A DISAGGREGATED MODEL OF AGRICULTURAL PRODUCTION RESPONSE

by

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ABSTRACT

A methodology is presented in this paper which allows a detailed set of elasticities to be calculated which characterise the price responsiveness of Australian agriculture. This methodology provides the scope for econometric models to overcome the criticism that they are generally too aggregated in nature to be of real use for policy or forecasting purposes.

A Generalised McFadden profit function is estimated with 7 net outputs (crops, livestock output, labour, capital, land, materials and services, and livestock inputs). Aggregator functions are then used to disaggregate the crops output into 6 components (wheat, coarse grains, industrial crops, vegetables, fruit, and hay) and the livestock output into 7 components (cattle, sheep, pigs, wool, milk, eggs, and poultry). Materials and services inputs are also further disaggregated into 4 components (services, fertiliser and chemicals, fuel and electricity, and seed and fodder).

The primary data source is the ABS Agricultural Finance Survey. Data are pooled across 6 States and 8 years in the period 1972/73 to 1986/87. In order to get sufficient detail on outputs it was necessary to supplement the Survey data with ABS Census data.

The findings of this study concur with our earlier work which pointed towards the unresponsiveness of Australian agriculture to price changes. Selected output own-price elasticities are: wheat 0.3, industrial crops 0.1, fruit 0.3, cattle 0.1, sheep 0.2, wool 0.3, and milk 0.2. Labour and capital were both found to have input demand elasticities close to -0.4. More price responsiveness was found within the materials and services group with the demand for fertilisers and chemicals being particularly elastic at -1.3.

1 INTRODUCTION

With the continuing secular decline in the rural sector's terms of trade and changes in relative output and input prices it is important to have a good understanding of the rural sector's flexibility in adapting to changing circumstances. Information on the ease with which the output mix can be altered, the intensity with which different outputs use the various inputs and the scope for substituting between inputs is crucial to assessing the effects of price and policy changes. The aim of this paper is to present detailed information on these aspects of rural production response using a new, up-to-date data set and taking advantage of recent econometric developments. In particular, we attempt to overcome criticisms of earlier econometric studies that they were unable to include a sufficient degree of disaggregation to be of practical use for policy or modelling purposes.

Most early econometric studies of rural production response concentrated on either the supply of a particular output (Malecky 1975) or the relationship between various inputs (Vincent 1977; McKay, Lawrence and Vlastuin 1980). Much of the analysis of the effects of policy and price changes in Australian agriculture has been undertaken using linear programming models such as APMAA (Wicks and Dillon 1989) or the relatively large ORANI general equilibrium model (Dixon, Parmenter, Sutton and Vincent 1982). While the ORANI model allows for a large degree of disaggregation, its agricultural sector is based on the restrictive CRESH/CRETH specification (Vincent, Dixon and Powell 1980; Adams 1987). This specification allows for joint production but assumes that no input has a comparative advantage in the production of any output.

The first econometric studies of Australian agriculture to allow for flexible production relationships between outputs and inputs were the profit function studies of McKay, Lawrence and Vlastuin (1982, 1983). In these studies the parameters of translog variable profit functions were derived from BAE Australian Sheep Industry Survey data to examine the production relations between 3 outputs, 2 variable inputs and 3 fixed inputs. More recently, the BAE has developed the EMABA econometric model which attempts to separate livestock output and inventory responses (Dewbre, Shaw and Corra 1985). Our earlier study (Lawrence and Zeitsch 1989) utilised a profit function methodology but with a new functional form and a new data set compared to the studies of McKay, Lawrence and Vlastuin. In spite of the differing methodologies and data sets used in these studies, a general finding is that Australian agriculture is relatively inelastic in its price responsiveness. This contrasts with recent overseas work which has found a high degree of price responsiveness in agriculture (Hertel 1988). Selected own-price elasticities from previous Australian studies are presented in Table 1.

TABLE 1: SELECTED ESTIMATES OF OWN PRICE ELASTICITIES IN AUSTRALIAN AGRICULTURE

Study	Wheat/ Crops	Wool/ Sheep	Cattle/ Other	Labour	Materials + Services	Land	Capital	Livestock Input
McKay, Lawrence and Vlastuin (1980)				-0.67	-0.98	-0.19	-1.22	-0.19
Wicks & Dillon (1978)	1.10	0.25	0.69					
Vincent, Dixon and Powell (1980)[a]	0.77	0.25	0.48					
Adams (1987)	0.74	0.46	0.70					
McKay, Lawrence and Vlastuin (1983)	0.50	0.72	0.12	-0.47	-0.10			
Dewbre, Shaw and Corra (1985)	0.92	0.39	0.34					
Wall and Fisher (1987)[b]	0.47	0.19, 0.49[c]	0.22					
Lawrence and Zeitsch (1989)	0.14	0.40		-0.68	-0.53	-0.07	-0.44	-0.20

a Relates to the Wheat/Sheep Zone.
b Relates to translog estimates for the Wheat/Sheep Zone.
c Wool and Sheep, respectively.

This paper builds on the work of McKay, Lawrence and Vlastuin (1982, 1983) and Lawrence and Zeitsch (1989). In particular, a much more detailed set of elasticities is presented due to the use of a number of aggregator functions. A profit function model is estimated utilising pooled cross-section, time-series data derived principally from the Australian Bureau of Statistics' Agricultural Finance Survey covering 6 states and 8 years in the period 1972-73 to 1986-87. To enable aggregator functions to be estimated for output components the agricultural Finance Survey data had to be supplemented by data obtained from the ABS annual censuses of agricultural production. The data are discussed in detail in the Appendix.

The recently developed Generalised McFadden (GM) functional form is used to estimate a variable profit function with 2 outputs (crops and livestock), 5 variable inputs (hired labour, capital, land, materials and services, and livestock) and one fixed input (operator and family labour). Use of the GM form has significant benefits in that curvature can be imposed on the estimated parameters without loss of flexibility. It also makes the use of aggregator functions more feasible to obtain a greater degree of detail. In this study aggregator functions are used to divide the crops, livestock, and materials and services netputs into a number of components. Six crop components are modelled as are seven livestock components and four materials and services components.

2 PROFIT FUNCTION METHODOLOGY

Duality theory and the variable profit function provide a convenient and flexible framework for examining the price responsiveness of Australian agriculture. With numerous small producers each having no control over the prices they receive or pay, agriculture is well modelled by the variable profit function framework where producers vary their outputs and inputs each period to maximise profits subject to exogenous prices and fixed input quantities. Joint production is allowed, as is input substitution and the use of different inputs in varying intensities by the various outputs.

Denoting variable net output quantities by the vector x (entries positive for outputs, negative for variable inputs), net output prices by the vector $p >> 0$, fixed input quantities by the vector z, fixed input shadow prices by the vector w and the production technology set by T, the production technology can be represented by the following variable profit function.

(1) $\pi(p;z) = \max_{x} (p^T x : (z,x) \text{ belongs to } T,\ p >> 0)$

The variable or restricted profit function (1) will be linearly homogeneous and convex in net output prices and monotonically increasing (decreasing) in the prices of variable outputs (inputs). It will be linearly homogeneous, concave and monotonically increasing in fixed input quantities.

If the variable profit function is differentiable with respect to p then the net output supply functions can be derived by applying Hotelling's (1932) Lemma:

(2) $x(p;z) = \nabla_p \pi(p;z).$

The properties of variable profit functions are outlined thoroughly in Diewert (1974, 1982).

In this study, the variable profit function framework is used to estimate production response among 7 netputs and one fixed input in Australian agriculture. The netputs consist of 2 outputs (crops and livestock) and 5 variable inputs (hired labour, capital, land, materials and services, and livestock inputs). Operator and family labour is treated as the sole quasi-fixed input. Data covering 8 years in the period 1972-73 to 1986-87 is pooled across the 6 States to produce a total of 48 observations. To conserve degrees of freedom, constant returns to scale with respect to the fixed input have been imposed. This facilitates estimation of a unit profit function where profits are maximised per unit of the fixed input.

The functional form used for the variable profit function is the Generalised McFadden (GM) developed by Diewert and Wales (1987). 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. Empirical implementations of the GM form in the international trade context can be found in Diewert and Morrison (1986) and Lawrence (1987).

The 7 netput GM unit variable profit function is given by:

$$(3) \quad \pi(p,z)/z = \tfrac{1}{2} \Sigma_{i=1}^{6} \Sigma_{j=1}^{6} b_{ij} p_i p_j / p_7 + \Sigma_{i=1}^{7} b_i p_i + \Sigma_{i=1}^{7} b_{it} p_i t + b_{tt} (\Sigma_{i=1}^{7} \gamma_i p_i) t^2$$

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

$$(4) \quad b_{ij} = b_{ji} \text{ for all } i,j=1,\ldots,6;$$

t is an index of technology and the γ_i are exogenous constants set equal to the respective mean unit net output quantities to conserve degrees of freedom.

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

$$(5) \quad x_i/z = b_i + \Sigma_{j=1}^{6} b_{ij} p_j/p_7 + b_{it} t + b_{tt} \gamma_i t^2; \; i=1,\ldots,6;$$

$$(6) \quad x_7/z = b_7 - \tfrac{1}{2} \Sigma_{i=1}^{6} \Sigma_{j=1}^{6} b_{ij} p_i p_j / p_7^2 + b_{7t} t + b_{tt} \gamma_7 t^2.$$

The estimating system would normally consist of equations (5) and (6) 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 variable profit function (3) is excluded from estimation as it adds no additional information.

In this application time-series and cross-section data are pooled and this needs to be allowed for in the estimation process as State differences in product mixes and production efficiency will make the sample nonhomogeneous. The theory of this situation is set out in detail in Fuss (1977). One option is to assume that the parameters of the unit net output supply equations are State specific. Degrees of freedom considerations would limit the implementation of this to the intercept terms. The alternative is to assume that State effects are stochastic and that error terms consist of two components : a State-specific component and an overall remainder. There are two techniques for handling such a specification - covariance and error components estimators. Covariance estimation is computationally equivalent to the use of State-specific intercepts. While error components estimators have some theoretically more desirable properties than covariance estimators, Swamy and Arora (1972) show that when the sample is small and the number of States is less than 10 the covariance estimator is to be preferred. Consequently, in this study an analogous approach to Fuss (1977) is adopted. The estimating system then becomes:

$$(7) \quad x_i/z = \Sigma_{k=1}^{6} d_{ki} D_k + \Sigma_{j=1}^{6} b_{ij}\, p_j/p_7 + b_{it} t + b_{tt} \gamma_i t^2 + \nu_i; \; i=1,\ldots,6;$$

$$(8) \quad x_7/z = \Sigma_{k=1}^{6} d_{k7} D_k - \tfrac{1}{2} \Sigma_{i=1}^{6} \Sigma_{j=1}^{6} b_{ij} p_i p_j / p_7^2 + b_{7t} t + b_{tt} \gamma_7 t^2 + \nu_7$$

subject to the symmetry restrictions (4). The D_k are State-specific dummy variables taking the value one for an observation in State k and zero otherwise. The error vectors are now independently multivariate normally distributed with zero means and covariance matrix Ω. The system (7) - (8) 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).

The technology index, t, was represented by an instrumental variable formed from the State-specific productivity indexes. This specification was chosen as use of a simple time trend fails to capture the impact of seasonal conditions which can significantly influence output, particularly across States, and use of a seasonal conditions index fails to capture the importance of advances in productivity and technology over time. An instrumental variable is required to avoid simultaneity problems. It was formed by regressing the productivity indices on an index of pasture growth, transformations of a time trend and various dummy variables.

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 variable profit 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:

$$(9) \quad B = AA^T \text{ where } A = [a_{ij}];\ i,j=1,\ldots,6;\ \text{and } a_{ij} = 0 \text{ for } i<j.$$

The GM function will then be globally convex in prices without having lost its flexibility properties (Diewert 1985). The cost of this procedure is that computer-intensive non-linear regression techniques have to be used.

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 crops, livestock, and materials and services netputs. Crops are divided into six components (wheat, coarse grains, industrial crops, vegetables, fruit, and hay), livestock into seven components (cattle, sheep, pigs, wool, milk, eggs, and poultry), and materials and services into four components (services, fertilisers and chemicals, fuel and electricity, and seed and fodder). 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 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 profit function can be written as:

$$(10) \quad \pi(p,z) = \pi\,(R,V)$$

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:

$$(11) \quad T(x,z) = T^*(Y,V) = 0$$

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:

$$(12) \quad \max_{x_n} [p_n x_n : Y_n(x_n) = Y_n]$$

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

$= Y_n R_n(p_n)$

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

$$(13)\quad \pi(p,z) = \max. [\Sigma_n p_n x_n : T^*(Y_1(x_n),\ldots,V) = 0]$$

$$= \max [\Sigma_n R_n(p_n) Y_n : T^*(Y,V) = 0]$$

$$= \pi^* (R,V)$$

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

$$(14)\quad R(p,X)/X = \Sigma_{i=1}^{N} \Sigma_{k=1}^{6} e_{ik} D_k p_i + \tfrac{1}{2} \Sigma_{i=1}^{N-1} \Sigma_{j=1}^{N-1} c_{ij} p_i p_j / p_N + \Sigma_{i=1}^{N} c_{it} p_i t + c_{tt} (\Sigma_{i=1}^{N} \delta_i p_i) t^2$$

where D_k, p_i and t are defined as before, X denotes the aggregate quantity of the relevant netput, δ_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 c_{ij} have the following symmetry restriction:

$$(15)\quad c_{ij} = c_{ji} \text{ for all } i,\ j = 1,\ \ldots,\ N-1.$$

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

$$(16)\quad x_i/X = \Sigma_{k=1}^{6} e_{ik} D_k + \Sigma_{j=1}^{N-1} c_{ij} p_j / p_N + c_{it} t + c_{tt} \delta_i t^2 + u_i;\quad i=1,\ldots,N-1$$

$$(17)\quad x_N/X = \Sigma_{k=1}^{6} e_{Nk} D_k - \tfrac{1}{2} \Sigma_{i=1}^{N-1} \Sigma_{j=1}^{N-1} c_{ij} p_i p_j / p_N^2 + c_{Nt} t + c_{tt} \delta_N t^2 + u_N$$

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 (9).

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 (16) and (17) are substituted in (14) to obtain an estimate of the aggregate netput price. The overall estimation process thus consists of two-steps. First, the netput component equations (16) and (17) are estimated subject to (15). These estimates are then fed into equation (14) 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 (7) and (8) subject to (4). 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 variable profit 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 quantity of the fixed input available. They are given by:

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

where DP_{ij} is the second-order price derivative of the variable profit function and x_i is the estimated unit net output quantity obtained from the system of equations (7) and (8). In the GM case the second-order price derivatives are given by:

(19) $DP_{ij} = b_{ij} / p_7$ for $i, j = 1, \ldots, 6$;

(20) $DP_{i7} = - \sum_{j=1}^{6} b_{ij} p_j / p_7^2 = DP_{7i}$ for $i = 1, \ldots, 6$; and

(21) $DP_{77} = \sum_{i=1}^{6} \sum_{j=1}^{6} b_{ij} \, p_i p_j / p_7^3$

Two sets of elasticities are obtained for the components of crops, livestock, and materials and services. From the first stage of estimation, elasticities can be derived using formulae analogous to (18) 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 quantity of the fixed factor being held constant can be derived as follows:

(22) $E_{ij}^{Z} = E_{ij}^{X} + s_j \, E_{XX}^{Z}$

where E^X_{ij} and E^Z_{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. s_j is the share of component j in the value of the netput.

3 PRODUCTION RESPONSE RESULTS

In this section results are initially presented for the second-stage of estimation, ie the profit function system. Following this the results for crops, livestock, and materials and services obtained from the first stage of estimation are discussed.

Initial estimation of the system of net output supply equations ((7) and (8) subject to (4)) produced estimates which failed to satisfy the convexity in prices property with two eigenvalues of the matrix B = $[b_{ij}]$ being negative. All 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 (9). 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 State dummy coefficients and zero for all other coefficients. The constrained system estimates are presented in Table 2. The elasticities obtained from the constrained estimates were only marginally different from those obtained from the unconstrained system. Most of the price terms are statistically significant as are all the technology coefficients, reflecting the superior performance of this variable relative to others tried such as simple time trends and seasonal indices.

Net output supply elasticities for Australia calculated at the means of the exogenous variables are presented in Table 3. The elasticities for Australia were obtained by weighting together the individual State elasticities according to shares in the mean netput quantity.

The elasticities given in Table 3 adhere largely to those that would apply to a "normal technology". That is, if production is relatively unconstrained by the availability of fixed factors (as is the case here with only family and owner-operator labour quasi-fixed), expanding one output would lower the costs of producing other outputs. Thus the following would be observed (Hertel 1984);

- gross complementarity between outputs;
- gross complementarity between inputs; and
- no regressive relationships between inputs and outputs.

TABLE 2 : ESTIMATED UNIT NET OUTPUT SUPPLY EQUATIONS[1]

	Coefficient													
	State dummy variables[2]						Second-order price terms (non-linear)						Technology Terms	
Equation i	d_{i1}	d_{i2}	d_{i3}	d_{i4}	d_{i5}	d_{i6}	a_{i1}	a_{i2}	a_{i3}	a_{i4}	a_{i5}	a_{i6}	b_{it}	b_{tt}
Crops	-15.371 (-2.94)	-19.863 (-3.82)	-7.400 (-1.43)	-16.464 (-3.09)	-7.885 (-1.48)	-23.280 (-4.48)	-1.152 (4.46)	-1.100 (-1.23)	1.238 (5.21)	-0.500 (-2.55)	0.071 (0.29)	0.939 (1.61)	31.436 (3.97)	-0.372 (-1.82)
Livestock	4.792 (0.61)	-1.479 (-0.19)	-3.777 (-0.48)	-2.051 (-0.26)	8.100 (1.01)	1.752 (0.22)		-2.072 (-3.22)	0.082 (0.15)	0.387 (0.91)	-0.477 (-1.57)	1.108 (1.95)	28.172 (2.27)	*
Labour	-1.806 (-0.98)	0.213 (0.12)	-2.304 (1.27)	-0.[illegible]6 (-0.39)	-2.436 (-1.29)	-1.084 (-0.58)			-1.074 (-3.37)	-0.331 (-0.72)	-0.153 (0.60)	1.988 (4.69)	-4.234 (-1.59)	*
Capital	-2.017 (-2.28)	-1.199 (-1.35)	-2.045 (-2.32)	-2.059 (-2.29)	-3.222 (-3.54)	-1.495 (-1.69)				0.723 (1.35)	-0.222 (-0.61)	-0.304 (-0.61)	-1.261 (-1.04)	*
Land	-10.95 (-2.81)	-5.668 (-1.46)	-8.107 (-2.08)	-8.267 (-2.10)	-16.832 (-4.26)	-6.058 (-1.56)					0.000 (0.00)	-0.000 (-0.00)	-7.588 (-1.26)	*
Materials & Service	-8.859 (-1.46)	-2.464 (-0.41)	-6.602 (-1.01)	-5.372 (0.87)	-15.905 (-2.57)	-2.966 (-0.49)						0.000 (0.00)	-16.268 (-1.78)	*
Livestock Input	-1.707 (-0.91)	-0.046 (-0.03)	-0.062 (-0.03)	0.896 (0.46)	-1.480 (-0.74)	0.250 (0.13)		Symmetric				-4.753	* (-1.89)	
System log likelihood			-373.18											

1 t-statistics in parentheses.
2 States 1,...,6 are NSW, Victoria, Queensland, South Australia, Western Australia and Tasmania, respectively.

TABLE 3: NET OUTPUT SUPPLY ELASTICITIES FOR AUSTRALIA AT MEAN EXOGENOUS VARIABLES

		With respect to price of:						
		Crops	Livestock	Labour	Capital	Land	M & S	Livestock Input
Change in Quantity of:	Crops	0.151	0.108	-0.124	0.049	-0.006	-0.094	-0.085
	Livestock	0.070	0.228	-0.064	-0.010	0.030	-0.140	-0.113
	Labour	0.358	0.289	-0.515	0.044	-0.032	0.16[illegible]	-0.313
	Capital	-0.392	0.129	0.120	-0.530	0.136	0.479	0.059
	Land	0.009	-0.076	-0.018	0.028	-0.021	0.060	0.018
	M & S	0.084	0.194	0.052	0.054	0.033	-0.366	-0.051
	Livestock Input	0.293	0.601	-0.370	0.025	0.039	-0.197	-0.390

As can be seen from Table 3 outputs are gross complements and, apart from the crops/capital and livestock/land interactions (the latter of which is near zero), there are no regressive relationships between inputs and outputs. On the input side, however, gross substitution between inputs is more prevalent with 7 of the 10 underlying gross substitution elasticities between inputs being positive. With low output supply elasticities this result probably derives from small expansion effects being dominated by the underlying substitution effects.

Returning to the specific elasticity estimates, the notable feature of Table 3 is the general lack of price responsiveness in Australian agriculture. The outputs of crops and livestock have own-price supply elasticities of around 0.15 and 0.23, respectively. The cross-elasticities between these outputs are almost as high reflecting the close relationship between cropping and livestock production. The hired labour and capital own-price demand elasticities show the most responsiveness at -0.52 and -0.53, respectively. Land input, on the other hand, shows a very inelastic own-price response at only -0.02. The inputs of aggregate materials and services, and livestock both have own-price elasticities of around -0.4.

These results are broadly in line with the findings of earlier studies although output responsiveness in this study is even more inelastic, particularly in regard to crops. As is to be expected, the aggregate results are very similar to those found in our earlier study. With the exception of McKay, Lawrence and Vlastuin (1983) who found the crop supply elasticity to be 0.5, most of the studies cited in Table 1 have found the crops elasticity to be closer to one. Livestock supply elasticities, on the other hand, have typically been lower ranging from 0.12 for McKay, Lawrence and Vlastuin's estimate for cattle and other outputs to their estimate of 0.72 for wool and sheep. On the input side the gross own-price elasticities of this study are similar in relative terms to the compensated cost function estimates of McKay, Lawrence and Vlastuin (1980) with the exception of capital and materials and services which are less elastic in our case. While these comparisons provide a useful check it must be remembered that the elasticities estimated here cover all of Australian agriculture and come from a different, more recent data source than most of the other studies referred to. These elasticities are also calculated subject to a different set of conditions being held fixed, namely the quantity of operator and family labour.

Turning to the cross elasticities in Table 3, crops output responds positively to an increase in the price of livestock outputs as noted and negatively to increases in the prices of 4 of the 5 inputs. Crops output is most sensitive to increases in the price of labour. The positive (although near zero) elasticity between crops output and capital prices is the only apparently anomalous result in the Table. Livestock output decreases in response to increases in the price of 4 of the 5

TABLE 4 : ESTIMATED UNIT CROPS AGGREGATOR EQUATIONS[1]

	Coefficient													
	State dummy variables[2]						Second-order price terms (non-linear)						Technology Terms	
Equation i	d_{i1}	d_{i2}	d_{i3}	d_{i4}	d_{i5}	d_{i6}	a_{i1}	a_{i2}	a_{i3}	a_{i4}	a_{i5}		b_{it}	b_{tt}
Wheat	0.252	0.153	-0.097	0.156	0.504	-0.126	-0.341	-0.023	0.057	0.020	0.196		0.053	0.168
	(3.95)	(2.48)	(-1.59)	(2.53)	(7.89)	(-2.35)	(-7.32)	(-0.57)	(1.92)	(0.47)	(4.41)		(0.95)	(3.16)
Coarse Grains	0.152	0.120	0.127	0.272	0.191	0.103		-0.000	0.000	-0.000	0.000		-0.046	*
	(4.10)	(3.45)	(3.63)	(7.65)	(5.15)	(3.22)		(-0.00)	(0.00)	(0.00)	(0.00)		(-1.50)	
Industrial Crops	0.180	0.070	0.722	0.071	0.066	0.058			0.000	-0.000	0.000		-0.076	*
	(6.51)	(2.71)	(27.33)	(2.65)	(2.43)	(2.44)			(0.00)	(-0.00)	(0.00)		(-3.04)	
Vegetables	0.028	0.144	0.281	0.074	-0.008	0.431				0.000	-0.000		0.006	*
	(0.54)	(2.88)	(0.56)	(1.41)	(-0.14)	(9.29)				(0.00)	(-0.00)		(0.15)	
Fruit	0.431	0.480	0.325	0.496	0.330	0.535		Symmetric		-0.000		-0.245	*	
	(8.51)	(10.15)	(6.96)	(10.07)	(6.40)	(12.15)					(-0.00)		(5.89)	
Hay	0.373	0.420	0.269	0.313	0.316	0.398							-0.210	*
	(7.20)	(8.74)	(5.52)	(6.27)	(6.09)	(9.03)							(-5.35)	
System log likelihood			609.13											

1 t-statistics in parentheses.
2 States 1,...,6 are NSW, Victoria, Queensland, South Australia, Western Australia and Tasmania, respectively.

TABLE 5 : CROPS ELASTICITIES SUBJECT TO A FIXED AGGREGATE QUANTITY OF CROPS: AUSTRALIA AT MEAN EXOGENOUS VARIABLES

With respect to price of:

		Wheat	Coarse Grains	Industrial	Vegetables	Fruit	Hay
	Wheat	0.298	0.018	-0.056	-0.019	-0.187	-0.055
	Coarse grains	0.063	0.004	-0.012	-0.004	-0.040	-0.011
Change in	Industrial	-0.183	-0.012	0.029	0.012	0.127	0.027
Quantity	Vegetables	-0.102	-0.006	0.019	0.006	0.065	0.019
of:	Fruit	-0.475	-0.029	0.088	0.029	0.296	0.091
	Hay	-0.215	-0.013	0.040	0.013	0.132	0.043

TABLE 6 : CROPS ELASTICITIES SUBJECT TO THE FIXED INPUT OF OPERATOR AND FAMILY LABOUR: AUSTRALIA AT MEAN EXOGENOUS VARIABLES

With respect to the price of:

		Wheat	Coarse Grains	Industrial Crops	Vegetables	Fruit	Hay
	Wheat	0.344	0.032	-0.048	-0.010	-0.174	-0.046
	Coarse Grains	0.100	0.018	0.004	0.006	-0.027	-0.003
Change in	Industrial	-0.170	-0.001	0.082	0.020	0.135	0.031
Quantity	Vegetables	-0.071	0.006	0.034	0.021	0.082	0.030
of:	Fruit	-0.441	-0.016	0.099	0.042	0.314	0.102
	Hay	-0.177	-0.001	0.050	0.026	0.149	0.055

TABLE 7 : ESTIMATED UNIT LIVESTOCK AGGREGATOR EQUATIONS[1]

	Coefficient													
	State dummy variables[2]						Second-order price terms (non-linear)						Technology Terms	
Equation i	d_{i1}	d_{i2}	d_{i3}	d_{i4}	d_{i5}	d_{i6}	a_{i1}	a_{i2}	a_{i3}	a_{i4}	a_{i5}	a_{i6}	b_{it}	b_{tt}
Cattle	0.356	0.329	0.592	0.277	0.171	0.370	0.142	0.116	0.005	-0.176	0.350	-0.083	-0.004	0.014
	(5.08)	(4.95)	(8.67)	(3.88)	(2.30)	(5.76)	(2.26)	(1.75)	(0.14)	(-1.84)	(0.55)	(-2.80)	(-0.08)	(0.44)
Sheep	0.037	0.067	-0.043	0.092	0.117	0.045		0.089	-0.049	-0.183	0.110	0.033	0.045	*
	(1.79)	(3.47)	(-2.16)	(4.44)	(5.46)	(2.38)		(0.93)	(-1.58)	(-3.10)	(2.43)	(0.77)	(2.68)	
Pigs	0.061	0.050	0.068	0.072	0.052	0.055			-0.0000	-0.000	0.000	0.000	-0.010	*
	(6.52)	(5.62)	(7.50)	(7.53)	(5.22)	(6.30)			(-0.00)	(-0.00)	(0.00)	(0.00)	(-1.24)	
Wool	0.295	0.186	0.167	0.364	0.502	0.238				-0.000	0.000	-0.000	-0.011	*
	(8.94)	(5.96)	(5.29)	(10.81)	(14.81)	(7.62)				(-0.00)	(0.00)	(-0.00)	(-0.34)	
Milk	0.091	0.256	0.097	0.088	0.042	0.212		Symmetric		0.000	-0.000	0.001	*	
	(6.38)	(19.01)	(6.96)	(6.11)	(2.87)	(15.97)					(0.00)	(-0.00)	(0.04)	
Eggs	0.079	0.062	0.069	0.055	0.049	0.066						-0.000	-0.024	*
	(10.02)	(8.53)	(9.17)	(6.83)	(6.18)	(8.76)						(-0.00)	(-4.07)	
Poultry	0.019	-0.021	-0.023	-0.012	-0.027	-0.026							0.045	*
	(1.62)	(-1.91)	(-2.03)	(-0.99)	(-2.20)	(-2.42)							(4.87)	
System Log Likelihood				994.39										

1 t-statistics in parentheses

2 States 1,...,6 are NSW, Victoria, Queensland, South Australia, Western Australia and Tasmania, respectively.

TABLE 8: LIVESTOCK ELASTICITIES SUBJECT TO A FIXED AGGREGATE QUANTITY OF LIVESTOCK: AUSTRALIA AT MEAN EXOGENOUS VARIABLES

		With respect to price of						
		Cattle	Sheep	Pigs	Wool	Milk	Eggs	Poultry
Change in Quantity of:	Cattle	0.039	0.033	0.002	-0.068	0.013	-0.028	0.009
	Sheep	0.137	0.173	-0.039	-0.427	0.153	-0.069	0.072
	Pigs	0.010	-0.053	0.042	0.159	-0.097	-0.035	-0.027
	Wool	-0.061	-0.088	0.025	0.023	-0.088	0.025	-0.036
	Milk	0.038	0.108	-0.050	-0.285	0.134	0.007	0.049
	Eggs	-0.159	-0.093	-0.035	0.160	0.014	0.134	-0.020
	Poultry	0.038	0.060	-0.018	-0.150	0.060	-0.015	0.025

TABLE 9: LIVESTOCK ELASTICITIES SUBJECT TO THE FIXED INPUT OF OPERATOR AND FAMILY LABOUR: AUSTRALIA AT MEAN EXOGENOUS VARIABLES

		With respect to the price of:						
		Cattle	Sheep	Pigs	Wool	Milk	Eggs	Poultry
Change in Quantity of:	Cattle	0.112	0.049	0.014	-0.003	0.046	-0.019	0.021
	Sheep	0.191	0.195	-0.028	-0.345	0.185	-0.061	0.083
	Pigs	0.076	-0.035	0.054	0.231	-0.066	-0.026	-0.015
	Wool	-0.003	-0.068	0.036	0.306	-0.061	0.034	-0.025
	Milk	0.103	0.126	-0.039	-0.223	0.176	0.016	0.060
	Eggs	-0.092	-0.076	-0.023	-0.229	0.046	0.144	-0.008
	Poultry	0.102	0.077	-0.006	-0.075	0.088	-0.005	0.039

inputs with this relationship being strongest for materials and services and livestock input price increases. Labour and capital inputs are shown to be slight substitutes as are labour and materials and services. Capital inputs are also substitutable with land, materials and services, and livestock inputs although the cross elasticities are again typically small in magnitude. Land inputs are very unresponsive to changes in any of the netput prices reflecting land's relatively fixed supply to Australian agriculture. Materials and services inputs are weakly complementary with livestock inputs. As expected, livestock input quantities also respond to increases in the price of livestock output and, in a negative way, to labour price increases.

Moving to the first stage of the estimation process, it was necessary to combine the Agricultural Finance Survey data with ABS Census data in order to disaggregate both the crops and livestock outputs into a number of components. Crops output has been divided into 6 components: wheat, coarse grains, industrial crops, vegetables, fruit, and hay. Livestock output has been divided into 7 components: cattle, sheep, pigs, wool, milk, eggs, and poultry. Use of the Census data was necessary as the AFS presents no detailed information on outputs for years other than 1986/87. Consequently, Census data was used entirely in the case of the crops and livestock aggregator systems. The aggregate prices obtained from these systems were then divided into the values of crops and livestock obtained from the AFS to get an aggregate quantity of the two outputs in the profit function estimation stage. For the materials and services aggregator system, sufficient detail is presented in the AFS data to enable this data source alone to be used.

Problems will inevitably arise from mixing data sources in the manner described for crops and livestock as the outputs are treated differently in the AFS to what they are in the Census data. In the Census data all outputs are measured in nett terms, ie. only sales from the agricultural sector to the non-agricultural sector are reported. All transactions between farms are netted out of the data. In the AFS, on the other hand, outputs are reported on a gross basis, ie. all sales from each farm are measured including sales to other farms. As well as this fundamental difference in the way in which outputs are measured, there will also be sampling differences between the two data sources which will make compatibility difficult. However, in spite of these difficulties, no alternative exists to mixing the two data sources in this instance if we are to obtain a detailed set of output response elasticities.

The estimated system for the crops aggregator is presented in Table 4. The system estimated without curvature imposed suffered from gross curvature violations and consequently the system was re-estimated using equation (9) and non-linear estimation. As can be seen from Table 4, however, the result of imposing the curvature restrictions has been to force most of the second-order price terms to zero. This is a common result using this technique as the least cost way of satisfying the restriction when there is gross curvature violation in the data is to set the offending second-order terms to zero. As yet there is no entirely satisfactory technique for imposing curvature on an errant data set. The Bayesian technique proposed by Chalfant and White (1987) would not be useful in this situation as it would merely indicate that there was zero probability of the restriction being satisfied and hence no estimates would be produced for the restricted system.

The low and near-zero values of the second-order price terms carry over to the estimated elasticities presented in Tables 5 and 6. The elasticities in Table 5 show the response subject to the aggregate quantity of crops being held fixed whereas the elasticities in Table 6 have been converted using equation (22) to the same basis as the elasticities in Table 3 (ie. subject to the available quantity of the fixed input, operator and family labour). Concentrating on Table 6, wheat is estimated to have an own-price elasticity of 0.34 while fruit is the next most responsive crop with an own-elasticity of 0.31. The other four crops all have estimated own-price elasticities of less than 0.1.

Wheat and coarse grains are shown to be slight complements while increases in the prices of the other four crops lead to very small reductions in wheat output. Coarse grain output is shown to be very unresponsive to changes in the prices of any of the crop components. Industrial crops which consists principally of sugar, rice and oilseeds is slightly complementary to the output of vegetables, fruit and hay. Vegetables and fruit, vegetables and hay, and fruit and hay are also each slightly complementary. The largest cross elasticity is that depicting the response of fruit output to an increase in the price of wheat. This elasticity has a value of -0.44 indicating that fruit output is substantially reduced to facilitate increased wheat production. The other cross elasticities are all less than 0.2 in absolute value with the majority being close to zero indicating that crop outputs are almost independent of one another. While this is plausible for some components where there is limited scope for substitution, the results obtained appear to be implausibly small overall.

The estimated livestock aggregator system is presented in Table 7. Again, the system estimated without curvature imposed exhibited gross violations of the curvature requirement and subsequent estimation was undertaken imposing the restrictions in equation (9). Almost half the estimated second-order price terms are again effectively zero with the remainder being small in magnitude.

The livestock elasticities subject to a fixed aggregate quantity of livestock output and the available quantity of the fixed input are presented in Tables 8 and 9, respectively. Again the striking feature of these elasticities is their small magnitude. This follows directly from the small magnitude of the estimated second-order price terms. Wool is shown to be the most responsive of the livestock outputs with an own-price elasticity of 0.31. Sheep output is the next most responsive with an own-price elasticity of 0.20, followed by milk at 0.18, eggs at 0.14 and cattle at 0.11. Pigs and poultry are both very unresponsive with own-price elasticities of 0.05 and 0.04, respectively.

Cattle are slightly complementary with wool and eggs and slightly substitutable with the other four livestock components. Sheep output is complementary to cattle and milk production. It is relatively substitutable with wool production with a cross elasticity of -0.35. This can be explained by an increase in wool prices leading to a withholding of sheep for sale as they are retained on-farm for their wool output. There is a negligible interaction between sheep output and the intensive products of pigs, eggs and poultry. The production of pigs shows very little response to changes in the prices of the other livestock products. The interaction between wool and the intensive livestock products is similarly negligible. Milk production is shown to be complementary to cattle and sheep outputs but substitutable with wool production. Eggs and poultry production both exhibit negligible interaction with the other livestock components.

Overall, the results of the livestock aggregator appear to be plausible with the major interactions occurring between cattle, sheep, wool and milk. The intensive livestock products of pigs, eggs and poultry are relatively independent of the more extensive products and also of each other. This is to be expected given the real lack of substitution possibilities between each of these intensive products and other forms of livestock production, suggesting that the appropriate technology here is a Leontief one. The own-price elasticities obtained for the major products are also close in magnitude to the elasticity obtained for livestock output as a whole from the profit function level of estimation, suggesting a reasonable degree of internal consistency.

Moving to the estimation of the materials and services aggregator function, the estimated system is presented in Table 10. In this case the matrix of price coefficients $C = [c_{ij}]$ was positive semi-definite indicating that the estimated aggregator function satisfied the property of price convexity. Furthermore, the price coefficients were strongly significant with one exception and all 4 equations fitted the data well.

The matrix of elasticities derived from the unit aggregator equations at the means of the exogenous variables are presented in Table 11. These elasticities are the response subject to the total quantity of materials and services being held constant and indicate that the fertilisers and chemicals component has an elastic response to changes in its own-price while the services, and fuel and electricity components have own-price elasticities close to -0.50. The own-price elasticity of seed and fodder is -0.3. Again cross elasticities are mostly relatively small with all pairs being substitutes except for the fertilisers and chemicals, and seed and fodder components.

TABLE 10 : ESTIMATED UNIT MATERIALS AND SERVICES AGGREGATOR EQUATIONS[1]

	State dummy variables[2]						Price Terms			Technology		Equation i
Equation i	e_{i1}	e_{i2}	e_{i3}	e_{i4}	e_{i5}	e_{i6}	C_{i1}	C_{i2}	C_{i3}	C_{it}	C_{tt}	R^2
Services	-0.587 (-23.13)	-0.566 (-23.69)	-0.545 (-22.36)	-0.566 (-21.20)	-0.544 (-20.52)	-0.551 (-23.45)	0.245 (6.47)	-0.167 (-9.76)	-0.041 (-2.42)	-0.040 (-1.47)	-0.002 (-0.13)	0.75
Fertilisers & chemicals	-0.148 (-9.92)	-0.172 (-11.79)	-0.177 (-11.69)	-0.185 (-11.78)	-0.270 (-16.39)	-0.199 (-14.19)		0.165 (11.35)	-0.015 (-1.73)	0.028 (1.85)	*	0.92
Fuel & electricity	-0.117 (-11.20)	-0.140 (-14.18)	-0.142 (-14.25)	-0.130 (-11.95)	-0.110 (-9.70)	-0.121 (-12.97)			0.080 (6.83)	-0.029 (-2.55)	*	0.80
Seed & fodder	-0.154 (7.87)	-0.131 (-6.98)	-0.145 (-7.62)	-0.129 (-6.23)	-0.084 (-3.89)	-0.141 (-8.06)	Symmetric		0.030	* (1.71)	0.68	
System Log Likelihood			644.48									

1 t-statistics in parenthesis

2 States 1,...,6 are NSW, Victoria, Queensland, South Australia, Western Australia and Tasmania, respectively.

TABLE 11 : MATERIALS AND SERVICES ELASTICITIES SUBJECT TO A FIXED AGGREGATE QUANTITY OF MATERIALS AND SERVICES : AUSTRALIA AT MEAN EXOGENOUS VARIABLES

		With Respect to Price of:			
		Services	Fertilisers & Chemicals	Fuel & Electricity	Seed & Fodder
Change in Quantity of:	Services	-0.464	0.301	0.060	0.103
	Fertilisers & Chemicals	1.332	-1.255	0.091	-0.168
	Fuel & Electricity	0.308	0.106	-0.472	0.057
	Seed & Fodder	0.458	-0.172	0.050	-0.337

TABLE 12 : MATERIALS AND SERVICES ELASTICITIES SUBJECT TO A FIXED INPUT OF OPERATOR AND FAMILY LABOUR: AUSTRALIA AT MEAN EXOGENOUS VARIABLES

		With Respect to Price of:			
		Services	Fertilisers & Chemicals	Fuel & Electricity	Seed & Fodder
Change in Quantity of:	Services	-0.669	0.240	0.014	0.061
	Fertilisers & Chemicals	1.128	-1.319	0.046	-0.209
	Fuel & Electricity	0.104	0.046	-0.517	0.015
	Seed & Fodder	0.252	-0.231	0.005	-0.381

Of more interest are the materials and services component gross elasticities which are derived using equation (22). Thes are presented in Table 12 and show the response subject to the quantity of the fixed input. They are thus directly comparable to the net output elasticities from the variable profit function shown in Table 3. Again fertilisers and chemicals have an elastic response to own price changes and are complementary to seed and fodder inputs. They are strongly substitutable with services inputs. Services inputs show the next highest response to own price changes and are slightly substitutable with the other components. The own-price elasticity of fuel and electricity is -0.5 but this input has only a weak response to changes in the prices of the other 3 components. Likewise seed and fodder is somewhat substitutable with services and fuel and electricity and is complementary to fertilisers and chemicals.

All of the own-price elasticities for the materials and services components shown in Table 12 are larger than the own-price elasticity for aggregate materials and services shown in Table 3 due to the predominance of substitutability between the 4 components. That is, the elasticities in Table 12 show the response when only the price of one component changes whereas the aggregate response in Table 3 is equivalent to an equi-proportionate increase in the price of all 4 components. This eliminates much of the scope for substitution indicated in Table 12.

4 CONCLUSIONS

This study has served to illustrate the possibility of deriving a detailed set of elasticities characterising production relationships by combining the use of the aggregator function procedure and recently developed econometric techniques for imposing the required curvature conditions. The study confirms earlier findings that Australian agriculture is relatively unresponsive to price changes.

The lack of price responsiveness in Australian agriculture as a whole is not surprising given the absence of alternative uses for agricultural land and the degree of adjustment required to move resources in and out of agriculture. This contrasts with the United States, for instance, where much higher levels of price responsiveness in agriculture have been reported in some studies. Given the larger US economy and its more geographically diverse nature it can be expected that the transfer of resources between agriculture and the non-agricultural sector would be easier thus contributing to a higher degree of price responsiveness.

This study has also highlighted that a lack of price responsiveness at an aggregated level may mask greater price responsiveness at the more disaggregated level. By using the aggregator function procedure for materials and services more information was recovered on the response of individual components.

However, some problems remain as illustrated by the results obtained from the crops aggregator. Failure of the data to satisfy the curvature requirements can in some extreme cases lead to the estimated price coefficients being all close to zero. This in turn causes nearly all of the estimated elasticities to be near zero. In this case a likely cause of this was the need to combine two data sources with less than full compatibility.

While this study represents a significant advance over previous studies in this area, some important areas of work remain. These relate mainly to the need to develop a more consistent detailed data set for Australian agriculture. Once such a consistent data set is available then there is much greater scope for econometric studies such as this to provide direct input into larger scale general equilibrium models and policy analysis.

APPENDIX 1: DATA SOURCES

The principal data source used in this study is the Australian Bureau of Statistics' Agricultural Finance Survey (ABS Cat. No. 7507.0). The first survey year used is 1972/73. The survey then had a sample of approximately 10 000 farms. It was then carried out on an annual basis until 1977-78 and again in 1980-81 and 1986-87. The survey presents data on the value of farm outputs and inputs. Stock values for the 3 durable inputs are presented from 1974-75 onwards. The survey value data is combined with ABARE (1988) prices received and prices paid indices to produce price and implicit quantity indices for 2 outputs and 4 input categories. A further 2 input categories are created from survey value data and ABS and ABARE quantity series. The data used here are at the aggregate level for each of the 6 States and 8 years producing a total of 48 observations.

For the components of the 2 outputs (crops and livestock) and the 2 non-durable inputs (hired labour, and materials and services) the ABARE State price indices were used along with the implicit quantities obtained by dividing the Survey values by the price indices as outlined in Appendix Table A.

For the 3 durable inputs (capital, land, and livestock inputs) a user cost value has been derived from the stock value by assuming that farmers aim to make a given rate of real return on their assets. A real opportunity cost rate of 4 per cent has thus been used along with a depreciation rate for each asset class. This approach differs from earlier studies such as Lawrence and McKay (1980) where a nominal opportunity cost was used. While the nominal opportunity cost rate varied from year to year it neglected the increasingly important role that capital gains have played. As no information was available on capital gains in this case the alternative of assuming a constant real rate of opportunity cost was opted for. This is equivalent to a constant difference between the nominal rate of opportunity cost and the rate of capital gains. A depreciation rate of 5 per cent was assumed for capital and 1 per cent for land and improvements. The average unit of livestock was assumed not to depreciate but this required inputs in the form of livestock purchases. Consequently, the livestock input user cost consists of the real opportunity cost and the value of purchases. As no reliable land price series was available a land price index was formed by dividing the land value by the area of agricultural land in each State (ABS Cat. No. 7321.0).

TABLE A: VALUE, PRICE AND QUANTITY SOURCES

Group	AFS Category	ABARE price index	ABS AND ABARE quantities
Crops	Sales from crops	crops	
Livestock	Sales from livestock Sales from livestock products Other miscellaneous revenue	livestock) livestock) products	
Hired labour	Wages, salaries and supplements Payments to contractors	wages contracts	
Capital	0.09 x Value of machinery and equivalent	repairs and maintenance	
Land	0.05 x Value of land and improvements		ABS area of agricultural land
Materials and Services			
Services	Marketing expenses Water and drainage charges Repairs and maintenance Other selected expenses Rates and taxes Insurance payments Other expenses	marketing) repairs and) maintenance) rates and taxes insurance other expenses	
Fertiliser and Chemicals	Payments for fertiliser Chemical and veterinary supplies	fertiliser chemicals	
Fuel and Electricity	Payments for fuel Payments for electricity	fuel electricity	
Seed and fodder	Payments for seed and fodder	seed and fodder	
Livestock inputs	0.04 x Value of livestock Purchases of livestock	) livestock)	
Operator and family labour			ABARE number of operators and unpaid family helpers allocated to States by ABS proportions.

No capital stock values were collected for 1972-73 or 1973-74 although capital purchase data was. The capital stocks for these years were estimated by deflating the stock for the following year after allowing for purchases and depreciation. Similarly no total livestock value was collected for 1972-73 or 1973-74. Livestock values for these years were estimated from the 1974-75 values by allowing for sales, purchases and an average rate of net natural increase observed for the rest of the sample period.

The most reliable estimates of the number of farm operators and unpaid family helpers were considered to be those of ABARE (1987, p.4). However, these are only presented for Australia as a whole. Estimates for the States were obtained by allocating this total according to the proportions observed from ABS employment data for March of each year. No value for this input was required as it was treated as being fixed. The implicit return to the input is the value of variable profit in each year. In only 9 of the 48 observations was this value non-positive.

For the components of crops and livestock the AFS presents no data other than for 1986/87. Consequently, to obtain this information it was necessary to use ABS Census data on Agricultural Production (Cat. No. 7102.0) to obtain values of the various categories of crops and livestock output. These values were then deflated by relevant ABARE prices received indices to obtain implicit quantities of the output components. As noted earlier, there will be incompatibilities between the Census data and the AFS due to differences in the way output is measured and statistical coverage. However, at present no alternative to this procedure exists if we are to obtain a more detailed set of elasticities for these output components. The concordance between the Census data categories and the ABARE price indices are outlined in Table B.

TABLE B : VALUE AND PRICE SOURCES FOR CROPS AND LIVESTOCK COMPONENTS

Component	ABS Category	ABARE Price Index
Wheat	Wheat	Wheat
Coarse Grains	Barley Grain Sorghum Maize Oats	Other Grain Crops
Industrial Crops	Sugar Rice Oilseeds Other Crops	Industrial Crops
Fruit	Total Fruit	Fruit
Vegetables	Vegetables	Vegetables
Hay	Hay	Hay
Cattle	Cattle and Calves	Catttle
Sheep	Sheep and Lambs	{Sheep {Lambs
Pigs	Pigs	Pork
Wool	Wool	Wool
Milk	Milk	Total Milk
Eggs	Eggs	Eggs
Poultry	Poultry	Poultry

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