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MULTIREGIONAL MODELLING OF THE AUSTRALIAN ECONOMY : EXPERIENCE FROM THE IMPACT PROJECT

by

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Contents

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I. INTRODUCTION

IMPACT is an economic research project supported by a number of agencies of the Australian Federal Government (especially the Industries Assistance Commission) and by the University of Melbourne and La Trobe University.[1] The main aim of the Project has been the development of policy information systems comprising formal models of aspects of the economy together with computer systems, documentation and training facilities necessary to make the models publicly accessible. To date users of the IMPACT models have included policy analysts at various levels of government, and academic and other private-sector researchers.

The relationship between economics and demography has been one aspect of research at IMPACT. BACHUROO is a demographic model which utilizes ideas from the "new home economics" (Schultz, 1973) in an attempt to account econometrically for economic aspects of the determination of demographic phenomena (marriage, fertility, etc.). The eventual aim is to use this economic/demographic basis in the projection of labour supply and of household consumption behavior at a disaggregated level. Experiments have been conducted with regional demographic projections as well as projections at the economy-wide level (Williams, Sams and Martin, 1982).

More orthodox multisectoral modelling has been the second main thrust of the Project. It is the regional aspects of this research which are the main concern of this paper. The centrepiece is ORANI, a multisectoral model of the Australian economy which distinguishes 112 industrial sectors and 114 commodity classes (Dixon, Parmenter, Sutton and Vincent, 1982; hereafter DPSV). ORANI-based analyses of numerous policy issues have been published. These include analyses of tariff rate changes, macroeconomic policy, world-trade developments, oil-price increases and changes in the structure of taxation.[2] For many of these issues, the effects on the economies of the individual States which constitute the Australian Federal system as well as the effects at the economy-wide level are of great policy significance. To meet the resulting need for regional analysis of economy-wide policy issues, ORANI includes a facility for the disaggregation of economy-wide projections to the State level. The facility uses "tops-down" principles. At the expense of the need for much more data on the structure of the individual State economies, it has proved possible to construct State-specific versions of the multisectoral model. These latter combine elements of both the "bottoms-up" and "tops-down" approaches to regional economic modelling, although falling short of a complete bottoms-up, multi-regional specification such as that employed by Liew (1982). Nevertheless, they can be expected to give more accurate State projections than those provided by the basic tops-down facility.

In this paper we review our experience with regional modelling in the multisectoral context and suggest the lines along which we plan further developments. In section II we outline the structure of ORANI, highlighting the scope for the elaboration of regional dimensions. Sections III and IV respectively contain brief descriptions of the basic State disaggregation facility and of the strategy employed in building State-specific versions of the multisectoral model. In section V we compare regional projections from the basic facility with corresponding projections from a State-specific version. Conclusions are given in section VI.

II. THE SCOPE FOR REGIONAL DIMENSIONS IN THE ORANI MODEL

ORANI is a multisectoral model in the tradition of Johansen (1960).[3] Formally the model consists of a system of simultaneous equations, with the number of variables (n) exceeding the number of equations (m). A solution to the system is taken to represent a conditional equilibrium for the economy, conditional, that is, on the values chosen for the (n - m) variables which are set exogenously. It is not necessary for the model always to reflect full market-clearing conditions often associated with general equilibrium systems. For example, in most short-run policy analysis real wage rates are set exogenously, with labour of all types assumed to be in excess supply at the going real wage rates.

The equations comprising the model fall into six main categories :

(i) commodity-demand equations. Commodities are demanded by industries as inputs to current production or capital formation, and by final users of three types : households, the government and foreigners (exports). All users regard imports and domestic supplies of commodities of the same input-output class as separate commodities, i.e., as less than perfect substitutes.

(ii) factor-demand equations, i.e., equations describing the demand by domestic industries for inputs of occupation-specific labour, of capital and of agricultural land to current production processes.

(iii) commodity supply equations. The model allows for multi-product industries and for the production of some commodities by more than industry. Hence equations are included which describe the output mixes of the multi-product industries.

(iv) pricing equations. These relate producers' selling prices to unit costs of production, and purchasers' prices to producers' prices, trade and transport margins, and commodity taxes.

(v) market clearing equations. Prices adjust to clear markets for domestic commodities. The treatment of factor markets varies, with factors often assumed to be in perfectly elastic supply at exogenous factor prices. This treatment is afforded to labour in most short-run simulations and to capital in the long run. Imports are always assumed to be elastically supplied at exogenous foreign-currency prices.

(vi) miscellaneous equations. These include definitions of macroeconomic variables (aggregate employment, aggregate trade flows, the balance of trade, the consumer price index, etc.) and various indexing facilities (e.g., wage indexation at user-specified rates).

The behavioral equations in the system are derived from orthodox neo-classical microeconomic foundations. For example, producers are assumed to minimize input costs subject to nested Leontief/CRESH production functions and to choose their output mixes to maximize revenue subject to inter-commodity transformation frontiers. Consumers are assumed to maximize utility subject to budget constraints. The inter-industry allocation of investment is assumed to respond to relative rates of return.

The standard version of ORANI is essentially an economy-wide model, which includes regional dimensions only incidentally.[4] The modelling methodology, however, readily allows regionalization on either an across-the-board or a piecemeal basis. The key is to realize that commodities, industrial sectors, final-demand categories and factor supplies can be defined on regional bases as well as according to conventional input-output classifications. To explain the implications of this we will consider briefly what modifications would be required for the six types of equations which constitute the model.

In the multiregional, multisectoral model, industries and commodities are defined on a regional basis as well as by their input-output categories, and domestic final-demand agents (households and government) are disaggregated to a regional basis. In specifying commodity demand equations it is now necessary to include equations describing the demand by each (intermediate or final) purchaser located in each region for commodities of each commodity class from each domestic regional source as well as from overseas. Commodities of a given type but sourced from different domestic regions could be modelled as perfect or imperfect substitutes. A single theoretical specification (e.g., CES or CRESH aggregation of regional commodity sources) could be employed, with differences across commodities in the degree of inter-source substitution being accommodated by differences in the substitution parameters. When industries are defined by regional location, available data on regional differences in technology within input-output sectors and on regional differences in the commodity composition of outputs can readily be incorporated in the model. Such differences are already included in the specification of agriculture in the standard version of ORANI.[5] Regional disaggregation of household final demand allows for the incorporation of regional differences in demand parameters, most obviously differences in the commodity composition of demand, and the determination of aggregate regional expenditure by regional disposable income.

In the regional model factor supplies can be modelled as region-specific, industry-specific or mobile between regions and/or industries. In short-run simulations, land and capital would usually be industry and region specific. In the longer run inter-industry and inter-regional mobility of all factors except land would be the appropriate assumption. Implementation of these alternative assumptions is made via the primary-factor market-clearing equations. In a similar way, commodity market-clearing equations reflect differences in the regional mobility of commodities. Since commodities of the same type but from different regional sources are regarded as separate commodities in the model, separate market-clearing equations are required for each source of each commodity type. In the case of commodities which are not traded between regions (most services, for example), the market-clearing equations collapse to regional commodity-balance constraints which force regional demand to be met by supply from the same region.

Since the regionalized model can include region-specific technology and regional primary-factor constraints, differences across regional sources of commodities in cost-based producers' prices can occur. The model includes a complete modelling of the trade and transport margins which account for the gap between producers' and purchasers' prices. Regional differences in transport costs can therefore readily be accommodated.

Once regional dimensions have been specified for commodities, industries, factor supplies and final demand, the computation of regional macroeconomic variables such as gross regional product and regional price indexes is straightforward. In the regionalized model, economy-wide macroeconomic variables are explicit aggregations of their regional counterparts.

Liew (1982) has specified a model which incorporates many of the features outlined above. It is a complete "bottoms-up" multiregional, multisectoral model implemented at a level of disaggregation of the Australian economy which distinguishes six States and 30 single-product industrial sectors. Economic agents (producers, consumers, etc.) in each State are separately identified and their decisions with regard to output, investment, commodity and factor demands, etc., are explicitly modelled at the State level, accounting for inter-State as well as inter-industry flows. Commodities of the same input-output category but from different States are treated as separate commodities which are regarded by users as imperfect substitutes. Factor supplies can be modelled as State-specific, industry-specific or mobile between States and industries. If economy-wide results are required, they are obtained by aggregation (across States) of the projections for State-specific variables. Note that a very similar specification could be used for a multi-country, multisectoral model.

Two major practical problems inhibit the implementation of models such as that specified by Liew. The first is the data problem. As well as a set of consistent State input-output tables, the model also requires data on inter-State commodity flows disaggregated by sectors of origin and destination. Only fragmentary State input-output data and almost no disaggregated data on inter-State trade are currently available in Australia. In compiling his multiregional input-output data base, Liew was therefore forced to rely on gravity methods (Leontief and Strout, 1963) together with the assumption that each industry's technology is constant across States. Primary estimation of regional behavioral parameters (substitution elasticities between alternative State sources of commodities for example) also proved impractical for Liew. Instead he completed his parameter file using values extrapolated from the standard ORANI data base.

The second practical problem is computing. Adding the 6-State dimension to a sectorally disaggregated model increases the size of the system dramatically. For example, adding the State dimension to an economy-wide multisectoral model distinguishing n industries and m commodities would increase the number of intermediate commodity flows to be explained from mn to 36mn. In order for the multiregional version to remain computationally manageable, some sacrifice is usually required, as compared to the economy-wide model, in the level of sectoral disaggregation and/or the range of intersectoral relationships which can be included. It should be noted, however, that developments in computer hardware and software continue to relax computational constraints at a very rapid rate (see, for example Pearson and Rimmer, 1983). It is our judgement that in the forseeable future, data deficiencies are likely to be a much more serious problem for multiregional modelling than are computing constraints.

As an alternative to producing a complete multiregional model, we have, at IMPACT, experimented with the piecemeal introduction of regional data into the economy-wide model. These experiments, which have proved very successful in meeting the demand for quantitative analysis of some important regional aspects of economic policy in Australia, are described in more detail in section IV. Before this, in section III we outline IMPACT's facility for "tops-down" disaggregation to the State level of results from the standard economy-wide version of ORANI. This in its own right is an important aspect of our research into regional modelling. In addition, it plays a key role in the application to policy issues of the partially regionalized versions of ORANI.

III. STATE DISAGGREGATION OF STANDARD ORANI RESULTS

The standard method for generating State-level results from ORANI is described in detail in Dixon, Parmenter and Sutton (1978) and DPSV (1982, chapters 6 and 7). It is an adaptation of a method proposed by Leontief, Morgan, Polenske, Simpson and Tower (1965), hereafter LMPST.

The ORANI-LMPST method accounts for differences in the industrial structures of the States and allows the introduction of State income-consumption multipliers, but it explains the intra-national geographical allocation of activity within an industry only for cases in which the geographical pattern of demand is the crucial factor, i.e., for industries producing commodities which are not traded between the States. The key assumption of the method is that the industries which are distinguished in the economy-wide model can be allocated to two non-overlapping groups : "national" industries the products of which can be traded freely between regions, and "local" industries producing goods which are not subject to inter-regional trade. For the "local" industries, regional demand is crucial in determining regional output. For "national" industries, the geographical pattern of production is assumed to be independent of the geographical pattern of demand. This dichotomy is very powerful in reducing the data requirements of the regional disaggregation. Because of the geographical distribution of population within the Australian States, it is particularly appropriate for State analysis of the Australian economy.[6]

An ORANI-LMPST solution for the effects on State r of an economy-wide disturbance entails a 3-stage computation (DPSV, chapter 6). *In the first stage*, ORANI is solved for the economy-wide results, i.e., for projections of the percentage effects on its endogenous variables of the shock under investigation. The ORANI solution can be represented as

$$z^{ew} = Ay^{ew} , \tag{1}$$

where z^{ew} and y^{ew} are vectors of the model's endogenous and exogenous variables. In levels of the variables, ORANI is a non-linear model, mainly because of the opportunities allowed for economic agents to modify their behavior in response to relative prices. Following Johansen (1960) it is solved as a linear system in the percentage changes of the variables (DPSV, chapter 5). The matrix A in equation (1) hence contains the elasticities of the endogenous with respect to the exogenous variables. The user of ORANI has a great deal of flexibility in partitioning the variables into exogenous and endogenous sets, but the endogenous variables will usually include economy-wide output and employment in each of the model's industries.

The second stage of the 3-stage computation is the allocation to the State level of the economy-wide output changes for the "national" industries. The model's theory does not explain the geographical distribution of output in these industries. An obvious rule to use for this allocation is that for each "national" industry the shares of the States in total output remain constant at base-period values.[7] This implies

$$z_N^r = z_N^{ew} , \tag{2}$$

where z_N^{ew} is a subvector of z^{ew} containing projected percentage changes in the economy-wide output levels of "national" industries, and z_N^r is a vector containing projections of output changes for these industries in State r. State projections of the output changes for the "national" industries are required both as an element in the aggregate impact of the shock on the State economy and because intermediate demands by "national" industries contribute to aggregate demand for the output of the State's "local" industries.

In the third stage of the ORANI-LMPST package a State commodity- balance equation is used to solve for the outputs of the State's "local" industries required to satisfy intermediate and final demands in the State. This can be represented by

$$z_L^r = (I - B_{LL}^r)^{-1} (B_{LN}^r z_N^r + d_L^r) , \tag{3}$$

where z_L^r is a vector of percentage changes in the outputs of "local" industries in State r and d_L^r is a vector combining those elements of final demand for the output of "local" industries in State r which are independent of the output changes of the State's industries. The matrices B_{LL}^r and B_{LN}^r are built up from the shares of "local" industry outputs accounted for by uses explainable as functions of the State outputs of "local" and "national" industries.[8] The State final demand vector (d_L^r) is itself computed from the results of the ORANI computation.

Together, equations (2) and (3) give projections of percentage output changes for all industries in State r. These projections can be used to calculate implied percentage changes in gross State product and aggregate State employment (see DPSV, subsection 45.3).

IV. STATE VERSIONS OF ORANI

In a federal system of government such as Australia's, there is a strong demand for information about the State effects of economy-wide policies. Negotiations between State and Federal governments are an important part of the policy-formation process. Moreover, State governments in Australia often intervene at the public hearings of bodies such as the Conciliation and Arbitration Commission (a wage-fixing tribunal) and the Industries Assistance Commission (which advises the Federal Government on tariff-protection policy). The ORANI-LMPST package which was described in the previous section has proved a useful device for elucidating these issues. Its major weakness is that the State allocation of output changes for "national" industries must be specified exogenously. The State versions of ORANI to be described in this section aim to reduce this weakness by including in the economy-wide model State-specific data about the major "national" industries in the particular State of interest. The result is a two-region model in which each of a number of industrial sectors is split into the component located in the particular State of interest and a residual component located in the rest of Australia. Such a model reflects the view that, for the range of policy issues to be addressed, it is the interaction of the particular State with the rest of the economy as a whole which is crucial rather than details of its interactions with other individual States.

To date a Tasmanian version of ORANI (called ORANI-TAS) has been completed (Higgs, Parmenter and Rimmer, 1983) and a Western

Australian version (ORANI-WA) is in preparation. The strategy of building single-State versions of the model largely avoids the two major difficulties with multiregional models which were discussed at the end of section II. Detailed intra- and inter-regional input-output data are required only for a subset of industrial sectors in each case and only for a single State. The subset of sectors of special interest will usually differ among the separate State versions. In the case of Western Australia, for example, interest is primarily in the export-oriented mining industries. These sectors are much less important in most other Australian States. Apart from initial data handling, the modifications to the existing ORANI-LMPST computing systems required in the implementation of the State versions have proved to be minor. The main reason is that no great increase in the size of the model is entailed.[9]

The relevant State version of ORANI (called ORANI-STATE for convenience) can replace the standard economy-wide version at stage one of the ORANI-LMPST procedure to produce projections of the effects of economy-wide shocks on the economy of a particular State ($State_i$) which are more reliable than the standard ORANI-LMPST projections. ORANI-STATE will include data specific to $State_i$ to identify as separate industries that State's components of those of its industries which might have characteristics (cost structures or sales patterns, for example) different from those of the corresponding industries in the rest of Australia. (In the Tasmanian version of ORANI for example we identify as separate industries "Fishing (Tasmania)" and "Fishing (Mainland"; see section V.) ORANI-STATE can be used to produce projections of the effects of shocks on all industries at the economy-wide level, and separate projections of the effects in $State_i$ and in the rest of Australia for the selection of industries for which the State-specific data have been introduced.

Clearly, the distinction of the separate State component of an industry in the model will be worthwhile only when those aspects of the standard ORANI theory which determine the relative responses of industries to shocks can be expected to throw some light on geographical differences in output changes in the industry. Differences in technology are one important factor. These determine the relative changes in industries' price/cost ratios caused by price and wage changes in the economy, and industries' relative responses to such changes. Differences in sales patterns among domestic users, and more crucially between domestic and overseas sales, are another cause of inter-industry variation in ORANI projections. If the intranational location of demand is an important factor in locating output changes (i.e., if inter-regional trade is restricted), then geographical definitions for industries will not be useful since the geographical demand pattern is not modelled in the economy-wide model, i.e., at stage one of the ORANI-LMPST (or ORANI- STATE-LMPST) procedure. It is however modelled at stage three of the procedure and used to determine the geographical pattern of output for "local" industries (cf. equation (3)). Thus it is clear that the State industries selected for explicit treatment in ORANI-STATE must all be industries which are classified as "national" in the ORANI-STATE-LMPST package. Otherwise the package would contain competing explanations of the output level for some industries; one at stage one of the package in ORANI-STATE itself, and another at stage three in the modified LMPST solution.

When the LMPST method is used in conjunction with a State version of ORANI in which the components in $State_i$ of major "national" industries are identified separately, then the essentially exogenous geographical allocation of the output projections for those industries (at stage two) creates no problems. Changes in the geographical pattern of output in the relevant industries are already incapsulated in the z_N^{ew} projected by ORANI-STATE. Equation (2) is then quite appropriate - all it does is transfer into the modified LMPST solution (equation (3)) the State output change determined in ORANI-STATE.[10] ORANI-STATE-LMPST will produce reliable projections for its State which are superior to those from ORANI-LMPST to the extent that the main State "national" industries are distinguished in ORANI-STATE, and to the extent that the model's theory is capable of explaining State differences in output responses within those "national" industries.

V. RESULTS : THE EFFECTS ON THE AUSTRALIAN AND TASMANIAN ECONOMIES OF A 25 PER CENT ACROSS-THE-BOARD INCREASE IN ALL TARIFF RATES

ORANI-TAS is a version of ORANI which includes explicit representation of parts of the Tasmanian economy.[11] In this section we compare projections from ORANI-TAS-LMPST with corresponding projections from the standard ORANI-LMPST package. The projections are of the short-run effects on Tasmania and on Australia as a whole of a general increase in the levels of protection against imports enjoyed by domestic industries. Real wage levels and the levels of aggregate real domestic consumption, investment and government spending are assumed not to be affected by the increase. A detailed analysis of the economy-wide and State results of the general tariff increase, under the same assumptions but derived using the standard ORANI-LMPST package, is provided in DPSV, chapter 7. Here we concentrate on the differences between those results and the results generated via ORANI-TAS; that is we attempt to show how adding Tasmanian detail to the model changes our estimate of the relative Tasmanian and economy-wide effects of the economy-wide shock.

V.1 A comparison between the economy-wide macroeconomic results from ORANI and ORANI-TAS

Table 1 lists the macroeconomic effects in ORANI and ORANI-TAS of the tariff increase. The most striking feature of the table is the similarity between its two columns. Both ORANI and ORANI-TAS project that the tariff increase will raise the domestic price level,

TABLE 1 : THE EFFECTS ON MACROECONOMIC VARIABLES IN ORANI AND ORANI-TAS OF A 25 PER CENT ACROSS-THE-BOARD TARIFF INCREASE[a]

Variable	ORANI	ORANI-TAS
Index of Consumer Prices	2.23	2.19
Aggregate Exports (foreign currency value)	-2.55	-2.56
Aggregate Imports (foreign currency value)	-1.60	-1.62
Balance of Trade	-0.03	-0.03
Aggregate Employment	-0.20	-0.20

NOTES

(a) All projections are percentage changes with the exception of the balance of trade which has the units "billions of 1968/69 Australian dollars".

reduce exports as well as imports, and cause slight reductions in the balance of trade surplus and aggregate employment. The key to understanding the general-equilibrium analysis of protection in the Australian economy is the recognition of the adverse effects on exports. It is reassuring that the magnitudes of these effects in ORANI and ORANI-TAS are so similar. We would not expect significant differences in economy-wide projections to be caused by disaggregation of the Tasmanian and mainland components of industries in a way which leaves unaffected the overall size of input-output flows in the model's data base and the average values of its parameters. This is especially so since Tasmania accounts for only a small share (about 2.5 per cent) of Australian GDP.

The minor differences between the columns of Table 1 are explained by the fact that in ORANI-TAS the economy is treated as slightly more export oriented than in the standard version of ORANI. Our practice is to treat as endogenously determined, exports of all commodities for which export sales account for more than 20 per cent of total sales. Export demand elasticities for most of these "export" commodities are assumed to be fairly high (see DPSV, subsection 29.6) so that the domestic prices of the commodities can be regarded as determined by approximately exogenous world prices. In ORANI-TAS there are two industries (Other Farming Export (Tasmania) and Milk Products (Tasmania)) which meet the criterion although the economy-wide categories in which they are aggregated in the standard ORANI data base do not.[12] Thus in ORANI-TAS a slightly higher share of total exports are subject to a cost-price squeeze on account of the tariff increase and the fall in aggregate exports is slightly higher. Similarly a slightly greater proportion of the CPI weights correspond to commodities whose domestic prices are held down by world-market conditions. The rise in the CPI projected to follow from the tariff increase is slightly less and domestic import-competing industries replace a slightly greater amount of imports.

V.2 Output results for the industries regionalized in ORANI-TAS

Table 2 permits us to compare -

(i) the ORANI-TAS output projections for the Tasmanian components of the regionalized industries with the projections for the mainland components, and

(ii) the ORANI-TAS output projections for the regionalized industries with the ORANI projections for the corresponding industries.

As well as the ORANI and ORANI-TAS projections for the relevant industries, the table also includes the results of a back-of-the-envelope (BOTE) explanation of the ORANI-TAS projections for the regionalized export industries. The BOTE explanation follows closely the explanation of the export-industry results given in DPSV, subsection 45.2.1. It uses the following short-run supply function which is implied by the CES primary-factor nests of the projection functions used in the models :

$$z_j = \frac{\sigma(1-S_{Kj})}{S_{Kj}} \left(p_{0j} \frac{1}{S_{Vj}} - p_{Ij} \left(\frac{1}{S_{Vj}} - 1\right) - w \right) , \qquad (4)$$

where z_j, p_{0j}, p_{Ij} and w are percentage changes, in turn, in the output of industry j, the basic price of its output, the average

TABLE 2 : OUTPUT PROJECTIONS[a] FROM ORANI AND ORANI-TAS FOR INDUSTRIES REGIONALIZED IN ORANI-TAS: 25 PER CENT ACROSS-THE-BOARD TARIFF INCREASE

ORANI Industry	ORANI Projection	ORANI-TAS Industry	ORANI-TAS Projection	BOTE[b] Explanation of ORANI-TAS Export Industry Projections: BOTE Estimate (via eq. (7))[c]	Cost Shares[d] S_{Kj}	Cost Shares[d] S_{Vj}
Other farming export	-1.42	Other farming export (T)[e]	-4.94	-4.63	.34	.46
		Other farming export (M)	-1.39	n.a.[f]		
Fishing	-2.54	Fishing (T)	-2.00	-2.04	.41	.77
		Fishing (M)	-2.53	-2.33	.48	.51
Iron	-0.28	Metallic minerals (T)	-2.13	-1.85	.51	.57
Other metallic minerals	-1.85	Iron (M)	-0.27	-0.23	.87	.72
		Other metallic minerals (M)	-1.74	-1.69	.52	.60
Milk products	0.01	Milk products (T)	-4.11	-23.23	.30	.11
		Milk products (M)	0.02	n.a.		
Pulp, paper	0.31	Pulp, paper (T)	0.27	n.a.	.41	.39
		Pulp, paper (MP	0.31	n.a.	.09	.27
Basic iron and steel	-2.18	Basic metals (T)	-2.04	-4.21	.50	.26
Other basic metals	-2.25	Basic iron and steel (M)	-2.16	-5.32	.37	.35
		Other basic metals (M)	-2.25	-5.88	.47	.21

(a) All projections are percentage changes.
(b) Back-of-the-envelope.
(c) The value for σ in equation (7) is 0.5 for all commodities.
(d) S_{Kj} and S_{Vj} are, respectively the share of fixed factors in total primary costs and the share of value added in total costs of industry j.
(e) (T) indicates Tasmania. (M) indicates Mainland.

price of its intermediate inputs and the nominal wage rate; σ is the elasticity of substitution between labour and fixed factors of production; and S_{Kj} and S_{Vj} are the shares of fixed factors in total primary costs in industry j and of primary factors in total costs. Nominal wage rates are indexed to the CPI in our simulation. In using (4) to explain our Export-industry results we assume that the average price of intermediate inputs moves in line with the CPI, that is, for each export industry j, we assume

$$p_{Ij} = w = cpi = 2.19 \quad , \tag{5}$$

where cpi is the percentage change in the CPI in the ORANI-TAS simulation and its value (2.19) is taken from Table 1. Finally, for export commodities a good approximation to the ORANI-TAS projections is to assume that selling prices are fixed, i.e.,

$$p_{0j} = 0 \quad . \tag{6}$$

This is because elasticities of demand on foreign markets for these commodities are assumed to be high.

Using (5) and (6), (4) reduces to

$$z_j = \frac{\sigma(1-S_{Kj})}{S_{Kj}\ S_{Vj}} \ .\ 2.19 \quad . \tag{7}$$

As can be seen from Table 2, equation (7) is a good explanation of the ORANI-TAS output projections for six out of the ten regionalized export industries. For industries whose selling prices are more or less fixed on world markets, ORANI projections of short-run responses to domestic cost shocks depend primarily on primary-factor cost shares which, given the production functions assumed in the model, determine industries' supply elasticities. In general, the more capital intensive is an industry the less willing is it to vary its output in the short-run.

For the Tasmanian Milk products and Basic metals industries and for the mainland Basic iron and steel and Other basic metals industries, equation (7) does not provide a good explanation. The problem is that for these industries the assumption that the average price of intermediate inputs moves in line with the CPI is not appropriate. Each buys its major intermediate input from another export or export-related industry whose selling price on the domestic market is assumed to be held down by an (approximately) fixed world price. Thus (5) is an overstatement of the rise in the prices of purchased inputs for these four industries and, as can be seen from Table 2, (7) overstates the severity of the effect of the cost-price squeeze on their outputs. Note however that within the basic metals group, (7) still explains the ORANI-TAS ranking of the output responses of the three regionalized industries.

We have not included in Table 2 BOTE explanations of the output responses of the regionalized non-export industries. For these, (7) would not be sufficient because the domestic output price ($\dot{p}_{0j}$) could not be set exogenously. For industries without the alternative of selling their outputs on world markets, output price is determined by the interaction of domestic supply and demand. In principle we could add a domestic demand equation and use the two-equation BOTE system to explain simultaneously the ORANI-TAS projections for output and domestic prices. However, for domestically oriented industries output prices move closely with input costs; that is, the difference computed in the term in square brackets on the RHS of (4) is usually very small. To fix this difference with sufficient accuracy requires us to use detail from large sections of the model's data files - approximations like (5) are inadequate. In these circumstances BOTE calculations cease to be useful in explaining the magnitudes of the model's projections. As can be seen from Table 2, introducing in ORANI-TAS regional detail about the non-export industries (Other farming export (M); Milk products (M); Pulp, paper (T) and Pulp, paper (M)) does not alter their sensitivity to the tariff shock from what was projected in ORANI.

V.3 Statewide and economy-wide results

A summary of our projections of the effects of the 25 per cent across-the-board tariff increase on output and employment in Tasmania and in Australia as a whole is given in Table 3. The Tasmanian results in the first two columns of the table are derived from the LMPST package used in conjunction with the standard version of ORANI. The corresponding results derived from ORANI-TAS and LMPST are given in the second two columns. Both sets of computations suggest that the adverse effects on Tasmania of the tariff increase would be more severe than the effects on the national economy.[13] For the six regionalized "national" industries ORANI-TAS allows a divergence between output performance in Tasmania and economy-wide. On average ORANI-TAS projects that these industries would do worse

TABLE 3 : PROJECTIONS FROM ORANI AND ORANI-TAS OF THE EFFECTS OF A 25 PER CENT ACROSS-THE-BOARD TARIFF INCREASE ON TASMANIAN AND AUSTRALIAN GROSS PRODUCTS AND EMPLOYMENT LEVELS[(a)]

	ORANI-LMPST		ORANI-TAS-LMPST	
	Gross Product	Index of Aggregate Employment	Gross Product	Index of Aggregate Employment
Tasmania	-0.54	-0.66	-1.40	-1.59
Australia	-0.12	-0.20	-0.11	-0.20

(a) All projections are percentage changes.

in Tasmania than did the corresponding economy-wide industries in ORANI (see Table 3). This accounts for 0.11 of the 0.86 percentage points difference between the two Tasmanian gross product projections in Table 3. The remaining 0.75 percentage points are accounted for by reduced output in Tasmanian "local" industries attributable to negative multiplier effects in the deteriorating State economy.

VI. CONCLUSION

Regional modelling based on IMPACT's economy-wide, ORANI model has proceeded along three lines. Liew (1982) experimented with a complete "bottoms-up" multiregional specification. This approach is theoretically appealing but from the point of view of quantitative policy analysis, its usefulness is currently circumscribed by data and computing difficulties.

The second line of development has been based on "tops-down" disaggregation of results from the economy-wide model to a State basis. For the range of policy issues for which it was designed, namely the effects of economy-wide policy on the State economies, this second line of research (the ORANI-LMPST package has proved very productive. State results from the package depend on differences among the States in industrial structure and on State income multipliers.

A third line of development, incorporating elements of both the "bottoms-up" and the "tops-down" approaches, has been reported in this paper. This approach (Higgs, Parmenter and Rimmer (1983)) has three main virtues. First, it allows important elements of a State's economy to be analysed conjointly with the national economy without requiring the massive data inputs of the "bottoms-up" approach. Second, the method is computationally tractable. The system developed under the new paradigm (ORANI-STATE-LMPST) is computationally identical to the purely "tops-down" (ORANI-LMPST) system and so can be implemented without extensive software development. An ORANI-STATE model itself is one example of the way in which special-purpose versions of ORANI can be developed to provide projections for particular sectors (or regions) which are more detailed than those available from the standard model (see Meagher, Parmenter, Rimmer and Clements, 1983).

ENDNOTES

* This paper draws on regional research done over a number of years by researchers associated with the IMPACT project. In particular, Peter Dixon, Peter Higgs, Liew Leong-Hoe, Russell Rimmer and John Sutton all played important roles. At a number of points, especially in section V the presentation in this paper follows closely that of Higgs, Parmenter and Rimmer (1983). Peter Higgs and Alan Powell provided valuable comments on an earlier draft.

1. The Industries Assistance Commission is responsible for advising the Australian Government on industry policy, especially tariff-protection policy. For an account of the establishment of the Project and its main aims, see Powell (1977). Institutional details are updated in Powell (1983).

2. For references to some of these, see DPSV, section 50.

3. Models of this general type are often referred to in the literature as computable general equilibrium models (CGEM's). Example of models of this general type, but not necessarily following the Johansen style, are Adelman and Robinson (1978), Boadway and Treddenick (1978) and Dervis (1980). For a complete technical description of ORANI, see DPSV (1982).

4. The incidental inclusion of a regional dimension occurs in the model's agricultural sector. Given the importance of geographic and climatic factors in Australian agricultural technology, agricultural industries in ORANI are defined on a geographic, rather than a commodity, basis (see DPSV, subsection 28.2.1).

5. See footnote 4.

6. The bulk of Australia's population is concentrated in metropolitan centres located hundreds of miles from the State boundaries. In implementing the modified LMPST method, it proved possible to classify industries accounting for 53 per cent of the economy's total employment and value added as "local".

7. Other rules could be used so long as they imply State output changes appropriately weighted averages of which give back the original economy-wide change. Cf. DPSV, section 42.

8. For details see DPSV, section 39. In implementing the equivalent of equation (3) some elements of final demand (e.g. demand for investment goods and, via a labour-income consumption link, household demand) were expressed as functions of z_N^r and z_L^r. DPSV, equations (39.29) and (39.30).

9. For the case of ORANI-TAS only 6 new regional sectors were created. For ORANI-WA the number is 11. For computing convenience we chose to keep the total number of sectors in the State versions equal to the number in the standard version of ORANI by aggregation of some of the service sectors.

10. In other words, it is quite appropriate to assume that the share of State_i in the total output of a State_i industry distinguished in ORANI-STATE remains fixed at its base-period value - the share must always be one.

11. Tasmania is the sole offshore island in the Australian Federation.

12. By making the Tasmanian disaggregations we have treated the production of directly exported fruit separately from the production of sugar cane although both these activities are aggregated in a single industry (Other farming export) in the standard data base. Similarly we have recognized that the Tasmanian dairy industry is more heavily oriented towards exportable milk products than is the mainland industry which concentrates largely on the production of whole milk for the domestic market.

13. When ORANI-LMPST is used to project the effects of the tariff increase on each of the six Australian States, Tasmania ranks third (after Queensland and Western Australia) in the ranking of States according to the severity of the impact of tariff increase. See DPSV, Table 45.7.

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