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SPATIAL DISAGGREGATION OF ORANI RESULTS : A REGIONAL BALANCE METHOD

by

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1. INTRODUCTION

ORANI is a disaggregated general equilibrium model of the Australian economy.[1] It is a multi-purpose model and recent applications have included the following[2] :

(i) a simulation of the effects of a devaluation on industry outputs, employment, the price level and the balance of trade under conditions of 70 per cent wage indexation ,

(ii) a simulation of the effects of a uniform across the board increase in tariffs on industry outputs, employment, etc.,

(iii) a simulation of the effects of increased export revenue (resulting from the mining boom) on industry outputs, employment, etc.,

(iv) a simulation of the effects of the wage explosion and equal pay for women on industry outputs, employment, etc.,

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1. ORANI is fully described in Dixon, Parmenter, Ryland and Sutton [1977], hereafter DPRS. It has been developed as part of the IMPACT Project. For a complete but non-technical description of IMPACT, see Powell [1977].

2. Applications of ORANI are reported in DPRS, Dixon, Harrower and Powell [1977], Dixon, Parmenter and Sutton [1977a and 1977b], Parmenter [1977], and Industries Assistance Commission [1977].

(v) a simulation of the effects of changes in Australia's terms of trade on industry outputs, employment, etc..

In all of these simulations, results have been reported at the national level only.[1] This paper proposes a method for allocating the national results to the states.[2] For example, in its present form, ORANI allows us to analyse the effect of tariff changes on the Australia-wide demand for labour by occupation. With the extension proposed here, we will be able to look at the effects of tariff changes on occupational labour demands at the state level.

Our method for regionalizing the ORANI results is adapted from the work by Leontief, Morgan, Polenske, Simpson and Tower [1965] (hereafter LMPST). The main advantage of the LMPST approach is that it is very economical in its data demands. In particular it avoids the necessity for detailed information about inter-regional trade flows.

The paper is organized as follows. Section 2 describes the theory of our regional computations. Section 3 outlines the construction of the necessary data base and section 4 reports an illustrative application. The results in section 4 are concerned with the implications for employment and output in each state of a 25 per cent increase in all tariffs. It will be clear, however, that our results are preliminary and that the emphasis of the paper is on the development of the method and data for regionalizing ORANI results.

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1. Industries Assistance Commission [1977] is an exception. It contains some preliminary regional results derived from ORANI computations.

2. In our applied work we aggregate the Northern Territory with South Australia and the Australian Capital Territory with New South Wales.

2. THE MODIFIED LMPST METHOD

A method for estimating the regional effects of an economic disturbance using a minimum of regional data is suggested in LMPST. Technology within an industry is assumed not to depend on regional location so that only national I-O data is required. Industries are divided into two distinct groups, national industries and local industries, on the basis of the degree of inter-regional trade in their products. National industries produce goods which are readily transferable between regions - steel for example. No intra-regional balance between demand and production is required for national goods. Commodities produced by local industries are non-transferable between regions so that the demand within a region for local goods must be met by production within that region. Services such as retail trade are the most obvious examples. The base period shares of each region in the aggregate output of national goods are required data for the LMPST method. The adaptation of the method to be presented here requires this information for local industries as well.

The computation suggested by LMPST proceeds in three stages. First, the national effects of an exogenous change[1] are computed via a conventional I-O model. This gives the new economy-wide output levels of all (national and local) industries. Next, the new outputs of the national industries are allocated to the regions in the same proportions as were evident in the base period. Finally, the new regional levels of output for the local industries are computed in a second I-O calculation which imposes regional balance between demand for and local output of local goods subject to regionalized exogenous changes in non-household final demand and

1. In LMPST the change considered is a reduction in military spending compensated (in terms of its aggregate employment effect) by an increase in non-military final demand.

to the changes in the regional output of national goods determined at stage two of the calculation. At this final stage households are treated as a local industry and the relevant I-O matrices are augmented to include a household row (wages) and column (personal consumption). Regional consumption is thus forced to change in the same proportion as regional labour income.

The LMPST method has three principal advantages. Firstly, the computations proceed sequentially so that no direct modification to the national model is required in order to facilitate the regional disaggregation of its results. Secondly, the regional data requirements are minimal : they certainly fall far short of the necessity for a complete set of regional I-O tables. Thirdly, the method possesses the attractive aggregation property that the sums of the regional results are always equal to the national results.[1]

In this paper, the I-O model used as the national model by LMPST is replaced by the ORANI model. The regional allocation of changes in the outputs of the national industries is made on the same proportional assumption as is employed by LMPST. Their basic method for regionalizing the effects on the local industries is also retained although modifications are introduced to allow greater flexibility in the treatment of the household sector and to make this final computation compatible with input from ORANI. Unlike the national I-O model used in LMPST, ORANI is solved in the percentage changes of its variables.[2] If the model is used to simulate the effects of a hypothetical policy change (a tariff cut, for example), the results include

1. The Appendix is a discussion of the aggregation properties of the modified LMPST method described in this paper.

2. See DPRS, ch. 2, section 1.

projections of the consequent percentage changes in the output levels of each of the model's industries[1] as well as percentage changes in the final demands for all commodities. Our modification of the LMPST procedure enables an estimate to be made of the percentage change in the output of each industry in each region.

2.1 Notational Conventions

In the algebraic description of our modified LMPST method, the following notational conventions are employed :

J is the set of all industries .

L is the set of local industries .

N is the set of national industries .

For vector or matrix variables the upper case subscripts J, L and N are used to denote sets of components for all industries, local industries and national industries respectively .

Bracketed superscripts are "usage" indicators :

(1) denotes intermediate usage ,

(2) denotes capital formation ,

(3) denotes household consumption ,

(4) denotes international exports ,

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1. The data base for the current version of ORANI is the ABS 1968-69 I-O tables. These tables distinguish 109 industries.

(5) denotes "other" final demand[1].

The unbracketed superscript, r, denotes region, r taking the values 1 to R. The omission of a regional superscript indicates that the variable in question refers to an aggregate for Australia as a whole. Values for such aggregates are obtained from the national ORANI computations.

Upper case symbols for variables indicate that the relevant units are levels. The corresponding lower case symbols indicate the appropriate percentage change variable[2].

Thus, for example,

$X_i^{(3)r}$ = the household consumption of good i in region r,

$x_i^{(3)r}$ = the percentage change in $X_i^{(3)r}$,

and

$x_L^{(3)r}$ is a vector of percentage changes in household consumption of local goods in region r, i.e., $x_L^{(3)r}$ is the vector formed from the $x_i^{(3)r}$ for $i \epsilon L$.

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1. This system is used in most of the ORANI documentation. See, for example, DPRS.

2. This system is used extensively in the ORANI documentation.

2.2 Algebraic Representation of the Modified LMPST Method.

2.2.1 Balance equations for national and local goods

We first assume that

$$X_n^r = X_n D_n^r \quad \text{for all } n\epsilon N \text{ and } r = 1, \ldots, R, \tag{1}$$

where

X_n^r is the output of industry n in region r,

X_n is the aggregate output of industry n,

and

D_n^r is the base period proportion of the aggregate output of industry n which is produced in region r.

Thus we are assuming a fixed regional distribution of the outputs of national industries and equation (1) implies

$$x_n^r = x_n \quad \text{for all } n\epsilon N, r = 1, \ldots, R. \tag{1a}$$

Equations (1) and (1a) correspond to equation (7) in LMPST. If there is a one per cent increase in the economy's aggregate output of steel (say), output of steel in all steel producing regions is assumed to increase by one per cent.

Next we impose balance constraints between the regional outputs of and the regional demands for local goods.

$$X_i^r = \sum_{n\epsilon N} A_{in}^{(1)} X_n^r + \sum_{\ell\epsilon L} A_{i\ell}^{(1)} X_\ell^r + \sum_{n\epsilon N} A_{in}^{(2)} Y_n^r + \sum_{\ell\epsilon L} A_{i\ell}^{(2)} Y_\ell^r + X_i^{(3)r} + X_i^{(5)r}, \tag{2}$$

$$\text{for all } i\epsilon L, r = 1, \ldots, R,$$

where :

Y_j^r is the investment by industry j in region r ,

$X_\ell^{(3)r}$ is the household consumption of good ℓ in region r ,

$X_\ell^{(5)r}$ is the "other" final demand for local good ℓ in region r ,[1]

$A_{ij}^{(1)}$ is an element from the local industry rows of the national matrix of I-O coefficients. It shows the intermediate input of good i required per unit output of good j ,

and

$A_{ij}^{(2)}$ is an element from the local industry rows of the national matrix of investment coefficients, i.e., $A_{ij}^{(2)}$ is the input of good i required per unit of investment for industry j .

The RHS of equation (2) sums the various categories of demand (intermediate, capital, consumption and "other" final demand) for local good i in region r . The absence of a regional superscript on the I-O and investment coefficients reflects the assumption that technology is independent of region.[2]

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1. The "other" final demand category employed in ORANI is defined in DPRS, sections 7 and 16.4(c). It consists primarily of current government expenditure and is usually exogenous in ORANI solutions.

2. There are no theoretical difficulties in adding an r superscript to the A coefficients. We prefer, however, to write the theory close to the level of generality of our empirical application (see sections 3 and 4).

Assuming constant I-O and investment coefficients,[1] the percentage change form of equation (2) is

$$(2a) \quad x_i^r = \sum_{n\epsilon N} \beta_{in}^{(1)r} x_n^r + \sum_{\ell\epsilon L} \beta_{i\ell}^{(1)r} x_\ell^r + \sum_{n\epsilon N} \beta_{in}^{(2)r} y_n^r + \sum_{\ell\epsilon L} \beta_{i\ell}^{(2)r} y_\ell^r$$

$$+ \beta_i^{(3)r} x_i^{(3)r} + \beta_i^{(5)r} x_i^{(5)r} \quad , \quad \text{for all } i\epsilon L \, , \; r = 1, \ldots, R \, .$$

The "β" coefficients in equation (2a) are shares of the various categories of demand in the total demand for local good i in region r. The coefficient $\beta_{ij}^{(1)r}$, for example, shows the share accounted for by intermediate demand from industry j.

The following assumptions are now made about the investment, consumption and "other" demand variables on the RHS of equations (2) and (2a).

2.2.2 Investment at the regional level

$$(3) \qquad Y_n^r = Y_n D_n^r \quad , \quad \text{for all } n\epsilon N \, , \quad r = 1, \ldots, R \, ,$$

and

$$(4) \qquad Y_\ell^r = \left(Y_\ell / X_\ell \right) X_\ell^r \quad , \quad \text{for all } \ell\epsilon L \, , \quad r = 1, \ldots, R \, ,$$

where

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1. In general, ORANI allows changes in the coefficients via substitution between import and domestic sources of good i. However, where good i is a local good, no substitution takes place since imports are zero.

Y_j and X_j are the economy-wide aggregate investment and current output of industry j .

Equations (3) and (4) impose the same type of condition on regional investment for local and national industries. In both cases the aggregate investment in an industry is allocated to regions in the same proportions as is the current output of that industry. The percentage change forms of equations (3) and (4) are

(3a) $$y_n^r = y_n \ , \quad \text{for all } n\varepsilon N \ , \quad r = 1, \ldots, R \ ,$$

and

(4a) $$y_\ell^r = y_\ell + x_\ell^r - x_\ell \ , \quad \text{for all } \ell\varepsilon L \ , \quad r = 1, \ldots, R \ .$$

2.2.3 Household consumption at the regional level

We assume that there is a link between regional household consumption of local goods[1] and labour income[2] in each region. In particular we assume

(5) $$X_\ell^{(3)r} = f_\ell^{(3)r}\left(X_\ell^{(3)}, \ {}^{V^r}/_V\right) \quad \text{for all } \ell\varepsilon L \ , \quad r = 1, \ldots, R \ ,$$

where

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1. A similar relation might be assumed to hold in the case of national goods. However, the model does not require the determination of regional consumption levels for national goods.

2. An alternative treatment might relate regional consumption to total factor payments in the region rather than to labour income alone. However, the employment of non-labour factors in the region does not necessarily generate income payments in that region. In any case, movements in labour income and in total income are likely to be similar.

$X_\ell^{(3)}$ is the economy-wide aggregate consumption of local good ℓ ,

V^r is the total wage bill in region r , and

V is the economy-wide aggregate wage bill .

The percentage change form of (5) is

(5a) $$x_\ell^{(3)r} = \alpha_\ell^r \, x_\ell^{(3)} + \gamma_\ell^r \, (v^r - v) \quad , \quad \text{for all } \ell \varepsilon L \; , \quad r = 1, \ldots, R$$

where

α_ℓ^r is the elasticity of region r's consumption of good ℓ with respect to the aggregate consumption of ℓ , and

γ_ℓ^r is the elasticity of region r's consumption of good ℓ with respect to the share of region r in the economy's aggregate wage bill.

In our computations we assume

(5b) $$\alpha_\ell^r = 1$$

and

(5c) $$\gamma_\ell^r = E_\ell \gamma \; , \quad 0 \leqslant \gamma \leqslant 1$$

for all $\ell \varepsilon L$ and $r = 1, \ldots, R$,

where

E_ℓ is the expenditure elasticity of demand for good ℓ ,[1] and

γ is a parameter whose value reflects the dependence of aggregate regional consumption on regional income .

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1. These parameters have been estimated for ORANI from a linear expenditure system. See DPRS, section 16.5(g).

If we set $\gamma = 1$, and E_ℓ happens to be 1, say, then (5a) - (5c) mean that the percentage increase in the consumption of good ℓ in region r will exceed the percentage increase in the consumption of good ℓ nationally by the same margin as the percentage increase in wage income in region r exceeds the national percentage increase in wage income. This is very close to the LMPST case. In fact, it is the LMPST case if

$$v = x_\ell^{(3)} \quad \text{for all } \ell \varepsilon L .$$

Then with $\gamma = E_\ell = 1$, (5a) reduces to

$$x_\ell^{(3)r} = v^r \quad \text{for all } \ell \varepsilon L, \quad r = 1, \ldots, R ,$$

i.e., consumption of each local good in region r expands proportionately with wage income in region r . However, (5a) - (5c) allow for other cases. For example, if we set $\gamma = 0$, then we would simulate a situation in which consumption in region r was independent of wage income in region r . This might be a suitable assumption for a short-run simulation where the effects of fluctuations in wage income on consumption are moderated by changes in social security payments and savings.

We next explain the wage bill variables, which appear in equations (5) and (5a), in terms of wage rates and industry specific employment levels. First, the regional wage bills, V^r, are

$$\text{(6)} \qquad V^r = \sum_{j \varepsilon J} P_{(g+2)1j} X^r_{(g+2)1j} , \qquad r = 1, \ldots, R ,$$

where

$P_{(g+2)1j}$ is the cost of a unit of labour to industry j,[1] and

$X^r_{(g+2)1j}$ is the employment of labour by industry j in region r.

In percentage change form, (6) becomes

$$\text{(6a)} \qquad v^r = \sum_{j\varepsilon J} \left[p_{(g+2)1j} + x^r_{(g+2)1j} \right] W^r_j \quad , \qquad r = 1, \ldots, R \ ,$$

where

the weights, W^r_j, are the shares of the industries in the regional wage bills.

Second, the national wage bill is

$$\text{(7)} \qquad V = \sum_{j\varepsilon J} P_{(g+2)1j} X_{(g+2)1j} \quad ,$$

and in percentage change form, we have

$$\text{(7a)} \qquad v = \sum_{j\varepsilon J} \left[p_{(g+2)1j} + x_{(g+2)1j} \right] W_j \quad ,$$

where

the variables and weights have interpretations analogous to those for (6) and (6a) except that they refer to the nation rather than to the regions.

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1. The notation is that used in DPRS where the subscript (g+2)1 refers to the primary factor (denoted by (g+2)) labour (denoted by 1). The absence of a regional subscript on $P_{(g+2)1j}$ indicates an assumption that wages do not vary regionally although they do vary across industries. Hence the j subscript.

The variables $p_{(g+2)1j}$ and $x_{(g+2)1j}$ are outputs of the national ORANI computation. But the use of (6a) requires employment by region as well as by industry. We assume that

(6b) $$x^r_{(g+2)1j} - x^r_j = x_{(g+2)1j} - x_j , \qquad \text{for all } j \epsilon J, \quad r = 1, \ldots, R ,$$

i.e., the percentage change in employment per unit of output in industry j in each region r is the same as the percentage change in employment per unit of output in industry j for the nation. This assumption is clearly more satisfactory for long-run analysis than for short-run. In the short-run, we could expect exogenous shocks, such as tariff changes, to have different impacts on capacity utilization and labour output ratios in different regions. For example, industries supplying local goods in regions which benefited from an exogenous shock, could, in the short-run, be expected to move towards higher capacity utilization (and higher labour output ratios). Labour-output ratios in similar industries in regions in which activity is depressed by the exogenous shock would move in the opposite direction. In the long-run, however, capital is inter-regionally mobile. If, as we have already assumed, wage rates move uniformly across regions, it is reasonable to assume that in the long-run, labour-output ratios move uniformly across regions.

To summarize, (6b) appears to be satisfactory for use in a model concerned with the <u>long-run</u> regional implications of an exogenous shock. Even for the short-run, it could be justified for national goods (i.e., $j \epsilon N$). On the other hand, for short-run analyses, the use of (6b) may lead to some underestimation of the employment created in regions where the expansion of local industries is greater than for the nation as a whole.

This is because it fails to allow for declining productivity associated with the more intensive use of fixed capital stocks. An offset to this bias, however, is the tendency for our regional model to overestimate short-run regional output responses. Notice that we are not allowing for short-run regional variations in product prices for local goods. Hence the use of (5a) will lead to overestimates of household demand for good ℓ in region r if the expansion of industry ℓ in region r is greater than the national average for industry ℓ. (5a) ignores short-run increases, relative to the national average for industry ℓ, in the production costs and output price of industry ℓ in region r induced by industry ℓ's greater than average expansion in region r. While keeping these biases in mind, for simplicity, we adopt (6b) even for local industries in short-run analyses.

On substituting from (7a) into (5a), from (6b) into (6a) and then into (5a), and on using (1a), (5b) and (5c), we obtain

$$\text{(5d)} \quad x_{\ell}^{(3)r} = x_{\ell}^{(3)} + E_{\ell}\gamma\left[\sum_{j\varepsilon J}\left(W_j^r - W_j\right)\left(p_{(g+2)1j} + x_{(g+2)1j}\right) + \sum_{\ell\varepsilon L} W_{\ell}^r\left(x_{\ell}^r - x_{\ell}\right)\right],$$

$$\text{for } \ell\varepsilon L, \quad r = 1, \ldots, R.$$

2.2.4 "Other" final demand at the regional level

Equation (8) describes the regional allocation of "other" final demand for local goods.

(8) $$X_\ell^{(5)r} = X_\ell^{(5)} Q_\ell^r \quad , \ \ell \epsilon L, \quad r = 1, \ldots, R \ ,$$

where

Q_ℓ^r is the share of "other" final demand for local good ℓ which is purchased from region r .

The implied percentage change form of (8) is

(8a) $$x_\ell^{(5)r} = x_\ell^{(5)} + q_\ell^r \quad , \ \text{for} \ \ell \epsilon L \ , \quad r = 1, \ldots, R \ .$$

q_ℓ^r , the percentage change in region r's share of "other" demands for local good ℓ , will normally be set exogenously at zero.

2.2.5 Solving for regional outputs of local goods

The six equations (1a), (2a), (3a), (4a), (5d) and (8a) summarise our regional model. They are repeated below in matrix notation for region r.

(1a) $$x_N^r = x_N \ ;$$

(2a) $$x_L^r = \beta_{LN}^{(1)r} x_N^r + \beta_{LL}^{(1)r} x_L^r + \beta_{LN}^{(2)r} y_N^r + \beta_{LL}^{(2)r} y_L^r + \hat{\beta}_L^{(3)r} x_L^{(3)r} + \hat{\beta}_L^{(5)r} x_L^{(5)r} \ ;$$

(3a) $$y_N^r = y_N \ ;$$

(4a) $$y_L^r = y_L + x_L^r - x_L \ ;$$

(5d) $$x_L^{(3)r} = x_L^{(3)} + \gamma E_L\left[\left(W_J^{r'} - W_J'\right)\left(p_{(g+2)1J} + x_{(g+2)1J}\right) + W_L^{r'}\left(x_L^r - x_L\right)\right] ;$$

(8a) $$x_L^{(5)r} = x_L^{(5)} + q_L^r \quad .$$

As explained in section 2.1, upper case subscripts are used for matrices of variables and parameters. The prime (') indicates transposition of a column to a row vector and the circumflex (^) denotes a diagonal matrix. The dimensions of vectors and matrices are implied by the sizes of the sets referred to by the upper case subscripts.

Equations (1a), (3a), (4a), (5d) and (8a) are substituted into (2a) and the system is solved for x_L^r , yielding

(9) $$x_L^r = \psi_L^r\Big\{\beta_{LN}^{(1)r}\, x_N + \left(-\,\beta_{LL}^{(2)r} - \gamma\hat{\beta}_L^{(3)r}\, E_L\, W_L^{r'}\right) x_L + \beta_{LN}^{(2)r}\, y_N$$

$$+ \beta_{LL}^{(2)r}\, y_L + \hat{\beta}_L^{(3)r}\, x_L^{(3)} + \gamma\hat{\beta}_L^{(3)r}\, E_L\left(W_J^{r'} - W_J'\right)\Big(p_{(g+2)1J}$$

$$+ x_{(g+2)1J}\Big) + \hat{\beta}_L^{(5)r}\, x_L^{(5)} + \hat{\beta}_L^{(5)r}\, q_L^r\Big\} ,$$

where

$$\psi_L^r = \left[I - \beta_{LL}^{(1)r} - \beta_{LL}^{(2)r} - \gamma\hat{\beta}_L^{(3)r}\, E_L\, W_L^{r'}\right]^{-1} \quad .$$

Equations of the form of (9) are the solution equations for the regional computation. They express the percentage changes in regional outputs of local goods as functions of percentage changes in the aggregate output, investment and employment levels of local and national industries, percentage changes in aggregate household and "other" final demands for local goods and the percentage changes in the national costs of labour. All of the variables on the RHS of equation (9) are either outputs of the national ORANI computation or are exogenously determined. Equation (1a) provides the percentage changes in the regional outputs of national industries. Thus (1a) and (9) together are sufficient to describe, via ORANI, the effects of national policy changes on all industry outputs at the regional level. Other variables which are of interest in describing the regional impacts of national policy can be derived by simple calculations. Equations (3a) and (4a) give us regional investment by industry. We could also compute, for example, regional employment and income changes.

3. EMPIRICAL IMPLEMENTATION

3.1 General Comments on Data Requirements

Inter-regional input-output models can absorb information on commodity flows from each industry in each region to each industry in each region, i.e., $(NR)^2$ intermediate flows in all where N is the number of industries and R is the number of regions.[1] In addition, data on final demands and primary input flows can be required. Figure 1 illustrates an "ideal" data base for a two region model, showing all inter-industry and inter-regional flows. While pioneering work on the construction of such data sets for the United States has been completed by Polenske[2] et al [1972-1978], no similar results are available for Australia.[3] Therefore, for practical applications in Australia, we must rely on regional models which have very modest data requirements.

The main virtue of our modified LMPST model is that the regional data requirements are in fact very modest. For those industries which we classify as local, we assume that all sales are to local users. Using the notation of Figure 1, we are saying that X_{LN}^{rs}, X_{LL}^{rs} and FD_{L}^{rs} are zero for all $r \neq s$. For those industries which are classified as

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1. An example of a model requiring such data is given by Liew [1977].
2. The Polenske study covers 80 industries for 51 states for three years.
3. There have been several input-output studies for Australia at the state and substate level. Examples are reported by Parker [1965], Edwards [1977], Jensen [1976], Dickinson [1977] and Mandeville [1977]. Hopefully, in the not too distant future, these and other studies will provide a starting point for the creation of a detailed and consistent set of accounts describing commodity and service flow within and between the states.

Figure 1 : Ideal Data Base for a 2 Region Input-Output Model

		Intermediate Flows				Final Demands		Total Usage
		Region 1		Region 2		Region 1	Region 2	
		jεL	jεN	jεL	jεN			
REGION 1	jεL	X_{LL}^{11}	X_{LN}^{11}	X_{LL}^{12}	X_{LN}^{12}	FD_{L}^{11}	FD_{L}^{12}	X_{L}^{1}
	jεN	X_{NL}^{11}	X_{NN}^{11}	X_{NL}^{12}	X_{NN}^{12}	FD_{N}^{11}	FD_{N}^{12}	X_{N}^{1}
REGION 2	jεL	X_{LL}^{21}	X_{LN}^{21}	X_{LL}^{22}	X_{LN}^{22}	FD_{L}^{21}	FD_{L}^{22}	X_{L}^{2}
	jεN	X_{NL}^{21}	X_{NN}^{21}	X_{NL}^{22}	X_{NN}^{22}	FD_{N}^{21}	FD_{N}^{22}	X_{N}^{2}
Value Added		V_{L}^{1}	V_{N}^{1}	V_{L}^{2}	V_{N}^{2}			
Total Outputs		X_{L}^{1}	X_{N}^{1}	X_{L}^{2}	X_{N}^{2}	FD^{1}	FD^{2}	

national, we do not require information on their sales patterns, i.e., our model does not use the rows of matrices X^{r1}_{NL} , X^{r1}_{NN} , ..., FD^{rR}_{N} . We simply assume that irrespective of its sales pattern, the national industry j in region r maintains its share in the economy-wide output of industry j . Thus only the intra-regional sales patterns of local industries are required data, that is the matrices X^{rr}_{LL} , X^{rr}_{LN} and FD^{rr}_{L} , which are not cross-hatched in Figure 1. Notice that data on inter-regional commodity flows is largely unnecessary. It is true that industries must be assigned to national and local categories on the basis of whether significant inter-regional transfers of their products can occur. This assignment can be accomplished however without any detailed knowledge of the origins and destinations of inter-regional flows. For technological and/or institutional reasons some industries can be assigned a priori to the local category. As explained below, manipulation of our data on regional production and absorption of commodities yields relevant empirical evidence for some other industries. The general criterion is that we wish to treat as local industries those industries for which an increase in demand within any region will be met mainly by an increase in production within that region.

3.2 The Construction of the Parameter Matrices for Implementation of Equation (9)

The parameter matrices, $\beta^{(1)r}_{LL}$, $\beta^{(2)r}_{LL}$, etc., appearing in equation (9) and the definition of ψ^{r}_{L} all refer to the sales pattern of local goods in region r . In the ideal data base the β's could be constructed from the data contained in the rows of matrices of the form X^{rr}_{LL}, X^{rr}_{LN} , FD^{rr}_{L} , (see Figure 1). In the absence of consistent regional input-output tables, we computed the elements of $\beta_{LL}^{(1)r}$, $\beta_{LN}^{(1)r}$, $\beta_{LL}^{(2)r}$, $\beta_{LN}^{(2)r}$ and $\hat{\beta}_{L}^{(3)r}$ by applying national technology coefficients to regional output and consumption data. We used the formulae

$$(10) \qquad \beta_{ij}^{(1)r} = \frac{A_{ij}^{(1)} X_j^r}{X_i^r} , \quad i \varepsilon L , \quad j \varepsilon J ,$$

$$(11) \qquad \beta_{ij}^{(2)r} = \frac{A_{ij}^{(2)} Y_j^r}{X_i^r} , \quad \text{where} \quad Y_j^r = \frac{Y_j X_j^r}{X_j} , \quad i \varepsilon L , \quad j \varepsilon J ,$$

and

$$(12) \qquad \beta_{i}^{(3)r} = \frac{C_i X^{(3)r}}{X_i^r} , \quad i \varepsilon L ,$$

where $A_{ij}^{(1)}$, $A_{ij}^{(2)}$ and C_i are economy-wide coefficients showing, respectively, the input of good i per unit of output of industry j, the input of good i per unit of investment in industry j and the share of household expenditure devoted to good i.[1] The X_j^r, Y_j^r and $X^{(3)r}$ are estimates of the base period values of output and investment in industry j in region r, and of the base period level of household consumption in region r.[2] The elements

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1. These economy-wide coefficients were derived from the ORANI input-output data base, see DPRS, section 16. The ORANI data base was derived from the ABS 1968-69 Input-Output Tables, see ABS [1977].

2. The construction of the regional output and consumption data is described in section 3.3. Investment in industry j in region r, Y_j^r, was computed on the basis of regional shares in national outputs, see (11), where Y_j is national investment in industry j.

of the matrices $\hat{\beta}_L^{(5)r}$ were constructed by using public finance statistics to assemble an estimated vector of government current expenditure for each state. These were normalized so that the sum across regions of the vectors was equal to the "other" final demand vector from the ORANI data base. The $\beta_i^{(5)r}$ were then computed as

$$(13) \qquad \beta_i^{(5)r} = X_i^{(5)r} / X_i^r \; , \qquad \text{for all } i \epsilon L \; ,$$

where $X_i^{(5)r}$ is an element from the relevant regional data vector.

As a check on the calculations described in (10) - (13), we computed the sums

$$(14) \qquad \text{Sum } (i,r) = \sum_j (\beta_{ij}^{(1)r} + \beta_{ij}^{(2)r}) + \beta_i^{(3)r} + \beta_i^{(5)r} \; , \quad i \epsilon L \; , \quad r = 1, \ldots, R \; .$$

For local industries, each of these sums should be 1. We forced this equality for all $r = 1, \ldots, R$ and $i \epsilon L$ by the obvious proportionate scaling. However, before we applied the scaling procedure, we used (14) as a check on the validity of our allocation of industries to the local and national categories. We also found (14) to be a useful check on our regional output data, the X_j^r's .

The remaining data required for equation (9) are the vectors W_J^r and W_J : the vector of expenditure elasticities , E_L , is taken from the ORANI data base[1] and the scalar , γ , is treated at this stage as a user specified parameter.

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1. See DPRS, section 16.5(g).

W_j is a vector of the shares of industries in the national wage bill. These shares can be computed directly from the national I-O data base.[1] The W_J^r are vectors of industrial shares in regional wage bills. In the ideal data base, Figure 1, they could be formed from the relevant rows in the value added matrices, (V_L^r, V_N^r) . Our approach was to apply the uniform technology assumption. That is, we estimated the wage bill in industry j in region r as

$$(15) \qquad Z_j^r = Z_j X_j^r \Big/ X_j , \qquad j \varepsilon J , \text{ and } r = 1, \ldots, R ,$$

where Z_j is the national wage bill for industry j . Then we computed W_j^r as

$$(16) \qquad W_j^r = Z_j^r \Big/ \sum_k Z_k^r , \qquad j \varepsilon J , \text{ and } r = 1, \ldots, R .$$

3.3 Sources of Regional Data

The only regional data required in the application of formulae (10) - (13), (15) and (16) are (a) regional outputs for each industry, (b) aggregate regional household consumptions, and (c) "other" (i.e., mainly government) final demands by commodity and region. For the I-O level of industry disaggregation even this data is not readily available in Australia. There were numerous points at which constrained "guesstimates" on the part of the authors were required to fill gaps. It is hoped that

1. See DPRS, section 16.4.

further work will improve the data base but at this stage the data underlying the computations presented in section 4 must be regarded as provisional and the results themselves must be approached with corresponding caution.

3.3.1 The agricultural sector outputs

The gross value of Australian production for the rural industries (1 - 6, 8 and 9) shown in the 1968-69 I-O tables was disaggregated using state proportions derived from the value of rural commodities given in CBCS Value of Production, 1968-69, Bulletin No. 5 (ref. 10.26). The required proportions for industry 7 (Services to agriculture) were computed from the weighted sums of agricultural outputs in each state. The weights employed were the national I-O coefficients for the input of industry 7 into the agricultural industries.

3.3.2 Mining outputs

The gross value of Australian production in the mining industries (10 - 13) was allocated to states according to the state shares in the total turnover of the mining industries. The required turnover statistics were derived from ABS Mining Establishments : Details of Operations, 1974-75 (ref. 10.60). Where the level of industry disaggregation available in that source was not appropriate, the data was supplemented with information on state mineral production from various State Year Books. The state allocation of industry 14 (Services to mining) was made according to the state shares in aggregate mining industry turnover.

3.3.3 Manufacturing outputs

For the manufacturing sector (industries 15 - 80) data on turnover by I-O industry by state was derived from ABS, 1974-75 manufacturing census publications.[1] Because of confidentiality problems many of the cells of the required (I-O industry by state) turnover matrix are not directly available. In these cases, the missing cells were filled in by the authors in such a way as to satisfy the available row and column constraints. For example, where there was no further available information, if \$x was to be allocated between industries a and b in region r where the national turnover aggregates of a and b are known, we assumed that turnover in a in region r is given by

$$\text{Turnover (a, r)} = \frac{\$x \times \text{unallocated turnover in a}}{\text{unallocated turnover in (a+b)}} .$$

The row proportions of the (industry × region) turnover matrix eventually estimated were used to allocate the gross value of Australian production for the manufacturing industries shown in the I-O tables.

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1. ABS, Manufacturing Establishments, Summary of operations by industry class; Australia, 1974-75 (ref. 12.23).

   ABS (NSW), Manufacturing Estabs., & Elec. & Gas Estabs., Summary stats. of opns., 1974-75 (ref. 8201.1).

   ABS (Vic.), Manuf. Estabs., Details of opns., 1974-75 (ref. 8201.2).

   ABS (Q'land), Manuf. Estabs., Selected items of data classified by indust. & employt. size, 1974-75 (ref. 82.304).

   ABS (SA), Manuf. Estabs., Details of opns., 1974-75 (ref. 8202.4).

   ABS (WA), Census of Manuf. Estabs., Summary of opns. by indust. class, 1974-75 (ref. 8201.5).

   ABS (Tas.), Manuf. Estabs., Details of opns. & small area stats, 1974-75 (ref. 8202.6).

   ABS, Manuf. Estabs., Northern Territory, 1974-75 (ref. 12.24)

   ABS, Manuf. Estabs., ACT, 1974-75 (ref. 12.25).

3.3.4 Tertiary outputs

Regional data for industries in the tertiary sector is extremely scanty in Australia. In the absence of more suitable data, the state proportions required to split the national output of the tertiary industries were based upon data on employment by industry by state compiled from the 1971 Population Census.

3.3.5 Household consumption

The shares of the states in aggregate consumption were computed from data on consumption by state for the year 1974-75 given in ABS, Australian National Accounts, National Income and Expenditure 1975-76 (ref. 7.1). These shares were used to split the aggregate consumption from the 1968-69 I-O tables into the $X^{(3)r}$'s used in equation (12).

3.3.6 "Other" final demands : government current expenditure

The data for the computation of the $X_i^{(5)r}$'s required in equation (13) were derived from ABS, Public Authority Finance, Local Authorities, 1975-76, No. 14 (ref. 5.12) and ABS, Public Authority Finance, State and Local Authorities, 1974-75 (ref. 5.43). These publications contain tables of government final consumption by purpose. A mapping from the "purpose" categories to industry of supply has been made in the IMPACT project. The state and local authority data is already disaggregated by state. Disaggregation of the federal authority expenditure for each industry of supply was achieved via the employment data used for the tertiary industry output disaggregations (see section 3.3.4).[1] The proportions across the industry by state, government current expenditure matrix derived from

1. Note that all the relevant supplying industries are treated as local industries.

these data were used for regional disaggregation of the "other" final demand vector from the 1968-69 ORANI I-O tables.

4. THE REGIONAL EFFECTS OF A 25 PER CENT INCREASE IN ALL TARIFFS

4.1 The National Results

In DPRS we made an illustrative application of the ORANI model by simulating the effects on industry outputs and employment of a uniform percentage change in all tariffs.[1] The extreme right column of Table 1 reproduces the DPRS results where the uniform change in tariffs is an increase of 25 per cent.[2] For example, in the DPRS simulation, a 25 per cent increase in all tariffs led to a 1.2689 per cent reduction in the output of the sheep industry. In this section, we illustrate our modified LMPST method by applying it to the DPRS simulation. That is, we allocate the national results for a 25 per cent tariff increase to the states.

While we hope that our actual results are of interest, our principal focus, for this paper, is on our modified LMPST method. We investigate the properties of the method by running equation (9) under alternative assumptions concerning the division of industries between local and national and with alternative values for the parameter γ, see sub-section 2.2.3. However, before we turn to our examination of the performance of the LMPST method, it will be helpful to review the national results to which we are applying it.

The most important assumptions underlying the DPRS simulation are that the tariff changes take place in an environment where

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1. See DPRS, section 21.2.

2. In DPRS the uniform percentage increase was 1 per cent. ORANI is linear in percentage changes. For this paper, we have multiplied the DPRS results by 25.

TABLE 1 : EXPERIMENT 1, ALL INDUSTRIES

CONTRIBUTION

	INDUSTRY	REGION : NSW (+ACT)	VIC	QLD
1	SHEEP	-.0272	-.0221	-.0270
2	CEREAL GRAINS	-.0207	-.0115	-.0149
3	MEAT CATTLE	-.0084	-.0076	-.0570
4	MILK CATTLE	-.0050	-.0122	-.0086
5	POULTRY	-.0010	-.0008	-.0009
6	OTHER FARMING	-.0000	-.0000	-.0001
7	L SERVICES TO AGRIC	-.0050	-.0050	-.0113
8	FORESTRY	-.0004	-.0005	-.0005
9	FISHING	-.0026	-.0021	-.0046
10	IRON	0.0000	0.0000	0.0000
11	OTHER METALLIC MINS	-.0099	-.0000	-.0442
12	COAL + CRUDE OIL	-.0167	-.0188	-.0414
13	NON-METALLIC NEC	-.0006	-.0006	-.0008
14	SERVICES TO MINING	-.0019	-.0016	-.0055
15	MEAT PRODUCTS	-.0095	-.0149	-.0209
16	MILK PRODUCTS	.0001	.0004	.0002
17	FRUIT + VEG PRODUCTS	.0003	.0008	.0004
18	MARGE,OILS + FATS	.0003	.0003	.0001
19	FLOUR + CEREAL PRODS	-.0002	-.0001	-.0001
20	L BREAD,CAKES	.0001	.0001	.0001
21	CONFECTIONERY	.0010	.0018	.0012
22	FOOD PRODUCTS NEC	-.0056	-.0057	-.0391
23	L SOFT DRINKS,CORDIALS	.0001	.0001	.0001
24	L BEER + MALT	.0006	.0006	.0006
25	ALCOHOLIC DRINKS NEC	.0012	.0012	.0001
26	TOBACCO	.0003	.0003	.0002
27	PREPARED FIBRES	-.0007	-.0006	-.0002
28	MAN-MADE FIBRES,YARN	.0040	.0147	0.0000
29	COTTON,SILK,FLAX	.0086	.0110	0.0000
30	WOOL + WORSTED YARNS	.0006	.0022	.0003
31	TEXTILE FINISHING	.0004	.0006	.0005
32	TEXTILE FLOOR COVERS	.0006	.0018	.0001
33	TEXTILE PRODUCTS NEC	.0014	.0019	.0005
34	KNITTING MILLS	.0011	.0040	.0000
35	CLOTHING	.0062	.0092	.0019
36	FOOTWEAR	.0040	.0131	.0027
37	SAWMILL PRODUCTS	.0010	.0009	.0013
38	PLYWOOD,VENEERS	.0012	.0005	.0014
39	JOINERY + WOOD PRODS	.0006	.0008	.0006
40	FURNITURE,MATTRESSES	.0014	.0014	.0012
41	PULP,PAPER	.0010	.0017	.0004
42	FIBREBOARD	.0008	.0010	.0006
43	PAPER PRODUCTS NEC	.0004	.0007	.0002
44	NEWSPAPERS + BOOKS	-.0009	-.0006	-.0006
45	COMMERCIAL PRINTING	.0026	.0030	.0009
46	CHEMICAL FERTILISERS	-.0007	-.0007	-.0031
47	INDUSTRIAL CHEMICALS	.0086	.0097	.0017
48	PAINTS,VARNISHES	.0014	.0012	.0010
49	PHARMACEUTICALS	.0030	.0015	.0003
50	SOAP + DETERGENTS	.0004	.0002	.0001

ASSIGNED TO THE NATIONAL CATEGORY

MATRIX SA (+NT)	WA	TAS	AUSTRALIA	DPRS RESULTS OUTPUTS
-.0357	-.0575	-.0282	-.0295	-1.2689
-.0379	-.0465	-.0019	-.0209	-1.1462
-.0161	-.0150	-.0168	-.0162	-1.6637
-.0055	-.0036	-.0126	-.0077	-.5615
-.0006	-.0008	-.0011	-.0009	-.4884
-.0000	-.0000	-.0001	-.0000	-.0025
-.0076	-.0089	-.0074	-.0065	-.8637
-.0005	-.0007	-.0024	-.0006	-.1891
-.0066	-.0174	-.0117	-.0047	-3.1393
-.0017	-.0111	-.0059	-.0013	-.2238
-.0085	-.0454	-.0068	-.0146	-1.4352
-.0017	-.0067	-.0010	-.0180	-2.4402
-.0007	-.0010	-.0004	-.0007	-.1894
-.0017	-.0091	-.0037	-.0006	-.2296
-.0098	-.0161	-.0093	-.0133	-1.6974
.0001	.0001	.0004	.0002	.0414
.0004	.0001	.0011	.0005	.1790
.0000	.0000	0.0000	.0002	.3812
-.0001	-.0001	-.0001	-.0002	-.0884
.0001	.0001	.0001	.0001	.0122
.0004	.0003	.0005	.0011	.8518
-.0037	-.0034	-.0106	-.0098	-2.0884
.0001	.0001	.0001	.0001	.0552
.0006	.0005	.0006	.0006	.1842
.0087	.0002	.0001	.0016	2.0590
0.0000	0.0000	0.0000	.0002	.1168
-.0010	-.0004	-.0034	-.0007	-.9279
0.0000	0.0000	.0174	.0062	2.7113
.0038	.0020	.0173	.0075	3.4224
.0025	.0002	.0013	.0012	.6848
.0001	.0000	.0003	.0004	.6531
.0002	.0000	.0002	.0008	.8927
.0006	.0001	.0007	.0012	.9290
.0001	.0000	.0000	.0016	.6089
.0025	.0007	.0002	.0056	.7292
.0067	.0016	.0017	.0065	2.6128
.0017	.0011	.0025	.0011	.2408
.0017	.0011	.0030	.0011	1.0280
.0009	.0007	.0027	.0008	.2406
.0013	.0013	.0008	.0014	.3727
.0013	.0006	.0171	.0016	.5635
.0006	.0003	.0004	.0007	.2868
.0005	.0001	.0002	.0005	.4006
-.0005	-.0005	-.0004	-.0007	-.1016
.0014	.0010	.0009	.0022	.3297
-.0035	-.0017	-.0010	-.0014	-.7260
.0018	.0009	.0112	.0068	1.3348
.0008	.0007	.0001	.0011	.7172
.0002	.0002	0.0000	.0016	.5816
.0001	.0001	.0000	.0002	.1529

TABLE 1

51		COSMETICS,TOILETRY	.0009	.0004	0.0000
52		CHEMICAL PRODS NEC	.0025	.0026	.0012
53		OIL + COAL PRODUCTS	-.0002	-.0002	-.0004
54		GLASS	.0017	.0018	.0007
55		CLAY PRODUCTS	.0008	.0007	.0004
56		CEMENT	-.0002	-.0001	-.0004
57	L	READY-MIXED CONCRETE	.0000	.0000	.0000
58		CONCRETE PRODUCTS	-.0001	-.0001	-.0001
59		NON-METAL MIN PRODS	.0004	.0004	.0002
60		BASIC IRON + STEEL	-.0469	-.0127	-.0067
61		OTHER BASIC METALS	-.0151	-.0070	-.0351
62		STRUCTURAL METAL	.0020	.0018	.0017
63		SHEET METAL PRODS	.0013	.0016	.0008
64		METAL PRODUCTS NEC	.0147	.0186	.0109
65		MOTOR VEHICLES,PARTS	.0339	.1110	.0372
66		SHIP + BOAT BUILDING	.0000	.0000	.0000
67		LOCOMOTIVES	-.0015	-.0012	-.0025
68		AIRCRAFT BUILDING	.0004	.0006	0.0000
69		SCIENTIFIC EQUIPT	.0003	.0007	.0001
70		ELECTRONIC EQUIPT	.0224	.0139	.0019
71		HOUSEHOLD APPLIANCES	.0043	.0033	.0014
72		ELECTRICAL MACHINERY	.0095	.0092	.0024
73		AGRICULTURAL MACH.	-.0007	-.0035	-.0028
74		CONSTRUCTION EQUIPT	.0004	.0004	.0001
75		OTHER MACHINERY	.0056	.0076	.0031
76		LEATHER PRODUCTS	.0027	.0020	.0017
77		RUBBER PRODUCTS	.0025	.0058	.0015
78		PLASTIC PRODUCTS	.0043	.0080	.0014
79		SIGNS,WRITING EQUIPT	.0009	.0011	.0001
80		OTHER MANUFACTURING	.0013	.0010	.0007
81	L	ELECTRICITY	-.0007	-.0006	-.0007
82	L	GAS	.0003	.0003	.0003
83	L	WATER,SEWERAGE	-.0004	-.0004	-.0004
84	L	RESIDENTIAL BUILDING	0.0000	0.0000	0.0000
85	L	BUILDING NEC	.0035	.0034	.0033
86	L	WHOLESALE TRADE	-.0184	-.0182	-.0180
87	L	RETAIL TRADE	-.0049	-.0047	-.0050
88	L	MOTOR VEHICLE REPAIR	-.0039	-.0037	-.0039
89	L	OTHER REPARS	-.0011	-.0010	-.0012
90		ROAD TRANSPORT	-.0147	-.0130	-.0078
91		RAILWAY TRANSPORT	-.0100	-.0084	-.0049
92		WATER TRANSPORT	-.0034	-.0028	-.0022
93		AIR TRANSPORT	-.0038	-.0029	-.0021
94	L	COMMUNICATION	-.0041	-.0041	-.0039
95	L	BANKING	.0001	.0001	.0001
96	L	FINANCE + LIFE INS	.0000	.0000	.0000
97	L	OTHER INSURANCE	-.0001	-.0001	-.0001
98	L	INVESTMENT,REAL EST	.0005	.0005	.0004
99	L	OTHER BUSINESS SERV	-.0015	-.0015	-.0013
100	L	OWNERSHIP OF DWELLG	.0000	.0000	.0000

(CONTINUED)

0.0000	0.0000	0.0000	.0004	.3913
.0010	.0008	.0002	.0020	.9864
-.0004	-.0003	-.0000	-.0002	-.0590
.0011	.0009	.0002	.0014	.6824
.0007	.0006	.0002	.0007	.1989
-.0003	-.0003	-.0003	-.0002	-.1412
.0000	.0000	.0000	.0000	.0275
-.0001	-.0001	-.0001	-.0001	-.0231
.0004	.0005	.0001	.0004	.2443
-.0335	-.0225	-.0301	-.0284	-1.5727
-.0147	-.0343	-.0459	-.0181	-1.7703
.0028	.0033	.0018	.0021	.3472
.0014	.0009	.0004	.0013	.2257
.0101	.0072	.0035	.0141	1.6662
.1261	.0056	.0053	.0622	3.1966
.0000	.0000	.0000	.0000	.0042
-.0020	-.0022	-.0023	-.0017	-.4706
.0001	.0001	0.0000	.0003	.1430
.0002	.0001	.0000	.0004	.3788
.0105	.0010	.0003	.0139	3.0186
.0079	.0006	.0002	.0036	.8046
.0049	.0022	.0004	.0072	.9861
-.0029	-.0032	-.0010	-.0022	-.9832
.0004	.0002	0.0000	.0003	.1349
.0029	.0028	.0010	.0053	.5463
.0018	.0008	0.0000	.0021	1.8199
.0027	.0002	.0000	.0031	.8412
.0027	.0013	.0001	.0045	.9921
.0004	.0005	.0001	.0008	.8452
.0013	.0005	.0007	.0011	.8419
-.0006	-.0006	-.0007	-.0007	-.0282
.0003	.0003	.0003	.0003	.1362
-.0004	-.0003	-.0004	-.0004	-.0491
0.0000	0.0000	0.0000	0.0000	0.0000
.0035	.0034	.0034	.0035	.0599
-.0179	-.0167	-.0178	-.0183	-.2281
-.0046	-.0043	-.0047	-.0048	-.0801
-.0037	-.0036	-.0040	-.0038	-.3267
-.0011	-.0011	-.0011	-.0011	-.2627
-.0135	-.0147	-.0154	-.0134	-.4677
-.0117	-.0120	-.0085	-.0093	-.7203
-.0041	-.0047	-.0054	-.0034	-.3115
-.0028	-.0029	-.0023	-.0031	-.5041
-.0040	-.0036	-.0040	-.0040	-.2088
.0001	.0001	.0001	.0001	.0059
.0000	.0000	.0000	.0000	.0014
-.0001	-.0001	-.0001	-.0001	-.0082
.0005	.0004	.0005	.0005	.0229
-.0014	-.0012	-.0014	-.0014	-.0637
.0000	.0000	.0000	.0000	.0000

TABLE 1

101	PUBLIC ADMIN	.0001	.0001	.0001
102	DEFENCE	0.0000	0.0000	0.0000
103 L	HEALTH	-.0001	-.0001	-.0001
104 L	EDUCATION,LIBRARIES	.0001	.0001	.0001
105 L	WELFARE SERVICES	-.0001	-.0001	-.0001
106 L	ENTERTAINMENT	-.0025	-.0024	-.0025
107 L	RESTAURANTS,HOTELS	.0013	.0012	.0013
108 L	PERSONAL SERVICES	-.0000	-.0000	-.0000
109 L	BUSINESS EXPENSES	0.0000	0.0000	0.0000
	TOTAL	-.0794	.0904	-.2913

EMPLOYMENT MATRIX

	REGION :	NSW (+ACT)	VIC	QLD
	OCCUPATION			
1	PROFESSIONAL	-.0671	.0418	-.2721
2	WHITE COLLAR SKILLED	-.0019	.1642	-.2288
3	WHITE COLLAR OTHER	-.0559	.0579	-.1897
4	BLUE- METAL AND ELEC	.0523	.5588	-.3044
5	BLUE- BUILDING	.0668	.1855	-.0094
6	BLUE- OTHER SKILLED	.0358	.1662	-.6468
7	BLUE COLLAR OTHER	-.0349	.3365	-.5076
8	RURAL	-1.7694	-1.6633	-1.8602
9	ARMED SERVICES	0.0000	0.0000	0.0000
	REAL WAGE BILL	-.1215	.1147	-.4874

(CONCLUDED)

.0001	.0001	.0001	.0001	.0033
0.0000	0.0000	0.0000	0.0000	0.0000
-.0001	-.0001	-.0002	-.0001	-.0048
.0001	.0001	.0001	.0001	.0044
-.0001	-.0001	-.0001	-.0001	-.0092
-.0326	-.0022	-.0028	-.0025	-.2207
.0012	.0011	.0012	.0012	.0519
-.0000	-.0000	-.0000	-.0000	-.0028
0.0000	0.0000	0.0000	0.0000	.0017
-.0416	-.3275	-.1718	-.0779	

(OCCUPATION X REGION)

SA (+NT)	WA	TAS	AUSTRALIA
-.0639	-.2675	-.1322	-.0740
.0380	-.2404	-.1289	.0049
-.0304	-.2149	-.1362	-.0499
.4509	-.3977	-.3321	.1639
.1585	-.0196	.0444	.0923
-.1677	-.5633	.1544	-.0492
.1275	-.4911	-.1655	.0012
-1.9251	-2.1581	-1.5750	-1.8211
0.0000	0.0000	0.0000	0.0000
-.0811	-.5239	-.2767	-.1309

TABLE 2 : 28 INDUSTRIES IN

CONTRIBUTION

REGION :	NSW (+ACT)	VIC	QLD
7 L SERVICES TO AGRIC	-.0055	-.0046	-.0092
20 L BREAD,CAKES	.0001	.0001	.0001
23 L SOFT DRINKS,CORDIALS	.0001	.0001	.0001
24 L BEER + MALT	.0006	.0006	.0006
57 L READY-MIXED CONCRETE	.0001	.0002	-.0002
81 L ELECTRICITY	-.0010	.0042	-.0063
82 L GAS	.0003	.0005	.0002
83 L WATER,SEWERAGE	-.0023	.0001	-.0011
84 L RESIDENTIAL BUILDING	-.0000	-.0000	-.0000
85 L BUILDING NEC	.0088	.0196	-.0190
86 L WHOLESALE TRADE	-.0015	.0121	-.0274
87 L RETAIL TRADE	.0024	.0030	-.0001
88 L MOTOR VEHICLE REPAIR	-.0036	-.0031	-.0044
89 L OTHER REPARS	-.0008	-.0005	-.0018
94 L COMMUNICATION	-.0016	.0020	-.0082
95 L BANKING	.0016	.0046	-.0039
96 L FINANCE + LIFE INS	.0007	.0012	-.0005
97 L OTHER INSURANCE	.0005	.0014	-.0010
98 L INVESTMENT,REAL EST	.0014	.0048	-.0036
99 L OTHER BUSINESS SERV	.0018	.0052	-.0044
100 L OWNERSHIP OF DWELLG	.0000	.0000	.0000
103 L HEALTH	-.0001	-.0000	-.0003
104 L EDUCATION,LIBRARIES	.0001	.0001	.0001
105 L WELFARE SERVICES	.0001	.0004	-.0005
106 L ENTERTAINMENT	-.0016	-.0010	-.0025
107 L RESTAURANTS,HOTELS	.0001	.0005	-.0007
108 L PERSONAL SERVICES	.0001	.0003	-.0002
109 L BUSINESS EXPENSES	0.0000	0.0000	0.0000
TOTAL(OVER 109 INDUSTRIES)	-.0404	.1777	-.3434

EMPLOYMENT MATRIX

OCCUPATION	REGION : NSW (+ACT)	VIC	QLD
1 PROFESSIONAL	-.0370	.1103	-.3053
2 WHITE COLLAR SKILLED	.0417	.2540	-.2763
3 WHITE COLLAR OTHER	.0121	.1902	-.2462
4 BLUE- METAL AND ELEC	.0815	.6378	-.3942
5 BLUE- BUILDING	.1174	.3332	-.2042
6 BLUE- OTHER SKILLED	.0605	.1950	-.6483
7 BLUE COLLAR OTHER	-.0078	.4002	-.5737
8 RURAL	-1.7704	-1.6427	-1.8492
9 ARMED SERVICES	0.0000	0.0000	0.0000
REAL WAGE BILL	-.0832	.1991	-.5440

THE LOCAL CATEGORY, GAMMA = 0

MATRIX

SA (+NT)	WA	TAS	AUSTRALIA
-.0079	-.0113	-.0058	-.0065
.0001	.0000	.0001	.0001
.0001	.0001	.0001	.0001
.0006	.0005	.0006	.0006
.0001	-.0003	.0000	.0000
.0006	-.0060	-.0018	-.0007
.0003	.0000	.0001	.0003
-.0003	-.0011	-.0002	-.0004
-.0000	-.0000	-.0000	0.0000
.0258	-.0233	.0024	.0035
-.0010	-.0280	-.0120	-.0183
.0019	-.0003	.0015	-.0048
-.0038	-.0047	-.0040	-.0038
-.0009	-.0017	-.0007	-.0011
-.0020	-.0088	-.0040	-.0040
.0018	-.0040	-.0013	.0001
.0007	-.0006	.0001	.0000
.0006	-.0011	-.0003	-.0001
.0020	-.0037	-.0010	.0005
.0020	-.0045	-.0014	-.0014
.0000	.0000	.0000	.0000
-.0001	-.0003	-.0002	-.0001
.0001	.0001	.0001	.0001
.0001	-.0005	-.0002	-.0001
-.0014	-.0022	-.0019	-.0025
.0001	-.0007	-.0003	.0012
.0001	-.0002	-.0000	-.0000
0.0000	0.0000	0.0000	0.0000
-.0045	-.3927	-.1640	-.0779

(OCCUPATION X REGION)

SA (+NT)	WA	TAS	AUSTRALIA
-.0346	-.3039	-.1293	-.0740
.0814	-.3012	-.1167	.0049
.0399	-.2831	-.1180	-.0499
.4730	-.5111	-.3315	.1639
.1847	-.2574	.0382	.0923
-.1406	-.5707	.1738	-.0492
.1508	-.5695	-.1643	.0012
-1.9249	-2.1861	-1.5584	-1.8211
0.0000	0.0000	0.0000	0.0000
-.0458	-.5996	-.2681	-.1309

TABLE 3 : 28 INDUSTRIES IN

CONTRIBUTION

REGION :	NSW (+ACT)	VIC	QLD
7 L SERVICES TO AGRIC	-.0055	-.0046	-.0092
20 L BREAD,CAKES	.0001	.0006	-.0007
23 L SOFT DRINKS,CORDIALS	.0002	.0005	-.0006
24 L BEER + MALT	.0008	.0017	-.0010
57 L READY-MIXED CONCRETE	.0001	.0005	-.0007
81 L ELECTRICITY	.0003	.0123	-.0180
82 L GAS	.0004	.0015	-.0013
83 L WATER,SEWERAGE	.0004	.0042	-.0070
84 L RESIDENTIAL BUILDING	.0025	.0160	-.0233
85 L BUILDING NEC	.0111	.0341	-.0399
86 L WHOLESALE TRADE	.0019	.0334	-.0574
87 L RETAIL TRADE	.0080	.0382	-.0512
88 L MOTOR VEHICLE REPAIR	-.0024	.0045	-.0154
89 L OTHER REPARS	-.0005	.0018	-.0050
94 L COMMUNICATION	-.0007	.0082	-.0169
95 L BANKING	.0025	.0103	-.0119
96 L FINANCE + LIFE INS	.0017	.0078	-.0099
97 L OTHER INSURANCE	.0011	.0052	-.0064
98 L INVESTMENT,REAL EST	.0027	.0130	-.0154
99 L OTHER BUSINESS SERV	.0029	.0119	-.0138
100 L OWNERSHIP OF DWELLG	.0077	.0492	-.0718
103 L HEALTH	.0018	.0120	-.0178
104 L EDUCATION,LIBRARIES	.0006	.0033	-.0045
105 L WELFARE SERVICES	.0004	.0028	-.0039
106 L ENTERTAINMENT	-.0005	.0057	-.0123
107 L RESTAURANTS,HOTELS	.0033	.0209	-.0304
108 L PERSONAL SERVICES	.0007	.0043	-.0060
109 L BUSINESS EXPENSES	0.0000	0.0000	0.0000
TOTAL(OVER 109 INDUSTRIES)	-.0016	.4253	-.7005

EMPLOYMENT MATRIX

OCCUPATION / REGION :	NSW (+ACT)	VIC	QLD
1 PROFESSIONAL	-.0073	.3113	-.5699
2 WHITE COLLAR SKILLED	.0808	.5049	-.6591
3 WHITE COLLAR OTHER	.0555	.4737	-.6906
4 BLUE- METAL AND ELEC	.1094	.8078	-.6872
5 BLUE- BUILDING	.1685	.6626	-.6974
6 BLUE- OTHER SKILLED	.0957	.3737	-1.0060
7 BLUE COLLAR OTHER	.0170	.5508	-.8330
8 RURAL	-1.7630	-1.5957	-1.8862
9 ARMED SERVICES	0.0000	0.0000	0.0000
REAL WAGE BILL	-.0512	.4025	-.8593

THE LOCAL CATEGORY, GAMMA = 1

MATRIX

SA (+NT)	WA	TAS	AUSTRALIA
-.0079	-.0113	-.0058	-.0065
.0002	-.0006	-.0002	.0001
.0002	-.0005	-.0001	.0001
.0009	-.0008	.0001	.0006
.0001	-.0007	-.0001	.0000
.0026	-.0163	-.0052	-.0007
.0006	-.0013	-.0004	.0003
.0007	-.0063	-.0020	-.0004
.0041	-.0204	-.0068	0.0000
.0095	-.0418	-.0038	.0035
.0044	-.0552	-.0210	-.0183
.0108	-.0450	-.0134	-.0048
-.0018	-.0143	-.0072	-.0038
-.0004	-.0046	-.0017	-.0011
-.0005	-.0166	-.0066	-.0040
.0032	-.0111	-.0037	.0001
.0023	-.0089	-.0027	.0000
.0015	-.0058	-.0019	-.0001
.0041	-.0142	-.0045	.0005
.0037	-.0128	-.0042	-.0014
.0125	-.0629	-.0209	.0000
.0029	-.0156	-.0053	-.0001
.0009	-.0040	-.0013	.0001
.0007	-.0036	-.0012	-.0001
.0003	-.0108	-.0048	-.0025
.0053	-.0267	-.0089	.0012
.0011	-.0053	-.0017	-.0000
0.0000	0.0000	0.0000	0.0000
.0585	-.7078	-.2687	-.0779

(OCCUPATION X REGION)

SA (+NT)	WA	TAS	AUSTRALIA
.0133	-.5121	-.1988	-.0740
.1475	-.6393	-.2247	.0049
.1139	-.6806	-.2412	-.0499
.5173	-.7832	-.4279	.1639
.2657	-.6988	-.0907	.0923
-.0711	-.9426	.0594	-.0492
.1927	-.7984	-.2341	.0012
-1.9164	-2.2216	-1.5721	-1.8211
0.0000	0.0000	0.0000	0.0000
.0073	-.8874	-.3591	-.1309

(1) the exchange rate is fixed ,

(2) the level of domestic absorption (public and private consumption and investment) is maintained independently of changes in tariffs ,

(3) labour markets are slack and producers can find as much labour as they want at a constant real wage,[1] and

(4) capital stocks in each industry are fixed .

Notice that the fourth assumption implies that the DPRS results are short-run. These results indicate the changes in the levels of production and employment which could be expected to occur (as a result of the tariff changes) over a period of time which is sufficiently short that changes (induced by the tariff changes) in each industry's capital stock may be ignored. It will be recalled from subsection 2.2.3 that there are theoretical problems with using our modified LMPST method for the regional disaggregation of <u>short-run</u> national results. Our present application will give us an opportunity for commenting upon the practical significance of those problems.

Very briefly, the highlights of the DPRS results are :

(1) The principal export industries (1, 2, 9, 10, 11, 12, 15, 22, 27, 60 and 61) and industries whose major customers are export industries (3, 4, 5, 6, 7, 46 and 73), are the main losers from a uniform tariff increase. Export industries are in a weak position to pass on cost increases -- tariff increases impose cost increases especially via their

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1. All wages are indexed 100 per cent to the ORANI consumer price index.

effects on the general price level and thus on money wages.

(2) The main gainers from the tariff increases are the import competing industries (18, 21, 25, 28 - 36, 38, 40 -43, 45, 47 - 49, 51, 52, 54, 62, 64, 65, 69 - 72, 75 - 80). The tariff increase improves their competitive position vis-à-vis imports, allowing import replacement.

(3) Employment generated in the import competing industries is not sufficient to offset the loss of employment in export and export related industries. The 25 per cent tariff increase leads to a small reduction (.1309 per cent) in the economy-wide real wage bill (see the extreme right column of the "Employment Matrix" in Table 1.) The losses in employment opportunities, especially for "rural workers," more than counter-balance the increased employment opportunities for other occupational groups.

4.2 The Regional Results

Regional disaggregations of the national results from the 25 per cent tariff increase simulation are presented in Tables 1 - 3. Each table refers to the operation of the modified LMPST method under a different set of assumptions. The results in Table 1 were generated using the model with the assumption that all industries are national. That is, Table 1 is based on regional output changes produced from equation (1a) alone. Hence, the different regional effects of the national policy change depend purely upon the different industrial structure of the regions. Table 2 contains results from the model with 28 industries (marked "L" in the tables) specified as local industries. For these results the parameter γ is set to zero so that regional household consumption of local goods does not respond to regional wage income,[1] (see equations (5a) - (5c)). The results in Table 3 are generated with the same assignment of national and local industries as for Table 2, but with the parameter γ set equal to one. Thus in Table 3, variations in regional wage income are fully reflected in regional household consumption levels.

4.2.1 The contribution matrices

The first matrix in each table is the contribution matrix. These show the effects of the tariff increase on Gross State Products (GSP). The ir^{th} elements are the percentage effects on value added in region r arising from the change in output in industry i in region r. For example, in Table 1 we see that the 25 per cent tariff increase produces a 1.2689 per cent reduction in the output in the sheep industry. This represents a .0295 per cent reduction in Australian value added or GNP. (The sheep industry accounted for 2.32 per cent of GNP in our base period data and $-1.2689 \times .0232 = -.0295$.) Since we classify sheep as a national industry, we assume that output is reduced by 1.2689 per cent in all states. In Western Australia, where sheep account for 4.53 per cent of total value added, the effect is a .0575 per cent reduction in GSP

1. Since in Table 1 there are no industries in the local set, these results are independent of the value of γ.

(- 1.2689 × .0453 = - .0575). By comparison, a 1.2689 per cent reduction in sheep output produces a .0221 per cent reduction in the GSP for Victoria, where sheep account for only 1.74 per cent of GSP. In Tables 2 and 3, the rows of the contribution matrices for the national industries would be identical to those in Table 1. Therefore, in the interests of saving space, we have omitted them. For the local industries, however, variations across the rows in Tables 2 and 3 reflect not only variations in industry shares in GSP's (as in Table 1), but also variations in the percentage changes in outputs induced by variations in the regional impacts of the tariff changes on demands for local goods. The column totals of the contribution matrices are the aggregate changes in the GSP's.

4.2.2 The employment matrices

The second matrix in each table shows the percentage changes in employment by occupation and region. The Australia-wide figures were taken from the DPRS simulation. (For example, the DPRS simulation implied that a 25 per cent uniform tariff increase reduces employment in the "professional" category by .0740 per cent.) Then the regional figures were calculated by (1) applying equation (6b) to obtain the percentage changes in employment by industry and region (the $x^r_{(g+2)1j}$'s), (2) by assuming that employment for each occupation in each industry in each region moves with total regional employment in each industry, and (3) by assuming that the occupational composition of employment in each industry is regionally invariant. Under these assumptions we can compute the mr^{th} element, ℓ^r_m, of the employment matrices according to the formula

$$\ell_m^r = \sum_{j \in J} \left(\frac{X_j^r L_{mj}}{\sum_s X_s^r L_{ms}} \right) x_{(g+2)1j}^r \quad ,$$

where L_{mj} is the national coefficient (available in the ORANI data base) showing the labour hours used from occupation m per unit of output in industry j. The final row in each employment matrix gives the percentage changes in the total real wage bill in each state. Since the national simulation was conducted under the assumption of fixed real wages, movements in the total regional real wage bills reflect movements in total regional employment. Consequently, the entries in the last row of the employment matrix may be computed as weighted averages of the entries in the columns where the weights are occupational shares in the regional real wage bills.

4.2.3 A survey of the results for Gross State Products and Regional Occupational Employment

All three tables rank the states in the same order with respect to the effect of a uniform tariff increase on their GSP's. The column totals of the contribution matrices show that the ordering is (from gainers to losers) Victoria, South Australia, New South Wales, Tasmania, Queensland and Western Australia. Within this ranking, Victoria is an outstanding gainer and Queensland and Western Australia are outstanding losers.

The explanation for these results is found in the bodies of the contribution matrices. Victoria's economy is relatively intensive in highly protected manufacturing industries. Following an increase in protection, these industries make large positive contributions to the change in the state's GSP. Industries 28, 29, 35, 36, 64, 65 and 70 are leading examples. At the same time, Victoria is not heavily dependent on export related industries. Thus the reductions in the output of the export industries are generally less severe in their effects on the GSP of Victoria than they are on the GSP of the other states.

The position of South Australia as the state second most favourably affected by the tariff increase is almost entirely explained by the contribution of the heavily protected motor vehicle industry (industry 65). The contractionary effects on total value added of decreases in the outputs of the export related industries are, in several cases, stronger for South Australia than for Australia as a whole (see, for example, industries 1, 2 and 60). However, the boost derived from the increase in value added in industry 65 is sufficient to ensure that the overall effect of the tariff increase on South Australia is relatively favourable.

The results for New South Wales are fairly close to those for Australia. The NSW economy represents a large share of the nation's economy and is diversified in its industrial structure. Both export-related and import competing industries are well represented.

Tasmania suffers, under the influence of the tariff increase, from a general lack of import competing manufacturing industries (exceptions being textiles, 28 and 29, and paper, 41). In addition, the state's GSP is reduced to an approximately average extent by the contraction of the rural industries, and to a more than average extent by the contraction of the metal processing industries (60 and 61).

The two big losers from tariff increases, Queensland and Western Australia, both have a heavy concentration of export related industries. For Queensland, the impacts of the tariff increases on the outputs of the beef industries (3 and 15), some mineral related industries (11, 12 and 61) and sugar (22) have a strong depressing effect on GSP. For Western Australia, the contraction of the sheep and wheat industries (1 and 2) and the mineral industries (10, 11, 60 and 61) are responsible for the relatively large reduction in GSP.

When we turn to the employment implications of the 25 per cent tariff increase, we see that these follow from the GSP effects. For each table, the aggregate employment effects (as measured by the percentage changes in the real wage bills) exhibit the same rankings as the GSP effects : Victoria, South Australia, New South Wales, Tasmania, Queensland and Western Australia. In Table 1, where the percentage changes in the regional industrial outputs are assumed to be the same as the percentage changes in the Australian industrial outputs, the variations across the occupational rows of the employment matrix reflect regional variations in the industrial employment pattern of the occupational groups. For example, rural workers in WA are particularly heavily concentrated in industries 1 and 2, two of the heaviest losers from the tariff increase. Consequently, the percentage reduction in employment opportunities for rural workers is greatest in Western Australia. In Tables 2 and 3 the employment matrices are influenced by regional variations in the percentage changes in the outputs of local goods. This does not have much effect on the employment results for rural workers who are predominantly employed in national industries. However, for occupations (e.g., white-collar, skilled) where employment is concentrated in local industries, the results vary considerably as we move from Table 1 to Tables 2 and 3, i.e., as we allow for intra-regional multiplier effects arising from regional differences in the impact effects of the tariff increase.

4.2.4 A comparison across experiments

On comparing the regional GSP and employment results across the three tables, we find a steady accentuation of the regional differences. The regions which tend to gain most significantly, as compared with the national results (Victoria and South Australia), increase their relative gains and the biggest losers (Queensland and Western Australia) do worse. The impact effects of the tariff change in altering the shares of the states in the overall economic activity of the nation are reflected in Table 1. Moving to Table 2 we are allowing the impact effects to be multiplied in the regions via intermediate and investment demands for local goods. Moving to Table 3 we are introducing additional multiplier effects by forcing regional consumption for local goods to follow regional labour income.

The comparison across tables highlights the problem referred to in the discussion of equations (6b) and (5a) in subsection 2.2.3, concerning short-run applications of our modified LMPST method. Notice the results for industry 100, ownership of dwellings. The primary factor input for this industry is entirely fixed capital.[1] Therefore, in the short-run, there can be no change in its output. This explains the 0.0000 entry for the DPRS output result in the 100th row of Table 1. When we reach Table 3, however, we find non-zero entries across the 100th row of the contribution matrix. Since there has been no change in the nation's stock of houses, the conclusion must be that we are allowing houses to move between

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1. The output is the annual rental value of the nation's stock of houses.

regions. Inter-regional capital mobility is implied in Tables 2 and 3 because we allow for the tariff increase to have regionally different impacts on the outputs of local goods.[1] At the same time we are holding constant the national capital stocks in each industry and failing to allow the tariff changes to have regionally different impacts on industry labour-output (and hence capital-output) ratios.

Further evidence of the role of inter-regional capital mobility is provided by the relationships between the GSP and real wage bill results in the three tables. In Table 1 we observe that for Australia as a whole, the ratio of the percentage change in total value added to the percentage change in the real wage bill (or employment) is about .6, (i.e., .0779/.1309). This ratio is approximately maintained across the state results, varying from a low of .51 for South Australia to a high of .78 for Victoria. The value .6 reflects the approximate wage shares in the GSP's. It is to be expected, therefore, that under conditions of fixed capital stocks, a 1 per cent increase in employment will be associated with a .6 per cent increase in value added. Now comparing Tables 1 and 2, we see that for Victoria, for example, the percentage change in GSP has gone from .0904 to .1777, i.e., an increase of .0873 per cent. This is very similar to the percentage change in total employment which has gone from .1147 to .1991, an increase of .0844 per cent. The reader will find, if he makes the calculations, that the movement from Table 1 to Tables 2 and 3 implies approximately balanced changes in the GSP and total employment results for all states. The explanation is that the changes in the outputs of the local industries which occur between Table 1 and Tables 2 and 3, are achieved with balanced changes in both capital and labour inputs.

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1. The problem of inter-regional capital mobility does not arise in Table 1 where all goods are treated as national.

5. CONCLUDING REMARKS

In this paper we have described a method of deriving the regional implications of projections obtained at the national level from the ORANI model. The method owes much to earlier work by LMPST. However, for our purposes, it was necessary to modify the LMPST approach to make it compatible with a national model in which the variables are in percentage changes rather than levels. We also generalized the LMPST treatment of household demands.

We chose the LMPST approach for three reasons :

(1) It is sequential. First we obtain projections from the national model. Then we apply our modified LMPST computations. Regional results are achieved with no modifications required to the existing national model, and there are no potentially computationally difficult feedbacks from the regional model to the national model.

(2) As with the original LMPST computations, our modified LMPST approach possesses attractive aggregation properties. The Appendix shows that (under empirically relevant conditions) the modified LMPST method produces regional projections which are consistent with the national projections from which they are derived. For example, if the national ORANI computation indicates a 10 per cent increase in employment in the bread industry, then the appropriately weighted average of the regional projections for changes in employment in the bread industry will also equal 10 per cent.

(3) The LMPST approach makes minimum demands for regional data. In subsection 3.1 (especially Figure 1) we found that our modified LMPST method could be implemented with only a small fraction of the information

contained in a complete integrated set of regional inter-industry accounts. In particular, the need for information on inter-regional commodity flows is largely avoided. For Australian applications, data economy is a key advantage. As can be seen in subsection 3.3, even the assembly of production data, at the state level and on the ABS Input-Output industrial classification, was a difficult task. It was made very frustrating by gaps in the published statistics caused by the application of ABS confidentiality rules.

Despite the virtues listed in the previous paragraph, perhaps the fairest assessment that can be made of the LMPST approach is that it is a sensible way to use limited data. It takes into account two of the phenomena - - differences across regions in the industrial composition of their Gross Regional Products, and intra-regional multiplier effects - - which we believe are important in explaining differences across regions in the impact of national economic policies. On the other hand, it has some obvious deficiencies. Among these we can mention :

(1) It requires a judgmental categorization of industries as either local or national. We cannot expect regional industries to fall neatly into two groups; one group having 100 per cent of its sales within its own region, the other group having its sales determined completely independently of the regional locations of the demands for the types of products it produces. The truth must be that the sales of industry i in region r depend to varying extents on shifts in the demands for good i in the different regions. For example, shifts in demand in region r or in regions physically close to region r are probably more influential in determing the sales from region r than demand shifts in

distant regions. Unfortunately, however, in the absence of inter-regional commodity flow data it is not clear that we can improve significantly upon the local-national dichotomy.[1]

(2) *The LMPST method does not allow for regional variations in the impact of changes in national economic policies on factor prices.* In the long-run, it may be acceptable to assume that factors move (or accumulate at different rates) so that national policy changes affect factor prices equally across regions (i.e., the price of labour of type m rises by 5 per cent in all regions, the rental value of houses falls by 2 per cent in all regions, etc.). As we discovered in section 4, difficulties arise when regional variations in the percentage changes in factor prices are ignored in the short-run. For example, in the short-run we expect that the rental price of houses in Victoria, R(VIC), would rise relative to that in Western Australia, R(WA), as a result of a 25 per cent tariff increase. This is because our computations (Table 3) implied that income and aggregate consumption expenditure in Victoria would rise relative to that in Western Australia. However, it will be recalled from section 4 that our computations failed to choke off the relatively stronger Victorian demand. (There was no short-run increase in R(VIC)/R(WA).) They allowed, instead, the increased demand in Victoria and the reduced demand in Western Australia to be satisfied by a transfer of houses out of Western Australia and into Victoria.

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1. One possibility is to estimate inter-regional commodity flows from a knowledge of (a) regional commodity absorptions, (b) regional commodity productions, and (c) inter-regional distances or preferably inter-regional transport costs. A suitable technique was proposed by Leontief and Strout (1963) and it would be useful to investigate the feasibility of applying their method with Australian data. L. H. Liew proposes to do this work as part of his current Ph.D. assignment at Monash University.

The problem is only serious for highly capital intensive industries assigned to the "local" category.[1] Apart from industry 100, the only other such industries under our current assignment are industries 24 (beer and malt), 81 (electricity) and 83 (water and sewerage).[2] *Ad hoc* procedures (manual over-riding of the results for these industries or reassignment of them to the national category) could be employed for short-run analysis. We have chosen, in this paper, not to implement any *ad hoc* corrections; our objective has been to illustrate our modified LMPST method, revealin~ its weaknesses as well as its strengths. The alternative to an *ad hoc* correction would be to expand our regional theory to allow short-run regional variations in factor scarcities to generate short-run regional variations in the percentage changes in factor prices. We expect, however, that our modified LMPST method will be of most use in application to long-run analyses. Our results indicate that, with suitable short-run assumptions about the responsiveness of regional consumption to regional income, the operation of the method produces results close to those obtained under the assumption that all industries are national. The results in Table 1, that is, are relatively close to those in Table 2. It is only when long-run assumptions about consumption are introduced (see Table 3)[3] that the modified LMPST method dramatically magnifies the regional consequences of the national policy change. For these

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1. As explained in section 4, the problem of short-run inter-regional capital flows arises only for local industries - - industries for which the LMPST approach allows regional variations in percentage output changes.

2. Industry capital intensities are deducible from the V2 series in DPRS, pp. 271-273. V2 is defined in DPRS, p. 236.

3. Recall that the results in Table 3 assumed $\gamma = 1$ so that changes in regional consumption fully reflect changes in regional income. As suggested earlier this would appear to be a suitable long-run assumption.

reasons the development of a complete short-run version of the model is not considered a high priority in our research strategy.

The concentration in this paper has been on methodological issues. Therefore methodology has also been the principal concern of this concluding section. However, while the actual results reported in section 4 must be considered to be preliminary, we find them to be encouraging. Their main implication was that Victoria is the only state which clearly gains in terms of overall economic activity from general increases in protection, while Western Australia and Queensland clearly lose. This result was both robust under wide variations in key parameters of our modified LMPST model and was easily interpretable in terms of what we know about the comparative industrial structures of the states of Australia.

APPENDIX

The Compatibility of Regional and National Computations

Our introductory remarks to section 2 listed, among the advantages of the LMPST approach, that it produces regional results which are compatible with the national results. The purpose of this appendix is to establish the conditions under which this aggregation property is retained by our modified LMPST method.

In section 2 we introduced regional variables for the percentage changes in industry outputs, industry investments, industry employment, household consumption for local goods, "other" demands for local goods, and total wage bills. Each of these variables has an economy-wide counterpart in a national ORANI simulation. When we apply the modified LMPST method to the results of an ORANI simulation, can we be sure that the appropriate weighted averages over the regional results return us to the ORANI results which we are seeking to disaggregate? In particular, can we be sure that

(i) $\sum_r x_n^r S(X_n^r) = x_n , \qquad n\varepsilon N ,$

(ii) $\sum_r x_i^r S(X_i^r) = x_i , \qquad i\varepsilon L ,$

(iii) $\sum_r x_i^{(3)r} S(X_i^{(3)r}) = x_i^{(3)} , \qquad i\varepsilon L ,$

(iv) $\sum_r x_i^{(5)r} S(X_i^{(5)r}) = x_i^{(5)} , \qquad i\varepsilon L ,$

$$\text{(v)} \qquad \sum_r y_n^r \, S(Y_n^r) = y_n \, , \qquad n \epsilon N \, ,$$

$$\text{(vi)} \qquad \sum_r y_i^r \, S(Y_i^r) = y_i \, , \qquad i \epsilon L \, ,$$

$$\text{(vii)} \qquad \sum_r v^r \, S(V^r) = v \, ,$$

$$\text{(viii)} \qquad \sum_r x_{(g+2)1j}^r \, S(X_{(g+2)1j}^r) = x_{(g+2)1j} \, , \qquad j \epsilon J \, ,$$

where the variables on the left are regional results computed via the modified LMPST method applied to an ORANI simulation from which the variables on the right are an output? The S's are the appropriate weights. For example, $S(X_n^r)$ is the share of region r in the national output of good n , $S(X_{(g+2)1j}^r)$ is the share of region r in national employment in industry j , etc..

Equations (i) and (v) follow immediately from (1a) and (3a), and from (8a) we obtain

$$\sum_r x_\ell^{(5)r} \, S(X_\ell^{(5)r}) = x_\ell^{(5)} + \sum_r q_\ell^r \, S(X_\ell^{(5)r}) \, , \qquad \ell \epsilon L \, .$$

Hence, (iv) is valid provided that we set the q_ℓ^r so that

$$(*)^1 \qquad \sum_r q_\ell^r \, S(X_\ell^{(5)r}) = 0 \, , \qquad \ell \epsilon L \, .$$

Obviously $q_\ell^r = 0$ for all r and ℓ is an acceptable set of values.

Unfortunately, to establish the remaining aggregation conditions ((ii), (iii), (vi), (vii) and (viii)) a simultaneous, rather than a sequential

1. (*) will be used to indicate the assumptions which are needed to establish the aggregation conditions.

approach, is required. In what follows we use equations (2a), (5a)-(5c), (4a), (6a), (6b) and (7a) to develop expressions for the LHS's of (ii), (iii), (vi), (vii) and (viii) . Then we establish (ii), (iii), (vi), (vii) and (viii) by considering our expressions for their LHS's as a set of simultaneous equations. We start with the LHS of (ii). Equation (2a) implies that

$$\text{(ix)} \qquad \sum_r x_i^r S(X_i^r) = \sum_{n\in N} \sum_r \beta_{in}^{(1)r} S(X_i^r)\, x_n^r + \sum_{\ell\in L} \sum_r \beta_{i\ell}^{(1)r} S(X_i^r)\, x_\ell^r$$

$$+ \sum_{n\in N} \sum_r \beta_{in}^{(2)r} S(X_i^r)\, y_n^r + \sum_{\ell\in L} \sum_r \beta_{i\ell}^{(2)r} S(X_i^r)\, y_\ell^r$$

$$+ \sum_r \beta_i^{(3)r} S(X_i^r)\, x_i^{(3)r} + \sum_r \beta_i^{(5)r} S(X_i^r)\, x_i^{(5)r} ,$$

$$\text{for all } i\in L .$$

On using (i), (v) and (iv) (these have already been established as valid), and on recognizing that

$$\beta_{ij}^{(1)r} S(X_i^r) = \left(\frac{A_{ij}^{(1)} X_j^r}{X_i^r}\right) \frac{X_i^r}{X_i} = \frac{A_{ij}^{(1)} X_j}{X_i} \frac{X_j^r}{X_j} = \beta_{ij}^{(1)} S(X_j^r)$$

$$\text{for all } i \text{ and } j ,$$

$$\beta_{ij}^{(2)r} S(X_i^r) = \frac{A_{ij}^{(2)} Y_j^r}{X_i^r} \frac{X_i^r}{X_i} = \frac{A_{ij}^{(2)} Y_j}{X_i} \frac{Y_j^r}{Y_j} = \beta_{ij}^{(2)} S(Y_j^r)$$

$$\text{for all } i \text{ and } j ,$$

$$\beta_i^{(3)r}\, S(X_i^r) = \frac{X_i^{(3)r}}{X_i^r}\,\frac{X_i^r}{X_i} = \frac{X_i^{(3)r}}{X_i^{(3)}}\,\frac{X_i^{(3)}}{X_i} = \beta_i^{(3)}\, S(X_i^{(3)r})$$

for all i ,

and

$$\beta_i^{(5)r}\, S(X_i^r) = \frac{X_i^{(5)r}}{X_i^r}\,\frac{X_i^r}{X_i} = \frac{X_i^{(5)r}}{X_i^{(5)}}\,\frac{X_i^{(5)}}{X_i} = \beta_i^{(5)}\, S(X_i^{(5)r})$$

for all i ,

where $\beta_{ij}^{(1)}$, $\beta_{ij}^{(2)}$, $\beta_i^{(3)}$ and $\beta_i^{(5)}$ are sales shares at the national level for good i , we can rewrite (ix) as

$$\text{(x)}\qquad \tilde{x}_i = \sum_{n\varepsilon N} \beta_{in}^{(1)}\, x_n + \sum_{\ell\varepsilon L} \beta_{i\ell}^{(1)}\, \tilde{x}_\ell + \sum_{n\varepsilon N} \beta_{in}^{(2)}\, y_n + \sum_{\ell\varepsilon L} \beta_{i\ell}^{(2)}\, \tilde{y}_\ell + \beta_i^{(3)}\, \tilde{x}_i^{(3)} + \beta_i^{(5)}\, x_i^{(5)} , \qquad i\varepsilon L ,$$

where

$$\tilde{x}_j = \sum_r x_j^r\, S(X_j^r) , \qquad j\varepsilon L ,$$

$$\tilde{y}_j = \sum_r y_j^r\, S(Y_j^r) , \qquad j\varepsilon L ,$$

and

$$\tilde{x}_j^{(3)} = \sum_r x_j^{(3)r}\, S(X_j^{(3)r}) , \qquad j\varepsilon L .$$

Equations (5a) - (5c) imply that the LHS of (iii) is given by

$$\text{(xi)} \qquad \sum_r x_\ell^{(3)r} S(X_\ell^{(3)r}) = x_\ell^{(3)} + E_\ell \gamma (\sum_r v^r S(X_\ell^{(3)r}) - v) \quad \text{for all } \ell \varepsilon L .$$

If we assume that

$$(*) \qquad S(X_\ell^{(3)r}) = S(V^r) , \quad \text{for all } \ell \varepsilon L \text{ and all } r ,$$

i.e., region r's share in aggregate household consumption of good ℓ equals its share in the economy-wide wage bill, then (xi) becomes

$$\text{(xii)} \qquad \tilde{x}_\ell^{(3)} = x_\ell^{(3)} + E_\ell \gamma (\tilde{v} - v) , \quad \text{for all } \ell \varepsilon L ,$$

where

$$\tilde{v} = \sum_r v^r S(V^r) .$$

For the LHS of (vi), we use equation (4a).

$$\text{(xiii)} \qquad \sum_r y_\ell^r S(Y_\ell^r) = y_\ell + \sum_r x_\ell^r S(Y_\ell^r) - x_\ell , \quad \text{for all } \ell \varepsilon L .$$

If we assume that

$$(*) \qquad S(Y_\ell^r) = S(X_\ell^r) ,$$

i.e., the share of region r in the total investment in industry ℓ equals the share of region r in the total output of industry ℓ, then (xiii) becomes

$$\text{(xiv)} \qquad \tilde{y}_\ell = y_\ell + \tilde{x}_\ell - x_\ell \ , \qquad \text{for all } \ell \varepsilon L \ .$$

The LHS of (vii) follows from equations (6a), (6b) and (7a).

$$\sum_r v^r S(V^r) = \sum_r \sum_{j \varepsilon J} p_{(g+2)1j} W_j^r S(V^r) + \sum_r \sum_{j \varepsilon J} x^r_{(g+2)1j} W_j^r S(V^r) \quad .$$

That is ,

$$\tilde{v} = \sum_{j \varepsilon J} p_{(g+2)1j} W_j + \sum_{j \varepsilon J} x_{(g+2)1j} W_j + \sum_r \sum_{j \varepsilon J} x_j^r W_j^r S(V^r)$$

$$- \sum_{j \varepsilon J} x_j \ W_j \quad .$$

That is,

$$\text{(xv)} \qquad \tilde{v} = v + \sum_{j \varepsilon L} W_j (\tilde{x}_j - x_j) \quad ,$$

In deriving (xv) we recognize that $W_j^r S(V^r)$ is the share of the economy's wage bill devoted to industry j in region r. Hence, $W_j^r S(V^r)$ equals W_j multiplied by $S(Z_j^r)$, the share of region r in industry j's national wage bill. Then (xv) follows if we apply (i) and assume that

$$(*) \qquad S(X_j^r) = S(Z_j^r) \qquad \text{for all } j\epsilon J ,$$

i.e., the share of region r in the national output of industry j equals the share of region r in the total wage bill of industry j.

Our final expression is for the LHS of (viii). It follows from (6b) that

$$\text{(xvi)} \qquad \sum_r x^r_{(g+2)1j} \, S(X^r_{(g+2)1j}) = x_{(g+2)1j} + \sum_r x^r_j \, S(X^r_{(g+2)1j}) - x_j ,$$

$$\text{for all } j\epsilon J .$$

If we assume that

$$(*) \qquad S(X^r_{(g+2)1j}) = S(X^r_j) ,$$

i.e., the share of region r in the total employment in industry j equals the share of region r in the total output of industry j, then (xvi) reduces to

$$\text{(xvii)} \begin{cases} \tilde{x}_{(g+2)1j} = x_{(g+2)1j} & \text{for all } j\epsilon N , \\ \tilde{x}_{(g+2)1j} = x_{(g+2)1j} + \tilde{x}_j - x_j & \text{for all } j\epsilon L , \end{cases}$$

where

$$\tilde{x}_{(g+2)1j} = \sum_r x^r_{(g+2)1j} \, S(X^r_{(g+2)1j}) .$$

Now we examine the five sets of equations (x), (xii), (xiv), (xv) and (xvii). We consider the unknowns in these equations to be :

$$\tilde{x}_i, \quad \tilde{x}_i^{(3)} \quad \text{and} \quad \tilde{y}_i \qquad \text{for } i\varepsilon L ,$$

$$\tilde{v} ,$$

and

$$\tilde{x}_{(g+2)1j} \qquad \text{for } j\varepsilon J .$$

Thus we have a system of $(3L^* + 1 + J^*)$ linear equations in the same number of unknowns where L^* and J^* are the numbers of elements in L and J . We assume that system has a unique solution. Then it is easy to check that the solution must be

$$\text{(xviii)} \quad \begin{cases} \tilde{x}_i = x_i & \text{for } i\varepsilon L , \\ \tilde{x}_i^{(3)} = x_i^{(3)} & \text{for } i\varepsilon L , \\ \tilde{y}_i = y_i & \text{for } i\varepsilon L , \\ \tilde{v} = v & \\ \text{and} & \\ \tilde{x}_{(g+2)1j} = x_{(g+2)1j} & \text{for } j\varepsilon J . \end{cases}$$

(xviii) satisfies (xii), (xiv), (xv) and (xvii) trivially. It also satisfies (x) because ORANI computations are constrained by the equations

$$x_i = \sum_{n\in N} \beta_{in}^{(1)} x_n + \sum_{\ell\in L} \beta_{i\ell}^{(1)} x_\ell + \sum_{n\in N} \beta_{in}^{(2)} y_n + \sum_{\ell\in L} \beta_{i\ell}^{(2)} y_\ell + \beta_i^{(3)} x_i^{(3)} + \beta_i^{(5)} x_i^{(5)} , \qquad i\in L .$$

That is, ORANI computations satisfy the constraint that the percentage change in the output of good i equals the appropriately weighted average of the percentage changes in demands for good i . When we turn back to the definitions of $\tilde{x}_i$, $\tilde{x}_i^{(3)}$, $\tilde{y}_i$, $\tilde{v}$ and $\tilde{x}_{(g+2)1j}$, we see that (xviii) has established (ii), (iii), (vi), (vii) and (viii) .

In summary, what we have done in this appendix is to prove that under the conditions marked by (*)'s, the modified LMPST method preserves the aggregation conditions (i) - (viii) . A check through sections 2 and 3 reveals that the (*)-conditions are all compatible (or even explicitly assumed) in our empirical implementation of the modified LMPST computations.

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