



# IMPACT PROJECT

A Commonwealth Government inter-agency project in co-operation with the University of Melbourne, to facilitate the analysis of the impact of economic demographic and social changes on the structure of the Australian economy



THE AGRICULTURAL SECTOR OF ORANI 78 :  
THEORY, DATA AND APPLICATION

by

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*The views expressed in this paper do not necessarily reflect the opinions of the participating agencies, nor of the Commonwealth Government.*



## CONTENTS

	Page
1. INTRODUCTION	1
2. A DESCRIPTION OF ORANI 78	4
2.1 Theoretical structure	4
(a) Commodity and factor demands	4
(b) Commodity supplies	11
(c) Zero pure profits	12
(d) Market clearing	14
(e) Miscellaneous equations	14
2.2 Model closure	15
2.3 Computational approach	20
3. THE AGRICULTURAL SECTOR OF ORANI 78	25
3.1 The reasons for the respecification of the agricultural sector	25
(a) The importance of agriculture in ORANI results	25
(b) Problems with the specification of agriculture in the Australian input-output tables	26
3.2 Theoretical specification	28
3.3 The data	32
3.3.1 Industries and commodities	32
3.3.2 Characteristics of the agricultural industries	33
(a) Outputs	33
(b) Inputs	38
3.3.3 Transformation parameters and supply elasticities	41
(a) Pastoral Zone	42
(b) Wheat-Sheep Zone	43
(c) High Rainfall Zone	44
(d) Comparisons with other studies	46

	Page
4. THE SHORT-RUN EFFECT OF A GENERAL TARIFF INCREASE ON THE AUSTRALIAN ECONOMY WITH SPECIAL REFERENCE TO THE AGRICULTURAL SECTOR	48
4.1 Assumptions underlying the simulation	50
4.2 The macroeconomic and employment results	52
4.3 The industry results	55
4.3.1 The general picture	55
4.3.2 The agricultural sector	58
4.3.3 Agricultural commodities by industry : the CRETH results	63
(a) Pastoral Zone	68
(b) Wheat-Sheep Zone	69
(c) High Rainfall Zone	70
4.3.4 Commodity exports	71
5. CONCLUDING REMARKS	74
REFERENCES	75
TABLES	
2.1 Schematic Representation of ORANI 78 : Equations	5
2.2 Schematic Representation of ORANI 78 : Variables	6
2.3 Schematic Representation of ORANI 78 : Typical List of Exogenous Variables	16
3.1 Commodity Shares of Value of Output by Industry (1968/69)	37
3.2 Industry Shares in the Production of Agricultural Commodities (1968/69)	39
3.3 Input Cost Shares in Agricultural Zones (1968/69)	40
3.4 Values for Transformation Parameters ( $\phi^j_r$ ) for Equation (3.4)'(b)	41
3.5 Estimated Own and Cross Price Elasticities : Pastoral Zone	42
3.6 Estimated Own and Cross Price Elasticities : Wheat-Sheep Zone	44
3.7 Estimated Own and Cross Price Elasticities : High Rainfall Zone	45
4.1 Projections of the Effects of a 1 Per Cent Across the Board Tariff Increase on Macro and Employment Variables	53
4.2 Projections of the Effects of a 1 Per Cent Across the Board Tariff Increase on Industry Activity Levels	57
4.3 Agricultural Commodity Outputs and Prices	64
4.4 Reciprocals of Export Demand Elasticities ( $\gamma_j$ ) and Projected Effects of a 1 Per Cent Across the Board Tariff Increase on Export Levels	66

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1. INTRODUCTION

This paper describes a respecification of the agricultural sector of the ORANI model. ORANI is a multi-sectoral model of the Australian economy developed as part of the IMPACT Project.<sup>1</sup> Salient features of ORANI are its high degree of disaggregation and very firm basis in microeconomic theory. There has been, in recent years, increasing interest by economists and policy makers in models of this general type. The economic disturbances of the early seventies -- for example, the changes in the international monetary system, the sudden escalation in energy prices and the dramatic increase in real wages -- left many econometric models floundering. They were unable to provide useful simulations of the effects of the shocks or to give guidance on the appropriate policy responses.

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\* The authors are indebted to Tony Lawson for detailed comments on an earlier draft.

1. IMPACT is a Commonwealth Government inter-agency project in co-operation with the University of Melbourne, to facilitate the analysis of the impact of economic, demographic and social changes on the structure of the Australian economy. For a comprehensive non-technical description of the project, see Powell [1977]. The first version of ORANI, hereafter ORANI 77, is fully described in Dixon, Parmenter, Ryland and Sutton [1977], hereafter DPRS. The current version of the model, which is the subject of this paper, is referred to in the text as ORANI 78.

It became apparent that while many models can fit available time series data, it is only by close attention to theory that one can hope to create models capable of giving insights into the implications of disturbances which carry the economy away from previously established historic trends.

In our modelling of the agricultural sector within ORANI we emphasise two aspects. First, we attempt to capture the interaction of the agricultural sector with the rest of the economy. Input-output linkages, both backward and forward, are one element of this interaction. Usually of more importance, however, is the effect on agriculture of general conditions within the economy. For example, to anticipate the application of ORANI presented later in the paper, it is the effect of tariff increases on general cost conditions (in particular wage costs) which is the main way in which those increases impinge on agriculture. Specific input-output linkages, the extent to which agriculture uses tariff protected inputs for instance, are of comparatively minor importance.

The second aspect of our modelling of agriculture which we wish to emphasize concerns the internal structure of the sector. It is in this respect that the specification for ORANI 78 represents a significant improvement over that used in ORANI 77. The multiproduct basis of farm enterprises and regional differences in production technology are fundamental characteristics of Australian agriculture. Both of these are explicitly recognized in ORANI 78. With this improvement we believe that the model is an appropriate

vehicle for analysing the effects of policy and/or naturally occurring changes not only on the agricultural sector as a whole but also on the internal structure of the sector.

The remainder of the paper is organized as follows. In section 2 we outline the theoretical structure of the ORANI model, discuss the alternative ways in which the model may be closed and describe our computational approach. Section 3 contains a fairly detailed presentation of the theoretical specification and data base for the agricultural sector in ORANI 78. An application of the model incorporating the respecified agricultural sector is given in section 4. The application is an analysis of the short-run effects of a general tariff increase. Brief concluding remarks appear in section 5.

## 2. A DESCRIPTION OF ORANI 78

### 2.1 Theoretical structure

ORANI is a large model with the numbers of equations and variables being several millions. The theoretical structure, however, is simple and orthodox. The main elements are represented in Tables 2.1 - 2.3.

In Table 2.1 we have set out a schematic version of the ORANI 78 equations. (The variables are defined in Table 2.2.) The equations can be classified into five groups : (a) demands for commodities and primary factors, (b) commodity supply equations, (c) pricing equations which impose the condition of zero pure profits in all activities, (d) market clearing equations for commodities and primary factors, and (e) miscellaneous equations. This last group can be used to introduce institutional factors such as wage indexation and to define useful summary variables such as the consumer price index, the balance of trade, etc..

#### (a) Commodity and factor demands

ORANI recognizes six categories of demand for commodities : intermediate input demands, demands for inputs to capital formation, household demands, export demands, demands for margins (e.g., transport, wholesale and retail services) and miscellaneous other demands (e.g., inventory and government demands). Equations (2.1) and (2.2) in Table 2.1 are an aggregation over the five domestic sources of demand for the 2n commodities recognized in the model. (Export demands are shown separately in equation (2.3).)

Table 2.1 Schematic Representation of ORANI 78 : Equations

Identifier	Description	Equations	Number
<u>Commodity and factor demands</u>			
2.1	Domestic commodities for domestic use	$D = f_D(Z, C, P_1, P_2, Q_D)$	n
2.2	Imported commodities	$M = f_M(Z, C, P_1, P_2, Q_M)$	n
2.3	Export demand	$E = \hat{f}_E(P_1^*, Q_E)$	n
2.4	Demands for primary factors	$L = f_L(Z, P_3, Q_L)$	k
2.5	<u>Commodity supplies</u>	$Y = f_Y(Z, P_1, Q_Y)$	n
<u>Zero pure profits</u>			
2.6	in production	$V(P_1, Q_V) = W(P_1, P_2, P_3, Q_W)$	h
2.7	in exporting	$P_1 = \hat{P}_1^* \Theta S$	n
2.8	in importing	$P_2 = \hat{P}_2^* \Theta T$	n
(^ denotes diagonal matrix)			
<u>Market clearing</u>			
2.9	for commodities	$D + E = Y$	n
2.10	for primary factors	$L = L^*$	k
<u>Other equations</u>			
2.11	Balance of trade	$B = (P_1^*)'E - (P_2^*)'M$	1
2.12	CPI	$\xi = f_\xi(P_1, P_2)$	1
2.13	Wage indexation	$P_3 = f_{P_3}(\xi, Q_{P_3})$	k
<u>Total = 7n+h+3k+2</u>			

Table 2.2 Schematic Representation of ORANI 78 : Variables

Variable	Description	Number
D	Demands for domestically produced commodities	n
Z	Activity levels for each industry	h
C	Aggregate real absorption	1
$P_1$	Local prices of domestic commodities	n
$P_2$	Local prices of imported commodities	n
M	Demands for imported commodities	n
E	Exports	n
$P_1^*$	Foreign currency prices for exports	n
$P_2^*$	Foreign currency prices for imports	n
L	Demands for primary factors	k
$P_3$	Prices for primary factors	k
Y	Commodity output levels	n
$\theta$	Exchange rate (\$A/\$Foreign)	1
T	One plus ad valorem rates of protection	n
S	One plus ad valorem rates of export subsidy	n
$L^*$	Factor employment levels	k
B	Balance of trade (foreign \$)	1
$\xi$	Consumer price index	1
$Q_{P3}$	Shift terms in factor price equations	k
		Total = $10n+h+4k+4$

$Q_D, Q_M, Q_E,$ $Q_L, Q_Y, Q_V,$ $Q_W$	}	Large number of variables designed to assist in the simulation of exogenous changes in technology, export demands, household preferences and indirect taxes
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The number of commodities is counted as  $2n$  rather than  $n$  to emphasize that imports are treated as distinct from domestically produced commodities. For example, imported footwear is treated as a different product from domestically produced footwear, although the two are allowed to be good (but not perfect) substitutes for one another. Consequently, the vectors of prices ( $P_1$  and  $P_2$ ) of both domestic and imported commodities appear as arguments in the demand functions for both domestic and imported commodities. An increase in the price of imported footwear will affect the demand for both types of footwear by generating substitution towards the domestic product.

By handling imported and domestic commodities as imperfect substitutes,<sup>1</sup> we avoid the unsatisfactory consequences of either of the two extremes frequently found in modelling exercises. On the one hand, the assumption of perfect substitutability, which is implied when imported footwear and domestic footwear are treated as a single product, is inconsistent with the commonplace empirical observation that prices of imported and domestic commodities can move independently of each other without causing the exclusion of either product from the market. At the other extreme, the quantity share of imports in each market is assumed to be fixed, i.e., imports are treated as non-competitive. The implied assumption, that the elasticity of substitution between imported and domestic footwear is

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1. Our treatment of import/domestic substitution follows that of Armington [1969, 1970]. See also Artus and Rhomberg [1973], Dixon [1976] and Dervis [1978].

zero, is inconsistent with the observation that the quantity share of imported footwear in the domestic market responds to changes in the relative prices of the imported and domestic products.

Naturally, there is a cost in terms of parameter estimation involved in specifying imports and domestic commodities as imperfect substitutes. Ideally, we should measure substitution elasticities between each pair of domestic and imported products from the point of view of each of our five categories of domestic users. In practice, however, data limitations have forced us to assume that

$$\sigma_i^{(\ell)} = \sigma_i, \quad \text{for all } \ell, \quad (2.14)$$

where  $\sigma_i^{(\ell)}$  is the elasticity of substitution between imported and domestic good  $i$  from the point of view of user  $\ell$ .<sup>1</sup> The  $\sigma_i$ 's have been estimated for about 30 of the more important import competing products in the input-output classification. These estimates have also been used to suggest plausible values for the remaining products where data problems have made direct estimation impossible.<sup>2</sup>

Apart from commodity prices, the other arguments in ORANI's domestic user commodity demand functions are activity variables and variables designed to allow simulation of the effects of technological changes and changes in tastes. In equations (2.1) and (2.2) these latter variables are represented by the vectors  $Q_D$

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1. In defence of this assumption, it can be pointed out that most of Australia's major imports are used predominantly in only one end-use category. See DPRS [1977], pp. 156-157.
  2. The data base and estimation of the  $\sigma_i$ 's are described briefly in DPRS [1977], pp. 155-159. Complete details are in Alaouze [1976, 1977a, 1977b], Alaouze, Marsden and Zeitsch [1977] and Marsden and Milkovits [1977].

and  $Q_M$  while the activity variables are  $Z$  and  $C$ .

The first of these activity variables,  $Z$ , is the vector of output levels for each of the model's  $h$  industries.  $Z$  appears in the ORANI equations explaining demands for intermediate inputs. Two points should be noted. First, the dimension of  $Z$  is  $h$  rather than  $n$ . ORANI 78 allows each industry to produce more than one product and each product to be produced by more than one industry. As will be explained in section 3, it is particularly important in modelling Australia's agricultural sector to recognize both multi-product industries and multi-industry supply possibilities for any one product. The second point is that the input demands by each industry are viewed as independent of the commodity composition of the industry's output.  $Z_j$  appears in the input demand functions but not  $Y_i(j)$ , where  $Y_i(j)$  is the output of the  $i^{\text{th}}$  commodity by the  $j^{\text{th}}$  industry. The assumption that input demands are industry (but not product) specific is discussed further in section 3.

The second activity variable appearing in equations (2.1) and (2.2) is the level of real domestic absorption,  $C$ , i.e., public and private consumption and investment. By including a single scalar variable to reflect the levels of final demands by domestic users we are simplifying considerably the ORANI treatment. The ORANI equations allow commodity demands to respond to the distribution of aggregate absorption across households, the government and capital formation by industry. For the present descriptive purposes, however, the single variable,  $C$ , will suffice.

By comparison with the functions describing commodity demands by domestic users, the ORANI export demand functions are very simple. They take the form

$$E_i = (P_i^*)^{-\gamma_i} (Q_E)_i, \quad i=1, \dots, n.$$

where  $E_i$  is the export volume for commodity  $i$ ,  $P_i^*$  is the foreign currency price of commodity  $i$ ,  $\gamma_i$  is the reciprocal of the foreign elasticity of demand<sup>1</sup> and  $(Q_E)_i$  is a variable allowing for shifts in the foreign demand curves. For example, an upward movement in the foreign demand curve for commodity  $i$  would be simulated by an increase in  $(Q_E)_i$ . In equation (2.3) of Table 2.1, we have shown the export vector with  $n$  components. Only the  $n$  domestically produced commodities are exported.<sup>2</sup> The model allows no imported commodities to be exported without first being processed in a domestic industry.

The final set of demand equations in Table 2.1 is for primary factors, i.e., demands for labour, capital and agricultural land. In ORANI 78 there are 9 types of labour, 113 types of capital (one for each industry) and 7 types of agricultural land. Thus  $k = 129$ , where  $k$  is the dimension of the factor demand vector  $L$ . In equation (2.4) we have explained  $L$  by the industry activity levels

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1. In the ORANI data base, foreign elasticities of demand for Australian products vary from 1.3 for wool to 20.0 for minor exports. These numbers were chosen in the light of the Australian shares in world commodity markets and fragmentary information concerning demand elasticities in importing countries and supply elasticities in competing export countries. See Freebairn [1978] and DPRS [1977], pp. 172-173.
  2. Of course, some will be exported at the zero level.

$Z$ , the factor prices  $P_3$  and a vector of technological change variables,  $Q_L$ . The fact that  $Z$  is the only activity variable included in equation (2.4) reflects the ORANI assumption that the sole use of primary factors is in current production. The use of primary factors in capital creation, for example, is captured via primary factor inputs to the current production of the construction and machinery industries. The fact that  $P_3$  is the only price variable included in equation (2.4) reflects the ORANI assumption that while primary factors can be substituted for each other, they cannot be substituted for intermediate inputs. For example, the steel industry can substitute capital for labour but not capital for coal. This also explains the absence of factor prices in the commodity demand equations, (2.1) and (2.2).

(b) Commodity supplies

Equation (2.5) is an aggregation of the commodity output vectors across the  $h$  industries. The vector of commodity outputs ( $Y(j)$ ) by industry  $j$  depends on  $j$ 's activity level  $Z_j$  and on commodity prices  $P_1$ . An increase in the price of wool relative to that of wheat will induce a change in the composition of  $j$ 's production towards wool and away from wheat, i.e., there will be a movement around the product transformation frontier. In addition to activity levels and product prices, equation (2.5) also includes the vector  $Q_Y$  which allows for shifts in transformation frontiers associated with technological changes.

As was explained earlier, inputs are treated as being industry rather than product specific. This accounts for the

absence of input prices in (2.5). Changes in input prices will affect industry  $j$ 's activity level,  $Z_j$ , but will not influence the commodity composition of  $j$ 's output once  $Z_j$  is determined.

In earlier versions of ORANI (see DPRS) equations such as (2.5) were unnecessary. This is because we observed the usual input-output convention that each industry produces only one product and each product is produced by only one industry. In this case industry activity levels can be identified with commodity output levels, i.e., there is no need to distinguish between the  $Y$  and  $Z$  vectors. The theory of ORANI 78 is written so that all industries may be treated as multi-product industries. In practice, however, we have continued to model each non-agricultural commodity as though it is produced by a single, one-product industry. Thus, for the non-agricultural industries and commodities, (2.5) degenerates to

$$Y_j = Z_j, \quad j = \text{non-agricultural commodity or industry}.$$

(c) Zero pure profits

The activities recognized in ORANI 78 are production,<sup>1</sup> exporting and importing. The zero pure profits condition for production implies that revenue per unit of activity in each industry equals costs per unit of activity. In ORANI 78, the production functions exhibit constant returns to scale. Therefore costs and revenue per unit of activity do not depend on the level of activity. Consequently, equation (2.6), which imposes the zero pure profits

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1. This includes production of goods and services and the creation of units of capital.

condition for production, can be written without reference to production levels. On the left, we have the  $h \times 1$  vector of average revenues per unit of activity in each industry expressed as functions of output prices and technological change variables. On the right, we have the  $h \times 1$  vector of costs per unit of activity expressed as functions of input prices and technological change variables.

It should be emphasized that equation (2.6) does not rule out profits. It does rule out pure profits, i.e., profits not accruing to a factor of production. In models incorporating equations such as (2.6), variations in profits are simulated by variations in the rentals on fixed factors. Adverse events in industry  $j$  will reduce the profitability of using capital in that industry, i.e., there will be reductions in the relevant input prices, namely the rentals on the fixed factors in industry  $j$ .

The second set of zero pure profit conditions (2.7) in Table 2.1 equates the revenue from exporting to the relevant costs. Thus on the right of (2.7) we have the vector showing the \$A values of exporting units of each commodity. On the left we have the cost of doing so, i.e., the domestic price of each commodity.

The final set of zero pure profit conditions (2.8) equates the selling prices of imported commodities to the cost of importing. The costs of importing include the foreign currency cost converted to domestic currency and the tariff.

(d) Market clearing

Equation (2.9) equates demand and supply for domestically produced commodities. Notice that imports are not added to domestic production in determining total supplies. This is because commodities from foreign and domestic sources are treated as distinct commodities.

In equation (2.10),  $L^*$  is the vector of factor employment levels. Thus (2.10) amounts to saying that employment demands ( $L$ ) are satisfied. Equation (2.10) does not necessarily impose full employment assumptions. Although we could set  $L^*$  exogenously at full employment levels, an obvious alternative would be to set some or all factor prices exogenously and to let the model determine the corresponding elements of  $L^*$ . Under this latter specification, our assumption would be that some factor markets are slack, i.e., supply constraints play no role in determining employment.

(e) Miscellaneous equations

The ORANI model contains many appended equations which are designed to facilitate applications. Table 2.1 gives three examples. Equations (2.11) and (2.12) define the balance of trade and the consumer price index. Equation (2.13) allows the introduction of different assumptions concerning wage indexation. For example, a typical equation in (2.13) is of the form

$$(P_3)_i = (\xi)^{h_i} (Q_{p3})_i \quad (2.15)$$

If we set the parameter  $h_i$  at 1 and the change in the variable  $(Q_{p3})_i$  is set at zero, then the wage of factor  $i$   $((P_3)_i)$  will move with the consumer price index  $(\xi)$ , i.e., there will be 100 per cent indexation of this factor price. Alternatively,  $(Q_{p3})_i$  can

be treated as an endogenous variable. If  $h_i$  continues to be set at 1, then movements in  $(Q_{P3})_i$  are the endogenously determined shifts in the real wage of factor  $i$ .

## 2.2 Model closure

We assume that all the variables  $Q_D, Q_M, \dots$ , etc., listed at the bottom of Table 2.2, are set exogenously. However, this still leaves a surplus of  $3n + k + 2$  in the number of variables compared with the number of equations, i.e., a further  $3n + k + 2$  variables must be set exogenously. It is a feature of ORANI that the choice of exogenous variables is left to the model user. Table 2.3 gives one possible choice for the schematic model set out in Tables 2.1 and 2.2. It will be useful to work through Table 2.3, considering some alternative choices. Much of the flexibility of ORANI in policy applications arises from the users' ability to swap variables between the exogenous and endogenous categories.

The first group of exogenous variables given in Table 2.3 are the foreign currency prices of imports. ORANI contains no equations describing foreign supply conditions and therefore it is difficult to imagine a plausible experiment in which  $P_2^*$  would be endogenous. By placing  $P_2^*$  in the exogenous category, we are adopting the "small country" assumption on the import side, i.e., world prices are independent of Australian demands. We are also allowing for the computation of answers to questions of the form : what were (or will be) the effects of past (or projected) changes in foreign import supply prices?

The second group of exogenous variables are the tariffs or tariff equivalents of quantitative restrictions. The tariffs are among the exogenous variables for any computation directed at the traditional effective protection question : which industries benefit

Table 2.3 Schematic Representation of ORANI 78 :  
Typical List of Exogenous Variables

Variable	Description	Number
$P_2^*$	Foreign currency prices for imports	n
T	One plus ad valorem rates of protection	n
$L_j^*, j \in H_1$ $(Q_{P3})_j, j \notin H_1$	A selection of factor employment levels and 'real' factor prices	k
$S_j, j \in H_2$ $E_j, j \notin H_2$		
C	Aggregate real absorption	1
$\theta$	Exchange rate (\$A/\$Foreign)	1
		<hr/> Total = $3n+k+2$ <hr/>
$Q_D, Q_M, Q_E,$ $Q_L, Q_Y, Q_V,$ $Q_W$	Large number of variables designed to assist in the simulation of exogenous changes in technology, export demands, household preferences and indirect taxes	

and which lose from protection? Other questions might concern the effects of protection on employment and on the rate of inflation. Each of these questions could be analyzed under exogenously given changes in the  $T$  vector. On the other hand, it is possible to conduct ORANI experiments in which some, or all, of the tariffs are endogenous. For example, we might wish to compute the level of protection which would be required to maintain current employment levels in footwear, say, in the face of exogenously given movements in foreign prices, domestic wages and the exchange rate. For such a computation, footwear employment would replace the footwear tariff in the exogenous list.

The third set of variables in Table 2.3 are a selection of factor employment levels and real factor prices. One possibility would be to set all the employment levels exogenously, i.e.,  $H_1$  would include all factors. This would accommodate the full employment case. Another possibility is to define  $H_1$  so that it excludes labour but includes other primary factors. This would be suitable for a short-run computation (i.e., one in which changes in capital stocks can be ignored) under slack labour market conditions. A third possibility is to endogenize the employment levels for capital but to exogenize the employment levels for labour. This would be suitable for long-run projections where we would assume (a) that capital stocks in each industry adjust to levels at which they can earn rates of return in line with historical experience and (b) that business cycle conditions are consistent with historically observed average levels of unemployment.

Our fourth group of typical exogenous variables are a selection of export subsidies and export levels. The model user specifies the set  $H_2$  containing the labels of those commodities for which the model is to be allowed to explain exports. For all other commodities, i.e.,  $j \notin H_2$ , exports are exogenous and the model produces the export subsidy (or tax) required to achieve the given export level. Certainly, the non-exported commodities, services, construction, etc., always appear in the list given by  $j \notin H_2$ . Their exports are set exogenously at zero. The resulting endogenously determined subsidy rates are quite artificial, but also harmless. (For example, referring to Table 2.1 we see that if  $(S)_j$  is endogenous then it can simply be deleted from the model by deleting the  $j^{\text{th}}$  component of (2.7).) In most ORANI computations we have included in  $H_2$  those commodities for which exports are more than 20 per cent of total output. For these commodities, it is reasonable to assume that world prices  $(P_1^*)_j$  strongly influence domestic prices  $(P_1)_j$ . Notice in equation (2.7) that if  $(S)_j$  is exogenous, then  $(P_1)_j$  will tend to move with  $(P_1^*)_j$ . By contrast if  $(S)_j$  is endogenous, then  $(P_1)_j$  will move independently of  $(P_1^*)_j$ . Movements in  $(P_1^*)_j$  will be absorbed by offsetting movements in  $(S)_j$ .

The next variable on our exogenous list is  $C$ , the real aggregate level of domestic absorption. By placing  $C$  on the exogenous list we are setting an economic environment in which real aggregate demand is controllable independently of other variables appearing in Table 2.3. The underlying assumption is that policy

makers have available macro instruments, not explained in ORANI, by which they can influence  $C$ . Alternatively, model users might set  $B$ , the balance of trade, exogenously in place of  $C$ . In this case, ORANI would indicate the change in real domestic absorption which would need to accompany a tariff cut, say, in order to maintain a target level for the balance of trade.

The last variable in Table 2.3 is the exchange rate,  $\theta$ . It acts as the numeraire, i.e., it determines the absolute price level. If wages are fully indexed and the exogenous variables are as in Table 2.3, then a one per cent increase in the exchange rate produces zero effect on all real endogenous variables and a one per cent increase in all domestic price and other nominal variables. Natural alternatives to  $\theta$  as the numeraire include the average wage rate<sup>1</sup> and the consumer price index.

We conclude with one final comment on the partitioning of variables into the exogenous and endogenous categories. While our discussion of Table 2.3 indicates a wide variety of legitimate possibilities, it is not true that ORANI can be closed by the exogenous setting of just any set of variables of the appropriate number. For example, at least one monetary variable should be included in the exogenous list. If all domestic currency prices, the exchange rate, all wages and all monetary aggregates are treated as endogenous, then our computations will fail since there is nothing to determine the absolute price level. Similarly, some

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1. This was the choice of Johansen [1960] and Taylor and Black [1974].

care is necessary to avoid inconsistencies. For example, if an attempt were made to set all four variables  $(P_1)_i$ ,  $(P_1^*)_i$ ,  $\Theta$  and  $(S)_i$  exogenously, then equation (2.7) would be violated. Although we can offer no formal theory to guide model users in their choice of exogenous variables, as a working rule, if a price appears on the exogenous list, then a corresponding quantity should be on the endogenous list and vice versa. If wages are exogenous, then employment will be endogenous; if subsidies are endogenous, then exports will be exogenous, etc..

### 2.3 Computational approach

The first step in computing ORANI solutions is to convert each of the structural equations (i.e., the equations illustrated by Table 2.1) into a linear, percentage change form. This approach was first applied to the solution of large scale, economy-wide models by Johansen [1960]. Equation (2.1), for example, becomes

$$d = \eta_{DZ} z + \eta_{DC} c + \eta_{DP1} p_1 + \eta_{DP2} p_2 + \eta_{DQD} q_D ,$$

where  $d$ ,  $z$ ,  $c$ , etc., are vectors of percentage changes in the corresponding upper case variables  $D$ ,  $Z$ ,  $C$ , etc., and  $\eta_{DZ}$ ,  $\eta_{DC}$ , etc., are matrices of elasticities. The  $ij^{\text{th}}$  element of  $\eta_{DZ}$  is the elasticity of demand for the  $i^{\text{th}}$  domestic product with respect to the activity level in the  $j^{\text{th}}$  industry. The  $i^{\text{th}}$  element of  $\eta_{DC}$  is the elasticity of demand for the  $i^{\text{th}}$  domestic product with respect to changes in real absorption, etc.. Once all the equations have been converted into a linear form, the model can be represented as

$$Ax = 0 \quad (2.16)$$

where  $A$  is a  $r \times s$  matrix of elasticities,  $x$  is the  $s \times 1$  vector of percentage changes in the model's variables,  $r$  is the number of equations and  $s$  is the number of variables.

The second step is to choose  $(s - r)$  exogenous variables. The economic implications of this choice were discussed in the previous subsection. Here we note that the choice involves a partitioning of the  $A$  matrix and  $x$  vector. We rewrite (2.16) as

$$A_1 x_1 + A_2 x_2 = 0 \quad (2.17)$$

where  $x_1$  is the  $r \times 1$  vector of endogenous variables and  $x_2$  is the  $(s - r) \times 1$  vector of exogenous variables. Finally, we solve the model by

$$x_1 = -A_1^{-1} A_2 x_2, \quad (2.18)$$

i.e., we express the percentage change in each endogenous variable as a linear function of the percentage changes in each of the exogenous variables.

The alternative to solving models such as ORANI in this linear form is to apply some non-linear solution algorithm to the structural equations,<sup>1</sup> i.e., the equations summarized in Table 2.1. The linear method, however, has considerable practical advantages. Firstly it allows solution of a very large model. The major step is the inversion of the  $A_1$  matrix. The power of modern computers

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1. Examples of large scale modelling exercises which use non-linear computational procedures are Adelman and Robinson [1978], Whalley [1978] and, in the context of IMPACT, the SNAPSHOT model -- see Dixon, Harrower and Powell [1976].

is such that data limitations, rather than computing difficulties, are the effective constraint on the size of the model provided that the solution procedure is linear.<sup>1</sup> Computational constraints are, on the other hand, generally a problem for those who prefer non-linear methods. Whalley [1978], p. 2, indicates that this has been his experience. Such constraints have certainly been responsible for limiting our theoretical specification of IMPACT's SNAPSHOT model.

To the extent that computing limitations on model specification have been avoided by those using non-linear methods,<sup>2</sup> this has only been achieved by the use of algorithms which are extremely model specific. The disadvantage of model specific as opposed to general purpose algorithms, especially simple matrix manipulation, is that they greatly reduce the flexibility available to the model builder in modifying the model and to the model user in employing the model in alternative configurations. We have found that the implementation of model improvements is not especially difficult with our solution method. Sections of the  $A$  matrix of equation (2.16) can easily be respecified or the dimensions of the matrix changed without requiring substantial modification of the solution programs. This has allowed the implementation of a research strategy based first on perfecting a comparatively simple version of ORANI and subsequently introducing increased degrees of sophistication as resources permit. The developments incorporated into ORANI 78 which are the subject of this paper are a good example.

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1. Note that the size of the  $A_1$  matrix to be inverted can always be reduced by algebraic elimination of endogenous variables. Values for the eliminated variables can be obtained following solution by back solving.

2. See, for example, Adelman and Robinson [1978], p. 11.

Flexibility in model use is another key advantage of our solution method. In subsection 2.2 we indicated that, by the selection of alternative sets of exogenous variables, ORANI can be used to answer a wide variety of different questions. The computational changes required for each new selection just depend on a new partition of the  $A$  matrix into the submatrices  $A_1$  and  $A_2$  (see equations (2.16) and (2.17)). With non-linear methods this type of flexibility can only be bought at the cost of much more fundamental changes to the solution routine.

The advantages of the linear solution method do, of course, have their own price. The price is that, for anything but a very small change in the exogenous variables, the solution obtained is only an approximation to the true solution of the non-linear system. The approximation results from the fact that the elements of the  $A$  matrix are treated as constants whereas in fact they are sensitive (in varying degrees) to changes in the variables. Various cost and sales shares for example are incorporated into the  $A$  matrix : where the prices of commodities which are identified as variables in the model are changing then clearly the shares of these commodities in the total costs of using industries or in the total sales of producing industries are likely to change.

The size of the linear approximation errors is a matter for empirical determination. A solution arbitrarily close to the true solution of the non-linear system can always be obtained using the linear method by breaking the exogenous change under consideration into a sufficiently large number of small changes and computing a

series of solutions for these small changes, updating the A matrix at each step. Research along these lines within IMPACT has so far indicated that, for a small model with the same degree of non-linearity in its structural form as ORANI 78, the errors are not very serious and moreover are regular so that the true solution can be predicted very accurately after only a small number (2 or 3) of iterations of the step procedure.<sup>1</sup>

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1. See Dixon [1979], section 5.3.

### 3. THE AGRICULTURAL SECTOR OF ORANI 78

In the last section the ease with which modifications can be made to the theoretical specification of parts of the model was advanced as a major advantage of the Johansen approach to solving general equilibrium models. In the development of ORANI the practical research strategy of first perfecting a fairly simple version of the model has been followed. For example, in ORANI 77 unique one-product production functions were specified for all commodities.<sup>1</sup> This section demonstrates that more complex assumptions about production technology can easily be grafted onto the basic model. It describes how the agricultural sector has been respecified for ORANI 78 in order to account for joint production, product-product transformation possibilities and region-specific technology.

#### 3.1 The reasons for the respecification of the agricultural sector

##### (a) The importance of agriculture in ORANI results

The results of simulations with ORANI generally emphasize the importance of analysing policy issues in an open economy context. For example, in a recent analysis of alternative approaches to macroeconomic recovery,<sup>2</sup> it was shown that the impacts of policies aimed at reducing domestic costs and of policies to stimulate domestic demand are quite different in the trading as compared to the

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1. See DPRS, pp. 20-25.

2. See Dixon, Parmenter and Powell [1978] and Dixon, Powell and Parmenter [1979].

non trading sectors. The agricultural industries are very prominent in this type of result because of their heavy export orientation. Similarly, the results of simulations presented in DPRS show that the agricultural industries are amongst the most sensitive to changes in the economy's trading conditions. They are, for example, amongst the main gainers from a successful devaluation and amongst the main losers from a tariff increase which raises the domestic price level.<sup>1</sup> For this reason accurate modelling of the production responses of the agricultural sector is of particular importance.

(b) Problems with the specification of agriculture in the Australian input-output tables

Industry structure in ORANI 77 is specified according to the Australian Bureau of Statistics (ABS) 1968/69 109 industry × industry input-output tables. In this data base six product groups are identified as agricultural "industries". They are

1. Sheep,
2. Cereal grains,
3. Meat cattle,
4. Milk cattle and pigs,
5. Poultry, and
6. Other farming.

With the exception of poultry production, however, these groupings do not conform to any identifiable production units. The Australian agricultural sector is to a large extent characterised by joint

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1. See DPRS, ch. 4.

production. For example, nearly all the output of the cereals livestock complex, i.e., wool, sheep, cattle, wheat, barley and other cereal grains, is produced on multienterprise farms. An implication of the joint production characteristics of Australian agriculture is that input bundles cannot be apportioned uniquely to the production of individual products. The columns in the input-output (I-O) tables for the agricultural product group "industries" therefore reflect arbitrary cost allocations.

A second problem with the I-O treatment of the agricultural sector is that it masks regional differences in production technology which, because of climatic and biological factors, are extremely important in the Australian context. The regional cost of production surveys of the Bureau of Agricultural Economics (BAE) provide an ideal data base for the recognition of these factors.

A final, more specific, problem concerns the "commodity" produced by the industry Other Farming, as defined by the ABS. Two of the major components included in this category are tobacco, which is import competing, and sugar, which is an export commodity. In a model like ORANI which emphasizes international trade it is unsatisfactory to have both import competing and export components aggregated in a single commodity classification.

Because of the importance of the agricultural sector, substantial modification of the I-O data base has been undertaken for ORANI 78.<sup>1</sup> The agricultural sector has been respecified as a

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a. See Vincent and Parmenter [1978] for details of the procedure used to modify the I-O data base.

10 commodity by 8 industry system which includes regional variation in production technology. In addition modifications have been made to the theoretical structure of ORANI to allow the modelling of price induced changes in product mixes within regional industries. The revised theoretical specification is outlined in section 3.2. Details of the data base are given in section 3.3.

### 3.2 Theoretical specification

Equation (3.1) gives a general form for a multi-product, multi-input production function for industry  $j$  :

$$H_j \left\{ Y(j), X(j) \right\} = 0, \quad (3.1)$$

where  $Y(j)$  is the  $1 \times u$  vector of  $j$ 's commodity outputs and  $X(j)$  is the  $1 \times v$  vector of inputs. Under (3.1) there are, at every point in the input-output space,  $uv$  free elasticities  $E_{ik}$ , where  $E_{ik}$  is the elasticity of output of product  $i$  with respect to factor  $k$ , i.e.,  $E_{ik}$  measures the effect on  $i$  of increasing  $k$  while holding all other outputs and inputs constant. The number of free elasticities can be reduced to a more manageable level by adopting the special case of (3.1),<sup>1</sup>

$$\text{and } \left. \begin{aligned} Z_j &= F_j \{ X(j) \} & (a) \\ Z_j &= G_j \{ Y(j) \} & (b) \end{aligned} \right\} (3.2)$$

Under (3.2) there are only  $u + v$  free elasticities since  $E_{ik}$  can now be written as

$$E_{ik} = A_i B_k, \quad i=1, \dots, u, \quad k=1, \dots, v, \quad (3.3)$$

where  $A_i$  and  $B_k$  are respectively the elasticity of  $Y_i(j)$

1. In (3.2),  $Z_j$  is a scalar. When (3.2) holds, the production technology is defined to be "separable between inputs and outputs" -- see Hasenkamp [1976].

with respect to  $Z_j$  and the elasticity of  $Z_j$  with respect to  $X_k(j)$ .  $A_i$  is computed from (3.2) (b) by allowing  $Z_j$  and  $Y_i(j)$  to vary while fixing all the other elements of  $Y(j)$ .  $B_k$  is obtained from (3.1) (a) by computing the effect of a change in  $X_k(j)$  on the level of  $Z_j$  with all the other elements of  $X(j)$  constant.

The simplification (3.3) implies that if the elasticity of (say) wool production with respect to labour inputs is twice that of wheat production with respect to labour inputs, then the elasticity of wool production with respect to capital inputs is also twice that of wheat production with respect to capital inputs. This means that factors are completely non-specific. If relative to wheat it is easier to expand wool output by applying more of factor 1, then it is also easier to expand wool output by applying more of factor 2. In summary, no factor has comparative advantage in increasing the output of any particular product.

It is clear that, in applications of models based on (3.2), the inputs  $X_k(j)$  should be broadly defined, e.g., labour, capital, land, intermediate inputs. Simplification (3.3) would not be appropriate if the factor list included, for example, contract shearing. Obviously, this input is quite specific to the particular output, wool. Fortunately, however, fully specific inputs, such as contract shearing, often have virtually zero substitution elasticity with respect to every other factor involved in the production of their specific output. For the firm's decision making, the costs of such factors can be deducted from the product price, i.e., treated as an excise tax. Other specific factors in this

category are commission and freight charges involved in getting products to market. Likewise, these factors do not possess identifiable substitutes. Thus in adopting (3.2) we are implicitly making the assumption that any factors which are product-specific do not have substitutes or at least that product-specific factors with substitutes can be ignored.

A theoretical implication of adopting (3.2) is that an industry's input and output decisions can be treated separately.

We assume that outputs are selected so as to maximize revenue

$\left[ \sum_{i=1}^u P_i Y_i(j) \right]$  subject to (3.2) (b).<sup>1</sup> This yields supply response equations of the form

$$Y_i(j) = g_{ij}(P_1, P_2, \dots, P_u, Z_j) \quad (3.4)$$

Inputs are assumed to be chosen to minimize costs  $\left[ \sum_{k=1}^v W_k X_k(j) \right]$  subject to (3.2) (a), yielding input demand functions of the form

$$X_k(j) = f_{kj}(W_1, \dots, W_v, Z_j) \quad (3.5)$$

The form in which equations such as (3.5) appear in ORANI 78 is unchanged from the earlier version of the model. The  $f_{kj}$  continue to reflect substitution possibilities between primary factors and between alternative sources (foreign and domestic) of intermediate inputs of the same commodity class.<sup>2</sup> Supply response equations were unnecessary in the earlier version of the model because it contains only single product industries. Equations like

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1. The  $P_i$ 's are domestic product prices net of the costs of product specific inputs. These  $P$ 's are not to be confused with the vectors of prices used in Tables 2.1 through 2.3. The  $W_k$ 's are the prices of the non-specific inputs.

2. For details, see DPRS, sections 2 and 3.

(3.4) appear, however, in ORANI 78 in percentage change form as

$$\left. \begin{aligned}
 y_i(j) &= \tilde{y}_r(j) \quad \text{where } i \text{ is included in} & (a) \\
 &\quad \text{composite commodity } r, \\
 \tilde{y}_r(j) &= z_j + \phi_r(j) \left( p_r(j) - \sum_q R_q^*(j) p_q(j) \right) & (b) \\
 &\quad \phi_r(j) \geq 0, \\
 p_q(j) &= \sum_t H_{tq}(j) p_t & (c)
 \end{aligned} \right\} (3.4)'$$

where the notation is explained below.

Equations (3.4)' were derived under the assumption that the function  $G_j$  in equation (3.2) has a CRETH<sup>1</sup> form. However, the arguments of the CRETH functions are composite-commodities rather than individual products. Within each composite commodity, individual products were assumed to be produced in fixed proportions. For example, as will be explained in section 3.3, it has been assumed that in the Pastoral Zone sheep-meat and wool are produced in fixed proportions, i.e., sheep/wool is a composite commodity for the Pastoral Zone industry. Equation (3.4)' (a) reflects the assumption of fixed commodity proportions within composite commodities. It states that the percentage change in the production of commodity  $i$  by industry  $j$  ( $y_i(j)$ ) is equal to the percentage change in the output of composite commodity  $r$  by industry  $j$  ( $\tilde{y}_r(j)$ ) for each commodity  $i$  included in that composite commodity. Equation (3.4) (b) shows that, under CRETH, the output of the  $r^{\text{th}}$  composite commodity produced in industry  $j$  changes in

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1. CRETH (Constant ratio elasticity of transformation, homothetic) is a generalization of CET (Constant elasticity of transformation). CRETH generalizes CET in the same way as CRESH generalizes CES. See Hanoch [1971] for CRESH, Powell and Gruen [1968] for CET, Arrow et al. [1961] for CES and Vincent, Dixon and Powell [1978] for CRETH.

proportion to the overall level of activity in industry  $j$  ( $Z_j$ ). It also responds to any deviation between the percentage change in price of the  $r$ th composite commodity  $p_r(j)$  and a weighted average of the prices of all composite commodities produced in the  $j$ th industry. The weight  $R_q^*(j)$  is related to the share (denoted by  $R_q(j)$ ) of composite commodity  $q$  in the total revenue of industry  $j$ .<sup>1</sup> Equation (3.4) (c) defines the percentage change in the price of a composite commodity as a weighted average of the percentage changes in the prices of the individual products included therein. The weights  $H_{tq}(j)$  are the shares of the products  $t$  in the total value of output of composite commodity  $q$  for industry  $j$ . The nonnegative parameter  $\phi_r(j)$  in equation (3.4)' (b) reflects the ease of transformation within industry  $j$  between composite commodity  $r$  and other composite commodities produced in the industry.

### 3.3 The data

#### 3.3.1 Industries and commodities

The commodity and industry categories used for ORANI 78 can be seen by glancing at Tables 4.2 and 4.3. The non agricultural sectors of the economy are modelled, as in ORANI 77, according to the industry  $\times$  industry classification of the ABS 1968/69 I-0 tables. Industries 9-112 are single commodity industries and, with one

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1.  $R_q^*(j) = \phi_q(j) R_q(j) / \sum_q \phi_q(j) R_q(j)$ . Notice that if  $\phi_q(j) = \phi(j)$  for all  $q$ , i.e., the CET case, then  $R_q^*(j) = R_q(j)$  for all  $q$ .

exception, correspond to industries 7-109 from the ABS tables.<sup>1,2</sup> The exception is ABS industry 12 (Coal and Crude Petroleum) which has been split, in the ORANI 78 data base, into industry 14 (Coal) and industry 15 (Crude Petroleum). The exporting part of the original industry has thus been separated from the import competing part. Industries 1-8 and commodities 1-10 comprise the respecified agricultural sector. Note that industries 1-4 are explicitly regional. The first three correspond to zones designated by the BAE in its Australian sheep industry survey.<sup>3</sup>

### 3.3.2 Characteristics of the agricultural industries

#### (a) Outputs

The Pastoral Zone industry occupies the largest area of the three BAE cereals-grazing zones. It includes all of the arid and most of the semi-arid parts of Australia which support a sheep population. Apart from some fringe areas, cropping is not feasible in this zone because of the inadequate and unreliable rainfall. Livestock are generally grazed extensively on natural vegetation. Hence stocking rates are low and property areas extremely large. Sheep are grazed in the Pastoral Zone almost entirely for their wool. Although a substantial amount of income is also obtained from the sale of cast for age sheep, this meat production occurs essentially in fixed proportions with that of wool. We have modelled production

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1. See DPRS, Table 13b, p. 120, for a numbered list of the ABS categories.
  2. The model also includes a 113<sup>th</sup> industry, which is a dummy category included to allow for the treatment of non-competing imports. No results for this artificial industry are included in the tables.
  3. See BAE [1973].

possibilities in the Pastoral Zone in terms of three groups of commodities, wool/sheep, meat cattle and other products.

The Wheat-Sheep Zone is the largest of the three zones in terms of sheep numbers and sheep properties, accounting for nearly one half the national sheep flock and well over half the number of sheep properties in Australia. Rainfall is generally sufficient for crop production, and nearly all dryland cropping of cereals is carried out in this zone. As well as forming the basis for Australian sheep and wheat production, the zone has become an increasingly important source of cattle output in recent years. Climate, topography and soil type are such that opportunities for diversification into various cropping and livestock activities are large. The zone thus forms a classic example of a multiproduct agricultural region. We recognize six groups of competing products in the Wheat-Sheep Zone - wool, sheep, meat cattle, wheat, barley and other products. The other products category includes small amounts of other cereal grains, milk cattle and pigs, and commodities in both the other farming export and other farming import competing categories, e.g., fruit (OFE) and tobacco (OFM).

The High Rainfall Zone consists entirely of land within 200 miles of the coast and is located predominantly in the south-east and south-west corners of Australia. Sheep concentration is highest in this zone. Sheep are often grazed in association with beef cattle. To a lesser extent, livestock are grazed in rotation with crop production. As in the Wheat-Sheep Zone, a large proportion

of properties combine wool growing with prime lamb production. That is, sheep meat production is an activity in its own right. Four groups of competing commodities are recognized; wool, sheep, meat cattle and other products. The other products category contains wheat, barley, other cereal grains, milk cattle and pigs and the commodities in the other farming export category.

Meat cattle are produced in Australia using two quite different technologies.

- (a) Beef grazing activity is conducted in each of the three BAE zones. On most properties in these zones, cattle are grazed in conjunction with sheep. The product is mainly high quality beef for domestic consumption.
- (b) An extensive specialist beef industry is located in northern Australia. Much of the product from these northern regions is exported as lower quality manufacturing beef. Climatic and biological factors are such that there are virtually no alternative commodity prospects to beef cattle for the northern industry. The Northern Beef industry in ORANI is defined to include the Kimberley region in W.A., the Victoria River, Alice Springs, Darwin and Gulf and Barkley Tableland regions of the Northern Territory (these regions comprise the entire Northern Territory), and

the Peninsular Gulf and Coastal Central regions of Queensland.<sup>1</sup> No competing products are permitted for the Northern Beef enterprise.

The Milk Cattle and Pigs industry produces two products, meat cattle (commodity 6) and milk cattle and pigs (commodity 7). They are assumed to be produced in fixed proportions.

The remaining three industries, Other Farming Export, Other Farming Import Competing and Poultry, are single product industries producing only the corresponding commodities.

Table 3.1 shows the base period shares of the agricultural commodities in the total value of output of each of the agricultural industries.<sup>2</sup> The composite commodity groups which were defined for some industries<sup>3</sup> for the purpose of estimating the CRETH system of product transformation<sup>4</sup> are identified by the lower case letters in the table. For example, for industry 1 (Pastoral Zone), commodities 1 (wool) and 2 (sheep) form one group, commodity 6 (meat cattle) is a single product group and commodities 3 (wheat), 4 (barley), 5 (other grains) and 9 (other farming import competing) form a third, other products group. Within each group commodities are assumed to be

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1. The designation of the various regions is that used by the BAE in their Beef industry reports of the Northern Territory and Kimberley Region Beef Cattle Industry [BAE 1974 (a)] and the Queensland Beef Cattle Industry [BAE 1974 (b)].
  2. Note that the column sums of the table are ones.
  3. In the present version of the model CRETH transformation possibilities have been estimated only for the first three industries, i.e., for the BAE regions. See Vincent, Dixon and Powell [1978].
  4. Described in section 3.2.

Table 3.1 Commodity Shares of Value of Output by Industry (1968/69)

Industries Commodities	(1) Pastoral Zone	(2) Wheat-sheep Zone	(3) High Rainfall Zone	(4) Northern Beef	(5) Milk Cattle and Pigs	(6) Other Farming Export	(7) Other Farming Import Competing	(8) Poultry
1. Wool	0.618 a	0.251 a	0.463 a					
2. Sheep	0.127 a	0.088 b	0.131 b					
3. Wheat	0.096 b	0.443 c	0.032 c					
4. Barley	0.001 b	0.033 d	0.012 c					
5. Other grains	0.005 b	0.046 e	0.023 c					
6. Meat cattle	0.137 c	0.088 f	0.229 d	1.000	0.234 a			
7. Milk cattle & Pigs		0.030 e	0.055 c		0.766 a			
8. Other Farming Export		0.010 e	0.055 c			1.000		
9. Other Farming Import Competing	0.016 b	* 0.011 e					1.000	
10. Poultry								1.000

Sources: Derived from BAE [1973] and ABS [1977].

Note: The lower case letters identify product groups within the industries.

produced in fixed proportions (see equation (3.4)' (a)).<sup>1</sup>

The parameters  $H$  and  $R^*$  of equations (3.4)' are based on the information contained in Table 3.1. For example,  $H_{tq}(j)$  is the share of commodity  $t$  (say sheep) in commodity group  $q$  (say group (a) wool/sheep) in industry  $j$  (say the Pastoral Zone). This is computed from Table 3.1 as  $0.127/(0.618 + 0.127) = 0.170$ . Similarly,  $R_q^*(j)$  requires the computation of the share of commodity group  $q$  (say (a) wool/sheep) in the total output of industry  $j$  (say the Pastoral Zone).<sup>2</sup>

Table 3.2 shows the shares of each of the agricultural industries in the aggregate production of agricultural commodities in the base year.<sup>3</sup> The three BAE zonal industries (industries 1-3) produce all the Australian output of wool, sheep and cereals (commodities 1-5) and about one half of the output of meat cattle (commodity 6). In addition they make minor contributions to the production of the remaining agricultural products (commodities 7-10) which are produced predominantly by specialist producers (industries 5-8).

(b) Inputs

As well as recognizing the marked regional differences in agricultural output structures which were outlined above, our respecification of ORANI's agricultural sector allows the model to

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1. Unfortunately the time series data on which the estimation of the relevant transformation frontiers was based, was not detailed enough to support an econometric analysis of the transformation behaviour of components of the other products categories. See Vincent, Dixon and Powell [1978].
  2. See footnote 1 on page 32.
  3. Note that the row sums of the table are ones.

Table 3.2 Industry Shares in the Production of Agricultural Commodities (1968/69)

Industries Commodities	(1) Pastoral Zone	(2) Wheat-sheep Zone	(3) High Rainfall Zone	(4) Northern Beef	(5) Milk Cattle and Pigs	(6) Other Farming Export	(7) Other Farming Import Competing	(8) Poultry
1. Wool	0.217	0.425	0.358					
2. Sheep	0.151	0.505	0.344					
3. Wheat	0.042	0.928	0.030					
4. Barley	0.005	0.852	0.143					
5. Other Grains	0.020	0.796	0.184					
6. Meat Cattle	0.068	0.211	0.252	0.240	0.229			
7. Milk Cattle & Pigs		0.080	0.069		0.851			
8. Other Farming Export		0.036	0.092			0.872		
9. Other Farming Import Competing	0.016	0.050					0.934	
10. Poultry								1.000

Source : Derived from BAE [1973] and ABS [1977].

account for regional differences in production technology. Table 3.3 illustrates these latter differences. It shows the shares of various cost categories in the total costs of each of the three BAE zones. Cost share information of this type is required for the empirical implementation of input demand functions of the form of equation (3.5).<sup>1</sup>

Table 3.3 Input Cost Shares in Agricultural Zones (1968/69)\*

Cost Category	Pastoral Zone	Wheat-Sheep Zone	High Rainfall Zone
Domestic intermediate inputs	0.35	0.28	0.36
Imported intermediate inputs	0.02	0.02	0.02
Wages	0.15	0.17	0.22
Fixed capital	0.20	0.16	0.09
Land	0.21	0.31	0.25
Other (including taxes)	0.07	0.06	0.06

\* Numbers in the table refer to shares in total costs.

The most important feature of Table 3.3 is that the High Rainfall Zone is notably more labour intensive than the other two zones.<sup>2</sup> This is especially important for short-run simulations in which inputs of both land and capital are held fixed.

1. See DPRS, sections 2 and 3.

2. Note that the share of labour in total primary costs (land, labour and fixed capital) is 0.39 in the High Rainfall Zone as opposed to 0.27 in the Pastoral and Wheat-Sheep Zones.

Although not shown in Table 3.3, the commodity composition of total intermediate inputs also differs across zones. For example, chemical fertilizers comprise 21 and 19 per cent of total intermediate input costs in the High Rainfall and Wheat-Sheep Zones respectively, but only one half of one per cent of intermediate input costs in the Pastoral Zone; oil and coal products (fuel) inputs in the Wheat-Sheep Zone represent 8 per cent of intermediate input costs compared with 7 per cent in the Pastoral Zone and 5 per cent in the High Rainfall Zone.

### 3.3.3 Transformation parameters and supply elasticities

In addition to data computed from Tables 3.1 - 3.3, estimates of the product-product transformation parameters ( $\phi_r^j$ ) are required for the CRETH equations (3.4)'. These are presented in Table 3.4. As explained above, to date the CRETH system has been estimated only for the first three of our agricultural

Table 3.4 Values for Transformation Parameters ( $\phi_r^j$ ) for Equation (3.4)'(b)

Pastoral Zone		Wheat-Sheep Zone		High Rainfall Zone	
Commodity group	$\phi_r^j$	Commodity group	$\phi_r^j$	Commodity group	$\phi_r^j$
Wool/sheep	0.1041	Wool	0.2976	Wool	0.0631
Meat cattle	1.6129	Sheep	0.2342	Sheep	0.1153
Other products	4.5455	Cattle	0.5181	Cattle	0.3745
		Wheat	1.6129	Other Products	3.8462
		Barley	0.5208		
		Other Products	1.3158		

industries, that is for the three BAE zones. Details of the economic work and various alternative presentations of the results can be found in Vincent, Dixon and Powell [1978]. Here we draw heavily on that source to present the results of the analysis for each zone as an asymmetric matrix of own and cross price elasticities of supply. For industry  $j$ , the elasticity of supply of composite commodity  $r$  with respect to the price of composite commodity  $q$  ( $\zeta_{rq}(j)$ ) is given, from equation (3.4)' (b), as

$$\left[ \zeta_{rq}(j) \right]_{Z_j = \bar{Z}_j} = - \phi_r(j) \left[ \delta_{rq} - R_q^*(j) \right]$$

where  $\delta_{rq} = 1$  for  $r=q$   
 $= 0$  for  $r \neq q$ .

(a) Pastoral Zone

The matrix of own and cross product supply elasticities for the three composite commodities produced in the Pastoral Zone is shown in Table 3.5.

Table 3.5 Estimated Own and Cross Price Elasticities : Pastoral Zone<sup>†</sup>

Percentage response one year later in the planned output* of :	Product whose expected price changes :		
	Wool	Cattle	Grains, etc.
Wool	0.083	-0.039	-0.043
Cattle	-0.332	1.008	-0.676
Grains, etc.	-0.929	-1.724	2.654

† The elasticities refer to changes in planned product outputs in response to expected price changes under the assumption that the scale of total capacity ( $Z$ ) remains constant.

\* Actual output may differ from planned output due to droughts, etc.

As would be expected, the ease of transformation is highest when the grains, etc., category is one of the product pairs. Consequently (and especially since it accounts for only a small share of total output in each zone) grains production shows more sensitivity to price changes than does the production of the other two products : the grains row in Table 3.5 contains the largest elasticities. Nevertheless for a one-year response, the elasticity of transformation between wool and cattle is quite large, implying a cross elasticity of cattle supply with respect to expected wool price of about -0.3. Planned production of wool in the pastoral zone is considerably less responsive to its expected price than either cattle or 'other' output to their respective prices. This result appears reasonable in view of the traditionally wool oriented activities of the pastoral zone.

(b) Wheat-Sheep Zone

The estimated own and cross price elasticities for the Wheat-Sheep Zone are shown in Table 3.6.<sup>1</sup> Wheat-Sheep Zone farmers have considerable possibilities for changing their output mix in response to relative price changes. As one might expect from the nature of the products, the sensitivity of supply to price changes is smaller for livestock enterprises than for grains, i.e., the elasticities in the first three rows of Table 3.6 tend to be considerably smaller than those in the rest of the table. In the Wheat-Sheep Zone, one can envisage few technical problems in

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1. These are derived from the reduced form of the CRETH system rather than from equation (3.4)' (b). They allow the scale of output to change in response to a change in the price of an individual product. The practical importance of the scale effect is small. For technical reasons the reduced form was not used for the other two zones. For a detailed discussion see Vincent, Dixon and Powell [1978], p. 22.

Table 3.6 Estimated Own and Cross Price Elasticities : Wheat-Sheep Zone

Per cent response one year later in planned output* of :	Product whose expected price changes :					
	Wool	Sheep	Cattle	Wheat	Barley	'Other'
Wool	0.256	-0.012	-0.020	-0.152	-0.014	-0.044
Sheep	-0.031	0.225	-0.015	-0.118	-0.011	-0.034
Cattle	-0.077	-0.023	0.483	-0.269	-0.025	-0.078
Wheat	-0.254	-0.075	-0.114	0.766	-0.080	-0.245
Barley	-0.078	-0.023	-0.036	-0.270	0.497	-0.078
'Other'	-0.204	-0.061	-0.092	-0.687	-0.064	1.111

\* Actual output may differ from planned output due to droughts, etc.

changing the relative areas of different types of grains in response to changes in relative product prices. On the other hand, there are obvious limits on the extent to which one type of livestock may be replaced throughout a zone with another over a one year period.

(c) High Rainfall Zone

Own and cross product price elasticities for the High Rainfall Zone are shown in Table 3.7. Once again, in a predominantly

Table 3.7 Estimated Own and Cross Price Elasticities : High Rainfall Zone<sup>†</sup>

Per cent response one year later in the planned output* of :	Product whose expected price changes :			
	Wool	Sheep	Cattle	Grains, etc.
Wool	0.060	-0.002	-0.005	-0.053
Sheep	-0.006	0.112	-0.010	-0.097
Cattle	-0.019	-0.010	0.343	-0.314
Grains, etc.	-0.196	-0.104	-0.320	0.620

† These elasticities are based on a constant scale of total capacity (Z).

\* Actual output may differ from planned output due to droughts, etc.

wool growing region, own supply elasticities for wool and sheep are considerably less than those of the two other product categories distinguished. Similarly, cross price effects are lower for wool output with respect to changes in the price of competing products than for other output and price combinations.

(d) Comparisons with other studies

We note that our estimated supply elasticities are considerably higher than those implied by the work of Powell and Gruen [1967] which used national time series data and a CET model.<sup>1</sup> Furthermore, our estimates of one year own and cross price elasticities of supply are considerably higher in absolute value than the estimates obtained from previous Australian agricultural supply studies which generally have employed conventional single equation techniques with the parameter space largely unconstrained.

Since the original CET work of Powell and Gruen in the mid-1960's, the only multiproduct model of Australian agriculture recognizing joint production to emerge has been the University of New England's Aggregative Programming Model of Australian Agriculture, APMAA.<sup>2</sup> The APMAA study has the advantage of a great deal of regional detail consisting of a set of approximately 500 regionally representative farms for each of which a complete activity analysis linear programming framework is developed. The APMAA model has been used to provide aggregate estimates of own and cross elasticities of supply for different product/price combinations. The methodology allows shifts in the land use between sheep, beef and wheat in response to changes in the gross margins of these activities.<sup>3</sup> For a number of reasons, the APMAA results are not strictly comparable with those from CRETH. An obvious difference is that the APMAA

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1. See footnote 1 on page 3.7.

2; Monypenny [1975].

3. APMAA [1977].

own and cross price elasticities differ according to the particular combination of beef, wheat, and wool prices chosen. Assuming a 'central' set of prices, viz. beef \$0.68/kg., wheat \$51.42/tonne and wool \$2.32/kg, the APMAA-model yielded the following elasticities :

wool with respect to price of wheat -0.19 (versus -0.15, our Table 3.6);

wool with respect to price of beef -0.21 (versus -0.02, our Table 3.6);

wool with respect to price of wool +0.25 (versus +0.26, our Table 3.6).

These long-run results provide corroborating evidence of the fairly high transformation possibilities between competing products on Australian farms.

4. THE-SHORT RUN EFFECT OF A GENERAL TARIFF INCREASE  
ON THE AUSTRALIAN ECONOMY WITH SPECIAL REFERENCE  
TO THE AGRICULTURAL SECTOR

In this section we present an application of ORANI 78.

The model is used to simulate the effects on industry activity levels, employment by occupation and various macroeconomic variables of a one per cent across the board tariff increase.<sup>1</sup> Protection policy is of great significance to the agricultural sector because of the heavy involvement of that sector in exporting. Tariff increases raise domestic costs especially when wage rates are indexed to the consumer price level. Export prices for most commodities can be regarded as more or less fixed from the point of view of a small economy such as Australia's. That is, Australian export industries cannot generally just pass on domestic cost increases to their customers and a tariff increase can be expected to reduce the profitability of the export sector. Clearly a general equilibrium approach is required for a quantitative analysis of these effects.

The 1977 version of ORANI has previously been used to analyse the effects of tariff increases. The results are reported in detail in chapter four of DPRS. One reason for wishing to repeat this experiment with ORANI 78 is that comparison of the results of the two simulations allows an assessment to be made of the significance of the modifications to the model which have been introduced.

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1. The model is linear in percentage changes. Hence, subject to a caveat concerning approximation errors in the linear form (see section 2.3) readers wishing to compute projections for, say, a 10 per cent tariff increase or a one per cent tariff decrease can simply multiply the results by 10 or -1 respectively.

Apart from the respecified agricultural sector, the only other relevant modification to the theoretical structure of ORANI which has been introduced in ORANI 78 concerns the modelling of commodity taxes.<sup>1</sup> In ORANI 77 these were modelled as specific. An implication is that changes in the domestic price level cause changes in the real value of tax revenue. ORANI 78 incorporates a more flexible treatment. Commodity tax rates may be set as specific, ad valorem or indexed to the consumer price level. Exogenous changes in the rates can be imposed under any of the three specifications. In the simulation reported here the tax rates are indexed so that for each product the real value of tax receipts per unit of sales is constant.

In addition some improvements have been made to the data and parameter files employed in the model. There are three principal changes. Firstly gross rather than net Input-Output tables are now used. This allows a more straight-forward treatment of import-domestic substitution in intra-industry intermediate demand and is of particular importance for the motor vehicle industry.<sup>2</sup> Secondly, the split of gross operating surplus between fixed capital and other claimants has been revised for some industries. Thirdly, the required household demand parameters have been re-estimated.<sup>3</sup> Finally, on the basis

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1. ORANI 78 also includes a facility for handling exogenous technological and taste changes. This extension of the ORANI structure is not, however, relevant to the simulations discussed here.
  2. For a description of the problems which arose in this regard with ORANI 77 see DPRS, pp.141-3.
  3. See Tulpule and Powell [1978].

of a paper produced for IMPACT by Freebairn [1978], slightly revised values for the foreign elasticities of demand for some Australian exports have been chosen. The values of the reciprocals of these demand elasticities which are used in ORANI 78 for the major export industries are shown in Table 4.4. The 'small country' assumption is not imposed in the export specification for ORANI, although, as can be seen from Table 4.4, for most export commodities fairly elastic foreign demand is assumed.

#### 4.1 Assumptions underlying the simulation

The economic environment which is assumed for the purposes of an ORANI experiment is determined basically by the choice of the set of variables which are to be treated as exogenous. The principles governing this choice are discussed in Section 2.2. For this experiment exactly the same environment is assumed as was used for the equivalent simulation reported in DPRS.<sup>1</sup> The key assumptions are :

- (i) fixed industry specific capital stocks;
- (ii) fixed real aggregate consumption, investment and government spending;
- (iii) a slack labour market for all occupations with 100 per cent indexation of wage rates to the ORANI consumer price index (i.e., fixed real wages); and
- (iv) a fixed exchange rate.

The first assumption implies that the results are short run. Investment takes place but is not allowed to augment capital stocks in the solution

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1. See DPRS, pp. 193-207.

period. A suitable calendar time interpretation of this short run would be 1-2 years. Assumption (ii) indicates that the simulations abstract from any effects which tariff changes may have on real domestic absorption. The latter is regarded as determined independently of tariff levels by other arms of government policy (fiscal and monetary policy for example) which are not modelled in ORANI. Assumption (iii) would seem to be appropriate for the current state of the Australian labour market. Employment levels are thus assumed to be demand determined. The last assumption fixes the numeraire in the model. Changes in domestic prices relative to world prices in this simulation are accommodated by changes in the domestic price level rather than by changes in the exchange rate.

As explained in Section 2.2, exports are determined endogenously in ORANI only for a group of major export commodities.<sup>1</sup> In the simulation reported here exports are endogenous for the following commodities: wool, wheat, barley, other cereal grains, fishing, iron, other metallic minerals, coal, meat products, food products n.e.c., prepared fibres, basic iron and steel and other basic metal products. These commodities constitute about 70 per cent of total exports in the data base. For the remaining commodities, changes in exports were specified exogenously to be zero. Note that, apart from the complications introduced by the respecification of the agricultural sector, this assignment conforms to that chosen for the experiments reported in DPRS.

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1. See also DPRS, pp. 204-5.

#### 4.2 The macroeconomic and employment results

Table 4.1 contains projections of the short run effects of the one per cent tariff increase on employment by occupation and on various macroeconomic variables.

These results confirm the conclusions about the effects of tariff protection which were drawn on the basis of the corresponding ORANI 77 simulation. They indicate that increased aggregate employment is not generated by tariff increases. In fact a slight fall in aggregate employment is projected. Increased employment in import competing industries is more than offset by falls in employment elsewhere in the economy, especially in the export sector.<sup>1</sup> This pattern is indicated by the projections of changes in occupation specific employment. The export related occupation "Rural Workers" experiences the largest decline. The occupation classification used is insufficiently industry specific to give such a clear reflection of the increase in employment enjoyed in the import competing sector. Only the fifth occupation "Skilled Blue Collar Building" experiences a net increase in employment. This increase reflects a shift in the allocation of investment from the exporting (especially the rural) sector towards import competing manufacturing. Investment in the latter is more intensive in construction inputs. Occupation 4 is also intensively used in import competing industries, hence its smaller

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1. Projections for employment by industry as well as by occupation are available. They are not presented here for reasons of space but may be obtained from the authors.

Table 4.1 Projections of the Effects of a 1 per cent Across the Board Tariff Increase on Macro and Employment Variables

Variable	Projection*	Employment Weights
Aggregate employment (hours)	-0.0078	
Employment		
1. Professional White Collar	-0.0054	0.0387
2. Skilled White Collar	-0.0023	0.1344
3. Semi and Unskilled White Collar	-0.0037	0.2744
4. Skilled Blue Collar (metal and electrical)	-0.0001	0.1028
5. Skilled Blue Collar (building)	0.0042	0.0425
6. Skilled Blue Collar (other)	-0.0006	0.0271
7. Semi and Unskilled Blue Collar	-0.0049	0.2993
8. Rural Workers	-0.0835	0.0645
9. Armed Services	0.0000	0.0163
Aggregate Exports (foreign currency value)	-0.1009	
Aggregate Imports (foreign currency value)	-0.0611	
Balance of Trade	-1.3	
Index of Consumer Prices	0.0880	
Capital Goods Price Index	0.1102	

\* All projections are percentage changes with the exception of the balance of trade which has the units "millions of 1968/69 Australian dollars".

than average employment loss.<sup>1</sup>

Just as the results cast doubt on the old conventional wisdom about the relationship between tariffs and employment, they also suggest that increased protection will not improve the balance of trade. The projected fall in aggregate imports is more than offset by the adverse effects of the cost-price squeeze on the export sector. Aggregate exports are projected to fall by an amount sufficient to result in a small move to deficit on the balance of trade. Domestic absorption is assumed constant so that, consistent with the deterioration in the trade balance, a slight decline in the GNP is implied.

The final items in Table 4.1 are two indexes of domestic prices. Both are projected to increase by about 0.1 per cent as a consequence of the tariff increase when 100 per cent wage indexation is imposed. The steeper rise in the investment price index compared to the consumer price index reflects the heavier weight in the former given to highly protected imports.<sup>2</sup>

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1. In the ORANI 77 tariff experiment occupation 4 experienced a small employment gain (see DPRS, pp. 208-9). The reason for the reversal of the sign on this projection in ORANI 78 is that, because of the indexation of commodity taxes, the tariff increase is slightly more inflationary in the new version of the model. All the employment results are therefore worse but especially those in occupations heavily concentrated in trading sectors of the economy (i.e., occupations 4 and 8). In the case of occupation 4 this was sufficient to cause the sign reversal.
  2. A detailed analysis of price level responses in ORANI can be found in DPRS, pp. 214-22.

### 4.3. The industry results

#### 4.3.1 The general picture

As in the case of the macro and employment results, the general pattern of the industry results from the current simulation confirms strongly the conclusions which were drawn on the basis of the equivalent ORANI 77 experiment.<sup>1</sup> Projected percentage changes in industry output levels are presented in Table 4.2. The average output response across industries is a decline of about 0.005 per cent. Various groups of industries can, however, be identified as faring clearly better than or worse than average.

Not surprisingly, the highly protected import competing sectors of the economy provide most of the industries which are projected to gain from the tariff increase. Industries 24, 28, 31-39, 41, 43, 44, 46, 48, 50-52, 54, 55, 57, 65-68, 71-75 and 78-83 can all be included in this category. All show relatively strong positive output responses in Table 4.2. Within the group relative performance is determined by the extent of import competition faced (measured by the import shares in the relevant markets), the elasticities of substitution between imports and domestic products and the base year ad valorem levels of protection.<sup>2</sup> Industries 31, 32, 39, 68 and 73 are the strongest gainers. All have base year ad valorem tariff rates of 25 per cent or greater and in each category the elasticity of substitution between imports and domestic sources is 2.0 or greater. Of these five, only industry 39 (Footwear) faces an import share in its market smaller

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1. See DPRS, pp. 249-53 for a detailed description of the latter results.
  2. The values of these parameters which were used in the simulation are in DPRS, Tables 7 and 13(b).

than 30 per cent. Its import share is only about 10 per cent but, offsetting this, it faces the largest of the substitution elasticities -- 6.8.

The main losers from the tariff increase are projected to be the export industries or those industries whose major customers are export industries. As suggested above, the effect of the tariff on the export dependent sector is to induce a cost-price squeeze. Tariff increases, especially when combined with wage indexation, are inflationary in the domestic economy and exporters find it hard to pass on increased domestic costs to their overseas customers. Industries 1-3, 11-14, 18, 25, 30, 63 and 64 are all major exporters, changes in whose export levels are determined endogenously. Industries 4-6, 9, 49, 76 and 93-6, on the other hand, are not direct export industries but are heavily dependent for their sales on customers in the export sector. The industries in these two groups generally show relatively large negative output responses in Table 4.2.

Most of the remaining industries, including almost all of the non-traded sector, experience approximately average output effects as shown in Table 4.2. Various inter industry connections explain the variation in output responses within this group.

The importance of fixed factors in influencing these short run output results should, finally, be noted. This is most evident with respect to the export related industries. In general the outputs of the agricultural exporters contract less strongly than do those of the non-rural export industries. In this simulation both capital and agricultural land were held constant with the result that the land using industries (1-7) are on average more fixed factor intensive than the rest of the

Table 4.2 Projections of the Effects of a 1 Per Cent Across the Board Tariff  
Increase on Industry Activity Levels

Industry	Projection	Industry	Projection
1. Pastoral Zone	-0.0286	57. Glass	0.0205
2. Wheat-Sheep Zone	-0.0286	58. Clay Products	0.0054
3. High Rainfall Zone	-0.0562	59. Cement	-0.0052
4. Northern Beef	-0.0431	60. Ready-Mixed Concrete	0.0043
5. Milk Cattle and Pigs	-0.0179	61. Concrete Products	0.0013
6. Other Farming Export	-0.0560	62. Non-Metal Mineral Products	0.0080
7. Other Farming Import Competing	-0.0110	63. Basic Iron and Steel	-0.0859
8. Poultry	-0.0153	64. Other Basic Metals	-0.0889
9. Services to Agriculture	-0.0363	65. Structural Metal	0.0192
10. Forestry	-0.0164	66. Sheet Metal Products	0.0197
11. Fishing	-0.1002	67. Metal Products n.e.c.	0.0614
12. Iron	-0.0110	68. Motor Vehicles, Parts	0.1048
13. Other Metallic Minerals	-0.0731	69. Ship and Boat Building	-0.0487
14. Coal	-0.1437	70. Locomotives	-0.0299
15. Crude Oil	-0.0053	71. Aircraft Building	0.0081
16. Non-Metallic Minerals n.e.c.	-0.0088	72. Scientific Equipment	0.0107
17. Services to Mining	-0.0096	73. Electronic Equipment	0.0964
18. Meat Products	-0.0493	74. Household Appliances	0.0371
19. Milk Products	0.0002	75. Electrical Machinery	0.0332
20. Fruit and Vegetable Products	0.0073	76. Agricultural Machinery	-0.0726
21. Margarine, Oils and Fats	0.0081	77. Construction Equipment	-0.0057
22. Flour and Cereal Products	-0.0047	78. Other Machinery	0.0240
23. Bread, Cakes	0.0004	79. Leather Products	0.0721
24. Confectionery	0.0214	80. Rubber Products	0.0277
25. Food Products n.e.c.	-0.1330	81. Plastic Products	0.0334
26. Soft Drinks, Cordials	0.0028	82. Signs, Writing Equipment	0.0341
27. Beer and Malt	0.0011	83. Other Manufacturing	0.0168
28. Alcoholic Drinks n.e.c.	0.0693	84. Electricity	-0.0030
29. Tobacco	0.0050	85. Gas	0.0056
30. Prepared Fibres	-0.0400	86. Water, Sewerage	-0.0027
31. Man-Made Fibres, Yarn	0.0923	87. Residential Building	0.0000
32. Cotton, Silk, Flax	0.1266	88. Building n.e.c.	0.0070
33. Wool and Worsted Yarns	0.0259	89. Wholesale Trade	-0.0097
34. Textile Finishing	0.0287	90. Retail Trade	-0.0029
35. Textile Floor Covers	0.0205	91. Motor Vehicle Repair	-0.0110
36. Textile Products n.e.c.	0.0299	92. Other Repairs	-0.0093
37. Knitting Mills	0.0261	93. Road Transport	-0.0204
38. Clothing	0.0310	94. Railway Transport	-0.0398
39. Footwear	0.1043	95. Water Transport	-0.0183
40. Sawmill Products	0.0043	96. Air Transport	-0.0078
41. Plywood, Veneers	0.0390	97. Communication	-0.0012
42. Joinery and Wood Products	0.0084	98. Banking	-0.0010
43. Furniture, Mattresses	0.0196	99. Finance and Life Insurance	-0.0004
44. Pulp, Paper	0.0124	100. Other Insurance	-0.0015
45. Fibreboard	0.0074	101. Investment, Real Estate	-0.0007
46. Paper Products n.e.c.	0.0115	102. Other Business Services	-0.0035
47. Newspapers and Books	-0.0060	103. Ownership of Dwellings	0.0000
48. Commercial Printing	0.0110	104. Public Administration	0.0001
49. Chemical Fertilisers	-0.0277	105. Defence	0.0000
50. Industrial Chemicals	0.0402	106. Health	0.0000
51. Paints, Varnishes	0.0251	107. Education, Libraries	0.0002
52. Pharmaceuticals	0.0209	108. Welfare Services	-0.0005
53. Soap and Detergents	0.0035	109. Entertainment	-0.0088
54. Cosmetics, Toiletry	0.0096	110. Restaurants, Hotels	-0.0003
55. Chemical Products n.e.c.	0.0333	111. Personal Services	-0.0005
56. Oil and Coal Products	-0.0053	112. Business Expenses	-0.0013

economy. In the short run fixed factors inhibit output flexibility. Only variable factor costs can be saved (or will increase) if output is cut (or increased) in the short run. The relative stability of the output of the exporting but extremely capital intensive Iron industry (12) is another good example of this phenomenon.<sup>1</sup>

#### 4.3.2 The agricultural sector

The modifications introduced into the 1978 version of ORANI do not have a great effect on the projected responsiveness of the agricultural sector as a whole to tariff changes. The tariff increase is slightly more inflationary in ORANI 78 than it was in ORANI 77 owing to the revised treatment of commodity taxes. Consequently agriculture as a whole is slightly more severely affected. What is added to the model by the CRETH respecification of agriculture is much more reliable detail about what happens within the agricultural sector.

Each of the three regional multi-product agricultural industries in Table 4.2 (industries 1-3) is projected to suffer a significant decline in output as a consequence of the tariff increase. All produce mixes of mainly export oriented, agricultural commodities<sup>2</sup> and are subject to comparable cost price squeezes following the inflationary increase in protection levels. The projected fall in output in both the

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1. In DPRS we provide, as well as a general description, a more formal, regression analysis of the output results from the ORANI 77 simulation of the effects of the tariff increase. Explanatory variables representing fixed factor intensity, export dependence and the usual effective protection measures together accounted for 87 per cent of the variance in the output results across industries. See DPRS, pp.253-9.
  2. See Table 3.1.

Pastoral Zone (industry 1) and the Wheat-Sheep Zone (industry 2) is about 0.029 per cent. In the High Rainfall Zone (industry 3) however the projected fall is 0.056 per cent. This difference can be seen as due to the greater labour intensity of production in the High Rainfall Zone as compared to the other two. The CES production functions employed in ORANI<sup>1</sup> imply short-run industry supply functions of the form

$$z_j = \frac{\sigma_j S_{Lj}}{1 - S_{Lj}} (p_j - w_j) , \quad (4.1)$$

where  $z_j$  is the percentage change in the output of industry  $j$ ,

$p_j$  is the percentage change in the unit price of value added in industry  $j$ ,

$w_j$  is the percentage change in the cost per unit of labour in industry  $j$ ,

$\sigma_j$  is the elasticity of substitution between primary factors in industry  $j$ ,

and  $S_{Lj}$  is the share of labour in primary factor cost in industry  $j$ .

Short run output flexibility is therefore positively related to the share of the variable factor (labour) in primary costs. The values of  $\frac{\sigma_j S_{Lj}}{1 - S_{Lj}}$ , with  $\sigma_j = 0.5$  for all industries, is 0.185 for the Pastoral and Wheat-Sheep Zones but 0.320 for the High Rainfall Zone.

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1. See DPRS, sections 2 and 3. ORANI 78 is specified to accommodate CRESH (see Hanoch [1971]) production functions. Attempts to estimate parameters for the CRESH system at a disaggregated level have not been successful (see Vincent, Dixon and Powell [1978]) and in the present version of the model a common value 0.5 for the elasticity of substitution between labour, land and capital was used. Hence CRESH collapses to CES. Within the IMPACT project, different pairwise elasticities of substitution between labour, land and capital have been estimated for the agricultural sector as a whole. See Vincent [1977] and Ryland and Vincent [1978].

The Northern Beef industry (industry 4) produces only meat cattle,<sup>1</sup> almost all of which is sold to intermediate usage in industry 18 (Meat Products). Since there are no competing imports, the input of domestically produced meat cattle must expand proportionately with the output of the Meat Products industry. The projected percentage decrease in the output of the Northern Beef industry (0.043 per cent) is however slightly less than the output fall projected for the Meat Products industry (0.049 per cent). The Northern Beef industry has slightly increased its share of the meat cattle market at the expense of the Pastoral Zone and the High Rainfall Zone which, as is shown in section 4.3.3 below, substitute away from meat cattle in their product mixes.

Industry 5 (Milk Cattle and Pigs) is projected to reduce its output by 0.018 per cent. It produces, in fixed proportions, meat cattle (commodity 6) and milk cattle and pigs (commodity 7).<sup>2</sup> The former is, once again, sold almost entirely to industry 18. The Milk Cattle and Pigs industry has also increased its share of the meat cattle market. Commodity 7 is sold as an intermediate input to industries 18 and 19 (Milk Products). The latter, which sells primarily to household consumption experiences almost no change in output. As noted earlier, the former decreases its output, and therefore its demand for inputs of commodity 7, by 0.049 per cent. Industry 5 is the predominant producer of this commodity,<sup>3</sup> sales of which to industry 18 account for about 35 per cent of its total sales. The decrease in intermediate demand for

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1. See Table 3.1.

2. See Table 3.1.

3. See Table 3.2.

commodity 7 by industry 18 therefore accounts for almost all of the projected 0.018 per cent fall in the production of the commodity by industry 5.<sup>1</sup>

Industry 6 (Other Farming Export) is projected in Table 4.2 to experience an output contraction of 0.056 per cent following the tariff increase. The industry produces only commodity 8 (other farming export)<sup>2</sup> and accounts for more than 87 per cent of the total output of that commodity.<sup>3</sup> A reduction of about 0.13 per cent in its sales to industry 25 (Food Products n.e.c.), mainly sugar for refining, and an increase of 0.018<sup>4</sup> per cent in the household consumption of commodity 8 account for most of the change in the output of industry 6. Sales to industry 25 constitute 45 per cent of total sales and sales to consumption about 26 per cent.<sup>5</sup>

The projected output fall in Table 4.2 for industry 7 (Other Farming Import Competing) is 0.011 per cent. It produces only, and is the predominant producer of, commodity 9 (other farming import competing).<sup>6</sup> This commodity enjoys a high level of protection (39 per cent) in the base period but is not subject to effective import competition. The main import competing product included in this commodity category is tobacco leaf. This accounts for the 11 per cent of the sales of domestically produced commodity 9 going to industry 29

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1. Note that  $-0.049 \times .35 = -0.017$ .

2. See Table 3.1.

3. See Table 3.2.

4. Results for household consumption by commodity are available from the authors.

5. Note that  $-0.13 \times .45 + .018 \times .26 = 0.06$ .

6. See Tables 3.1 and 3.2.

(Tobacco). For institutional reasons the tobacco processing industry does not vary its mix of inputs between domestic and foreign sources in response to relative prices. The elasticity of substitution between imported and domestic supplies of commodity 9 is therefore set at close to zero in the model.

The sales of commodity 9 are generally more diverse than those of the other products produced by the agricultural sector. About 53 per cent of total sales of commodity 9 is absorbed into intermediate usage and the remainder into household consumption. Our simulation projects a small increase in sales to consumption (0.0045 per cent) since the basic value price of the commodity increases by only 0.056 per cent<sup>1</sup> compared to an overall increase in consumer prices of 0.088 per cent.<sup>2</sup> The negative result for the output of industry 7 is explained primarily by its intermediate sales to industries 2, 3, 5, 25 and 30 which collectively account for almost 20 per cent of total sales. Each of these purchasing industries experiences a marked decline in its output level.<sup>3</sup>

The final industry in ORANI's agricultural sector is industry 8 (Poultry). The projected fall in its output (0.015 per cent) is accounted for by the reduction in the demand for inputs to industry 18. Sales to industry 18 account for 32 per cent of the total sales of poultry and the output of that industry falls by about

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1. See Table 4.3.

2. See Table 4.1.

3. See Table 4.2.

0.05 per cent as noted above.<sup>1</sup> Sales to final consumption account for most of the remaining sales of poultry (62 per cent). Consumption of poultry is projected to remain almost static.

#### 4.3.3 Agricultural commodities by industry : the CRETH results

Recall from section 3.2 that, under the CRETH specification of production possibilities within the three agricultural zones, commodity outputs by industry are determined according to equation (3.4)<sup>1</sup>. Table 4.3 contains projected percentage changes in agricultural commodity outputs in aggregate and by industry (the  $y_i(j)$ ). Also included in the table are projected percentage changes in the basic-value prices of the commodities (the  $p_t$ ) and projected percentage changes in the industry outputs (the  $z_j$ ) which are taken from Table 4.2.

The basic value commodity prices are equivalent to farm gate prices. That is they represent prices received by the producer and exclude the margins (trade, transport and commodity taxes) which are included in the prices paid for the commodities by users.<sup>2</sup> These margins are explicitly modelled in ORANI.<sup>3</sup> The importance of an explicit treatment of them in the model's price accounting system can be illustrated using the results presented in Table 4.2.

Consider first commodity 1 (wool) which is almost all exported either directly or indirectly via sales to the export

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1. Note that  $0.05 \times .32 = 0.016$ .

2. For the case of exports user or purchasers' prices are defined as prices at port of exit.

3. See DPRS, pp. 55-72.

Table 4.3 Agricultural Commodity Outputs and Prices

Commodity	Pastoral Zone	Wheat-Sheep Zone	High Rainfall Zone	Aggregate Output	Commodity Prices (basic values)
1. Wool	-0.0260	-0.0179	-0.0551	-0.0330	0.0152
2. Sheep	-0.0260	-0.0380	-0.0629	-0.0448	-0.0607
3. Wheat	0.0088	-0.0365	-0.0325	-0.0345	-0.0255
4. Barley	0.0088	-0.0314	-0.0305	-0.0311	-0.0260
5. Other cereal grains	0.0088	0.0044	-0.0305	0.0020	-0.0362
6. Meat cattle	-0.0753	-0.0448	-0.0746	-0.0478	-0.0518
7. Milk cattle and pigs		0.0044	-0.0305	-0.0170	0.0515
8. Other farming export		0.0044	-0.0305	-0.0515	-0.0037
9. Other farming import competing	0.0088	0.0044		-0.0100	0.0557
Industry output <sup>(a)</sup> ( $z_j$ )	-0.0286	-0.0286	-0.0562		
CRETH weighted industry prices <sup>(b)</sup>	-0.0229	-0.0206	-0.0029		

(a) Note that the share weighted sum of the changes in commodity outputs in each zone (where the shares are shares in base year zone outputs) equals the change in the output of the zone.

(b) These are defined by the term  $\sum_q p_q^{(j)} R_q^{*(j)}$ . See equation (3.4)<sup>(b)</sup>.

industry 30 (Prepared Fibres). Since the level of exports for commodity 1 is determined endogenously in these results, its domestic price is controlled by the world price via equations (4.3) and (4.4).,

$$p_i^e = -\gamma_i x_i^{(4)} \quad (4.3)$$

$$p_i^e = S_{BVi} p_{i1} + S_{mi} p_m, \quad (4.4)$$

where

$p_i^e$  is the percentage change in the at port export price of commodity  $i$ ,

$x_i^{(4)}$  is the percentage change in the level of exports of commodity  $i$ ,

$p_{i1}$  is the percentage change in the basic value price of commodity  $i$ ,

$p_m$  is the percentage change in the price of margins services,

$\gamma_i$  is the reciprocal of the foreign elasticity of demand for commodity  $i$  and  $S_{BVi}$  and  $S_{mi}$  are, respectively, the shares of basic value and margins in the at port export value of a unit of commodity  $i$ .

Table 4.4 shows the projected percentage changes in export volumes (the  $x_i^{(4)}$ ) for the endogenous export commodities. The reduction in the volume of exports of commodity 1 (0.034 per cent)<sup>1</sup> is

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1. The other main sale of wool is to industry 30 which, in the absence of an import source for its wool inputs, will reduce its demand for domestic wool by a percentage amount equal to the reduction in its output (0.04 from Table 4.2). Notice that this reduction plus the reduction in exports account for almost all of the reduction in the aggregate output of wool shown in Table 4.3. That is

$$\begin{aligned} y_1 &= S_{30}^{(1)} y_{1,30}^{(1)} + S^{(4)} x_1^{(4)} \\ &= 0.10 \times -0.04 + 0.88 \times -0.034 = -0.034 \end{aligned}$$

since the share of the sales of wool absorbed by industry 30  $\left( S_{30}^{(1)} \right)$  is about 0.10 and the share absorbed by exports is about 0.88.

Table 4.4 Reciprocals of Export Demand Elasticities ( $\gamma_j$ ) and Projected Effects of a 1 Per Cent Across the Board Tariff Increase on Export Levels

Commodity	$\gamma_j$	Projection
1. Wool	0.77	-.0338
3. Wheat	0.08	-.0343
4. Barley	0.05	-.0482
5. Other cereal grains	0.05	.1035
13. Fishing	0.05	-.1875
14. Iron	0.05	.0319
15. Other metallic minerals	0.05	-.0378
16. Coal	0.05	-.3663
20. Meat products	0.06	-.1942
27. Food products n.e.c.	0.05	-.4530
32. Prepared fibres	0.38	-.1092
65. Basic iron and steel	0.05	-.6683
66. Other basic metals	0.05	-.2722

associated, via equation (4.3), with a rise in its at port export price ( $p_1^e$ ) of 0.026 per cent. If we assume that the costs of selling and delivering wool to the wharf have risen in line with the domestic consumer price index (i.e., assume  $p_m = 0.088$ ) then, from equation (4.4), it follows that the farm gate price of wool must have

risen by about 0.016 per cent.<sup>1</sup> This is confirmed by Table 4.3.

Pursuing a similar chain of reasoning for commodity 3 (wheat) we are able to explain the prima facie surprising result that, although the output and export volumes of wheat have fallen, the farm gate price of wheat is projected to decline. Since the elasticity of export demand for wheat is assumed to be greater than that for wool,<sup>2</sup> the rise in the at port export price of wheat induced by the fall in its export volume is smaller than was the case for wool.<sup>3</sup> In addition the share of margins in the at port price of wheat ( $S_{m3}$ ) is 0.29, significantly higher than was the case for wool. Given this, equation (4.4) indicates that, assuming once again a rise in the price of margins of the same order as the rise in the general price level, the farm gate price of wheat actually falls.<sup>4</sup> The rise in the cost of transferring wheat from the farm to the port more than absorbs the

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1. The value for  $S_{BV1}$  is 0.86 and that for  $S_{m1}$  is 0.14 so that

$$\begin{aligned} P_{11} &= \frac{P_1^e - S_{m1} P_{m1}}{S_{BV1}} \\ &= \frac{0.026 - 0.14 \times 0.088}{0.86} = 0.016 . \end{aligned}$$

2. See Table 4.4.

3. In fact, from equation (4.3),  $p_3^e = -\gamma_3 x_3^{(4)} = 0.003$  .

4. That is, from (4.4)

$$\begin{aligned} P_{13} &= \frac{P_3^e - S_{m3} P_m}{S_{BV3}} \\ &= \frac{0.003 - .29 \times 0.088}{0.71} = -0.03 . \end{aligned}$$

slight increase in the at port price. The movements shown in Table 4.3 in the basic value prices of the remaining agricultural commodities can be explained in analogous ways.

We turn now to the results for commodity outputs by industry which reflect the operation of the CRETH product - product transformation triggered by the relative changes in the farm gate prices of the commodities. Results for each zone will be considered in turn.

(a) Pastoral Zone

Recall from section 3.3.2 that, for the Pastoral Zone (industry 1), CRETH was estimated for three product groups: wool/sheep, meat cattle and other products. Within each group, individual commodities are assumed to be produced in fixed proportions so that in Table 4.3 the projected percentage change in output is the same for each component of a commodity group. For example, the output of wool and sheep in the Pastoral Zone are both projected to decline by 0.026 per cent. Using equation (3.4)' (c), basic values price changes for the commodity groups in the Pastoral Zone are as follows: wool/sheep 0.0023 per cent, meat cattle -0.0518 per cent, other products -0.0146 per cent. That is the price at the farm gate of wool/sheep has risen relative to the prices of both the other groups. The extent of price induced product transformation, however, will depend on the ease of transformation between products as well as the relative price change. For example, consider the wool/sheep result. In equation (3.4)' (b), the difference between the price of wool/sheep and the CRETH share weighted prices of the three product groups  $(p_r(1) - \sum_q p_q(1) R_q^*(1))$  is +0.0252, i.e., moderately favourable to wool/sheep. However, the estimated transformation parameter,  $\phi$ , for wool/sheep is 0.1041.<sup>1</sup> That is, trans-formation elasticities between wool/sheep and the other two product groups

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1. See Table 3.4.

are low. Hence the positive contribution to wool/sheep output from the relative price change in favour of wool/sheep is negligible and the net effect is a contraction in wool and sheep output only a little less than the contraction in the output of the zone. In the case of cattle however the term  $(p_r(1) - \sum_q p_q(1) R_q^*(1))$  is  $-0.0289$  and the transformation parameter,  $\phi$ , is  $1.6129$ , hence the larger contraction in output from the unfavourable relative price change and the overall output contraction considerably in excess of the contraction in the output of the zone. For the 'other' category of commodities, the price of which has fallen relative to wool/sheep and increased relative to cattle, the CRETH relative price term  $(p_r(1) - \sum_q p_q(1) R_q^*(1))$  is  $+0.0083$  i.e. slightly favourable to 'other products' and the transformation term is large ( $\phi = 4.5455$ ). (It will be recalled from section 3.3.3 that transformation possibilities are comparatively high between the 'other products' category and competing products). Hence the favourable output response from the relative price induced transformation towards other products is large and the net effect is an expansion in the 'other products' commodities.

(b) Wheat-Sheep Zone

Only one composite commodity group (other products) was necessary for the estimation of CRETH parameters for the Wheat-Sheep Zone. The weighted average price increase for this other products group is, via equation (3.4)' (c),  $0.0045$  per cent. The remaining product classifications for this zone consist of single commodities so that the relevant basic value price changes can be read directly from Table 4.3.

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1. See section 3.3.3.

As remarked earlier, the Wheat-Sheep Zone is the classic example in the Australian context of a multi-product, agricultural industry. Table 3.4 reveals that transformation possibilities are much more uniform here than in the other two zones. Nevertheless the influence of the comparatively high values of the transformation parameters ( $\phi$ ) for 'other products' and wheat are evident in the results. In the case of 'other products' the combination of a positive price term and a fairly high transformation parameter in equation (3.4)' (b) is sufficient to outweigh the industry activity variable ( $z_j$ ). Although the output of the Wheat-Sheep Zone as a whole falls, its output of 'other products' increases.

(c) High Rainfall Zone

The estimation of CRETH for the High Rainfall Zone once again involved only one composite commodity group. For this zone the weighted average price increase for the composite 'other products' group is 0.0039 per cent. Again the transformation parameter ( $\phi$ ) for 'other products' is significantly higher than others for this zone.<sup>1</sup> For the High Rainfall Zone however, the decline in overall activity is much stronger than for the other two zones.<sup>2</sup> The consequence is that its output of all products declines although a change in product mix in favour of 'other products' is clearly evident in the results.

Before concluding this section, it is interesting to speculate on the plausibility of the results in Table 4.3. To a

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1. See Table 3.4.

2. See section 4.3.2 and Table 4.3.

large extent, the results depend on the estimates of transformation and hence cross-price elasticities between product groups in each zone. These parameter estimates proved reasonably robust.<sup>1</sup> The weakest part of the story is obviously the assumption (forced upon us by the limitations of the data base for estimation) that commodities are produced in fixed proportions in the 'other products' groups. However, in all zones, the commodities in the 'other products' group constitute only a small proportion of total commodity outputs. Thus although the output of wheat in the Pastoral Zone is projected to increase, only 4 per cent of wheat output is produced in this zone. The performance of the wheat commodity as a whole is tied closely to its performance in the Wheat-Sheep Zone, which produces 93 per cent of the crop.

In summary then, these differences in commodity performance across zones reflect the influences of the two most important features of our modelling of the agricultural sector, namely the recognition of regional variations in production technology and region specific transformation possibilities for commodities.

#### 4.3.4. Commodity exports

Projected percentage changes in export volumes for the 13 commodities for which exports are determined endogenously in this simulation are presented in Table 4.4. As explained in section 4.3.2, the tariff increase generates domestic cost increases especially via wage indexation and imposes a cost price squeeze on exporting industries. Export volumes are projected to contract for 11 of the 13 export

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1. See Vincent, Dixon and Powell [1978] for details.

commodities. Agricultural commodity exports generally decline less than non-agricultural exports owing to the greater fixed factor intensity of the land using agricultural industries.

Commodity 5 (other cereal grains) is the only agricultural commodity for which exports expand. The explanation for the expansion is to be found in the CRETH product transformation discussed in the previous section. In all zones, this commodity is part of the 'other products' category. In each zone the product transformation term in equation (3.4) (b) is positive and in two of the zones is sufficient to outweigh the effect of the contraction in zone activity. However, it will be noted that the expansion in commodity 5's exports exceeds the expansion in its output. That is, diversion from domestic sales to exports has taken place. The reason lies in commodity 5's comparatively large sales (58 per cent of total sales) to industry 22 (Flour and Cereal Products) the output of which contracts slightly.

Commodity 14 (iron) is the other commodity for which exports increase. As noted in section 4.3.2, the producing industry (industry 12, Iron) is highly capital intensive so that its short run output flexibility is very limited. Nevertheless the projected output change for the industry is a decline of 0.011 per cent as shown in Table 4.2. Hence some diversion of iron output towards exports has occurred. In the base year, 36 per cent of iron sales were to industry 63 (Basic Iron and Steel), itself the producer of an export commodity, and 63 per cent were to exports. Industry 63 is particularly hard hit by increased

domestic costs following the tariff increase. Both its output and exports contract sharply (Tables 4.2 and 4.4). The consequent fall in the domestic demand for iron induces a fall in the basic value price of iron, via a squeeze on rentals on fixed factors in the Iron industry, sufficient to allow an expansion in iron exports.

## 5. CONCLUDING REMARKS

This paper has demonstrated that quite major modifications can be made, in a piecemeal fashion, to the specification of ORANI. The flexibility which this allows is important from the point of view of adapting the model to the requirements of alternative users. As was explained in section 2.3, our linear computational procedure is crucial in allowing this flexibility.

The revisions to the specification of the agricultural sector which were documented here have significantly increased the realism with which that sector is modelled in ORANI. The input-output treatment of agriculture, which was incorporated into ORANI 77, represents the sector as consisting of single-product, single-technology industries. The CRETH system adopted in ORANI 78, on the other hand, recognises multi-product enterprises and regional differences in technology and allows enterprises to alter their product mixes in response to changes in relative product prices. It is important to note however that the performance of the agricultural sector as a whole is not particularly sensitive to the respecification. The results discussed in section 4 illustrate this. The response of agriculture to the general tariff increase simulated in that section depends primarily on how the sector is linked to the rest of the model rather than on its internal structure. The modifications are nevertheless important from the point of view of capturing changes within the sector. Thus ORANI 78 expands the scope for ORANI applications in a way which should be of special interest to agricultural economists.

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