THE SUPPLY RESPONSE OF AUSTRALIAN AGRICULTURAL EXPORTS

by

Denis Lawrence

Industries Assistance Commission
Canberra, Australia

Contributed Paper to the 34th Annual Conference of the Australian Agricultural Economics Society, Brisbane, 13-15 February, 1990. The views expressed in the paper do not necessarily represent those of the Industries Assistance Commission.

1 INTRODUCTION

Information on the price responsiveness of export supply and import demand is important in determining a country's response to various policy and external price shocks. For instance, the effects of an import tariff or export subsidy are influenced by the magnitude of these trade elasticities. The effects of changes in factor prices (eg. due to favourable taxation treatment or increased unionisation) will depend on the economy's industrial structure and flexibility.

Traditional empirical trade models have typically attempted to model export supply and import demand relations by the use of linear or log-linear functions of real income and the price of traded goods relative to the price of domestic substitutes. In so doing, they have ignored much of the information available on the industrial structure of the economy and the properties of demand systems.

In this paper the influence of the industrial structure of the economy on export supply and import demand is captured by using the GNP function framework first implemented by Kohli (1975, 1978). The GNP function model is in keeping with the neo-classical Heckscher-Ohlin theory of international trade and assumes that the domestic country behaves as a price-taker in both its export and import markets. Prices for exports and imports and the quantities of factors are exogenously given. Export supply and import demand are determined by maximising domestic profit subject to world prices and domestic factor endowments.

Australian exports are divided into 3 groups according to similarities in price movements, the basis of Hicks aggregation. A system of 5 net output equations is then estimated comprising the 3 export supply equations, an import demand equation, and a domestic supply equation. Labour and capital are treated as fixed inputs to the economy. Aggregator functions are then used to produce a more detailed set of elasticity estimates for a total of 10 export and 5 import components. Time-series Balance of Payments and National Accounts data covering the period 1969/70 to 1987/88 are used.

With regard to agriculture, a large body of empirical research points to the production responsiveness of all Australian agricultural outputs being relatively low (Lawrence and Zeitsch 1990). Since most of Australia's agricultural production is exported, the implication from these studies specific to agriculture is that agricultural export supply elasticities could also be expected to be low. The current study provides an opportunity to verify this result using an economy-wide model and data set.

2 GNP FUNCTION METHODOLOGY

The GNP function model assumes that the economy is made up of profit-maximising firms operating under conditions of perfect competition in goods and factors markets. Factors are assumed to be in fixed supply in the short run but to be mobile between firms with their market prices equal to their shadow prices. The aggregate technology is assumed to be characterised by constant returns to scale, free disposal, non-increasing marginal rates of substitution and transformation, and to be bounded from above for given finite factor endowments. The competitive equilibrium can then be represented as the solution to the problem of maximising GNP subject to the available technology, factor endowments, and given output and import prices.

Exports are treated as an output of the production sector, while imports are treated as an input. Treating imports as an input to production may be justified by appealing to the fact that many imports are intermediate inputs and even those imports that are "final" consumer goods still have to go through distribution and retail channels before reaching the consumer. Treating exports as separate goods for which there is no domestic demand is not necessarily restrictive, since domestic consumers may demand other goods from the production sector which are highly or even perfectly substitutable with the goods classified as exports.

While this approach enables us to model export supply and import demand by concentrating on the production sector, not explicitly including the consumption sector which is usually difficult to model, the cost of this procedure is that the resulting model is partial equilibrium in nature. For instance, the price of domestic sales is taken as being exogenous, and it is assumed that firms can sell any amount of domestic sales output at the existing price. Also, no allowance is made for forces that would tend to eliminate disequilibrium in the balance of payments. No attempt is made to explain the process of capital accumulation and the economy is assumed to fully adjust to changes in input and output prices in each period.

The underlying theory for the GNP function model was exposited by Diewert (1974), while the first empirical applications were those of Kohli (1975, 1978, 1983). More recent applications are those of Diewert and Morrison (1986) to US data and Lawrence (1987, 1989) to Canadian data. Lawrence (1990) extends the GNP function framework to allow for costly adjustment of the capital stock.

In this study exports are divided into the following 3 groups;

- Group 1: Meat, dairy produce, fruit, metal ores and metal manufactures;
- Group 2: Grains and sugar; and
- Group 3: Wool, coal, machinery, equipment and services.

These groupings were arrived at on the basis of similarities in price movements over the period, the basis of Hicks aggregation. In addition to the 3 export groups, aggregate imports and domestic sales are treated as variable net outputs (or netputs) in the first stage of estimation. Labour and capital are treated as being in fixed supply to the economy annually. Time-series data for the period 1969/70 to 1987/88 are used. The data are described in more detail in the Appendix.

Denoting netput quantities by the vector x (entries positive for outputs, negative for variable inputs), netput prices by the vector $p >> 0$, and fixed input quantities by the vector z, the production technology can be represented by the following Generalised McFadden (GM) GNP function (Diewert 1985);

$$(1) \quad G(p,z) = \tfrac{1}{2} \Sigma_{i=1}^{4} \Sigma_{j=1}^{4} b_{ij} p_i p_j / p_5 + \Sigma_{i=1}^{5} b_i p_i$$

$$+ \Sigma_{i=1}^{5} \Sigma_{m=1}^{2} c_{im} p_i z_m + (1/2)(\Sigma_{i=1}^{5} \delta_i p_i) \Sigma_{m=1}^{2} \Sigma_{n=1}^{2} d_{mn} z_m z_n$$

$$+ \Sigma_{i=1}^{5} b_{it} p_i t + (\Sigma_{i=1}^{5} \delta_i p_i)(\Sigma_{m=1}^{2} c_{mt} t z_m + (1/2) b_{tt} t^2) ,$$

where the b_{ij} parameters are estimated subject to the following symmetry restrictions;

$$(2) \quad b_{ij} = b_{ji} \text{ for all } i,j=1,\ldots,4;$$

t is an index of technology and the δ_i are exogenous constants set equal to the respective mean netput quantities to conserve degrees of freedom.

The GNP function (1) will be linearly homogeneous and convex in net output prices and monotonically increasing (decreasing) in the prices of variable outputs (inputs). The GM function is superior to earlier flexible forms such as the translog in that curvature conditions can be imposed on the model without loss of flexibility.

By applying Hotelling's (1932) Lemma the following set of net output supply equations is obtained;

$$(3) \quad x_i = b_i + \Sigma_{j=1}^{4} b_{ij} p_j / p_5 + \Sigma_{m=1}^{2} c_{im} z_m + (1/2) \delta_i \Sigma_{m=1}^{2} \Sigma_{n=1}^{2} d_{mn} z_m z_n$$

$$+ b_{it} t + \delta_i (\Sigma_{m=1}^{2} c_{mt} t z_m + (1/2) b_{tt} t^2); \; i=1,\ldots,4;$$

$$(4) \quad x_5 = b_5 - \tfrac{1}{2} \Sigma_{i=1}^{4} \Sigma_{j=1}^{4} b_{ij} p_i p_j / p_5 + \Sigma_{m=1}^{2} c_{5m} z_m + (1/2) \delta_5 \Sigma_{m=1}^{2} \Sigma_{n=1}^{2} d_{mn} z_m z_n$$

$$+ b_{5t} t + \delta_5 (\Sigma_{m=1}^{2} c_{mt} t z_m + (1/2) b_{tt} t^2).$$

The estimating system consists of equations (3) and (4) with vectors of error terms attached and assumed to be independently distributed with a multivariate normal distribution with zero means and covariance matrix Ω. The GNP function (1) is excluded from estimation as it adds no additional information. The system (3) - (4) can be estimated using Zellner's (1962) iterative seemingly unrelated regressions estimator. This can be carried out using the SYSTEM command in SHAZAM (White 1978).

A limitation of applied duality theory models in the past has been the failure of many models to satisfy the necessary curvature conditions. Jorgenson and Fraumeni (1981) attempted to overcome this problem by imposing semi-definiteness conditions on the matrix of second-order coefficients from translog functions. However, this procedure can introduce large biases in the estimated elasticities and hence destroys the constrained translog's flexibility (Diewert and Wales 1987). In the GM case, if the matrix of estimated quadratic terms $B = [b_{ij}]$ is positive semi-definite then the GNP function is globally convex in prices. If B is not positive semi-definite then it can be reparameterised using the Wiley, Schmidt and Bramble (1973) technique of replacing B by the product of a lower triangular matrix and its transpose:

$$(5) \quad B = AA^T \text{ where } A = [a_{ij}];\ i,j=1,\ldots,4;\ \text{and } a_{ij} = 0 \text{ for } i<j.$$

A criticism sometimes made of applied duality models is that they cannot accommodate a sufficiently fine level of commodity disaggregation to be of use for policy purposes. In this study the aggregator function technique of Fuss (1977) is used to further disaggregate the 3 export groups and imports. While not new, the aggregator function technique is now more tractable with the development of functional forms such as the GM which permit imposition of curvature conditions at each stage of the estimation process. The first and second export groups are each divided into 2 components, the third export group into 6 components and imports into 5 components as follows;

Export Group 1	- Meat, dairy and fruit - Metal ores and metal manufactures
Export Group 2	- Grains - Sugar
Export Group 3	- Wool - Coal - Other minerals - Equipment - Other non-rural - Services
Imports	- Food and services - Fuels - Basic materials and chemicals - Textiles, clothing and footwear - Equipment and Other.

The aggregator function procedure relies on the assumption of homogeneous weak separability which implies that optimisation proceeds by a two-stage process. First, the optimal quantities of the relevant aggregates are chosen and then the composition of the aggregates is chosen. The composition of an aggregate is thus independent of both the level and the composition of all other aggregates.

The GNP function can be written as:

$$(6) \quad G(p,z) = G(R,V) \;,$$

where $R = (R_1,\ldots,R_n,\ldots)$, $V = (V_1,\ldots,V_m,\ldots)$, $R_n = R_n(p_n)$, $V_m = V_m(z_m)$ and p_n, z_m belong to p,z, respectively. $R_n(p_n)$ is a price index for the goods in group n and $V_m(z_m)$ is a quantity index for the fixed inputs in m. The transformation function is:

$$(7) \quad T(x,z) = T^*(Y,V) = 0 \;,$$

where $Y = (Y_1,\ldots, Y_n,\ldots)$ and $Y_n(x_n)$ is a quantity index assumed to be linearly homogeneous. It follows that:

$$(8) \quad \max_{x_n} [p_n x_n : Y_n(x_n) = Y_n]$$

$$= Y_n \max_{x_n/Y_n} [p_n x_n/Y_n : Y_n(x_n/Y_n) = 1]$$

$$= Y_n R_n(p_n) \;,$$

where $R_n(p_n)$ is an aggregator function (Woodland 1982). We then have:

$$(9) \quad \begin{aligned} G(p,z) &= \max. [\Sigma_n p_n x_n : T^*(Y_1(x_n),\ldots,V) = 0] \\ &= \max [\Sigma_n R_n(p_n) Y_n : T^*(Y,V) = 0] \\ &= G^*(R,V). \end{aligned}$$

In this study the following GM function is specified for each of the 4 aggregators:

$$(10) \quad R(p,X)/X = \Sigma_{i=1}^{N} e_i p_i + \tfrac{1}{2} \Sigma_{i=1}^{N-1} \Sigma_{j=1}^{N-1} e_{ij} p_i p_j / p_N + \Sigma_{i=1}^{N} e_{it} p_i t$$

$$+ e_{tt}(\Sigma_{i=1}^{N} \beta_i p_i) t^2 \;,$$

where p_i and t are defined as before, X denotes the aggregate quantity of the relevant netput, β_i are exogenous constants set equal to the mean of the ratio of the relevant component quantity to the aggregate quantity of the netput and the e_{ij} have the following symmetry restriction:

$$(11) \quad e_{ij} = e_{ji} \text{ for all } i, j = 1,\ldots,N-1.$$

Profit maximisation implies that the N component quantities per unit of the total netput quantity are given by:

$$(12) \quad x_i/X = e_i + \Sigma_{j=1}^{N-1} e_{ij} p_j / p_N + e_{it} t + e_{tt} \beta_i t^2 + u_i; \quad i=1,\ldots, N-1$$

$$(13) \quad x_N/X = e_N - \tfrac{1}{2} \Sigma_{i=1}^{N-1} \Sigma_{j=1}^{N-1} e_{ij} p_i p_j / p_N^2 + e_{Nt} t + e_{tt} \beta_N t^2 + u_N \;.$$

The quantity of the aggregate netput (X) is obtained as a Divisia index of the N component quantities. The vectors of error terms are again assumed to be independently, multivariate normally distributed with zero means and covariance matrix Ω. If the matrix $C = [c_{ij}]$ is not positive semi-definite then price convexity can be imposed on the model by using the same technique as in (5).

While producers do not have control over the prices of the individual components of the netput, their choice of the mix of components will influence the aggregate price of the netput they face. To allow for this, an instrumental variable is needed for the aggregate prices of the relevant netputs. Following Fuss (1977), the parameters of (12) and (13) are substituted in (10) to obtain an estimate of the aggregate netput price. The overall estimation process thus consists of two steps. First, the netput component equations (12) and (13) are estimated subject to (11). These estimates are then fed into equation (10) to obtain the estimate of the aggregate netput price. In the second stage, this estimate of the netput price is used as an instrumental variable in the estimation of the system (3) and (4) subject to (2). Application of this conditional estimation procedure produces estimates which are full information maximum likelihood.

For simplicity of presentation, only the conventional net output supply elasticities are discussed in this paper. For the GNP function, the elasticities represent the change in the net supply of i with respect to a change in the price of net output j, subject to the quantities of the fixed inputs available. They are given by:

$$(14) \quad E_{ij} = d \ln x_i / d \ln p_j = DP_{ij} p_j / x_i; \quad i,j = 1,\ldots, 7;$$

where DP_{ij} is the second-order price derivative of the GNP function and x_i is the estimated netput quantity obtained from the system of equations (3) and (4).

Two sets of elasticities are obtained for the components of the 3 export groups and imports. From the first stage of estimation, elasticities can be derived using formulae analogous to (14) which give the response subject to the aggregate quantity of the relevant netput being held fixed. By combining these elasticities with the results of the second stage of estimation a set of elasticities for the N components subject to the quantities of the fixed factors being held constant can be derived as follows:

$$(15) \quad \overset{Z}{E}_{ij} = \overset{X}{E}_{ij} + s_j \overset{Z}{E}_{XX},$$

where $\overset{X}{E}_{ij}$ and $\overset{Z}{E}_{XX}$ are the cross-price elasticity between components i and j given a constant quantity of aggregate netput and the own-price elasticity of the aggregate netput for a given quantity of the fixed input respectively. The term s_j is the share of component j in the value of the netput.

TABLE 1 : ESTIMATED NET OUTPUT SUPPLY EQUATIONS[1]

	Coefficient													
	Constant	Second-order price terms (non-linear)				Technology terms		Fixed input terms					Cross terms	
Equation i	b_i	a_{i1}	a_{i2}	a_{i3}	a_{i4}	b_{it}	b_{tt}	c_{iK}	c_{iL}	d_{KK}	d_{LL}	d_{KL}	c_{Kt}	c_{Lt}
Exports 1	10.875 (20.83)	-0.199 (-1.92)	0.066 (0.86)	-0.203 (-1.43)	-0.242 (-0.62)	0.662 (19.77)	0.462 (0.55)	-102.450 (-17.59)	-7.211 (-20.60)	-0.138 (-0.17)	-0.250 (-0.30)	239.760 (36.72)	-8.193 (-7.19)	-1.004 (-22.99)
Exports 2	3.909 (16.56)		-0.131 (-2.16)	0.103 (0.66)	0.277 (0.75)	0.240 (16.37)	"	-39.458 (-13.64)	-2.050 (-14.41)	"	"	"	"	"
Exports 3	10.494 (15.75)			0.134 (1.01)	-0.735 (-4.47)	0.705 (16.84)	"	-110.820 (-13.06)	-6.985 (-16.07)	"	"	"	"	"
Imports	-26.084 (-24.70)		Symmetric		0.000 (0.00)	-1.621 (-24.76)	"	259.670 (36.85)	15.096 (19.97)	"	"	"	"	"
Domestic Supply	83.658 (34.29)					5.212 (29.02)	"	-830.59 (-76.36)	-51.521 (-21.57)	"	"	"	"	"
System log likelihood			223.150											

1 t-statistics in parentheses.

3 PRODUCTION RESPONSE RESULTS

In this section results are initially presented for the second-stage of estimation, ie the GNP function system. Following this the results for the 3 export groups and imports obtained from the first stage of estimation are discussed.

Initial estimation of the system of net output supply equations ((3) and (4) subject to (2)) produced estimates which failed to satisfy the convexity in prices property with 2 eigenvalues of the matrix B = $[b_{ij}]$ being negative. Most of the estimated own-price elasticities from this system were, however, of the correct sign. Subsequent estimation of the system was undertaken imposing positive semi-definiteness on the B matrix using equation (5). The non-linear regression algorithm of the SHAZAM package (White 1978) was used with starting values set equal to the mean of the dependent variable for the constant terms and zero for all other coefficients. The constrained system estimates are presented in Table 1.

The matrix of net output supply elasticities (evaluated at the means of the exogenous variables) is presented in Table 2. The results indicate that the supply of all 3 export groupings is relatively inelastic while the demand for imports is relatively elastic. Export group 1 consisting of meat products, agricultural exports nec, metal ores and metal manufactures has the lowest supply elasticity with a value of 0.12. Grains and sugar exports have a supply elasticity of 0.25 as does the third export grouping consisting of wool, coal, other minerals, manufactures and services exports.

TABLE 2: NET OUTPUT SUPPLY ELASTICITIES, EVALUATED AT MEANS OF EXOGENOUS VARIABLES

		With Respect to Price of:				
		Exports 1	Exports 2	Exports 3	Imports	Domestic Supply
Change in Quantity of:	Exports 1	0.121	-0.044	0.159	0.191	-0.427
	Exports 2	-0.136	0.245	-0.360	-0.706	0.958
	Exports 3	0.115	-0.084	0.255	-0.077	-0.210
	Imports	-0.068	0.080	0.038	-1.233	1.183
	Domestic Supply	-0.049	0.035	-0.033	-0.383	0.430

The inelastic supply response of Australia's exports is not surprising given the predominance of rural and mining resource-based industries which typically have long lead times involved in adjusting output levels, particularly under the assumptions of this model of fixed aggregate levels of capital and labour each period. Import levels, on the other hand, can be adjusted more quickly and scope exists to substitute between imported and domestic sources of supply leading to an elastic own-price demand elasticity for imports of -1.23. The domestic supply own-price elasticity of 0.43 reflects the fact that Australian domestic supply is largely made up of products whose output can be varied more readily in response to price changes than can those products destined for export.

Turning to the cross elasticities in Table 2, it can be seen that meat and metal exports are slightly substitutable with grain and sugar exports, reflecting their competition for resources, but complementary with exports group 3. This would reflect, among other things, the close relationship between meat and wool exports. Meat and metals exports are also substitutable with domestic supply but an increase in imports prices leads to a small increase in meat and metals exports as the competing exports group of grains and sugar is strongly disadvantaged by the import price increase. Grains and sugar exports are in turn substitutable with exports group 3 but relatively complementary with domestic supply. An increase in import prices leads to a small decrease in exports group 3 while these exports are substitutable with domestic supply production. Finally, domestic supply appears to be a relatively intensive user of imports as an increase in the price of domestic supply leads to a more than proportionate increase in the quantity of imports.

Putting these elasticities into context it can be seen that a 10 per cent across-the-board import tariff would have the effect of reducing production of grains and sugar exports by 7 per cent and domestic supply production by 4 per cent. Exports of wool, coal, manufactures and services, etc in Group 3 would also fall but by less than 1 per cent while meat and metals exports would actually increase by 2 per cent, presumably because they are the least intensive users of imports. Due to the elastic demand for imports, the quantity of imports would fall by more than 12 per cent following imposition of the tariff.

A more complete set of elasticities characterising the economy's production relationships such as the intensity with which the various outputs use the fixed inputs labour and capital and the effects of changes in the shadow prices of these fixed factors can be derived from this model (McKay, Lawrence and Vlastuin 1982). However, the focus of this paper is on the conventional net supply elasticities and to this end aggregator functions for the 3 exports groups and imports were estimated. The estimated GM aggregator functions for the 3 export groups with curvature conditions imposed are presented in Table 3. The aggregator functions differ in format to the GNP function system presented in Table 1 due to the imposition of constant returns to scale with respect to the aggregate quantity of the relevant export group.

TABLE 3: ESTIMATED UNIT EXPORT AGGREGATOR EQUATIONS[1]

Export Group 1		Coefficient		
Equation i	e_i	a_{11}	e_{it}	e_{tt}
Meat & Ag. nec	0.357	0.193	0.000	-0.000
	(9.29)	(2.16)	(0.19)	(-6.02)
Metals	0.613		0.006	"
	(26.49)		(5.67)	
System Log Likelihood		123.16		

Export Group 2		Coefficient		
Equation i	e_i	a_{11}	e_{it}	e_{tt}
Grains	0.715	-0.180	-0.000	-0.000
	(22.96)	(-2.18)	(-0.12)	(-0.07)
Sugar	0.266		-0.002	"
	(12.96)		(-1.28)	
System Log Likelihood		102.74		

Export Group 3				Coefficient				
Equation i	e_i	a_{i1}	a_{i2}	a_{i3}	a_{i4}	a_{i5}	e_{it}	e_{tt}
Wool	0.270	0.161	-0.013	-0.017	0.138	0.079	-0.008	-0.000
	(11.69)	(5.02)	(-0.215)	(-1.57)	(1.71)	(1.29)	(-5.27)	(-0.87)
Coal	0.088		-0.157	-0.015	0.059	0.150	0.005	"
	(4.81)		(-3.97)	(-1.04)	(0.69)	(2.39)	(6.92)	"
Other Minerals	0.018			0.000	-0.000	0.000	0.001	"
	(4.91)			(0.00)	(-0.00)	(0.00)	(4.13)	
Equipment	0.085				-0.000	-0.000	-0.002	"
	(2.32)				(-0.00)	(-0.00)	(-2.66)	
Other Non-rural	0.074	Symmetric				-0.000	0.004	"
	(3.36)					(-0.00)	(4.22)	
Services	0.431						0.000	"
	(12.58)						(0.142)	
System Log Likelihood		360.73						

1 t-statistics in parentheses.

TABLE 4: EXPORT GROUP 1 ELASTICITIES SUBJECT TO FIXED AGGREGATE CAPITAL AND LABOUR, EVALUATED AT MEANS OF EXOGENOUS VARIABLES

		With Respect to Price of:	
		Meat & Agriculture nec	Metal Ores & Manufactures
Change in Quantity of:	Meat & Agriculture nec	0.148	-0.027
	Metal Ores & Manufactures	-0.017	0.138

Only the elasticities calculated from equation (15) which show the response of the export group's components subject to the constraint of a fixed supply of labour and capital are presented to conserve space. The component elasticities for export group 1 are presented in Table 4. In this case neither of the component own-price elasticities differ greatly from the own-price elasticity for the group as a whole obtained from the GNP function. The supply of exports of both meat and agriculture nec, and metal ores and manufactures is very inelastic with own-price elasticities close to 0.15. As indicated earlier, this result is not surprising given the long lead times involved in making significant changes to the supply of either of these products. There is only a weak cross relationship between the supply of these components.

TABLE 5: EXPORT GROUP 2 ELASTICITIES SUBJECT TO FIXED AGGREGATE CAPITAL AND LABOUR, EVALUATED AT MEANS OF EXOGENOUS VARIABLES

		With Respect to Price of:	
		Grains	Sugar
Change in Quantity of:	Grains	0.223	0.021
	Sugar	0.064	0.181

The component elasticities for export group 2 are presented in Table 5. Again the grains and sugar own-price elasticities are both close to the value of the aggregate's own-price elasticity with values of 0.22 and 0.18, respectively. As is to expected there is again a weak cross relationship between the export supply of these two commodities. It should be noted that in the case of the equation (15) elasticities the rows of Tables 4, 5, 6 and 8 sum to the value of the corresponding aggregate own-price elasticity in Table 2 and not to zero as is the case with most conventional net supply elasticities.

TABLE 6: EXPORT GROUP 3 ELASTICITIES SUBJECT TO FIXED AGGREGATE CAPITAL AND LABOUR, EVALUATED AT MEANS OF EXOGENOUS VARIABLES

		With Respect to Price of:					
		Wool	Coal	Other Minerals	Equip.	Other Non-Rural	Services
Change in Quantity of:	Wool	0.164	0.033	-0.021	0.128	0.103	-0.151
	Coal	0.038	0.324	0.070	-0.062	-0.186	0.071
	Other Minerals	-0.079	0.226	0.087	-0.139	-0.169	0.329
	Equipment	0.263	-0.111	-0.078	0.254	0.264	-0.337
	Other Non-Rural	0.151	-0.238	-0.067	0.188	0.305	-0.084
	Services	-0.102	0.042	0.060	-0.110	-0.039	0.405

More variability of the component own-price elasticities relative to the corresponding aggregate elasticity is found in export group 3, as indicated in Table 6. Wool's own-price elasticity is of the same order of magnitude as most of the other rural products with a value of 0.16. Coal, on the other hand, shows more price responsiveness than the other minerals with an own-price elasticity of 0.3. This is consistent with the large-scale, open cut nature of most coal mines and the scope to vary supplies from existing mines to a greater extent. The Other Minerals component shows little price responsiveness with an elasticity of less than 0.1. The non-resource-based export activities of equipment, non-rural nec, and services all show some degree of price responsiveness with values of 0.25, 0.3 and 0.4, respectively. Most of the cross relationships between these components are relatively small, although some degree of complementarity exists between equipment and non-rural nec, and between services and other minerals. Some substitutability exists between services and equipment exports.

If coal prices were to increase by 10 per cent then coal exports would increase by over 3 per cent in the short run while minerals nec exports would also go up by over 2 per cent. Exports of non-rural nec products and equipment would fall by over 2 per cent and over

1 per cent, respectively, while exports of wool and services would remain largely unchanged.

TABLE 7: ESTIMATED UNIT IMPORT AGGREGATOR EQUATIONS[1]

Equation i				Coefficient			
	e_i	a_{i1}	a_{i2}	a_{i3}	a_{i4}	e_{it}	e_{tt}
Food & Services	-0.535 (-4.71)	0.545 (5.26)	-0.009 (-2.08)	-0.171 (-3.15)	0.038 (0.67)	0.005 (3.58)	0.001 (6.86)
Fuels	-0.039 (-10.58)		0.029 (3.48)	0.101 (2.58)	-0.015 (-0.56)	0.001 (7.06)	"
Materials & Chemicals	-0.067 (-3.06)			-0.000 (0.00)	0.000 (-0.00)	0.000 (0.05)	"
Clothing	-0.080 (-3.03)	Symmetric			0.000 (-0.00)	0.001 (3.24)	"
Equipment	-0.378 (-6.33)					0.004 (-2.05)	"
System Log Likelihood			357.70				

1 t-statistics in parentheses.

The estimated unit aggregator equations for the 5 import components are presented in Table 7. The corresponding matrix of elasticities appears in Table 8. Again there is considerable variation in the component own-price elasticities. Food and services imports show the most elastic demand response followed by equipment imports. Fuel imports have a relatively inelastic responsiveness, while clothing imports appear to be very inelastic. Materials and chemicals show some responsiveness with an own-price elasticity of -0.4.

Complementarity is the predominant relationship existing between the import components. In particular, imports of equipment, and materials and chemicals are relatively complementary with a cross elasticity of -1.0. Equipment imports are also complementary with fuel and clothing imports. Materials and services imports are substitutable with fuel imports. The predominance of complementarity relationships among the import components means that increases in the price of any one component, such as that resulting from the imposition of a selective tariff, will generally be associated with a decline in the demand for most imports.

TABLE 8: IMPORT ELASTICITIES SUBJECT TO FIXED AGGREGATE CAPITAL AND LABOUR, EVALUATED AT MEANS OF EXOGENOUS VARIABLES

		With Respect to Price of:				
		Food & Services	Fuels	Materials & Chemicals	Clothing	Equipment
Change in Quantity of:	Food & Services	-1.264	-0.045	0.153	-0.103	0.026
	Fuels	-0.151	-0.250	-0.295	-0.030	-0.507
	Materials & Chemicals	0.432	-0.248	-0.436	-0.002	-0.979
	Clothing	-0.662	-0.057	-0.005	-0.073	-0.436
	Equipment	0.015	-0.085	-0.196	-0.038	-0.929

4 CONCLUSIONS

The partial equilibrium econometric model of the Australian economy estimated in this study indicates that Australian exports are generally unresponsive to price changes in the short run. This result is consistent with the resource-based nature of most of our exports and the long lead times involved in changing output levels. It also confirms the findings of previous studies which have found little price responsiveness for agricultural output. Import demand, on the other hand, is relatively elastic even in the short run, while domestic supply exhibits more price responsiveness than do exports.

These results imply that protection and other policy and price changes affecting imports will have a significant impact on the sourcing of both inputs and consumer goods and the industrial structure of the economy. Export price changes have only a small impact on the composition of the economy's output in the short run.

A fuller understanding of the production relationships in the economy can be gained from extending the range of elasticities calculated from a GNP model. By examining the linkages between the fixed inputs, labour and capital, and the net outputs, the effects of changes in factor endowments and their shadow prices can be explored. This remains the subject of further work. Another important area for additional work is the role of imperfect adjustment, particularly with regard to export supply. A thorough understanding of the effects of export price changes for resource-based industries will only be gained by explicitly modelling the process by which production adjusts to a new set of relative prices through time.

APPENDIX 1: DATA SOURCES

The data required for this study were price and implicit quantity series for each of the net outputs and quantities for each of the 2 fixed inputs. In all cases price indices were based at 1.0 in the first year of the series and an implicit quantity derived by dividing the value by the corresponding price index. Since the underlying theoretical model is based on profit maximisation within the production sector of the economy, the government sector is excluded from the data for domestic supply and factor endowments. All exports and imports are assumed to pass through the private production sector. The principal data sources are the ABS National Accounts and Balance of Payments series. Time-series data covering the period 1969/70 to 1987/88 are used.

Balance of Payments data (ABS, Cat. No. 5332.0) were used for exports and imports as this provided the longest time-series of consistently classified trade data. Series in both current and 1979/80 constant prices were available for 12 export and 9 import categories. These categories were aggregated to a total of 10 export and 5 import components as outlined in Section 2 using Divisia indices in the SHAZAM package. These components were further aggregated to form the 3 export groups and total imports used in the GNP function.

The value of private domestic supply was formed by summing: total private enterprise wages, salaries and supplements paid; gross operating surpluses of corporate trading enterprises, farm and non-farm unincorporated enterprises; minus indirect taxes less subsidies; and, minus exports less imports. The price of domestic supply was taken to be the GDP deflator. With the exception of the value of exports and imports which were obtained from the Balance of Payments data, the components of domestic supply were obtained from the National Accounts (ABS Cat. No. 5204.0).

The quantity of labour available to the private sector each period was taken to be the total number of persons employed less the number of government employees (ABS, Cat. No. 6213.0). While it would be desirable to have a corresponding series for aggregate hours worked, this was not available for all years in the time period. For those parts of the time-series where both measures were available there was a very close correlation. The price of labour was taken to be average weekly earnings of employees (ABS, Cat. No. 6101.0).

Finally, the quantity of capital used by the private production sector was assumed to be proportional to the capital stock available each period. The capital quantity was taken to be the total private non-dwelling construction and equipment net capital stock in 1979/80 prices (ABS, Cat. Nos. 5221.0 and 5204.0). The value of capital inputs was taken to be the residual between total revenue and total costs arising from the other input categories. This permitted a consistent scaling of the capital quantity with a price index equal to 1.0 in 1969/70. It should be noted that the prices of the fixed inputs were not used directly in the models estimated.

REFERENCES

Australian Bureau of Statistics (various years), Australian National Accounts: National Income and Expenditure, Cat. No. 5204.0.

Australian Bureau of Statistics (various years), Civilian Employees, Australia, Cat. No. 6213.0.

Australian Bureau of Statistics (various years), Estimates of Capital Stock, Cat. No. 5221.0.

Australian Bureau of Statistics (various years), Exports and Imports (Balance of Payments Basis) at Constant Prices, Australia, Cat. No. 5332.0.

Australian Bureau of Statistics (various years), Labour Statistics, Australia, Cat. No. 6101.0.

Diewert, W.E. (1974), "Applications of Duality Theory", in M.D. Intrilligator and D.A. Kendrick (eds), Frontiers of Quantitative Economics, vol. II, North-Holland, Amsterdam, pp. 106-171.

Diewert, W.E. (1985), 'The Measurement of the Economic Benefits of Infrastructure Services', Department of Economics Working Paper No. 85-11, University of British Columbia.

Diewert, W.E. and C.J. Morrison (1986), 'Export Supply and Import Demand Functions: A Production Theory Approach', Department of Economics Discussion Paper No. 86-10, University of British Columbia.

Diewert, W.E. and T.J. Wales (1987), "Flexible Function Forms and Global Curvature Conditions", Econometrica 55, 43-68.

Fuss, M. (1977), "The Demand for Energy in Canadian Manufacturing: An Example of the Estimation of Production Structures with Many Inputs", Journal of Econometrics 5, 89-116.

Hotelling, H. (1932), "Edgeworth's Taxation Paradox and the Nature of Demand and Supply Functions", Journal of Political Economy 40, 577-616.

Jorgenson, D.W. and B.M. Fraumeni (1981), "Relative Prices and Technical Change", in E. Berndt and B. Field (eds), Modelling and Measuring Natural Resource Substitution, MIT Press, Cambridge.

Kohli, U.R. (1975), 'Canadian Technology and Derived Import Demand and Export Supply Functions', Ph.D. thesis, University of British Columbia.

Kohli, U.R. (1978), "A Gross National Product Function and the Derived Demand for Imports and Supply of Exports", Canadian Journal of Economics 11, 167-82.

Kohli, U.R. (1983), "The Le Chatelier Principle and the Derived Demand for Imports in the Short Run and the Medium Run: Australia, 1959-60 to 1978-79", Economic Record 59, 149-65.

Lawrence, D.A. (1987), 'Export Supply and Import Demand Elasticities', Ph.D. thesis, University of British Columbia.

Lawrence, D.A. (1989), "An Aggregator Model of Canadian Export Supply and Import Demand Responsiveness", Canadian Journal of Economics 22, 503-21.

Lawrence, D.A. (1990), "An Adjustment Costs Model of Export Supply and Import Demand", Journal of Econometrics (forthcoming).

Lawrence, D. and J. Zeitsch (1990), 'A Disaggregated Model of Agricultural Production Response', Invited Paper Presented to the 34th Annual Conference of the Australian Agricultural Economics Society, Brisbane.

McKay, L., D. Lawrence and C. Vlastuin (1982), "Production Flexibility and Technical Change in Australia's Wheat/Sheep Zone", Review of Marketing and Agricultural Economics 50, 9-26.

McKay, L., D. Lawrence and C. Vlastuin (1983), "Profit, Output Supply, and Input Demand Functions for Multiproduct Firms : The Case of Australian Agriculture", International Economic Review 24, 323-39.

White, K.J. (1978), "A General Computer Program for Econometric Methods - SHAZAM", Econometrica 46, 239-40.

Wiley, D.E., W.H. Schmidt and W.J. Bramble (1973), "Studies of a Class of Covariance Structure Models", Journal of the American Statistical Association 68, 317-23.

Woodland, A.D. (1982), International Trade and Resource Allocation, North-Holland, Amsterdam.

Zellner, A. (1962), "An Efficient Method for Estimating Seemingly Unrelated Regressions and Tests for Aggregation Bias", Journal of the American Statistical Association 57, 348-68.