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REGIONAL DISAGGREGATION OF A NATIONAL ECONOMIC MODEL : THE 'BOTTOMS-UP' APPROACH

by

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ABSTRACT

A multi-region, multi-sector Walrasian type model adopting the 'bottoms-up' approach to regional modelling is constructed for Australia. The novel features of the model are the incorporation of inter-regional commodity flows, explicit modelling of region-specific factor supply constraints and provision for analysis of the impacts on the national economy of policy and other changes occurring at the regional level. The model is applied to an analysis of the impact of changes in customs tariffs on the national and state economies of Australia.

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REGIONAL DISAGGREGATION OF A NATIONAL ECONOMIC MODEL :

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Leong H. Liew*

1. INTRODUCTION

During the last decade, considerable efforts have been made by academic institutions and government agencies such as the Treasury, the Reserve Bank and the Industries Assistance Commission to construct models of the Australian economy.[1] Most of these models seek to explain economy-wide aggregates such as the gross national product (GNP), the inflation rate and the level of unemployment. Few of them disaggregate the economy-wide aggregates into outputs for each industry, employment of each type of labour, etc. Three notable exceptions are Evans (1972), Dixon, Harrower and Powell (1976) and Dixon, Parmenter, Sutton and Vincent (1982).

These three are basically economy-wide models focusing on broad sectors of the Australian economy. Except for Dixon, Parmenter, Sutton and Vincent (1981), there is no attempt towards regional disaggregation. Dixon, Parmenter, Sutton and Vincent (1982)

* This paper is based on my doctoral thesis at Monash University (Liew 1981). I wish to thank Professor Peter Dixon for his supervisory role and Professor Alan Powell for comments on an earlier draft of the paper.

1. A survey of modelling in Australia is given by Challen and Hagger (1979a, 1979b). These two references complement one another.

rely on a 'tops-down' approach in their regional disaggregation.

The aims of this paper are:

(i) to present a multi-regional, multi-sectoral general equilibrium model of the Australian economy which is constructed following the 'bottoms-up' approach, and

(ii) to analyse the national and regional impacts of a 25 per cent tariff increase using this model.

Tops-down versus Bottoms-up Approach

Before actually proceeding to construct a regional model[2] we consider the two principal methods of regional modelling : the 'tops-down' and the 'bottoms-up' approaches. In the 'tops-down' approach, the regional model is developed as a satellite or appendage to a national model. First, a national model is constructed. Regional variables are then related to national variables through a one-way interface, i.e., without feedback. National variables which normally are endogenous in a national model are exogenous to the regional model. In other words, while national developments can affect regional performance, regional developments cannot affect national performance.

In contrast, the 'bottoms-up' approach involves the construction of a model with explicit detail concerning each region of

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2. For a survey of regional modelling, see Kendrick (1971) and Klein and Glickman (1977). A short survey of some existing regional models using the 'tops-down' approach is given by Saltzman and Chi (1977), pp. 49-51. Courbis (1979) provides an example of a regional model using the 'bottoms-up' approach. A hybrid version of the 'tops-down' and 'bottoms-up' approaches is given by Higgs, Parmenter, Rimmer and Liew (1981).

the national economy. Such a model recognises decision makers (producers, consumers, etc.) specific to each region. It is the simultaneous interaction of the decisions of these agents with respect to output, planned purchases, etc., that generates a solution to the model. The various relationships explaining the behaviour of the regional decision makers are then summed to obtain national aggregates. This is a fully interdependent system and it allows policies aimed at the regional level to affect national performance, as well as enabling national policies to affect the regions. From a theoretical perspective, therefore, the 'bottoms-up' approach is clearly preferred.

In practice, the 'tops-down' approach is more often used. There are two reasons for this. First, since in most cases national models are in existence, it is easier to build a satellite regional model and attach it to an existing national model than to construct a model from scratch. Second, regional data are scarce and the implementation of a 'bottoms-up' model would in many instances require a good deal of ad hoc augmentation of the data base. Issues of theoretical nicety aside, the necessary work on data amplification is very costly in terms of the number of professional man hours required. This tends to discourage the construction of these types of models by policy makers.

The paper is organised as follows. In section 2 the theoretical structure of the model is presented. The solution of the model is explained in section 3. Section 4 describes the projections obtained by the model of a 25 per cent tariff increase. The paper ends with a conclusion in section 5.

2. THEORETICAL STRUCTURE OF THE MODEL

In this section we present the theoretical structure of the model, which is essentially neo-classical in character. Households are assumed to choose bundles of commodities on the basis of given prices and incomes to maximise their utilities. Firms have constant returns to scale production functions and maximise profits. The assumption that all of the excess of revenue over the costs of materials is distributed to primary factors -- i.e., that there are no 'pure profits' -- ensures that commodity prices equal costs.

Figure 1, together with tables A.1 - A.4 in the appendix, sets out the theoretical structure of the model. Appendix table A.1 lists the equations of the model (in percentage change form), while tables A.2, A.3 and A.4 respectively define the variables, share parameters and elasticities of the model.

Technology for the Production of Current Goods

The production technology for current goods is summarized in figure 1. To produce output, a given industry in a particular region requires inputs of materials, primary factors and other costs. Supplies of materials are provided domestically and from abroad. Domestic material inputs of the same kind (for example type j) supplied by the domestic regions are combined together through a CES function[3] to form an index of aggregated domestic material input j. This in turn combines with imported material input j through a CES function

3. CES means constant elasticity of substitution. See Arrow, et al. (1961).

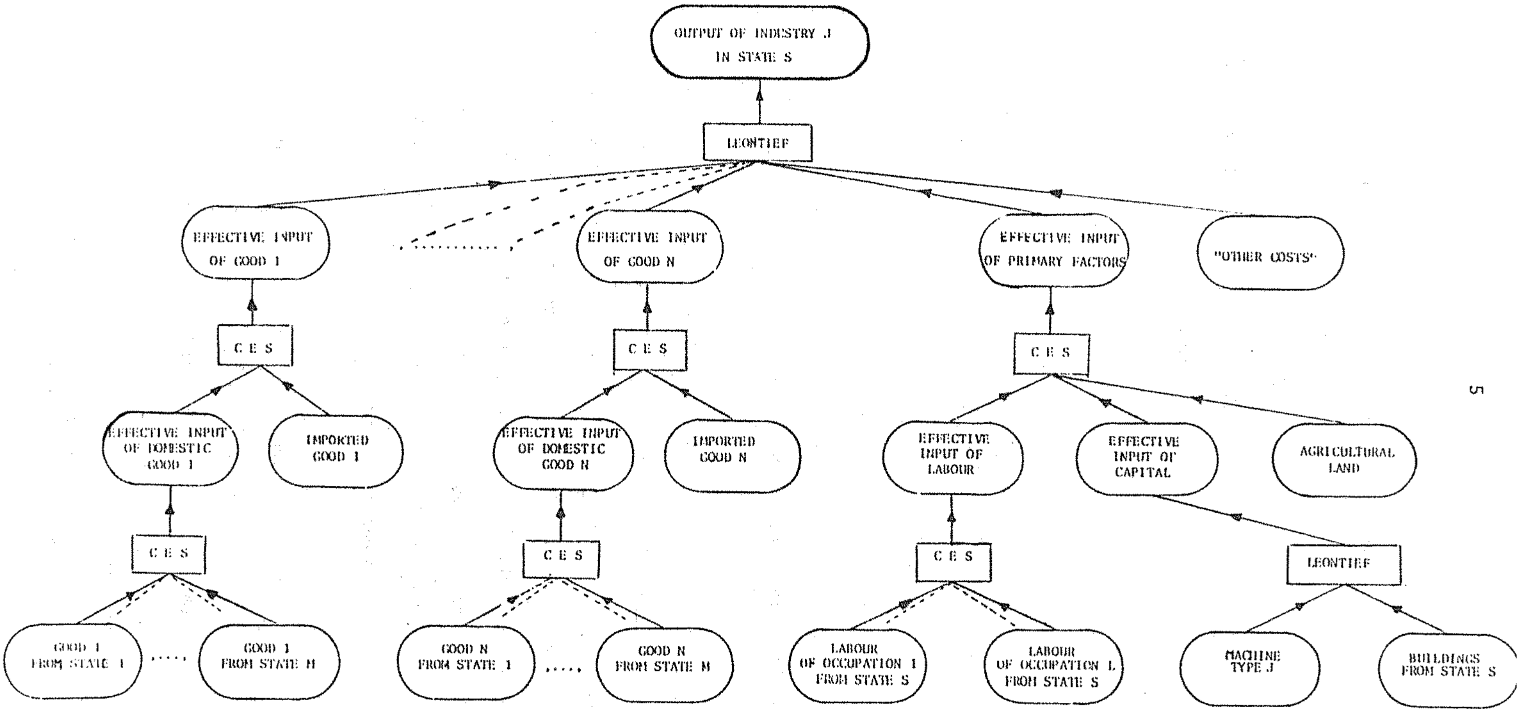

FIGURE 1 PRODUCTION TECHNOLOGY IN MISMAE FOR CURRENT GOODS IN INDUSTRY J IN STATE S.

to form the effective material input j. By this formulation we allow for imperfect substitution between material inputs of the same kind from the various sources of supply[4] and the movement of commodities used as material inputs between domestic regions. In fact, the model assumes inter-regional mobility for all commodities.

The index of primary factors is made up of labour, capital and land. They are nested together within a CES function. Labour is further disaggregated into various skills. Different categories of labour skills are combined together by a CES function to form the effective labour input. Unlike commodities, we assume that labour is region-specific. Industries located in each domestic region derive their labour requirements from labour available in their own regions. There is no inter-regional labour mobility.

Capital comprises machines and buildings. Machines and buildings are combined by a Leontief function to form the index of capital input. This rules out substitution between machines and buildings. They have to be used in fixed proportions. Machines are industry-specific. They can be moved from one domestic region to another but not from one industry to another. On the other hand, buildings are region specific. They can be used by any industry but cannot be shifted from one region to another.

In summary, we recognize a relatively full range of substitution possibilities between all the primary inputs of different labour skills, machines, buildings and land. The major exception is machines and buildings which are not substitutable.

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4. The idea of imperfect substitution between domestic and imported sources of supply is derived from Armington (1969).

'Other costs' involve production taxes and costs of working capital. They are included to enable simulations to analyse the effects of changing these two economic variables.

Demand for Commodities

The demand for commodities in the model includes the demand by producers for material inputs in the production of current goods, machines and buildings; consumption demand by households; and finally, exports and 'other final demands'.[5]

Producers and households are assumed to be price takers and to minimize the costs of producing, respectively, any given level of output and any given level of utility. For the producers, substitution between effective material inputs and primary factors is absent. However, producers can choose between differentiated material inputs of the same type from the different domestic regions and overseas.[6] In the production of current and capital goods producers minimize their costs by choosing least cost combinations from the various sources of supply of each and every type of material.

Households' demands in each domestic region are dependent on total regional labour incomes and government transfer payments. The incorporation of government transfer payments enables us to simulate the effects of deliberate government actions to help economically disadvantaged domestic regions by direct financial help. Given the total

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5. 'Other final demands' are mainly demands by the government.

6. 'Same' is used in the sense of being produced by like named industries in the different domestic regions and overseas. The sources are nevertheless differentiated because commodities of the same type originating from the different sources are imperfect substitutes.

income available, each household is allowed to choose quantities of the different types of commodities to maximize their utilities. Once having decided the quantities of each type of good they desire to consume, the typical household then chooses for each type of good the quantities from the various sources of supply.

Export demands are modelled under two assumptions. For those exports which comprise a very small share of the world's supply we assume that the quantity exported does not affect the world price, the well known 'small country' assumption of international trade theory. Exports which make up a significant proportion of the world supply are assumed to face a less than perfectly elastic demand curve. This implies that the economy cannot increase the supply to the world of these export commodities without facing a reduction in their world prices.

Each type of export good is composed of quantities of the export good from the various domestic regions. Quantities of export goods of the same type (for example j) from different domestic regions, combine together through a CES function to give an index of export good of type j. We assume that for each export commodity, overseas buyers take into account the fact that they can purchase from the various domestic regions. Thus foreign buyers minimize the cost of obtaining a desired 'effective quantity' of a given export good by selecting appropriate quantities from the various domestic regions subject to the CES constraint.

In this model there is no theory of 'other final demands' and no special theory of the demand for 'margins' services. By 'margins' here is meant the services of wholesale and retail trade, of transport, insurance, etc.. 'Other final demands' are assumed to be exogenous. The demand for margins is treated just like the demand for other commodities. This is a simplification which can be easily argued against on theoretical grounds.[7] This approach is adopted solely on the grounds that it enables the model to be solved with less computing effort.

Demand for Primary Factors

The demands for primary factors are derived only from the production of current goods. The creation of machines and buildings requires no primary factors or 'other costs'. The creation of machines and buildings depends on inputs from the machinery and construction industries. Thus, the use of primary factors and 'other costs' in the manufacture of investment goods is recognized via the demand for inputs from the machinery and construction industries.

Capital is made up of machines and buildings. They are used in fixed proportions. Substitution possibilities between machines and buildings are therefore absent. However, different categories of labour skills are substitutes for one another. Furthermore, substitution possibilities of a CES type exist between the aggregate indices of capital, labour and land. Therefore, at any given output levels, we have producers choosing quantities of the different available labour skills and of land and capital so as to minimize the cost of primary factors used. Their ability to do so is constrained by the CES function

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7. For example, retail trade facilitates the sale of clothing and footwear. If we treat retail trade just like any other good, we may find retail trade being substituted for clothing and footwear by consumers if the price of clothing and footwear rises relative to other goods! What is more likely to happen in reality is that the demand for clothing and footwear would fall and with it, the associated demand for margins.

combining the different categories of labour and the CES function aggregating labour, capital and land.

Indexation Equations

The percentage change form of the model has three sets of indexation equations. They are:

(I.1) $p^{os}_{(n+2)j} = cpi$, $j = 1, \ldots , n,$ $s = 1, \ldots , m,$

(I.2) $p_{(n+1)21j} = \beta_j(cpi) + (rm)_j$, $j = 1, \ldots n$,

(I.3) $^{\ell}p^z_t = \alpha^z_t\ (cpi) + (rp)^z_t$, $z = 1, \ldots , m,$ $t = 1, \ldots , \ell,$

where α^z_t and β_j are coefficients and $(rm)_j$ and $(rp)^z_t$ are (percentage changes in) shift variables. The first set of equations fully indexes 'other costs' per unit of output $(p^{os}_{(n+2)j})$ to the general price level (cpi). The second set of equations allows indexation of the rentals of machines $(p_{(n+1)21j})$, while the last set makes provision for indexation of wages.

By including these indexing equations for rentals and for wages we can allow flexibility in what is being assumed about the states of the rental market for machines and of the labour market. If we put the parameter $\beta_j = 1$ and set the variable $(rm)_j$ exogenously to zero we are fully indexing the rentals of machines to the consumer price index (cpi). In this case the model will solve for the percentage changes in the employment of machines. On the other hand we could set

$\beta_j = 1$, but let $(rm)_j$ be endogenous. The model would then solve for the changes $(rm)_j$ in real rentals of machines consistent with an exogenously set employment level for machines.

Similarly, setting the demand for labour exogenously and putting $\alpha_t^z = 1$, the model calculates $(rp)_t^z$, the required percentage change in real wages. Alternatively, we could set $(rp)_t^z$ exogenously to zero and put $\alpha_t^z = 1$, thus imposing full wage indexation (i.e., constant real wages). The model would then solve for the percentage changes in employment consistent with this assumption.

Other Structural Equations

The rest of the model comprises price formation, market clearing and definitional equations. The price equations fall into two groups. The first equates prices with costs. They ensure that factors in fixed supply are costed at their shadow prices and that there are consequently no 'pure profits'. With constant returns to scale production functions and competitively structured markets, commodity prices are functions only of materials and factor prices. They do not depend on production levels. The second group of price equations provides links between domestic and world prices. These prices are set such that no unexploited opportunity for arbitraging exists.

Summary of the Complete Model and Required Data

The equations of the model are linear in percentage changes and could be written as

$$A\pi = 0 \quad ,$$

where π is the $r \times 1$ vector of variables of the model in percentage changes and A is a $q \times r$ matrix, the elements of which are built up from estimates of substitution elasticities and of other behavioural parameters, and from cost and sales shares obtainable from a multi-regional input-output table.

There is as yet not available in Australia a set of consistent multi-regional input-output tables from which the elements of the matrix A could be derived. To overcome this problem we adopt the technique of Leontief and Strout (1963) to estimate inter-regional commodity flows from a knowledge of regional commodity absorptions and regional commodity productions. From these inter-regional commodity flows and the Australian input-output tables for 1968-69, we are able to derive a consistent multi-regional input-output table by assuming (a) that for any given region s, the proportion of the value of commodity i flowing in from the domestic region r is the same for all users and (b) there are no regional differences in technology.[8] Estimates of regional outputs and absorptions used are those constructed by Dixon, Parmenter and Sutton (1978).

3. SOLUTION OF THE MODEL[9]

Our general equilibrium model of q equations and r variables can be written as

$$F(Z) = 0 , \tag{S1}$$

8. For more details, see Liew (1981), chapter 3.

9. This material draws on Dixon, Parmenter, Sutton and Vincent (1982), chapter 5.

where Z is a $r \times 1$ vector consisting of variables of the model in levels and F is a vector of twice differentiable functions of the vector Z. The variables are divided into exogenous and endogenous groups so that the above equation can be rewritten as

$$\text{(S2)} \qquad F(X, Y) = 0 \;,$$

where X is the subvector of Z consisting of the exogenous variables and Y is the subvector of endogenous variables. The reduced form or solution of this model is

$$\text{(S3)} \qquad Y = H(X) \;,$$

where H is a vector of q differentiable functions. For sufficiently small changes in the exogenous variables, the movement from one equilibrium position to the next can be shown as

$$\text{(S4)} \qquad dY = H_x(X)dX \;,$$

where $H_x(X)$ is the $q \times (r-q)$ matrix of first order partial derivatives of H. In percentage change form the equation becomes

$$\text{(S5)} \qquad y = G_x(X)x \;,$$

where

$$G_x(X) = \hat{Y}^{-1} H_x(X)\hat{X} \;,$$

in which $\hat{Y}$ and $\hat{X}$ are the diagonal matrices formed from the vectors Y and X.

We now discuss the computation of the matrix $G_X(X)$. For a sufficiently small change in the exogenous variables, (S2) can be transformed to

$$\frac{\partial F(X_I, Y_I)}{\partial X} dX + \frac{\partial F(X_I, Y_I)}{\partial Y} dY = 0 ,$$

where the subscript I denotes initial values of X and Y. Rewriting the above in percentage change form we obtain

(S6) $$Nx + My = 0 ,$$

where

$$N = \frac{\partial F(X_I, Y_I)}{\partial X} X_I ,$$

$$M = \frac{\partial F(X_I, Y_I)}{\partial Y} Y_I .$$

N and M will be recognized as submatrices of the A matrix appearing in section 2. From (S6) we can compute $G_x(X)$ as

(S7) $$G_x(X) = -M^{-1}N .$$

The matrix $G_x(X)$ can be regarded as the solution matrix. The ij^{th} element of this matrix is the elasticity of the i^{th} endogenous variable with respect to the j^{th} exogenous variable. By specifying values for the set of exogenous variables x we can solve for the set of endogenous variables y.

The method of solution ensures flexibility in the use of the model. A fixed classification of variables into exogenous and endogenous is avoided. Depending on the policy questions that interest us, we can classify a variable as exogenous in one experiment and endogenous in another as long as it makes economic sense.

Linearization Errors

In solving our system of equations we have assumed that the elements of our solution matrix, $G_x(X)$, are constant at $G_x(X_I)$. This assumption is acceptable as long as we are dealing only with a small change in our exogenous variables. For a large change we cannot assume that the costs, sales and other shares from which $G_x(X)$ is evaluated are constant. To simulate a large change in our exogenous variables we will theoretically need to divide the change into k parts, where k is sufficiently large. Formally, to solve for the effect of changing the exogenous variables from X_I to $X_I + \Delta X$ we first compute the effect of changing the exogenous variables from X_I to $X_I + \frac{1}{k}\Delta X$, obtaining

(S8) $$y^1 = -(\tfrac{1}{k})M^{-1}(X_I, Y_I)N(X_I, Y_I)x^1 ,$$

where $$x^1 = \hat{X}_I^{-1}\Delta X ,$$

with the operator ^, as before, turning a vector into the corresponding diagonal matrix. We have included the arguments of M and N to emphasize that these matrices are being evaluated for the initial cost and sales shares. Next, the M and N matrices are re-computed at the point $\left(X_I + \frac{1}{k}\Delta X,\ (I + \hat{y}^1)Y_I\right)$. This involves updating the input-output tables to take account of the changes in prices and quantities resulting from the change in the exogenous variables from X_I to $X_I + \frac{1}{k}\Delta X$.

Having re-computed N and M we now compute the impact of changing the exogenous variables from $(X_I + \frac{1}{k}\Delta X)$ to $(X_I + \frac{2}{k}\Delta X)$. Following the notation of (S8) we write

$$y^2 = -\frac{1}{k} M^{-1}\left(X_I + \frac{1}{k}\Delta X,\ (I + \hat{y}^1)Y_I\right)N\left(X_I + \frac{1}{k}\Delta X,\ (I + \hat{y}^1)Y_I\right)x^2 ,$$

where

$$x^2 = \left(\widehat{X_I + \frac{1}{k}\Delta X}\right)^{-1}\Delta X .$$

After computing y^2, we again compute M and N, this time at the point $\left(X_I + \frac{2}{k}\Delta X,\ (I + \hat{y}^2)(I + \hat{y}^1)Y_I\right)$. We keep re-computing M and N through this process until we get our final solution for Y as $(I + \hat{y}^k)(I + \hat{y}^{k-1})\ldots.(I + \hat{y}^1)Y_I$.

In solving our model, we have used only a one step procedure.[10] There is nothing to prevent us in our future research from attempting the k step procedure. Experiments by Dixon, Parmenter, Sutton and Vincent (1982) with the ORANI model indicate that the value of k required for highly accurate solutions will probably be small. In fact they found for ORANI that k=2 will normally be more than adequate, provided use is made of an appropriate extrapolation procedure.

10. This is the method Johansen (1974) adopted in solving his model.

Choice of Exogenous Variables

A count of the number of equations and variables of the model shows that the number of variables exceeds the number of equations by $(2mn + 5m + 5n + \ell m + 1)$. Thus, we have to make $(2mn + 5m + 5n + \ell n + 1)$ variables exogenous. A possible choice of the variables to be made exogenous is listed in table 1.

There are no equations explaining the numbers of units of buildings and machines created or the number of households in each region. They are therefore treated as exogenous. Transfer payments are determined by the Federal Government of Australia. Thus they are normally assumed to be exogenous. We can set these payments exogenously to a non zero value in order to simulate the effects of Federal Government aid to a depressed region. We can for example compare the use these policy instruments to the use of specific export subsidies.

Outputs going into 'other domestic demands' and 'other imported demands' are small components of overall demands which are not explained within the model, being determined exogenously by government purchases. Exogenous movements in the export shift variables are used to simulate exogenous shifts in overseas demand for exports, such as a shift in the demand for coal due to a restriction of oil exports by OPEC.

By treating world prices of imports exogenously, we are adopting the small country assumption in relation to imports. We are assuming that Australian demands are not significant on the world market, such that the supplies of imports to Australia are perfectly elastic at the going world prices.

Table 1 : A Possible List of Exogenous Variables

Variable	Definition*	Number**
z^s	Units of buildings created	m
y_j	Units of machines created	n
h^s	Number of households	m
w_2^s	Transfer payments	m
f_i^z	Domestic outputs going into other domestic demands	mn
f_i^2	Other imported demands	n
Ω_i	Export shift variables	n
p_j^I	World prices of imports	n
t_j	One plus nominal tariff rates ('power of the tariff')	n
k_2^s	Employment of buildings	m
b^s	Employment of land	m
$(rp)_t^z$	Wage indexation shift variables	ℓm
$(rm)_j$	Indexation of rentals of machines shift variables	n
s_j^s	Export subsidies	4m
e_j^s	Exports overseas	mn-4m
θ	Exchange rate	1
	Total number of exogenous variables	$2mn+5m+6n+\ell m+1$

* All the variables are in percentage change form.

** m is the number of regions, n is the number of products and ℓ is the number of skill categories of labour recognized in the model.

To study the effects of trade liberalization, we specify the nominal tariff rates exogenously and observe their impact on the production levels of domestic industries, employment and inflation. (Actually the tariffs are entered in the model in the form of their 'powers'; i.e., the variable explicitly appearing is one plus the nominal ad valorem tariff rate expressed as a fraction). Alternatively we could set national output levels exogenously for some commodities and let the model solve for the nominal tariff rates required to achieve the targeted output levels. In other words, we could endogenize the powers of the tariffs and exogenize the output levels.

The employment of buildings and land in each region is set exogenously leaving the model to solve for the rentals of buildings and land. On the other hand we could set the rentals of buildings and land exogenously and allow the model to solve for the employment of buildings and land. Normally, we would expect to set the employment of buildings and land exogenously at the full employment level, i.e., we would expect that buildings and land are fully employed and would set the percentage changes in the employment of buildings and land exogenously to zero.

If we follow table 1, the percentage changes of the shift variables in the equations for wage indexation and for indexation of rentals of machines would be set exogenously. This is equivalent to making real wages and real rentals of machines exogenous and the employment of labour and machines endogenous. We could, however, envisage an experiment in which the employments of labour and machines are set exogenously at their full employment levels and the model solves for the real wages and real rentals of machines required to achieve such a result.

Four industries are normally designated as export industries. Since they are located in m regions we effectively have 4m export industries. The export subsidies (or export taxes) of these industries are set exogenously and the model is allowed to solve for their exports. For the remaining (mn-4m) non-exporting industries, we set their percentage changes in exports exogenously. The resulting export subsidies (or export taxes) are meaningless. However, since they appear only in equation (27) of the model (appendix table A.1), no matter what values they take, they will not affect the other variables of the model.

The exchange rate is the last variable in our possible list of exogenous variables. In most simulations, the exchange rate simply acts as the numeraire. In other models, for example that of Taylor and Black (1974), the money wage is used as a numeraire. We need to specify a numeraire in our model, i.e., at least one monetary variable should be treated as exogenous because failure to do so will mean that there is nothing to determine the absolute price level and the model will not be able to generate a unique solution. We can see this by (i) setting $\theta=1$ and all other exogenous variables in table 1 to zero and (ii) setting the indexation parameters to equal 1, i.e.,

$$\alpha_t^z = 1 , \quad t=1,\ldots,\ell, \quad z=1,\ldots,m,$$

and

$$\beta_j = 1 , \quad j=1,\ldots,n.$$

By working through the equations of the model in appendix table A.1 we will realise that all the real endogenous variables are homogenous of degree zero with respect to the exchange rate and all domestic monetary variables are homogenous of degree 1.

4. AN APPLICATION OF THE MODEL : A 25 PER CENT TARIFF INCREASE

In this section we apply the model[11] to analyse the effects on the Australian economy of a uniform 25 per cent increase in all tariffs. The analysis pays particular attention to the impacts of this hypothetical government policy on the outputs and prices of each of the 30 industries in each state,[12] aggregate employment, employment by each occupation in each state, the gross national product and the balance of trade.

Economic Environment of the Simulation

As a prelude to simulating the impact of any exogenous shock on the economy we have to specify the economic environment under which the exogenous shock would take place. For the tariff experiment, the economic environment under which it is carried out is illustrated in table 2. Four industries are chosen as export industries. They are Agriculture, Mining, Food manufacturing (animal origins) and Basic metals. The industries are selected as export industries on the basis that their exports overseas as a percentage of total sales in the base year is 25 per cent or larger. These industries are considered to be closely tied to international trade such that world prices are important determinants of their domestic prices. Changes in exports from these industries are treated as endogenous with the corresponding changes in export subsidies exogenous. With regard to the non exporting industries, the change in export quantities are set exogenously to zero.

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11. The model is hereafter referred to as MRSMAE, Multi-Regional, Sectoral Model of the Australian Economy.

12. The word region is sometimes substituted in place of state.

Table 2 : Economic Environment Under Which Simulation of a Uniform 25 Per Cent Increase in Tariffs Was Carried Out

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Choice of Export Industries

No. 1 Agriculture
No. 3 Mining
No. 4 Food manufacturing - animal origins
No. 14 Basic metals

Exogenous Variables

As listed in table 1

Indexation Parameters/Variables

Wage indexation : equation (I.3) $\alpha_t^z = 1, (rp)_t^z = 0$

Indexation of 'Other costs' per unit output:

equation (I.1) $p_{(n+2)j}^{os} = cpi$

Rentals of machines indexation : equation (I.2)

$$\beta_j = 1, \quad (rm)_j = 0$$

Values of Exogenous Variables

All set to zero, except the percentage change in one plus the nominal tariffs. They are set such that the percentage changes in nominal tariffs are 25 per cent.

In carrying out the tariff experiment, we have totally indexed (i.e., in equation (I.3) $\alpha_t^z = 1$ and $(rp)_t^z = 0$) the money wages of the different types of labour in all the regions to the national consumer price index,[13] and allowed the model to solve for the percentage changes in employment. This is equivalent to adopting the slack labour market assumption, that the available supplies of labour do not act as constraints to the number of workers that could be employed in any occupation or state in Australia at the going real wage.

The prices of 'other costs' are forced to move according to the CPI.[14] It is reasonable to expect that these prices (which reflect the costs per unit output of holding working capital and of production taxes) would move with the general price level.

We have indexed the rentals of machines to the CPI and have made changes in the employment of machines in each industry endogenous (i.e., in equation (I.2), $\beta_j = 1$ and $(rm)_j = 0$). Originally it was intended to fix the employment of machines in each industry and to allow changes in the rentals of machines to be endogenous. However, when this endogenous-exogenous split was chosen, the resulting M matrix (see equation (S7)) could not be inverted; the determinant was not significantly different from zero. The explanation is that machines and buildings are constrained by the theoretical specification to be used in fixed proportion by each industry. This means that once we have fixed the use of machines in each industry, then the use of buildings in each industry is automatically determined. Given that the base period

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13. This is not to be confused with the consumer price indices of each of the regions. Hereafter, it is referred to as the CPI and the percentage change in it is written cpi.

14. See equation (49), appendix table A.1.

data exogenously tie down the regional locations of industries, the net effect of specifying exogenously the usage of machines by industries is virtually to endogenise the regional usage of buildings. Thus we cannot fix exogenously both the amount of buildings used in each region and the amount of machines in each industry.

Ideally, to overcome the problem we might wish to model explicitly flows of second-hand machines between regions but within industries, allowing where necessary for the creation of new (and the retirement of redundant) floor space within the period of solution of the model. However, at this stage of our work, we simply recognize that with the existing treatment, and with the elasticity of substitution between buildings and machines being set at zero, we can fix the amounts of machines in each industry or fix the amounts of buildings in each state, but not both. In the event, we have chosen to exogenize the use of buildings and to tie movements in the rentals of machines to movements in the CPI.

Industry Output Results

The output results are presented in table 3. We find that the import competing industries gain the most from a uniform 25 per cent tariff increase. The main losers are the export industries.

The import competing industries that gain the most (Motor vehicles and parts, Textiles and Clothing and footwear) tend to have high import substitution elasticities, high base period import shares in their domestic markets, and high percentage changes in their

Table 3 : Outputs of Industries in Each Region[1]
(Percentage Change)

		N.S.W.	Vic.	Q'land	S.A.	W.A.	Tas.	Aust.
1	Agriculture	-.60	-.64	-.61	-.62	-.63	-.54	-.61
2	Forestry, fishing and hunting	.02	.03	-.01	.05	-.07	.15	.02
3	Mining	-2.55	-2.58	-2.67	-2.68	-2.65	-2.64	-2.63
4	Food manufacturing-animal origins	-1.28	-1.27	-1.21	-1.23	-1.19	-1.22	-1.25
5	Food manufacturing-vegetable origins	.11	.11	.14	.10	.08	.11	.11
6	Beverages and tobacco products	.91	.90	.96	.92	.93	.95	.91
7	Textiles	3.24	3.48	2.84	3.20	2.63	3.47	3.34
8	Clothing and footwear	2.12	2.05	2.21	2.10	2.24	2.19	2.08
9	Wood, wood products and furniture	.68	.70	.68	.72	.78	.82	.71
10	Paper and paper products, printing and publishing	.78	.84	.70	.74	.58	.95	.79
11	Chemicals	1.62	1.74	1.37	1.54	1.22	1.51	1.61
12	Petroleum and coal products	-.23	-.14	-.29	-.18	-.47	-.26	-.25
13	Glass, clay and other non-metallic mineral products	.23	.24	.24	.25	.18	.23	.23
14	Basic metals	-1.67	-1.55	-1.69	-1.45	-1.79	-1.62	-1.65
15	Fabricated metal products	1.14	1.18	1.15	1.26	1.13	1.10	1.16
16	Motor vehicles	5.64	5.41	5.92	5.54	6.09	5.79	5.53
17	Transport equipment	.33	.35	.32	.33	.24	.27	.32
18	Other machinery and equipment	.82	.88	.75	.88	.69	.77	.84
19	Leather, rubber and plastic goods and manufacturing n.e.c.	1.30	1.46	1.15	1.50	.91	1.17	1.37
20	Electricity, gas and water	-.16	.08	-.35	-.06	-.50	-.30	-.14
21	Construction	-.01	-.00	-.01	-.01	-.00	-.01	-.01
22	Wholesale and retail trade	-.55	-.42	-.70	-.51	-.73	-.64	-.55
23	Repairs	-.52	-.30	-.79	-.44	-.90	-.65	-.53
24	Transport, storage and communication	-.43	-.44	-.35	-.41	-.37	-.37	-.42
25	Finance, insurance, real estate and business services	-.08	.04	-.22	-.05	-.26	-.17	-.08
26	Ownership of dwellings	.07	-.08	.36	.02	.63	.19	.11
27	Public administration and defence	-.01	-.01	-.02	-.01	-.02	-.02	-.01
28	Health, education and welfare	-.17	-.04	-.35	-.12	-.39	-.25	-.17
29	Entertainment and personal services	-.50	-.28	-.75	-.42	-.84	-.65	-.49
30	Business expenses	-.01	.16	-.19	.04	-.29	-.13	-.00

1. The Australia-wide production result of each commodity is obtained by weighting each regional production result with the share of production contributed by each region. In this paper we include the Australian Capital Territory as part of N.S.W. and the Northern Territory as part of S.A.

'power of the tariff'.[15] These factors encourage the substitution from imports to locally made goods for the corresponding domestic import competing industries.[16]

The export industries are the main losers. The tariff increases raise their costs in two ways:

(i) the increase in tariffs raises the cost of intermediate inputs which have import duties levied upon them;

(ii) the general price level increases with the increase in protection. Through indexation, this in turn increases the costs of hiring labour and machines, and raises 'other costs'.

Non-trading industries[17] face the same upward shift in their costs. However, they are able to pass on their cost increases. On the other hand, because they are constrained by the world market, export industries are in a weak position to pass on any cost increases.

The rankings of the export industries in terms of the extent of the fall in their exports are shown in table 4. These may be explained by the different export elasticities and the different shares of costs in each industry accounted for by imports. The greater the export demand elasticity and the higher the share of imports in total costs,

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15. One plus the nominal tariff.

16. Removing subscripts and superscripts, the substitution terms in the demand equations for domestic goods (see for example equation (1), appendix table 1) can be written as $\sigma S(p_1-p_2)$, where σ is the import substitution elasticity, S is the import share and p_1 and p_2 are the percentage changes in domestic and foreign prices respectively.

17. Industries that do not face international competition.

Table 4 : Characteristics of Export Industries

Industry	Export demand elasticities	Imports as % of costs	Exports as % of sales	% change of exports
Basic metals	20	11.8	26	-9.7
Mining	20	7.7	30	-6.9
Food manufacturing - animal origins	17.3	6.8	25	-4.8
Agriculture	5.4	6.9	28	-0.8

Table 5 : Share of the Value of Output in Each Region Contributed by Three Groups of Industries (in percentages)

Industry group	N.S.W.	Vic.	Q'land	S.A.	W.A.	Tas.
Export	13.5	12.6	23.4	15.6	25.8	19.2
Import competing	34.8	39.9	28.2	35.0	25.7	30.6
Non-traded	51.7	48.4	48.4	49.4	48.5	50.1

the greater the reduction in exports. The higher the share of imports in total costs, the higher would tend to be the increase in costs, and the higher the export elasticity, the more difficult it is to pass on cost increases by raising export prices.

The reduction in export sales provides a partial explanation for contractions of output in the export industries. Another explanatory factor is the percentage that exports contribute to total sales. This is highlighted by the Basic metals and Mining industries. Basic metals experiences a greater drop in export sales than Mining, but because Mining depends for its sales more on exports than Basic metals,[18] the reduction in the output of Mining is relatively greater.

Of all the export industries, Agriculture shows the smallest decline in output. The explanation for this relatively small decline lies in the assumptions that the supply of land is fixed, that land is used only by the agricultural industry, and that land is not transferable between the states.

Non-trading industries are dependent on the general state of the economy. Although they are free of the constraints imposed by the international economy, they are nevertheless constrained by the domestic economy's demand for their products. The 25 per cent increase in tariffs has reduced the real GNP by 0.05 per cent. This reduces the demand for the products of non-trading industries, in particular

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18. For Mining the proportion of sales exported abroad in the base period is 30 per cent, for Basic metals it is 26 per cent. The corresponding figures for Agriculture and Food manufacturing - animal origins are 28 per cent and 25 per cent respectively.

Wholesale and retail trade and Entertainment and personal services, both of which are sold largely to households.

Among the non-trading industries, the two most adversely affected by the tariff increase are Wholesale and retail trade and Repairs. The output declines for both industries are significantly larger than the decline in GNP. In the case of Wholesale and retail trade the explanation lies in its large expenditure elasticity.

The explanation for the Repairs industry lies in the nature of its demand and cost structure. The rise in protection causes the Repairs industry to face a significant rise in its cost of intermediate inputs. This is due to the high import content of motor vehicle parts used by the industry. Simultaneously, its sales are adversely affected because it sells mainly to households, Wholesale and retail trade, and to Agriculture.

The contraction of Transport, storage and communication can be understood by examining the role played by this industry in the economy. A large proportion of the sales of this industry is accounted for by mineral and agricultural exports which both have been affected adversely by the tariff increase.

So far we have discussed the national output results. What can we say about the regional variation in the change in industry outputs? Recall that in estimating the data needed for implementing the MRSMAE model, we assumed constant technology across the six states for each industry. Furthermore, price and expenditure elasticities were postulated to be the same for all regions. Differences in the responses of outputs in the different states for the same industry are therefore due to the non-uniform reactions in these states of factor prices and differences in transportation costs between states.

The first arises at the model specification stage, the second arises when data are being generated for the model. Immobility of factors across regions causes the non-uniformity of factor prices across the regions. Transportation costs cause the tendency of purchases in each region to be biased in favour of goods from the same region, over and above the bias implied by the imperfect substitutability between goods of the same kind from different regions.

To highlight the roles of region-specific factors and transport costs, we select two industries and explain the changes in their outputs on a regional basis. The first industry is Ownership of dwellings.[19] Victoria is the only state in which the tariff increase produces an increase in gross state product (GSP) (table 6). In estimating the data for the study, we had assumed zero inter-regional flows for the Ownership of dwellings industry. This is equivalent to assuming extremely large transport costs. In addition the differences in relative price changes and thus the degree of substitution between Ownership of dwellings and other commodities do not vary much between states. We would therefore expect that the rank for each state in the changes in the output of Ownership of dwellings to correlate with the rank of its GSP. However, this is not what it turned out to be. We find the output of the ownership of dwellings falls in Victoria while they rise in other states.

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19. Ownership of dwellings is an artificial industry whose output is the flow of services of the housing stock and the flow of services of associated machinery. The output of the Victorian Ownership of of dwellings industry depends only on the stock of housing/machines in Victoria, not on the place of residence of those holding the titles to this stock.

Table 6 : General-Macro and Regional Results
(Percentage Change)

	N.S.W.	Vic.	Q'land	S.A.	W.A.	Tas.	Aust.
Real GSP[1]	-0.0550	0.0018	-0.1004	-0.0301	-0.1286	-0.0713	-0.0484
Real Consumption[2] Expenditure	-0.14	0.12	-0.30	0.001	-0.44	-0.26	
Price Indices	0.59	0.70	0.37	0.61	0.27	0.49	0.54
Regional Employment	-0.09	0.27	-0.48	0.06	-0.72	-0.31	-0.08
Real Rentals[3] (buildings)	-1.26	-0.17	-2.44	-0.81	-3.28	-1.90	
Real Rentals (agri. land)	-1.51	-1.58	-1.62	-1.56	-1.71	-1.44	
Real Rentals (machines)	-0.04	-0.16	0.18	-0.06	0.28	0.05	
Real Wages	-0.04	-0.16	0.18	-0.06	0.28	0.05	0.0

Balance of Trade = - $29.7 million (1968/69 prices).

1. Obtained from the formulae :

$$(gsp)^s = \sum_{j=1}^{n} x_j^s S_j^s ,$$

where x_j^s is the percentage change in the output of industry in region s and S_j^s is the share of industry j in the total gross state product of region s, and

$$(gnp) = \sum_{s=1}^{m} (gsp)^s S^s ,$$

where S^s is the share of region (state) s GSP in the total GNP.

2. The percentage change in real consumption expenditure is obtained by subtracting the percentage change in the price index of each region from the percentage change in consumption expenditure, i.e., $c^{os} - (cpi)^s$.

3. The percentage changes in rentals of factors are derived by subtracting the percentage change in the price index of each region from the percentage changes in factor rentals. The money rentals are obvious given the real rentals and the price indices, and they are therefore not presented in this table.

Rentals of buildings rise in Victoria relative to the other states (table 6). With buildings responsible for most of the cost of producing Ownership of dwellings, this means a rise in the relative cost of producing this output in Victoria in comparison to the rest of Australia. Demand for Ownership of dwellings would have increased relatively in Victoria because of the positive rate of change in its GSP. However, the relative rise in the costs of producing Ownership of dwellings is sufficient to offset the relative increase in demand for it. Put it in another way, the leftward shift in the supply curve of ownership of dwellings in Victoria is of a relatively larger magnitude than the rightward shift of its demand curve.

In Queensland and Western Australia the reverse occurs -- their GSPs are reduced together with the rentals of buildings (table 6). With respect to these states, the fall in the costs of Ownership of dwellings more than offsets the reduction in demand for it. Thus, output of this industry rises relatively in Queensland and Western Australia, which is contrary to what one may expect on the basis of the movement in their GSP.

Turning to the import competing Motor vehicles industry, we find state-specific output responses varying inversely with the GSP of the six states. The key to this counter intuitive result lies in the role played by transport costs in the generation of data for the application of the model. Transportation costs were considered sufficiently low for inter-regional trade to take place in motor vehicles. Production of motor vehicles by each state is therefore not consumed wholly within each state. In other words, purchasers of motor vehicles in Victoria for example, on the basis of price differentials can substitute motor vehicles produced in Victoria for motor vehicles manufactured in other states. (Of course it is not claimed that this is a feature of the real world. First, car makers pursue pricing policies that tend to equalize new vehicle prices between states. Second, the consumer will be aware of the make of the car, but probably not its state of manufacture).

In every state, money wages, rentals of machines and 'other costs' per unit of output are forced to move with the national CPI. Payments to labour, machines and other costs account for about 52 per cent of costs in Motor vehicle manufacturing. Of the remaining costs, approximately 75 per cent are attributed to domestic material intermediate inputs. They would explain the regional variations in the price and output of motor vehicles as modelled.

The data base tells us that purchases of domestic intermediate inputs by each industry in each state tend to originate from the home state and from states nearest the home state because of transportation costs. In other words, the Motor vehicle industry in Victoria (the state with the largest increase in GSP) buys most of its intermediate inputs from industries within Victoria, South Australia and New South Wales, the two latter states being the closer and therefore the cheapest from which to transport commodities to Victoria. From table 7 we see that the prices of commodities from industries in these three states increase more than the prices of similar industries in other states. This leads to costs of the Motor vehicle industry in Victoria experiencing the largest increase and offsetting the fact that the GSP increases the most in Victoria.

Table 7 : Prices of Commodities in Each Region[1]
(Percentage Change)

		N.S.W.	Vic.	Q'land	S.A.	W.A.	Tas.	Aust.
1	Agriculture	.19	.27	.04	.22	-.07	.14	.15
2	Forestry, fishing and hunting	.69	.78	.58	.73	.50	.63	.66
3	Mining	.48	.64	.27	.54	.13	.37	.35
4	Food manufacturing-animal origins	.29	.33	.22	.32	.12	.27	.28
5	Food manufacturing-vegetable origins	.48	.53	.41	.51	.35	.46	.47
6	Beverages and tobacco products	.57	.64	.49	.60	.42	.53	.58
7	Textiles	1.00	1.05	.94	1.02	.89	.97	1.02
8	Clothing and footwear	1.28	1.32	1.24	1.30	1.22	1.26	1.30
9	Wood, wood products and furniture	.78	.83	.71	.80	.65	.74	.77
10	Paper and paper products, printing and publishing	1.13	1.19	1.06	1.15	1.00	1.09	1.14
11	Chemicals	.80	.86	.72	.83	.66	.76	.81
12	Petroleum and coal products	.42	.45	.39	.44	.35	.41	.41
13	Glass, clay and other non-metallic mineral products	.53	.59	.46	.56	.40	.50	.53
14	Basic metals	.50	.55	.44	.52	.37	.48	.49
15	Fabricated metal products	.64	.69	.57	.66	.51	.61	.64
16	Motor vehicles	.65	.71	.58	.68	.52	.62	.68
17	Transport equipment	.77	.82	.71	.79	.66	.74	.77
18	Other machinery and equipment	.77	.81	.73	.79	.68	.75	.78
19	Leather, rubber and plastic goods and manufacturing n.e.c.	1.02	1.06	.96	1.04	.92	.99	1.03
20	Electricity, gas and water	.33	.55	.06	.43	-.13	.19	.32
21	Construction	.69	.72	.66	.70	.62	.68	.69
22	Wholesale and retail trade	.49	.61	.34	.54	.24	.41	.49
23	Repairs	.94	1.04	.82	.99	.74	.88	.94
24	Transport, storage and communication	.62	.71	.51	.66	.43	.57	.62
25	Finance, insurance, real estate and business services	.40	.57	.20	.47	.05	.30	.40
26	Ownership of dwellings	-.25	.50	-1.20	.07	-1.83	-.75	-.28
27	Public administration and defence	1.03	1.05	1.02	1.04	1.00	1.03	1.03
28	Health, education and welfare	.62	.68	.54	.65	.48	.58	.61
29	Entertainment and personal services	.59	.72	.42	.64	.31	.50	.58
30	Business expenses	.65	.75	.54	.70	.44	.59	.65

1. The Australia-wide price result of each commodity is obtained by weighting each regional price result with the share of production contributed by each region.

At the other end of the spectrum we have the Motor vehicle industry of Western Australia (the state with the largest decline in GSP) experiencing the largest increase in output. In terms of transport costs, Western Australia is the most remote of all the other states from the rest of Australia. Its Motor vehicle industry buys most of its domestic intermediate inputs from within the state. Prices rise the least in Western Australia (table 7) and thus costs of its Motor vehicle industry rise the least relative to the costs of similar industries in other states.

The impact of the increase in costs is especially significant because of the infinitely elastic supply curves of the Motor vehicle industries in the six states. As one recalls, unlike the Agriculture industry, the Motor vehicle industry has no fixed factors. For any given demand curve, the more elastic the supply curve the larger is the reduction in the output for any upward shift in the supply curve.

We can summarise the above argument as : increases in tariff protection raise the output of the Motor vehicle industry in all states. However, variations in transportation costs between states have made the rankings of the Motor vehicle industry of the states uncorrelated with the rank of the GSP of each state.

Overall, the state with the highest proportion of its industries being import competing and relying least on export industries gains the most. The state having the lowest reliance on import competing industries and relying mainly on export industries is worst off. This can be inferred from tables 5 and 6. Ranking the states according to their changes in GSP, with the state having the largest positive change in GSP ranked number one, table 6 produces the following ordering : Victoria, South Australia, New South Wales, Tasmania, Queensland and Western Australia. This follows the ranking of States according to the share of the state's economy in the import competing sector exactly (table 5).

Prices

The percentage changes in prices of commodities from the various industries resulting from a 25 per cent uniform tariff increase are presented in table 7.[20] As can be seen from the table, import competing and non-trading industries tend to have larger price increases compared to export industries. As a group, export industries are restrained in their pricing behaviour by foreign competition. Cost increases due to the increase in tariff protection cannot easily be passed on to foreign buyers.

Agriculture, despite its having the lowest export elasticity among the export industries, exhibits the lowest increase in price. The explanation for this is that Agriculture is the only industry that has a fixed factor, land. Thus its supply curve is less elastic than the supply curves of other export industries. Given any demand curve, the more inelastic the supply curve, the smaller is the increase in price for any increase in costs.

20. It is assumed throughout that the percentage change of buyers' and sellers' prices are the same (the constant markup assumption).

For the other export industries we find that the rankings of industries in terms of their price increases are directly related to the share of their costs represented by imports (table 4). Thus the price of Food manufacturing - animal origins records the smallest price rise after Agriculture followed by the prices of Mining and then Basic metals. In addition, export sales as a share of total sales and export elasticities are important determinants of changes in the prices of export goods. The higher the export elasticity the more binding the constraint on price increases. Both Mining and Basic metals have the same export elasticities, but Mining relies more on export sales than Basic metals (table 4). This means that the price of Mining is more constrained by the international market than Basic metals.

The absence of a fixed factor results in a fairly elastic supply curve for industries other than Agriculture. In these industries, price responses are dominated by cost factors. The exceptions are the export industries where prices are set internationally. For non-exporting industries an important determinant of prices is the share of costs contributed by imports. With the exceptions of Chemicals, and Petroleum and coal, the seven industries (Nos. 7, 8, 10, 11, 12, 19 and 27) that depend most on imported inputs are also the industries that exhibit the largest price increases. Most of the inputs imported by Chemicals, and Petroleum and coal have low or zero import duty levied upon them. For example, about 85 per cent of imports to the Petroleum and coal industry comes from Mining which has a very low import duty.

Another key determinant of variations in the change of prices between non-exporting industries is the share of costs attributed to rental payments of buildings. The GNP falls (table 6) with the increase in protection. The rentals of buildings fall in all states (table 6). Industries relying largely on buildings as inputs will experience a low rate of increase in costs. In some cases where the share of costs contributed by buildings is very large, costs may actually fall. This is exemplified by Ownership of dwellings where a majority of its costs are attributed to the use of buildings. Prices of this industry fall in every state except Victoria (table 7), the only state which experiences an increase in its real GSP.

Regional variations in prices are explained by the variations in changes in GSP of each state. Aside from land, the only costs per unit of output that vary across the states are those pertaining to intermediate inputs and buildings. Movements in money wages, rentals of machines and 'other costs' per unit of output follow the movement in the national CPI, and the percentage changes in the prices of imported inputs do not vary across states under the fixed mark-up assumption.

Buildings and land are the fixed factors for each state. While land is used only in Agriculture, buildings are used generally by all industries. Thus the rentals of buildings vary with changes in the GSP of each state. Furthermore, a significant share of domestic intermediate inputs used by each industry in each state was assumed to come from the home state when data were generated for use by the model. It is therefore not surprising that variations in the change in prices across the states correlate very much with changes in their GSP.

Since with the exception of Agriculture there are no fixed factors, supply curves are fairly elastic. Hence the demand for each industry's product in each state does not much affect prices. Costs are therefore the key element in determining prices. For Agriculture where we have upward sloping supply curves, demand only reinforces the costs effect. The smaller the change in GSP, the smaller is the change in demand, giving a smaller change in price.

Employment

A summary of the impact on employment of the 25 per cent tariff increase is presented in table 8. From the table we can see that employment of the different types of labour depends heavily on whether they are employed mainly in the non-trading, import competing or export industries. As import competing industries expand because of the tariff increase, those skills that rely largely on these industries for employment experience an increase in demand. On the other hand, those skills that are employed mainly in non-trading and export industries face a reduction in demand due to the contraction of these industries.

We find that except for the blue collar workers, all types of labour experience a reduction in employment. The greatest decline in employment occurs among Rural workers, a reduction of 0.85 per cent Australia wide. Rural workers are heavily dependent on Agriculture, the industry most adversely affected by the rise in the tariff structure.

Employment of white collar workers as a group falls. They

Table 8 : Employment, Occupations and Regions
(Percentage Change)

	N.S.W.	Vic.	Q'land	S.A.	W.A.	Tas.	Aust
Professional white collar	-.20	.04	-.57	-.12	-.79	-.40	-.23
Skilled white collar	-.11	.23	-.49	.02	-.71	-.32	-.10
Semi & unskilled white collar	-.22	.07	-.54	-.10	-.71	-.40	-.21
Skilled blue collar (metal and electrical)	.16	.80	-.17	.70	-.62	-.39	.29
Skilled blue collar (building)	.06	.24	-.03	.21	-.12	.05	.10
Skilled blue collar (other)	.26	.60	-.44	.12	-.70	.32	.23
Semi & unskilled blue collar	.05	.55	-.41	.26	-.79	-.19	.09
Rural workers	-.78	-.76	-.99	-.81	-1.05	-.72	-.85
Armed services	-.01	-.01	-.02	-.01	-.02	-.02	-.01
Regional employment	-.09	.27	-.48	.06	-.72	-.31	(-.08)

are concentrated in the non-trading industries which contract due to the general decline in GNP. The smallest decline occurs in the Skilled white collar category which has 20 per cent of its members employed by import competing industries. Professional white collar workers suffer the largest fall in employment; only 9 per cent of this group are employed by import competing industries.

In terms of employment, the major beneficiaries from this tariff policy are the blue collar workers. All categories of blue collar workers show an increase in employment. Of all the blue collar workers, Skilled blue collar (metal and electrical) shows the largest increase. Although 47 per cent of Skilled blue collar (other) are employed by import competing industries compared to 43 per cent of Skilled blue collar (metal and electrical), 17 per cent of Skilled blue collar (other) compared to only 10 per cent of Skilled blue collar (metal and electrical) are employed by export industries. Export industries contract more than non-trading industries with the increase in tariffs. So, while the larger percentage of Skilled blue collar (other) being employed in the import competing industries would benefit it vis-a-vis the Skilled blue collar (metal and electrical) group, its greater employment by the export industries compared to Skilled blue collar (metal and electrical) would tend to disadvantage it relatively. This explains why employment in Skilled blue collar (metal and electrical) increases relatively to the employment of Skilled blue collar (other), in spite of the relative proportions employed by import competing industries suggesting otherwise.

It is worth pointing out that 67 per cent of Skilled blue collar (other) are employed in the Construction industry. Since the Construction industry contracts one would expect employment of this skill group to fall. However, the Construction industry contracts by only 0.005 per cent. The loss in employment of the Skilled blue collar (other) category due to its contraction is more than compensated by the gain in employment resulting from the expansion of import competing industries which employ about 20 per cent of the available supply of Skilled blue collar (other).

The variations across the states of changes in employment correlate closely with the changes in output. The rankings of the states in terms of the change in employment follow the rankings of the states in terms of their changes in output and real GSP (tables 6 and 8). Victoria shows the largest positive change in employment, followed by South Australia, New South Wales, Tasmania, Queensland and Western Australia. In every skill category, Victoria and South Australia experience an increase in employment relative to the other states of Australia. Not only do Victoria and South Australia have a larger proportion of their industries in the import competing sector, but their employment is also helped by the nature of wage indexation in Australia, where money wages are indexed according to the national CPI. Being the two states most dependent on protection,[21] Victoria and South Australia have the largest increases in prices. Consequently, given the same percentage change in money wages across all states, real wages would have fallen relatively in Victoria and South Australia. The relative gain in employment by Victoria and South Australia arises partly because of this regional reduction in real wages.

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21. Dependence is here defined in terms of having the largest and smallest concentration of import competing and export industries respectively (refer to table 5).

General Macro and Regional Results

A uniform 25 per cent increase in the tariff rate in Australia would increase the distortions to international trade. According to the model, the misallocation of resources as a result of this policy would cause the real GNP of Australia to fall by 0.05 per cent. All the states except Victoria would be adversely affected. It is estimated that the real gross state product (GSP) of Victoria would rise by 0.002 per cent. The greatest loser would be Western Australia which has the greatest concentration of export industries and the lowest concentration of import competing industries. Its real gross state product (GSP) is estimated to fall by 0.129 per cent.

In the model, consumption expenditure in each state is assumed to be a function of labour incomes. Except for Victoria and South Australia, the two most protected states, all the states experience a fall in real consumption expenditure. Victoria and South Australia are the only two states that exhibit an increase in aggregate employment with the increase in the tariff.

The real rentals of buildings and agricultural land fall in all states. Agricultural land is used only by the Agriculture industry. Therefore, the contraction of the Agriculture industry in all states explains the reduction in the real rentals of land in all the states.

Variations in real wages across the states provide a plausible explanation for the reduction of the real rentals of buildings in all the states, including Victoria. Real wages in Victoria fall absolutely and relatively to the other states because of full wage indexation. This encourages Victorian industries to substitute away from the use of buildings towards labour. The real rentals of buildings in Victoria could therefore fall even with a rise in the real GSP. This arises if the substitution effect more than offsets the income effect. Overall, the change in the real rentals of buildings of each state exhibit the same rankings as those pertaining to changes in GSP and employment in the following order : Victoria, South Australia, New South Wales, Tasmania, Queensland and Western Australia.

Turning our attention to changes in the real rentals of agricultural land, we see that the rankings for each state do not correspond to the rankings with respect to changes in the output of Agriculture. This is shown in table 6. For example, with the increase in protection, output of Agriculture in Victoria falls the most compared to the other states. However, the real rental of agricultural land in Western Australia falls the most. To understand this counter-intuitive result, we return to the structure of the model. Following equation (4) (appendix table A.1), the market clearing equation for agricultural land in region z can be written as :

$$q^z - \sigma(r^z - p_f^z) = 0 \quad , \qquad z = 1,\ldots,6,$$

where q^z is the percentage change in agricultural output; σ is the elasticity of substitution between labour, capital and land in forming the index of primary factor used by Agriculture; r^z is the percentage change in the rental of land and p_f^z is the percentage change in the price of the index of primary factor. The left hand side of the equation shows the demand for agricultural land; the zero on the right hand side signifies that the supply of land to agriculture in each state is fixed.

From equation (25) (appendix table A.1), the percentage change in the price of Agriculture can be written as :

$$p^z = p_f^z S_f^z + p_m^z S_m^z \quad , \qquad z = 1,\ldots,6,$$

where

$$S_f^z + S_m^z = 1 \quad ,$$

and p^z and p_m^z are respectively the percentage changes in the price of Agriculture and in the price of other factors used in the production of Agriculture. The capital letters S_t^z are the shares of either primary $(t = f)$ or other factors $(t = m)$ in the total cost of production in Agriculture.

If we substitute this equation into the market clearing equation for land we obtain the expression :

$$q^z = \sigma (r^z - p^z) - \sigma S_m^z (p_f^z - p_m^z) \quad , \qquad z = 1,\ldots,6,$$

the term $(r^z - p^z)$ being the percentage change in the real rental of land. The above expression shows that the rank of each state in terms of its percentage change in agricultural output need not correspond with its rank in terms of its percentage change in the real rental of land.

The rankings would correspond if all the inputs to Agriculture were substitutes for one another, instead of having primary and other inputs used in fixed proportions. If we had assumed the production function of Agriculture to be CES, the market clearing equation for land would be of the form :

$$q^z - \sigma(r^z - p^z) = 0 , \qquad z = 1,\ldots,6.$$

In this case the two rankings for each state clearly would correspond.

Like money wages in each state, rentals of machines of each industry in each state are forced to move according to the CPI. This makes changes in real rentals of machines equal to changes in the real wages in each state (table 6).

The 25 per cent increase in tariffs, while reducing the value of imports into Australia, nevertheless reduces the value of exports through increasing the costs of the export industries. Overall, the model projects a net change in the balance of trade of negative $A29.7 million (1968/9 prices).

5. CONCLUSION

This paper has demonstrated the experimental feasibility of constructing a multi-regional general equilibrium model for the Australian economy using the 'bottoms-up' approach. This approach has the obvious advantage over the popular 'tops-down' approach in that it takes into account more fully the interactive nature of the Australian economy. In particular, the 'bottoms-up' approach (i) allows the analyses of impacts on the national economy of policy and other changes occurring at the regional level; (ii) takes into account explicit state (regional) specific factor supply constraints (iii) explains inter-regional commodity flows.

Using our model to analyse the impacts of a uniform 25 per cent tariff increase, we project that such a policy could lead to a reduction in the gross state products of all states, except Victoria. These results are qualitatively similar to those obtained by Dixon, Parmenter, Sutton and Vincent (1982) using a 'tops-down' disaggregation of ORANI. The main explanatory variables for the regional results are the industrial composition of each state and intra-regional multiplier effects. Data limitations preclude the incorporation of regional diversity in industrial technology and price and expenditure elasticities.

At several points in the discussion of the results it will have been noted that aspects of the design of the model have led to mechanisms operating which perhaps are less than realistic descriptions of the actual economy. Changing the specification to obtain greater realism presents a challenge, but not the major one. The factor imposing the greatest problem for model improvement is the supply of inter-regional input-output data.

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APPENDIX TABLES

Table A.1 : Equations of the Model (in Percentage Changes)

Demand for Intermediate Inputs in Producing Current Goods

(1) $$x_{ij}^{rs} = x_j^s - \sigma_{ij}^{os} \left(p_{ij}^{rs} - \sum_{r=1}^{2} S_{ij}^{rs} p_{ij}^{rs} \right) ,$$

$i,j=1,\ldots,n,$
$r=1,2,$
$s=1,\ldots,m.$

(2) $$x_{ij}^{z1s} = x_{ij}^{1s} - \sigma_{ij}^{1s} \left(p_{ij}^{z1s} - \sum_{z=1}^{m} S_{ij}^{z1s} p_{ij}^{z1s} \right) ,$$

$i,j=1,\ldots,n,$
$s,z=1,\ldots,m.$

(3) $$p_{ij}^{1s} = \sum_{z=1}^{m} S_{ij}^{z1s} p_{ij}^{z1s} ,$$

$i,j=1,\ldots,n,$
$s=1,\ldots,m.$

Demand for Primary Inputs

(4) $$x_{(n+1)aj}^{os} = x_j^s - \sigma_{(n+1)j}^{s} \left(p_{(n+1)aj}^{os} - \sum_{a=1}^{3} S_{(n+1)aj}^{s} p_{(n+1)aj}^{os} \right) ,$$

where $p_{(n+1)3j}^{os} = p_{(n+1)3}^{os}$,

$a=1,2,3,$
$j=1,\ldots,n,$
$s=1,\ldots,m.$

(5) $$x_{(n+1)1uj}^{os} = x_{(n+1)1j}^{os} - {}^{\ell}\sigma_j^s \left({}^{\ell}p_u^s - \sum_{t=1}^{\ell} {}^{\ell}p_t^s S_{tj}^{os} \right) ,$$

$j=1,\ldots,n,$
$s=1,\ldots,m,$
$u=1,\ldots,\ell.$

... *continued*

Table A.1 continued ...

Demand for Primary Inputs *(cont'd)*

(6) $$p^{os}_{(n+1)1j} = \sum_{t=1}^{\ell} {}^{\ell}p^{s}_{t}\, S^{os}_{tj} \quad ,$$

j=1,...,n,
s=1,...,m.

(7) $$x^{os}_{(n+1)2bj} = x^{os}_{(n+1)2j} \quad ,$$

b=1,2,
j=1,...,n,
s=1,...,m.

(8) $$p^{os}_{(n+1)2j} = p_{(n+1)21j}\, G^{os}_{1j} + p^{os}_{(n+1)22}\, G^{os}_{2j} \quad ,$$

j=1,...,n,
s=1,...,m.

(9) $$x^{os}_{(n+2)j} = x^{s}_{j} \quad ,$$

j=1,...,n,
s=1,...,m.

Demand for Intermediate Inputs for the Creation of Machines and Buildings

(10) $$y^{ro}_{ij} = y_j - \sigma_{ij} \left(p^{ro}_{ij} - \sum_{r=1}^{2} S^{ro}_{ij}\, p^{ro}_{ij} \right) \quad ,$$

i,j=1,...,n,
r=1,2.

(11) $$y^{z1o}_{ij} = y^{1o}_{ij} - \sigma^{1o}_{ij} \left(p^{z1o}_{ij} - \sum_{z=1}^{m} S^{z1o}_{ij}\, p^{z1o}_{ij} \right) \quad ,$$

i,j=1,...,n,
z=1,...,m.

(12) $$z^{rs}_{io} = z^{s} - \sigma^{os}_{io} \left(p^{rs}_{io} - \sum_{r=1}^{2} S^{rs}_{io}\, p^{rs}_{io} \right) \quad ,$$

i=1,...,n,
r=1,2,
s=1,...,m.

... continued

Table A.1 continued ...

Demand for Intermediate Inputs for the Creation of Machines and Buildings *(cont'd)*

(13) $$z_{io}^{z1s} = z_{io}^{1s} - \sigma_{io}^{1s} \left(p_{io}^{z1s} - \sum_{z=1}^{m} S_{io}^{z1s} \, p_{io}^{z1s} \right) ,$$

i=1,...,n,
s,z=1,...,m.

(14) $$p_{ij}^{1o} = \sum_{z=1}^{m} S_{ij}^{z1o} \, p_{ij}^{z1o} ,$$

i,j=1,...,n.

(15) $$p_{io}^{1s} = \sum_{z=1}^{m} S_{io}^{z1s} \, p_{io}^{z1s} ,$$

i=1,...,n,
s=1,...,m.

Consumption Demand

(16) $$c_i^{os} = \sum_{j=1}^{n} \eta_{ij}^{s} \, p_j^{os} + \varepsilon_i^{s} \, c^{os} + (1 - \varepsilon_i^{s}) h^{s} ,$$

i=1,...,n,
s=1,...,m.

(17) $$c_i^{rs} = c_i^{os} - \sigma_i^{s} \left(p_i^{rs} - \sum_{r=1}^{2} S_i^{rs} \, p_i^{rs} \right) ,$$

i=1,...,n,
r=1,2,
s=1,...,m.

(18) $$c_i^{z1s} = c_i^{1s} - \sigma_i^{1s} \left(p_i^{z1s} - \sum_{z=1}^{m} S_i^{z1s} \, p_i^{z1s} \right) ,$$

i=1,...,n,
s,z=1,...,m.

(19) $$p_i^{os} = \sum_{r=1}^{2} S_i^{rs} \, p_i^{rs} ,$$

i=1,...,n,
s=1,...,m.

... *continued*

Table A.1 continued ...

Consumption Demand *(cont'd)*

(20) $$p_i^{1s} = \sum_{z=1}^{m} S_i^{z1s} \, p_i^{z1s} \, , \qquad i=1,\ldots,n, \; s=1,\ldots,m.$$

(21) $$c^{os} = \phi_1^s \sum_{t=1}^{\ell} \left({}^{\ell}p_t^s + \ell_t^s \right) {}^{\ell}S_t^s + \phi_2^s \, w_2^s \, , \qquad s=1,\ldots,m.$$

Export Demand

(22) $$p_i^e = \Omega_i + \eta_i^e \, e_i \, , \qquad i=1,\ldots,n.$$

(23) $$e_i^z = e_i - \sigma_i \left(p_i^{ze} - \sum_{z=1}^{m} {}^{e}S_i^z \, p_i^{ze} \right) , \qquad i=1,\ldots,n, \; z=1,\ldots,m.$$

(24) $$p_i^e = \sum_{z=1}^{m} {}^{e}S_i^z \, p_i^{ze} \, , \qquad i=1,\ldots,n.$$

Price Equations

(25) $$p_j^{s1} = \sum_{i=1}^{n} \sum_{r=1}^{2} p_{ij}^{rs} \, T_{ij}^{rs} + \sum_{a=1}^{3} p_{(n+1)aj}^{os} \, T_{(n+1)aj}^{os} + p_{(n+2)j}^{os} \, T_{(n+2)j}^{os} \, , \qquad j=1,\ldots,n, \; s=1,\ldots,m.$$

(26) $$p_j^2 = p_j^I + \theta + t_j \, , \qquad j=1,\ldots,n.$$

... *continued*

Table A.1 continued ...

Price Equations *(cont'd)*

(27) $$p_j^{s1} = p_j^{se} + \theta + s_j^s ,$$ j=1,...,n, s=1,...,m.

(28) $$p_{ij}^{z1s} = p_i^{z1} ,$$ i,j=1,...,n, s,z=1,...,m.

(25) $$p_{ij}^{2s} = p_i^2 ,$$ i,j=1,...,n, s=1,...,m.

(30) $$p_{ij}^{z1o} = p_i^{z1} ,$$ i,j=1,...,n, z=1,...,m.

(31) $$p_{ij}^{2o} = p_i^2 ,$$ i,j=1,...,n.

(32) $$p_{io}^{z1s} = p_i^{z1} ,$$ i=1,...,n, s,z=1,...,m.

(33) $$p_{io}^{2s} = p_i^2 ,$$ i=1,...,n, s=1,...,m.

(34) $$p_i^{z1s} = p_i^{z1} ,$$ i=1,...,n, s,z=1,...,m.

(35) $$p_i^{2s} = p_i^2 ,$$ i=1,...,n, s=1,...,m.

Market Clearing Equations

(36) $$x_i^z = \sum_{j=1}^{n} \sum_{s=1}^{m} x_{ij}^{z1s} J_{ij}^{z1s} + \sum_{j=1}^{n} y_{ij}^{z1o} J_{ij}^{z1o} + \sum_{s=1}^{m} z_{io}^{z1s} J_{io}^{z1s} + \sum_{s=1}^{m} c_i^{z1s} {}^{c}J_i^z + e_i^z \, {}^{e}J_i^z + f_i^z \, {}^{f}J_i^z ,$$ i=1,...,n, z=1,...,m.

... *continued*

Table A.1 continued ...

Market Clearing Equations *(cont'd)*

(37) $$\sum_{j=1}^{n} x^{s}_{(n+1)1tj} \, L^{s}_{tj} = \ell^{s}_{t} \; ,$$

s=1,...,m,
t=1,...,ℓ.

(38) $$\sum_{s=1}^{m} x^{s}_{(n+1)21j} \, (SM)^{s}_{j} = k_{1j} \; ,$$

j=1,...,n.

(35) $$\sum_{j=1}^{n} x^{s}_{(n+1)22j} \, (SB)^{s}_{j} = k^{s}_{2} \; ,$$

s=1,...,m.

(40) $$\sum_{j=1}^{n} x^{s}_{(n+1)3j} \, B^{s}_{j} = b^{s} \; ,$$

s=1,...,m.

Balance of Trade

(41) $$er = \sum_{i=1}^{n} \sum_{z=1}^{m} \left(p^{ze}_{i} + e^{z}_{i}\right) e_{S^{z}_{i}} \; ,$$

(42) $$x^{(IM)}_{i} = \sum_{j=1}^{n} \sum_{s=1}^{m} x^{2s}_{ij} \, H^{s}_{i1j} + \sum_{j=1}^{n} y^{2o}_{ij} \, H_{i2j} + \sum_{s=1}^{m} z^{2s}_{io} \, H^{s}_{i3} + \sum_{s=1}^{m} c^{2s}_{i} \, H^{s}_{i4} + f^{2}_{i} \, H_{i5} \; ,$$

i=1,...,n,

(43) $$m = \sum_{i=1}^{n} \left(p^{I}_{i} + x^{(IM)}_{i}\right) M^{f}_{i} \; .$$

(44) $$\Delta BT = erER - mM \; .$$

... continued

Table A.1 continued ...

Price Indices

(45) $$(cpi)^s = \sum_{i=1}^{n} (SC)_i^s \; p_i^{os} \; , \qquad s=1,\ldots,m.$$

(46) $$(cpi) = \sum_{s=1}^{m} (SC)^s \; (cpi)^s \; .$$

Aggregate Employment

(47) $$\ell^s = \sum_{t=1}^{\ell} (SL)_t^s \; \ell_t^s \; , \qquad s=1,\ldots,m.$$

(48) $$\ell = \sum_{s=1}^{m} (SL)^s \; \ell^s \; .$$

Indexation Equations

(49) $$p_{(n+2)j}^{os} = cpi \; , \qquad j=1,\ldots,n, \; s=1,\ldots,m.$$

(50) $$p_{(n+1)21j} = \beta_j \; (cpi) + (rm)_j \; , \qquad j=1,\ldots,n.$$

(51) $$\ell_{p_t^z} = \alpha_t^z \; (cpi) + (rp)_t^z \; , \qquad z=1,\ldots,m, \; t=1,\ldots,\ell.$$

Table A.2 : Variables of the Model (as Percentage Changes)

Variable	Definition	Number
x_{ij}^{rs}	Demand by industry j in domestic region s for good i from source r in the production of current goods.	$2mn^2$
i=1,...,n j=1,...,n r=1,2 s=1,...,m.		
x_j^s	Production by industry j in domestic region s.	mn
j=1,...,n s=1,...,m.		
p_{ij}^{rs}	Price paid by industry j in region s for good i from source r.	$2mn^2$
i=1,...,n j=1,...,n r=1,2 s=1,...,m.		
x_{ij}^{z1s}	Demand by industry j in domestic region s for good i coming from domestic region z.	m^2n^2
i,j=1,...,n s,z=1,...,m.		
p_{ij}^{z1s}	Price paid by industry j in region s for locally produced good i coming from region z.	m^2n^2
i,j=1,...,n s,z=1,...,m.		
$x_{(n+1)aj}^{os}$	Demand by industry j in region s for type 'a' primary input.	3mn
a=1,2,3 j=1,...,n s=1,...,m.		
$p_{(n+1)aj}^{os}$	Rental paid by industry j in region s for type 'a' primary input.	2mn + m
a=1,2,3 j=1,...,n s=1,...,m.	(Only m rentals for land, i.e. for a=3 the j subscript is redundant.)	

... *continued*

Table A.2 continued ...

Variable	Definition	Number
$x^{os}_{(n+1)1uj}$ j=1,...,n s=1,...,m u=1,...,ℓ.	Demand by industry j in region s for type 'u' labour.	ℓmn
$^{\ell}p^{s}_{u}$ s=1,...,m u=1,...,1.	Price of labour skill u in region s.	ℓm
$x^{os}_{(n+1)2bj}$ b=1,2 j=1,...,n s=1,...,m.	Demand by industry j in region s for type 'b' capital.	2mn
y^{ro}_{ij} i=1,...,n j=1,...,n r=1,2	Demand by industry j for good i from source r in the creation of machines and capital equipment.	$2n^2$
y_j j=1,...,n	Number of fixed units of machines and capital equipment created for use in industry j.	n
p^{ro}_{ij} i=1,...,n j=1,...,n r=1,2	Price paid by industry j in region s for good i from source r used in the creation of machines and capital equipment.	$2n^2$
$x^{os}_{(n+2)j}$ j=1,...,n s=1,...,m.	Input of 'other costs' into industry j at region s.	mn

... continued

Table A.2 continued ...

Variable	Definition	Number
$p^{os}_{(n+2)j}$ $j=1,\ldots,n$ $s=1,\ldots,m.$	Price of 'other costs' ('other costs' per unit output) used by industry j at region s.	mn
z^s $s=1,\ldots,m.$	Number of fixed units of buildings and construction created for use in region s.	m
z^{rs}_{io} $i=1,\ldots,n$ $r=1,2$ $s=1,\ldots,m.$	Demand by region s for good i from source r used for the creation of buildings and construction.	2mn
p^{rs}_{io} $i=1,\ldots,n$ $r=1,2$ $s=1,\ldots,m.$	Price paid by region s for good i from source r used for the creation of buildings and construction.	2mn
y^{z1o}_{ij} $i,j=1,\ldots,n$ $s=1,\ldots,m.$	Demand by industry j for good i from domestic region z used for the creation of machines and capital equipment.	mn^2
p^{z1o}_{ij} $i,j=1,\ldots,n$ $s=1,\ldots,m.$	Price paid by industry j for good i from domestic region z used for the creation of machines.	mn^2
z^{z1s}_{io} $i=1,\ldots,n$ $s,z=1,\ldots,m.$	Demand by region s for good i from domestic region z used for the creation of buildings and construction.	m^2n
p^{z1s}_{io} $i=1,\ldots,n$ $s,z=1,\ldots,m.$	Price paid by region s for good i from domestic region z used for the creation of buildings and construction.	m^2n

... continued

Table A.2 continued ...

Variable	Definition	Number
c_i^{os} $i=1,\ldots,n$ $s=1,\ldots,m.$	Aggregate consumption of good i in domestic region s.	mn
p_j^{os} $j=1,\ldots,n$ $s=1,\ldots,m.$	Price of good j for final consumption in domestic region s.	mn
h^s $s=1,\ldots,m.$	The number of households or consumers in region s.	m
c_i^{rs} $i=1,\ldots,n$ $r=1,2$ $s=1,\ldots,m.$	Demand of good i by domestic region s from source r for final consumption.	2mn
p_i^{rs} $i=1,\ldots,n$ $r=1,2$ $s=1,\ldots,m.$	Price paid by consumers in domestic region s for good i from source r.	2mn
c_i^{z1s} $i=1,\ldots,n$ $s,z=1,\ldots,m.$	Demand by consumers in region s for good i from domestic region z.	m^2n
p_i^{z1s} $i=1,\ldots,n$ $s,z=1,\ldots,m.$	Price paid by consumers in region s for good i from domestic region z.	m^2n
c^{os} $s=1,\ldots,m.$	Aggregate consumption expenditure in domestic region s.	m

... continued

Table A.2 continued ...

Variable	Definition	Number
w_2^s $s=1,\ldots,m.$	Transfer payments to domestic region s.	m
e_i^z $i=1,\ldots,n$ $s=1,\ldots,m.$	Export good i from domestic region z.	mn
e_i $i=1,\ldots,n.$	Exports from industry i.	n
p_j^2 $j=1,\ldots,n.$	Basic value of imported good j, i.e. the unit cost of good j incurred by importers up to the port of entry. It excludes margins.	n
Ω_i $i=1,\ldots,n$ $s=1,\ldots,m.$	Shift variable of export equation of good i.	n
p_i^e $i=1,\ldots,n.$	Foreign price in foreign currency paid by overseas for exports of good i.	n
p_i^{ze} $i=1,\ldots,n$ $z=1,\ldots,m.$	Foreign price in foreign currency paid by overseas for exports of good i from domestic region z.	mn
p_j^I $j=1,\ldots,n.$	World price of good j in terms of foreign currency.	n
θ	Exchange rate.	1
t_j $j=1,\ldots,n.$	One plus ad valorem tariff (power on tariff) of good j.	n

... continued

Table A.2 continued ...

Variable	Description	Number
p_j^{s1} $j=1,\ldots,n$ $s=1,\ldots,m.$	Basic value of domestic industry j in region s.	mn
s_j^s $j=1,\ldots,n$ $s=1,\ldots,m.$	One plus export subsidy of industry j in region s.	mn
f_i^z $i=1,\ldots,n$ $z=1,\ldots,m.$	Other final demands that are satisfied by good i from domestic region z.	mn
k_{1j} $j=1,\ldots,n.$	Total supply of machines and equipment available for use in industry j or total employment of machines in industry j.	n
k_2^s $s=1,\ldots,m.$	Total supply of buildings and construction available for use in region s or total employment of buildings in region s.	m
b^s $s=1,\ldots,m.$	Supply of land in region s.	m
er	Export receipts.	1
$x_i^{(IM)}$ $i=1,\ldots,n.$	Aggregate demand for imported good i.	n
f_i^2 $i=1,\ldots,n.$	Other demands of imported good i.	n
m	Demand for foreign currency used for importing.	1

... continued

Table A.2 continued ...

Variable	Description	Number
ΔBT	Change in balance of trade.	1
$p_{(n+1)21j}$ $j=1,\ldots,n.$	Rental of machines and capital equipment used by industry j.	n
$p^{os}_{(n+1)22}$	Rental of buildings and construction used in region s.	m
ℓ^s_t $s,z=1,\ldots,m$ $t=1,\ldots,\ell.$	Total available supply of labour skill t in domestic region s or total employment of skill t in region s.	ℓm
$(cpi)^s$ $s=1,\ldots,m.$	Consumer price index for region s.	m
(cpi)	Consumer price index.	1
ℓ^s $s=1,\ldots,m.$	Employment of labour in region s.	m
ℓ	Total employment of labour.	1
$(rp)^z_t$ $t=1,\ldots,\ell$ $z=1,\ldots,m.$	Wage indexation shift variable.	ℓm
$(rm)_j$ $j=1,\ldots,n.$	Rental of machines shift variable.	n
Total number of variables ...		$(10m + 12n + 25mn + 4m^2n + 6mn^2 + 4n^2 + 2m^2n^2 + 3\ell m + \ell mn + 6)$
Total number of equations ...		$(15m + 18n + 27mn + 4m^2n + 6mn^2 + 4n^2 + 2m^2n^2 + 4\ell m + \ell mn + 7)$
Total number of exogenous variables		$5m + 6n + \ell m + 2mn + 1$

Table A.3 : Share Parameters

Equation	Parameter	Description
(1)	S_{ij}^{rs}	Share of input i from source r (r=1 for domestic, r=2 for foreign) in the total cost of material inputs i into industry j at region s for current production.
(2) and (3)	S_{ij}^{zls}	Share of input i from domestic region z in the cost of aggregated domestic material input i used by industry j at region s for current production.
(4)	$S_{(n+1)aj}^{s}$	Share of type 'a' labour (a=1), capital (a=2), land (a=3) primary input in the total cost of primary factors used by industry j in region s for current production.
(5) and (6)	S_{tj}^{os}	Share of labour skill t in the total cost of labour in the j industry in region s.
(8)	G_{bj}^{os}	Share of capital type b in the total cost of capital used by industry j in region s.
(10)	S_{ij}^{ro}	Share of material input i from source r (r=1 for domestic, r=2 for foreign) in the total cost of material input i for creating machines by industry j.
(11) and (14)	S_{ij}^{zlo}	Share of material input i from domestic region z in the total cost of domestic material input i used for creating machines by industry j.
(12)	S_{io}^{rs}	Share of material i from source r (r=1 for domestic, r=2 for foreign) in the total cost of material input i used in constructing buildings in region s.
(13) and (15)	S_{io}^{zls}	Share of material i from domestic region z in the total cost of domestic material input i used in constructing buildings in region s.
(17) and (19)	S_{i}^{rs}	Share of good i from source r (r=1 for domestic, r=2 for foreign) in the total consumption expenditure of good i in region s.

... *continued*

Table A.3 continued ....

Equation	Parameter	Description
(18) and (20)	S_i^{zls}	Share of good i from domestic region z in the total consumption expenditure of domestic good i in region s.
(21)	${}^{\ell}S_t^s$	Share of labour payments in region s being accounted for by labour skill t.
(23) (24) and (41)	${}^{e}S_i^z$	Share of good i from domestic region z in the total value of exports of good i.
(25)	T_{ij}^{rs}	Share of good i from source r (r=1 for domestic, r=2 for foreign) in the total cost of production in industry j at region s.
(25) *(cont'd)*	$T_{(n+1)aj}^{os}$	Share of primary input a(a=1 for labour, a=2 for capital, a=3 for land) in the total cost of production in industry j at region s.
	$T_{(n+2)j}^{os}$	Share of 'other costs' in the total cost of production in industry j at region s.
(36)	J_{ij}^{zls}	Share of sales of domestic good i from region z absorbed by industry j in domestic region s for current production.
	J_{ij}^{zlo}	Share of sales of domestic good i from region z absorbed by industry j in creating machines.
	J_{io}^{zls}	Share of sales of domestic good i from region z absorbed by region s in creating buildings.
	J_i^{ze}	Share of sales of domestic good i from region z absorbed by exports.
	J_i^{zf}	Share of sales of domestic good i from region z absorbed by 'other final demands'.
(37)	L_{tj}^s	Share of employment of labour skill t in region s which is accounted for by industry j.

... continued

Table A.3 continued ....

Equation	Parameter	Description
(38)	$(SM)_j^s$	Share of machines in industry j used by region s.
(39)	$(SB)_j^s$	Share of buildings in region s used by industry j.
(40)	B_j^s	Share of land located in region s used by industry j.
(42)	H_{i1j}^s	Share of imported good i being used by industry j in region s for current production.
	H_{i2j}	Share of imported good i being used by industry j to create machines.
	H_{i3}^s	Share of imported good i being used by region s to create buildings.
	H_{i4}^s	Share of imported good i being used for current consumption in region s.
	H_{i5}	Share of imported good i being used as 'other final demands'.
(43)	M_i^f	Share of good i in the total foreign currency value of imports.
(44)	ER	Total foreign currency value of exports.
	M	Total foreign currency value of imports.
(45)	$(SC)_i^s$	Share of good i in the total final consumption expenditure in region s.
(46)	$(SC)^s$	Share of region s in the total consumption expenditure of the economy.
(47)	$(SL)_t^s$	Share of labour skill t in the total employment of labout in region s.
(48)	$(SL)^s$	Share of region s in the total employment of labour.

Table A.4 : Elasticities of the Model

Elasticity	Description
σ_{ij}^{os}	Elasticity of substitution between domestic and foreign produced material input i in the creation of an effective input i used by industry j in region s for use in current production.
σ_{ij}^{1s} *	Elasticity of substitution between domestic material inputs of type i used in creating the index of aggregate domestic material input i needed for current production by industry j in region s.
$\sigma_{(n+1)j}^{s}$	Elasticity of substitution between capital, labour and land in the formation of the index of primary factors by industry j in region s.
$^{\ell}\sigma_{j}^{s}$	Elasticity of substitution between various labour skills in forming the index of labour input for industry j in region s.
σ_{ij}	Elasticity of substitution between domestic and foreign produced material input i in the creation of an effective input i used by industry j to create machines.
σ_{ij}^{1o} *	Elasticity of substitution between domestic material inputs of type i used in creating the index of aggregate domestic material input i needed to create machines by industry j.
σ_{io}^{os} *	Elasticity of substitution between domestic and foreign produced material input i in the creation of an effective input i used by region s to create buildings.
σ_{io}^{1s} *	Elasticity of substitution between domestic material inputs of type i used in creating the index of aggregate domestic material input i needed to create buildings by region s.
η_{ij}^{s}	Price elasticity of good i with respect to a change in the price of good j in region s.

Table A.4 continued....

Elasticity	Description
ε_i^s	Household expenditure elasticity of good i region s.
σ_i^s	Elasticity of substitution between the aggregate domestic good i and foreign good i in forming the effective good i for consumption in region s.
σ_i^{1s} *	Elasticity of substitution between the good i from the different domestic regions which form the index of aggregate domestic good i consumed by households in region s.
ϕ_1^s *	Elasticity of consumption expenditure with respect to a change in labour incomes in region s.
ϕ_2^s *	Elasticity of consumption expenditure with respect to a change in transfer payments in region s.
η_i^e	Reciprocal of the foreign elasticity of demand for exports of industry i.
σ_i *	Elasticity of substitution between the different good i from the domestic regions which form the index of effective export good i.

A large number of the elasticities used in the model are from the ORANI elasticities file as set out in Dixon, Parmenter, Sutton and Ryland (]977) adjusted by the ORANI aggregation-disaggregation facility written by Hagan, Wright and Smith (1980). The exceptions are those with asterisks. Of these, the σ_i, ϕ_1^s, ϕ_2^s, σ_{io}^{os} and σ_{io}^{1s} and are all set to 1.0. The rest are set equal to the elasticities of substitution between domestic and imported goods of the same kind in the ORANI elasticities' file. These elasticities do not have a regional dimension. We assume they are the same across the regions.