Appendix P Economic Modelling

Construction of the QMRM

The methodology used in the construction of the QMRM is similar to that developed by Professor Guild at the University of Auckland. There are, however, some important differences that strengthen the QMRM. These are the use of Queensland Specific data, derived by the Government Statistician's Office, and, in particular, the use of hierarchically balanced input-output tables that are specifically designed to limit the double counting and over-estimation problems associated with traditional input-output tables. This differences to the guild model are outlined below.

Guild used a national table, as the parent table. The current model was able to achieve greater disaggregation by using a sub-national table, Queensland, as the parent table. The use of a State-based parent table offers the advantage of being less reliant on identifying external trade patterns. It is well established that external trade is more important to the national economy than to the state economy and, while interstate and international trade is clearly important to the Queensland economy, it has less effect on the State than for the nation as a whole. The choice of Queensland as the parent table also allowed us to use the hierarchically balanced input-output tables for Queensland and Queensland regions constructed by the Government Statistician's Office.

Guild uses the parent table as a means of estimating, through mechanical techniques, the regional tables required. By comparison, the I-O tables for Queensland regions are those derived by data intensive methods by the Queensland Treasury and balanced to the Queensland table. As such, these tables represent a superior form of data.

Guild, due to the unavailability of inter-regional trade data, was forced to construct his data artificially. To do this, he assumed that regions import in proportion to total production in exporting areas. The current model relies upon officially supplied and estimated inter-regional data.

Some key elements of the QMRM model include the following:

For a given input I, exporting regions (those with a location quotient greater than 1) are assumed to export all their surplus (EI), and importing regions are assumed to import a total amount T of input i in proportion to the surplus from each region.

Actual data on inter-regional imports were obtained from the Government Statistician's Office (GSO). These were allocated across regions on the basis of data supplied by GSO. Where hard data were not available, it was assumed that regions' import in proportion to total production in exporting districts.

As a result of this simplifying assumption, input specific trade vectors can be generated (see below) and spliced together to form the inter-regional trade matrix.

Compared with the simple location quotient method of estimating trade flows, which generates many pairs of zero trade between regions, and Guild's artificial methods, this trade matrix exhibits larger and seemingly more realistic trade flows. As a result, the standard objections to multi-regional input-output models are significantly reduced.

In other diagnostics tests the model has performed well. The disaggregated regional multipliers aggregate the State total and demonstrate stability in the coefficients and in terms of ten per cent stability shocks. As a result the current model provides an efficient means of estimating industrial significance and allocating this across regions and to the rest of Australia.

Regional technical coefficients matrix

AR = The technical coefficients matrix for each of R regions.

A^R_{11}	….	A^R_{1j}
…	….	…
A^R_{i1}	….	A^R_{ij}

The multi-regional technical coefficients matrix

A = Multi-Regional Technical Coefficients Matrix constructed as a diagonal matrix. In this case it comprises a 224X224 for the 7 regions (including the rest of Australia).

A^1	0	0	0
0	A^2	0	0
0	0	A^3	0
0	0	0	A^n

Inter-regional trade coefficients

C = The multi-regional trade table and is constructed by splicing together the individual regional trade matrices, and again forms a 224X224 matrix (7 regions).

$C\wedge R_1 R_1$	$C\wedge R_1 R_2$	….	$C\wedge R_1 R_j$
$C\wedge R_2 R_1$	$C\wedge R_2 R_2$	….	$C\wedge R_2 R_j$
….	….	….	….
$C\wedge R_{ji} R_1$	$C\wedge R_{ji} R_2$	….	$C\wedge R_i R_j$

Where CR1R2 = the trade vector for a set of n inputs between region 1 and region 2.

And c1R1R2 = the ratio of imports of an input from Region 1 to Region 2 compared to the total level of that imports of that input to Region 2. The final form of C is obtained by first converting the trade vector to a diagonal matrix for computation.

Non-Linear Input Output Models[1]

The following description of the Non-linear model properties is taken from CEPM model descriptions (West 2003).

The Non-Linear Input-Output Model (NLIO) aims to correct one of the major limitations of standard input-output analysis by removing the assumption of linear coefficients for the household sector and allowing marginal income coefficients adjustment. This is because, as is widely known, the household sector is the dominant component of multiplier effects in an input-output table. As a result, using marginal income coefficients for the household sector will provide a more accurate, and empirically more valid, estimate of the multiplier effects, which in turn, provides results closer to those of a computable general equilibrium (CGE) model. The transactions flows in the input-output table can be expressed in matrix equation form as:

$$\mathbf{T}(\hat{\mathbf{X}}^{-1})\mathbf{X} + \mathbf{Y} = \mathbf{X}$$

That is, for each industry, total industry sales equals intermediate sales to other industries for further processing plus sales to final users, where T is the matrix of intermediate transactions, X is the column vector of sector total outputs and Y is the column vector of aggregate final demands. This can be rewritten as:

$$\mathbf{AX + Y = X}$$

where A is the matrix of direct coefficients which represents the amounts of inputs requires from sector i per unit of output of sector j. Thus, for a given direct coefficient matrix, it is possible to solve the set

[1] The description of the Non-linear model properties is taken from CEPM model descriptions (West 2003)

of simultaneous equations to find the new sector production levels X which will be required to satisfy a potential or actual change in the levels of sector final demands Y. By rearranging and converting to differences, this equation can be rewritten as:

$$\Delta \mathbf{X} = (\mathbf{I} - \mathbf{A})^{-1} \Delta \mathbf{Y}$$

where $(\mathbf{I} - \mathbf{A})^{-1}$ is termed the total requirements table, Leontief inverse matrix or general solution, and represents the direct and indirect change in the output of each sector in response to a change in the final demand of each sector. ΔY can incorporate any element of final demand expenditure, including household expenditure, government expenditure and capital expenditure.

This model is the traditional linear model where the A matrix represents a (constant) matrix of average input propensities. Normally, the A matrix endogenises the household sector[2] so that household consumption induced effects can be measured. This is referred to as the type II model; the alternative type I model is where households are treated as exogenous to local economic activity. Generally speaking, the consumption-induced effects are the largest component of the total multipliers. This is because consumer driven consumption (and income) to a large extent dominates local economic activity.

Total inputs are equal to intermediate inputs plus primary inputs (labour and capital). In the conventional input-output model, the inputs purchased by each sector are a function only of the level of output of that sector. The input function is assumed linear and homogeneous of degree one, which implies constant returns to scale and no substitution between inputs. A more reasonable assumption is to allow substitution between primary factors. If there is an expansion in economic activity due to a development project, employers will attempt to increase output without corresponding proportional increases in employment numbers, particularly in the short term (e.g. construction projects, where there are economies of scale in getting the existing workforce to work longer hours rather than employ additional persons). This occurs for two reasons.

Firstly, there is evidence in Australia that labour productivity (output per employee) is increasing over time. Secondly, as companies strive to reduce costs and satisfy the micro-economic reform processes imposed on all states by the National Competition Policy, there is evidence of a shift in primary factor use from labour to capital. This implies that the conventional input-output model has a tendency to overestimate impacts, in particular the income and employment impacts. Therefore, a more realistic approach to modelling impacts is to replace the average expenditure propensities for labour income by employers with marginal input propensities. In other words, the household income row in the A matrix, which are average input coefficients, should be replaced by income elasticities of demand. Note that, as in the CGE model, the linear coefficients assumption between intermediate inputs, and also total primary inputs, and total inputs is retained.

One problem associated with this approach is that the solution procedure is now more complex. Now the income impacts will be a function of ΔX but the income coefficients are included in the A matrix which determines ΔX. Therefore the equation set becomes recursive; ΔX depends on A and A depends on ΔX. Solving the input-output equation therefore requires an iterative procedure, a common method being the Gauss-Seidel method.

The income and employment flow-ons from the initial impact also need to be modified. In the conventional input-output model, income and employment flow-ons are calculated as linear functions of the output flow-ons, but in the revised model the parameters relating income to output are no longer constant. The impact on household income needs to be calculated as the difference between the base (i.e. before impact) income levels and the post impact income levels. It can be shown that this is equivalent to using the matrix equation

$$\Delta \mathbf{Inc} = \hat{\mathbf{X}}_{\mathbf{0}}^{-1} (\Delta \hat{\mathbf{X}}) \hat{\mathbf{L}} \mathbf{U}_{\mathbf{0}}$$

where U is a vector of household income flows and L is a vector of sectoral household income elasticities of demand. The zero subscript denotes the base level values and the hat denotes a

[2] That is, household income varies with the level of intersectoral activity.

diagonal matrix formed from the elements of the corresponding vector. This equation simply states that, for each sector, the change in household income payments equals the proportional change in output times the base level income payments multiplied by the income elasticity of demand. These income elasticities of demand can be shown to be equal to:

$$I_j = \eta_{WX} + \eta_{EX}$$

where ηWX is the elasticity of wage rate with respect to output, and ηEX is the elasticity of labour demand with respect to output; that is, they are made up of two components, the wage price component and the labour productivity component.

Similarly, the change in sectoral employment can be calculated as the change in the sectoral wage bill times the wage rate:

$$\Delta Emp = \hat{H}_0^{-1}\hat{P}_0^{-1}\Delta Inc$$

where H is a vector of average household income coefficients and P is a vector of coefficients representing average output per employee.

There are several implications arising from the use of this model, compared to the conventional input-output model. Firstly, while the output multipliers and impacts should not be significantly different between the two models, we would expect the income and employment impacts to be smaller in the marginal coefficient model. This is because many industries, especially those which are more capital intensive and can implement further productivity gains, can increase output, particularly in the short run[3], without corresponding proportional increases in employment and hence income payments. The term 'short run' here does not refer to any specific time period; rather it will vary from industry to industry. It is used here in the conventional economic sense to mean that the full adjustment from any shock has not had time to occur, i.e. the system has not yet returned to full, long run, equilibrium

Secondly, unlike the conventional input-output model in which the multiplier value is the same for all multiples of the initial shock, the multiplier values from the marginal coefficient model vary with the size of the initial impact. Thus larger changes in final demand will tend to be associated with smaller multipliers than small changes in final demand. Therefore, the differential impacts of the marginal coefficient model are not additive, unlike the conventional (linear) Leontief model and CGE model.

Overall, within the confines of a static model, the major improvements brought by the non-linear model are to improve the overall accuracy of the factor income and employment impact projections.

[3] The term 'short run' here does not refer to any specific time period; rather it will vary from industry to industry. It is used here in the conventional economic sense to mean that the full adjustment from any shock has not had time to occur, i.e. the system has not yet returned to full, long run, equilibrium.