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POLICY ANALYSIS USING A COMPUTABLE GENERAL EQUILIBRIUM MODEL: A REVIEW OF EXPERIENCE AT THE IMPACT PROJECT

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I INTRODUCTION

Since the mid 1970's the Australian federal government has supported the IMPACT economic research project, currently located at the University of Melbourne and conducted in cooperation with that university, La Trobe University and the Australian National University. The role of the Project has been the development of policy information systems, in particular large formal models of various aspects of the Australian economy (Powell, 1977).

ORANI is one such model. It is a computable general equilibrium (CGE) model in the tradition of Johansen (1960) (see Dixon, Parmenter, Sutton and Vincent, hereafter DPSV, 1982). The behaviour of economic agents identified in the model (producers, investors, household consumers, importers, exporters, etc.) is modelled according to orthodox neoclassical microeconomic theory with relative prices playing an active role in the determination of economic outcomes. Although nonlinear in the levels of its variables, the model is solved, following Johansen (1960), in a linear form in percentage changes of the variables. The basic model is implemented on a data base which recognises 115 commodity categories, 113 domestic industries and 9 labour occupations (DPSV, 1982, chapter 4). Various "add on" facilities have been developed which allow ORANI projections to be mapped into more detailed labour-force classifications (e.g.,72 occupations or various socio-economic categories) or to be regionalized (e.g., to the level of the six Australian States). Where for the purposes of particular policy issues the basic model includes insufficient detail about some sector of the economy, special purposes versions have been constructed. Examples are ORANI-TAS (Higgs, Parmenter and Rimmer, 1983),which concentrates on the Tasmanian economy and its interactions with the rest of Australia, and ORANI-WINE (Meagher, Parmenter, Rimmer and Clements, 1983),which was specifically designed for the analysis of the effects of changing the structure of indirect taxes levied on alcoholic beverages.

The IMPACT Project has no direct role in the provision of policy advice. Nevertheless as part of the documentation of the Project's progress, associated researchers have published numerous papers describing applications of ORANI to policy issues. The emphasis has been on comparative static "what if" policy studies rather than on forecasting. In principle, CGE models such as ORANI could be used in forecasting exercises. However, the models typically have very little to say about likely developments in a number of economic dimensions (factor availabilities, technology, policy settings, world prices, etc.) which are likely to be crucial for the accuracy of the forecasts in any but very short-run time frames.

The main aim of this paper is to provide a review of how ORANI has been used in the provision of policy information. As a preliminary, in section II we give a brief schematic guide to the structure of the model. In section III we outline more formally how CGE models might be used for forecasting on the one hand and for "what if" policy analysis on the other. Section IV classifies the major ORANI-based policy studies which have been produced to date and discusses some results illustrative of the main themes which arise in the analyses. Concluding remarks are offered in section V.

II A BRIEF DESCRIPTION OF ORANI[1]

A schematic outline of the theoretical structure of ORANI is given in Table 1, with the notation defined in Table 2.[2] The model distinguishes 113 domestic industries (h=113), 115 commodity categories (n=115) and 9 labour occupations. The equations are derived from orthodox microeconomic assumptions about the behaviour of price-taking economic agents, e.g., producers minimizing costs, consumers maximizing utility subject to budget constraints, etc. Overall, the model contains more variables than equations. Hence prior to solution a number of variables (usually all the Q's and $3n + h + 2$ other variables) must be set exogenously.

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1. In explaining results from ORANI a summary of the model is frequently required. This presentation draws heavily on Dixon, Parmenter, Powell and Vincent (1983) and Dixon, Parmenter and Powell (1984).

2. For further details, see DPSV (1982).

Table 1
Schematic Representation of ORANI: Equations

Identifier	Description	Equations	Number
	Commodity and factor demands		
(1.1)	Domestic commodities for domestic use	$D = f_D(Z, C, P_1, P_2, Q_D)$	n
(1.2)	Imported commodities	$M = f_M(Z, C, P_1, P_2, Q_M)$	n
(1.3)	Export demand	$E = f_E(P_1^*, Q_E)$	n
(1.4)	Demands for primary factors	$L = f_L(Z, P_3, Q_L)$	k
(1.5)	Commodity supplies	$Y = f_Y(Z, P_1, Q_Y)$	n
	Pricing		
(1.6)	in production	$V(P_1, Q_V) = W(P_1, P_2, P_3, Q_W)$	h
(1.7)	in exporting	$P_1 = \hat{P}_1^* \Theta S$	n
(1.8)	in importing	$P_2 = \hat{P}_2^* \Theta T$ (^ denotes diagonal matrix)	n
	Market clearing		
(1.9)	for commodities	$D + E = Y$	n
(1.10)	for primary factors	$L = L^*$	k
	Other equations		
(1.11)	Balance of trade	$B = (P_1^*)'E - (P_2^*)'M$	1
(1.12)	CPI	$\xi = f_\xi(P_1, P_2)$	1
(1.13)	Wage indexation	$P_3 = f_{P3}(\xi, Q_{P3})$	k
			Total = 7n+h+3k+2

Table 2
Schematic Representation of ORANI: Variables

Variable	Description	Number
D	Demands for domestically produced commodities	n
Z	Activity levels for each industry	h
C	Aggregate real absorption	1
P_1	Local prices of domestic commodities	n
P_2	Local prices of imported commodities	n
M	Demands for imported commodities	n
E	Exports	n
P_1^*	Foreign currency prices for exports	n
P_2^*	Foreign currency prices for imports	n
L	Demands for primary factors	k
P_3	Prices for primary factors	k
Y	Commodity output levels	n
Θ	Exchange rate ($A/$Foreign)	1
T	One plus ad valorem rates of protection	n
S	One plus ad valorem rates of export subsidy	n
L*	Factor employment levels	k
B	Balance of trade (foreign $)	1
ξ	Consumer price index	1
Q_{P3}	Shift terms in factor price equations	k
		Total = 10n+h+4k+4
$Q_D, Q_M, Q_E, Q_L, Q_Y, Q_V, Q_W$	Large number of variables designed to assist in the simulation of exogenous changes in technology, export demands, household preferences and indirect taxes	

II.1 Commodity and factor demands

ORANI recognizes six categories of demand for commodities: intermediate input demands, demands for inputs to capital formation, household demands, export demands, demands for margins (e.g., transport, wholesale and retail services) and miscellaneous other demands (e.g., inventory and government demands). Equations (1.1) and (1.2) in Table 1 are aggregations over the five domestic sources of demand for the 2n commodities recognized in the model (n domestically produced and n imported). Export demands are shown separately in equation (1.3).

According to equations (1.1) and (1.2), domestic demands depend on domestic activity variables (Z and C), on taste and technology variables (Q_D and Q_M) and on commodity prices. Following Armington (1969, 1970) domestic output and imports of the same commodity class are treated as imperfect substitutes. Hence the vectors of domestic (P_1) and import (P_2) prices appear in the demand functions for both domestic and imported commodities.

Equation (1.3) indicates that the world prices of commodities exported by Australia are assumed not to be independent of Australian export volumes. That is, the demand curves for Australian exports are downward sloping, not horizontal. The variable Q_E is usually exogenous and allows for shifts in the export demand curves.

The demand for primary factors (occupation-specific labour, industry-specific capital and region-specific land) depends, according to equation (1.4), on the domestic industry-activity variables (Z), on the technology variable (Q_L) and on factor prices (P_3). The fact that P_3 is the only price variable included in equation (1.4) reflects the ORANI assumption that while primary factors can be substituted for each other, they cannot be substituted for intermediate inputs. This also explains the absence of factor prices in the commodity demand equations, (1.1) and (1.2).

II.2 Commodity supplies

Equation (1.5) is an aggregation of the commodity output vectors across the h industries. Products produced in more than one industry and multi-product industries are included in ORANI. The vector of commodity outputs (Y(j)) produced by industry j depends on j's activity level (Z_j) and on domestic commodity prices (P_1). Changes in relative commodity prices will cause industries to move around their product transformation frontiers. The variable Q_Y allows for shifts in transformation frontiers associated, for example, with technological changes.

II.3 Pricing

The activities recognized in ORANI are production,[3] exporting and importing. In each case a condition of zero pure

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3. This includes production of goods and services and the creation of units of capital.

profits is imposed implying that revenue per unit of activity equals costs per unit of activity. In ORANI, the production functions exhibit constant returns to scale. Therefore costs and revenue per unit of production do not depend on the level of activity. Consequently, equation (1.6) can be written without reference to production levels - output prices depend only on input prices (including rental prices on capital) and on technology. Equations (1.7) and (1.8) equate the domestic currency prices of exports and imports to the domestic-currency equivalents of their foreign currency values plus any export subsidy or import tariff.

II.4 Market clearing

Equation (1.9) equates demand and supply for domestically produced commodities. In equation (1.10), L^* is the vector of factor employment levels. Thus (1.10) amounts to saying that employment demands (L) are satisfied. Equation (1.10) does not necessarily impose full-employment assumptions. Although we could set L^* exogenously at full-employment (or any other) levels, an obvious alternative would be to set some or all factor prices exogenously and to let the model determine the corresponding elements of L^*.

II.5 Miscellaneous equations

Many equations which are designed to facilitate applications are appended to ORANI. Three examples are equations (1.11) and (1.12) which define the balance of trade and the consumer price index and equation (1.13) which allows the introduction of different assumptions concerning wage indexation.

II.6 Solving the complete model

Table 1 represents schematically a model which is nonlinear in the levels of its variables. To solve the model we first linearize the equations by converting from the levels to the percentage changes of the variables. We can write the linearized model as:

$$Az = 0 \quad , \qquad\qquad (II.1)$$

where z is a $(q \times 1)$ vector of the percentage change variables and A is an $(r \times q)$ matrix containing the coefficients from the linearized equations. The number of variables (q) exceeds the number of equations (r),[4] hence $(q - r)$ of the variables must be specified exogenously. Denoting the $(r \times 1)$ and $((q - r) \times 1)$ vectors of endogenous and exogenous variables z_2 and z_2, respectively, we can rewrite (II.1) as:

$$A_1 z_1 + A_2 z_2 = 0 \quad , \qquad\qquad (II.2)$$

4. For the basic structural form of ORANI both q and r are <u>very</u> large, several million in fact (DPSV, 1982, section 32), although many of the variables are included primarily for accounting purposes and are of no policy interest. The model is condensed to a size manageable in the computer by straightforward algebraic elimination. In what follows it will be helpful to think of (II.1) as representing a suitably condensed form of ORANI with q and r being respectively the numbers of variables and equations in the condensed form.

where A_1 and A_2 are, respectively, $(r \times r)$ and $(r \times (q - r))$ submatrices of A.

As will become clear when we discuss applications, flexibility allowed to the user in assigning variables to the endogenous and exogenous lists is an important feature of ORANI. Alternative assignments allow us to use the model:

(i) with different time horizons. For short-run simulations we assume that shocks cannot alter the amount of capital available to each industry within the solution period but can change relative rates of return between industries. Hence industry-specific capital stocks are assigned to the exogenous list and industries' rates of return are endogenous. For long-run simulations the assignment is reversed implying the assumption that in the long run, changes in the relative sizes of industries (via net investment) will eliminate any tendency for shocks to disturb the established pattern of relative profitability across industries.

(ii) to represent different economic environments. For example, we might wish to impose a full-employment assumption in which case the amount of labour available would be exogenous with endogenous real wage rates adjusting to clear the labour market. Alternatively real wage rates might be exogenous and labour supplies endogenous. The latter, slack-labour-market, assumption is appropriate for an economy facing general unemployment and institutional constraints in the labour market which prevent wages falling to their full-employment levels.

(iii) to simulate different types of shocks. For example, if we assign to the exogenous list rates of protection against imports we can simulate the effects on the model's import-competing industries of changes in these rates. Alternatively, with protection rates endogenous and output levels in the import-competing industries exogenous, we can use the model to project the changes in protection rates which would be necessary to preserve output in the import-competing sector in the face of some other shock, a reduction in the world prices of imports for example.

With our solution technique, changing the list of exogenous variables is clearly straightforward from a computational viewpoint. All that is required is repartitions of the vector z and the matrix A in II.1.

Having made the endogenous/exogenous assignment of variables (II.2), solution proceeds by calculation of the matrix, E, of elasticities of the endogenous with respect to the exogenous variables. This matrix satisfies

$$A_1 E = -A_2 \ . \tag{II.3}$$

An obvious way to calculate E is via inversion of A_1,[5] i.e., to calculate

$$E = -A_1^{-1} A_2 \ . \tag{II.4}$$

This is the method described in DPSV (1982, chapter 5). More recently we have preferred a more efficient procedure which calculates E indirectly. The matrix A_1 is first factorized into

$$A_1 = LU \ , \tag{II.5}$$

where L and U are respectively lower triangular and upper triangular matrices. Next a matrix X is computed by forward substitution in

$$LX = A_2 \ . \tag{II.6}$$

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5. The matrix A_1 will not be invertible for all conceivable partitions of z but our experience is that the matrix is non-singular for partitions corresponding to sensible economic problems. Rather than establishing it a priori by formal means, we use the invertability of A_1 as a check on our economic logic in using the model.

Finally E is obtained by back substitution in

$$UE = X \quad . \tag{II.7}$$

The procedure (II.1), (II.2) and (II.5) - (II.7) is implemented using sparse matrix code (see Pearson and Rimmer, 1983).

Having computed E, we can calculate the effects on the endogenous variables of shocks to the exogenous variables via:

$$z_1 = E\, z_2 \quad . \tag{II.8}$$

Under the Johansen solution method the elasticities in E are treated as constants, calculated from a set of input-output accounts for some reference year and various econometrically estimated behavioural parameters (substitution and transformation elasticities, expenditure and price elasticities of household demand, etc.) - see DPSV (1982, especially sections 23-29 and 32). Thus (II.8) provides only an approximation to the exact solution of the non-linear model. Experience with ORANI indicates that the linearization errors are usually small (DPSV, 1982, section 47). In DPSV (1982, sections 31, 33 and 35) we have shown that error-free solutions can be obtained using (II.1) - (II.3) and (II.8) to evaluate the effects of shocks to the exogenous variables in steps, updating the data and recalculating E between each pair of steps.

III FORECASTING VS. POLICY ANALYSIS

The studies to be described in section IV are all "what if" policy analyses rather than forecasts. Our interpretation of these "what if" policy simulations will be explained with the aid of Figure 1 (see also Powell, Cooper and McLaren, 1983, pp.9-12). We measure (hypothetical) time on the horizontal axis with t^o representing the base year and t^* the solution year.[6] On the vertical axis we measure the level of some endogenous variable $((Z_1)_j)$. We assume that we know a control value $((Z_1)_j^c)$ for the variable, i.e., the value which it would take in the solution year given some control setting of the exogenous variables. In principle the control settings of all the variables come from the data base on which the model is implemented, that is, from projected input-output accounts and a set of behavioural parameters applicable to the <u>solution</u> year. In practice under the Johansen solution method only various ratios from the input-output data (cost and sales shares, for example) are required to compute the matrix A in (II.1); the levels of the individual prices and quantities underlying the data are not necessary. The usual procedure is to compute the required ratios from some recent historical input-output table, the assumption being that the implicit control projection of the data to the solution year would not alter these ratios (see Dixon, Parmenter and Rimmer, 1984). We then assume that some permanent shock is applied <u>in the base year</u> to the exogenous variables; i.e., starting in the base year, one or more of the exogenous variables is shifted from its control path to some new shocked path which differs by a time-invariant percentage from the control path. The vector z_2 in (II.2) and (II.8) contains percentage differences between the

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6. The calendar relationship between t^o and t^* (i.e., the length of the solution period) is only implicit. See below for a more extended discussion.

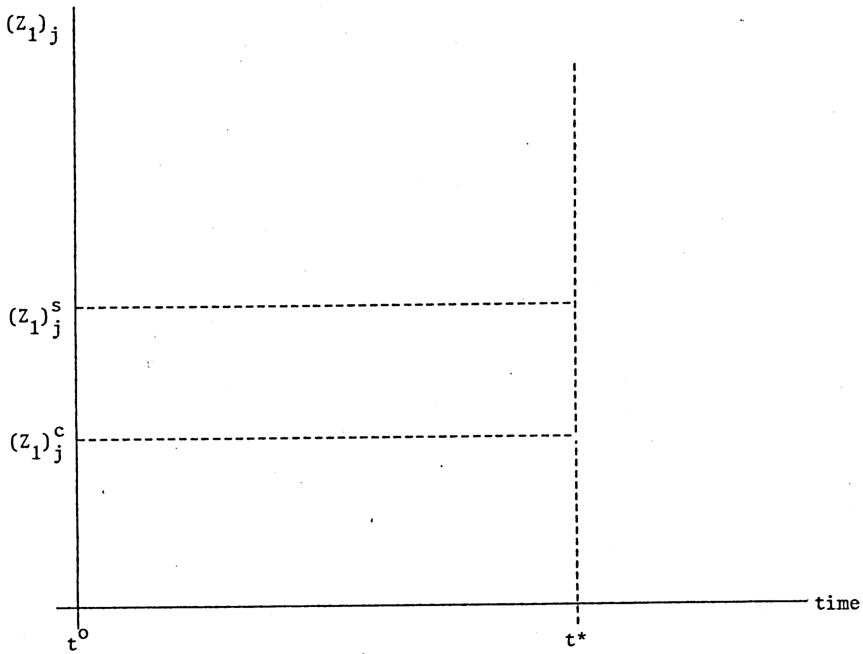

Figure 1

shocked and unshocked levels of the exogenous variables. The model then projects the effect of this shock on the endogenous variables in the solution year. The percentage-change projections (z_1) are interpreted as percentage differences between the values which the endogenous variables would take in the solution year with and without the shock. In the diagram $(Z_1)_j^s$ is the with-shock value for $(Z_1)_j$. The projection $(z_1)_j$ for the illustrated endogenous variable is the difference $(Z_1)_j^s - (Z_1)_j^c$ expressed as a percentage of $(Z_1)_j^c$.

A further issue of interpretation is the calendar-time relationship between the solution year and the base year, that is the length of the solution period, $t^* - t^o$ in Figure 1. ORANI identifies no explicit calendar time paths for its variables; there are no explicit lags for example. Rather, (II.8) represents a comparative-static solution with only an implicit calendar relationship between the solution and base years. The length of the implicit solution period must be consistent with the types of adjustment to the shock envisaged in the simulation. This depends on how the model is configured in making the particular simulation (i.e., on the choice of exogenous variables) and on the settings of various parameters. We have used ORANI in short-run mode (in which industry-specific capital availability is fixed and various substitution parameters are set to reflect what the data reveal about the degree of short-run flexibility in the economy) and in long-run mode (in which the rates of return on industries' capital stocks are fixed, the sizes of capital stocks are endogenous and all parameters set to reflect full adjustment). Empirical work on the calendar length of the ORANI short run indicates that a two-year interpretation is appropriate. This is based on comparisons between projections from ORANI and projections from a small macroeconometric model which has explicit timing (Cooper, 1983). Given the unreliability of medium-to long-run econometric forecasts, similar attempts to calibrate the ORANI long run are unlikely to be possible.

To what extent can this same framework be used for forecasting as opposed to "what if" policy analysis? One method for projecting the required solution-year control values for the model's variables would be to assume no change from the base year.[7] Our interpretation of projections for the endogenous variables subject to any shock to the exogenous variables would then imply that they are percentage differences between the with-shock values for the endogenous variables and their values in the base year. To complete the forecast we would use as our shock a set of percentage differences between independently forecast levels for the exogenous variables in the solution and base years.

A number of problems are immediately apparent with this forecasting story. One is that our shock (i.e., our independently forecast changes to the exogenous variables) cannot be regarded as imposed in a single base year (t^o in Figure 1). Instead the forecast shocks must be presumed to evolve over the period between the base and solution years. Unless we assume instantaneous adjustment it is not legitimate to assume that a new equilibrium would necessarily have been reached by the solution year t^*. It seems that an explicit timing for the variables in the model is needed for forecasting. (The technicalities of appending explicit dynamics to ORANI have been investigated, in another context, by Cooper and McLaren, 1980). Even ignoring this we would still be confronted with the practical problem of the immense information load entailed in making extraneous forecasts of the exogenous variables. These will usually include things such as technology, factor supplies, world prices and the

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7. Note that we assume that we have a solution to the model for the base year. This can be thought of as projected from available historical data.

settings of economic policy instruments about many of which economic science may have very little to say.[8] For "what if" policy analysis on the other hand we must assign as exogenous input nonzero values only to those elements of z_2 which reflect variables which we wish to shock. For example, in simulating the effects of a 25 per cent across-the-board increase in rates of protection against imports we would include percentage changes in the tariff rates on the exogenous list with values +25 and assign the value zero to all other exogenous variables. Each element of z_1 would then be interpreted as a projection of differences between the values of an endogenous variable (an industry's output level or aggregate employment, for example) in two alternative possible states of the economy which differ only in that in one all rates of protection are 25 per cent higher than in the other.

IV POLICY APPLICATIONS OF ORANI

Table 3 classifies a selection of publicly documented ORANI policy applications by the type of shock simulated and the variables for which projections are reported in the studies. In many cases this two-way classification provides an adequate description of the content of the studies. For example, the first study listed (Dixon,

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8. A related study is Dixon, Harrower and Vincent (1978) in which a large scale model of Australia (SNAPSHOT) was used to make an historical forecast of 1971 on the basis of a 1962-63 input-output data base and known changes in the exogenous variables between the reference and forecast years.

Table 3
A Taxonomy of ORANI Policy Applications

Endogenous variables of special interest (a)	Type of shock: Macro policy	Protection and industry policy: Across-the-board changes	Protection and industry policy: Industry-specific changes (b)	Other micro policy (c)	Exogenous pressures (d)
Standard ORANI output (macro variables, output by industry, employment by 9 occupations)	Dixon, Powell & Parmenter (1979, ch.3) Corden and Dixon (1980)† [wage-tax bargain]	DPSV (1982,ch.7) Cooper (1983)* IAC (1982a,b)	Sutton, Vincent & Zeitsch (1984)* [dairy industry] IAC (1981a)* [motor vehicles] IAC (1981b)* [wood products] IAC (1983a) [sugar] IAC (1983b)* [steel] IAC (1983c)* [dairy industry]	Meagher, Parmenter, Rimmer & Clements (1983)* [wine tax] Vincent, Dixon, Parmenter & Sams (1979) [oil pricing policy] Parmenter, Sams & Vincent (1979) [home-price schemes for exportables] Higgs (1981) [oil pricing policy] Warr & Parmenter (1984) [government procurement]	Dixon, Powell & Parmenter (1979,ch.4) [mining boom, terms of trade] Vincent, Dixon, Parmenter & Sams (1980) [oil price changes] Campbell, Crowly & Demura (1983) [drought]
Employment - by > 9 occupations	Chew (1984)	Cook & Dixon (1982) Dixon, Parmenter & Powell (1984) Chew (1984)	Dixon, Parmenter & Powell (1984)		Cook & Dixon (1982) [mining boom, terms of trade]
- by sex and birthplace		Cook & Dixon (1982)			Cook & Dixon (1982) [mining boom, terms of trade]
- by sex and migrant status	Chew (1984)	Chew (1984)			
- by age	Bonnell, Parmenter, Rimmer & Scorgie (1983)				
Regional effects	Dixon, Powell & Parmenter (1979,ch.3) IAC (1981c)†	DPSV (1982,ch.7) Higgs, Parmenter & Rimmer (1983)* IAC (1981c)†			IAC (1981c)† [mining boom]
Effects on trading partners		Warr & Lloyd (1983)			

(a) Generation of results for all but the first row of the table (Standard ORANI output) requires post-solution processing of the ORANI results in "add-on" computer programmes. Where "add-on" processing is used in studies in the first row the superscript † is used. This superscript is also used in the row labelled "Regional effects" to indicate where an extension of the standard ORANI regional equation system (DPSV, 1982, chapter 6) has been used.

(b) Notes in square brackets indicate the industry for which a change in protection is simulated.

(c) Notes in square brackets indicate the policy change simulated.

(d) Notes indicate the shocks simulated.

* Special-purpose version of ORANI used.

† See footnote (a).

Powell and Parmenter, 1979, chapter 3) contains projections of the effects of alternative macroeconomic strategies on macroeconomic indicators and on the industrial and employment structures of the economy. This study is also listed in the sixth row (first column) of the table indicating that projections of effects on the regional structure are also made. Where the description provided by the two-way classification is inadequate we include additional explanatory notes in square brackets. Finally, we use an asterisk (*) to indicate studies which use special-purpose versions of ORANI rather than the standard version. For example, in the second column, the study by Cooper (1983) uses a system which interfaces a short-run macroeconometric model with ORANI while the study by Higgs, Parmenter and Rimmer (1983) uses the Tasmanian version (ORANI-TAS). In the rest of this section we explain in more detail some of the studies classified in Table 3. The aim is both to illustrate the main policy conclusions which have been drawn from ORANI together with the mechanisms which underly them and to show how the model can be adapted to a wide range of policy contexts by post-solution manipulation of the results and by the implementation of special-purpose modifications to its structure.

IV.1 ORANI and macroeconomic policy

IV.1.1 The basic analysis

Studies using ORANI emphasize two aspects of macroeconomic policy in a small open economy such as Australia: the role of costs in the domestic economy relative to those of its trading partners and the structural implications of alternative macroeconomic strategies. The central study is Dixon, Powell and Parmenter (1979, chapter 3) which compares domestic demand expansion and wage-cost reduction as strategies for increasing domestic employment. Table 4 contains projections which are illustrative of the main results. Columns I and II show the projected effects of increasing real domestic aggregate demand (with real wages held constant) and of cutting real wage costs (with real domestic aggregate demand held constant), in both cases by amounts necessary to generate a 5 per cent increase in aggregate employment.

At the core of the contrast between the two sets of projections is that the demand expansion causes a marked increase in domestic costs relative to world prices whereas the cut in wage costs causes a marked reduction. These relative cost changes are indicated in the table by the CPI projections.[9] The demand expansion imposes a cost-price squeeze on the export sector causing it to contract and worsens the competitive position of the domestic import-competing sector allowing an increase in imports in excess of the increase in

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9. The results were generated from simulations in which the nominal exchange rate is the numeraire, the world prices of Australian imports are taken as exogenous (small-country assumption) and the elasticities of demand for Australian exports are generally assumed quite high. Hence the CPI projections are an accurate indicator of the crucial domestic cost/world price relative price index, often referred to as the real exchange rate (see Dixon, Parmenter and Powell, 1982).

Table 4
ORANI Projections of the Effects of Macroeconomic Policy Alternatives[(a)]

Variable	Policy I: 8.7% increase in real domestic aggregate demand[(a)]	Policy II: 9.7% cut in real wage costs	Policy III: 3.2% increase in real domestic demand plus 6.2% cut in real wage costs
Aggregate employment	5.0	5.0	5.0
Consumer price index (CPI)	14.8	-10.8	-1.4
Aggregate exports	-16.2	13.2	2.3
Aggregate imports	15.8	-6.1	1.9
Balance of trade (% GDP)	-4.6	2.7	0.0
Employment			
- skilled construction workers	9.3	1.0	4.1
- Victoria	6.8	3.7	4.8
- Queensland	2.2	7.4	5.5

(a) All projections are percentage changes except those for the balance of trade changes which are expressed as percentages of the GDP.

(b) Real domestic aggregate demand is defined as real domestic consumption, investment and government spending. The shares of the components in the total are held fixed.

Source: Calculated from Dixon, Powell and Parmenter (1979, Tables 3.1 and 3.3).

aggregate demand.[10] The wage-cost reduction on the other hand stimulates the export sector and allows the import-competing sector to increase its share of the domestic market. For these reasons the balance of trade deteriorates sharply with demand expansion but moves towards surplus following the wage-cost reduction.

Further insights into the structural effects of the two macroeconomic policy strategies can be gained from the final three rows of Table 4. First, there is an index of the employment of skilled construction workers, used here as an index of employment in the sectors of the domestic economy not closely associated with international trade (the "non-trading" sectors). It indicates that these sectors derive strong stimulation from domestic demand expansion but are relatively insensitive to wage costs.[11] Finally, the table contains projections of employment change for the least export-oriented (Victoria) and most export-oriented (Queensland) States in the Australian federation. From these it is clear how the uneven sectoral impact of the alternative macro policies translate into uneven regional incidence, the strength of regional stimulation and the degree of export orientation of the regional economy being negatively correlated for the case of the demand stimulation but positively correlated for the case of wage-cost reduction.

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10. Note that the spillover to imports of the domestic demand expansion is only partial: the expansion still causes stimulation of the import-competing sector.

11. Minor deviations between the rates of expansion of domestic aggregate demand and of the construction sector reflect reallocations of investment spending between capital formation of varying construction-intensities.

Columns I and II of Table 4 clearly reflect the implication of the ORANI simulations that the indirect effects of employment stimulation engineered via demand expansion are largely opposite to those of stimulation engineered by wage-cost reduction. Column III of the table contains projections of the effects of a package of the two policies designed again to give a 5 per cent boost to employment but avoiding any change in the balance of trade. With the package, the increase in employment is spread quite evenly over the exporting, import-competing and non-trading sectors and over the regions.

IV.1.2 The tax-wage bargain: an extension

Corden and Dixon (1980) have provided an extension of ORANI projections similar to those summarized in Table 4 in which they investigate the feasibility of implementing the macro package[12] (cf. column III of Table 4) via a tax-wage bargain. Under the bargain the reduction in real wage costs would be engineered entirely by a reduction in taxes on employing labour (P.A.Y.E. income taxes and payroll taxes, for example) so that real post-tax wage rates remain constant. The question is whether, given the implied effects of the bargain on non-wage components of disposable income (including unemployment benefits), the net effect on private disposable income is likely to be consistent with the increase in domestic aggregate demand required by the package.

12. A minor difference of detail between the packages analysed in Dixon, Powell and Parmenter (1979) and in Corden and Dixon (1980) is that the latter consider an increase in domestic aggregate demand devoted entirely to consumption rather than balanced across consumption, investment and government spending.

The standard version of ORANI lacks the public-finance details necessary to answer this question. Corden and Dixon filled in these details in some post-solution calculations. Their conclusion was that the bargain alone would be a feasible solution to the policy implementation problem only if the propensity to save the additional private disposable income were about 40 per cent, much higher than historical evidence suggests is likely.

IV.2 ORANI and protection policy

IV.2.1 Economy-wide effects

ORANI-based studies of the effects of changes in protection policy for the domestic import-competing sector have emphasized the role of interdependence between sectors, especially in an economy in which real wages are largely fixed by institutional factors independent of protection policy. The studies have generally focused on the short-run adjustment pressures imposed by reductions in protectionism rather than the long-run welfare effects. There are two reasons for this focus. Firstly, at least in the Australian case, the main obstacle to protection reform has been the unwillingness of politicians to confront the short-run adjustments rather than doubts about the long-run benefits. Secondly, as has been argued by Dixon (1978), Harris (1984) and others, the current generation of CGE models which assume constant returns to scale and fail to deal adequately with intra-industry specialization are unsuitable for assessing the long-run effects of trade policy.

As indicated in Table 3, ORANI has been used extensively to analyse the effects on the Australian economy of prospective changes in tariff policy imposed on an across-the-board basis and on particular industries or groups of industries. For many of the latter studies special disaggregations of the model's standard data base have been undertaken to provide more detail about the sectors directly affected. The economy-wide results of any reduction in protection, the aggregate-employment effects for example, can be understood as a combination of some bad news for the sector whose rate of protection is cut (and perhaps for some sectors which have strong forward input-output linkages to it) and some good news for the rest of the economy. The extent of the bad news depends primarily on the elasticity of substitution between the output of the directly affected domestic sector and the imports with which it competes; that is, on the extent to which imports increase their market share when their relative prices fall. The good news is transmitted via reductions in domestic costs relative to overseas prices which flow from the reduction in the domestic prices of the imports against which protective barriers have been lowered. The link between nominal wages and the domestic cost of living is the key element in this transmission process for most sectors; hence the direct and indirect weight of the relevant imports in the CPI is the crucial parameter. It is sectors for which selling prices are largely independent of costs, especially export sectors, which are most responsive to the good news.

For ORANI an extensive data-mobilization and econometric exercise has been undertaken to estimate values for the crucial bad-news parameters, i.e., commodity-specific elasticities of substitution between imports and domestic output (DPSV, 1982, section 29.1). Estimates range up to 6.8 (Footwear) and 5.0 (Motor vehicles). ORANI projections indicate that only for sectors facing the most severe import competition is the bad news in the directly affected sectors bad enough to outweigh the good news elsewhere (Dixon, Parmenter and Powell, 1984). Thus the model indicates that for most potential reductions in protection, the short-run effect on aggregate employment at fixed real-wage levels is unlikely to be significantly adverse: employment losses in the directly affected sectors are at least offset by employment gains elsewhere, notably in the export-dependent sectors.

IV.2.2 Regional effects: an extension

As indicated by Table 3, ORANI has been extended in a number of ways to provide policy information on the regional consequences of economic change. We outline these methods more fully by considering studies of the regional consequences of protection reform which, in addition to the aggregate employment effects, are another important aspect of the associated short-run adjustment problem.

DPSV (1982, section 45.3) report projections for the effects on gross state product and State employment of a uniform across-the-board change in ad valorem rates of protection. These projections were made using the standard ORANI regional equation system (ORES) which provides a tops-down, post-solution disaggregation to the State level of economy-wide ORANI projections (DPSV, 1982, chapter 6). ORES separates the industrial sectors in the ORANI data base into "national" industries (producing interregionally traded commodities) and "local" industries (producing commodities, mainly services, for which interregional trade is not possible, or at least insignificant).[13] For "national" industries the State allocation of economy-wide output changes is made exogenously, usually (but not essentially) on the assumption that States retain their base-period shares in industries' output levels. The State outputs for "local" industries are determined in ORES by regional balance computations which account for intermediate demand by the State's "national" and "local" industries and allow for a link between final demand and income generated in the State. Under ORES, therefore, State projections depend on differences across States in industrial structure and on regional income/expenditure multipliers. The State results reported in DPSV (see especially Table 45.7) indicate clearly why individual Australian States show considerable political interest in the protection issue. With changes in State labour income fully reflected in changes in State household expenditure, the results imply that a 25 per cent across-the-board

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13. ORES is thus an adaptation of the method of Leontief et al. (1965). The local/national dichotomy is especially appropriate for the State disaggregation of the Australian economy because of the geographical concentration of population within each State in population centres very distant from State boundaries.

cut in protection would cause in the short run a 0.4 per cent reduction in gross state product in Victoria (the State with the heaviest concentration of import-competing industry) but gains of 0.9 per cent and 0.7 per cent in Queensland and Western Australia (the most export-oriented of the States).

Higgs, Parmenter and Rimmer (1983) report similar results from a system in which ORES is appended to a special-purpose version of ORANI (ORANI-TAS) in which key "national" industries of the Tasmanian economy are included as separate industrial sectors in the economy-wide model. For example, whereas in ORANI the Tasmanian fruit growing industry is aggregated into an economy-wide industry "Other Farming (export oriented)", in ORANI-TAS Tasmanian fruit growing appears as a sector separate from the residual other farming activity. The ORANI-TAS solution is thus allowed to determine directly Tasmania-specific output responses for many of the State's most important "national" industries, output responses which are then transferred directly into ORES.

The net effect of using ORANI-TAS-ORES rather than ORANI-ORES is to recognize that a number of Tasmania's main "national" industries are rather more export-oriented than are the economy-wide sectors into which they are aggregated in ORANI. Hence ORANI-TAS-ORES projects a short-run gain in gross state product of 1.4 per cent from a 25 per cent across-the-board cut in protection whereas ORANI-ORES projects a gain of only 0.5 per cent.

From the viewpoint of the adjustment problems imposed by protection reform, the State level may not be a sufficiently detailed regional disaggregation. It is often argued, for example, that the most serious regional adjustment problems are those imposed on small country towns. IAC (1981c) examined this question by further disaggregating ORANI-ORES projections of the effects of an across-the-board cut in protection to 58 Australian Statistical Divisions. The results do not suggest any serious intra-state adjustment problems. The industrial structures of the Statistical Divisions are sufficiently diverse that contractions in import-competing activity are to a large extent offset by expansions in export-related sectors. Offsetting contraction in country areas with significant pockets of import-competing industry, for example, is the role of those areas as service centres for export-oriented primary industries.

IV.2.3 Protection and the structure of the labour market: a second extension

Dixon, Parmenter and Powell (1983) recognize that even though the aggregate-employment effect of a cut in protection is small, serious labour-market disruption may be caused if the cut leads to large-scale displacement of employees from particular occupations. Using a 72-occupation disaggregation of employment by industry, they analyse in post-solution calculations the labour-market implications of ORANI projections of the effects of alternative approaches to protection reform, including across-the-board cuts. They report an index of labour-market disruption which expresses the sum over 72 occupations of net losses of employment as a percentage of aggregate employment. This implies that labour market disruption is defined as occurring only if new vacancies created in any occupation are insufficient to allow absorption of workers displaced from that occupation. The results indicate that disruption generated by modest reforms in protection would not be unmanageably large in relation to the amount of disruption normally accommodated by the labour market. For example a 25 per cent across-the-board protection cut is projected to cause about 1/8th of the labour-market disruption observable from the labour-market statistics covering the intercensal period 1971-76 or about 1/20th of the disruption observable through 1966-71.

Using data which cross classify employment by occupation and other demographic characteristics (sex, birthplace and migrant status), Cook and Dixon (1982) and Chew (1984) have extended the analysis still further. They are able to provide information on the likely effects of tariff reform on demographic groups, assuming that the groups' shares in occupation-specific employment remain reasonably stable when the reform occurs. The key to the results is to understand that the occupational diversity of employment in most demographic groups constitutes a buffer to soften the impact on the groups of changes in the occupational structure, just as the industrial diversities of occupational and regional employment buffer the impact on occupations and regions of employment changes originating at the industrial level. Hence, Cook and Dixon and Chew generally fail to identify serious problems for employment in particular demographic groups as consequences of changes in protection policy.

IV.3 ORANI-WINE: a special-purpose study

A frequently raised question in Australian taxation policy is whether an indirect tax should be imposed to reduce the tax distortion between domestically produced wine (currently tax-exempt) and other alcoholic beverages (currently taxed at very high rates). The distortion exists largely as a means of supporting the Australian grape-growing industry. The standard version of ORANI is ill-suited to elucidate these issues since neither wine making nor grape growing are identified as separate sectors in the model's data, and since the standard parameter file is based on additive preferences, an assumption incapable of dealing with substitution effects between closely related consumer goods.

ORANI-WINE (Meagher, Parmenter, Rimmer and Clements, 1983) is an attempt to overcome these problems. Both grape growing and wine production are separately distinguished, with wine modelled as produced jointly (according to a constant elasticity of transformation specification) with spirits (brandy). Specialist spirit and beer producing industries are also included. Consumption behavior is respecified with additive preferences still assumed between alcoholic beverages as a group and all other commodities but with a non-additive utility specification for beer, wine and spirits within the alcoholic-beverages nest.

Table 5 gives the key results from this model for the case of a wine tax imposed at the same rate as the pre-existing tax on beer, a rate somewhat lower than that levied against spirits.

Table 5
The Projected Effects (in Percentage Changes) of a Wine Tax on Industry and Commodity Outputs in the Domestic Alcoholic Beverages Sector

	Wine and brandy	Spirits	Beer and malt	Total commodity outputs
Wine	-18.05			-18.05
Spirits	2.52	0.81		1.85
Beer and malt			-0.76	-0.76
Total industry outputs	-16.00	0.81	-0.76	

<u>Source</u>: Meagher, Parmenter, Rimmer and Clements (1983), Table III.3.

According to the model the imposition of the wine tax contracts the Wine and brandy industry (with a corresponding contraction in demand for grapes), stimulates the specialist spirit producer (although it loses market share in the spirit market to the wine and brandy producer) but causes a contraction in beer production. Although beer, wine and spirits are all <u>net</u> substitutes, the strength of the substitution effect between wine and beer is insufficient to outweigh the overall decline in the demand for alcoholic beverages. The general equilibrium effects of the tax outside the alcohol sector are projected to be small but not insignificant. Wine is a sufficiently important item in household expenditure (almost 1 per cent) for the tax, in the presence of full indexation of nominal wages to the CPI, to cause a significant rise in domestic costs with attendant adverse effects on the major trading sectors.

V. CONCLUSION

In this paper we have attempted to show how ORANI is being used in the provision of information for policy analysis and to illustrate the type of projections which emanate from the model. Two factors allow the model to be applied to such a wide range of questions. The first is that it is a very large, detailed model, able to be shocked in numerous dimensions and producing results (industrial structure, labour force structure, trade flows, etc.) of interest to a wide range of policy analysts. The second is that it has proved practical to extend the basic model both by way of post-solution manipulation of its projections and in constructing special-purpose versions to address issues not obviously addressable in the standard version. Underlying all this is our Johansen, linear solution method. Without it, computing problems would constrain seriously the scope of the modelling exercise and the ease with which modifications could be implemented.

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