemporal problem which endogenizes asset prices and some other variables of macroeconomic interest. The *Impact paradigm*, on the other hand, uses a macro model to endogenize the macroeconomic environment for the general equilibrium model. It involves

> 'the following, strong, maintained hypothesis: financial and money markets, as well as fiscal actions, are only important for individual industries and occupations insofar as they exert a real effect upon the big components of national income; namely, private consumption, private capital formation, and government spending' [McAleer, Powell, Dixon and Lawson (1981, p. 170)].

It is clear that

> 'such a high degree of neutrality (with respect to their incidence across industries) of monetary and financial variables [can] only hold as a first approximation. Particular exceptions [spring] immediately to mind (for example, the specific incidence of money market conditions on housing starts)' [Powell (1981)].

The Impact paradigm was developed by Cooper and McLaren (1980, 1982, 1983; see also Cooper, McLaren and Powell, 1985) and used to interface the RBII macro model[1] (see Jonson, McKibbin and Trevor,1980) with ORANI; an important practical spin-off was that this work gave, for the first time, empirically based estimates of the ORANI short run (t*).

In view of the fact that RBII is no longer being maintained, the recent development of the Murphy Model (Murphy 1988a, 1988b, 1990) is fortunate. It presents an opportunity to interface ORANI for the first time with a macro model which implements rational expectations in financial markets and which has a long-run that is neoclassically interpretable.[2] Our aim in this paper is to use the Impact paradigm as developed by Cooper and McLaren to interface ORANI with the Murphy Model (MM). Because the Murphy model deals explicitly with investment in residential buildings, however, we are able to soften the strong separability between the macro- and the microeconomies as originally formulated in the Impact paradigm. We do this by allowing MM to determine housing investment in the interfaced model.

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1 Also known as RBA79.

2 Parsell, Powell and Wilcoxen (1989) have pointed out that the Murphy Model's long-run properties are similar to those of many of the open-economy theoretical macro models developed during the 1980s; and that this feature enhances prospects for integrating applied macro and applied GE models.

Although the approach taken here follows the Cooper and McLaren methodology, the details of the implementation differ. Firstly, the original interface was developed on the assumption that the macro model (like RBII) would be formulated in continuous-time; MM, on the other hand, is a discrete-time (quarterly) model. Moreover, while the Cooper-McLaren methodology allows for two-way flows of information between the macro model and ORANI, in this paper we implement a top-downs approach in which macro variables endogenized in MM drive ORANI without any feedbacks to MM. This is not an overly restrictive simplification, since currently there are no exogenous variables in MM which are obvious candidates for endogenization by ORANI.[3]

It may be better to identify, from the start, some problems which we do not claim to solve in this paper. In the context of earlier work, Cooper, McLaren and Powell (1985) pointed out that at least two areas of tension between a macro and an applied GE model are left unresolved by the construction of an interface between them; namely, the presence of macrorelations in the macro model that cannot be derived as explicit aggregations of microrelations in the GE model; and the failure of the macro model to pass homogeneity tests. The latter has become less of a problem with the new breed of macro model typified by MM because such models converge to long-run configurations which do pass these tests.

How serious, and how avoidable, are the aggregation problems? The production structures of ORANI and MM differ not only in numbers of commodities, industries, and agents, but also in qualitative respects. For example, the only kind of material input recognized in MM is aggregate imports; besides disaggregating imports into about 100 commodities, ORANI also recognizes a like number of domestically made material inputs. In the version of MM used here the elasticity of substitution between aggregate imports and aggregate primary factors as a whole is 0.77; in the version of ORANI we have used, the corresponding *micro* parameters are all zero. In spite of this rather major difference, it does not necessarily follow that aggregate imports in the two models behave very differently — in fact, in the interfacing experiments below it proves relatively easy to eliminate discrepancies in this variable. Again, the elasticity $\sigma_{KL}$ of substitution between capital and labour in all industries in the version of ORANI used here is

3 If two-way feedbacks were allowed, MM would become a portion of a new, very large, integrated simultaneous system. Consequently the information set utilized in formulating the rational expectations variables contained in MM in principle would become dependent on all the relevant information contained in the newly created integrated system. Although it is technically feasible to construct such a system, it is beyond the scope of this paper.

0.5; the corresponding macro parameter in MM is 0.77. Nevertheless, aggregate results for employment in the two models seem to be easily reconciled in the interfacing experiments below.

Although the above examples indicate that aggregation difficulties may not be a serious problem in the current context, they cannot, in principle, be avoided by methods other than building a disaggregated macro model (if that is not a contradiction in terms) from the bottom up. If (as in this paper) the independently built macro and the GE model are taken as given, then the optimal choice of macro parameters depends on the shocks being studied. Thus, for example, in an application of ORANI involving $\sigma_{KL} = 0.5$ in *all* industries, the appropriate value for the corresponding macro parameter in an aggregative miniature model used to explain the results was 0.28 (Dixon, Parmenter and Powell, 1984).

The layout of the remainder of this paper is as follows. In Section 2 we present a brief overview of the general methodology and construct a tops-down interface between MM and ORANI. In Section 3 we implement the interface and calibrate the ORANI-MM system for a "neutral" shock in government expenditures. Section 4 utilizes these results to compute 'as-if' shocks for endogenizing ORANI's macro environment. We offer concluding remarks in Section 5.

## *2. METHODOLOGY* [4]

The ambitious objective of the methodology developed by Cooper and McLaren is to interface a *dynamic* macroeconometric model with a *static* CGE model. The procedure begins by placing both models on a common platform with respect to the treatment of time. This involves endowing the static model with a dynamic structure which is assumed to characterize the CGE model's responses within its own *short run* (but not necessarily elsewhere). This is a necessary step since the static model cannot handle the time-varying impulse responses which are typically output by a dynamic model. More concretely, ORANI expects to receive shocks having the form of a step function (with just one step). A typical example of such a shock would be a sustained increase in government spending at ten per cent above its control trajectory.

The ORANI model after augmentation by a dynamic specification is known as ORANI$^+$. The dynamic parameters of ORANI$^+$ are not known at this stage. The name *ORANI+MM* is used to describe the system obtained by interfacing ORANI$^+$ with MM; it is the model in which ORANI variables have a within-short-run dynamics that is driven by variables which are endogenous to MM, but exogenous

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4 This section draws freely on the presentation by Cooper, McLaren and Powell (1985).

to ORANI. Thus in principle we distinguish *four* models: ORANI, MM, $ORANI^+$, and *ORANI+MM*.

The parent models, ORANI and MM, contain a number of macro variables (such as real GDP, price-level indexes, employment, and variables associated with the trade account) which are endogenous to both of them. These potentially embarrassing double endogeneities are the key to the interfacing method. The aim is to choose the dynamic parameters of $ORANI^+$ in a way which minimizes the potential discrepancy between the story told by MM about the doubly endogenous variables in stand-alone mode, and the story told by $ORANI^+$ within *ORANI+MM*.

Let t* be the (as yet undetermined) length of the short run in ORANI. If after the endogenization of its macroeconomic environment by MM, $ORANI^+$ is tracking the macroeconomy within *ORANI+MM* consistently with MM, then t* periods after a shock, the $ORANI^+$ solutions for the doubly endogenous variables in *ORANI+MM* should have values which are close (ideally, equal) to the values projected by MM alone at this lag.[5] The interfacing method consists of choosing t* and the dynamic parameters of $ORANI^+$ to minimize the discrepancies between the double endogeneities at t* as projected by $ORANI^+$ within*ORANI+MM* and by MM in stand-alone mode[6].

## *2.1 ORANI*

ORANI is a CGE model of the Australian economy. For an appropriate short-run closure of the model (i.e., declaration of endogenous/exogenous variables), the model provides the following contemporaneous differential comparative static (cdcs) solution:

$$y_o = C_o z_o \quad . \qquad (2.1.1)$$

where $y_o$ is a vector of proportional deviations from control in the endogenous variables, $z_o$ is a vector of indefinitely sustained proportional deviations from control in the exogenous variables, and $C_o$ is the elasticities matrix (treated as a constant in the 1-step Johansen procedure commonly used to solve ORANI), while the subscript o refers to ORANI.

In comparative static models statements about timing are usually vague. Notionally, however, a sustained shock is injected at a given instant (the end of period 0, say); after a lag which is compatible with the length of run implicitly

5 Keep in mind that t* is a parameter of $ORANI^+$.

6 Note that since there are no feedbacks from $ORANI^+$ into MM, the MM values of the double endogeneities within *ORANI+MM* coincide with stand-alone MM values.

defined by the closure of the model, a new equilibrium is attained. The deviations $y_o$ represent the proportional differences between two equilibria; namely, what the values of the endogenous variables would have been at this length of run with and without the shock. We make this explicit in the case of the standard short-run closure of ORANI by rewriting (2.1.1) as:

$$y_o(t^*) = C_o z_o \quad . \tag{2.1.2}$$

Thus if upper-case letters are used to represent the logarithms of variables in the levels, $y_o(t^*)$ is the vector of deviations of $Y_o$ from control at time t*. This interpretation of (2.1.2) is of course dependent on the maintenance of an exogenously specified macroeconomic environment. Specifically, some of the elements in the vector $z_o$ are assumed to be zero, when in fact it may be more plausible to allow them to vary.[7] Our aim is to use MM to supply this plausible variation.

### *2.2 The Murphy Model*

The Murphy Model of the Australian economy is a discrete-time model in which dynamic adjustment processes are modelled by first and higher order difference equations. MM contains rational expectations which are of vital concern during the estimation and solution of the model. However, in our tops-down approach this treatment of expectations plays no immediate role in the interfacing process, except that we need to make explicit assumptions concerning the information sets of agents when applying shocks to MM.

Following some shock introduced at t = 0, let $y_m(t)$ (t = 0, 1, ..., ) be the deviations from control in the variables endogenized by MM. Those elements of $y_m(t)$ which are supposed to determine particular elements of $z_o$ evolve in MM as a quarterly series of impulses, which cannot be processed by ORANI; ORANI$^+$, however, will be able to accept shocks in the form of time-varying impulses.

### *2.3 ORANI$^+$*

ORANI$^+$ is assumed to have the following reduced form[8]:

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7 To make matters concrete, think of a change in the tariff on automobiles; in the standard short-run closure of ORANI (Dixon *et al.*, 1982, p. 143), the maintained macroeconomic environment involves zero change in real aggregate spending. Some commentators believe that the government would be unable or unwilling to sterilize the effects on aggregate spending of such a shock.

8 Notice that (2.3.1) could be written as the following adjustment equation

$$\delta Y_o(t) \equiv Y_o(t) - Y_o(t\text{-}1) = A_o^* Y_o(t\text{-}1) + B_o Z_o(t) , \qquad \text{where } A_o^* = -(I - A_o).$$

$$Y_o(t) = A_o\, Y_o(t-1) + B_o\, Z_o(t)\ , \qquad (2.3.1)$$

where $Y_o(t)$ and $Z_o(t)$ respectively are the logarithms of the endogenous and exogenous variables in quarter t; thus the final form of ORANI+ is

$$Y_o(t) \;=\; \sum_{j=0}^{t} A_o^{t-j}\, B_o\, Z(j) + A_o^{t+1}\, Y(-1)\ . \qquad (2.3.2)$$

For later use we note that in terms of deviations from control, this may be written:

$$y_o(t) \;=\; \sum_{j=0}^{t} A_o^{t-j}\, B_o\, z(j)\ . \qquad (2.3.2')$$

Consider now a sustained shock z so that the sequence Z(0), Z(1), ... Z(t) is replaced by Z(0) + z, Z(1) + z, ... Z(t) + z. Then the deviations from control in the endogenous variables at t may be written:

$$y_o(t) \;=\; \Big(\sum_{j=0}^{t} A_o^{t-j}\, B_o\Big)\, z. \qquad (2.3.3)$$

Evaluated at t*, (2.3.3) is

$$y_o(t^*) \;=\; C_o^{*}\, z \qquad (2.3.4)$$

where

$$C_o^{*} = \Big(\sum_{j=0}^{t^*} A_o^{t^*-j}\Big)\, B_o\ , \qquad (2.3.5)$$

$$= [I - A_o]^{-1}[I - A_o^{t^*+1}]\, B_o\ . \qquad (2.3.6)$$

However, at t* the response of ORANI and ORANI+ to the sustained shock z are (by construction) identical. Thus $C_o^{*}$ in (2.3.5) and $C_o$ in (2.1.2) are the same matrix; from now on we will write the coefficient of z in (2.3.4) as $C_o$ .

So far we have established that the standard ORANI coefficients matrix $C_o$ via (2.3.6) has implications for the dynamic coefficients $A_o$ and $B_o$ of ORANI+. In particular, for given $A_o$, and $C_o$ , $B_o$ must satisfy:

$$B_o \;=\; [I - A_o^{t^*+1}]^{-1}\, [I - A_o]\; C_o\ . \qquad (2.3.7)$$

In order to interpret the role of $A_o$, first note that the accumulated response after an elapsed time of t periods to a time varying shock, (2.3.2'), can be written as

$$y_o(t) = \sum_{j=0}^{t} A_o^{t-j} B_o z(0) + \sum_{j=1}^{t} A_o^{t-j} B_o [z(1) - z(0)]$$

$$+ \sum_{j=2}^{t} A_o^{t-j} B_o [z(2) - z(1)] + \ldots + \sum_{j=t-1}^{t} A_o^{t-j} B_o [z(t-1) - z(t-2)] + B_o [z(t) - z(t-1)] \; ,$$

i.e., the time varying shock z(0), z(1), ..., z(t*) can be interpreted as a sustained shock of z(0) from 0 to t*, followed by sustained shocks of z(1) – z(0) from period 1 to t*, z(2) – z(1) from period 2 to t*, etc. The latter may be termed *incremental sustained components* of the time varying shock: z(2) – z(1), for example, is the incremental sustained component commencing in period 2.

To simplify the interpretation, consider the case of a scalar $A_o = a$. In this case, the accumulated response after t periods to a sustained shock in z at time 0 can be written as

$$y_o(t) = \sum_{j=0}^{t} a^{t-j} \frac{1-a}{1\text{-}a^{t^*+1}} C_o z$$

which can be interpreted as the proportion of $y_o(t^*) = C_o z$ accumulated after t periods. For a =1 this accumulated response is linear in t; as a decreases below unity the response is more concentrated in earlier periods, while as a increases above unity the response is concentrated in later periods. In the limiting case, as $a \to \infty$ all of the response is delayed until period t*. For a sustained shock occurring at period 0, the full effect (equal to $C_o z$) is always registered by t*, but for the incremental sustained components of a time varying shock, a value of a below unity means that the majority of their total impact is registered early, whereas a value of a above unity means that a (perhaps substantial) part of their impact is delayed until the $(t^*)^{th}$ period after the period in which the incremental sustained components start to act. In the latter case only a small proportion of the total response may have been registered even as late as (t* – 1) periods after the time of the initial shock.

The responses of an $ORANI^+$ endogenous variable within the ORANI short run are shown in Figure 1 for a variety of values of the parameter a. When below we choose $A_o$ to be a diagonal matrix, the adjustment paths of

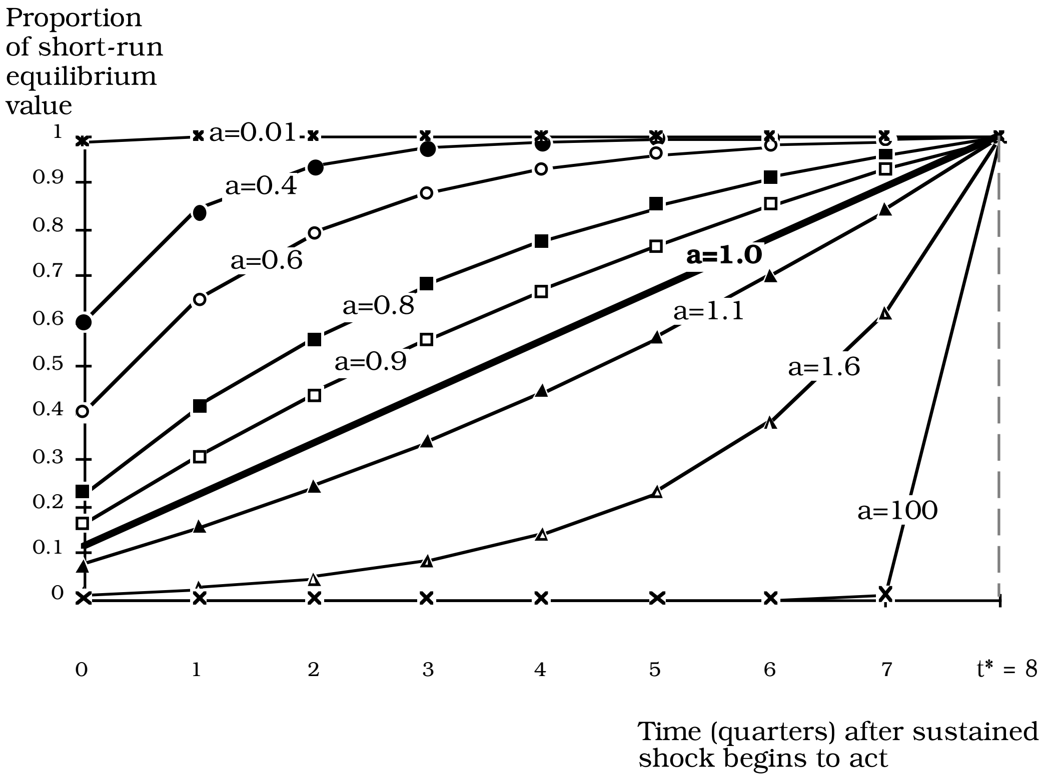


*Figure 1 Possible adjustment paths within the ORANI short run when t* = 8*

individual endogenous variables remain essentially independent, and hence Figure 1 remains a valid qualitative depiction of $ORANI^+$ responses.[9]

## *2.4 The Role of the Standard Shock*

To determine the unknowns t* and $A_0$ we first must decide on a standard shock. In this paper we take an unanticipated, sustained, credible increase in government spending[10] (of which details will be found below). In the spirit of rendering unto Walras the things that are Walras', and unto Keynes the things that are Keynes', a demand-side shock is chosen; such are the kinds of shocks whose consequences macroeconometric models are designed to track.[11]

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9 Some numerical examples may aid the interpretation of Figure 1. With t* = 8 and a $\geq 10^4$, the proportion of the total impact of a sustained shock registered at t = 7 does not exceed $10^{-4}$. With the same t* and a = 0.1, 90 per cent of the impact of the shock is felt immediately (i.e., with t = 0), while 99 per cent has been registered at t = 1. With t* = 7, 90 per cent of the total response would have occurred by the middle of the adjustment period (i.e., at t = 4) if the value of a were equal to 0.67255.

10 The assumption that the shock is both unanticipated and credible has a bearing on the results because of the rational expectations in financial markets in MM.

11 As noted previously, MM extends the traditional Keynesian paradigm by implementing rational expectations in financial markets and a long run which is neoclassically interpretable. The latter feature indicates that it is designed for

We inject this shock into MM using Murphy's (1990) standard software package. The time projections of two sets of variables are of immediate interest to the interfacing experiment: (i) the variables (such as the nominal exchange and real wage rates) which are endogenous to MM but exogenous to ORANI; and (ii) the variables which are endogenous to both models. In terms of deviations from control, let the time sequences of these MM projections be $z^{\Diamond}(1)$, $z^{\Diamond}(2)$, ..., $z^{\Diamond}(20)$; and $y^{\Diamond}(1)$, $y^{\Diamond}(2)$, ..., $y^{\Diamond}(20)$ respectively.[12] Our approach uses the $z^{\Diamond}$s as the z(j)s in (2.3.2'). Some further preliminaries are necessary, however.

## *2.5 Parsimony of Dynamic Parameters*

The unknown matrix $A_o$ has $n^2$ parameters, where n is the number of double endogeneities (seven, in the present case). Calibration of 49 dynamic parameters scarcely seems feasible. We have therefore restricted our attention to candidate $A_o$ matrices which are diagonal. The unknown dynamic parameters then are t* and $a_1, a_2, \ldots, a_7$.

Our calibration experiments can now be described precisely. First we choose a $\tau$ ($\tau = 1, 2, \ldots, 20$) which is a candidate value for t*. Enforcing (2.3.7) and using the $z^{\Diamond}$s from MM we compute $y_o(\tau)$ using (2.3.2') from an arbitrary value of $\boldsymbol{a} \equiv a_1, a_2, \ldots, a_7$. The value so obtained for $y_o(\tau)$ contains the ORANI$^+$ endogenization of the double endogeneities at $\tau$ within *ORANI+MM*. Still keeping $\tau$ at the same value, we then search over $\boldsymbol{a}$ for a conditional minimum of the criterion function,

$$\Phi(\tau) = \sum_{j=1}^{7} \left( y_j^{\Diamond}(\tau) - y_{oj}^{+}(\tau) \right)^2, \qquad (2.5.1)$$

where $y_j^{\Diamond}(\tau)$ is the value of the $j^{th}$ double endogeneity at $\tau$ as endogenized by MM in stand-alone mode, and $y_{oj}^{+}(\tau)$ is the corresponding value as endogenized by ORANI$^+$ in *ORANI+MM*. Let the optimized value of criterion function (2.5.1) be $\hat{\Phi}(\tau)$, and the optimizing $\boldsymbol{a}$ be $\hat{\boldsymbol{a}}(\tau)$. We then select the next candidate value for t*, and repeat the optimization over $\boldsymbol{a}$. After we scanned $\tau = 1, 2, \ldots, 20$, we look for the value of $\tau$ which yields the smallest value of $\hat{\Phi}(\tau)$. This is then chosen as t*, the length of run of ORANI which minimizes the discrepancies between the macroeconomic stories told about the double endogeneities by MM and ORANI$^+$ within *ORANI+MM*. We

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analyzing economy-wide (but not sector-specific) supply shocks in addition to demand shocks.

12 The Murphy software provides projections for the first 20 quarters after a shock.

choose $\hat{\boldsymbol{a}}(t^*)$ as the dynamic parameters to generate the $A_o$ matrix for ORANI$^+$. $B_o$ is then recovered from (2.3.7).

## 3. THE CALIBRATION RESULTS

The calibration exercise can now be performed once we collect the relevant data and coefficients as prescribed by equation (2.3.2'), (2.3.7) and (2.5.1) above. As noted earlier, it is not necessary to utilize the complete list of ORANI variables and equations. Only the exogenous ORANI variables which are being endogenized by MM and the doubly endogenous variables need to be included in the interface procedure. These variables are listed below in Tables 1 and 2 respectively. The ORANI variable names and definitions are taken from Codsi, Horridge and Pearson (1988), and the mapping with MM names and definitions is explained in Appendix B.

The ORANI $C_o$ matrix is tabulated in Appendix A. Citations documenting in full the underlying database, closure and computing methods are given in Appendix F.

Whilst there are many exogenous variables available in ORANI and MM, we chose to calibrate on a shock to a doubly exogenous variable; namely, government spending.[13] Given the current make-up of the $z_o$ and $y_m$ vectors, the only doubly exogenous variable other than the average tariff rate is general government expenditures – **f5gen**. Since a shock in government expenditures is relatively more "neutral" in terms of sectoral responses than a shock in the average tariff rate – and since, in any case MM is not designed with any special emphasis on its response to a tariff shock – our calibration experiments involve a 10 per cent increase in real general government expenditures.

Although a shock in government expenditures can be thought of as being relatively "neutral," the method of financing the resulting deficit can alter the outcome. Consequently, we try two calibration experiments: in the first, the deficit initially is fully financed by issuing bonds, which results in a big initial jump in the real exchange rate; in the second, the deficit is partially monetized such that the real exchange rate is relatively unchanged (from control) over the simulation period.

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13 A shock to government spending is commonly used also in comparing the projections of different macro models; see e.g., Parsell, Powell and Wilcoxen (1991).

Table 1

*ORANI Exogenous Variables Being Endogenized by MM*

| | |
|---|---|
| 1. **phi** | Exchange rate (nominal) |
| 2. **fwage** | Overall wage shifter (real hourly wage rate) |
| 3. **cR** | Real household consumption |
| 4. **prinvr** | Aggregate real private investment (excluding investment in housing) |
| 5. **f2(103)** | Real investment in housing |
| 6. **f5gen** | Overall shift term for other demands (representing general government expenditures) |
| 7. **curcap(j)** | Capital stock in use in industry j ($j \in [1, 112], j \neq 103$) |
| 8. **curcap(103)** | Capital stock in use in housing |

Table 2

*Doubly Endogenous Variables*

| | |
|---|---|
| 1. **exp** | Foreign currency value of exports |
| 2. **gdpreal** | Real GDP |
| 3. **imp** | Foreign currency value of imports |
| 4. ***l*** | Aggregate employment |
| 5. **xi3** | Consumer price index |
| 6. **xi4** | Export price index in domestic currency |
| 7. **xigdp** | GDP price index |

### *3.1 Bond Financing*

In order to correctly interpret how MM responds to an increase in government expenditures, it is helpful to consider what would happen if the increase in government expenditures were restricted to consumption goods.

In the short run, fiscal expansion (the purchase of consumption goods) financed by bonds in MM produces results which are consistent with the well-known Mundell-Fleming (MF) benchmark with perfect asset substitutability. Specifically, in MF and in MM there is very little change in the interest rate and real output since the increase in government spending is matched by a decline in net exports caused by an exchange rate appreciation. During the medium run, investment is briefly crowded out in MM due to the adjustment in interest rates in response to the exchange rate seeking its long-run level. In the long run, due to an income-tax reaction function in MM which keeps the government on its intertemporal budget constraint, the increase in government spending crowds out consumption.

In ORANI, government purchases (**f5gen**) generate demands not only on consumption goods *(GGCO)*, but also on direct government employment *(NGG)*.[14] The shock to MM involved increasing each of the MM-exogenous components of government spending (namely, *GGCO* and *NGG*) by 10 per cent (see Appendix B).

This treatment of government expenditures leads to a slight modification of the Mundell-Fleming result. In the long run the increase in government employment totally crowds out private employment. Table 3 reports the calibration parameters, and Table 4 reports the resulting variable values along with the values obtained from stand-alone ORANI and stand-alone MM. Details on the value of the objective function and how it changed over different candidate values of $t^*$ are given in Appendix C.

### *3.2 Balanced Financing*

In the simulation above, MM projected a significant change in the real exchange rate, an economic event which has vast implications for various industries. This experiment attempts to reduce these sectoral biases by dampening the deviation from control in the real exchange rate. This is done by partially monetizing the debt resulting from the fiscal expansion.

Again, some general insights into MM may be helpful in interpreting the results. MM resembles the well-known Dornbusch model in its response to expansionary monetary policy. Specifically, an increase in money is neutral in the long run, leading to matching proportional changes in the price level and the exchange rate without disturbing real output or the real interest rate.

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14 From this point on, ORANI variables under discussion are denoted by **bold** type, while MM variables are written in *italics*.

Table 3

*Experiment 1: Estimated Values of Interface Parameters*
*(fully bond-financed 10 per cent sustained increase in MM-exogenous government spending)*

| i Variable | Parameter Value, $a_i$ |
|---|---|
| 1. **exp** | $7.17 \times 10^9$ |
| 2. **gdpreal** | 1.047461 |
| 3. **imp** | 1.123579 |
| 4. ***l*** | 0.725262 |
| 5. **xi3** | 0.000329 |
| 6. **xi4** | 0.000682 |
| 7. **xigdp** | 0.000324 |
| 8. ORANI short run, **t*** | 5 quarters |

Table 4

*Experiment 1: Solution Values of Doubly Endogenous Variables*
*(fully bond-financed 10 per cent sustained increase in MM-exogenous government spending)*

| Variable[a] | ORANI+ $\overset{+}{y}_0(t^*)$ (within *ORANI+MM*) | MM $y^{\lozenge}(t^*)$ (stand-alone) | ORANI[b] $y_0$ (stand-alone) |
|---|---|---|---|
| 1. **exp** | –2.52525 | –2.01365 | –0.94248 |
| 2. **gdpreal** | 0.56924 | 0.56924 | 1.26223 |
| 3. **imp** | 2.69880 | 3.62590 | 1.22403 |
| 4. ***l*** | 0.67829 | 0.67829 | 1.99173 |
| 5. **xi3** | –1.93460 | –0.14888 | 0.84670 |
| 6. **xi4** | –5.79909 | –5.16368 | 0.12011 |
| 7. **xigdp** | –1.78212 | –0.01664 | 0.88578 |

(a) For key to notation, see Table 2.

(b) In stand-alone ORANI absorption is exogenous.

In the short run however, the price level is sticky and consequently the real money supply is changed. This results in a change in the interest rate and causes the exchange rate to overshoot its long-run target. The combination of changes in the exchange and interest rates causes real output to change.

In this experiment, the increase in the money supply works to offset the appreciation in the exchange rate caused by the expansionary fiscal policy. The net effect on real output in the short-run should be more expansionary than before, but should be about the same in the long run. The specifics of this experiment involve shocking the MM-exogenous components of real govern

Table 5

*Experiment 2: Estimated Values of Interface Parameters*
*(10 per cent sustained increase in MM-exogenous government spending with balanced financing)*

| i | Variable | Parameter Value, $a_i$ |
|---|---|---|
| 1. | **exp** | $4.94 \times 10^9$ |
| 2. | **gdpreal** | $4.11 \times 10^4$ |
| 3. | **imp** | 0.468109 |
| 4. | ***l*** | 0.887108 |
| 5. | **xi3** | 0.362476 |
| 6. | **xi4** | 0.002311 |
| 7. | **xigdp** | 0.641901 |
| 8. | ORANI short run **t*** | 8 quarters |

Table 6

*Experiment 2: Solution Values of Doubly Endogenous Variables*
*(10 per cent sustained increase in MM-exogenous government spending with balanced financing)*

| Variable[(a)] | ORANI+ $y_0^+(t^*)$ (within *ORANI+MM*) | MM $y^\Diamond(t^*)$ (stand-alone) | ORANI[(b)] $y_0$ (stand-alone) |
|---|---|---|---|
| 1. **exp** | –0.79713 | –0.43555 | –0.94248 |
| 2. **gdpreal** | 1.28921 | 1.32841 | 1.26223 |
| 3. **imp** | 2.60069 | 2.60069 | 1.22403 |
| 4. ***l*** | 1.04611 | 1.04611 | 1.99173 |
| 5. **xi3** | 9.47640 | 9.47640 | 0.84670 |
| 6. **xi4** | 6.40106 | 6.42779 | 0.12011 |
| 7. **xigdp** | 9.08040 | 9.07931 | 0.88578 |

(a) For key to notation, see Table 2.

(b) In stand-alone ORANI absorption is exogenous.

ment spending (namely *GGCO* and *NGG*) by 10 per cent above control, and the time rate of growth in the money supply is increased by 1.1 percentage points per quarter above control. The MM output for this and the previous experiment is displayed in Appendix D. Tables 5 and 6 report the results of this experiment.

Details on the value of the objective function and how it changed over possible values of t* are found in Appendix C.

## 4. *ENDOGENIZING ORANI'S MACRO ENVIRONMENT: FINAL CHOICE OF INTERFACE AND COMPUTATION OF 'AS-IF' SHOCKS*[15]

The results in Table 6 encourage us to attempt the final step in the interfacing procedure. This consists of finding explicit values for those elements of the macroeconomic environment (mentioned in the Introduction) about which ORANI is agnostic. We refer to these values as 'as-if' shocks: they are the sustained percentage deviations from control in variables 1-4, 7 and 8 of Table 1 which, when injected into ORANI in stand-alone mode, give a replacement for the last column in Table 6 which is a very good approximation to the MM column of that table. In other words, allowing the shock to government spending to affect the nominal exchange rate, real wage rate, and so on, by the percentages reflected in the 'as-if' shocks, brings the ORANI stand-alone projections for 8 quarters after the shock into line with the MM story at that length of run. How do we find the values of these 'as-if' shocks?

There are seven ORANI-exogenous variables endogenized by MM (those listed in Table 1 with the exception of **f5gen**) and also seven double endogeneities. Unfortunately, however, only six of the former are available as instruments for achieving the targets for the double endogeneities. As we have seen in the Introduction, an attractive feature of MM is that it endogenizes housing investment in a way which takes account of conditions in financial markets; the MM endogenization of **f2(103)** at t* = 8 quarters, therefore, itself becomes a target (to which it is natural to assign itself as the instrument).

The six exogenous variables available to implement the 'as-if' shocks to ORANI are:

- (i) the nominal exchange rate, **phi**
- (ii) the real wage rate, **fwage**
- (iii) real household consumption, **cR**
- (iv) aggregate real investment, **prinvr**
- (v) capital stock in use in industries other than ownership-of-dwellings, **curcap(j)**
- (vi) capital stock in use in housing **curcap(103).**

15 This section draws freely on the ideas of Cooper (1983).

Since there are seven doubly endogenous targets to be attained with just these six instruments (see the MM column of Table 6), some approximation is unavoidable.

In stand-alone mode ORANI produces results according to (2.1.1). We wish to find the set of shocks, $z_o^{as\text{-}if}$, which minimizes the discrepancy between the stand-alone solutions of MM at 8 quaarters and of ORANI — $y^{\lozenge}$ and $y_o$ respectively. If a least-squares criterion is chosen, $z_o^{as\text{-}if}$ is found using the six relevant columns of $C_o$ as regressors.

This is exactly how we proceeded. First, we removed the contributions of **f5gen** and **f2(103)** from the MM solution; that is, we calculated the following 7-vector:

$$y^{**} = y^{\lozenge} - [\mathbf{f5gen}]\, \underline{\underline{c}}^5 - [\mathbf{f2(103)}]\, \underline{\underline{c}}^h \ , \tag{4.1}$$

where $\underline{\underline{c}}^5$ and $\underline{\underline{c}}^h$ respectively are the columns of the $C_o$ matrix corresponding to the ORANI-exogenous variables by which they are multiplied in (4.1); $\underline{\underline{c}}^h$, for instance, shows the responses in ORANI of the variables listed in Table 2 to a sustained one per cent change in investment in housing. We then regressed $y^{**}$ on the six columns of $C_o$ corresponding to the available ORANI-exogenous variables (i) – (vi) listed above. That is, we computed the 6-vector:

$$z_o^{as\text{-}if} = \{[C_o^6]'\,[C_o^6]\}^{-1}\ [C_o^6]'\, y^{**}, \tag{4.2}$$

where $C_o^6$ is the 7 × 6 sub-matrix of $C_o$ obtained by taking the columns of $C_o$ corresponding to the variables (i) through (vi) listed above. The resulting $z^{as\text{-}if}$ vector is shown in column *(1)* of Table 7. This vector provides the response of the *macroeconomic environment* to the fiscal shock: in a stand-alone simulation of such a shock in standard ORANI the variables in this vector would remain undisturbed (i.e., would experience zero change).

Column *(4)* shows the regression estimates of $y^*$; namely:

$$\hat{y}^* = \hat{y}^{**} + [\mathbf{f5gen}]\ \underline{\underline{c}}^5 + [\mathbf{f2(103)}]\ \underline{\underline{c}}^h$$

where

$$\hat{y}^{**} = C_o^6\, z_o^{as\text{-}if} \ . \tag{4.4}$$

Thus the column in Part B of Table 7 gives the calibrated values of the double endogeneities; with the exception of the foreign currency values of exports (**exp**), the discrepancies from the middle column of Table 6 are mild. (The root mean squared error is given as the last entry in Table 7.)

When reading Table 7 it should be kept in mind that the results for the double endogeneities incorporate not only the conditional least squares vector of 'as-if' shocks $z_o^{as\text{-}if}$ , but also the doubly exogenous shock **f5gen** = 10 per cent and the MM result for housing investment, **f2(103)** = 1.0816 per cent. The sectoral responses are presented in Appendix E.

The industry results, at this stage, should be treated with caution. Although they aggregate to the controlled values of the macro variables indicated in Table 7, some major differences in the design of MM and ORANI complicate their interpretation. In addition to the problems mentioned in the Introduction, there is the difference between the treatment of the gestation lags for investment in the two models.

Table 7

*'As-if ' Shocks and Final Values of the Doubly Endogenous Variables*

| *(1)* ORANI exogenous variable endogenized by MM | *(2)* Values of the 'as-if' shocks, $z_o^{as\text{-}if}$ | *(3)* Doubly endogenous variable | *(4)* Value in ORANI with macro environment as in column *(2)*, $\hat{y}_j^*$ |
|---|---|---|---|
| 1. **phi** | 6.2814 | 1. **exp** | –0.4119 |
| 2. **fwage** | 2.3978 | 2. **gdpreal** | 1.2829 |
| 3. **cR** | –0.7256 | 3. **imp** | 2.5694 |
| 4. **prinvr** | 4.5927 | 4. ***l*** | 1.1313 |
| 5. **curcap (j)** (j≠103) | 5.8482 | 5. **xi3** | 9.3731 |
| 6. **curcap (103)** | –6.6367 | 6. **xi4** | 6.3683 |
| | | 7. **xigdp** | 9.2420 |
| | | Root-mean squared error (RMSE)(a) | 0.085709 |

(a) The RMSE is calculated as $\sqrt{\frac{1}{7}\sum_{j=1}^{7}\left(\hat{y}_j^* - y_j^{\lozenge}(t^*)\right)^2}$ .

(b) Finally calibrated solution for double endogeneities shown in column *(4)*.

Two of the 'as-if' shocks above refer to capital stocks (**curcap(j)** and **curcap(103)**). If MM and ORANI handled the accretion of capital in the same way, then, in terms of deviations from control, after the injection of a shock no new capital would come on stream in MM until t* quarters had elapsed. In fact the lag built into MM is two quarters. The discrepancy may be overstated, however, by comparing this delay with the estimated ORANI short run of t* = 8 quarters. This is because the ORANI capital stocks 'jump' to their new levels at t* = 8; in MM they evolve smoothly throughout all time subsequent to the initial delay of two quarters; thus the 'average' gestation lag in MM exceeds two quarters, but is clearly less than eight (see Chart 5 Appendix E). This source of tension between the two models cannot be lessened without radical redesign of MM (and perhaps ORANI as well). As a consequence, the role of the 'as-if' shocks to the capital and housing stocks in determining the industry results remains somewhat obscure.

Space prevents our giving a detailed discussion of the industry projections. The additional real exchange rate appreciation from MM (embodied in the 'as-if' shocks and the housing investment shock) generates a greater cost/price squeeze than that experienced in the ORANI stand-alone simulations. Many of the discrepancies between the latter results and those obtained by including also the 'as-if' shocks can be explained by the impact on industries producing internationally traded goods of changes in the real exchange rate endogenized by MM. In ORANI, the trading conditions of such industries are substantially affected by the difficulty of passing domestic cost rises on to customers with alternative sources of supply. For example, industry 18 (Meat Products — see Appendix E) sells a large share of its output overseas. In stand-alone mode ORANI projects about a one per cent decline in its activity, but faced with an additional squeeze of two percentage points between costs and prices as endogenized by MM,[16] the decline in output of industry 18 is half as large again (viz., 1.57 per cent — see Appendix E). Similar stories could be told for industries vulnerable to import competition (such as industry 68, Motor Vehicles and Parts).

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16 To a first approximation the total effect of the shocks to ORANI — i.e., of the standard shock to **f5gen**, the shock to housing investment **f2(103)**, and the 'as-if' shocks — can be summarized for an 'average' export industry as a 9 per cent rise in costs (**xigdp** = 9.24, 1st col. of Table 7) and a 6 per cent rise in price (**phi** = 6.28, 1st col. of Table 7); the total cost-price squeeze is thus about 3 per cent. The joint contributions of the shocks other than f5gen to these changes are: to **xigdp**, 8.30 percentage points; to **phi**, 6.28 percentage points (recall that **phi** is exogenously set to zero in the ORANI stand-alone simulations). That is, about 2 percentage points of the squeeze are endogenized by MM.

## 5. CONCLUDING REMARKS

These experiments are the first stage in providing ORANI with a new short-run macroeconomic closure. The striking feature of our results is the robustness of the estimated ORANI short run to a major change in the macro model providing the closure. Comparison with earlier work is facilitated by a similar choice of double endogeneities for calibration, and by choosing an increase in government spending as the calibration shock. Whereas the RBII (continuous-time) model yielded an estimate of 7.9 quarters (Cooper 1983), the Murphy Model gave values of 5 or 8 quarters (depending on how the fiscal expansion was financed)[17].

Less pleasing (but given MM's cyclical short-run dynamics, not surprising) is the size of the discrepancies between MM and ORANI$^+$ within *ORANI+MM* remaining after calibration to the first (bond-financed) shock in government spending. In the earlier interfacing experiments, complete reconciliation was achieved between the (RBII-driven) ORANI$^+$ results and the RBII results at 7.9 quarters. In the case of the second shock (with partial monetization of the deficit) the current experiments yielded a rather close (but by no means perfect) reconciliation of MM and ORANI$^+$ .

It proved possible to compute 'as-if' shocks which endogenized ORANI's macroeconomic environment. Subjecting ORANI in stand-alone mode to these shocks, plus the calibration shock of a 10 per cent increase in real government spending coupled with MM's projection of housing investment, enabled us to obtain results on activity levels in ORANI's 112 industries. Although we have some reservations about them, these disaggregated results demonstrate the power of the coupled system.

17 The ORANI data bases also differ between current and earlier work (1980-81 versus 1968-69).

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Appendix A: *ORANI Elasticities Matrix* $C_o$ [(a)]

| Endogenous Variables | Exogenous Variables | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Exchange Rate | Overall Wage Shifter | Real Household Consumption | Aggregate Real Private Investment | Real Housing Invest- ment | Overall Shift Term for other demands | Capital Stock | Housing Stock |
| | **[phi]** | **[fwage]** | **[cR]** | **[prinvr]** | **[f2(103)]** | **[F5gen]** | **[curcap( j)]** | **[curcap(103)]** |
| Foreign Currency Value of Exports **[exp]** | 0.000 | -1.954812 | -1.749024 | -0.092173 | -0.054180 | -0.094248 | 1.467769 | 0.625790 |
| Real GDP **[gdpreal]** | 0.000 | -0.452808 | 0.087998 | 0.062083 | 0.039384 | 0.126223 | 0.324854 | 0.159304 |
| Foreign Currency Value of Imports **[imp]** | 0.000 | 0.636242 | 1.186298 | 0.215340 | 0.067568 | 0.122403 | -0.395421 | -0.290964 |
| Aggregate Employment **[*l* ]** | 0.000 | -0.668148 | 0.041372 | 0.084980 | 0.054070 | 0.199173 | 0.217304 | 0.142841 |
| Consumer Price Index **[xi3]** | 1.000 | 1.539332 | 1.817374 | 0.062348 | 0.040075 | 0.084670 | -0.916734 | -0.738973 |
| Export Price Index in Domestic Currency **[xi4]** | 1.000 | 0.260366 | 0.221492 | 0.011271 | 0.006677 | 0.012011 | -0.187197 | -0.081223 |
| GDP Price Index **[xigdp]** | 1.000 | 1.701375 | 1.719243 | 0.071327 | 0.054368 | 0.088578 | -0.962329 | -0.675686 |

(a) Notation is from Codsi *et al*. (1988).

## APPENDIX B

### *Mapping Murphy Model Variables to ORANI*

Below is an explanation of the mapping between Murphy Model variables and ORANI variables. For many of the ORANI variables there is a corresponding MM variable. However, for several of the ORANI variables, a corresponding MM variable had to be constructed. The ORANI variables are written bold, and in parentheses **[ ]**; they are fully defined in Codsi, Horridge and Pearson (1988). The corresponding MM variable or constructed variable is then described. The operator % Δ represents percentage deviation from control. For example, the first entry below states that the ORANI variable **[phi]**, the percentage deviation from control in the nominal exchange rate ($A per U.S. dollar), is minus the percentage deviation from control in the MM variable E (the exchange rate in U.S. dollars per $A).

*Relevant Exogenous Variables*

1. Nominal exchange rate **[phi]**: –%Δ E

   The exchange rate in MM is the reciprocal of the exchange rate in ORANI, hence the negative sign.

2. Real wage **[fwage]**: % Δ WA – %Δ PCPIT

   WA is the nominal wage rate including payroll taxes, and PCPIT is the consumer price index.

3. Real household expenditure **[cR]:** % Δ CON

4. Real private investment **[prinvr]:** % Δ IBF

   IBF is real private enterprise business fixed investment.

5. Real investment in housing **[f2(103)]**: % Δ IH

6. Real Government Expenditure **[f5gen]**: % Δ NGG. $w_{15}$ + % Δ GGCO.$w_{25}$

   where $w_{15}$ = WA.NGG/{WA.NGG + PYD.GGCO} ;

   $w_{25} = 1 - w_{15}$ ;

   NGG in general government employment, WA is the nominal wage rate including payroll taxes, GGCO is real general government purchases of consumption goods, and PYD is the price of the domestic good.

7. Tariffs **[iacrate(i)]**: % Δ POL5

8. Capital stock **[curcap(j)]**: % Δ K

9. Housing capital stock **[curcap(103)]:** % Δ KH

*Double Endogeneities*

9. Foreign Currency Value of Exports **[exp]:**

$$\% \Delta PX + \% \Delta (EXC + EXO) + \% \Delta E$$

where PX is the domestic price of exports, EXC is commodity exports, EXO is non-commodity exports and E is the exchange rate.

10. Real GDP [**gdpreal**]: % Δ NA14

11. Foreign Currency Value of Imports [**imp**]: % Δ IM

12. Aggregate Employment [***l***]: % Δ NT

MM measures employment in terms of the number of persons employed, whereas ORANI measures employment in terms of total labour hours. The ORANI measure is therefore broader in that it allows for variation not only in the number of persons employed, but also in average hours worked per person employed. This distinction between the ORANI and MM measures of employment is ignored here. While it is true that for very short time horizons, variations in hours worked are a significant part of the employment adjustment process, variations in the number of persons employed dominate for longer horizons. This is certainly true for a horizon of two years, which turns out to be the relevant consideration in view of our finding that t* is eight quarters.

13. Consumer Price Index **[xi3]**: % Δ PCPIT

14. Export Price Index in Domestic Currency **[xi4]:** % Δ PX

14. GDP Price Index [**xigdp**]: % Δ PGDPT

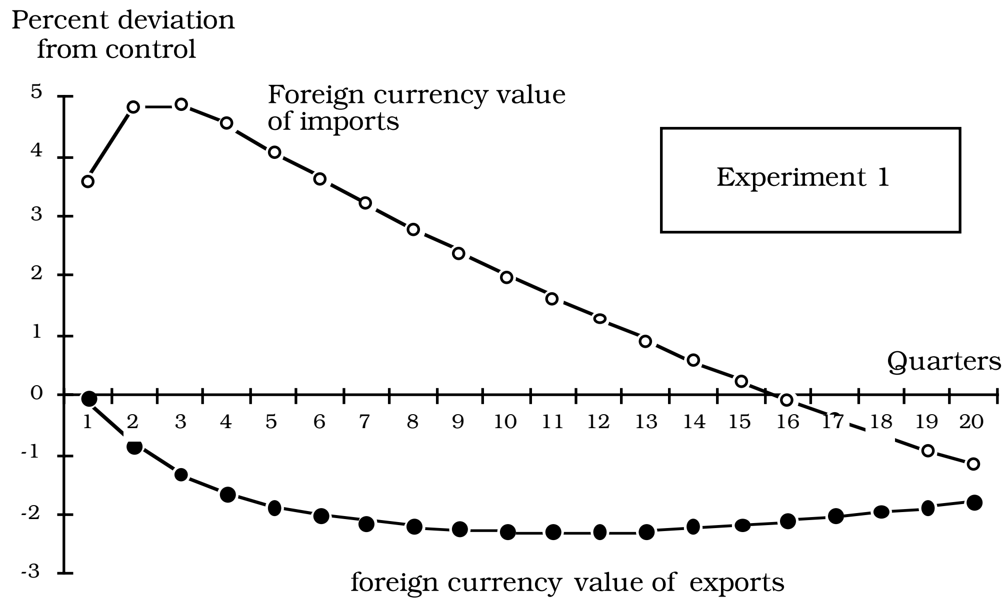
## APPENDIX C

***Solution Values of the Objective Function for Alternative t****

| t* | Experiment 1 | Experiment 2 |
|---|---|---|
| 1 | 39.542875 | 17.588439 |
| 2 | 21.939841 | 10.523284 |
| 3 | 13.521144 | 4.078107 |
| 4 | 11.531822 | 1.762137 |
| 5 | 7.830685 | 1.294669 |
| 6 | 14.283253 | 0.811608 |
| 7 | 12.166044 | 0.400303 |
| 8 | 10.250941 | 0.132992 |
| 9 | 9.262460 | 0.262691 |
| 10 | 9.273710 | 2.218293 |
| 11 | 8.739791 | 7.484422 |
| 12 | 9.072647 | 16.304682 |
| 13 | 9.650471 | 29.148531 |
| 14 | 10.176586 | 64.136049 |
| 15 | 10.537239 | 81.876627 |
| 16 | 10.728606 | 106.640116 |
| 17 | 10.771381 | 134.395646 |
| 18 | 10.678085 | 166.305809 |
| 19 | 10.490784 | 202.026714 |

## APPENDIX D

### *Plots of Murphy Model Simulations*



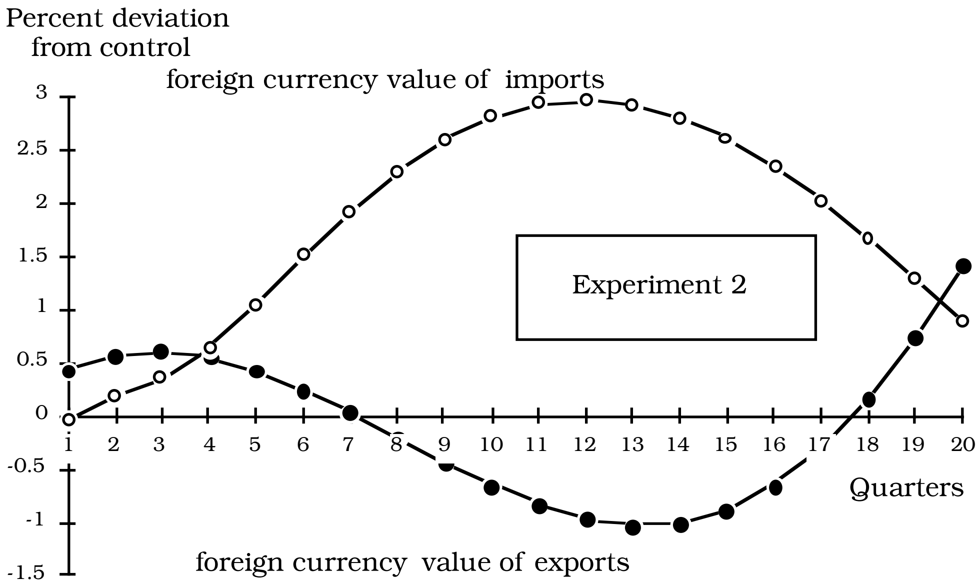




Chart 1: Murphy Model Projections of the Trade Account

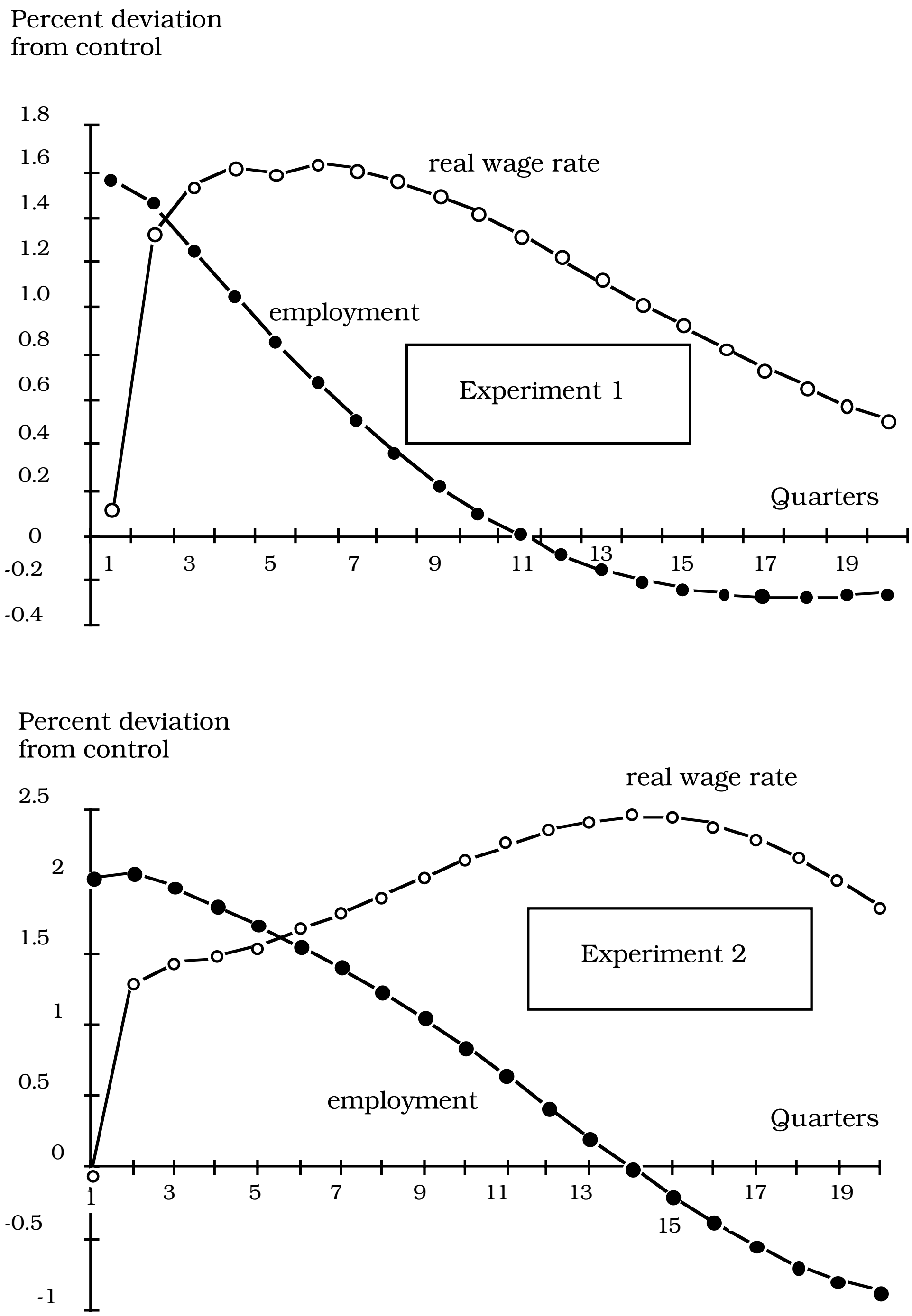
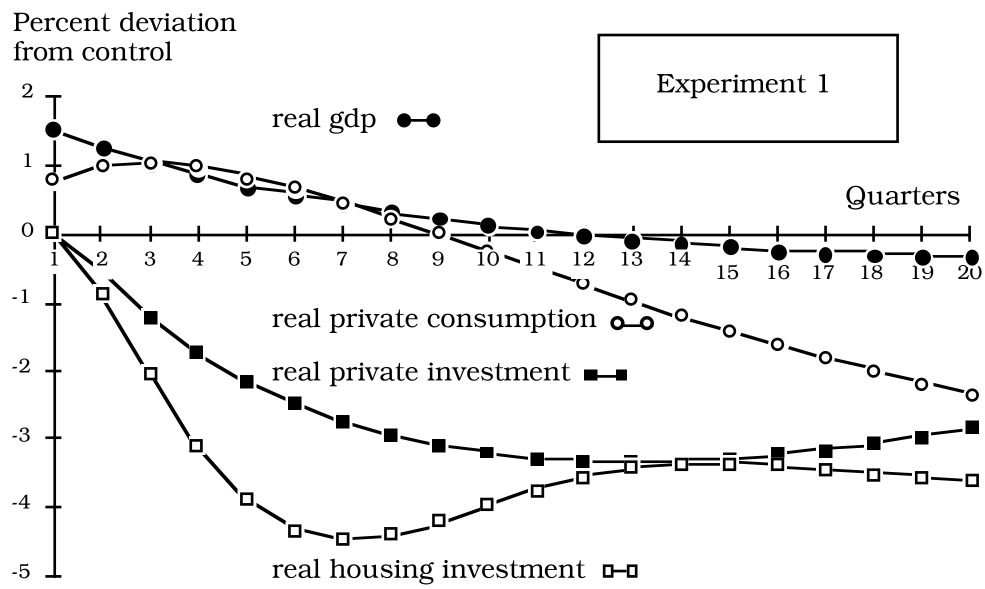



Chart 2: Murphy Model Projections of the Labour Market



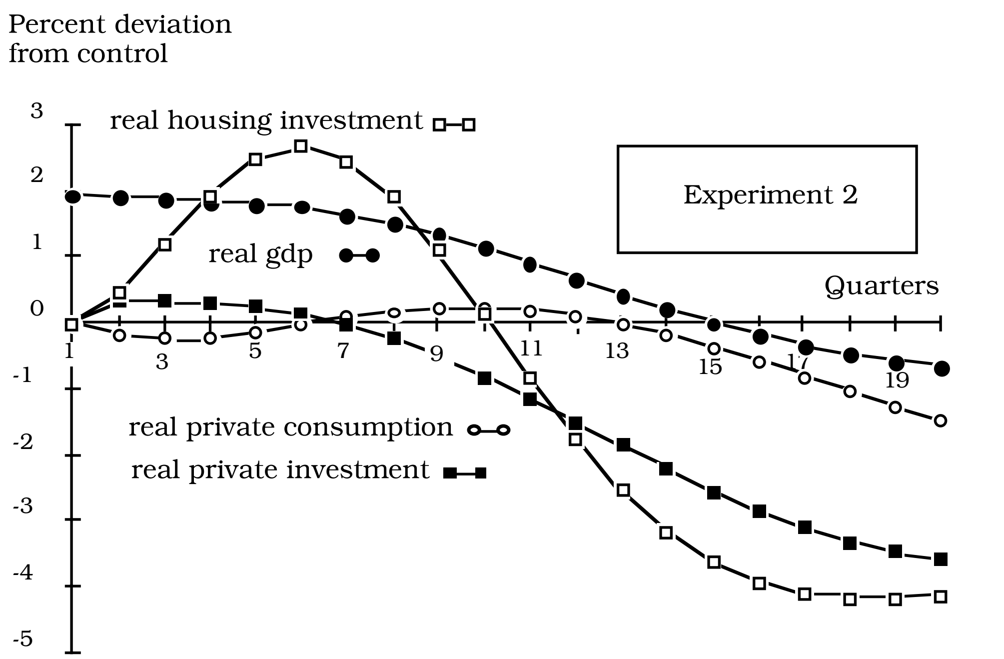




Chart 3: Murphy Model Projections of Activity

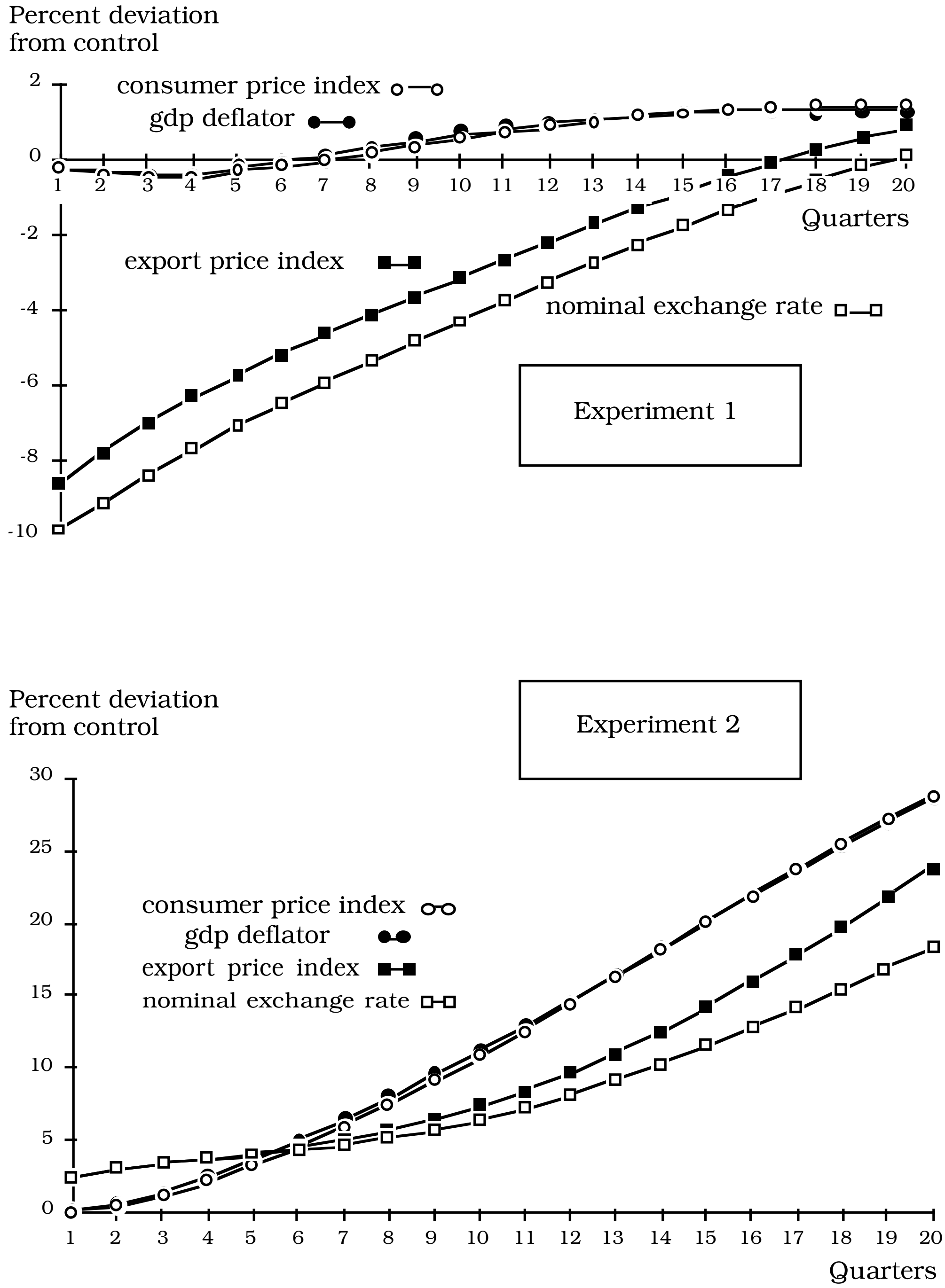



Chart 4: Murphy Model Projections of Prices

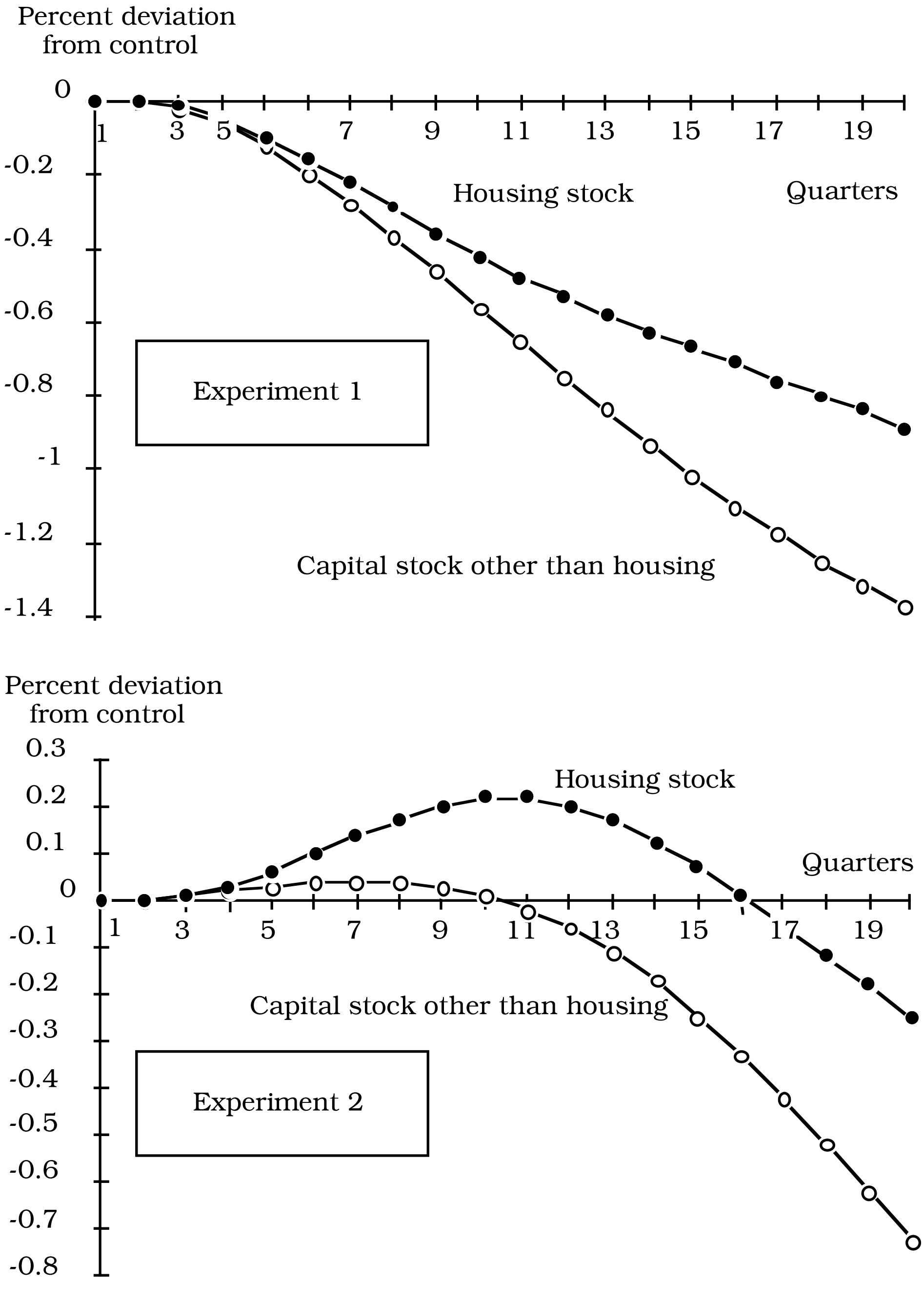



Chart 5: Murphy Model Projections of Capital Stocks

## Appendix E

### Comparison of ORANI Projections of the Effects of a 10 Per Cent Sustained Rise in Real Government Spending, with and without Macroeconomic Closure by the Murphy Model

| Industry<br>(per cent deviation from control) | ORANI closed by MM<br>[I] | ORANI stand-alone<br>[II] |
|---|---|---|
| 1. Pastoral Zone | -0.607719 | -0.599032 |
| 2. Wheat-sheep Zone | -0.326510 | -0.456166 |
| 3. High Rainfall Zone | -1.894719 | -0.700083 |
| 4. Northern Beef | -1.382751 | -0.958614 |
| 5. Milk Cattle and Pigs | -0.462542 | -0.203049 |
| 6. Other Farming (Sugar, Fruit & Nut) | -1.712368 | -1.172180 |
| 7. Other Farming (Veg., Cotton, Seeds, Tobacco) | -0.693200 | -0.327289 |
| 8. Poultry | -0.885139 | -0.513437 |
| 9. Agricultural Services | 2.018673 | 2.269640 |
| 10. Forestry and Logging | 1.190146 | 0.819535 |
| 11. Fishing and Hunting | -0.687631 | -0.447789 |
| 12. Ferrous Metal Ores | 3.274285 | -0.577353 |
| 13. Non-Ferrous Metal Ores | 1.855717 | -0.813316 |
| 14. Black coal | 0.400089 | -1.150477 |
| 15. Oil, Gas and Brown Coal | 5.260663 | -0.114843 |
| 16. Other Minerals | 0.995158 | 0.075107 |
| 17. Services to Mining | 8.087697 | -0.666524 |
| 18. Meat Products | -1.574910 | -0.900507 |
| 19. Milk Products | 0.065782 | 0.065704 |
| 20. Fruit and Vegetables | 0.101050 | 0.055953 |
| 21. Margarine, Oils and Fats | 0.095612 | -0.004124 |
| 22. Flour and cereal Products | -0.014988 | -0.040974 |
| 23. Bread Cakes and Biscuits | 0.169156 | 0.068005 |
| 24. Confectionery and Cocoa | 0.004467 | 0.008308 |
| 25. Other Foods Products | -2.352658 | -1.673127 |
| 26. Soft Drinks and Cordials | 0.503482 | 0.147657 |
| 27. Beer and Malt | 0.686057 | -0.006598 |
| 28. Other Alcoholic Drinks | 0.993852 | -0.309308 |
| 29. Tobacco Products | 0.088339 | -0.047532 |
| 30. Cotton Ginning etc. | -2.570450 | -1.237667 |
| 31. Man-made Fibres, Yarns | -2.186183 | -1.025712 |
| 32. Cotton Yarns and Fabrics | -1.976546 | -0.743195 |
| 33. Worsted and Woollen Yarn | -0.376050 | -0.123210 |
| 34. Textile Finishing | -0.182443 | 0.023540 |

*continued ......*

| Industry (per cent deviation from control) | ORANI closed by MM [I] | ORANI stand-alone [II] |
|---|---|---|
| 35. Textile Floor Overlays | 0.525679 | -0.040230 |
| 36. Other Textile Products | 0.719195 | 0.448669 |
| 37. Knitting Mills | -0.301438 | 0.122098 |
| 38. Clothing | -0.276556 | 0.039775 |
| 39. Footwear | -2.433534 | -0.729769 |
| 40. Sawmill Products | 0.312701 | -0.086679 |
| 41. Veneers and Boards | 0.631973 | 0.338094 |
| 42. Joinery and Wood nec | 0.809375 | 0.512942 |
| 43. Furniture and Mattresses | 1.338881 | 0.563547 |
| 44. Pulp Paper Paperboard | 0.717881 | 0.659980 |
| 45. Bags, Fibreboard Boxes | 0.392724 | 0.172919 |
| 46. Paper Products nec | 1.044801 | 0.834939 |
| 47. Newspapers and Books | 1.362763 | 1.362062 |
| 48. Commercial Printing | 1.733119 | 1.474513 |
| 49. Chemical Fertilisers | 0.065568 | -0.082803 |
| 50. Other Basic Chemicals | 0.337000 | -0.165236 |
| 51. Paints, Varnishes | -1.080595 | 0.079086 |
| 52. Pharmaceutical Goods | 1.467769 | 1.547308 |
| 53. Soap and Detergents | 0.716656 | 0.455180 |
| 54. Cosmetics and Toiletries | 0.358372 | 0.239173 |
| 55. Other Chemical Goods | 0.964744 | 0.659285 |
| 56. Petrol and Coal Products | 1.153328 | 0.448728 |
| 57. Glass and Glass Products | 0.407933 | 0.127511 |
| 58. Clay Products; Refract's | 0.460110 | -0.065378 |
| 59. Cement | 1.085922 | 0.208694 |
| 60. Ready Mixed Cement | 1.205115 | 0.217645 |
| 61. Concrete Products | 1.249454 | 0.224625 |
| 62. Non-Metallic Ore Goods | 0.673777 | 0.091527 |
| 63. Basic Iron and Steel | 0.563600 | 0.032244 |
| 64. Other Basic Metals | 1.661653 | -0.828080 |
| 65. Structural Metal Ores | 1.496373 | 0.216248 |
| 66. Sheet Metal Products | 0.775045 | 0.161944 |
| 67. Other Metal Products | 0.603193 | 0.214865 |
| 68. Motor Vehicles and Parts | -1.159401 | -0.602697 |
| 69. Ships and Boats | 3.781787 | 2.071441 |
| 70. Locomotives | 0.749535 | 0.013049 |
| 71. Aircraft | 3.084714 | 1.914036 |
| 72. Scientific Equipment | 1.308694 | 1.202777 |
| 73. Electronic Equipment | 0.383439 | 0.413034 |
| 74. Household Appliances | 0.954956 | -0.123878 |
| 75. Other Electrical Goods | 1.403851 | 0.130527 |

*continued ......*

| Industry (per cent deviation from control) | ORANI closed by MM [I] | ORANI stand-alone [II] |
|---|---|---|
| 76. Agricultural Machinery | -13.609202 | -3.681289 |
| 77. Construction Machinery | 4.965384 | 0.037665 |
| 78. Other Machinery and Plant | 3.439776 | -0.019844 |
| 79. Leather Products | -1.007198 | -0.188040 |
| 80. Rubber Products | 0.553687 | 0.311417 |
| 81. Plastic Products, etc. | 0.252179 | 0.155710 |
| 82. Signs; Writing Gear | 1.003605 | 0.856727 |
| 83. Other Manufacturing | 0.102855 | 0.118041 |
| 84. Electricity | 1.994081 | 0.602714 |
| 85. Gas | 1.725588 | 0.512274 |
| 86. Water; Sewers and Drains | -1.280909 | 1.111985 |
| 87. Residential Building | 0.462077 | 0.000001 |
| 88. Other Construction | 1.791454 | 0.359036 |
| 89. Wholesale Trade | 0.817972 | 0.222039 |
| 90. Retail Trade | 0.547735 | 0.135304 |
| 91. Mechanical Repairs | 0.371133 | 0.293324 |
| 92. Other Repairs | 0.946578 | 0.438866 |
| 93. Road Transport | 1.084610 | 0.565109 |
| 94. Rail and Other Transport | 0.911745 | 0.171068 |
| 95. Water Transport | 0.434391 | -0.184602 |
| 96. Air Transport | 0.772384 | 0.666096 |
| 97. Communication | 1.710189 | 1.073516 |
| 98. Banking | 0.958355 | 1.640395 |
| 99. Non-Banking Finance | 1.292065 | 0.392025 |
| 100. Investment and Services | 2.064744 | 0.933012 |
| 101. Insurance and Services | 1.540382 | 2.063790 |
| 102. Other Business Services | 1.824999 | 1.093966 |
| 103. Ownership of Dwelling | -6.636695 | 0.000000* |
| 104. Public Administration | 8.559950 | 8.560609 |
| 105. Defence | 9.906232 | 9.906232 |
| 106. Health | 4.643453 | 4.882968 |
| 107. Education, Libraries | 8.172524 | 8.361033 |
| 108. Welfare and Religious | 5.623899 | 5.734663 |
| 109. Entertainment, Leisure | 2.138055 | 1.788357 |
| 110. Restaurants, Hotels | 0.786330 | 0.185887 |
| 111. Personal Services | 1.554052 | 0.313984 |
| 112. Non-Competing Imports | 5.000000 | 5.000000 |

## *Appendix F*

## *Documentation of the Version of ORANI, its Closure, Database and Parameter File as used in this Paper*

This appendix contains full documentation of the equations, data base, and parameter settings of the ORANI model as used in this study. It also describes the software used to solve the model. This information is provided so that our results can be replicated if desired by independent researchers.

### *A1.1 Equations*

The equations of the economic model consist of those used in the ORANI model as described in Dixon, Parmenter, Sutton, and Vincent (1982), slightly modified to the extent documented in Codsi, Horridge and Pearson (1988), plus one further modification. The last-mentioned consists of cutting the indexation link between real government spending and real private consumption. This was accomplished as follows. Equation *OTH_DEM* [Codsi, Horridge and Pearson (1988, p.26)] of the ORANI model reads as follows:

```
EQUATION OTH_DEM
# 16.1 "Other" demands #
(all,i,COM)(all,s,SOURCE)
x5cs(i,s) = UH5*cR + f5(i,s)  + f5gen;
```

Above the language is *TABLO* [see, e.g., Codsi and Pearson (1988)]; COM is the set of all 114 commodities in ORANI [as listed in Kenderes and Strzelecki (1988b)]; SOURCE is the set of just two regions of supply (Australia and the rest of the world). x5cs(i,s) is the percentage change in real government demand for commodity i from source s; UH5 is an indexation parameter (set equal to unity in the default parameter file used by us); cR is the percentage change in real private consumption; and the remaining terms are respectively an i&s-specific, and a general, shift term for real government demands. In the closure used by us, the first two variables are endogenous; f5(i,s) is exogenous and set equal to zero for all i and s; f5gen is the shocked double exogeneity underlying our interfacing experiments (f5gen = 10). According to equation *OTH_DEM,* any change in cR involves also a matching (percentage) rise in all real government demands, which is not consistent with the closure which we require. Accordingly, we subtracted cR times the effect of a 1 per cent shock to f5gen from every endogenous response to cR in the model as set up. This is equivalent to setting UH5 in equation *OTH_DEM* to zero.

### *A1.2 Data Base and Parameter Settings*

The data base and parameter settings are described in Kenderes (1988) and Kenderes and Strzelecki (1988a,b). *Inter alia,* this involves the use of the edited 1980-81 input-output accounts for Australia. Note that we have used the short-run setting $\sigma_{KL} = 0.5$ for the elasticity of substitution between labour and capital.

### *A1.3 Software*

The model was solved using the *TABLO* version of the *GEMPACK* software package (see Pearson (1988) and Codsi and Pearson (1988)) mounted on a Toshiba 5200/100 laptop personal computer.[18]

### *A1.4 Closure*

The closure used is the standard neo-classical short-run closure of ORANI under slack labour market conditions [as documented in Dixon *et al.* (1982, p. 143)]. As noted above in section A1.1, the indexation of government spending to real private consumption was 'turned off'.

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18 The process of solving the linear equations used the Harwell sparse matrix code (Duff, 1977).]