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STRUCTURAL ESTIMATES OF DOMESTIC DEMAND FOR AGRICULTURAL PRODUCTS IN AUSTRALIA: A REVIEW†

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Applied economists have devoted significant resources to the econometric estimation of demand and price parameters of markets for agricultural products. This paper provides a review of research in this area for the Australian domestic market. Identified publications are classified on the basis of various levels of aggregation over products and markets and are evaluated in terms of the use of economic theory, econometric methods and data. In the final section of the paper there is a discussion of some questions and problems arising from the existing literature, and the implications for future research in this area.

1 INTRODUCTION

Research on demand and prices for agricultural products has generally been justified on the basis of a need for information in the formulation of rural policy. Such information may also be useful to a wider audience if it improves the understanding of market structure, market response to changes in such variables as prices and income, and prediction of short- or long-term trends in prices and demand. The objective of this paper is to summarize the major parameters of the domestic market which have been estimated and to discuss some implications for future research of this type.

Analyses of demand and prices for agricultural products have been motivated by a variety of objectives, and in each case the type of analysis and the nature of results varies. Where the provision of short-term outlook or forecast information is the objective, fairly simple techniques of analysis predominate; trends in the market are described and less attention is devoted to considerations of market structure.

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At the other extreme economists use data from markets to test hypotheses suggested by specific assumptions involved in economic theory. This type of research may contribute primarily to the development and modification of economic theory and only secondarily to the understanding of market forces. This paper is confined to a review of econometric analyses of demand and prices which relate to commodity policy. In research of this kind, economic theory is utilized to varying degrees and the focus is on analysis of the structural variables presumed to describe the behaviour of demand and prices.

The results of these so-called commodity policy analyses are summarized in the form of estimated parameters. These parameters include direct-price, cross-price and income elasticities and/or flexibilities, as well as a variety of other parameters. Estimated results may be used in the evaluation of supply management, price support and related policies; they may also be used in forecasting in some instances.

In reviewing the literature several attributes which characterize research in demand and price analysis are evaluated. These attributes relate to the use of economic theory, choice of estimation methods and data and the results that have been reported in published research. Literature reviewed includes all identified econometric studies of demand and prices for the Australian domestic market for agricultural products.

At the outset it must be recognized that the results of this research must be evaluated in the context of changing domestic and export market structures facing the rural sector. Australian agriculture performs a dual role of supplying domestic food and fibre needs and of earning export income. In 1972–73, for example, the gross value of Australian rural production was $4,608 million and the export value was $3,319 million. This latter figure represents 53 per cent of total export income. While the figures on gross value of production and exports are not strictly comparable, over 50 per cent of the value of agricultural products is represented by exports and this percentage has increased over time. Wool, wheat, sugar, beef and veal, mutton, dried vine fruits and grain sorghum are all dependent on export markets. For these products an understanding of the structure of world market forces is relevant particularly because, over time, producers of these products are becoming more dependent on export markets. While this paper contains no explicit review of econometric studies of demand for agricultural products on export markets, the relationships between the two markets cannot be satisfactorily ignored.

In the three following sections of the paper empirical results are reviewed in some detail. The literature is classified according to the degree of product aggregation used by various authors, the types of models utilized, and on the basis of a subjective grouping of related products. In each section results are summarized in tabular form and discussed. Comments are made on the form of models utilized, the choice and use of estimation techniques and statistical and data problems involved in the analyses. In Section 5 of the paper some implications for future research in demand and price analysis are discussed.

2 AGGREGATE DEMAND STUDIES

The most aggregated level of analysis of demand is one in which total consumer expenditure is divided between a small number of product groups. In such studies all food is aggregated into one group and its demand parameters are jointly estimated, along with those for other major commodity groups such as housing, services, etc. By virtue of the explicit recognition of interdependency between all groups of products, this may be called a "Systems Approach".

This systems approach is based on the use of some specified form of the consumer's utility function, and exploits restrictions and assumptions derived from theories of consumer behaviour. Analysis of consumer demand begins with the proposition that the individual consumer exhausts a total income (M) in period t such that

$$M_t \equiv Y_t + S_t, \tag{1}$$

where S_t and Y_t are respectively, savings and expenditure. Savings are assumed to be exogenously determined and total expenditure is divided between products groups such that

$$Y_t \equiv \sum_{i=1}^{n} P_{it}X_{it}, \tag{2}$$

where P and X are respectively prices and quantities of $i(= 1,2, \ldots ,n)$ product groups consumed in period t. The demand for the ith product group in period t, X_i, is given by

$$X_{it} = D_i(P_{1t}, P_{2t}, \ldots, P_{nt}, Y_t). \tag{3}$$

Multiplying both sides of (3) by P_{it} identifies the expenditure for the ith product as a function of all prices and income,

$$P_{it}\, X_{it} = P_{it}\, D_i(P_{1t}, P_{2t}, \ldots, P_{nt}, Y_t). \tag{4}$$

If the right hand side of (4) is linear in all prices and income, it is a Linear Expenditure System (L.E.S.). In the estimation of the L.E.S., interdependencies in demand between the n product groups are taken into account. Because of the large number of parameters to be estimated, further restrictions must be incorporated in the model in order to estimate a matrix of elasticities.

Restrictions utilized in the estimation of systems of demand equations are of two types. First, in choosing a form of the consumer's utility function, the number of endogenous parameters in the system can be reduced. The relationship between product groups which enter the expenditure system and the utility function may be specified as additive, block additive or separable. Second, restrictions on the demand behaviour may be specified as a consequence of assumptions about utility maximization by consumers. These restrictions include the assumptions of homogeneity of the utility function, exhaustion of the consumer's budget and symmetry of price effects.[1] Using these restrictions, the number of parameters to be estimated from a given set

[1] Restrictions utilized in the estimation of systems of demand equations are discussed in detail by Powell [36].

of data can be reduced to more manageable proportions. The resulting estimates of demand parameters are based on explicit recognition of the joint determination of demand for all product groups, subject to a set of restrictive assumptions.

In studies of aggregate demand, total consumer expenditure is usually divided between from four to ten product groups. Price and quantity data for these product groups are derived from such sources as the National Income Accounts, the Consumer Price Index and cross-sectional survey data on household consumption and expenditure patterns. These data are analyzed on a per caput or per household basis which is equivalent to a "representative" consumer or household approach. "All food" is normally treated as a single product group and represents 25 to 30 per cent of total consumer expenditure.

Results for "all food" from estimated systems of demand equations for Australia are summarized in Table 1. The demand for food in aggregate is found to be inelastic with respect to both income and its own price. Differences between the elasticities from various studies may be attributed partly to the use of a range of alternate models and estimation techniques, and partly to changes in the underlying behavioural structure through time. While the food group is comparable between studies there are varying degrees of product disaggregation as noted in the table.

The earliest work reported for Australia was the study by Leser [23] in which a L.E.S. was estimated. While the model is computationally simple, it involves an assumption that elasticities of substitution are equated between product groups and are constant. In both of the models estimated by Leser, the elasticity of substitution was assumed to be 0.5. Leser noted that the resulting price elasticities are likely to be unreliable.

Powell [35], Gruen *et al.* [19] and Byron [12, 13] all used models of consumer utility based on an assumption of additive preferences in the consumer utility function. The resulting models do not require the assumption of a constant elasticity of substitution involved in Leser's model. Powell [35] argued that in Leser's model, price elasticities were over-estimated relative to the additive preference model. This is supported by the two estimates made by Powell that appear in Table 1. Woodland [56] and Clements [14] have analyzed demand with a view to durable commodities and asset holdings of consumers respectively. Tran Van Hoa [50] disaggregated data by States and found differences between elasticities for various States.

Several studies have been published in which elasticities estimated from cross-sectional data are reported. The most ambitious of these is a study by Podder [33] which was based on a survey of consumer expenditures by a sample of 5 500 urban families. Smaller studies by the Bureau of Agricultural Economics (BAE) [8, 9] and Quilkey [37] also resulted in cross-sectional estimates of demand parameters. In addition to income elasticities, cross-sectional data has also been used to estimate elasticities of expenditure on all food with respect to changes in income and household size.

TABLE 1: *Estimates of Demand Parameters for "All Food", Australia*

Author	Data	Area	Estimation method and comments (a)	Estimated elasticities	
				Price	Income/Other
Leser [23]	1948–49 to 1956–57 A	Australia	O.L.S., constant elas. of substn. = 0.5; L.E.S., 4 product groups.	−0.53	0.57 to 0.74
Leser [24]	1949–50 to 1959–60 A	Australia	O.L.S., as above, 9 product groups	−0.51	0.56 (b)
Powell [35]	1949–50 to 1961–62 A	Australia	O.L.S., constant elas. of substn. = 0.5; L.E.S., 10 product groups.	−0.47	0.38
Powell [35]	1949–50 to 1961–62 A	Australia	O.L.S., iterative procedure, additive preferences, 10 product groups.	−0.30	0.48
Gruen *et al.* [19]	1949–50 to 1962–63 A	Australia	O.L.S., iterative procedure, additive preferences, 10 product groups.	−0.30	0.55 (b)
Byron [12]	1949–50 to 1961–62 A	Australia	O.L.S., with various restrictions, 5 product groups	−0.43 to −0.73	0.21 to 0.70
Byron [13]	1950 to 1970 Q	Australia	O.L.S., with various restrictions, 5 product groups	−0.41 to −0.51	0.37 to 0.56
Woodland [56]	1948–49 to 1963–64 A	Australia	O.L.S., iterative procedure, 2 products (food and durables).	−0.55	0.23 (b)
Clements [14]	1968 to 1973 Q	Australia	Max. likelihood, 9 product groups (c)	−0.26 (d)	0.69 (e)
Podder [33]	Cross-sect. 1966–68	Australian Capital Cities	O.L.S., 5,500 urban families	..	0.49, 0.39 (f)
Podder [33]	Cross-sect. 1966–68	Australian Capital Cities	O.L.S., as above, instrumental variables	..	0.47, 0.40 (f)
Podder [33]	Cross-sect. 1966–68	Australian Capital Cities	O.L.S., as above, instrumental variables	..	0.39 to 0.52 0.25 to 0.45 (f)
Tran Van Hoa [50]	1948–49 to 1964–65 A	Australia	G.L.S., 9 product groups	−0.30	0.50
Tran Van Hoa [50]	1948–49 to 1964–65 A	Various states	G.L.S., 9 product groups	−0.22 to −0.49	0.38 to 0.76
BAE [8]	1964–65 cross-sec.	Sydney	O.L.S., 451 households	..	0.22 (g), −0.30 (h)
BAE [9]	1967 cross sect.	Melbourne	O.L.S. 803 households	..	0.19 (g), −0.32 (h)
Quilkey [37]	1967 cross-sect.	Melbourne	O.L.S. 782 households	..	0.19 (g)
Quilkey [37]	1967 cross-sect.	Sydney	O.L.S. 711 households	..	0.13 (g)

(a) Notation for the estimation method is as follows: Ordinary Least Squares (O.L.S.) and Generalized Least Squares (G.L.S.). Variants of these basic techniques were used by Byron and Van Hoa. (b) Expenditure elasticity. (c) The model includes 3 commodity groups and 6 durable asset groups. (d) Uncompensated price elasticity for a single period (quarterly). (e) Spending power elasticity for a single period. (f) With respect to family size. (g) Elasticity of food expenditure with respect to income. (h) Elasticity of food expenditure per person with respect to household size.

Variants of Ordinary Least Squares (O.L.S.) were the most common estimation techniques used in the research summarized in Table 1. Byron [12] has shown that the magnitude of elasticities is sensitive to the choice of modelling assumptions and estimation techniques. He, therefore, examined the properties of alternate estimators for a given set of data, devoting less attention to empirical results. Another writer, Deaton [15], has argued that models based on additive preferences do not provide accurate estimates of parameters and he questions the use of this modelling assumption. There are unresolved issues relating to the choice of models and estimation techniques. The models generally involve restrictive assumptions and focus attention on testing hypotheses about the underlying utility function, rather than on magnitudes of price and income responses.

3 AGGREGATE DEMAND FOR RURAL PRODUCTS

In the literature discussed in the preceding section, it is assumed that all food is a homogenous commodity which consumers treat as a single item. The next logical step is to disaggregate the food group, in order to examine the demand and price structure facing the rural sector.[2] Three such studies appear in the literature, each involving a different approach to modelling, estimation and use of data. Gruen *et al.* [19] estimated a system of demand equations for a six-product classification of food produce in Australia. Podder [34] estimated cross-sectional expenditure and family size elasticities for five food-product groups. Butler and Saad [11] estimated elasticities and flexibilities of domestic and export demand for Australian food produce.

Results from the study by Gruen *et al.* are summarized in Table 2. The analysis was based on the L.E.S. model that was used by Leser [23, 24] and an estimate of the "money flexibility" of -2.87 derived from a study of aggregate expenditure by Powell [35]. The model involved a separable utility function[3] and the authors sought to relate it to Powell's model, which was updated for the purposes of the study. The assumption of equal cross-elasticities of substitution between food items was made to estimate income elasticities, marginal value shares and trend coefficients. Estimates of the money flexibility and marginal value shares were used to calculate a matrix of demand parameters by use of an elasticity formula. Data for the model were annual per caput consumption and price indices for the food groups for the period 1948/49 to 1962/63.

The authors point out [19, pp. 4–23], that the estimation procedure, in which money flexibility estimates from the aggregate model are applied to food commodity data, is not internally consistent.

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[2] While non-food products are a large component of total agricultural production, econometric analysis of their markets have not been found in the literature.

[3] For example, price changes for any group of products other than food (say clothing) only affect the general food group and do not affect items within that group directly.

TABLE 2: *Estimated Demand Parameters for a Six Commodity Classification of Australian Food Consumption* (a)

	Bread and cereals	Meat and fish	Dairy products and eggs	Sugar preserves and confectionery	Fruit and vegetables	Other	Row total = Negative of total food expenditure elasticity for each group	Income elasticity of demand (b)
Bread and cereals	−0.482	−0.168	−0.245	−0.076	−0.095	−0.028	−1.094	0.60
Meat and fish	−0.119	−0.647	−0.288	−0.090	−0.112	−0.033	−1.289	0.71
Dairy products and eggs	+0.009	+0.015	+0.055	+0.006	+0.009	+0.003	+0.097	−0.05
Sugar, preserves and confectionery ..	−0.128	−0.212	−0.309	−0.578	−0.120	−0.035	−1.382	0.76
Fruit and vegetables	−0.128	−0.212	−0.308	−0.096	−0.599	−0.035	−1.378	0.76
Other	−0.141	−0.233	−0.340	−0.106	−0.132	−0.568	−1.520	0.84

(a) Based on Leser-type estimates of marginal value shares, and on a prior estimate of −2.87 for Frisch's "money flexibility". Elasticities are measured at mean prices and expenditures. The figure in the table estimates the percentage change in the consumption of commodity *i* when the price of *j* rises by one per cent, total money food expenditure and all other prices remaining constant. (b) Estimated using Leser's model, and independently of the price parameter estimates in the remainder of the table.

Source: Gruen *et al.* [19].

The results of this study appear to be of limited practical value due to the predominance of signs in Table 2 which are contrary to prior expectations. For all food groups, income elasticities are positive and inelastic with the exception of dairy products and eggs.[4] The direct and cross price elasticities are all negative, again with the exception of dairy products and eggs. While this is a laudable attempt to exploit theoretical restrictions in estimating a system of demand equations, the results are of limited value. Gruen *et al.* also estimated demand parameters for individual products and these results are reported in Section 4 of this paper.

Podder [34] provided further information on expenditure for five commodity groups from a cross-sectional study for Australia. These groups were analyzed in terms of sociological and demographic variables and income and family size parameters were estimated; the results are summarized in Table 3. The expenditure elasticity of demand for "food eaten away from home" was found to be elastic while for all other product groups, it was inelastic. These results were estimated using O.L.S. on cross sectional data.

TABLE 3: *Estimated Elasticities for Major Food Groups Cross.*

Product group	Expenditure elasticity	Family size elasticity	R^2
Groceries	0.36	0.56	0.67
Fruit and vegetables	0.43	0.45	0.42
Fresh meat, fish, poultry ..	0.59	0.36	0.47
Frozen meat, fish, poultry ..	0.52	0.03	0.18
Food away from home	1.90	0.20	0.46
Total food	0.49	0.39	0.78

Source: Podder [34].

Podder estimated two versions of this basic model. First, dummy variables were used to examine variations between elasticities for higher and lower income groups. Significant differences in income elasticity magnitudes were found between various income levels. Second, dummy variables for country of origin were used to identify differences in the elasticities between various cultural groups of consumers included in the sample. Statistically significant differences between sample groups of people, based on region of origin (areas of Europe and Asia as a whole), were identified. Finally dummy variables were used to show variations in consumption patterns of households with varying age structures. This is the most detailed cross-sectional analysis of consumption patterns for major food groups which has been reported in the literature. Smaller studies in Sydney and Melbourne by Quilkey [37] resulted in estimates of the income elasticity of food expenditure

[4] This result suggests that the product group "dairy products and eggs" is an inferior product. This result also occurs for butter in single equation models.

for meat of 0.12 and 0.29 respectively, for fruit and vegetables 0.22 in both cities and for groceries and all other food of 0.10 and 0.14 in Sydney and Melbourne respectively.

Butler and Saad [11] estimated elasticities and flexibilities of domestic and export demand for Australian food produce. Domestic demand parameters were estimated at both farm and retail levels, while export demand parameters were estimated at the farm gate level. This study has similarities with those reviewed in Section 2 of the paper, because only the demand for all food was considered. However, while Butler and Saad confined their study to the demand for food produce, they did not exploit restrictions derived from consumer theory. The analysis was based on annual aggregate price and quantity indices for food over the period 1948/49 to 1969/70. The results, summarized in Table 4, indicate that domestic retail and farm level demand for food is price inelastic, while farm level export demand is price elastic.

TABLE 4: *Estimated Price Elasticities and Flexibilities for Australian Food Produce*

	Estimation method (a)	Price elasticity	Price flexibility	Income elasticity
Domestic retail—				
Short-run	2.S.L.S.	−0.10	−7.10	0.07
Long-run	2.S.L.S.	−0.13	−7.32	..
Farm gate—domestic—				
Short-run	(b)	−0.09	−7.92	..
Long-run	(b)	−0.12	−8.16	..
Farm gate—export—				
Short-run	O.L.S.	−1.76	..	..
Long-run	O.L.S.	−2.34	..	..

(a) Ordinary Least Squares (O.L.S.) and Two Stage Least Squares (2.S.L.S.) were used.

(b) These parameters were calculated by dividing retail level elasticities by an estimated price elasticity of transmission from retail to farm level.

Source: Butler and Saad [11].

There appear to be some problems of model construction in the paper by Butler and Saad. The domestic retail sector of the model is a two-equation simultaneous system, estimated by Two Stage Least Squares (2.S.L.S.), with current prices and quantities as endogenous variables. No supply shifting variables are included in the model, however, which raises questions as to whether demand parameters can be really identified. A further problem is that, if both equations are to be interpreted as demand equations, the use of lagged prices and quantities as explanatory variables, in order to estimate long-run parameters, seems to lack economic rationale at retail.[5]

[5] At the retail level food produce could hardly be regarded as a durable product, particularly when the analysis is based on annual data.

In estimating elasticities and flexibilities at the farm level, the authors resorted to two approaches. First, a regression equation was used to calculate the elasticity of price transmission between domestic retail and farm gate levels of the market. Retail price was treated as an exogenous variable in this model whereas it was endogenous in the model discussed above. The elasticity of price transmission may conceal rather complex margin behaviour between the farm and retail levels and constrain farm level parameters in magnitude relative to the retail estimates. Second, farm level output demand was represented by a single equation model in which farm level price was treated as an exogenous variable.

Comparing the retail and farm level models used by Butler and Saad a critical and unanswered question is that of whether any of the prices should be treated as exogenous? If all prices are regarded as endogenous then a larger simultaneous model would be necessary and the results of the present models appear to be of questionable value.

4 INDIVIDUAL COMMODITY STUDIES

Econometric analyses of demand and prices for individual products, or small groups of products, have been widely reported in the literature. This section of the paper is devoted to a summary and review of research in this area. For the purposes of this presentation products are subjectively divided into groups which are related in production and/or consumption. Results for each group are presented in tabular form and discussed together. The tables include information on the market level, data and estimation method as well as estimated parameters. Only statistically significant estimates, based on inspection of standard errors or t-test results, are included in the tables. Discussion is generally confined to the most recent studies.

Individual commodity studies have generally been motivated by a specific problem orientation. This is in contrast to studies reviewed above which relate to theoretical and estimation problems or to the rural sector as a whole. Such a contrast is also demonstrated by the balance of theoretical and empirical content of papers reporting econometric analyses of demand and prices for individual commodities.

Only limited violence is done to the authors of such papers, if the broad approach they adopt is described as "Ad Hoc". Econometric studies of demand and prices for individual commodities generally do not exploit a rigorous basis for analysis in terms of consumer behaviour or factor demand theories. The approach is rather one of ad hoc selection of variables to enter estimating equations. Consistency with the arguments of underlying utility or production functions of demanders is largely ignored. The most widely used model is one in which quantities demanded (Q_i), at some specified market level, are hypothesized to be a function of price (P_i), a related price (P_j) and income (Y). Thus the model is

$$Q_i = f(P_i, P_j, Y), \tag{5}$$

An alternate formulation of the model is

$$P_i = f(Q_i, P_j, Y), \tag{6}$$

Equations (5) and (6) incorporate the most common economic variables used in ad hoc models and form a basis for the estimation of elasticities and flexibilities respectively. Variations in the way variables are measured and interpreted are numerous. In individual studies other variables are included which relate to specific aspects of the market for the commodity under consideration, or the nature of the problem being studied.

Equations are generally estimated by O.L.S. estimation techniques using linear or log linear formulations. For equation (5) these are respectively

$$Q_i = a + b_1 P_i + b_2 P_j + b_3 Y + e, \tag{7}$$

and

$$\log Q_i = a + b_1 \log P_i + b_2 \log P_j + b_3 \log Y + e. \tag{8}$$

Choice between these functional forms is frequently based on statistical considerations such as the fit of the data or on a desire to interpret the parameters directly as elasticities, in the case of the log-linear model. Such statistical problems as multicollinearity and autocorrelation, common in time series models, are often ignored in the analysis of demand for individual commodities. Econometric estimation has mainly been based on static models which do not allow for adjustment through time, possible simultaneity of demand between products, or adjustment of stock levels over time. Perhaps the most fundamental issues are those of the choice of simultaneous or single equation models, given the types of data series available, and the choice between alternate sources of data.

Issues raised above are taken up in more detail in following sub-sections of the paper, as part of the discussion of econometric estimates of demand and price parameters for agricultural products.

4.1 MEAT PRODUCTS

Products included in this group are beef and veal, lamb, mutton, pigmeat, poultry and fish. Beef, lamb and mutton have proved to be the favourite products in empirical study. Results of various econometric studies are summarized in Table 5.

Retail price elasticities have been estimated from a variety of data sources for all commodities in the group. For beef, demand elasticity estimates range from -0.76 to -1.33 using various estimation techniques and data sources. For lamb the range of estimates is from -1.55 to -2.07 and for mutton -1.09 to -1.40. Price elasticities of demand for pigmeat vary from -1.20 for bacon and ham to -3.29 for pork. Only one study has been identified for chicken meat with price elasticity estimates of -1.31 and -1.63. A cursory inspection of these results leads to the tentative conclusion that the demand for individual meat types is price elastic, with the exception of beef, for which the value is about unity.

Demand and price equations based on farm and/or wholesale data have been estimated for beef, lamb, mutton and pigs. The estimated price elasticities are lower in absolute value than corresponding values at the retail level, with the exception of a study by Papadopolous [29] of factors hypothesized to determine monthly saleyard prices of beef cattle.

Income, expenditure and related variables have been used as explanatory factors in meat demand analyses. The resultant elasticities fall into two groups. Cross-sectional estimates based on data collected by the BAE [8, 9] are all less than 0.30. Time series data, on the other hand, have formed the basis of income elasticity estimates of from 0.22 for beef to 1.50 for pork. Gruen *et al.* [19] found negative income and expenditure elasticities for mutton. McShane [27] concluded, from a cross-sectional survey, that "financial factors" (i.e. measures of income) only affect the quantity of meat purchased for low income households, while "quality" of meat purchased may change with income.

Comparisons of income elasticities from various sources must be made with care since the choice of estimates depends upon what they are to be used for. Despite this problem it may be argued that time series data lead to over- or in the case of mutton, under-estimates because income, time and unquantifiable factors related to tastes and preferences are often highly correlated and bias the results.

Cross elasticities of demand between meats have been reported by a number of researchers. While such elasticities are low in absolute value for beef (0.04 to 0.4), they are higher in the demand equations for lamb and mutton at retail (0.30 to 1.24). Cross elasticities of demand for mutton with respect to beef prices were estimated to be elastic by both Marceau [25] and Gruen *et al.* [19]. Pender and Erwood [31] reported a retail cross elasticity of demand for pork with respect to the prices of "all other meats" of 1.85. The diversity of cross elasticities and other such parameters reported in Table 5, indicate the extent to which analysts have searched for significant explanatory variables in problem oriented econometric work.

Econometric analyses of demand and prices have been based on a variety of data sources and models. Annual and quarterly time series data were used in most cases and estimation was by O.L.S. regression. In response to one of the earliest studies by Taylor [46], Duloy and Van der Meulen [16] argued that the demand for beef should be specified as a function of endogenous beef prices in a model of demand for all meats at retail. Subsequently, three attempts have been made to develop simultaneous models of demand for meat. These efforts, reported by Gruen *et al.* [19], Marceau [25] and Throsby [48, 49], met with varying degrees of success. Gruen *et al.* estimated a four-equation model of demand for beef, mutton and lamb using 2.S.L.S. estimation procedures. The results were, as the authors say, disappointing, because many coefficients were non-significant and/or contrary to prior expectations. Consequently they reverted to single equation estimation which is the basis of their results reported in Table 5.

TABLE 5: *Estimated Demand Parameters for the Meat Group of Products, Australia*

Product and market level	Author(s)	Data (a)	Area	Estimation method (b)	Estimated elasticity (c)		
					Price	Income	Other
Beef—retail	Throsby [48]	1962 to 1972 Q	Aust.	2.S.L.S.	−1.90	0.59	
Beef—retail	Throsby [49]	1962 to 1972 Q	Aust.	O.L.S.	−0.76	0.22	0.04 (e)
Beef—retail	Taylor [45]	1950–51 to 1959–60 A	Aust.	O.L.S.	−0.96		0.02 (f)
Beef—retail	Taylor [46]	1950–51 to 1959–60 A	Aust.	O.L.S.	−0.87, −1.03		
Beef—retail	Marceau [25]	1951 to 1963 Q	N.S.W.	O.L.S.	−1.33		
Beef—retail	Van der Meulen [55]	1948–49 to 1959–60 A	Sydney	O.L.S.	−0.71	0.40	0.35, 0.49 (e)
Beef—retail	Gruen/McLaren [20]	1949–50 to 1964–65 A	Aust.	O.L.S.	−0.79, −0.96 (g)		
Beef—retail	B.A.E. [8]	1964–65 cross sect.	Sydney	O.L.S.		0.27 (h)	−0.30 (i), −0.36 (j)
Beef—retail	B.A.E. [9]	1967 cross sect.	Melb.	O.L.S.		0.21 (h)	−0.50 (i), −0.57 (j)
Beef—auction	Marceau [25]	1951 to 1963 Q	N.S.W.	O.L.S.	−0.50		
Beef—auction	Papadopolous [29]	1962 to 1971 Q	Various states	O.L.S.	−0.05 to −0.44 (F)		
Lamb—retail	Marceau [25]	1951 to 1963 Q	N.S.W.	O.L.S.	−2.07		0.92 (k)
Lamb—retail	Taylor [46]	1950–51 to 1959–60 A	Aust.	O.L.S.	−1.82		
Lamb—retail	Taylor [47]	1950–51 to 1959–60 A	Aust.	O.L.S.	−0.49, −0.68 (F)		0.31 (F) (l)
Lamb—retail	Gruen/McLaren [20]	1949–50 to 1964–65 A	Aust.	O.L.S.	−1.55	0.83 (m)	0.50 (l)
Lamb—retail	Gruen/McLaren [20]	1949–50 to 1964–65 A	Aust.	O.L.S.	−1.40	0.45	0.63 (l)
Lamb—retail	Van der Meulen [55]	1948–49 to 1959–60 A	Sydney	O.L.S.	−0.75 (F)	0.23	0.50 (n)
Sheepmeat—retail	B.A.E. [8]	1964–65 cross sect.	Sydney	O.L.S.		0.15 (h)	−0.17 (i), −0.23 (j)
Lamb—wholesale	Van der Meulen [55]	1945–46 to 1959–60 A	N.S.W.	O.L.S.	−0.62 to −1.0	0.97 to 1.40 (F) (o)	
Lamb—auction	Marceau [25]	1951 to 1963 Q	N.S.W.	O.L.S.	−0.70		
Lamb—auction	Bain [3]	1955 to 1971 (p)	Vic.	O.L.S.	−0.34 (F)		1.00 (F) (r)
Lamb—auction	Bain [3]	1955 to 1971 (q)	Vic.	O.L.S.	−1.66 (F) (r)		−0.28 (F) (s)
Lamb—auction	Sault [40]	1955 to 1964 Q	Various states	O.L.S.			0.45 to 0.72 (F) (r)
Lamb—auction	Taplin [44]	1951 to 1964 (t)	N.S.W.	O.L.S.	−1.70		
Lamb—auction	Taplin [44]	1951 to 1964 (t)	Vic.	O.L.S.	−1.40		

TABLE 5: *Estimated Demand Parameters for the Meat Group of Products, Australia—continued*

Product and market level	Author(s)	Data (a)	Area	Estimation method (b)	Estimated elasticity (c)		
					Price	Income	Other
Mutton—retail	Marceau [25]	1951 to 1963 Q	N.S.W.	O.L.S.	−1.09		1.24 (l), 0.79 (e)
Mutton—retail	Taylor [45]	1950–51 to 1959–60 A	Aust.	O.L.S.	−1.21		0.79 (e)
Mutton—retail	Taylor [46]	1950–51 to 1959–60 A	Aust.	O.L.S.	−0.82 (F)		−1.32 (F) (l), −0.29 (F) (u)
Mutton—retail	Gruen/McLaren [30] (g)	1949–50 to 1964–65 A	Aust.	O.L.S.	−1.38	−1.73 (m)	1.20 (l)
Mutton—retail	Gruen/McLaren [30] (g)	1949–50 to 1964–65 A	Aust.	O.L.S.	−1.02	−0.59	0.82 (l)
Mutton—auction	Marceau [25]	1951 to 1963 Q	N.S.W.	O.L.S.	−0.25		0.30 (l)
Pork—retail	Pender/Erwood [31]	1952–53 to 1968–69 A	Aust.	I.L.S.	−3.29	1.50 (v)	1.85 (w)
Pork—retail	Gruen/McLaren [20]	1949–50 to 1959–60 A	Aust.	O.L.S.	−2.19	2.81 (m)	
Pork—retail	Hill [21]	1948–49 to 1961–62 A	Aust.	O.L.S.	−1.20		
Bacon/ham—retail	Hill [21]	1948–49 to 1961–62 A	Aust.	O.L.S.	−1.30		
Pigs—wholesale	Hill [21]	1948–49 to 1962–63 A	Aust.	O.L.S.	−1.14		
Pigs—wholesale	Hill [21]	1948–49 to 1962–63 Q	Aust.	O.L.S.	−0.86 to −1.30		
Chicken—retail	Paton [30]	1954 to 1969 A	Aust.	O.L.S.	−1.31, −1.63		0.42, 0.44 (e)
All meat	BAE [8]	1964–65 cross-sect.	Sydney	O.L.S.		0.25 (h)	−0.16 (i)
All meat	BAE [9]	1967 cross-sect.	Melb.	O.L.S.		0.22 (h)	−0.20 (i), −0.30 (j)

(a) For the data A, annual; Q, quarterly; M, monthly. (b) Estimation methods include Ordinary Least Squares (O.L.S.), Two Stage Least Squares (2.S.L.S.) and Indirect Least Squares (I.L.S.). (c) Flexibilities are indicated by (F). (d) Using instrumental variables. (e) With respect to lamb price. (f) With respect to price of lamb and mutton loin chops. (g) These results are reported and discussed in three publications [19, 20, 26]. (h) Elasticity of expenditure with respect to changes in income. (i) Elasticity of quantity purchased per person with respect to change in household size. (j) Elasticity of expenditure with respect to change in household size. (k) With respect to beef price in an equation in which the own-price elasticity is non-significant. (l) With respect to beef price. (m) Expenditure elasticity. (n) With respect to beef quantity. (o) Derived at various points in the data range. (p) Data for the export period October-December. (q) Data for the period January-September. (r) With respect to prices at Smithfield Markets. (s) With respect to mutton supplies. (t) Data for the period June to August. (u) With respect to quantity of lamb. (v) This may be an over-estimate because of the effects of "tastes" on consumption over time. (w) With respect to an index of all other meat prices.

Marceau [25] studied the demand for meats at auction, wholesale and retail levels using quarterly data for N.S.W. While recognizing the existence of interdependence between equations in the model, he avoided estimating simultaneous equations. This was done by transforming the original data, on the basis of an auto-regressive scheme, calculated from the residuals of estimated equations. Marceau then proceeded to estimate margin equations and demand and price equations at auction and retail. Non-significant coefficients and signs contrary to prior expectations were a feature of the estimates, as Gruen *et al.* had found.

In a more recent quarterly econometric analysis, Throsby [48, 49][6] estimated the parameters of a four-equation model for Australian beef. Instrumental variables were used in order to estimate the model in which farm and retail beef prices and domestic and export demand, were treated as endogenous. Non-significance of coefficients in the model complicated interpretation of the results. One aspect of Throsby's model is that export demand was included in the model. While Throsby attempted to use the model for prediction, hindsight suggests that his equations do not really capture the relationship between the domestic and export markets.

Overall it is apparent that the existing data have generally failed to support hypothesized simultaneity in demand and price formation for meat products. Diverse sources of data and a variety of model specifications are evident in the literature. One is tempted to conclude that, after many experiments in the manipulation of data and variables, evidence on the magnitude of the structural parameters of the meat market is conflicting.

4.2 DAIRY PRODUCTS AND EGGS

Estimates of demand parameters for dairy products and eggs are summarized in Table 6. O.L.S. has been the only estimation technique used and it appears that domestic demand for all products is price inelastic at the retail level.[7] Income and household size elasticities are also reported in the table.

In most studies of demand for dairy products in which time series data were used, authors had difficulty in identifying significant coefficients with appropriate signs, on such variables as own price, the prices of related products and income. Gruen *et al.* [19] for example, estimated demand equations for milk in Australia and none of the coefficients were significant. Rutherford [39] plotted relationships between prices and quantities for dairy products, but did not estimate elasticities from time series data. Using cross-sectional data he found that such factors as household composition and the crude birth rate influenced milk consumption.

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[6] The earlier of these two papers [48] was primarily exploratory in nature.

[7] Results in the table by Ross [38] are in fact estimates derived by calculation from simple regressions reported in that paper.

The most recent work on the demand for milk is the econometric study by Street [42]. He concluded that retail level demand for milk is price inelastic in both the short-run and the long-run. Using a principal component analysis, Street also found that age structure of the population affects aggregate demand for milk. He also concluded that income is not a significant factor in milk consumption in a quarterly time series model. Kinsman and Anderson [22], on the other hand, reported a statistically significant income elasticity of demand for milk using cross-sectional data. Gruen *et al.* [19] estimated parameters from annual time series data for butter and cheese. In the case of butter the negative income elasticity is probably due to unquantifiable taste and preference factors that are correlated with income over time.

Demand parameters for eggs have been estimated by Gruen *et al.* [19] and Banks and Mauldon [5]. Gruen *et al.* found that price was a non-significant variable while expenditure elasticities were 0.23 from a linear model and 0.20 from a log-linear model. Banks and Mauldon, using Western Australian data for eggs, estimated a price elasticity of demand of -0.32 and an income elasticity of 1.42.

4.3 FRUIT, FRUIT PRODUCTS AND VEGETABLES

This group of products covers a wide range of commodities and markets. For many of these products, no attempt has been made to estimate elasticities or flexibilities, perhaps largely due to a lack of reliable data. Elasticity estimates are summarized in Table 7 and are all based on the use of O.L.S. With the exception of work by Gruen *et al.* [19], the BAE [7, 10] and Miller and Roberts [28], data were for the Sydney markets.

Of the fruit and fruit products, econometric studies of demand and prices have been published for bananas, pineapples, canned and dried fruit and wine. Most analyses indicate that demand for these products is inelastic, wine being the notable exception. Cross-elasticities were generally not estimated or were not found to be statistically significant. The most recent studies are those of Aggrey-Mensah and Guise [1] and Stuckey and Anderson [43], for bananas. Aggrey-Mensah and Guise estimated price elasticities of wholesale demand for bananas ranging from -0.5 to -1.3 for different periods of the year, indicating a systematic seasonal demand for the product.

The elasticities of demand for bananas reported by Stuckey and Anderson were based on cross-sectional data from a pricing experiment in Sydney supermarkets. They concluded that demand for bananas at retail is just price inelastic. Weekly demand functions were also estimated at high and low price ranges and it was found that demand was price inelastic in both segments, but that the lower priced segment has more inelastic demand. This study involved a novel approach, at least in the Australian context, of a controlled cross-sectional experiment as a basis for estimating price elasticities. One may speculate, however, that direct price elasticities are overestimated in a study such as this. The authors apparently did not allow for cross-elasticities

TABLE 6: *Estimated Demand Parameters for Dairy Products and Eggs, Australia*

Product and market level	Author(s)	Data	Area	Estimation method	Estimated elasticities	
					Price	Income/Other
Milk—retail	Ross [38]	1955–56 to 1960–61 A	Aust.	O.L.S.	−1.68, 2.37	
Milk—retail	Rutherford [39]	1959 cross sect.	Sydney	O.L.S.		0.68 (a), 0.45 (b)
Milk—retail	Kinsman/Anderson [22]	1955 cross sect.	Canberra	O.L.S.		0.35
Milk—retail	Kinsman/Anderson [22]	1955 cross sect.	Canberra	O.L.S.		0.14 to 0.40 (c)
Milk—retail	Street [42]	1959 to 1972 Q	Sydney	O.L.S.	−0.47, −0.58 (d)	
Milk—retail	Street [42]	1959 to 1972 Q	Sydney	O.L.S.	−0.19, −0.23 (e)	0.26 (a), 0.62 (b)
Milk—retail	Gruen *et al.* [19]	1950–51 to 1962–63 A	Aust.	O.L.S.	−0.28, −0.69	−1.40 (f)
Cheese—retail	Gruen *et al.* [19]	1950–51 to 1962–63 A	Aust.	O.L.S.		0.75 (f)
Eggs—retail	Gruen *et al.* [19]	1947–48 to 1963–64 A	Aust.	O.L.S.		0.20 to 0.23 (f)
Eggs—retail	Banks/Mauldon [5]	1951–52 to 1962–63 A	W. Aust.	O.L.S.	−0.32	1.42

(a) Slope parameter with respect to an additional child in household size. (b) Slope parameter with respect to an additional adult in household size. (c) Income elasticity for various sizes of household from 2 to 5 or more; the elasticity increased with household size. (d) Long-run (annual) elasticities evaluated at the lowest and highest price in the range of sample data respectively. (e) Short-run (quarterly) elasticities evaluated at the lowest and highest price in the range of sample data respectively. (f) Expenditure elasticity.

TABLE 7: *Estimated Demand Parameters for Fruit and Vegetables, Australia*

Product and market level	Author(s)	Data	Area	Estimation method	Estimated elasticities (a)	
					Direct	Income/Other
Bananas—wholesale	Stuckey/Anderson [43]	1968 to 1972 W	Sydney	O.L.S.	−0.55, −0.61 (b)	
Bananas—wholesale	Stuckey/Anderson [43]	1968 to 1972 W	Sydney	O.L.S.	−0.3, −0.39 (c)	
Bananas—wholesale	Aggrey-Mensah/Guise [1]	1953 to 1967 W	Sydney	O.L.S.	−0.80 (d)	
Bananas—wholesale	Van der Meulen [51]	1952 to 1957 M	Sydney	O.L.S.	−0.65 (F) (e)	
Bananas—retail	Stuckey/Anderson [43]	1972 cross sect.	Sydney	O.L.S.	−0.82	
Canned fruit—retail	Gruen *et al.* [19]	1946–47 to 1963–64 A	Aust.	O.L.S.		1.30 (f)
Dried fruit—retail	Gruen *et al.* [19]	1946–47 to 1963–64 A	Aust.	O.L.S.		1.57 (f), 2.44 (g)
Fortified wine—retail	Miller/Roberts [28]	1970–71	Aust. (h)	O.L.S.	−0.96	
Table wine—retail	Miller/Roberts [28]	1970–71	Aust. (h)	O.L.S.	−1.80 (i)	
Pineapples—wholesale	Van der Meulen [52]	1952 to 1957 W	Sydney	O.L.S.	−0.25 (F), −0.51 (F) (j)	
Peas—wholesale	Van der Meulen [53]	1955 to 1959 W	Sydney	O.L.S.	−0.79 (F), −0.93 (F)	−0.45 (F) (k)
Beans—wholesale	Van der Meulen [53]	1955 to 1959 W	Sydney	O.L.S.	−1.05 (F) (l), −1.26 (F) (l)	0.66 (F) (k)
Potatoes—wholesale	Van der Meulen [54]	1952–53 to 1958–59 A	Sydney	O.L.S.	−2.59 (F), −2.91 (F)	
Potatoes—retail	Van der Meulen [54]	1952–53 to 1958–59 A	Sydney	O.L.S.	−1.52 (F)	
Potatoes—retail	BAE [7]	1952–53 to 1963–64 A	Aust.	O.L.S.	−1.70 (F)	0.03 (F)

(a) Where the estimated parameter is a flexibility it is denoted by (F). (b) Higher priced summer and winter segments of the demand function respectively. (c) Lower priced summer and winter segments of the demand function respectively. (d) This is the average of weekly price elasticities from weekly demand equations. The authors found consistent seasonal patterns in elasticity estimates. (e) This figure is an estimate based on the author's results. (f) Expenditure elasticity. (g) Cross-elasticity with respect to flour consumption. (h) Calculated arc elasticities. (i) The authors consider this the "most likely" of the estimates made. (j) These estimates are for winter and summer respectively. (k) Cross price flexibility with respect to the price of a "market basket" of vegetables. (l) Using data for June, July and August only. W, weekly data. M, monthly data. A, annual data.

between bananas and substitute products. Nor would variations in numbers of consumers, in response to the price policies adopted by the cooperating supermarkets as part of the experiment, be allowed for. To the extent that these comments are applicable, the price elasticities may be over-estimated relative to those from time series data.[8]

Other estimates for fruit and fruit products are also reported in Table 7. Van der Meulen [52] estimated price elasticities of demand for pineapples and found that the results varied between summer and winter. Gruen *et al.* [19] used annual data for the whole of Australia and found no significant direct price elasticities for canned or dried fruits at retail. They reported a significant cross-elasticity of demand of 2.44 for dried fruit at retail with respect to flour consumption. Miller and Roberts [28] estimated arc elasticities of demand for fortified and table wine of -0.96 and -1.80 respectively. These results were calculated from the price changes which occurred in the 1970/71 period.

For vegetables the only estimates available are those of van der Meulen [53] for peas, beans and potatoes in Sydney, and a BAE [7] estimate for potatoes. Van der Meulen reported flexibilities of demand for peas and beans which indicated that short-term (weekly) demand was elastic while longer-term demand was inelastic. Cross price flexibilities between peas and beans and between these two products and "other vegetables", were also found to be statistically significant. These results were based on the estimation of a series of single and multiple regression equations to search for relationships in the data. For potatoes, van der Meulen's results indicated that demand was price inelastic at wholesale, while both the BAE and van der Meulen estimated retail price elasticities of demand for potatoes in the range -0.6 to -0.7.

4.4 GRAINS AND GRAIN PRODUCTS

Grains are produced for human consumption and also as inputs in the production of livestock products. The results in Table 8 indicate that retail demand for grain products is price inelastic while Bain's [2, 4] results suggest that demand for grains for animal consumption is price elastic. Income elasticities for grains for human consumption are low in cases where they are statistically significant.

The most detailed of the studies for grain products is an unpublished one by Quilkey [37] in which both time series and cross-sectional data were used in the analysis of demand and prices for rice in Australia. Quilkey used time series data to study annual and seasonal demand and sought to identify the effects of age structure and advertising on demand for rice. Lagged prices were also used in an attempt to distinguish between short-run and long-run elasticities, the latter allowing for stock adjustments by consumers. Cross-sectional data were collected and provided a range of elasticities as indicated in the table.

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[8] These considerations amount to little more than a cautionary note to those placing a broad interpretation on results of a study of this kind.

Bain [2, 4] estimated parameters of the demand for feedgrains assuming there was simultaneity in the markets for feed wheat, barley and oats. Using O.L.S. on models for barley and oats where their prices and quantities were specified relative to feed wheat prices and their shares of stockfeed usage, significant price elasticities resulted. However, applying 2.S.L.S. to an explicitly simultaneous model, identification problems occurred and only the oat price elasticity and a selection of cross price parameters were significant. This indicates that the hypothesized relationships are not revealed by the available data, when a model widely regarded by applied economists as preferable, is applied.

5 SOME ISSUES ARISING FROM THE LITERATURE

A review of the kind attempted here raises a multitude of pragmatic and theoretical issues for future research. The literature reviewed does not rest easily in the boxes into which it has been forced. In many cases the estimation of demand parameters, as an objective, is subsidiary to other problems specified by authors. Results reported, however, should form a basis for further consideration of productive lines of research and problems in the econometric analysis of demand for agricultural commodities.

The issues which seem to arise from this review may be broadly grouped as follows. First, there are several possible approaches to the modelling of market behaviour, among which analysts choose. Second, choice of estimation techniques and statistical problems in relation to the models developed for analysis. Finally, sources of data and the availability of measures of hypothesized variables may be a constraint on future work in this area. These three issues, which are closely related, are now discussed in more detail.

5.1 MODELLING MARKET BEHAVIOUR

Most of the papers reviewed here are based on models of price formation at retail or farm gate levels. These models have generally been of the ad hoc type in which single equation models are used, and interdependence between products or product groups receives limited attention. Where multi-equation models have been specified, statistical and data problems frequently force the analyst back to the estimation of simpler models, if he is to report statistically significant estimates. The types of data series available appear to act as a severe constraint on the degree of sophistication in models.

The choice of models reflected in the literature ranges from systems approaches to consumer behaviour, to multi-equation econometric models and finally ad hoc single equation estimation. Choice between these approaches will no doubt continue to be based on specific objectives involved in commodity policy analyses. Where the objective is one of estimating the broad structure of retail demand for related products or product groups, more sophisticated modelling may well be justified.

TABLE 8: *Estimated Demand Parameters for Grains and Grain Products, Australia*

Product and market level	Author	Data	Area	Estimation method	Estimated elasticities	
					Price	Income/Other
Grains for Human Consumption—						
Flour—retail	Gruen *et al.* [19]	1947–48 to 1963–64 A	Aust.	O.L.S.	−0.47 (a)	
Wheat products—retail	Gruen *et al.* [19]	1946–47 to 1963–64 A	Aust.	O.L.S.	−0.65	
Rice—retail	Quilkey [37]	1959 to 1967 A	Aust.	O.L.S.	−0.10	
Rice—retail	Quilkey [37]	1959 to 1967 M	Aust.	O.L.S.	−0.09 to −0.16 (b)	0.07
Rice—retail	Quilkey [37]	1959 to 1967 M	Aust.	O.L.S.	−0.44 to −0.76 (c)	
Rice—retail	Quilkey [37]	1959 to 1967 M	Aust.	O.L.S.	−0.06 to −0.21 (d)	
Rice—retail	Quilkey [37]	1967 cross-sect.	Sydney	O.L.S.	−0.92 to −3.39 (e)	0.00 to 0.14 (f)
Rice—retail	Quilkey [37]	1967 cross-sect.	Melbourne	O.L.S.	−0.32 to −0.68 (e)	0.00 to 0.20 (f)
Grains for Animal Consumption—						
Barley—farm	Bain [2]	1948 to 1970 A	Aust.	O.L.S.	−2.29 (g)	
Oats—farm	Bain [2]	1948 to 1970 A	Aust.	O.L.S.	−1.37 (h)	
Oats—farm	Bain [4]	1948 to 1970 A	Aust.	2.S.L.S.	−4.95	
Wheat—farm	Bain [4]	1948 to 1970 A	Aust.	2.S.L.S.		−3.56 (i), 1.06 (j)

(a) With respect to the price of bread. (b) Range of estimates for various months and various functional forms. (c) Range of monthly short-run estimates ignoring consumer inventory adjustments. (d) Range of long-run estimates from models including monthly lagged prices. (e) Range of estimates. (f) Range of estimates from various equations. (g) Estimated from a function in which barley as a proportion of total stock feed is regressed on barley prices as a percentage of feed wheat prices. (h) Function for oats the same as (g). (i) With respect to the lambing percentage. (j) With respect to intensive sector production. A, annual data. M, monthly data.

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The work of Gruen *et al.* [19] is the only attempt to use systems approaches to modelling the domestic demand for rural products. One may question whether this is likely to be a fruitful line of further research. As a modelling exercise it appears to subject the data to rather restrictive assumptions about consumer behaviour. One consequence of this is that the results may form a basis for testing hypotheses which flow from economic theory, rather than providing usable results of practical value for policy or forecasting.

Systematic estimation for agricultural products has been reported in other countries [e.g. 6, 17]. A similar endeavour for Australia may serve to integrate results for individual products at various levels of aggregation. To date no attempt has been made to link the results of aggregate estimates from systems of equations and the ad hoc single equation estimates for Australia. Such a link could be made through the general hypothesis of a "nested" utility function for food, the arguments of which are utilities derived from products entering the food consumption set. Demand parameters could be derived for successively more disaggregated product groups, while retaining some formal link with the underlying theory. Further research along these lines may, however, be limited by data availability. For example, the data required to estimate the L.E.S. for disaggregated commodity groups are not readily available in Australia. Such models also impose restrictive assumptions on the data including homogeneity, symmetry and budget restrictions. More importantly, the use of specific forms of the consumer's utility function, notably the separability and additivity assumptions may become more unrealistic as successively more disaggregated product groupings are used.

While we may attempt to use systems of demand equations at the retail level, the application of such models to farm level price formation is more difficult. In an American study [17] estimates of marketing margins formed the basis for deriving elasticities of price transmission between retail and farm levels. A matrix of farm level elasticities for agricultural products was then estimated by applying the elasticities of price transmission to a matrix of retail elasticities. At least two objections to this approach may be raised. First, there may be low explanatory power in the margin equations which leads to unreliable estimates of the elasticities of price transmission. Second, the estimated farm level elasticities may be of limited value, to the extent that they reflect the combined distortions inherent in both retail and margin estimates.

In principal it seems preferable to model demand at farm and retail, and margin formation separately, then attempt to evaluate their consistency or otherwise. A possible example of this approach may be derived from the literature on the market for meat. Marceau [25] used quarterly data to study farm and retail demand for meats and to estimate margin relations. In a more recent study of meat marketing margins, Griffith [18] tested hypotheses of price averaging and levelling in margin formation. His results could be checked against those for retail and farm level demand parameters, in order to study relations between the two market levels.

The role of export markets is an additional complication in systematic analyses of farm level demand for Australian agricultural products. Studies of export demand for Australian agricultural products have not been considered explicitly in this review. For many products including wool, beef, wheat, dairy, grain and fruit products a large proportion of annual production is exported. The relationship between domestic and export prices and quantities is likely to be significant for such products. Export demand for agricultural products is generally presumed to be price elastic and the "small-country" argument is used. This assumption may be an inappropriate one in some cases. Export demand may be related to institutional and market access factors, rather than more conventional price parameters. The point of all this is that farm level demand parameters may be largely unrelated to domestic demand where there is a close substitutability between domestic and export products.

Ad hoc models will continue to be used in the future primarily because of their pragmatic value in problem oriented studies. Single equation models appear to be more attuned to the constraints of data availability than the systematic models and have advantages of flexibility in incorporating variables relevant to individual markets, commodities and research objectives. Where the objective is to examine the broad structure of demand for food, however, there may be little to choose between the two broad modelling approaches. Regression analysis is common to both, and the assumption that prices of related products are exogenous in ad hoc models is an abstraction from reality, just as separable utility functions are in systematic models. Assumptions of separability enable the analyst to treat a related group of products as being close substitutes. Simultaneous equation models involve similar assumptions through the specification of endogenous variables.

Several factors affecting farm level demand and price formation for agricultural products may be noted. Major institutional factors include government price support, supply management and related policies, and the policies of marketing boards and farmer co-operatives. In export markets various forms of restraints on international trade through tariff and exchange rate policies and government-to-government bilateral trade negotiations, affect demand and prices for internationally traded commodities of which Australia is a major producer. Domestic and export markets are distorted by government rural policies both in Australia and overseas. In this context there arises the problem of determining the nature of market response to *existing* policies. Market prices and quantities at any point in time are, at least partially, a response to present and prospective intervention in the market. The role of intervention and response factors must be incorporated in models of demand and prices if such models are to identify market behaviour. This implies a need to explicitly recognize dynamic factors in models of demand for agricultural products. A further complication relates to the role of marketing boards and cooperatives in the marketing system, and the possible price and non-price strategies they may adopt. While such institutional effects are recognized in the literature they have rarely been incorporated in econometric analyses of demand and prices.

5.2 ESTIMATION METHODS AND STATISTICAL PROBLEMS

Commodity policy analyses have generally been based on the application of O.L.S. to time series and cross-sectional data. In many of the specifically problem oriented studies available in the literature, O.L.S. appears to have been appropriately applied given the sophistication of models used and data available. O.L.S. is, however, an exacting statistical technique and many of its assumptions are not easily met, particularly in applications to time series data. There appear to be only a selection of studies, for example [25], in which authors have taken account of statistical problems in the application of O.L.S.

The joint problems of multicollinearity and identification often appear in estimated parameters in the literature. Respectively, they raise the issues of the specification of explanatory variables that are really endogenous in simultaneous systems, and the problem of deleted variables. These two problems can often be traced to a failure to use models which adequately represent the reality of market behaviour, and/or to the unavailability of quantifiable measures of the appropriate variables. When simultaneous models have been used a common result has been the aggravation of such problems due to non-significance of estimated coefficients. One may hypothesize that the measures available for such variables as prices, quantities and income generally do not reveal the orderly behaviour economists seek, when tortured by more refined techniques.

5.3 DATA AND AGGREGATION

Two basic sources of data are utilized in econometric studies of demand and prices for agricultural products. Time series data are the most commonly used and very few cross-sectional data series have been collected for Australia. Availability of data is perhaps the most significant problem in econometric analysis of the demand for agricultural products. This is demonstrated by the types of analyses which are reported in this review.

Dealing first with cross-sectional data, Australia is one of the few developed countries in the world for which no comprehensive study of cross-sectional consumer expenditure patterns for disaggregated groups of commodities, has been undertaken. Apart from one survey in 1966–8 [33, 34] and several smaller studies [8, 9, 37], there is no extensive source of cross-sectional data. In 1974–75 the Australian Bureau of Statistics (A.B.S.) conducted a detailed national survey of consumer expenditure. This survey should provide data for the estimation of cross-sectional income and related elasticities of demand. Such estimates would add to the stock of knowledge on consumer behaviour and may facilitate analyses of time series data.

The degree of aggregation over products, time and markets in time series data are of fundamental importance in econometric demand analysis. In the case of many product-oriented demand studies, available data provide an inadequate representation of the choice situation facing consumers. For example, consumers may choose between such related

products as various cuts of meat, rather than between beef and lamb as "products". Disaggregation on the basis of choice sets faced by consumers may produce quite different results from those based on physical commodity types. The magnitude of various elasticities and the choice of variables appropriate to demand equations may be changed if more disaggregated data were available. *Ceteris paribus* assumptions used in deriving various elasticities are unrealistic for disaggregated analyses and "total elasticities" may be more appropriate measures of response.

Demand parameters estimated for groups of products are in fact weighted averages of parameter estimates for components of the group. Studies of demand for product groups may conceal the policy implications for individual products. Analyses of the type identified in this paper may be a prelude to further disaggregation of products. There remains, however, the fundamental question of whether analyses should be conducted at disaggregated levels, followed by aggregation, or vice versa.

The grouping of products for analysis and identification of products within groups, is a further consideration in analyses of demand and prices at retail. Appropriate product groups at farm and retail levels are likely to be different. Availability of data may restrict the choice of products and product-groups for analysis. At the national level there are data available on apparent consumption of foodstuffs and nutrients. These data are for major farm-produced groups of products. To provide relevant information on consumer demand parameters price and quantity data should be further disaggregated to more nearly approximate the choice of products facing the individual consumer.

One potentially productive area of research is the construction of input-output tables to trace the transformation of farm level products into final consumer commodities. This would involve disaggregation of quantity data for agricultural products and would contribute to the understanding of demand interrelationships in markets. Given an analogous set of price series, econometric analyses of demand could then be conducted at farm, wholesale and retail levels. In this "ideal" situation interdependencies between products at any market level, and for single products between market levels, could be analyzed in detail.

Disaggregation of price and quantity data to shorter time intervals may also be desirable. Series of quarterly, monthly and even weekly price and quantity data may be useful from several standpoints. Such data can be used to study seasonality of demand and prices as has already been done for bananas [1] for example. It would also reduce the degrees of freedom problem, which is common in time series studies. Finally, more frequent class intervals in data series enable the analyst to reduce the temporal length of time series, thus reducing the likelihood that structural change in underlying market forces will interfere with the results.

The discussion above is a plea for the collection of increased quantities of data. Whether the cost of this can be justified remains an unanswered

question. In cases where data is aggregated for publication, it may be that the marginal cost of publishing the less aggregated series would be low. Publication of disaggregated series would at least give research workers the flexibility to aggregate data in accordance with particular problem-oriented objectives.

Issues of data quality, as well as quantity, are also worthy of consideration. The quality of data is broadly related to consistency of measurement over time, the accuracy of measurement and objectivity in measurement. Consistency of measurement requires that product, market and price definitions do not change and that there be a correspondence of interval between data series for prices, quantities and related variables through time. In terms of accuracy the reliability of of data should be indicated when data are published and, where data are estimates, this should be stated explicitly. As a general principle data collection agencies should attempt to record data for objectively measured qualities of product which are as homogenous as possible.

Some of the issues judged to be of importance in the collection and aggregation of data for econometric analyses of demand are discussed above. It is argued that in terms of both quantity and quality of data, a greater allocation of resources to data collection is necessary to improve the understanding of market behaviour through econometric analysis. Whether there would be an attractive return on this investment is difficult to determine. However, if further research in the area reviewed in this paper is to be more relevant to real world problems, research workers must be involved in the determination of what data are collected and of collection procedures and retrieval systems for secondary data.

6 CONCLUSIONS

Econometric analyses of demand and price parameters are reviewed in this paper. Analyses which do not lead to estimates of elasticities have been deliberately excluded. To this extent an injustice has been done to many publications covering such topics as spectral analyses of prices and studies of marketing margins and margin behaviour, both of which add to the stock of knowledge about the demand and prices for agricultural products.

Results summarized in the tables indicate that domestic demand for agricultural products is often both price and income inelastic. There are some exceptions including meat products with the exception of beef, wine and selected other commodities. Significant cross-elasticities of demand between products or groups of products, have generally not been identified in the literature. Published research has often been single commodity oriented and related to specific problems at one level of economic activity (e.g. retail or farm level). The principal tool of analysis used has been O.L.S. regression applied to time series data.

There appears to be a lack of overall direction and purpose in research on structural estimation of demand and price parameters. This is hardly surprising since a diversity of objectives have motivated this

research. Objectives include the provision of information for commodity policy decision making, forecasting and the evaluation of welfare effects. Analyses have frequently been limited by the availability of satisfactory data series and statistical and estimation problems in the use of existing data. One may question the usefulness of many of the results in terms of their relevance to real-world policy alternatives which frequently involve more than price, quantity and income variables. While authors of many of the studies refer to the policy or forecasting implications of their work, no on-going program of up-dating estimates for a range of products appears to be under way. In contrast the BAE [10, 41] now has a series of supply models which are periodically updated for the purposes of forecasting.

A conclusion suggested by this review is that the impact of estimated demand and price parameters on policy making has been limited. Research workers interested in this area face a challenge to become more relevant in adapting their analyses to practical problems in marketing.

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