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# M087: A THREE-SECTOR MINIATURE ORANI MODEL

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ABSTRACT

Miniature versions of computable general equilibrium (hereafter CGE) models are valuable as prototypes. They allow attention to be focussed on mechanisms which are key to the purposes at hand without the distraction of excessive dimensionality. Particular lines of development dictate particular miniatures. The present paper describes a miniature version of ORANI, MO87, developed as a vehicle for generating portfolio-analytic decision rules within a CGE framework. To be suitable for this purpose the prototype must be capable of providing estimates of the elasticities of performance indicators (each as rates of return on capital) for industries with fundamentally differing commercial exposures (exporting, import-competing, non-trading) with respect to exogenous variables of interest (e.g., real wages, aggregate demand, tariffs). The required model is very similar to the miniature ORANI (MO) model developed by Dixon, Parmenter, Sutton, and Vincent (1982). However, it differs from MO in that: it contains three industries rather than two; it is calibrated using an aggregated version of the 1978-79 Australian input-output table, rather than a hypothetical input-output table; and it contains equations describing the allocation of investment across industries (incorporating the modifications suggested by Bruce and Horridge (1986)), whereas MO does not explicitly distinguish investment behaviour.

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# MO87: A THREE-SECTOR MINIATURE ORANI MODEL*

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## 1. INTRODUCTION

In this paper we construct MO87, a stylized miniature CGE model of the Australian economy. It is similar to the original miniature ORANI (MO) model, developed by Dixon, Parmenter, Sutton and Vincent (1982), in that: it distinguishes imported and domestic commodities; industries require inputs of commodities, labour, and capital for current production; and household consumption and exports are explicitly modelled. However, MO87 differs from MO in that: it contains three industries representing the export, import-competing, and non-traded sectors, rather than two; it is calibrated using an aggregated version of the 1978-79 Australian input-output table (see Australian Bureau of Statistics (1984)), rather than a hypothetical input-output table; and it contains equations describing the allocation of investment across industries (incorporating the modifications suggested by Bruce and Horridge (1986)), whereas MO does not explicitly distinguish investment behaviour. Finally, the model is solved in a linearized form (following Johansen (1960)) using GEMPACK a general purpose software system for CGE models; see Pearson (forthcoming).

The rest of the paper is organized as follows. In section 2 of the paper the theoretical structure of MO87 is first derived. The model is then calibrated and its solution method is discussed. In section 3 an economic environment is specified for the model and some illustrative results are analysed. Some concluding remarks are offered in section 4. Finally, an Appendix contains the derivation of MO87's equations for allocating investment across industries; a description of how the 1978-79 ORANI data base at basic values was aggregated to a three sector input-output table at purchasers' prices; and the derivation of the implied long-run industry growth rates.

## 2. THE MO87 MODEL

In this section we first describe the theoretical structure of the MO87 model. A discussion is then presented of how MO87 is calibrated. Finally, the solution method for MO87 is explained.

### 2.1 Theoretical Structure

Following Dixon, Parmenter, Sutton and Vincent (1982) the theoretical structure of a CGE model consists of:

(i) a series of equations representing household and other final demands for commodities;

(ii) a series of demand equations for intermediate and primary-factor inputs;

(iii) a series of pricing equations relating commodity prices to costs;

(iv) a series of market clearing equations for primary factors and commodities;

and

(iv) miscellaneous equations.

The model distinguishes six commodities, three of which are domestically produced and three are imported. The domestic commodities are assumed to be produced by three single-product industries. There are three sources of final demands modelled here: investment, household consumption, and exports.[1]

When describing MO87 the following notational conventions will be observed. A variable written $X^{(k)}_{(is)j}$ will denote the demand by user j for input i from source s for purpose k. Where i equals 1, 2, or 3 we refer to commodities 1, 2, or 3 and where i equals 4 we refer to primary factors. The subscript s can take the values 1 or 2. In the context of commodities, s = 1 means domestically sourced while s = 2 means imported. In the context of primary factors (i = 4), s = 1 means labour while s = 2 means capital. The subscript j can refer to industries 1, 2 or 3. Finally, if the superscript (k) equals (1) this denotes inputs to current production; a superscript (2) denotes inputs to capital formation; a superscript (3) refers to commodity flows to household consumption; and a superscript (4) denotes exports.

Following Johansen (1960) the MO87 model is solved in percentage-change form. Thus after each equation of the model is derived, it is rewritten in percentage-change form.[2] The convention is adopted that lower-case variables represent the percentage change in the respective upper-case variables.

### 2.1.1 Final Demands

There are 3 sources of final demands distinguished in the stylized CGE model; namely, investment, household consumption, and exports. Each of these will be discussed in turn.

Investment

Here we are concerned with the demands for inputs to the construction of fixed capital. We assume that a unit of fixed capital for use in industry j can be created according to a two-tiered technology; see Figure 2.1. At the first level, industry j chooses effective intermediate inputs $X^{(2)}_{(1\cdot)j}$ , $X^{(2)}_{(2\cdot)j}$ , and $X^{(2)}_{(3\cdot)j}$ to minimize costs:

$$\sum_{i=1}^{3} P_{(i\cdot)} X^{(2)}_{(i\cdot)j} \quad ; \tag{2.1}$$

subject to a Leontief production function:

$$Y_j = \min \{X^{(2)}_{(1\cdot)j}/A^{(2)}_{(1\cdot)j}, \ldots, X^{(2)}_{(3\cdot)j}/A^{(2)}_{(3\cdot)j} \}; \tag{2.2}$$

where $P_{(1\cdot)}$, $P_{(2\cdot)}$, and $P_{(3\cdot)}$ are the prices paid for effective inputs of goods 1, 2 and 3; $Y_j$ is the level of investment in industry j; and the $A^{(2)}$'s are technological parameters. On solving the above problem, the industry demands for inputs to the construction of units of fixed capital take the form:

$$Y_j = X^{(2)}_{(i\cdot)j} / A^{(2)}_{(i\cdot)j} \qquad i = 1,2,3 \quad j = 1,2,3 . \tag{2.3}$$

The percentage-change form of (2.3) is given by:

$$y_j = x^{(2)}_{(i\cdot)j} \qquad i = 1,2,3 \quad j = 1,2,3 ; \tag{2.4}$$

where a lower-case variable represents the percentage change in the respective upper-case variable. Equation (2.4) says that the percentage change in the effective inputs of goods 1,2, and 3 is equal to the

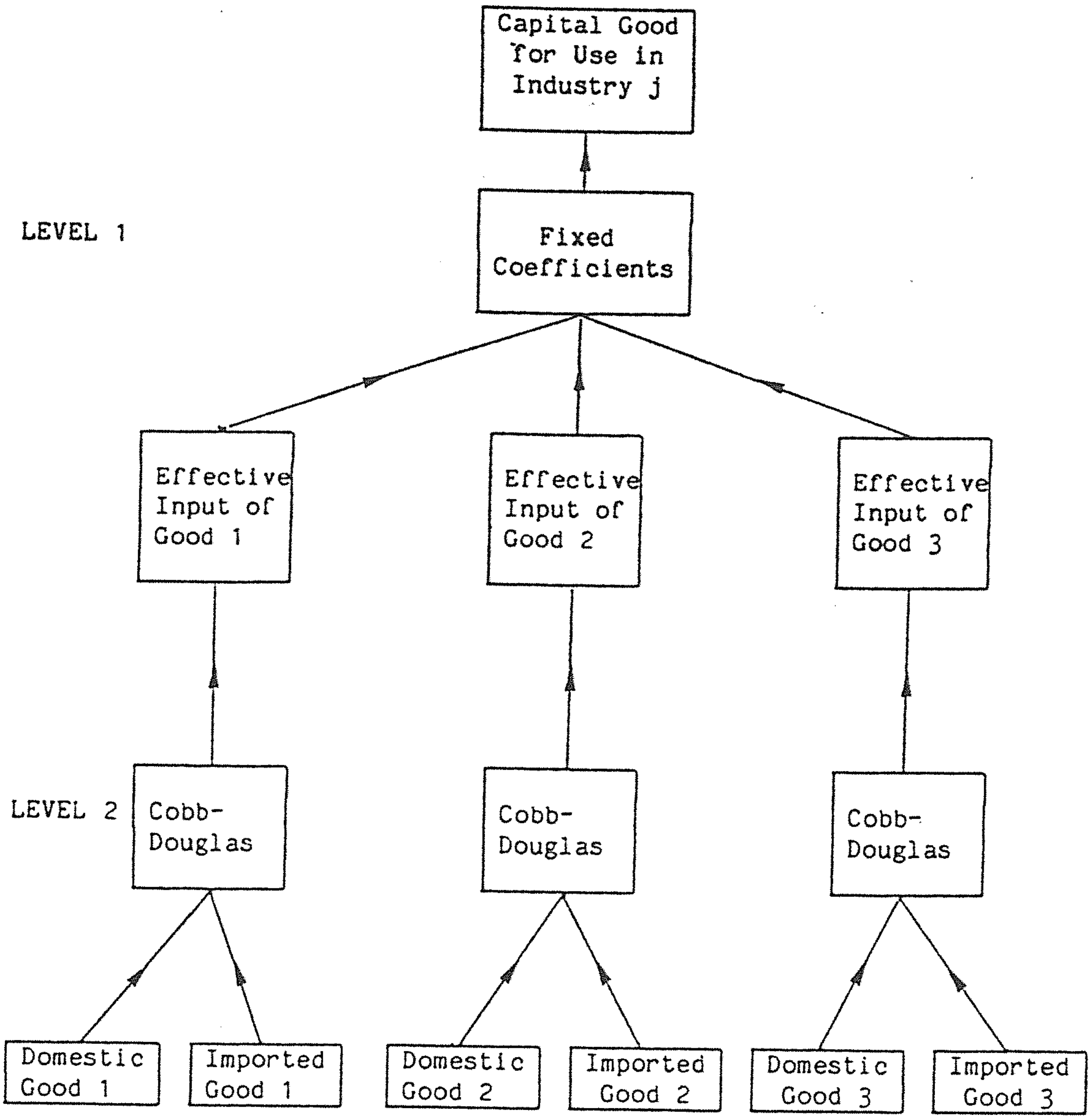


Figure 2.1: Technology for Assembling Units of Capital in MO87

percentage change in investment in industry j (i.e., these inputs are used in fixed proportions).

At the second level, industry j chooses its inputs of domestic (s = 1) and imported (s = 2) good i to minimize the costs of the effective input of good i (i = 1,2,3). These costs can be written:

$$\sum_{s=1}^{2} P_{(is)} X^{(2)}_{(is)j} \qquad i = 1,2,3 \quad j = 1,2,3. \qquad (2.5)$$

In each case the cost minimization is done subject to a Cobb-Douglas production function:

$$X^{(2)}_{(i\cdot)j} = \psi^{(2)}_{(i\cdot)j} \prod_{s=1}^{2} X^{(2)\,\alpha^{(2)}_{(is)j}}_{(is)j} \qquad i = 1,2,3 \quad j = 1,2,3 \; ; \qquad (2.6)$$

where the $\psi^{(2)}$'s and $\alpha^{(2)}$'s are positive parameters with:

$$\alpha^{(2)}_{(i1)j} + \alpha^{(2)}_{(i2)j} = 1 \qquad i = 1,2,3 \quad j = 1,2,3. \qquad (2.7)$$

The industry demand functions for inputs to the construction of units of fixed capital derived from the above problem are given by:

$$X^{(2)}_{(is)j} = \alpha^{(2)}_{(is)j} Q^{(2)}_{(i\cdot)j} X^{(2)}_{(i\cdot)j} \prod_{r=1}^{2} P_{(ir)}^{\alpha^{(2)}_{(ir)j}} / P_{(is)} \qquad i = 1,2,3 \quad s = 1,2 \quad j = 1,2,3 \; ; \qquad (2.8)$$

where

$$Q^{(2)}_{(i\cdot)j} = \prod_{r=1}^{2} \alpha^{(2)\,-\alpha^{(2)}_{(ir)j}}_{(ir)j} / \psi^{(2)}_{(i\cdot)j} \qquad i = 1,2,3 \quad j = 1,2,3 \; . \qquad (2.9)$$

The percentage-change form of (2.8) and (2.9) is given by:

$$x^{(2)}_{(is)j} = x^{(2)}_{(i\cdot)j} - \left(p_{(is)} - \sum_{r=1}^{2} \alpha^{(2)}_{(ir)j} \, p_{(ir)}\right) \qquad i = 1,2,3 \quad s = 1,2 \quad j = 1,2,3 \; . \qquad (2.10)$$

Using (2.4) we can rewrite (2.10) as:

$$x^{(2)}_{(is)j} = y_j - (p_{(is)} - \sum_{r=1}^{2} \alpha^{(2)}_{(ir)j}\, p_{(ir)}) \qquad i = 1,2,3;\ s = 1,2;\ j = 1,2,3 . \tag{2.11}$$

Equation (2.11) says that in the absence of changes in relative prices (i.e., $p_{(is)} = 0$, for s = 1,2) industry j will change its demand for input (is) to be used for capital creation by the same percentage as its investment level (i.e., $x^{(2)}_{(is)j} = y_j$, for i = 1,2,3, s = 1,2, and j = 1,2,3). On the other hand, if the percentage increase in the price of imported good 1, for example, is greater than the percentage increase in total expenditure on good 1 as an input to capital creation (where the weights are the share of good 1 as an input to capital creation, that is the $\alpha^{(2)}_{(is)j}$'s) then the industry will substitute away from imported good 1 towards domestically produced good 1.

Household consumption

It is assumed that the household sector chooses its consumption levels to maximize a nested utility function; see Figure 2.2. The nested utility function can be written:

$$U = \min \{ X^{(3)}_{(1\cdot)}/A^{(3)}_{(1\cdot)}, \ldots, /X^{(3)}_{(3\cdot)}/A^{(3)}_{(3\cdot)} \} \quad ; \tag{2.12}$$

where

$$X^{(3)}_{(i\cdot)} = X^{(3)^{\alpha^{(3)}_{(i1)}}}_{(i1)} \; X^{(3)^{\alpha^{(3)}_{(i2)}}}_{(i2)} \qquad i = 1,2,3 \; ; \tag{2.13}$$

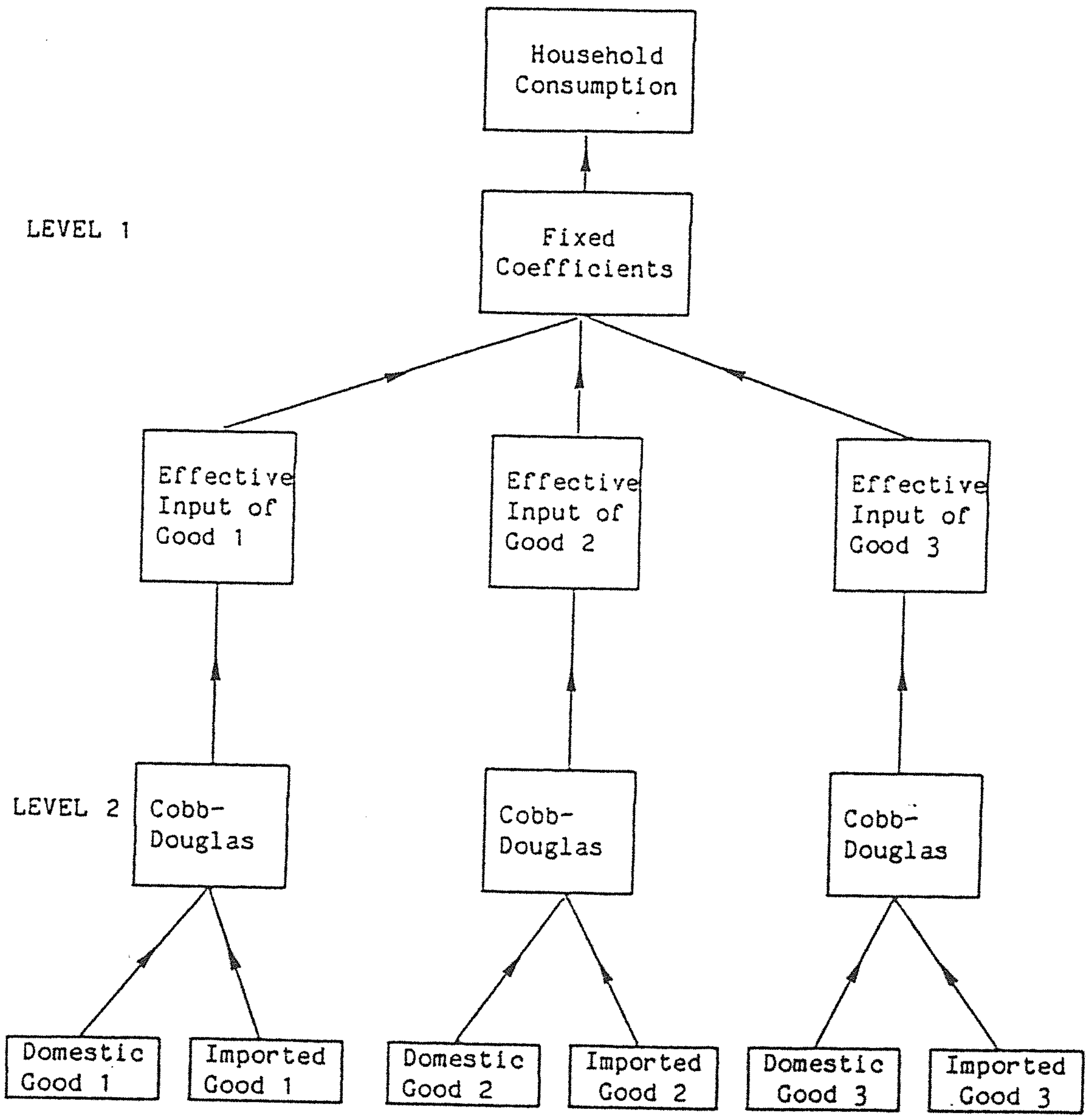


Figure 2.2: Specification of Household Consumption in MO87

and the $A^{(3)}$'s and the $\alpha^{(3)}$'s are positive parameters with $\alpha^{(3)}_{(i1)} + \alpha^{(3)}_{(i2)} = 1$, for i equals 1, 2, and 3. The specification (2.12) and (2.13) implies that, at the first level, consumers derive utility from effective inputs of goods 1,2, and 3. Here it is assumed that the household sector behaves as if effective units of goods are nonsubstitutes.[3] At the second level, units of domestic and imported good i are assumed to substitute for each other with unitary elasticity in the creation of effective units of good i, i.e., equation (2.13) has a Cobb-Douglas form.[4]

The household budget constraint is given by:

$$\sum_{i=1}^{3} \sum_{i=1}^{2} P_{(is)} X_{(is)} = C \quad ; \qquad (2.14)$$

where $P_{(is)}$ is the price in the domestic market for commodity i from source s; and C is the household sector's aggregate expenditure level.

On maximizing (2.12) subject to (2.13) and (2.14), we can derive the household demand functions; see, for example, Dixon, Parmenter, Sutton, and Vincent (1982, pp. 15-18). In percentage-change form the household demand functions can be written:

$$x^{(3)}_{(is)} = \varepsilon_{(is)} c + \sum_{q=1}^{3} \sum_{r=1}^{2} \eta_{(is)(qr)} \, p_{(qr)} \qquad i = 1,2,3 \quad s = 1,2 \; ; \qquad (2.15)$$

where the lower-case variables represent the percentage change in the respective upper-case variables; $\varepsilon_{(is)}$ is the expenditure elasticity of demand for good i of type s; and $\eta_{(is)(qr)}$ is the cross-price elasticity of demand for good i of type s with respect to a change in the price of good q of type r.

The expenditure and cross-price elasticities are determined as follows. Given the utility specification (2.12) and (2.13),[5] a 1 per cent increase in total expenditure, in the absence of relative price changes, will be allocated as a 1 per cent increase in expenditure on each commodity. Thus the expenditure elasticities are all equal to one:

$$\varepsilon_{(is)} = 1 \qquad i=1,2,3 \quad s = 1,2. \tag{2.16}$$

The price elasticities are a little more difficult to derive. Even though the utility function is specified as having fixed coefficients between effective inputs of the goods, a fall, for example, in the price of domestic good 1 will have an impact on the demand for, say, imported good 2. This is because a fall in the price of a good increases the real income of the household and as a result its demands for all goods increase. Following the Hicks-Slutsky partition, price elasticities can be split into an income effect plus a price effect:

$$\eta_{(is)(qr)} = -\varepsilon_{(is)} S^{(3)}_{(qr)} + \bar{\eta}_{(is)(qr)} \qquad \begin{matrix} i,\ q = 1,2,3 \\ s,r = 1,2; \end{matrix} \tag{2.17}$$

where $S^{(3)}_{(qr)}$ is the share of the total household budget devoted to commodity q from source r; and $\bar{\eta}_{(is)(qr)}$ is the utility compensated cross elasticity of demand for good (is) with respect to changes in the price of good (qr). Since no substitution possibilities are allowed between effective inputs of goods in (2.12) we know:

$$\bar{\eta}_{(is)(qr)} = 0 \quad , \quad \text{if } i \neq q \quad . \tag{2.18}$$

On the other hand, there are substitution possibilities modelled between domestic and imported goods of the same type in (2.13):[6]

$$\bar{\eta}_{(is)(is)} = -1 + \alpha^{(3)}_{(is)} \qquad , \qquad s = 1,2 \; ; \tag{2.19}$$

$$\bar{\eta}_{(is)(ir)} = \alpha^{(3)}_{(ir)} \qquad , \qquad \text{where } s \neq r . \tag{2.20}$$

Finally we note that since (2.13) has the Cobb-Douglas form then $\alpha^{(3)}_{(is)}$ is the share of good i from source s in the household's total expenditure on good i.

<u>Exports</u>

The final source of final demand is exports. The export demand functions are written as:

$$P^{*}_{(i1)} = X^{(4)-\gamma_i}_{(i1)} \, F^{(4)}_{(i1)} \qquad i = 1,2,3 \; ; \tag{2.21}$$

where $P^{*}_{(i1)}$ is the foreign-currency price of domestic good i; $X^{(4)}_{(i1)}$ is the export volume of good i; $\gamma_i$ is minus the reciprocal of the foreign elasticity of demand (a positive parameter); and $F^{(4)}_{(i1)}$ is a variable that can be used to simulate shifts in the foreign demand curve. In percentage-change form (2.21) becomes:

$$p^{*}_{(i1)} = -\gamma_i \; x^{(4)}_{(i1)} + f^{(4)}_{(i1)} \qquad i = 1,2,3. \tag{2.22}$$

2.1.2 Current Production

Industry decisions can be thought of as being made at two levels; see Figure 2.3. At the first level, industry j chooses its effective intermediate inputs $X^{(1)}_{(1\cdot)j}$, $X^{(1)}_{(2\cdot)j}$, and $X^{(1)}_{(3\cdot)j}$ and an effective input of primary factors denoted by $X^{(1)}_{(4\cdot)j}$ to minimize costs:

$$\sum_{i=1}^{4} P_{(i\cdot)} X^{(1)}_{(i\cdot)j} \; ; \tag{2.23}$$

subject to a Leontief production function:

$$X_j = \min \{X^{(1)}_{(1\cdot)j}/A^{(1)}_{(1\cdot)j}, \ldots, X^{(1)}_{(4\cdot)j}/A^{(1)}_{(4\cdot)j}\} \quad ; \tag{2.24}$$

where $P_{(1\cdot)}$, $P_{(2\cdot)}$, and $P_{(3\cdot)}$ are the prices paid for effective inputs of goods 1, 2, and 3; $P_{(4\cdot)}$ is the average price paid by industry j for primary factors; $X_j$ is the activity level of industry j (which is equal to the output of commodity j since industry j is a single-product industry); and the $A^{(1)}$'s are technological parameters. On solving the above problem, the industry input demand functions take the form:

$$X_j = X^{(1)}_{(i\cdot)j}/A^{(1)}_{(i\cdot)j} \qquad i = 1,\ldots,4 \quad j = 1,2,3 \,. \tag{2.25}$$

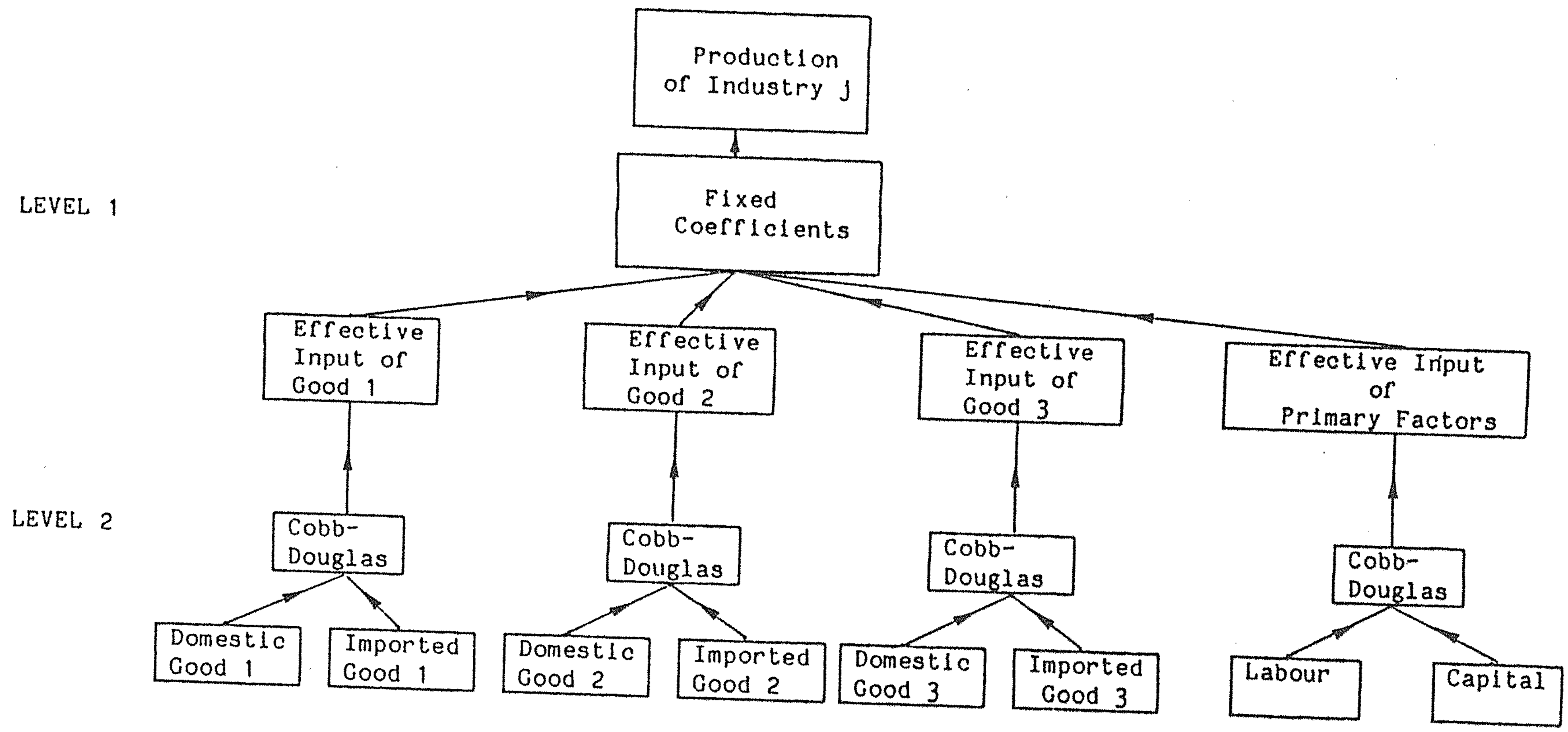


Figure 2.3: Technology for Production in MO87

The percentage-change form of (2.25) is given by:

$$x_j = x^{(1)}_{(i\cdot)j} \qquad \begin{array}{l} i = 1,\ldots,4 \\ j = 1,2,3\ . \end{array} \quad (2.26)$$

Equation (2.26) says that in industry j the percentage change in the effective inputs of goods 1, 2, and 3 and the percentage change in the effective input of primary factors are equal to the percentage change in output (i.e., these inputs are used in fixed proportions).

At the second level, industry j chooses its inputs of domestic (s=1) and imported (s=2) good i to minimize the costs of the effective input of good i (i=1,2,3). These costs can be written:

$$\sum_{s=1}^{2} P_{(is)} X^{(1)}_{(is)j} \qquad \begin{array}{l} i = 1,2,3 \\ j = 1,2,3. \end{array} \quad (2.27)$$

In each case the cost minimization is done subject to a Cobb-Douglas production function:

$$X^{(1)}_{(i\cdot)j} = \psi^{(1)}_{(i\cdot)j} \prod_{s=1}^{2} X^{(1)\,\alpha^{(1)}_{(is)j}}_{(is)j} \qquad \begin{array}{l} i = 1,2,3 \\ j = 1,2,3; \end{array} \quad (2.28)$$

where the $\psi^{(1)}$'s and the $\alpha^{(1)}$'s are positive parameters with:

$$\alpha^{(1)}_{(i1)j} + \alpha^{(1)}_{(i2)j} = 1 \qquad \begin{array}{l} i = 1,2,3 \\ j = 1,2,3. \end{array} \quad (2.29)$$

The industry input demand functions derived from the above problem are given by:

$$X^{(1)}_{(is)j} = \alpha^{(1)}_{(is)j} Q^{(1)}_{(i\cdot)j} X^{(1)}_{(i\cdot)j} \prod_{r=1}^{2} P_{(ir)}^{\alpha^{(1)}_{(ir)j}} / P_{(is)} \qquad \begin{array}{l} i = 1,2,3 \\ s = 1,2 \\ j = 1,2,3\ ; \end{array} \quad (2.30)$$

where

$$Q^{(1)}_{(i\cdot)j} = \prod_{r=1}^{2} \alpha^{(1)\,-\alpha^{(1)}_{(ir)j}}_{(ir)j} / \psi^{(1)}_{(i\cdot)j} \qquad \begin{array}{l} i = 1,2,3 \\ j = 1,2,3 . \end{array} \quad (2.31)$$

The percentage-change form of (2.30) and (2.31) is given by:

$$x^{(1)}_{(is)j} = x^{(1)}_{(i\cdot)j} - ( p_{(is)} - \sum_{r=1}^{2} \alpha^{(1)}_{(ir)j} p_{(ir} ) \qquad \begin{array}{l} i = 1,2,3 \\ s = 1,2 \\ j = 1,2,3 . \end{array} \quad (2.32)$$

Using (2.26) we can rewrite (2.32) as:

$$x^{(i)}_{(is)j} = x_j - (p_{(is)} - \sum_{r=1}^{2} \alpha^{(1)}_{(ir)j} p_{(ir)}) \qquad \begin{array}{l} i = 1,2,3 \\ s = 1,2 \\ j = 1,2,3. \end{array} \quad (2.33)$$

Equation (2.33) says that in the absence of changes in relative prices (i.e., $p_{(is)} = 0$, for s = 1, 2) industry j will change its demand for input (is) by the same percentage as its output (i.e., $x^{(1)}_{(is)j} = x_j$, for i = 1,2,3; s = 1,2; j = 1,2,3). On the other hand, if the percentage increase in the price of imported good 1, for example, is greater than the percentage increase in total expenditure on good 1 (where the weights are the share of good 1 from source s in the total expenditure by the industry on good 1, that is the $\alpha^{(1)}_{(is)j}$'s), then the industry will substitute away from imported good 1 and towards domestically produced good 1.

At this second level industry j also chooses its input of labour (s=1) and capital (s=2) to minimize the cost of the effective input of primary factors (i=4) subject to a Cobb-Douglas production function. This problem is identical to the one above except that the price (or rental) of capital is modelled as being industry specific (i.e., there is a j subscript on $p_{(42)j}$). Thus the input demand functions for labour and capital are, respectively, given by:

$$x^{(1)}_{(41)j} = x_j - \left(p_{(41)} - \left(\alpha^{(1)}_{(41)j}\, p_{(41)} + \alpha^{(1)}_{(42)j}\, p_{(42)j}\right)\right) \qquad j = ,1,2,3; \quad (2.34)$$

$$x^{(1)}_{(42)j} = x_j - \left(p_{(42)j} - \left(\alpha^{(1)}_{(41)j}\, p_{(41)} + \alpha^{(1)}_{(42)j}\, p_{(42)j}\right)\right) \qquad j = 1,2,3. \quad (2.35)$$

### 2.1.3 Zero Pure Profits

The activities recognized in MO87 are production, investment, exporting, and importing. The zero-pure-profits condition for production implies that:

$$P_{(i1)}X_j = \sum_{i=1}^{3} \sum_{s=1}^{2} P_{(is)}\, X^{(1)}_{(is)j} + P_{(41)}\, X^{(1)}_{(41)j} + P_{(42)j}\, X^{(1)}_{(42)j} \qquad j = 1,2,3 \,. \quad (2.36)$$

In percentage-change form (2.36) becomes:

$$p_{(i1)} + x_j = \sum_{i=1}^{3} \sum_{s=1}^{2} (p^{(1)}_{(is)} + x^{(1)}_{(is)j}) S_{(is)j}$$

$$+ (p_{(41)} + x^{(i)}_{(41)j}) S^{(1)}_{(41)j} + (p_{(42)j} + x^{(1)}_{(42)j}) S^{(1)}_{(42)j}$$

$$j = 1,2,3; \quad (2.37)$$

where the $S^{(1)}_{(is)j}$'s are production cost shares. Equation (2.37) can be simplified by observing from (2.33), (2.34), and (2.35) that:

$$\sum_{s=1}^{2} x^{(1)}_{(is)j} \alpha^{(1)}_{(is)j} = x_j \qquad \begin{matrix} i = 1,\ldots, 4 \\ j = 1,2,3. \end{matrix} \quad (2.38)$$

On using (2.38) in (2.37) and on noting that:

$$S^{(1)}_{(is)j} = \alpha^{(1)}_{(is)j} S^{(1)}_{(i\cdot)j} \qquad \begin{matrix} i = 1,\ldots, 4 \\ j = 1,2,3; \end{matrix} \quad (2.39)$$

where $S^{(1)}_{(i\cdot)j}$, $i = 1,2,3$ is the share of j's total production costs represented by inputs of good i from both domestic and foreign sources and $S^{(1)}_{(4\cdot)j}$ is the primary-factor share, we see that (2.37) reduces to:

$$\boxed{\begin{aligned} p_{(j1)} &= \sum_{i=1}^{3} \sum_{s=1}^{2} p_{(is)} S^{(1)}_{(is)j} \\ &+ p_{(41)} S^{(1)}_{(41)j} + p_{(42)j} S^{(1)}_{(42)j} \qquad j = 1,2,3\,. \end{aligned}} \quad (2.40)$$

Equation (2.40) says that for each industry the output price equals an appropriately weighted average of the percentage changes in input prices.

The second set of zero-pure-profit conditions sets the value of new capital equal to the cost of its production:

$$\Pi_j Y_j = \sum_{i=1}^{3} \sum_{s=1}^{2} P_{(is)} X_{(is)j}^{(2)} \qquad j = 1,2,3 \; ; \qquad (2.41)$$

where $\Pi_j$ is the cost of a new unit of fixed capital in industry j, and $Y_j$, $P_{(is)}$, and $X_{(is)j}^{(2)}$ are as defined above. In percentage-change form (2.41) becomes:

$$\pi_j + y_j = \sum_{i=1}^{3} \sum_{s=1}^{2} (p_{(is)} + x_{(is)j}^{(2)}) S_{(is)j}^{(2)} \qquad j = 1,2,3 \; ; \qquad (2.42)$$

where the $S_{(is)j}^{(2)}$'s are investment cost shares. Equation (2.42) can be simplified by observing from (2.11) that:

$$\sum_{s=1}^{2} x_{(is)j}^{(2)} \alpha_{(is)j}^{(2)} = y_j \qquad \begin{matrix} i = 1,2,3 \\ j = 1,2,3. \end{matrix} \qquad (2.43)$$

On substituting (2.43) in (2.42) and on noting that:

$$S_{(is)j}^{(2)} = \alpha_{(is)j}^{(2)} S_{(i\cdot)j}^{(2)} \qquad \begin{matrix} i = 1,2,3 \\ j = 1,2,3 \; ; \end{matrix} \qquad (2.44)$$

where $S_{(i\cdot)j}^{(2)}$, i = 1,2,3 is the share of j's total investment cost represented by inputs of good i from both domestic and foreign sources, we see that (2.42) reduces to:

$$\pi_j = \sum_{i=1}^{3} \sum_{s=1}^{2} p_{(is)} S_{(is)j}^{(2)} \qquad j = 1,2,3 . \qquad (2.45)$$

The third set of zero-pure-profit conditions equates the revenue from exporting to the equivalent costs:

$$P^*_{(i1)} V_i \ \Phi = P_{(i1)} \qquad i = 1,2,3 ; \quad (2.46)$$

where $P^*_{(i1)}$ is, as in equation (2.21), the foreign currency price of domestic good i; $\Phi$ is the exchange rate ($A/$ foreign); and $V_i$ is one plus the ad valorem rate of export subsidy. Thus, on the left hand side of (2.46) is the $A value, to the exporter, of exporting a unit of commodity i. On the right hand side of (2.46) is the cost of doing so, i.e., the domestic price of a unit of commodity i. The percentage-change form of (2.46) is given by:

$$p^*_{(i1)} + v_i + \phi = p_{(i1)} \qquad i = 1,2,3 . \qquad (2.47)$$

The final set of zero-pure-profit conditions equates the cost of importing to the selling prices of imported commodities:

$$P^*_{(i2)} T_i \ \Phi = P_{(i2)} \qquad i = 1,2,3 ; \qquad (2.48)$$

where $T_i$ is one plus the ad valorem rate of tariff on imports of good i; and $P^*_{(i2)}$ is the foreign currency price of good (i2). The percentage-change form of (2.48) is given by:

$$p^{*}_{(i2)} + t_i + \varphi = p_{(i2)} \qquad i = 1,2,3 . \qquad (2.49)$$

2.1.4 Market-Clearing Equations

The market-clearing equations for the three domestically produced commodities are given by:

$$X_i = \sum_{k=1}^{2} \sum_{j=1}^{3} X^{(k)}_{(i1)j} + X^{(3)}_{(i1)} + X^{(4)}_{(i1)} \qquad i = 1,2,3 . \qquad (2.50)$$

Equation (2.50) says that the supply of good i equals the sum of demands for good i for use in current production (k=1), investment (k=2), household consumption, and exporting. In percentage-change form (2.50) is written:

$$x_i = \sum_{k=1}^{2} \sum_{j=1}^{3} x^{(k)}_{(i1)j} B^{(k)}_{(i1)j} + x^{(3)}_{(i1)} B^{(3)}_{(i1)} + x^{(4)}_{(i1)} B^{(4)}_{(i1)} \qquad i = 1,2,3 ; \qquad (2.51)$$

where $B_{(i1)}$'s are the shares of the sales of domestically produced goods which are absorbed by the various types of demand identified on the right hand side of (2.50).

The market-clearing equations for industry capital stocks are given by:

$$X^{(1)}_{(42)j} = K_j(0) \qquad j = 1,2,3 \; ; \qquad (2.52)$$

where $K_j(0)$ is the employment of capital in industry j. The percentage-change form of (2.52) can be written:

$$\boxed{x^{(1)}_{(42)j} = k_j(0) \qquad j = 1,2,3 \; ;} \qquad (2.53)$$

2.1.5 Miscellaneous Equations

For M087 the miscellaneous equations can be divided into four groups. The first group explains how aggregate investment is allocated across industries. The remaining groups consist of some miscellaneous definitional equations.

Allocation of investment across industries

In section 2.1.1 we described the technology for creating units of capital. Here we determine the number of units that will be created for each industry, given some aggregate level of investment. Note that the theory of allocation of investment across industries presented here is based on Bruce and Horridge (1986).

The first step in the theory of the allocation of investment across industries is to note that the current net rate of return on fixed capital in industry j, $R_j(0)$, is given by:

$$R_j(0) = P_{(42)j}/\Pi_j - D_j \qquad j = 1,2,3 \; ; \qquad (2.54)$$

where $D_j$ is the rate of depreciation; and $P_{(42)j}$ and $\Pi_j$ are, as previously defined, the rental value and cost of a unit of capital in industry j. The percentage-change form of (2.54) is given by:[7]

$$100\,\Delta R_j(0) = Q_j\,(p_{(42)j} - \pi_j) - 100\Delta D_j \qquad j = 1,2,3 \; ; \qquad (2.55)$$

where $100\Delta R_j(0)$ and $100\Delta D_j$ are the percentage-point changes (as opposed to percentage changes) in the rate of return and depreciation rate, respectively. (The rate of return is written in change form since rates of return can be zero in the data base.) The $Q_j$ is defined as the ratio of the rental value of capital to the cost of capital in industry j:

$$Q_j = K_j(0)\,P_{(42)j}/\,(K_j(0)\,\Pi_j) \qquad j = 1,2,3 \; ; \qquad (2.56)$$

where $K_j(0)$ is the current level of capital stock in industry j.

The second step is to assume that capital in industry j takes one period to install. The third step is to assume that investors are cautious in assessing the effects of expanding the capital stock in industry j. They behave as if they expect that industry j's rate of return schedule in one period's time will have the form:

$$R_j(1) = R_j(0) - \beta_j \log (Z_j/Z_j^*) \qquad j = 1,2,3 \; ; \quad (2.57)$$

where $R_j(1)$ is the anticipated rate of return one period into the future; $z_j$ is the current growth rate in industry j's capital stocks; $Z_j^*$ is the expected long-run growth rate in industry j's capital stock; and $\beta_j$ is a positive parameter. Note that $Z_j$ is defined by:

$$Z_j = K_j(1)/K_j(0) \qquad j = 1,2,3 \; ; \quad (2.58)$$

where $K_j(1)$ is the level of industry j's capital stock at the end of one period. Thus according to equation (2.57) if the current rate of growth in the capital stock is equal to the expected long-run rate of growth (i.e., if $Z_j = Z_j^*$) then the expected rate of return at the end of one period is equal to the current rate of return. However, if the current rate of growth is greater than the expected long-run rate of growth (i.e., if $Z_j > Z_j^*$) then investors will expect the rate of return at the end of one period to be less than the current rate of return.

The fourth step is to assume that total investment expenditure, I, is allocated across industries so as to equate the expected rates of return:

$$R_j(1) = \Omega \qquad j = 1,2,3 \; ; \quad (2.59)$$

where $\Omega$ is some economy-wide rate of return. Note that it is assumed that (2.59) does not imply disinvestment in any industry beyond that which would occur via depreciation at a zero level of gross investment. By combining (2.57) and (2.59) we get:

$$\Omega = R_j(0) - \beta_j \log (Z_j/Z_j^*) \qquad j = 1,2,3 \text{ . } (2.60)$$

The percentage-change form of (2.60) is given by:[8]

$$100\Delta R_j(0) - 100\Delta\Omega = \beta_j z_j - \beta_j z_j^* \qquad j = 1,2,3 \text{ . } (2.61)$$

where 100ΔΩ is the percentage-point change in the economy-wide rate of return. Next we rewrite (2.58) in percentage-change form:

$$z_j = k_j(1) - k_j(0) \qquad j = 1,2,3. \quad (2.62)$$

Using (2.62) we can rewrite (2.61) as:

$$100\Delta R_j(0) - 100\Delta\Omega = \beta_j\big(k_j(1) - k_j(0)\big) - \beta_j\, z_j^* \qquad j = 1,2,3 \text{ . } \quad (2.63)$$

The fifth step is to assume that the only variables which influence the capital stock at the end of one period are the current capital stock, the depreciation rate, and the current level of investment:

$$K_j(1) = K_j(0)\,(1 - D_j) + Y_j \qquad j = 1,2,3 \text{ . } \quad (2.64)$$

The percentage-change form of (2.64) is given by:[9]

$$k_j(1) = k_j(0)\ (1-G_j) - 100\Delta D_j\ G_j^* + y_j G_j \qquad j = 1,2,3\ ; \tag{2.65}$$

where $G_j$ is the ratio of gross investment in industry j to its next-period capital stock, i.e., $G_j = Y_j/K_j(1)$; and $G_j^*$ is the ratio of the level of the capital stock in industry j to its next-period capital stock, i.e., $G_j^* = K_j(0)/K_j(1)$.

The sixth step is to define aggregate investment, I, as the sum of investment expenditure across industries:

$$I = \sum_{j=1}^{3} \Pi_j\ Y_j \quad . \tag{2.66}$$

The percentage-change form of (2.66) is given by:[10]

$$i = \sum_{j=1}^{3} (\pi_j + y_j)\ \delta_j \quad ; \tag{2.67}$$

where $\delta_j$ is the share of total aggregate fixed investment accounted for by investment in industry j:

$$\delta_j = Y_j\ \Pi_j / \sum_{k=1}^{3} Y_k\ \Pi_k \qquad j = 1,2,3\ . \tag{2.68}$$

Real aggregate investment and consumption

Real aggregate investment, $I_R$, is defined as:

$$I_R = I/\, \Xi^{(2)} \qquad ; \qquad (2.69)$$

where $\Xi^{(2)}$ is a capital-goods price index. The percentage-change form of (2.69) is given by:

$$\boxed{i_R = i - \xi^{(2)} \qquad .} \qquad (2.70)$$

The capital-goods price index is defined as:

$$\Xi^{(2)} = \prod_{j=1}^{3} \Pi_j^{\delta_j} \qquad . \qquad (2.71)$$

The percentage-change form of (2.71) is given by:

$$\boxed{\xi^{(2)} = \sum_{j=1}^{3} \delta_j \ \pi_j \ , \qquad .} \qquad (2.72)$$

Real aggregate consumption, $C_R$, is defined as:

$$C_R = C/\Xi^{(3)} \qquad ; \qquad (2.73)$$

where $\Xi^{(3)}$ is the consumer price index. The percentage-change form of (2.73) is given by:

$$c_R = c - \xi^{(3)} \quad . \tag{2.74}$$

The consumer price index is defined as:

$$\Xi^{(3)} = \prod_{i=1}^{3} \prod_{s=1}^{2} P_{(is)}^{W_{(is)}^{(3)}} \quad ; \tag{2.75}$$

where $W_{(is)}^{(3)}$ is the share of the total household budget devoted to commodity (is). The percentage-change form of (2.75) is given by:

$$\xi^{(3)} = \sum_{i=1}^{3} \sum_{s=1}^{2} W_{(is)}^{(3)} \, p_{(is)} \quad . \tag{2.76}$$

Finally it is useful to specify an equation relating real aggregate investment and consumption:

$$F_R = I_R/C_R \tag{2.77}$$

The percentage-change form of (2.77) is given by:

$$f_R = i_R - c_R \quad . \tag{2.78}$$

Import volumes and employment indices

For the imported commodities it is assumed that supply of imported commodity i, $X_{(i2)}$, is equal to the demand for that commodity;

$$X_{(i2)} = \sum_{k=1}^{2} \sum_{j=1}^{3} X_{(i2)j}^{(k)} + X_{(i2)}^{(3)} \qquad i = 1,2,3 \; ; \quad (2.79)$$

where $X_{(i2)j}^{(k)}$ is the demand for imported good i by industry j for purpose k (k = 1 refers to current production and k = 2 refers to investment); and $X_{(i2)}^{(3)}$ is the household demand for imported good i. The percentage-change form of (2.79) is given by:

$$x_{(i2)} = \sum_{k=1}^{2} \sum_{j=1}^{3} x_{(i2)j}^{(k)} \, B_{(i2)j}^{(k)} + x_{(i2)}^{(3)} \, B_{(i2)}^{(3)} \qquad i = 1,2,3 \; ; \quad (2.80)$$

where the $B_{(i2)}$'s are the shares in total import flows.

Two employment indices are specified, aggregate employment (L) and the aggregate capital stock in base-period value units (K(0)). Aggregate employment is calculated as:

$$L = \sum_{j=1}^{3} X_{(41)j}^{(1)} \quad . \quad (2.81)$$

The percentage-change form of (2.81) is given by:

$$\ell = \sum_{j=1}^{3} x_{(41)j}^{(1)} W_{(41)j} \quad ; \qquad (2.82)$$

where $W_{(41)j}$ is the share of labour in industry j in total employment of labour.

The aggregate capital stock in base-period value units is calculated as:

$$K(0) = \sum_{j=1}^{3} K_j(0) \quad . \qquad (2.83)$$

The percentage-change form of (2.83) is given by:

$$k(0) = \sum_{j=1}^{3} k_j(0) \; W_{(42)j} \quad ; \qquad (2.84)$$

where $W_{(42)j}$ is the share of capital of type j (valued at base-period prices) in the total value of fixed capital in the economy.

Aggregate imports, exports, and the balance of trade

Recall from equation (2.52) that the aggregate demand for imported good i is denoted by $X_{(i2)}$. Thus, in terms of foreign-currency cost, the aggregate value of imports, M, is calculated as:

$$M = \sum_{i=1}^{3} P^{*}_{(i2)} \; X^{(0)}_{(i2)} \quad . \qquad (2.85)$$

The percentage-change form of (2.85) is given by:

$$m = \sum_{i=1}^{3} (p^{*}_{(i2)} + x^{(0)}_{(i2)}) \; M_{(i2)} \quad ; \qquad (2.86)$$

where $M_{(i2)}$ is the share of the aggregate foreign-currency cost of commodity imports which is accounted for by good i.

The aggregate foreign-currency earnings of exports, E, is calculated as:

$$E = \sum_{i=1}^{3} P^{*}_{(i1)} \; X^{(4)}_{(i1)} \quad . \qquad (2.87)$$

The percentage-change form of (2.87) is given by:

$$e = \sum_{i=1}^{3} (p^{*}_{(i1)} + x^{(4)}_{(i1)}) \; E_{(i1)} \quad ; \qquad (2.88)$$

where $E_{(i1)}$ is good i's share in aggregate export receipts.

Finally, the balance of trade is defined as:

$$B = E - M \quad . \qquad (2.89)$$

The percentage-change form of (2.89) is given by:

$$100\Delta B = Ee - Mm \quad ; \qquad (2.90)$$

where ΔB is the change in B and has as units base-period Australian dollars at the base-period exchange rate. If equation (2.90) is divided by the base-period value for GDP then ΔB/GDP is the change in the balance of trade as a share of the base-period GDP:

$$100\Delta B/GDP = S_E e - S_M m \quad ; \qquad (2.91)$$

where $S_E$ and $S_M$ are the base-period shares of exports and imports, respectively, in GDP.

Wage indexation

The final equation of the stylized CGE model allows for the modelling of different degrees of wage indexation:

$$P_{(41)} = (\Xi^{(3)})^h \, F_{(41)} \quad ; \qquad (2.92)$$

where h is a user-specified indexation parameter; and $F_{(41)}$ is a wage-shift variable. The percentage-change form of (2.92) is given by:

$$p_{(41)} = \xi^{(3)} h + f_{(41)} \quad . \qquad (2.93)$$

Equation (2.93) is quite flexible. If the parameter h is set at unity and the wage-shift variable is held constant (i.e., $f_{(41)} = 0$), for example, then the wages will move in line with the consumer price index.

In summary, the percentage-change form of M087 is given by equations (2.11), (2.15), (2.22), (2.33) - (2.35), (2.40), (2.47), (2.49), (2.51), (2.53), (2.55), (2.63), (2.65), (2.67), (2.70), (2.72), (2.74), (2.76), (2.78), (2.80), (2.82), (2.84), (2.86), (2.88), (2.91), and (2.93). To assist in interpreting the model, these equations and the variables contained within are given in Tables 2.1 and 2.2, respectively. There are 93 equations and 118 variables in the percentage-change form of M087.

## 2.2 NUMERICAL SPECIFICATION

To calibrate a CGE Model involves choosing values for its parameters and coefficients which guarantee that some selected benchmark data set is a solution to the model (i.e., an equilibrium). Parameters whose values cannot be inferred from an input-output table (such as substitution elasticities in most cases) are obtained from econometric studies, or are set arbitrarily. An aggregated version of the 1978-79 Australian input-output table is given in Table 2.3. (Note that Appendix A.2 contains a detailed description of how the 1978-79 ORANI data base at basic values was aggregated to the three-sector input-output table at purchasers' prices). Since judicious use was made of Leontief and Cobb-Douglas functional forms nearly all of the parameters and coefficients of the model can be deduced from the input-output table.

TABLE 2.1 : THE PERCENTAGE-CHANGE FORM OF MO87

| Identifier | Equation | Subscript Range | Number of Equations | Description |
|---|---|---|---|---|
| **Final Demands** | | | | |
| (2.11) | $x^{(2)}_{(is)j} = y_j - (p_{(is)} - \sum_{r=1}^{2} \alpha^{(2)}_{(ir)j}\, p_{(ir)})$ | i = 1,2,3<br>s = 1,2<br>j = 1,2,3 | 18 | Demands for inputs to capital creation |
| (2.15) | $x^{(3)}_{(is)} = \varepsilon_{(is)} c + \sum_{q=1}^{3} \sum_{r=1}^{2} \eta_{(is)(qr)}\, p_{(qr)}$ | i = 1,2,3<br>s = 1,2 | 6 | Household demands for commodities classified by source |
| (2.22) | $p^{*}_{(i1)} = -\gamma_i\, x^{(4)}_{(i1)} + f^{(4)}_{(i1)}$ | i = 1,2,3 | 3 | Export demand functions |
| **Current Production** | | | | |
| (2.33) | $x^{(1)}_{(is)j} = x_j - (p_{(is)} - \sum_{r=1}^{2} \alpha^{(1)}_{(ir)j}\, p_{(ir)})$ | i = 1,2,3<br>s = 1,2<br>j = 1,2,3 | 18 | Demands for intermediate inputs, domestic and imported |
| (2.34) | $x^{(1)}_{(41)j} = x_j - (p_{(41)} - (\alpha^{(1)}_{(41)j}\, p_{(41)} + \alpha^{(1)}_{(42)j}\, p_{(42)j}))$ | j = 1,2,3 | 3 | Demands for labour |
| (2.35) | $x^{(1)}_{(42)j} = x_j - (p_{(42)j} - (\alpha^{(1)}_{(41)j}\, p_{(41)} + \alpha^{(1)}_{(42)j}\, p_{(42)j}))$ | j = 1,2,3 | 3 | Demands for capital |
| **Zero Pure Profits** | | | | |
| (2.40) | $p_{(j1)} = \sum_{i=1}^{3} \sum_{s=2}^{2} p_{(is)}\, S^{(1)}_{(is)j} + p_{(41)}\, S^{(1)}_{(41)j} + p_{(42)j}\, S^{(1)}_{(42)j}$ | j = 1,2,3 | 3 | Zero pure profits in production |
| (2.45) | $\pi_j = \sum_{i=1}^{3} \sum_{s=1}^{2} p_{(is)}\, S^{(2)}_{(is)j}$ | j = 1,2,3 | 3 | Zero pure profits in capital creation |
| (2.47) | $p^{*}_{(i1)} + v_i + \phi = p_{(i1)}$ | i = 1,2,3 | 3 | Zero pure profits in exporting |
| (2.49) | $p^{*}_{(i2)} + t_i + \phi = p_{(i2)}$ | i = 1,2,3 | 3 | Zero pure profits in importing |
| **Market Clearing** | | | | |
| (2.51) | $x_i = \sum_{k=1}^{2} \sum_{j=1}^{3} x^{(k)}_{(i1)j}\, B^{(k)}_{(i1)j} + x^{(3)}_{(i1)}\, B^{(3)}_{(i1)} + x^{(4)}_{(i1)}\, B^{(4)}_{(i1)}$ | i = 1,2,3 | 3 | Demand equals supply for domestically produced commodities |
| (2.53) | $x^{(1)}_{(42)j} = k_j(0)$ | j = 1,2,3 | 3 | Demand equals supply for capital |

Table 2.1 continued:

| Identifier | Equation | Subscript Range | Number of Equations | Description |
|---|---|---|---|---|
| <u>Miscellaneous Equations</u> | | | | |
| (2.55) | $100\Delta R_j(0) = Q_j\ (p_{(42)j} - \pi_j) - 100\ \Delta D_j$ | $j = 1,2,3$ | 3 | Rates of return on capital in each indust |
| (2.63) | $100\Delta R_j(0) - 100\Delta\Omega = \beta_j\ \left[k_j(1) - k_j(0)\right] - \beta_j z_j^*$ | $j = 1,2,3$ | 3 | Equality of rates of return acro industries |
| (2.65) | $k_j(1) = k_j(0)\ (1-G_j) - 100\Delta D_j G_j^* + y_j G_j$ | $j = 1,2,3$ | 3 | Capital accumulatio |
| (2.67) | $i = \sum_{j=1}^{3}\ (\pi_j + y_j)\ \delta_j$ | | 1 | Investment budget |
| (2.70) | $i_R = i - \xi^{(2)}$ | | 1 | Real investment expenditure |
| (2.72) | $\xi^{(2)} = \sum_{j=1}^{3}\ \delta_j\ \pi_j$ | | 1 | Capital-goo price index |
| (2.74) | $c_R = c - \xi^{(3)}$ | | 1 | Real househ expenditure |
| (2.76) | $\xi^{(3)} = \sum_{i=1}^{3}\ \sum_{s=1}^{2}\ W^{(3)}_{(is)} p_{(is)}$ | | 1 | Consumer pr index. |
| (2.78) | $r_R = i_R - c_R$ | | 1 | Ratio of re investment real consumption. |
| (2.80) | $x_{(i2)} = \sum_{k=1}^{2}\ \sum_{j=1}^{3}\ x^{(k)}_{(i2)j}\ B^{(k)}_{(i2)j} + x^{(3)}_{(i2)}\ B^{(3)}_{(i2)}$ | $i = 1,2,3$ | 3 | Import volumes |
| (2.82) | $\ell = \sum_{j=1}^{3}\ x^{(1)}_{(41)j}\ W_{(41)j}$ | | 1 | Aggregate employment |
| (2.84) | $k(0) = \sum_{j=1}^{3}\ k_j(0)\ W_{(42)j}$ | | 1 | Aggregate capital stoc |
| (2.86) | $m = \sum_{i=1}^{3}\ (p^*_{(i2)} + x_{(i2)})\ M_{(i2)}$ | | 1 | Foreign currency val of imports |
| (2.88) | $e = \sum_{i=1}^{3}\ (p^*_{(i1)} + x^{(4)}_{(i1)})\ E_{(i1)}$ | | 1 | Foreign currency val of exports |
| (2.91) | $100\Delta B/GDP = S_E e - S_M m$ | | 1 | The balance trade |
| (2.93) | $p_{(41)} = \xi^{(3)} h + f_{(41)}$ | | 1 | Flexible handling of wages |
| | | Total = | 93 | |

TABLE 2.2 : VARIABLES IN THE PERCENTAGE-CHANGE FORM OF MO87

| Variable | Subscript Range | Number | Description |
|---|---|---|---|
| $x_j$ | j = 1,2,3 | 3 | Industry ( and commodity) outputs |
| $x^{(k)}_{(is)j}$ | i = 1,2,3<br>s = 1,2<br>j = 1,2,3<br>k = 1,2 | 36 | Demands for inputs (domestic and imported) for current production and capital creation |
| $x^{(1)}_{(41)j}$ | j = 1,2,3 | 3 | Industry demands for labour |
| $x^{(1)}_{(42)j}$ | j = 1,2,3 | 3 | Industry demands for capital |
| $x^{(3)}_{(is)}$ | i = 1,2,3<br>s = 1,2 | 6 | Household demands for commodity by source |
| $x^{(4)}_{(i1)}$ | i = 1,2,3 | 3 | Export volumes |
| $y_j$ | j = 1,2,3 | 3 | Capital creation by using industry |
| $p_{(is)}$ | i = 1,2,3<br>s = 1,2 | 6 | Price of commodities |
| $p_{(41)}$ | | 1 | Wage rate |
| $p_{(42)j}$ | j = 1,2,3 | 3 | Rental rate on capital |
| $p^{*}_{(i1)}$ | i = 1,2,3 | 3 | Foreign currency export prices (f.o.b.) |

Table 2.2 continued

| Variable | Subscript Range | Number | Description |
|---|---|---|---|
| $p^*_{(i2)}$ | i = 1,2,3 | 3 | Foreign currency import prices (c.i.f.) |
| c | | 1 | Aggregate household expenditure |
| $f^{(4)}_{(i1)}$ | i = 1,2,3 | 3 | Shifts in export demands |
| $\phi$ | | 1 | The exchange rate, $A per $US, for example |
| $v_i$ | i = 1,2,3 | 3 | One plus the ad valorem export subsidies |
| $t_i$ | i = 1,2,3 | 3 | One plus the ad valorem tariffs |
| $k_j(0)$ | j = 1,2,3 | 3 | Current capital stocks |
| $k_j(1)$ | j = 1,2,3 | 3 | Future capital stocks |
| $100\Delta R_j(0)$ | j = 1,2,3 | 3 | Percentage-point change in the current rates of return on fixed capital |
| $\pi_j$ | j = 1,2,3 | 3 | Cost of units of capital |
| $100\Delta D_j$ | j = 1,2,3 | 3 | Percentage-point change in the depreciation rate |

Table 2.2 continued

| Variable | Subscript Range | Number | Description |
|---|---|---|---|
| $100\Delta\Omega$ | | 1 | Percentage-point change in the economy-wide expected rate of return on capital |
| $z_j^*$ | j = 1,2,3 | 3 | Expected long-run industry growth rate |
| $i$ | | 1 | Aggregate investment expenditure |
| $i_R$ | | 1 | Aggregate real investment expenditure |
| $\xi^{(2)}$ | | 1 | Capital goods price index |
| $c_R$ | | 1 | Aggregate real household consumption expenditure |
| $\xi^{(3)}$ | | 1 | Consumer price index |
| $f_R$ | | 1 | The ratio of real investment expenditure to real household consumption expenditure |
| $x_{(i2)}$ | i = 1,2,3 | 3 | Aggregate imports by commodity |

Table 2.2. continued

| Variable | Subscript Range | Number | Description |
|---|---|---|---|
| $\ell$ | | 1 | Aggregate employment |
| k(0) | | 1 | Aggregate capital stock |
| ΔB/GDP | | 1 | Change in the balance of trade as a share of base-period GDP |
| e | | 1 | Foreign currency value of exports |
| m | | 1 | Foreign currency value of imports |
| $f_{(41)}$ | | 1 | Wage shift variable |
| | TOTAL = | 118 | |

TABLE 2.3: A THREE-SECTOR INPUT-OUTPUT TABLE OF THE AUSTRALIAN ECONOMY AT PURCHASERS' PRICES (MILLIONS OF 1978-79 DOLLARS)

| | | Current Production | | | Final Demands | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | (Domestic Industries) | | | Investment (Domestic Industries) | | | Consumption | Exports | | Row Totals |
| | | 1. | 2. | 3. | 1. | 2. | 3. | | | | |
| | | | A | | | B | | C | D | | |
| Domestic Commodities | 1. | 8,022 | 5,323 | 1,546 | 325 | 0 | 12 | 6,179 | 11,446 | | 32,853 |
| | 2. | 2,341 | 13,404 | 15,309 | 1,115 | 750 | 3,515 | 21,197 | 2,964 | | 60,595 |
| | 3. | 7,268 | 16,874 | 20,710 | 1,281 | 422 | 14,605 | 51,216 | 2,221 | | 114,597 |
| | | | F | | | G | | H | | Duty | |
| Imported Commodities | 1. | 83 | 1,403 | 68 | 0 | 0 | 0 | 344 | | -15 | 1,883 |
| | 2. | 686 | 4,983 | 4,101 | 688 | 464 | 2,169 | 5,771 | | -1,119 | 17,743 |
| | 3. | 163 | 355 | 1,137 | 1 | 0 | 6 | 1,270 | | 0 | 2,932 |
| | | | L | | | | | | | | |
| Labour | | 8,131 | 15,066 | 53,582 | | | | | | | 76,779 |
| | | | K | | | | | | | | |
| Capital | | 6,159 | 3,187 | 18,144 | | | | | | | 27,490 |
| Column Totals | | 32,853 | 60,595 | 114,597 | 3,410 | 1,636 | 20,307 | 85,977 | 16,631 | -1,134 | |

The first equation in MO87 is (2.11), industry demands for inputs to capital creation. The $\alpha^{(2)}_{(ir)j}$ parameters in (2.11) are the shares of good i from source r in industry j's total expenditure on good i as an input to capital creation. These shares can be calculated from the input-output table and they are listed in Table 2.4.

The second type of equation in MO87 is equation (2.15), household demands for commodities classified by source. We know from (2.16) that the expenditure elasticities, i.e., the $\varepsilon_{(is)}$'s are all equal to one. This leaves the own-price and cross-price elasticities, i.e., the $\eta_{(is)(qr)}$'s, to be determined. As 6 commodities are distinguished in the model, there are 6 × 6 = 36 own- and cross-price elasticities in total; see Figure 2.4. From equations (2.17) and (2.19) we know that the own-price elasticities, i.e., the diagonal elements of Figure 2.4, are given by:

$$\eta_{(is)(is)} = -S^{(3)}_{(is)} - 1 + \alpha^{(3)}_{(is)} \qquad i = 1,2,3 \quad s = 1,2 \; . \tag{2.94}$$

The shares $s^{(3)}_{(is)}$ (i.e., the share of the total household budget devoted to good i from source s) and $\alpha^{(3)}_{(is)}$ (i.e., the share of good i from source s) in the household's total expenditure on good i) can be calculated from the input-output table. These shares are listed in Table 2.5. Thus the own-price elasticity for domestically produced commodity 1, for example, is calculated as follows:

$$\eta_{(11)(11)} = -0.0719 - 1 + 0.9473 = -0.1246 \; .$$

From equations (2.17) and (2.20) we know that the cross-price elasticities within the import-domestic substitution nests are given by:

TABLE 2.4 : INPUT SHARES FOR CAPITAL CREATION

| Share[a] | Value | Share[a] | Value | Share[a] | Value |
|---|---|---|---|---|---|
| $\alpha^{(2)}_{(11)1}$ | 1.0000 | $\alpha^{(2)}_{(11)2}$ | n.a.[b] | $\alpha^{(2)}_{(11)3}$ | 1.0000 |
| $\alpha^{(2)}_{(12)1}$ | 0.0000 | $\alpha^{(2)}_{(12)2}$ | n.a. | $\alpha^{(2)}_{(12)3}$ | 0.0000 |
| | 1.0000 | | n.a. | | 1.0000 |
| $\alpha^{(2)}_{(21)1}$ | 0.6184 | $\alpha^{(2)}_{(21)2}$ | 0.6178 | $\alpha^{(2)}_{(21)3}$ | 0.6856 |
| $\alpha^{(2)}_{(22)1}$ | 0.3816 | $\alpha^{(2)}_{(22)2}$ | 0.3822 | $\alpha^{(2)}_{(22)3}$ | 0.3144 |
| | 1.0000 | | 1.0000 | | 1.0000 |
| $\alpha^{(2)}_{(31)1}$ | 0.9992 | $\alpha^{(2)}_{(31)2}$ | 1.0000 | $\alpha^{(2)}_{(31)3}$ | 0.9996 |
| $\alpha^{(2)}_{(32)1}$ | 0.0008 | $\alpha^{(2)}_{(32)2}$ | 0.0000 | $\alpha^{(2)}_{(32)3}$ | 0.0004 |
| | 1.0000 | | 1.0000 | | 1.0000 |

a $\alpha^{(2)}_{(is)j}$ is the share of good i from source s in industry j's total expenditure on good i for the purpose of capital creation.

b Not applicable. Note that neither domestic nor imported good 1 is used by industry 2 for capital creation; see Table 2.3.

| | | | | | |
|---|---|---|---|---|---|
| $\eta(11)(11)$ | $\eta(11)(12)$ | $\eta(11)(21)$ | $\eta(11)(22)$ | $\eta(11)(31)$ | $\eta(11)(32)$ |
| $\eta(12)(11)$ | $\eta(12)(12)$ | $\eta(12)(21)$ | $\eta(12)(22)$ | $\eta(12)(31)$ | $\eta(12)(32)$ |
| $\eta(21)(11)$ | $\eta(21)(12)$ | $\eta(21)(21)$ | $\eta(21)(22)$ | $\eta(21)(31)$ | $\eta(21)(32)$ |
| $\eta(22)(11)$ | $\eta(22)(12)$ | $\eta(22)(21)$ | $\eta(22)(22)$ | $\eta(22)(31)$ | $\eta(22)(32)$ |
| $\eta(31)(11)$ | $\eta(31)(12)$ | $\eta(31)(21)$ | $\eta(31)(22)$ | $\eta(31)(31)$ | $\eta(31)(32)$ |
| $\eta(32)(11)$ | $\eta(32)(12)$ | $\eta(32)(21)$ | $\eta(32)(22)$ | $\eta(32)(31)$ | $\eta(32)(32)$ |

| | | | | | |
|---|---|---|---|---|---|
| -0.1246 | 0.0487 | -0.2465 | -0.0671 | -0.5957 | -0.0148 |
| 0.8754 | -0.9517 | -0.2465 | -0.0671 | -0.5957 | -0.0148 |
| -0.0719 | -0.0040 | -0.4605 | 0.1469 | -0.5957 | -0.0148 |
| -0.0719 | -0.0040 | 0.5395 | -0.8531 | -0.5957 | -0.0148 |
| -0.0719 | -0.0040 | -0.2465 | -0.0671 | -0.6199 | 0.0094 |
| -0.0719 | -0.0040 | -0.2465 | -0.0671 | 0.3801 | -0.9906 |

Figure 2.4: Own- and Cross-Price Elasticities in MO87

TABLE 2.5 : HOUSEHOLD EXPENDITURE SHARES

| Share[a] | Value | Share[b] | Value |
|---|---|---|---|
| $S^{(3)}_{(11)}$ | 0.0719 | $\alpha^{(3)}_{(11)}$ | 0.9473 |
| $S^{(3)}_{(12)}$ | 0.0040 | $\alpha^{(3)}_{(12)}$ | 0.0527 |
| | | | 1.0000 |
| $S^{(3)}_{(21)}$ | 0.2465 | $\alpha^{(3)}_{(21)}$ | 0.7860 |
| $S^{(3)}_{(22)}$ | 0.0671 | $\alpha^{(3)}_{(22)}$ | 0.2140 |
| | | | 1.0000 |
| $S^{(3)}_{(31)}$ | 0.5957 | $\alpha^{(3)}_{(31)}$ | 0.9758 |
| $S^{(3)}_{(32)}$ | 0.0148 | $\alpha^{(3)}_{(32)}$ | 0.0242 |
| | 1.0000 | | 1.0000 |

a $S^{(3)}_{(is)}$ is the share of total household expenditure devoted to good i from source s.

b $\alpha^{(3)}_{(is)}$ is the share of good i from source s in the total household expenditure on good i.

$$\eta_{(is)(ir)} = - S^{(3)}_{(ir)} + \alpha^{(3)}_{(ir)} \qquad i = 1,2,3 \quad s \neq r \quad (s,r = 1,2) \quad .(2.95)$$

Thus the cross-price elasticity between domestic and imported good i, for example, is calculated as follows:

$$\eta_{(11)(12)} = - 0.0040 + 0.0527 = 0.0487 \quad .$$

Finally, from equations (2.17) and (2.18) we know that the cross-price elasticities outside the import-domestic substitution nests are given by:

$$\eta_{(is)(qr)} = - S^{(3)}_{(qr)} \qquad i \neq q \quad (i,q = 1,2,3) \quad s,r = 1,2 \ . \quad (2.96)$$

The next equation in the stylized CGE model is equation (2.22), the export demand functions. The $\gamma_i$ parameters in (2.22) must be assigned values, preferably on the basis of econometric studies. For the stylized CGE model the values chosen for $\gamma_1$, $\gamma_2$, and $\gamma_3$ are 0.50, 0.05, and 0.05, respectively, i.e., the foreign elasticities of demands for goods 1, 2, and 3 are assumed to be 2.0, 20.0, and 20.0.

The next block of equations (2.33)-(2.35), concern industry decisions about current production. The $\alpha^{(1)}_{(ir)j}$ parameters in (2.33) are the shares of good i from source r in industry j's total expenditure on good i for use in current production. The $\alpha^{(1)}_{(41)j}$ and $\alpha^{(1)}_{(42)j}$ shares in equations (2.34) and (2.35) are the shares of returns to labour and capital in industry j's total returns to primary factors. The above shares can be calculated from the model's input-ouput table and they are listed in Table 2.6.

The first zero-pure-profits condition in production, equation (2.40), requires the estimation of the industry current-production cost shares, i.e., the $S^{(1)}_{(is)j}$'s. These cost shares can be calculated from the input-output table and they are listed in Table 2.7.

The second zero-pure-profits condition, equation (2.45), requires the estimation of the industry capital-creation cost shares, i.e., the $S^{(1)}_{(is)j}$'s. These cost shares can be calculated from the input-output table and they are listed in Table 2.8.

The market-clearing equations are the next group of equations in the stylized model. Equation (2.51) requires the estimation of sales shares of the domestic commodities, i.e., the $B_{(i1)}$'s. These sale shares can be calculated from the input-ouput table and they are listed in Table 2.9.

The next set of equations (2.55)-(2.67), describe the allocation of investment across industries. To calibrate these equations we require, in addition to the input-output data, estimates for each industry of the value of the capital stocks in the base period, the depreciation rate on capital, and the $\beta_j$ parameters (see equation (2.67)) that reflect the speed with which investors respond to changes in the industry's rate of return. The values assumed for these are listed in Table 2.10.

TABLE 2.6 : INPUT SHARES FOR CURRENT PRODUCTION

| Share[a] | Value | Share[a] | Value | Share[a] | Value |
|---|---|---|---|---|---|
| $\alpha^{(1)}_{(11)1}$ | 0.9898 | $\alpha^{(1)}_{(11)2}$ | 0.7914 | $\alpha^{(1)}_{(11)3}$ | 0.9579 |
| $\alpha^{(1)}_{(12)1}$ | 0.0102 | $\alpha^{(1)}_{(12)2}$ | 0.2086 | $\alpha^{(1)}_{(12)3}$ | 0.0421 |
| | 1.0000 | | 1.0000 | | 1.0000 |
| $\alpha^{(1)}_{(21)1}$ | 0.7734 | $\alpha^{(1)}_{(21)2}$ | 0.7290 | $\alpha^{(1)}_{(21)3}$ | 0.7887 |
| $\alpha^{(1)}_{(22)1}$ | 0.2266 | $\alpha^{(1)}_{(22)2}$ | 0.2710 | $\alpha^{(1)}_{(22)3}$ | 0.2113 |
| | 1.0000 | | 1.0000 | | 1.0000 |
| $\alpha^{(1)}_{(31)1}$ | 0.9781 | $\alpha^{(1)}_{(31)2}$ | 0.9794 | $\alpha^{(1)}_{(31)3}$ | 0.9480 |
| $\alpha^{(1)}_{(32)1}$ | 0.0219 | $\alpha^{(1)}_{(32)2}$ | 0.0206 | $\alpha^{(1)}_{(32)3}$ | 0.0520 |
| | 1.0000 | | 1.0000 | | 1.0000 |
| $\alpha^{(1)}_{(41)1}$ | 0.5690 | $\alpha^{(1)}_{(41)2}$ | 0.8254 | $\alpha^{(1)}_{(41)3}$ | 0.7470 |
| $\alpha^{(1)}_{(42)1}$ | 0.4310 | $\alpha^{(1)}_{(42)2}$ | 0.1746 | $\alpha^{(1)}_{(42)3}$ | 0.2530 |
| | 1.0000 | | 1.0000 | | 1.0000 |

a $\alpha^{(1)}_{(is)j}$ is the share of input i from source s in industry j's total expenditure on good i used in current production for i = 1,2,3. While $\alpha^{(1)}_{(4s)j}$ is the share of returns to primary factor of type s in industry j's total returns to primary factors.

TABLE 2.7 : INDUSTRY COST SHARES FOR CURRENT PRODUCTION

| Share[a] | Value | Share[a] | Value | Share[a] | Value |
|---|---|---|---|---|---|
| $S^{(1)}_{(11)1}$ | 0.2442 | $S^{(1)}_{(11)2}$ | 0.0878 | $S^{(1)}_{(11)3}$ | 0.0135 |
| $S^{(1)}_{(12)1}$ | 0.0025 | $S^{(1)}_{(12)2}$ | 0.0232 | $S^{(1)}_{(12)3}$ | 0.0006 |
| $S^{(1)}_{(21)1}$ | 0.0713 | $S^{(1)}_{(21)2}$ | 0.2212 | $S^{(1)}_{(21)3}$ | 0.1336 |
| $S^{(1)}_{(22)1}$ | 0.0209 | $S^{(1)}_{(22)2}$ | 0.0822 | $S^{(1)}_{(22)3}$ | 0.0358 |
| $S^{(1)}_{(31)1}$ | 0.2212 | $S^{(1)}_{(31)2}$ | 0.2785 | $S^{(1)}_{(31)3}$ | 0.1807 |
| $S^{(1)}_{(32)1}$ | 0.0050 | $S^{(1)}_{(32)2}$ | 0.0059 | $S^{(1)}_{(32)3}$ | 0.0099 |
| $S^{(1)}_{(41)1}$ | 0.2474 | $S^{(1)}_{(41)2}$ | 0.2486 | $S^{(1)}_{(41)3}$ | 0.4676 |
| $S^{(1)}_{(42)1}$ | 0.1875 | $S^{(1)}_{(42)2}$ | 0.0526 | $S^{(1)}_{(42)3}$ | 0.1583 |
| | 1.0000 | | 1.0000 | | 1.0000 |

a $S^{(1)}_{(is)j}$ is the share of input (is) in industry j's total costs of current production.

TABLE 2.8 : INDUSTRY COST SHARES FOR CAPITAL CREATION

| Share[a] | Value | Share[a] | Value | Share[a] | Value |
|---|---|---|---|---|---|
| $S^{(2)}_{(11)1}$ | 0.0953 | $S^{(2)}_{(11)2}$ | 0.0000 | $S^{(2)}_{(11)3}$ | 0.0006 |
| $S^{(2)}_{(12)1}$ | 0.0000 | $S^{(2)}_{(12)2}$ | 0.0000 | $S^{(2)}_{(12)3}$ | 0.0000 |
| $S^{(2)}_{(21)1}$ | 0.3270 | $S^{(2)}_{(21)2}$ | 0.4585 | $S^{(2)}_{(21)3}$ | 0.1731 |
| $S^{(2)}_{(22)1}$ | 0.2018 | $S^{(2)}_{(22)2}$ | 0.2836 | $S^{(2)}_{(22)3}$ | 0.1068 |
| $S^{(2)}_{(31)1}$ | 0.3756 | $S^{(2)}_{(31)2}$ | 0.2579 | $S^{(2)}_{(31)3}$ | 0.7192 |
| $S^{(2)}_{(32)1}$ | 0.0003 | $S^{(2)}_{(32)2}$ | 0.0000 | $S^{(2)}_{(32)3}$ | 0.0003 |
| | 1.0000 | | 1.0000 | | 1.0000 |

a $S^{(2)}_{(is)j}$ is the share of input (is) in industry j's total costs of capital creation.

TABLE 2.9 : SALES SHARES FOR DOMESTIC COMMODITIES

| Share[a] | Value | Share[a] | Value | Share[a] | Value |
|---|---|---|---|---|---|
| $B^{(1)}_{(11)1}$ | 0.2442 | $B^{(1)}_{(21)1}$ | 0.0386 | $B^{(1)}_{(31)1}$ | 0.0634 |
| $B^{(1)}_{(11)2}$ | 0.1620 | $B^{(1)}_{(21)2}$ | 0.2212 | $B^{(1)}_{(31)2}$ | 0.1472 |
| $B^{(1)}_{(11)3}$ | 0.0471 | $B^{(1)}_{(21)3}$ | 0.2526 | $B^{(1)}_{(31)3}$ | 0.1807 |
| $B^{(2)}_{(11)1}$ | 0.0099 | $B^{(2)}_{(21)1}$ | 0.0184 | $B^{(2)}_{(31)1}$ | 0.0112 |
| $B^{(2)}_{(11)2}$ | 0.0000 | $B^{(2)}_{(21)2}$ | 0.0124 | $B^{(2)}_{(31)2}$ | 0.0037 |
| $B^{(2)}_{(11)3}$ | 0.0004 | $B^{(2)}_{(21)3}$ | 0.0580 | $B^{(2)}_{(31)3}$ | 0.1274 |
| $B^{(3)}_{(11)}$ | 0.1881 | $B^{(3)}_{(21)}$ | 0.3499 | $B^{(3)}_{(31)}$ | 0.4470 |
| $B^{(4)}_{(11)}$ | 0.3483 | $B^{(4)}_{(21)}$ | 0.0489 | $B^{(4)}_{(31)}$ | 0.0194 |
| | 1.0000 | | 1.0000 | | 1.0000 |

a The $B_{(i1)}$'s are the shares of domestic commodity i sold to the respective users in the total sales of domestic commodity i.

TABLE 2.10: DATA FOR CALIBRATING THE EQUATIONS WHICH DESCRIBE THE ALLOCATION OF INVESTMENT ACROSS INDUSTRIES

| Industry | Base period capital stock $K_j(0)\Pi_j$ | Depreciation rate $D_j$ | Speed of adjustment parameter $\beta_j$ |
|---|---|---|---|
| 1. Export | $ 22,811m | 0.07 | 2.5 |
| 2. Import-Competing | $ 13,857m | 0.08 | 2.5 |
| 3. Non-Traded | $113,400m | 0.06 | 2.5 |

The first equation of those which describe the allocation of investment across industries is (2.55). Recall from (2.56) that $Q_j$ in (2.55) is the ratio of the rental value of capital to the cost of capital in industry j:

$$Q_j = K_j(0)\, P_{(42)j}/(K_j(0)\Pi_j) \qquad j = 1,2,3 . \qquad (2.97)$$

If we substitute the estimates of the base-period capital stocks listed in Table 2.10 along with the rental values from the input-output table into equation (2.97) we obtain: $Q_1$ = 6,159/22,811 = 0.2700; $Q_2$ = 3,187/13,857 = 0.2300; and $Q_3$ = 18,144/113,400 = 0.1600.

The second equation of those which describe the allocation of investment across industries is (2.63). The $\beta_j$ parameters in (2.63) must be assigned values, preferably on the basis of econometric studies. For the stylized CGE model we have assumed that $\beta_j$ = 2.5 for j = 1,2,3 ; see Table 2.10.

Equation (2.65) requires the calculation of the $G_j$'s and the $G_j^*$'s. Recall from section 2.1.5 that $G_j$ is the ratio of gross investment in industry j to its next-period capital stock:

$$G_j = Y_j/K_j(1) \qquad j = 1,2,3 . \qquad (2.98)$$

Equation (2.98) can be rewritten:

$$G_j = Y_j\, \Pi_j/(K_j(1)\Pi_j) \qquad j = 1,2,3 . \qquad (2.99)$$

The base-period value of gross investment, $Y_j\Pi_j$, can be read from the input-output table, however the value of next period's capital stock, $K_j(1)\Pi_j$, must be calculated as follows. Recall from equation (2.65) that:

$$K_j(1) = K_j(0)(1-D_j) + Y_j \qquad j = 1,2,3 \ . \quad (2.100)$$

Similar to above, equation (2.100) can be rewritten:

$$K_j(1)\Pi_j = K_j(0)\ \Pi_j\ (1-D_j) + Y_j\Pi_j \qquad j = 1,2,3 \ . \quad (2.101)$$

If we substitute the estimates of the values of the base-period capital stocks and the depreciation rates listed in Table 2.10 along with the value of investment by industry from the input-output table into equation (2.101) we obtain: $K_1(1)\Pi_1$ = 22,811 × (1 - 0.07) + 3,410 = \$24,624m; $K_2(1)\Pi_2$ = 13,857 × (1 - 0.08) + 1,636 = \$14,384m; and $K_3(1)\Pi_3$ = 113,400 × (1 - 0.06) + 20,307 = \$126,903m. Thus we are now in a position to calculate the $G_j$'s. By substituting the base-period values of gross investment from the input-output table and the above values of the next-period capital stocks into equation (2.99) we obtain: $G_1$ = 3,410/24,624 = 0.1385; $G_2$ = 1,636/14,384 = 0.1137; and $G_3$ = 20,307/126,903 = 0.1600.

Recall from section 2.1.5 that $G_j^*$ is the ratio of the current level of the capital stock in industry j to its next-period capital stock:

$$G_j^* = K_j(0)/K_j(1) \qquad j = 1,2,3 \ . \quad (2.102)$$

Equation (2.102) can be rewritten:

$$G_j^* = K_j(0)\Pi_j/(K_j(1)\Pi_j) \qquad j = 1,2,3 . \qquad (2.103)$$

If we substitute the estimates of the values of the base-period capital stocks listed in Table 2.9 along with the values of the next-period capital stocks calculated above, we obtain: $G_1^* = 22{,}811/24{,}624 = 0.9264$; $G_2^* = 13{,}857/14{,}384 = 0.9634$; and $G_3^* = 113{,}400/126{,}903 = 0.8936$.

The next shares to require calculating are the shares of total aggregate fixed investment accounted for by investment in industry j, i.e., the $\delta_j$'s. These shares can be calculated from the input-output table: $\delta_1 = 3{,}410/25{,}353 = 0.1345$; $\delta_2 = 1{,}636/25{,}353 = 0.0645$; and $\delta_3 = 20{,}307/25{,}353 = 0.8010$.

To calibrate the consumer price index equation, (2.76), the weights of each of the commodities, distinguished by source of supply, in household consumption must be calculated. These can be obtained from the input-output table:

$$W_{(11)}^{(3)} = 6{,}179/85{,}977 = 0.0719; \; W_{(12)}^{(3)} = 344/85{,}977 = 0.0040;$$

$$W_{(21)}^{(3)} = 21{,}197/85{,}977 = 0.2465; \; W_{(22)}^{(3)} = 5{,}771/85{,}977 = 0.0671;$$

$$W_{(31)}^{(3)} = 51{,}216/85{,}977 = 0.5957; \; W_{(32)}^{(3)} = 1{,}270/85{,}977 = 0.0148.$$

The next group of equations in the stylized CGE model define some aggregate measures. The $B_{(i2)}$'s in equation (2.80) are the sales shares of imported commodities. These can be calculated from the input-output table and they are listed in Table 2.11. The $W_{(41)j}$'s in equation (2.82) are the base-period shares of total employment of labour accounted for by employment in industry j. These shares can be calculated from the input-output table: $W_{(41)1}$ = 8,131/76,779 = 0.1059; $W_{(41)2}$ = 15,066/76,779 = 0.1962; and $W_{(41)3}$ = 53,582/76,779 = 0.6979. Similarly, the $W_{(42)j}$'s in equation (2.84) are the base-period shares of total usage of capital accounted for by industry j, $W_{(42)1}$ = 6,159/27,490 = 0.2240; $W_{(42)2}$ = 3,187/27,490 = 0.1159; and $W_{(42)3}$ = 18,144/27,490 = 0.6601.

The last group of equations in MO87 to require calibration determine the foreign currency value of imports, exports and the balance of trade. In equation (2.86), $M_{(i2)}$ is the share of imports of commodity i in the total c.i.f. value of imports. These shares can be calculated from the input-output table and they are given by: $M_{(12)}$ = 1,883/22,558 = 0.0835; $M_{(22)}$ = 17,743/22,558 = 0.7865; and $M_{(32)}$ = 2,932/22,558 = 0.1300. In equation (2.88), $E_{(i1)}$ is the share of exports of commodity i in the total f.o.b. value of exports. These shares can also be calculated from the input-output table and they are given by: $E_{(11)}$ = 11,446/16,631 = 0.6883; $E_{(21)}$ = 2,964/16,631 = 0.1782; and $E_{(31)}$ = 2,221/16,631 = 0.1335.

Finally, $S_E$ and $S_M$ in equation (2.91) are the base-period shares of the domestic currency value of exports and imports in GDP. In the input-output table aggregate imports and aggregate exports are equal to \$22,558m and \$16,631m, respectively, i.e., there is a balance of trade deficit of \$5,927m. GDP can also be calculated from the input-output table. On the expenditure side GDP is equal to:

TABLE 2.11 : SALES SHARES FOR THE IMPORTED COMMODITIES

| Share[a] | Value | Share[a] | Value | Share[a] | Value |
|---|---|---|---|---|---|
| $B^{(1)}_{(12)1}$ | 0.0437 | $B^{(1)}_{(22)1}$ | 0.0364 | $B^{(1)}_{(32)1}$ | 0.0556 |
| $B^{(1)}_{(12)2}$ | 0.7393 | $B^{(1)}_{(22)2}$ | 0.2642 | $B^{(1)}_{(32)2}$ | 0.1211 |
| $B^{(1)}_{(12)3}$ | 0.0358 | $B^{(1)}_{(22)3}$ | 0.2174 | $B^{(1)}_{(32)3}$ | 0.3878 |
| $B^{(2)}_{(12)1}$ | 0.0000 | $B^{(2)}_{(22)1}$ | 0.0365 | $B^{(2)}_{(32)1}$ | 0.0003 |
| $B^{(2)}_{(12)2}$ | 0.0000 | $B^{(2)}_{(22)2}$ | 0.0246 | $B^{(2)}_{(32)2}$ | 0.0000 |
| $B^{(2)}_{(12)3}$ | 0.0000 | $B^{(2)}_{(22)3}$ | 0.1150 | $B^{(2)}_{(32)3}$ | 0.0020 |
| $B^{(3)}_{(12)}$ | 0.1812 | $B^{(3)}_{(22)}$ | 0.3059 | $B^{(3)}_{(32)}$ | 0.4332 |
| | 1.0000 | | 1.0000 | | 1.0000 |

a The $B_{(i2)}$'s are the shares of imported commodity i sold to the respective users in the total sales of imported commodity i.

$$GDP = C + I + E - M \quad ; \qquad (2.104)$$

where C is household consumption; I is aggregate investment; E is exports; and M is imports. On the income side GDP is given by:

$$GDP = L + K + Duty \quad ; \qquad (2.105)$$

where L and K are the earnings of labour and capital, respectively. Both equations (2.104) and (2.105) give GDP as $105,403m. Thus we can calculate that $S_E$ = 16,631/105,403 = 0.1578 and $S_M$ = 22,558/105,403 = 0.2140.

## 2.3 Solution Method

The percentage-change form of MO87, as given in Table 2.1, can be written:

$$Az = 0 \quad ; \qquad (2.106)$$

where A is a (93 × 118) matrix containing the coefficients of the linear equations; and z is a (118 × 1) vector of percentage-change variables (industry and commodity outputs, commodity and factor prices, employment levels of factors, etc.). The number of variables (118) identified in the model exceeds the number of equations (93). To close the model we need to set values for twenty-five variables (i.e., 118 - 93) exogenously. A solution then consists of projections of the percentage changes in the endogenous variables generated by a given set of shocks to the exogenous variables. That is, we rewrite (2.106) as:

$$A_1z_1 + A_2z_2 = 0 \; ; \tag{2.107}$$

where $z_1$ and $z_2$ are, respectively, (93 × 1) and ((118 - 93)×1) vectors of the endogenous and exogenous variables; and $A_1$ and $A_2$ are the corresponding (93 × 93) and (93×(118 - 93)) submatrices of A. We then calculate:

$$z_1 = Ez_2 \; ; \tag{2.108}$$

where E is a matrix of the elasticities of the endogenous variables with respect to the exogenous variables. The matrix E can be calculated in a variety of ways (see Pearson and Rimmer (1983) for a discussion of sparse matrix methods), but clearly:

$$E = -A_1A_2^{-1} \quad . \tag{2.109}$$

The equations of MO87 were implemented and solved using the GEMPACK general purpose software system for CGE models; see Pearson (forthcoming). The process of solving the linear equations used the Harwell sparse matrix code; see Duff (1977).

# 3. PROJECTIONS

In this section we will use MO87 to study the effects of an increase in tariffs, real absorption, and the real wage.

## 3.1 The Economic Environment

Certain features of the economy are not projected endogenously by MO87. For these the user of the model must specify an environment before computing solutions, i.e., select which variables are to be exogenous. One possible choice for MO87 is given in Table 3.1.

The first two groups of exogenous variables in Table 3.1 concern imports. The foreign currency prices of imports, i.e., the $p^*_{(i2)}$'s, are exogenous. Here we are allowing for the analysis of the effects of exogenously projected changes in foreign import supply prices. The second group of exogenous variables are the tariffs or tariff equivalents of quantitative restrictions, i.e., the $t_i$'s. By making tariffs exogenous we can compute the effects of exogenously projected changes in the government's policy on protection.

The next set of exogenous variables concern exports. The export subsidy, $v_1$, for the major export commodity (see Table 2.3) is set exogenously. This setting allows for export volumes of commodity 1 to be determined endogenously. For the minor export commodities (commodities 2 and 3) the export volumes, i.e., the $x^{(4)}_{(i1)}$'s, are exogen-

TABLE 3.1 : THE ECONOMIC ENVIRONMENT

| Variable | Subscript Range | Number | Description |
|---|---|---|---|
| $p^*_{(i2)}$ | i = 1,2,3 | 3 | Foreign currency import prices (c.i.f.). |
| $t_i$ | i = 1,2,3 | 3 | One plus the ad valorem tariffs. |
| $v_i$ | i = 1 | 1 | One plus the export susbidy for the major export commodity. |
| $x^{(4)}_{(i1)}$ | i = 2,3 | 2 | The export volumes for the minor export commodities. |
| $f^{(4)}_{(i1)}$ | i = 1,2,3 | 3 | Shifts in export demands. |
| $k_j(0)$ | j = 1,2,3 | 3 | Current capital stocks. |
| $100\Delta D_j$ | j = 1,2,3 | 3 | Percentage-point change in the depreciation rate. |
| $z^*_j$ | j = 1,2,3 | 3 | Expected long-run industry growth rate. |
| $c_R$ | | 1 | Aggregate real household consumption expenditure. |
| $i_R$ | | 1 | Aggregate real investment expenditure. |
| $f_{(41)}$ | | 1 | Wage shift variable. |
| $\phi$ | | 1 | The exchange rate, \$A per \$US, for example. |
| | Total = | 25 | |

ous. Export volumes are set exogenously for the minor export commodities as it is not reasonable to assume that shifts in world prices for these commodities strongly influence their domestic prices. The other exogenous variables related to exports are the shifts in foreign demand for domestic products, i.e., the $f^{(4)}_{(i1)}$'s. Here we allow for the simulation of the effects on the domestic economy of exogenously specified movements in export demand.

The next set of variables in the exogenous list are the current industry capital stocks, i.e., the $k_j(0)$'s. This choice can serve to define the time period of the model's projections. For example, setting industry capital stocks exogenously at zero change defines the short run, the length of which has been estimated for the ORANI model by Cooper (1983) as about 2 years. (Note that if the industry rates of return are exogenous and set to zero change, then this choice can serve to define a long-run simulation.)

The percentage-point changes in the depreciation rates are the next group of exogenous variables. For most experiments we would probably set these at zero change. Similarly, for most short-run experiments we would also probably set the expected long-run industry growth rates, i.e., the $z^*_j$'s, at zero change.

The next variables in the exogenous list are $c_R$ and $i_R$. In this case the model indicates, among other things, the change in the balance of trade that would be required to maintain a projected target level for real absorption. (Alternatively, $\Delta B/GDP$ and $f_R$ may be set exogenously and $c_R$ and $i_R$ will be determined by the model. Note that if $f_R$ is set at zero change, then real consumption and real absorption will adjust by the same percentage.)

The next variable on the exogenous list is $f_{(41)}$. If we assume that the user-specified parameter h in equation (2.93) is set at unity, then $f_{(41)}$ is the exogenous percentage change in real wages. Alternatively, if h is set at zero, then $f_{(41)}$ is the exogenouspercentage change in nominal wages. Here we will set h at unity and allow for the calculation of the effects of exogenously projected movements in real wages. In this economic environment aggregate employment, $\ell$, is endogenous. (Note that an alternative economic environment would be one in which aggregate employment is exogenous and the real wage is endogenous.)

The final variable in Table 3.1 is the nominal exchange rate, $\phi$. This variable acts as the numeraire, i.e., it determines the absolute price level. Note that the model will determine the change in the <u>real</u> exchange rate, however there are no mechanisms in the model suitable for determining the extent to which these changes will be realized as changes in the domestic inflation rate relative to the foreign rate or as changes in the nominal exchange rate.[11] If the nominal exchange rate is the numeraire, changes in domestic price indices can be interpreted as changes in domestic relative to world prices.

## 3.2 Effects of Changes in the Economic Environment

In this section we report the macroeconomic and sectoral results of a one per cent increase in: the tariff on the import-competing good, real domestic absorption, and the real wage.

### 3.2.1 Short-Run Macroeconomic Projections

The short-run macroeconomic effects of a one per cent increase in tariffs, real absortion, and real wages are given in Table 3.2 Each of these shocks will be discussed in turn.

Protection

The first column of Table 3.2 shows the effects of a one per cent increase in the ad valorem tariff equivalent on imports of good 2. The ad valorem tariff equivalent includes estimates of the extent to which tariff and quota protection raise the domestic prices of imported goods. Before these results are discussed however, we will first explain the relationship between the ad valorem tariff equivalent and one plus the ad valorem tariff which is the variable included in the model.

Recall from equation (2.48) that the variable $T_i$ is one plus the ad valorem rate of tariff on imports of good i. In other words we could write:

$$T_i = 1 + AV_i \qquad i = 1,2,3 \quad ; \quad (3.1)$$

where $AV_i$ is the ad valorem rate of tariff on imports of good i. It is possible to calculate the ad valorem tariff from the input-output table. From Table 2.3 we know that the duty paid on imports of good 2 is \$1,119m, while the landed duty free value of imports of good 2 is \$17,743m. Thus the ad valorem tariff on imports of good 2, as recorded

TABLE 3.2 : SHORT-RUN MACROECONOMIC RESULTS*

| | Variable | One per cent increase in: The ad valorem tariff on the import-competing good | Real domestic absorption | Real wages |
|---|---|---|---|---|
| $\xi^{(3)}$ | Consumer price index | 0.1329 | 1.1893 | 2.4437 |
| $\xi^{(2)}$ | Investment price index | 0.1436 | 1.1642 | 2.3908 |
| c | Aggregate household expenditure | 0.1329 | 2.1893 | 2.4437 |
| i | Aggregate investment expenditure | 0.1436 | 2.1642 | 2.3908 |
| e | Foreign currency value of exports | -0.0589 | -0.6243 | -1.2646 |
| m | Foreign currency value of imports | -0.0281 | 1.6189 | 1.4205 |
| $\Delta B/GDP$ | Change in the balance of trade as a share of base-period GDP | -0.0000 | -0.0045 | -0.0050 |
| P(41) | Nominal wage rate | 0.1329 | 1.1893 | 3.4437 |
| $\ell$ | Aggregate employment | -0.0191 | 0.7935 | -1.1479 |
| $100\Delta\Omega$ | Percentage-point change in the economy-wide expected rate of return on capital | -0.0115 | -0.2001 | -0.0657 |

* All projections, with the exceptions of $\Delta B/GDP$ and $100\Delta\Omega$, are percentage deviations from the value the variable would have taken in the absence of the shock at the head of each column. The $\Delta B/GDP$ and $100\Delta\Omega$ projections, while also deviations from control, are, respectively, the change in the balance of trade as a share of base-period GDP and the percentage-point change in the economy-wide expected rate of return on capital.

in the input-output table, equals 0.0631 (i.e., $1,119m/$17,743m). Now assume that we are interested in a change in the ad valorem tariff rate. The size of the shock to be imposed on $T_i$ to achieve this change can be calculated as follows. First express equation (3.1) in percentage-change form:

$$t_i = (AV_i/(1 + AV_i))\ av_i \qquad i = 1,2,3 \quad ; \qquad (3.2)$$

where the lower-case variables refer to the percentage change in the respective upper-case variables. Thus a one per cent increase in the ad valorem tariff rate, as recorded in the input-output table, on imports of good 2 would require an increase in $t_2$ of 0.0594 per cent (i.e., 0.0631/1.0631 × 1). Next we note that it is sometimes the case, as it is here, that we are really interested in the effects of an increase in protection, which includes quotas as well as tariffs. We will define $AV_i^*$ to be the ad valorem tariff equivalent on imports of good i. The size of the shock to be imposed on $T_i$ to achieve a change in the ad valorem tariff equivalent rate is then given by:

$$t_i = (AV_i/(1 + AV_i)\ u_i\ av_i \qquad i = 1,2,3 \quad ; \qquad (3.3)$$

where

$$u_i = ((1 + AV_i)/AV_i) \times (AV_i^* \ / \ (1 + AV_i^*)) \qquad i = 1,2,3 \quad . \qquad (3.4)$$

The average ad valorem tariff equivalent for 1981-82 was estimated by Chai and Dixon (1985) to be 0.2830. Thus if we are interested in the effects of a one per cent increase in the ad valorem tariff equivalent, as estimated by Chai and Dixon, the appropriate shock to $t_2$ can be calculated by substituting $AV_2 = 0.0631$, $AV_2^* = 0.2830$ and $av_2 = 1$ into equations (3.3) and (3.4), such that $t_2$ equals 0.2206.

An increase in the tariff on imports is projected to cause an increase in both the consumer and investment price indices. The consumer price index (hereafter CPI) is projected to increase slightly more than the investment price index (hereafter IPI) due to the relatively larger share of sales of imported goods in household consumption as opposed to investment. Both aggregate household consumption and investment expenditure are projected to increase in line with their respective price indices. This reflects the assumption of real domestic absorption being exogenous and set to zero change.

The tariff increase is projected to cause a contraction in both exports and imports. The export sector contracts due to the increase in domestic costs as reflected by the CPI (note that nominal wages are assumed to move in line with the CPI). Imports are projected to decrease due to the increase in the domestic selling price of imported good 2 brought about by the tariff increase. Since exports are projected to decrease at a faster rate than imports, the change in the balance of trade as a share of GDP is projected to fall.

A fall in the balance of trade due to the tariff increase suggests that real GDP must also have fallen, assuming real absorption remains unchanged. Since capital stocks are assumed not to change then a fall in real GDP is accommodated by a contraction in aggregate employment; see column one of Table 3.2.

Finally, the economy-wide expected rate of return on capital is projected to decline slightly. This rate of return adjusts to ensure that real investment attains the exogenous value assigned to it.

Real absorption

The next column in Table 3.2 shows the effects of a one per cent increase in real absorption. An increase in real absorption is inflationary, causing both the CPI and IPI to increase. Aggregate household and investment expenditure are projected to increase by one percentage point more than the increase in their respective price indices. This is as expected given that the shock here is a one per cent increase in real absorption.

The increase in real absorption is projected to cause a contraction in exports and an expansion in imports. The export sector contracts due to the increase in domestic costs as reflected by the CPI. On the other hand, an increase in real absorption generates an increase in demand for imports as well as domestic output. The contraction in exports and increase in imports generates a deterioration in the balance of trade.

An increase in real absorption is projected to increase aggregate employment. Finally, the expected economy-wide rate of return on capital is projected to fall.

Real wages

The final column of Table 3.2 shows the effects of a one per cent increase in real wages as a cost to employers. An increase in real wages is inflationary, causing both the CPI and IPI to increase. Aggregate household and investment expenditure are projected to increase in line with their respective price indices. This reflects the assumption of real domestic absorption being exogenous and set to zero change.

The increase in real wages causes a deterioration in the competitiveness of the export and the import-competing sectors. As a result, aggregate imports are projected to increase and aggregate exports are projected to decline. The contraction in exports and increase in imports generates a deterioration in the balance of trade.

An increase in real wages as a cost to employers is projected to cause a fall in aggregate employment. Finally, the expected economy-wide rate of return on capital is projected to fall.

### 3.2.2 Short-Run Effects on Industry Output, Employment by Industry, and Commodity Prices

The short-run effects on industry outputs, employment by industry, and commodity prices of the exogenous shocks are given in Table 3.3.

It can be shown that the short-run industry supply function for industry j in the stylized CGE model is given by:[12]

TABLE 3.3: SHORT-RUN EFFECTS ON INDUSTRY OUTPUTS, EMPLOYMENT BY INDUSTRY, AND COMMODITY PRICES*

| Industry/Commodity | One per cent increase in: | | |
|---|---|---|---|
| | The ad valorem tariff on the import-competing good | Real domestic absorption | Real wag |
| Industry Outputs | | | |
| 1. Export | -0.0825 | -0.5100 | -2.0732 |
| 2. Import-competing | 0.0184 | 0.4301 | -0.9646 |
| 3. Non-traded | -0.0058 | 0.7208 | -0.3956 |
| Employment by Industry | | | |
| 1. Export | -0.1665 | -1.0296 | -4.1856 |
| 2. Import-competing | 0.0267 | 0.6238 | -1.3990 |
| 3. Non-traded | -0.0089 | 1.1190 | -0.6142 |
| Commodity Prices | | | |
| 1. Export | 0.0856 | 0.9070 | 1.8374 |
| 2. Import-competing | 0.1348 | 1.1429 | 2.4032 |
| 3. Non-traded | 0.1321 | 1.4141 | 2.8860 |

* All projections are percentage deviations from the values that would have occurred in the absence of the shock at the head of the column.

$$x_j = (\alpha^{(1)}_{(41)j}/\alpha^{(1)}_{(42)j})[p_j/H_{PFj} + p_{Ij}(1-1/H_{PFj}) - p_{(41)}] \qquad j = 1,2,3 ; \qquad (3.5)$$

where $x_j$ is the percentage change in industry j's output; $p_j$, $p_{Ij}$, and $p_{(41)}$ are the percentage changes in the prices of industry j's output, intermediate inputs, and wage costs, respectively; $\alpha^{(1)}_{(41)j}$ and $\alpha^{(1)}_{(42)j}$ are the base-period shares of labour and capital in primary-factor inputs in industry j for use in current production; and $H_{PFj}$ is the base-period share of primary-factor inputs in total inputs to current production in industry j.

If it is assumed that wages are 100 per cent indexed to the CPI (i.e., $p_{(41)} = \xi^{(3)}$, where $\xi^{(3)}$ is the percentage change in the CPI) and the approximation is made that the average cost of intermediate inputs moves in line with the CPI (i.e., $p_{Ij} = \xi^{(3)}$) then equation (3.5) reduces to:

$$x_j = \lambda_j \ (p_j - \xi^{(3)}) \qquad j = 1,2,3 ; \qquad (3.6)$$

where

$$\lambda_j = \alpha^{(1)}_{(41)j}/(\alpha^{(1)}_{(42)j}H_{PFj}) \qquad j = 1,2,3 . \qquad (3.7)$$

The $\lambda_j$'s can be calculated from the data base (see Table 2.3): $\lambda_1$ = 3.0349; $\lambda_2$ = 15.6951; $\lambda_3$ = 4.7173. Furthermore, the projections for domestic commodity prices are listed in Table 3.3. Thus it is possible to check the consistency of the industry output projections by substituting the values for $\lambda_j$, $p_j$, and $\xi^{(3)}$ into equation (3.6).

Protection

An increase of one per cent in the ad valorem tariff on the import-competing good is projected to increase the price of the export good by 0.0856 per cent; see Table 3.3. This price rise is less than the increase in variable costs for the export sector (which roughly increase by 0.1329 per cent, i.e., by the CPI; see Table 3.2). Thus according to equation (3.6) the output of the export sector will contract by about 0.1 per cent (i.e., 3.0349 × (0.0856 - 0.1329) = -0.1436). This roughly corresponds with the projected fall in output of 0.0825 per cent for the export sector; see Table 3.3.

The import-competing sector experiences an increase in output when there is an increase in the tariff of the corresponding imported commodity. A one per cent increase in the ad valorem tariff on the import-competing good is projected to cause a 0.1348 per cent increase in the price of the domestic import-competing good. Thus according to equation (3.6) the output of the import-competing sector will increase by approximately 0.03 per cent (i.e., 15.6951 × (0.1348 - 0.1329) = 0.0298). This roughly corresponds with the projected increase in output of 0.0184 per cent.

The demand curves for the output of the non-traded sector are relatively inelastic. Hence this sector is able to pass on most of the increase in its variable costs into its selling price. For example, a one per cent increase in the ad valorem tariff on the import-competing good causes the variable costs for the non-traded sector increase by roughly 0.1329 per cent, i.e., by the CPI. However the price of the non-traded good is projected to increase by 0.1321 per cent; see Table

3.3. Thus according to equation (3.6) the output of the non-traded sector should have contracted by only about 0.004 per cent (i.e., 4.7173 × (0.1321 - 0.1329) = -0.0038). This roughly corresponds with the projected fall in output for the non-traded sector of 0.0058 per cent; see Table 3.3.

Real absorption

An increase in real absorption is most beneficial to the non-traded sector. A one per cent increase in real absorption is projected to cause a 0.7208 per cent increase in the output of the non-traded sector. The increase in real absorption is less beneficial to the traded sectors. A general increase in demand is inflationary, which deteriorates the competitiveness of the domestic traded commodities. For the import-competing sector, however, the expansion in demand outweighs the deleterious impact of the increase in costs, and it is projected to experience a 0.4301 per cent increase in output. On the other hand, the export sector does not experience a significant compensating increase in demand for its product, and as a result its output is projected to decline by 0.5100 per cent.

Real Wages

An increase in the real wage as a cost to employers is projected to cause a decline in output in all sectors. Note that equation (3.6) only holds when wages are fully indexed to the CPI. Recall from section 2, equation (2.93), that the wage rate, $p_{(41)}$ can be written:

$$p_{(41)} = \xi^{(3)} h + f_{(41)} \quad ; \qquad (3.8)$$

where $\xi^{(3)}$ is the percentage change in the CPI, h is a user-specified parameter; and $f_{(41)}$ is a wage-shift variable. In this case h is set at unity such that $f_{(41)}$ is the shift in the real wage rate. Given the above, and the approximation that the average cost of intermediate inputs moves in line with the CPI, then the short-run industry supply function can be written:

$$x_j = \lambda_j \, [p_j - (\xi^{(3)} + f_{(41)} \, H_{PFj})] \qquad j = 1,2,3 \; ; \qquad (3.9)$$

where $\lambda_j$ is as defined above in equation (3.7); and $H_{PFj}$ is the base-period share of primary-factor inputs in total inputs to current production in industry j. The $H_{PFj}$ can be calculated from the input-output table (see Table 2.3): $H_{PF1} = 0.4350$ ; $H_{PF2} = 0.3012$ ; and $H_{PF3} = 0.6259$.

Equation (3.9) can be used to check the consistency of the industry output projections with the commodity price projections in the case of a change in the real wage. For example, if the real wage is increased by one per cent (i.e., $f_{(41)} = 1$) then the price of the export sector's output is projected to increase by 1.8374 per cent; see Table 3.3. This price rise is less than the increase in variable costs which approximately increase by 2.8787 per cent (i.e., $\xi^{(3)} + f_{(41)} H_{PF1} = 2.4437 + 1 \times 0.4350 = 2.8787$). Thus according to equation (3.9) the output of the export sector will contract by about 3 per cent (i.e., $3.0349 \times (1.8374 - 2.8787) = -3.1602$), which is close to the projected contraction of 2.0732 per cent. The real wage increase is also detrimental to the import-competing sector as it causes a reduction in the international competitiveness of the sector. Finally, the contraction in the traded sectors causes a small decline in the output of the non-traded sector.

### 3.2.3 Short-Run Effects on Capital

Recall from section 2.1.5, equation (2.54), that the current net rate of return on fixed capital in industry j, $R_j(0)$, is given by:

$$R_j(0) = P_{(42)j}/\Pi_j - D_j \qquad j = 1,2,3 \; ; \; (3.10)$$

where $P_{(42)j}$ is the rental value of a unit of capital in industry j; $\Pi_j$ is the cost of a unit of capital in industry j; and $D_j$ is the rate of depreciation. The percentage-change form of (3.10) is given by (note that depreciation rates are exogenous and set to zero change):

$$100\Delta R_j(0) = Q_j \; (p_{(42)j} - \pi_j) \qquad j = 1,2,3 \; ; \; (3.11)$$

where the lower-case variables are the percentage changes in the respective upper-case variables; $100\Delta R_j(0)$ is the percentage-point change in the rate of return on fixed capital in industry j; and $Q_j$ is the ratio in the base period of the rental value of capital to the cost of capital in industry j.

The projected changes in the rental values, creation costs, and rates of return on capital are given in Table 3.4. In each of the simulations the rates of return on capital differ fairly significantly across the industries. The largest percentage-point changes occur in the export sector. This sector is very sensitive to the exogenous shocks as it competes on world markets. The import-competing sector

TABLE 3.4 SHORT-RUN EFFECTS ON CAPITAL*

| Industry | One per cent increase in: | | |
|---|---|---|---|
| | The ad valorem tariff on the import-competing good | Real domestic absorption | Real wages |
| Rental Rates on Capital | | | |
| 1. Export | -0.0336 | 0.1597 | -0.7419 |
| 2. Import-competing | 0.1596 | 1.8131 | 2.0447 |
| 3. Non-traded | 0.1240 | 2.3083 | 2.8295 |
| Creation Costs of Capital | | | |
| 1. Export | 0.1464 | 0.9914 | 2.0451 |
| 2. Import-competing | 0.1585 | 0.8887 | 1.8461 |
| 3. Non-traded | 0.1420 | 1.2154 | 2.4927 |
| Rates of Return on Capital[a] | | | |
| 1. Export | -0.0569 | -0.2630 | -0.8811 |
| 2. Import-competing | 0.0005 | 0.3781 | 0.0812 |
| 3. Non-traded | 0.0041 | 0.2460 | -0.0758 |

* All projections, with the exceptions of the rates of return on capital, are percentage deviations from what the variable in question would have been in the absence of the shock at the head of the column. The rates of return on capital, while also deviations from control, are percentage-point deviations.

[a] See equation (3.11).

also faces competition from goods produced on the world market, however it benefits from any general expansions in the size of the domestic economy. These two characteristics sometimes work in opposite directions to stabilize the projected changes in rates of return for the import-competing sector; for example, this is the case when real domestic absorption is increased. Finally, the non-traded sector is most responsive to changes in the size of the domestic economy.

The source of the differences between industries in the rates of return projections, can be traced using equation (3.11). The projected changes in the creation costs of capital appear to be fairly similar across industries; see Table 3.4. On the other hand, the $Q_j$ parameters differ across industries: $Q_1 = 0.2700$; $Q_2 = 0.2300$; and $Q_3 = 0.1600$. However the differences across industries in the rates of return projections are largely due to variations across industries in the projections of rental rates on capital; see Table 3.4.

## 4. CONCLUDING REMARKS

It is envisaged that MO87, which has been described above, will be a useful tool in future development work on generating portfolio-analytic decision rules within a CGE framework. Relative to other available miniatures which might serve as a prototype, MO87 has the following advantages:

(a) it allows disaggregation to the three major types of commercial exposure (exporting, import-competing, and non-trading);

(b) it includes explicit rates of return variables;

and

(c) it uses an aggregated version of the input-output data base that is currently used to calibrate the ORANI model.

# APPENDIX

This appendix is divided into three parts. The first concerns the derivation of the percentage-change form of the equations which allocate investment across industries. The second part describes how the 1978-79 ORANI data base at basic values was aggregated to a three sector input-output table at purchasers' prices. The final part calculates the base-period industry growth rates.

## A.1 DERIVATION OF THE PERCENTAGE-CHANGE FORM OF THE EQUATIONS WHICH ALLOCATE INVESTMENT ACROSS INDUSTRIES

In this note we will derive the percentage-change form of equations (2.54), (2.60), (2.64), and (2.66). These equations were suggested by Bruce and Horridge (1986) and they represent a small extension of the ORANI model developed by Dixon, Parmenter, Sutton, and Vincent (1982).

Recall that equation (2.54) defines the current rate of return on fixed capital:

$$R_j(0) = P_{(42)j}/\Pi_j - D_j \qquad j = 1,2,3 . \qquad \text{(A1.1)}$$

Totally differentiate (A1.1):

$$d(R_j(0)) = d(P_{(42)j})/\Pi_j - d(\Pi_j)\, P_{(42)j}/\Pi_j^2 - d(D_j) \qquad j = 1,2,3 . \qquad \text{(A1.2)}$$

Equation (A1.2) can be rewritten:

$$\begin{aligned} 100d(R_j(0)) = {} & [100\, d(P_{(42)j})/P_{(42)j}]\, P_{(42)j}/\Pi_j \\ & - [100\, d(\Pi_j)/\Pi_j]\, P_{(42)j}/\Pi_j \\ & - 100\, d(D_j) \end{aligned} \qquad j = 1,2,3 . \qquad \text{(A1.3)}$$

Thus:

$$100\, \Delta R_j(0) = P_{(42)j}/\Pi_j (p_{(42)j} - \pi_j) - 100\, \Delta D_j \qquad j = 1,2,3 ; \qquad \text{(A1.4)}$$

where a lower-case variable represents the percentage change in the respective upper-case variable.

Next we introduce the following notation:

$$Q_j = P(42)j/\Pi_j \qquad j = 1,2,3 . \qquad \text{(A1.5)}$$

Note that since we only observe a price times a quantity in the data it is helpful to express $Q_j$ as:

$$Q_j = K_j(0)\ P(42)j/(K_j(0)\ \Pi_j) \qquad j = 1,2,3 . \qquad \text{(A1.6)}$$

By substituting (A1.6) into (A1.4) we obtain:

$$\boxed{100\ \Delta R_j(0) = Q_j\ (p(42)j - \pi_j) - 100\ \Delta D_j \qquad j = 1,2,3 .} \qquad \text{(A1.7)}$$

The next equation is (2.60):

$$\Omega = R_j(0) - \beta_j \log\ (Z_j/Z_j^*) \qquad j = 1,2,3 . \qquad \text{(A1.8)}$$

Before we totally differentiate (A1.8) it is helpful to introduce the following notation:

$$\psi_j = \beta_j \log\ (Z_j/Z_j^*) \qquad j = 1,2,3 . \qquad \text{(A1.9)}$$

Thus (A1.8) can be written:

$$\Omega = R_j(0) - \psi_j \qquad j = 1,2,3 . \qquad \text{(A1.10)}$$

Totally differentiate (A1.10):

$$d(\Omega) = d(R_j(0)) - d(\psi_j) \qquad j = 1,2,3 . \qquad (A1.11)$$

Note that $d(\psi_j)$ can be obtained by totally differentiating (A1.9):

$$d(\psi_j) = d(\log (Z_j/Z_j^*))\beta_j \qquad j = 1,2,3 ; \qquad (A1.12)$$

recall that $\beta_j$ is a parameter. Next we introduce the following notation:

$$\phi_j = Z_j/Z_j^* \qquad j = 1,2,3 . \qquad (A1.13)$$

Substitute (A1.13) into (A1.12):

$$d(\psi_j) = d(\log \phi_j)\beta_j \qquad j = 1,2,3 . \qquad (A1.14)$$

Thus:

$$d(\psi_j) = [d(\phi_j)/\phi_j]\ \beta_j \qquad j = 1,2,3 . \qquad (A1.15)$$

Now totally differentiate (A1.13):

$$d(\phi_j) = d(Z_j)/Z_j^* - d(Z_j^*)Z_j/Z_j^{*2} \qquad j = 1,2,3 . \qquad (A1.16)$$

Substitute (A1.13) and (A1.16) into (A1.15):

$$d(\psi_j) = [d(Z_j)/Z_j - d(Z_j^*)/Z_j^*]\ \beta_j \qquad j = 1,2,3 . \qquad (A1.17)$$

Next substitute (A1.17) into (A1.11):

$$d(\Omega) = d(R_j(0)) - [d(Z_j)/Z_j - d(Z_j^*)/Z_j^*]\ \beta_j . \qquad j = 1,2,3 . \qquad (A1.18)$$

Thus:

$$100\ d(\Omega) = 100\ d(R_j(0)) - [100\ d(Z_j)/Z_j]\beta_j + [100\ d(Z_j^*)/Z_j^*]\ \beta_j \qquad j = 1,2,3\ . \qquad (A1.19)$$

Equation (A1.19) can be rewritten:

$$100\ \Delta\Omega = 100\ \Delta R_j(0) - z_j\beta_j + z_j^*\ \beta_j \qquad j = 1,2,3\ . \qquad (A1.20)$$

Recall from (2.62) that:

$$z_j = k_j(1) - k_j(0) \qquad j = 1,2,3\ . \qquad (A1.21)$$

Finally, we substitute (A1.21) into (A1.20):

$$100\ \Delta R_j(0) - 100\ \Delta\Omega = \beta_j(k_j(1) - k_j(0)) - \beta_j z_j^* \qquad j = 1,2,3\ . \qquad (A1.22)$$

In equation (2.64) it is assumed that the only variables which influence the capital stock at the end of one period are the current capital stock, the depreciation rate, and the current level of investment:

$$K_j(1) = K_j(0)\ (1 - D_j) + Y_j \qquad j = 1,2,3\ . \qquad (A1.23)$$

Totally differentiate (A1.23):

$$d(K_j(1)) = d(K_j(0))(1-D_j) - d(D_j)\ K_j(0) + d(Y_j) \qquad j = 1,2,3\ . \qquad (A1.24)$$

Thus:

$$[100\ d(K_j(1))/K_j(1)]\ K_j(1) = [100\ d(K_j(0))/K_j(0)]\ K_j(0)\ (1-D_j)$$

$$- 100\ d(D_j)\ K_j(0) + [100\ d(Y_j)/Y_j]\ Y_j \qquad j = 1,2,3\ . \quad (A1.25)$$

Equation (A1.25) can be written:

$$k_j(1)\ K_j(1) = k_j(0)\ K_j(0)\ (1-D_j)$$

$$+ y_jY_j \ - 100\ \Delta D_jK_j(0) \qquad j = 1,2,3\ . \quad (A1.26)$$

Divide (A1.26) by $K_j(1)$:

$$k_j(1) = k_j(0)\ [K_j(0)\ (1-D_j)/K_j(1)] + y_j[Y_j/K_j(1)]$$

$$- 100\ \Delta D_j[K_j(0)/L_j(1)] \qquad j = 1,2,3\ . \quad (A1.27)$$

We now introduce the following notational conventions:

$$G_j = Y_j/K_j(1) \qquad j = 1,2,3\ . \quad (A1.28)$$

and

$$G_j^* = K_j(0)/K_j(1) \qquad j = 1,2,3. \quad (A1.29)$$

Note that (A1.28) can be rearranged:

$$1 - G_j = 1 - Y_j/K_j(1) \qquad j = 1,2,3\ . \quad (A1.30)$$

Thus:

$$1 - G_j = (K_j(1) - Y_j)/K_j(1) \qquad j = 1,2,3 \ . \quad (A1.31)$$

Substitute (A1.23) into (A1.31) :

$$1 - G_j = K_j(0)\ (1-D_j)/K_j(1) \qquad j = 1,2,3 \ . \quad (A1.32)$$

Finally, substitute (A1.32), (A1.28), and (A1.29) into (A1.27) :

$$\boxed{k_j(1) = k_j(0)\ (1-G_j) + y_j\ G_j - 100\ \Delta D_j\ G_j^* \qquad j = 1,2,3 \ .} \quad (A1.33)$$

The final equation for which we will derive the percentage-change form is (2.66), the definition of aggregate investment:

$$I = \sum_{j=1}^{3} \Pi_j\ Y_j \ . \quad (A1.34)$$

Totally differentiate (A1.34):

$$d(I) = \sum_{j=1}^{3} d(\Pi_j)\ Y_j + d(Y_j)\ \Pi_j \ . \quad (A1.35)$$

Thus:

$$[100\ d(I)/I]I = \sum_{j=1}^{3} \{[100d\ (\Pi_j(/\Pi_j]\Pi_j Y_j + [100\ d\ (Y_j)/Y_j]\ \Pi_j Y_j\} \ . \quad (A1.36)$$

Divide (A1.36) by I:

$$i = \sum_{j=1}^{3} (\pi_j + y_j) \Pi_j Y_j / I \quad . \qquad (A1.37)$$

Let:

$$\delta_j = \Pi_j Y_j / I \qquad j = 1,2,3 \ . \qquad (A1.38)$$

Thus:

$$\boxed{i = \sum_{j=1}^{3} (\pi_j + y_j) \delta_j \quad .} \qquad (A1.39)$$

## A.2 THE THREE-SECTOR INPUT-OUTPUT TABLE

In this note we describe how the ORANI model's 112 sector 1978-79 input-output table valued in basic-value prices was converted to a 3 sector input-output table valued in purchasers' prices. This procedure essentially involved 2 steps. The first was to aggregate the input-output table valued in basic-value prices to 3 sectors. Then the second involved revaluing this aggregated table in purchasers' prices.

The 3 sectors selected to aggregate to represent the export, import-competing, and non-traded areas of the economy. In terms of the industry classification used in ORANI (see, for example, Higgs (1986)), the export sector is defined to consist of industries 1-18, 25, 30, and 64. This predominantly consists of agricultural and mining industries. The import-competing sector is defined to consist of industries 19-24, 28, 29, 31-33, 35-59, 62, 63, and 65-83. This predominantly consists of manufacturing industries and is consistent with the definition of the import-competing sector adopted by Higgs, Parmenter, and Powell (1984). Finally the non-traded sector is defined to consist of all remaining industries, that is, industries 26, 27, 34, 60, 61, and 84-112.

The computer program AGGREGATION, developed by Bruce, Sutton, and Strzelecki (1987), was then run using the above definitions for the export, import-competing, and non-traded sectors. The program AGGREGATION reads the 1978-79 input-output table and then (as its name suggests) aggregates the table from 112 industries to the number of aggregated industries specified. The resulting input-output table, at basic-value prices, is presented in Table A2.1.

TABLE A2.1: A THREE-SECTOR INPUT-OUTPUT TABLE OF THE AUSTRALIAN ECONOMY AT BASIC VALUES (MILLIONS OF 1978-79 DOLLARS)

| | | Current Production (Domestic Industries) 1. | 2. | 3. | Final Demands: Investment (Domestic Industries) 1. | 2. | 3. | Consumption | Exports | Other | | Row Totals |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | A | | | B | | C | D | E | | |
| Domestic Commodities | 1. | 7,177 | 3,927 | 1,169 | 324 | 0 | 12 | 4,218 | 9,708 | 130 | | 26,665 |
| | 2. | 1,887 | 11,674 | 12,320 | 915 | 616 | 2,884 | 11,338 | 2,523 | 289 | | 44,446 |
| | 3. | 2,274 | 3,319 | 18,742 | 1,280 | 422 | 14,600 | 26,909 | 2,021 | 17,434 | | 87,001 |
| | | | F | | | G | | H | | J | DUTY | |
| Imported Commodities | 1. | 75 | 1,035 | 51 | 0 | 0 | 0 | 239 | | 1 | -15 | 1,386 |
| | 2. | 552 | 4,340 | 3,300 | 565 | 380 | 1,780 | 3,128 | | 3 | -1,119 | 12,929 |
| | 3. | 161 | 342 | 1,116 | 1 | 0 | 6 | 1,127 | | 30 | 0 | 2,783 |
| | | | K | | | L | | M | N | O | | |
| Use of Commodity 3 to facilitate domestic flows | 1. | 808 | 459 | 365 | 1 | 0 | 0 | 1,840 | 1492 | 0 | | 4,965 |
| | 2. | 422 | 1652 | 2526 | 182 | 122 | 573 | 7,507 | 449 | 0 | | 13,433 |
| | 3. | 13 | 95 | 238 | 1 | 0 | 6 | 1,236 | 16 | 0 | | 1,605 |
| | | | P | | | Q | | R | | T | | |
| Use of Commodity 3 to facilitate imported flows | 1. | 8 | 121 | 16 | 0 | 0 | 0 | 104 | | 0 | | 249 |
| | 2. | 124 | 614 | 677 | 112 | 76 | 354 | 2,071 | | 0 | | 4,028 |
| | 3. | 1 | 10 | 14 | 0 | 0 | 0 | 52 | | 0 | | 77 |
| | | | KT | | | LT | | MT | NT | OT | | |
| Tax on domestic flows | 1. | 37 | 937 | 12 | 0 | 0 | 0 | -9 | 246 | 0 | | 1,223 |
| | 2. | 32 | 78 | 463 | 18 | 12 | 58 | 2,063 | -8 | 0 | | 2,716 |
| | 3. | 16 | 27 | 125 | 0 | 0 | -1 | 1,464 | 3 | 0 | | 1,634 |
| | | | PT | | | QT | | RT | | TT | | |
| Tax on imported flows | 1. | 0 | 247 | 1 | 0 | 0 | 0 | 0 | | 0 | | 248 |
| | 2. | 10 | 29 | 124 | 11 | 8 | 35 | 569 | | 0 | | 786 |
| | 3. | 1 | 3 | 7 | 0 | 0 | 0 | 61 | | 0 | | 72 |
| | | | U | | | | | | | | | |
| Labour | | 6,472 | 10,712 | 45,150 | | | | | | | | |
| | | | V | | | | | | | | | |
| Capital | | 3,277 | 2,266 | 15,239 | | | | | | | | |
| | | | W | | | | | | | | | |
| Land | | 1,626 | 0 | 0 | | | | | | | | |
| | | | X | | | | | | | | | |
| Other | | 1,692 | 2,559 | 9,703 | | | | | | | | |
| Column Totals | | 26,665 | 44,446 | 111,358 | 3,410 | 1,636 | 20,307 | 63,890 | 16,450 | 17,887 | -1,134 | |

There are a few points to note about Table A2.1. The first is that all the ORANI margin commodities have been aggregated in the non-traded sector. The second is that the returns to labour includes imputed wages. The third is that the inputs of "other", that is vector X, consists of returns to working capital, payroll tax, land tax, other indirect taxes, and sales by final buyers. Finally, the "other" final demand category has had the following balancing items added: export sector -17, import-competing +241, and non-traded -229.

The second step is to convert the input-output table at basic values into one at purchasers' prices. A procedure for making this conversion is set out in Dixon, Parmenter, and Powell (forthcoming). Briefly, this procedure first involves adding the margin services and sales tax to the basic value flows they are associated with. For example, according to Table A2.1 the demand for domestic commodity 1 by industry 1 for use in current production is $7,177m at basic values, it requires margin services worth $808m and incurs sales tax of $37m. Hence, in Table A2.2 the purchasers' value of the demand for domestic commodity 1 by industry 1 is shown as $8,022m (= 7,177 + 808 + 37).

The second step in the procedure is to record the use of the margin commodity as a direct sale to the industry producing the good whose sales it facilitates. For example, according to Table A2.1 the total use of commodity 3 to facilitate the sale of domestic commodity 1 is $4,965m. Hence, in Table A2.2 the purchasers' value of the demand for domestic commodity 3 by industry 1 is given by $2,303m (i.e., 2,274 + 13 + 16; see above) plus $4,965m, which equals $7,268m.

TABLE A2.2: A THREE-SECTOR INPUT-OUTPUT TABLE OF THE AUSTRALIAN ECONOMY AT PURCHASERS' PRICES (MILLIONS OF 1978-79 DOLLARS)

| | | Current Production | | | Final Demands | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | (Domestic Industries) 1. | 2. | 3. | Investment (Domestic Industries) 1. | 2. | 3. | Consumption | Exports | | Row Totals |
| | | | A | | | B | | C | D | | |
| Domestic Commodities | 1. | 8,022 | 5,323 | 1,546 | 325 | 0 | 12 | 6,179 | 11,446 | | 32,853 |
| | 2. | 2,341 | 13,404 | 15,309 | 1,115 | 750 | 3,515 | 21,197 | 2,964 | | 60,595 |
| | 3. | 7,268 | 16,874 | 20,710 | 1,281 | 422 | 14,605 | 51,216 | 2,221 | | 114,597 |
| | | | F | | | G | | H | | Duty | |
| Imported Commodities | 1. | 83 | 1,403 | 68 | 0 | 0 | 0 | 344 | | -15 | 1,883 |
| | 2. | 686 | 4,983 | 4,101 | 688 | 464 | 2,169 | 5,771 | | -1,119 | 17,743 |
| | 3. | 163 | 355 | 1,137 | 1 | 0 | 6 | 1,270 | | 0 | 2,932 |
| | | | L | | | | | | | | |
| Labour | | 8,131 | 15,066 | 53,582 | | | | | | | 76,779 |
| | | | K | | | | | | | | |
| Capital | | 6,159 | 3,187 | 18,144 | | | | | | | 27,490 |
| Column Totals | | 32,853 | 60,595 | 114,597 | 3,410 | 1,636 | 20,307 | 85,977 | 16,631 | -1,134 | |

There are four remaining points about Table A2.2 to be explained. The first is that the "other" final demand category in Table A2.1 has been included in consumption in Table A2.2. The second concerns margins associated with the sale of imports. From Table A2.1 the total use of commodity 3 to facilitate the sale of imports is \$4,354m. In Table A2.2 this was split proportionately between sales of domestic commodity 3 to consumption and exports. The next two points concern inputs. The third point is that just as margins are recorded in Table A2.2 as a direct input to the industry producing the goods whose sales are facilitated, so must the sales tax be recorded as a direct input. The total sales tax associated with domestic goods 1, 2, and 3 are, respectively, \$1,223m, \$2,716m and \$1,634m. The final point is that returns to land and capital were first aggregated together. Then the input of "other" and the above inputs of sales tax were split proportionately between the returns to labour and "aggregated" capital.

Finally we will calculate the industry rates of return implied by the aggregated ORANI data base. Recall from equation (2.54) that:

$$R_j(0) = K_j(0)\ P_{(42)j}/(K_j(0)\Pi_j) - D_j \qquad j = 1,2,3\ ; \qquad \text{(A2.1)}$$

where $K_j(0)P_{(42)j}$ is the returns to capital in industry j; $K_j(0)\Pi_j$ is the value of the capital stock in industry j; and $D_j$ is the depreciation rate in industry j. The returns to capital (and land) can be read from Table A2.1, and these have been rewritten in Table A2.3. Estimates of the value of the capital stocks are contained in the ORANI model, and these are also presented in Table A2.3. Note that we are not very confident of these values as they were principally estimated to provide a commodity breakdown of the creation of a unit of investment in each industry rather than to estimate the total value of the capital stock in

TABLE A2.3: ESTIMATES OF RATES OF RETURN BY INDUSTRY

| Industry | Returns to Capital | Capital Stocks | Depreciation Rate | Rate of Return on Capital |
|---|---|---|---|---|
| ORANI Data Base | | | | |
| 1. Export | $ 4,903m | $ 20,224m | 0.07 | 0.17 |
| 2. Import-Competing | $ 2,266m | $ 9,131m | 0.08 | 0.17 |
| 3. Non-Traded | $15,239m | $170,003m | 0.06 | 0.03 |
| Revised Estimates | | | | |
| 1. Export | $ 6,159m | $ 22,811m | 0.07 | 0.20 |
| 2. Import-Competing | $ 3,187m | $ 13,857m | 0.08 | 0.15 |
| 3. Non-Traded | $18,144m | $113,400m | 0.06 | 0.10 |

in each industry. Furthermore, they are based on relatively out of date data (see Hourigan (1980)). The industry depreciation rates listed in Table A2.3 are based on estimates contained in Bruce and Horridge (1986). If the above estimates are substituted into equation (A2.1) we obtain rates of return of 17 per cent for the export sector, 17 per cent for the import-competing sector, and 3 per cent for the non-traded sector. Given that in Table A2.2 we allocated a proportion of "other" and sales taxes to returns to capital it would be possible to preserve these rates of return in the stylized model by adjusting the value of the capital stocks in each industry. However, it was decided to use the following rates of return as a benchmark: export sector 20 per cent, import-competing sector 15 per cent, and non-traded sector 10 per cent. The export sector's rate of return was increased relative to the import-competing sector's rate of return due to its relatively higher exposure to world market fluctuations. The non-traded sector's rate of return was increased to 10 per cent to remove some of the influence of the rates of return in government owned non-traded industries. Given the returns to capital listed in Table A2.2, the values of the capital stocks were then calibrated to achieve these revised rates of return.

## A.3 CALCULATION OF INDUSTRY GROWTH RATES

Recall from equation (2.58) that the growth rate in industry j is calculated as:

$$Z_j = K_j(1)/K_j(0) \qquad j = 1,2,3 . \qquad (A3.1)$$

Equation (A3.1) can be rewritten:

$$Z_j = K_j(1)\Pi_j/(K_j(0)\ \Pi_j) \qquad j = 1,2,3 . \qquad (A3.2)$$

The base-period capital stock estimates are listed in Table A3.2 and the next period capital stocks were calculated from equation (2.101) in section 2.2. If we substitute these estimates into (A3.2) we obtain: $Z_1$ = 24,624/ 22,811 = 1.0795; $Z_2$ = 14,384/13,857 = 1.0380; and $Z_3$ = 126,903/113,400 = 1.1191.

Finally, if we assume that the expected base-period economy-wide rate of return is, say, 14 per cent (i.e. $\Omega = 0.14$) then we can calculate the expected long-run growth rates for each industry. Recall from equation (2.60) that:

$$\Omega = R_j(0) - \beta_j \log (Z_j/Z_j^*) \qquad j = 1,2,3 . \qquad (A3.3)$$

By rearranging (A3.3) we can solve for $Z_j^*$ :

$$Z_j^* = Z_j\ e^{(\Omega - R_j(0))/\beta_j} \qquad j = 1,2,3 . \qquad (A3.4)$$

If we substitute the $Z_j$'s as calculated above, the $R_j(0)$'s given in Table A2.3, and the assumed values for $\Omega$ and the $\beta_j$'s (see Table 2,10) into (A3.4) we obtain: $Z_1^*$ = 1.0539 ; $Z_2^*$ = 1.0339 ; and $Z_3^*$ = 1.1371.

# NOTES

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1. This should be contrasted with a more realistic CGE model such as the ORANI model of the Australian Economy (developed by Dixon, Parmenter, Sutton and Vincent (1982)), which distinguishes: 216 commodities; 112 industries, some of which are multiproduct; household consumption, investment, government demands, and exports; explicit modelling of margin services, etc.

2. For a discussion on the conversion of equations to percentage-change form see Dixon, Bowles, and Kendrick (1980) and Dixon, Parmenter, and Powell (forthcoming).

3. Note that in more realistic CGE models this assumption is relaxed by the use of, say, the linear expenditure system which allows for substitution between effective units of goods; see, for example, Dixon, Parmenter, Sutton, and Vincent (1982).

4. Note that a more realistic specification for the aggregation of units of domestic and imported good i is the CES functional form of which Cobb-Douglas is a special case; see Dixon, Parmenter, Sutton, and Vincent (1982).

5. That is the utility function is homothetic.

6. For more details see Dixon, Parmenter, Sutton and Vincent (1982, pp. 16-18). Note that some intuition on how (2.19) and (2.20) are derived can be found in equation (2.33). Consider the thought experiment in (2.33) of increasing the price of a commodity by 1 per cent holding output and all other prices constant.

7. See Appendix A.1.

8. See Appendix A.1.

9. See Appendix A.1.

10. See Appendix A.1.

11. See Powell, Cooper, and McLaren (1983).

12. See Higgs (1986, Appendix A.2).

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