Forum
Agricultural Supply Response

Some Comparisons of Recent Estimates of Agricultural Supply Elasticities for the Australian Economy

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1. Introduction

An accurate knowledge of the supply responsiveness of agricultural exporting industries is crucial if sensible judgements are to be made about diverse policy initiatives, including initiatives having no obvious connection with agriculture. In this paper we compare some recent estimates of short-run supply elasticities for agricultural commodities in the Australian economy. Our attention is focussed particularly on the different types of production technologies and econometric methods used to derive values for these elasticities.

The plan for the remainder of this paper is as follows. In Section 2, elasticity estimates derived in Adams (1987) (hereinafter, just Adams), Dewbre, Shaw, Corra and Harris (1985) (DSCH), Fisher and Munro (1983) (FM), McKay, Lawrence and Vlastuin (1983) (MLV), and Wicks and Dillon (1978) (WD), are compared.[1] Possible reasons for differences are then discussed. In Section 3 some concluding remarks are offered.

2. Comparisons

The "preferred elasticity estimates" derived in Adams were based on the multi-level industry production systems developed for the ORANI computable general equilibrium model of the Australian economy.[2] ORANI distinguishes in total eight agricultural industries, of which three correspond to the geographic areas designated by the Australian Bureau of Agricultural and Resource Economics (ABARE) as the High Rainfall, Wheat-Sheep and Pastoral Zones. These zonal industries each produce nine agricultural products, while the remaining five industries produce only single products. In the ORANI system, inputs are treated as completely non-specific to outputs, so that no factor has a comparative advantage in the production of any particular output. This assumption reduces the number of elasticities relating outputs to inputs in each of the three multi-product agricultural industries to a manageable level and allows relatively simple supply response and input demand equations to be derived. Each supply response equation is a solution to a revenue maximization problem, subject to a CRETH (Constant Ratios of Elasticities of Transformation, Homothetic) function with given prices for all inputs and outputs and a given (scalar) capacity for production. On the input side, the representative firm for each of the agricultural industries chooses its mix of primary factors and material inputs to minimize costs subject to a nesting of input

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[1] This paper was written in 1987. It therefore does not cover some of the more recent contributions to the literature such as Wall and Fisher (1987) and Hall, Fraser and Purtill (1988).

[2] A complete description of ORANI is given in Dixon, Parmenter, Sutton and Vincent (1982).

production functions embodying both Leontief (fixed coefficient) and Constant Elasticity of Substitution (CES) technologies. Again, all prices and the capacity for production are treated as exogenous variables. In short-run simulations of the model, intermediate inputs and labour are variable factors of production; on the other hand, industry-specific fixed capital and land are held constant. Parameters of the agricultural production system consist of cost and revenue shares and CRETH transformation and CES substitution elasticities. Data for the cost and revenue shares are computed from Input/Output statistics which reflect the agricultural sector in a recent "typical year", while data for the transformation and substitution elasticities are estimated econometrically using the full information maximum likelihood technique applied to data from ABARE survey reports.[3] Each elasticity presented in Adams referred to the total projected change in a commodity's output resulting from a change in a single output price. In short-run applications of ORANI, complete adjustment is estimated to have taken place about 2 years after the initial change in expected prices.[4]

Compared with the elasticities derived in Adams (and, as we will see shortly, in MLV), those estimated in FM were based on a rather loosely specified production technology. Using a single equation estimator (*i.e.* OLS), FM regressed cross-sectional data for intended sheep numbers, intended cattle numbers, intended breeding ewe numbers and intended wheat plantings for each of three regions in New South Wales, on corresponding data for current output, for the expected prices of the commodities produced in the region concerned, and for a variable measuring the proportion of improved pasture in that region. The current output of the commodity, whose expected numbers/plantings was to be explained, was used as an explanatory variable to introduce a degree of dynamics into the system via a partial adjustment process towards an expected short-run equilibrium. All of the data required were obtained from a survey based on a random sample of properties carrying 200 or more merino sheep as at 31 March 1978 in three regions of New South Wales; namely, the Southern Tablelands, the South-West Slopes, and a portion of the Western Division. "These regions correspond to the [ABARE's] High Rainfall, Wheat-Sheep and Pastoral Zones, respectively" (Fisher and Munro 1983, p. 2). The time profile of each elasticity was approximately 3 years.

The elasticities derived in MLV were based on a much more tightly constrained theoretical framework than those derived in FM. MLV's approach used the theory of duality (see Blackorby, Primont and Russell 1979) applied to a second order approximation to the true (but unspecified) variable profit function. This approximation had a trancendental logarithmic form of the type described in Diewert (1974). The advantage of MLV's "dual approach" to studying production decisions' over that adopted for ORANI was that it allowed inputs to be specific to outputs. MLV's model was applied to three composite outputs (sheep and wool, "crops", and cattle and "other"), and five inputs, three of which were assumed to be fixed. In addition to the prices for inputs and outputs and quantities of fixed inputs, MLV introduced time as an explanatory variable to proxy the level of technology.[5] The system was then estimated by the restricted Aitken estimator developed in Byron (1970), using annual data from the ABARE's Australian Sheep Industry Survey for the 25 years

[3]Details of the creation of the synthetic Input/Output data file for ORANI, known as the typical year agricultural data base, are given in Higgs (1985). The econometric procedures followed to estimate the relevant transformation and substitution parameters are described in Dixon, Vincent and Powell (1976), and Vincent, Dixon and Powell (1977 and 1980).

[4]The time dimensioning of 2 years for each elasticity was an estimate based on the work summarised in Cooper, McLaren and Powell (1985).

[5]The use of a logarithmic time trend as a proxy variable for changes in the level of technology was criticised in Watts and Quiggin (1984). Their criticism, which is acknowledged in (McKay et al .1983, p. 327, footnote 5), was that the parameter estimates of MLV's system were extremely sensitive to the essentially arbitrary choice of starting date for the time trend.

spanning 1952-53 through 1976-77. The time profile of each elasticity corresponded "to a period of time (say 1 year) that was sufficiently long for producers to adjust the composition of their outputs and variable inputs but was too short for them to adjust their endowments of relatively fixed inputs" (McKay *et al.* 1983, p. 330).

The approach taken by WD to estimate their supply elasticities differed markedly from that taken by all other authors cited. They made use of a simplified version of the finely disaggregated APMAA (Aggregate Programming Model of Australian Agriculture).[6] This model consists of a system of 521 linear programs, each embodying data for a farm firm representing a given location. The simplified APMAA model was used to generate hypothetical data on outputs for the three commodities wool, wheat and meat cattle for a total of 125 parametric variations in the three product prices. These synthetic data were then used to estimate (by OLS) a quadratic supply function which provided the information necessary to calculate the elasticity estimates. A time dimension for these elasticities was not reported.

The elasticity estimates reported in DSCH came from the Econometric Model of Australian Broadacre Agriculture (EMABA). EMABA has been developed within the ABARE to depict the determination of demand, supply and prices in the cattle, sheep and crops industries. A unique feature of the model is its separation of livestock output response from changes in livestock inventories. In the view of the authors this was essential for modelling price determination in those industries and allowed meaningful interpretation of the model's output projections. The supply system in EMABA consists of equations for eleven commodities (six crop and five livestock).[7] The livestock supply system contains a set of loosely constrained behavioural equations explaining slaughterings, retentions, deaths and yields; and identities which track inventory dynamics and production outcomes. The crop supply system, reflecting "a sequence of hierarchical allocation decisions", consists of two components. The first allocates the total area of land to crop production and to livestock production according to the present value of expected real returns accruing to each broadly defined activity. The second component allocates total crop area amongst the six crops based on relative expected returns. Both supply systems were estimated by OLS using annual data from surveys carried out by the Australian Bureau of Statistics and ABARE. The time profile for the short-run elasticities reported in Table 2.1 was "unambiguously time dimensioned" as the response after 5 years.

Estimates of short-run elasticities of agricultural commodity supply collected from the five studies cited are compared in Table 2.1 for the three most important agricultural commodities in Australia; namely, wool, wheat and meat cattle. The estimates of own-price elasticities are all positive, which is an implication of standard neo-classical production theory. The theory, however, is eclectic about the signs on the cross-price elasticities. A positive sign (for instance, on the elasticity of wool with respect to wheat reported in DSCH) indicates that the expansion effect of the change in relative price has more than offset the associated transformation effect, while a negative sign (for instance, on the elasticity of wool with respect to wheat reported in WD) implies that the transformation effect has dominated the expansion effect.

Close inspection of Table 2.1 reveals significant discrepancies. This is indicative of the current lack of consensus concerning short-run supply elasticities for agricultural commodities in Australia.

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[6] An overview of APMAA is given in Walker and Dillon (1976).

[7] There is a twelfth commodity called "live sheep exports". However, in the present version of the model, live sheep exports are treated as exogenous.

Table 2.1: Alternative estimates of short-run own and cross price elasticities of agricultural commodity supply(a)

Response in the output of	Study	Product whose expected price changes: wool	wheat	meat cattle
wool	Adams (1987)	0.46	-0.01	0.09
	Fisher and Munro (1983)			
	Southern Tablelands	0.26		
	South-West Slopes	0.28		
	Western Division	0.52		-0.99
	McKay, Lawrence and Vlastuin(b) (1983)	0.72	0.15	0.08
	Wicks and Dillon (1978)	0.25	-0.20	-0.18
	Dewbre, Shaw, Corra and Harris (1985)	0.39	0.16	-0.12
wheat	Adams (1987)	0.02	0.74	-0.09
	Fisher and Munro (1983)			
	South-West Slopes		2.05	
	McKay, Lawrence and Vlastuin(c) (1983)	0.43	0.50	-0.42
	Wicks and Dillon (1978)	-0.21	1.10	-0.21
	Dewbre, Shaw, Corra and Harris (1985)	0.33	0.92	0.14
meat cattle	Adams (1987)	0.18	-0.12	0.60
	Fisher and Munro (1983)			
	South-West Slopes	-0.83		0.70
	Western Division	-1.27		0.40
	McKay, Lawrence and Vlastuin(d) (1983)	0.25	-0.48	0.12
	Wicks and Dillon (1978)	-0.38	-0.44	0.69
	Dewbre, Shaw, Corra and Harris (1985)	-0.14		0.34

(a)The source for some of the estimates attributed to Dewbre, Shaw, Corra and Harris (1985) was personal communication with the authors. A blank indicates that the elasticity was either not estimated, or in the view of the authors, had no statistical significance.
(b)The elasticity of sheep and wool with respect to the price of sheep and wool, 'crops', and cattle and 'other', respectively.
(c)The elasticity of 'crops' with respect to the price of sheep and wool, 'crops' and cattle and 'other', respectively.
(d)The elasticity of cattle and 'other' with respect to the price of sheep and wool, 'crops', and cattle and 'other', respectively.

The discrepancies result primarily from differences in the approach taken in each study with respect to:

- i) the level of disaggregation assumed for the agricultural production system;
- ii) the specification of the production technology;
- iii) the data from which each elasticity was evaluated;
- iv) the choice of estimation technique; and
- v) the adjustment period allowed.

These differences are highlighted in Table 2.2.

From Table 2.2, the two major causes of disparity appear to be differences in the levels of disaggregation and differences in the specifications of the production technology. The supply systems of EMABA and ORANI employed relatively fine commodity specifications compared to those used in MLV, WD and FM. The production systems employed by Adams, MLV and (to a somewhat lesser extent) WD, make extensive use of *a priori* theoretical information. These systems relied on constraints among the coefficients of different equations which forced certain homogeneity and symmetry restrictions upon their parameters. By contrast, the production systems used by FM and DSCH were relatively unconstrained by such restrictions and by any constraints imposed by jointness in the production process.[8] They relied instead on explorations of the sample data to provide guidance for determining which explanatory variables finally to include. Differences in data, another reason for disparity among the elasticity estimates, appeared to be only a minor factor. Each study employed data derived from surveys in holdings in geographic areas representative of the ABARE's Pastoral, Wheat-Sheep and High Rainfall Zones.

There is of course another possible reason for the lack of consensus amongst the various studies; namely, differences in the lists of other variables which were conceptually being held constant when measuring the response of an output (say, of wool) to a price (say, of wheat). In the models used by Adams, DSCH, MLV and WD, the prices of variable inputs and quantities of fixed inputs explicitly enter the equations explaining the responsiveness of each output to an individual product price. Thus, in those studies, the elasticities reported were measured by holding constant variable input prices and fixed input quantities. On the other hand, FM derived their elasticities from supply response equations which made no particular allowance for the costs to producers of variable inputs or for the supply constraints imposed by fixed inputs. It follows therefore that the particular interpretation of *ceteris paribus* adopted in FM may have been quite different from that adopted in the other studies. What stops us from making a more definitive statement on this point is the possibility that, in the survey carried out by FM, the answers of the growers were based on the assumption that there would be no changes in the prices of variable inputs or in the quantities of fixed inputs over the time-horizon to which their expectations related. If this were the case, then the elasticities FM report would be based on similar *ceteris paribus* assumptions as those reported in the other studies.

3. Concluding Remarks

From Section 2 several areas of future research can be identified. Firstly, the supply response systems in EMABA, ORANI and MLV's model cover producers representative of geographic zones which together encompass the whole of Australia. The only data source of sufficient scope to support

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[8] The constraints imposed by jointness in the production process are outlined in Wall and Fisher (1988).

Table 2.2: Comparison of the principal features of supply studies

	Adams[(a)]	DSCH	FM	MLV	WD
<u>Level of aggregation</u>					
Unit (agents)	Zone (3 industries)	Enterprise (4 industries)	Region (3 representative farms)	All agriculture (1 producer)	Locality (521 representative farms)
Commodities (unit)	3,6 or 4 (composite commodity)	3,6, 1 or 1 (sgle commodity)	4 (sgle commodity)	3 (comp. commodity)	3 (sgle commodity)
<u>Specification of production technology</u>	CES-CRETH at zonal level	Linear supply functions for 4 enterprises	Linear supply functions for 3 regions	Translog variable profit function	Aggregate of 521 linear programs (quadratic in prices)
<u>Data</u>	'Typical' Input/Output data for 1977-78 plus BAE survey data	ABS and ABARE survey data	FM's survey of 62, 61 and 32 properties, respectively, in S. Tablelands, S.W. Slopes and W. Division of NSW	ABARE survey data	APMAA survey data
<u>Econometric Approach</u>	FIML	OLS	OLS	Restricted GLS	OLS on synthetic data from 521 LPs
<u>Adjustment period allowed</u>	About 2 years	5 years	About 3 years	About 1 year	na.

(a) For greater comparability with the other studies, this table covers only the Pastoral Zone, Wheat-Sheep Zone and High Rainfall Zone industries of ORANI.

na. Not available.

such studies is the ABARE survey system. However, the ABARE is gradually reducing the size of its survey samples. Does this represent a threat to the maintenance of the current Australia-wide agricultural models? If so, does the future lie with models employing more detailed but (in terms of geographic area covered) limited survey data such as that used by FM and WD?

A second issue for further research concerns the flexibility of MLV's "dual approach" to modelling production decisions vis a vis the treatment of the production process in ORANI. Conceptually, the former approach is superior, because it does away with the restrictive assumption of input/output separability. However, it is not yet clear whether this advantage in flexibility can be maintained when each approach is applied to real world data. Certainly, the evidence put forward by MLV is less than conclusive. Their claim for superior flexibility would have been definitive if: (a) they had worked at the same level of disaggregation as ORANI; and (b) they had demonstrated that their estimated system was globally regular (*i.e.* that their estimated parameters were consistent with input demand and output supply functions which could be derived by constrained optimisation at any setting of the exogenous variables). In fact, so far as (a) is concerned, MLV work at the level of one representative industry for the whole of Australia (versus three multi-product zonal industries in ORANI). Thus, it does not appear to be true to say that aggregate supply behaviour in ORANI necessarily is highly constrained by comparison with that in MLV's estimates. To take an example, under the CRETH specification (the maintained hypothesis at the industry level in ORANI), the cross-price elasticity of supply of wool with respect to the price of meat cattle in the Pastoral Zone is negative. Yet the aggregation across different industries in ORANI leads to a positive value for the elasticity at the aggregate level. Such a possibility in MLV's terms would be seen as enhanced flexibility (relative to CRETH). As far as (b) goes, in fact MLV's estimated system is not globally regular as evidenced by their finding that the "estimated translog variable profit function was not convex in p at mean exogenous prices and quantities" (McKay *et al.* 1983, p. 331).

Finally, a distinguishing feature of the supply system in EMABA is its explicit treatment of livestock inventory dynamics. Such an approach might be regarded as preferable to the alternative treatment, adopted in ORANI and by MLV, which accommodates inventory changes by defining livestock output variables to represent output (whether actually sold or in the form of a change in inventories). However, past empirical efforts to model the complex dynamics of livestock inventory changes have suffered from serious statistical problems.[9] Can EMABA track inventory dynamics without such problems? If so, can this feature be incorporated into a more tightly constrained supply system, like that of ORANI?

References

ADAMS, P.D. (1987), "Agricultural supply response in ORANI", *Review of Marketing and Agricultural Economics* 55(3), 213-29.

BLACKORBY, C., PRIMONT, D. and RUSSELL, R. (1979), *Duality, Separability and Functional Structure: Theory and Economic Applications,* North-Holland, Amsterdam.

BYRON, R.P. (1970), "The restricted aitken estimation of sets of demand relations", *Econometrica* 38(6), 816-30.

[9] Some of the statistical problems that have arisen are discussed in Rucker, Burt and La France (1984).

COOPER, R.J., MCLAREN, K.R. and POWELL, A.A. (1985), "Short-run macro-economic closure in applied general equilibrium modelling: experience from ORANI and agenda for further research", in J. Piggot and J. Whalley (eds), *New Developments in Applied General Equilibrium Analysis*, Cambridge University Press, Cambridge.

DEWBRE, J., SHAW, I., CORRA, G. and HARRIS, D. (1985), *EMABA Econometric Model of Australian Broadacre Agriculture*, Bureau of Agricultural Economics, Canberra.

DIEWERT, W.E. (1974), "Applications of duality theory", in Intriligator, M.D. and Kendrick, D.A. (eds), *Frontiers of Quantitative Analysis, Volume II*, North-Holland, Amsterdam.

DIXON, P.B., PARMENTER, B.R., SUTTON, J. and VINCENT, D.P. (1982), *ORANI: A Multisectoral Model of the Australian Economy,* North- Holland, Amsterdam.

DIXON, P.B., VINCENT, D.P. and POWELL, A.A. (1976), "Factor Demand and Product Supply Relations in Australian Agriculture: The CRESH/CRETH Production System", IMPACT Preliminary Working Paper No. OP-08, IMPACT Research Centre, University of Melbourne.

FISHER, B.S. and MUNRO, R.G. (1983), "Supply response in the Australian extensive livestock and cropping industries: a study of intentions and expectations", *Australian Journal of Agricultural Economics* 27(1), 1-11.

HALL, N., FRASER, L. and PURTILL, A. (1988), Supply Response in Broadacre Agriculture, paper presented to the 32nd Annual Conference of the Australian Agricultural Economics Society, LaTrobe University, Melbourne, 8-12 February.

HIGGS, P.J. (1985), "Implementation of Adams' Typical Year for the Agricultural Sector in the ORANI 1977-78 Data Base", IMPACT Preliminary Working Paper No. OP-49, IMPACT Research Centre,University of Melbourne.

MCKAY, L., LAWRENCE, D. and VLASTUIN, C. (1983), "Profit, output supply, and input demand functions for multiproduct firms: the case of Australian agriculture", *International Economic Review* 24(2), 323-40.

RUCKER, R.R., BURT, R.B. and LA FRANCE, T. (1984), "An econometric model of cattle inventories", *American Journal of Agricultural Economics* 66(2), 131-44.

VINCENT, D.P., DIXON, P.B., and POWELL, A.A. (1977), "Estimates of the CRETH Supply System in Australian Agriculture", IMPACT Preliminary Working Paper No. OP-17, IMPACT Research Centre, University of Melbourne.

VINCENT, D.P., DIXON, P.B. and POWELL, A.A. (1980), "The estimation of supply response in Australian agriculture: the CRESH/CRETH production system", *International Economic Review* 21(1), 221-42.

WALKER, N. and DILLON, J.L. (1976), "Development of an Aggregate Programming Model of Australian Agriculture", *Journal of Agricultural Economics* 27(2), 243-8.

WALL, C.A. and FISHER, B.S. (1987), *Modelling a Multiple Output Production System: Supply Response in the Australian Sheep Industry*, Research Report No. 11, Department of Agricultural Economics, University of Sydney.

WALL, C.A. and FISHER, B.S. (1988), "Supply response and the theory of production and profit functions", *Review of Marketing and Agricultural Economics,* 56(3), 383-404.

WATTS, G. and QUIGGIN, J. (1984), "A note on the use of a logarithmic time trend", *Review of Marketing and Agricultural Economics* 52(2), 91-9.

WICKS, J.A. and DILLON, J.L. (1978), "APMAA estimates of supply elasticities for Australian wool, beef and wheat", *Review of Marketing and Agricultural Economics* 46(1), 48-57.