Previous Demand Elasticity Estimates For Australian Meat Products

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Acronyms and Abbreviations Used in the Report

ABARE	Australian Bureau of Agricultural and Resource Economics
AIDS	Almost Ideal Demand System
BEEF CRC	Cooperative Research Centre for the Cattle and Beef Industry
EDM	Equilibrium displacement model
EMABA	Econometric Model of Australian Broadacre Agriculture
FIML	Full Information Maximum Likelihood
LA/AIDS	Linear Approximate Almost Ideal Demand System
MLA	Meat and Livestock Australia
OLS	Ordinary Least Squares
R&D	Research and Development
SUR	Seemingly Unrelated Regression
2SLS	Two Stage Least Squares

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Executive Summary

Reliable estimates of the responsiveness of the supply of and demand for agricultural commodities to prices and other factors are fundamental to accurate economic forecasting, sound analyses of the impacts of new production technologies or promotion campaigns and effective policy decision making. This is true whether the estimates are used by academics, government departments such as NSW Agriculture, research institutions such as ABARE or the Beef CRC, or producer organisations such as MLA.

This paper reports a listing and review of previous demand elasticity estimates for major Australian meat products. This review considers analyses from the early 1960s, such as Taylor (1961), through the major surveys by Gruen *et al.* (1967) and by Richardson (1976) to more recent work such as by Piggott *et al.* (1996) and Vere *et al.* (2000). However, not all of the studies that have been conducted in the area have been able to be covered in the review.

The studies reviewed vary substantially in terms of geographic coverage, sample periods, estimation method, functional form, inclusion of other explanatory variables and reliance on the underlying utility theory. Data limitations have restricted the majority of demand studies to estimates of aggregate demand elasticities. Most studies have been oriented to retail demand and have used data for livestock types, rather than on the various choices of meat available to the consumer. Only a few studies have focussed on demand at the saleyard or wholesale levels or on the demand for meats of different quality. Export elasticities have also been largely overlooked in the literature.

One area for further analysis could be a formal meta-analysis of the domestic retail market estimates to better separate out the effects on previous own- and cross-price elasticity estimates of time period, functional form, model specification, and the like. Another could be an up-to-date study of Australian retail meat demand using modern functional forms and estimation methods. Also, in spite of the trade status of the Australian meat industries, there are significant gaps in knowledge about export demand elasticities. Analyses covering export demand by region and by product would seem to be an obvious area for further effort.

1 Introduction

Reliable estimates of the responsiveness of the supply of and demand for agricultural commodities to prices and other factors are fundamental to accurate economic forecasting and sound policy decision making. For example, own-price elasticities of supply indicate the extent to which producers will expand or contract output, over different lengths of run, as the price for a product rises or falls. These are measured as movements along the supply curve. Cross-elasticities of supply provide an understanding of the output and input interactions between different but closely related production enterprises. These are measured as shifts in the location of the supply curve. Such an understanding is necessary for the accurate analysis of the farm level impacts of new production technologies, promotion campaigns or policy changes, in a multi-product production system. These interactions are particularly important in the Australian agricultural sector where many farms contain many different enterprises.

Similarly, own-price elasticities of demand indicate the extent to which buyers vary their purchases as the price of the product rises and falls. These variations are measured as movements along the demand curve. Cross-elasticities of demand provide a framework for understanding the interactions in food and fibre choice decisions by consumers. These are reflected in shifts in the location of demand curves. This understanding is necessary for the accurate analysis of the response of consumers to changes in prices and availabilities of products due to changes in their external environment.

Many of the types of analyses mentioned above are conducted using structural econometric models (eg, Dewbre *et al.* 1985; Vere, Griffith and Jones 2000), where the relationships describing producer and consumer decision making are estimated using historical data. In such cases, the relevant elasticity values are embedded in the model. In other cases, perhaps because of a lack of historical data or of the time required to properly estimate an empirical model, analyses are conducted using a synthetic model of the industry of interest (eg Hill *et al.* 1996; Zhao *et al.* 2000). In these situations, the elasticity values have to be assumed or synthesised from theory or the empirical literature. The question for researchers is which value to choose?

This paper reports previous demand elasticity estimates for major Australian meat products, with the aim of presenting possible base parameters for use as inputs into synthetic modelling exercises. Such exercises could be part of National Competition Policy legislative reviews or for studies on the evaluation of livestock sector R&D or advertising investments. An example of the latter is the study by Zhao *et al.* (2000) which used an equilibrium displacement model (EDM) of the beef industry and related sectors. This review considers analyses from the early 1960s, such as Taylor (1961), through the major surveys by Gruen *et al.* (1967), Richardson (1975,1976) and MacAulay *et al.* (1990) to more recent work such as by Piggott *et al.* (1996) and Vere *et al.* (2000). While the earlier surveys provide important evaluations of the state of knowledge about meat demand at points in time, they are now quite dated. Since it is likely that elasticity values vary over time with changes in the external environment, it is crucial to have as current an assessment as possible when applying these parameters to current policy or R&D analyses. However not all the studies that have been published could be included in this review.

Previous retail demand studies for the major meat products in Australia (beef, lamb, pork and chicken), are reported in Tables 1, 2, 3 and 4 respectively and are discussed in section 2 below. Earlier demand studies were based on linear or logarithmic regression of time series data that was subject to seasonal variation and this contributed to significant autocorrelation. The early studies typically did not correct for these effects. They also had little regard for utility maximisation theories that should have introduced further restrictions on the models. Most of the more recent studies have constrained their models by some form of underlying utility function and have corrected for autoregressive errors. Some studies have set out to examine the existence of structural changes in meat demand caused by perceived nutritional hazards, but few have incorporated dynamic consumer responses.

Data limitations have restricted the majority of demand studies to estimates of aggregate demand elasticities. Most studies have been oriented to retail demand and have used data for livestock types, rather than on the various choices of meat available to the consumer. One important study by Cashin (1991) has disaggregated the demand for pork into three subgroups. Only a few studies have focussed on demand at the saleyard or wholesale levels (Papadopolous 1973, Freebairn and Gruen 1977) (see Table 5) or to the links with quality (Harrison and Richardson 1980, Ball and Sloane 1988).

Export elasticities have been largely overlooked in the literature, although some assumed and estimated values are available (see Table 6).

2 Previous Demand Elasticity Studies

2.1 Background

Estimates of market parameters such as own-price, cross-price and income elasticities of demand, provide a means of analysing the operation of price in the consumer segment of the market under varied circumstances. Estimates of demand elasticities have been widely used in policy formation, in particular in attempting to forecast the likely effects of intervention in the form of taxes or subsidies, and more recently, the likely impacts of deregulation. Elasticity estimates are also of use in R&D and extension programs, such as evaluations of the market impacts of the widespread adoption of new technologies.

Different methods of estimation lead to discrepancies amongst the various elasticities calculated. But these differences cannot be attributed to model specifications alone. The estimates range over different data periods so each estimate over the last four decades provides an extensive picture of the dynamic changes that the meat products have experienced. From actual data it is known that the market shares and relative importance of the meats has changed significantly in this period. The elasticities reflect this to a certain extent but do not fully explain demand responses as some studies have pointed out.

2.2 Domestic Retail Demand

2.2.1 Aggregated Retail Demand Analyses

Retail demand and prices for Australian meat have been the subject of extensive econometric analysis. Tables 1, 2, 3 and 4 summarise the own- and cross-price and income elasticity estimates, in relation to the data periodicity, the time period covered by the data sets, the estimation methods applied and the functional forms assumed, for each of the four major meat types. As the tables show, earlier studies used Ordinary Least Squares (OLS) regression techniques to look for a linear or logarithmic relationship of the general form:

$Q_B = f(P_B, P_L, P_P, P_c, Y, A, D_N)$

where Q is per capita domestic disappearance of a particular meat (B-beef, L-lamb, P-pork, C-chicken), P is the real retail price, Y is real disposable income, and A and D are constant and seasonal dummy variables, if the analysis was based on quarterly observations (N=1,2,3). According to Richardson (1976) in his review of these studies, such simple models can lead to arbitrary selection of key variables to explain or establish relationships. Many of the specified variables were omitted in the published results.

However, there have been numerous variations in the methods of measurement and interpretation of these variables. Several key studies stand out as representative of the state-of-the-art at the time. For example Gruen *et al.* (1967) found that a four-equation model did not satisfactorily explain the postulated relationships between the quantity of meat demanded and price, and therefore reverted to estimation of single equations, despite their theoretical weaknesses, expressing data in logarithmic form. For beef, the only significant price variable found was an own-price elasticity of -0.96, however for lamb three significant coefficients were found, an own-price elasticity of -1.55, an income elasticity of 0.83 and a cross-price elasticity with respect to beef of 0.50. For pork, two variables were significant, an own-price elasticity of -2.19 and an income elasticity of 2.80. This aggregate pork variable depicts the change in carcass pigmeat consumption. Carcass pigmeat consumption had doubled in the 10 years up to the study but the other disaggregated components, ham and bacon, had remained relatively stable. This suggests that disaggregation of variables is not always necessary as only one component may be subject to changing consumer diets. The Gruen *et al.* study did not consider the demand for chicken as chicken was only a minor product at that time. In fact the first estimate of chicken demand was not until 1970, and chicken was not incorporated into a meat demand system until 1979.

Main, Reynolds and White's (1976) study of the Australian retail meat market included data from the early 1970s, a time of much more rapid shifts in demand patterns for meat incorporating the extremes of economic cycles. For example, 1972 and 1973 saw large rises in consumer income that was followed by strong demand for goods. As a result the price increased for all meats, in particular lamb. Then 1974 saw both a decline in domestic consumer income and a sharp reduction in exports to Japan and Korea. The increased supply placed on the domestic market in the face of declining demand caused a sudden and large drop in retail meat prices. Lamb and beef prices experienced the sharpest drop and lamb did recover some of this but beef continued to fall to its lowest level in more than a decade.

The Main, Reynolds and White study attempted to refine the original approach formulated by Gruen, in that the inter-relationships between different meats was explicitly recognised by specifying a system of regression equations. The consumption of one meat was believed to be affected by the consumption of other meats, so it was seen as consistent to use Zellner's Seemingly Unrelated Regression (SUR) in addition to the conventional double-log OLS regression. Statistical procedures were also improved by using quarterly instead of annual data, and correcting for first-order autocorrelation by using the Cochrane-Orcutt transformation. There was also evidence of multicollinearity, as data for meat prices inevitably lacked independent variation, as groups of prices rose and fell in unison. To counteract this, the mutton and lamb variable was combined into a sheepmeat variable. In Table 2 the aggregated (sheepmeat) and disaggregated (lamb) values are shown separately. Tables 1 and 3 also compare the cross-price effects of using lamb or sheepmeat.

The SUR estimates provided an own-price elasticity for beef of -1.38, and a positive cross-price effect of 0.32 with lamb, highlighting their substitutability. The income effect was also inelastic, a value of 0.43. The own-price elasticity for lamb was -1.89 while that for sheepmeat was much lower -1.24, which may be explained by aggregation. The cross-price elasticities in the lamb equation were both positive and of approximately the same magnitude, representing beef and pork as substitutes with lamb. The income elasticity for lamb was -0.14 while the value with respect to sheep meat was -0.51. This negative income response in lamb demand was also seen in several later studies. For pork, the own-price elasticity was very high at -1.89 in keeping with expectations. Pork had similar substitution relationships with beef and lamb, of around 0.4, but a complementary relationship with chicken of -0.61, which the authors rejected as counter-intuitive. The income response for pork was -0.44 contrary to expectations and the authors attribute this to the chicken variable, as this negative value was reversed when chicken was removed. Overall, the SUR and OLS methods gave similar results.

Fisher (1979) was the first to estimate a demand system formally derived from a utility function. He used the indirect translog utility function, but found he had to transform the demand equations to a linear form to obtain reliable results. Using a Full Information Maximum Likelihood (FIML) estimator, the beef own-price elasticity was estimated as -1.19, with small positive cross-price effects of 0.14 with lamb and pork highlighting their substitutability with beef. The response with chicken was insignificant. The income effect was also inelastic, a value of 0.54. For lamb, the own-price elasticity was -1.58, and the cross-price elasticities were both positive, 0.47 and 0.33 with respect to beef and pork respectively. But the cross effect with chicken was negative and very small, at -0.12, and the income elasticity for lamb was only 0.09. In relation to pork, the own-price elasticity was -0.95, a lower response than previous estimates but it could be representative of that particular period in time. Pork was shown to be a major substitute for beef (1.00) and lamb (0.70) and to have a complementary relationship with chicken of (-0.27). Fisher suggested that this was an appropriate response as the two products are complements in production. The income response was 0.04, once again an insignificant response and this could be due to the use of aggregate expenditure data (on all goods, not meat exclusively). After Paton (1970), Fisher's study was the first to extensively analyse chicken meat. An own-price elasticity of -0.23 was obtained showing a quite inelastic response. Chicken was shown to be a substitute with beef in consumption with a cross-price elasticity of 0.28, but was shown as a complement to pork and lamb, with negative cross-price elasticities of -0.27 and -0.25 respectively. This is as we would expect except for lamb. The income response was 0.20.

Murray (1984) was another of the early studies to formally derive demand systems for meat from a number of utility functions. Utility theory assumes that the consumer has particular preference for different 'baskets' of the commodity group. One advantage of this approach is that the restrictions derived from consumer preference theory can be taken into account in the estimation procedures. Murray considered a total of ten demand systems or models, each derived from a particular perception of consumer behaviour, and all based on a static utility theory approach.

These ten models each comprised five equations, the dependent variables being budget shares of the five meats under study: beef, mutton, lamb, pork and chicken. As in a later study by Alston and Chalfant (1987), weak separability was assumed between the meat group and other goods. Expenditure on meat was therefore used as the relevant income variable, and non-meat prices were excluded. The models were also subjected to various tests for serial correlation.

All but three models were rejected as inconsistent with the data: the Almost Ideal Demand System (AIDS), the translog and the indirect addilog systems. The AIDS model is a flexible functional form model in which demand equations are derived from an expenditure function. Deaton and Muellbauer (1980) give a detailed description of the model.

Murray found own-price elasticities for beef ranging from -1.95 to -1.42, much higher than most other studies. Also calculated was a complete set of cross-price elasticities. Lamb and pork were found to be substitutes for beef, and chicken was found to have an insignificant effect. The expenditure response for beef ranged from 0.93 to 1.37. For lamb, the own-price elasticities ranged from -1.29 to -1.50, similiar to other studies. The cross-price elasticities showed lamb, beef and pork to be substitutes, but again chicken price did not have a significant effect. The expenditure response for lamb ranged from 0.76 to 0.85. For pork, the own-price elasticities ranged from -1.38 to -1.87. The cross-price elasticities again show pork as a substitute for beef and lamb but here chicken is shown to be a complement to pork. The expenditure response for pork ranged from 1.06 to 1.70. Finally, for chicken the own-price elasticities ranged from -0.40 to -1.14. The cross-price elasticities show chicken and beef as substitutes, except for the AIDS estimate, but the prices of pork and lamb were shown to have little effect on chicken demand. The expenditure response for chicken ranged from 0.57 to 1.34, ignoring the indirect addilog estimate.

The 1980s saw much publicity on the supposed harmful effects of a diet high in red meat, and several research studies examined whether this publicity and accompanying changes in consumer lifestyles and preferences had in fact translated into a structural change in the demand for meat. Martin and Porter (1985) looked for evidence of this structural change by applying cumulative sum, cumulative sum of squares and Farley-Hinich tests to a range of models, to ensure that any rejection of the stability hypothesis was not due to a mis-specification of models. Little evidence was found of a move away from red meat consumption. It was concluded that the perceived nutritional dangers of red meat, and changes in buying habits due to the changing structure of population, did not influence meat demand significantly. The prices of the various meats and of their substitutes remain by far the major influences on consumer behaviour. From an application of a nonparametric approach to meat consumption data from Australia and the United States, Chalfant and Alston (1988) concluded that "the data from both countries could have been generated by stable preferences...Relative prices, instead, can account for the observed shifts in consumption patterns".

A more recent study by Piggott *et al*. (1996) examined single equation models against a Linear Approximate AIDS model (LA/AIDS) and the full nonlinear AIDS model. They found the complete systems to be quite similar and to provide better estimates than the single equation model. However, the elasticity estimates were not reported for these complete systems. For the single equation model, the own-price elasticity for beef was -0.42, much lower than most other studies. The cross-price elasticity showed beef as a substitute for lamb and pork and a complement to chicken, a questionable result. The expenditure response for beef was 1.82. For lamb the own-price elasticity was -1.26. The cross-price elasticities showed lamb as a substitute for beef, pork and chicken. The expenditure response for lamb was 0.43. For pork the own-price elasticity was -0.87. The cross-price elasticities show pork as a substitute for beef, lamb and chicken. This is not consistent with previous estimates that showed chicken to have a negative (or complementary) value. The expenditure response for pork was 0.15. Finally, for chicken the own-price elasticity was -0.46, and the cross-price elasticities show chicken as a substitute for beef and pork and a complement to lamb. The expenditure response for chicken was 0.18.

2.2.2 Disaggregated Retail Demand Analyses

Various studies have split aggregate domestic demand for meat into components, or analysed demand over different periods of time, different states, different price regimes, or different markets. This literature primarily covers the beef sector (eg, Freebairn and Gruen 1977, Johnson 1978) but a recent study by Cashin (1991) disaggregates pigmeat into pork, ham and bacon.

Freebairn and Gruen (1977) extended the analysis of Main, Reynolds and White (1976) to run tests of parameter constancy and of the algebraic form of the beef demand function used. They rejected the hypothesis that the demand for beef was more (or less) responsive at relatively low price levels. They then estimated the own-price elasticity of demand for beef at -1.85 in 1973, a time of high beef prices, and -0.90 in 1975, after the sharp fall in prices referred to earlier. These results indicate that a relationship does exist between the responsiveness of demand for beef and the price level.

Johnson (1978) calculated elasticities for beef at two-year intervals from 1962 to 1975, and found evidence of declining elasticity values over time, with this trend again interrupted by the unusual market conditions of 1973-75. But his results differed to that of Freebairn and Gruen. He estimated an own-price elasticity of demand for beef at -1.26 in 1973, a time of high beef prices, and -1.56 in 1975, a time of low prices. In this study it is interesting to note the relative stability of the income elasticity variable at 0.40 over the period which saw large fluctuations in consumer income. This suggests that the major contributor to increased and decreased beef demand was the price of beef itself and not an income effect.

Ball and Sloane (1988) investigated the effects on meat demand of differences in quality of beef and lamb at the retail level, and found an inverse relationship between elasticity and quality. High quality beef had an estimated elasticity of -0.54 while very low quality beef had an elasticity of -1.42.

Cashin (1991) used a new disaggregated data set on Australian consumption of fresh pork, ham and bacon. A LA/AIDS demand system was estimated for these disaggregated products, using quarterly consumption data from 1982 to 1990, and one for the more usual aggregated meat types classing all pigmeat together as one type, using data from 1967 to 1990. Tests were carried out for autocorrelation, and for the applicability of the imposition of restrictions derived from utility theory.

The results of Cashin's study show some surprising features, notably a significant difference between own-price elasticities between the two models. In many cases, the findings were contrary to *a priori* expectations. There were a large number of negative uncompensated cross-price elasticities particularly in the disaggregated model. The result was most pronounced for beef, indicating that the other meats are not substitutes but complements! Cashin suggests that either strong income effects or inadequacies in the data sets are to blame. Substitution in consumption between meats, as estimated by their partial elasticities of substitution, was thought to give a more realistic picture. Allen elasticities of substitution were calculated for both models, and the results show the expected positive signs for beef with respect to the other meats.

Using the disaggregated estimate for pork, the own-price elasticity for beef was -0.82 while the cross-price elasticities showed beef as a complement to the other meats. The reasons for this are outlined above. In this model, the expenditure response for beef was 1.38. For lamb, the own-price elasticity was -0.99. The cross- price elasticities showed lamb to be a substitute with pork and chicken and to have an insignificant relationship with beef. The expenditure response for lamb was 0.77. For pork, the own-price elasticity was -1.20 and the cross- price elasticities show pork as a substitute for beef and lamb and a complement to chicken. This is consistent with previous estimates for chicken. The expenditure response for pork was 0.31. Finally for chicken, the own-price elasticity was -0.23. The cross-price elasticities show chicken as a strong substitute for beef and lamb and a complement to pork. The expenditure response for chicken was 1.11.

As part of a larger quarterly structural econometric model of the Australian livestock grazing industries, Vere *et al*. (2000) estimated per capita demand equations for beef, lamb, pork, and bacon and ham. The own-price elasticities for beef, lamb and pork were found to be negative and elastic, ranging between -1.4 and -1.6, while the cross-price elasticities were all positive and less than one, confirming the strong substitution relationships between these three meats. The price of chicken was shown to have a strong negative impact on pork and lamb consumption, with cross-price elasticities around 0.7, but not on beef. The demand for bacon and ham was estimated with a lagged dependent variable, and most of the explanatory power resided in this term and in income. Price response was very inelastic in this equation, even in the long run. Overall, income was of only marginal significance in the beef, lamb and pork equations, with elasticity values between 0.1 and 0.3. However the income response was elastic in the bacon and ham equation at around 1.4.

2.3 Domestic Demand Analyses at Other Market Levels

In a closed domestic market, price elasticities are usually expected to be greater at the retail than at the wholesale or auction level due to the theory of derived demand. However this general conclusion may not hold when export markets are important, as in Australia, in determining prices at the auction level.

Papadopolous (1973) used supplies of beef cattle in a particular State and in other States, auction prices of sheep and lambs in the State, and beef export prices, to construct a set of equations explaining the farm level demand for beef cattle in different States. OLS methods were used for estimation. Price flexibilities of between -0.26 and -0.44 (approximate price elasticities of between -4 and -2) were found for four of the five cattle producing States. Queensland was markedly different in having a price flexibility of only -0.05 (an approximate price elasticity of -20), reinforcing the general view that external factors such as export prices were the chief determinants of beef cattle prices in Queensland at that time. However the model also found variations in sheep meat prices in the Eastern States to be significant in explaining variations in beef prices.

A similar line of investigation was pursued by Harrison and Richardson (1980), who assumed that beef was not homogeneous and could be split into table quality (domestic market and some export markets) and manufacturing quality (primarily the United States market). They specified a structural model with these characteristics and then derived a reduced form representation of price determination for the two qualities. They calculated price flexibilities of -0.34 for table quality cattle (Victorian yearlings) and -0.25 for manufacturing quality cattle (Queensland cows), or approximate price elasticities of between -3 and -4. Again, the demand for cattle was found to be more elastic in those market segments (Queensland cows) where export effects are more important.

2.4 Export Demand Analyses

Early modelling of market behaviour and price formation for Australian exports of beef was rather tentative. Data on export prices were not as readily available as on the domestic market, and there was the complication of the quota arrangements in the largest market outlet, the United States, and in other important markets. Freebairn and Gruen (1977) were one of the few studies to attempt econometric estimation. They estimated a price elasticity of demand for Australian beef exports to markets other than the United States, Canada, Japan and the European Community of -1.27. For these residual markets, this elasticity is much lower than widely believed.

Most other studies of the 1970s were based on applications of standard formulae, of varying levels of sophistication. Papadopolous (1973) assumed a relationship between the importing country's price responsiveness and the small market share of imported Australian beef to conclude that exports were highly price elastic. Her estimate was -32. Other estimates during this period were made by Parton (1978), Scobie and Johnson (1979), Throsby and Rutledge (1979), and Cronin (1979). Parton recognised that the world demand for Australian beef was subject to periodic shifts, and that beef exports were subject to some restriction in the late 1970s. He assumed the export elasticity of demand to be between -1.00 and -2.00 when prices were high, and between -0.25 and -1.00 when they were low. Scobie and Johnson used 1965 data and a formula approach to estimate the price elasticity of export demand for a number of unprocessed and processed food products. For beef and veal, their estimate of the "extreme lower bound" of the export demand elasticity was -10.3, and for mutton and lamb it was -6. In their reply, Throsby and Rutledge suggest that the export price elasticity for unprocessed products may be as low as -0.7. Cronin (1979) provides two estimates based on a more sophisticated formula approach. Under a free market set of assumptions his estimate is -67, while under a set of assumptions recognising some of the policy interventions in other countries his estimate is around -4.

Since these earlier studies, access to export markets for Australian beef has changed radically. The trend has been toward opening up of the East Asian markets, especially Japan and Korea, and maintaining exports to the United States. The EMABA model (Dewbre *et al*. 1985, Harris and Shaw 1992) reflects this change. The model assumes total imports of a particular country, and the supplying country shares of that total, to be determined by relative price movements. Each trade flow from one country to another becomes a determinant of the market clearing quantity and hence the market price in the supplying country. The 1985 version of EMABA contains export demand elasticities of -1.7 for the United States market during non-quota periods, and -1 for non-United States Pacific Rim markets, both evaluated at the saleyard price level. Evaluation at the export price level would increase these estimates, perhaps by double their current values.

The Harris and Shaw (1992) version of EMABA estimates the aggregate export demand elasticities for Australian beef to be -0.64 in the short run, -0.88 over a 5 year time horizon and about -1.37 over a 10 year time horizon. These estimates reflect the replacement of Japanese import quotas by a 70 per cent tariff.

More recent estimates by Vere *et al.* (2000) for the United States and Japanese markets suggest similarly relatively low responses. In the United States market, the price elasticity of import demand for Australian beef with respect to a ratio of Australian and New Zealand import prices was found to be about minus one. In the Japanese market, the price elasticity of import demand for Australian beef with respect to the Australian import price was found to be less than -0.1. The sample period for both estimated equations included long periods where import quotas were in place.

3 Comparison and Evaluation of Previous Demand Elasticity Estimates

There has been a wide range of approaches discussed above and a wide range of results as summarised for the four meats in Tables 1, 2, 3 and 4, respectively. Specification and estimation errors aside, a preliminary inspection would suggest that domestic retail demand elasticity estimates have changed over time in response to the different economic conditions at the various points in time.

The own-price elasticity of retail demand for beef has generally been regarded as slightly elastic, with a value about -1.2. However the latest studies such as Cashin (1991) and Piggott *et al.* (1996) point to a slightly lower value and possibly a declining trend, as demonstrated by Johnson (1978).

The cross-price elasticities for beef with respect to other meats, with the exception of Cashin (1991) who had some data problems and Papadopoulos (1971) who used NSW data, show that beef will readily substitute with the other meats. Despite the growing importance of chicken, it appears that the price of chicken has a relatively minor effect on the consumption of beef. Lamb and pork cross-elasticity values have changed over the period reflecting different consumer responses to the prices of these products as market and economic conditions have changed. These values are quite inelastic. The income elasticity for beef tended to be quite inelastic for the first two decades of the sample covered in this review but in the last two decades it has increased. The more recent studies show expenditure elasticities of about 1.5.

Lamb's own-price elasticity has generally been elastic with a value of around -1.4, but again the estimates calculated more recently tend to be less elastic than earlier estimates. The cross-price elasticities with respect to other meats all show that lamb is a substitute for the other meats. Beef is a major substitute and more recent studies show chicken as a major substitute also. The expenditure elasticity for lamb is about 0.7, while those studies using consumer income as the explanatory variable came up with insignificant estimates, as can be seen in Table 2.

In earlier periods pork was viewed as a luxury good and thus commanded a high price. The estimated own-price elasticities reflected this, being on average about -1.7 in studies up to the early 1980s. From the 1980s onwards this estimate fell to become about -1.0. This fall highlights the structural changes that have occurred in the production of pork and chicken brought about by new technologies and production methods, with price implications. The cross-price elasticities with respect to other meats show that pork is a substitute for beef and lamb and a complement with chicken. Fisher (1979) provides a valid explanation for this as discussed above. The income elasticity for pork was very high at 1.50 to 2.8 prior to 1970, but then fell substantially, with the more recent estimates around 0.25.

Chicken has an own-price elasticity of about -0.3 showing that the demand for chicken is relatively constant and little influenced by price changes. The cross-price elasticities with respect to other meats show chicken as a substitute for beef and lamb, but many studies show this effect to be small. The response to the price of pork has been largely insignificant in previous studies but many of these show support for pork and chicken being complements. The income elasticity for chicken shows little agreement between the studies, although again this must be attributed to the income data used. The most recent estimate by Piggott *et al.* (1996) shows a value of 0.18, which is in agreement with the Alston and Chalfant (1987) value of 0.17. They use expenditure on meats only and not on all products.

The major difficulty in forming any consensus opinion on domestic retail demand elasticity values over the last four decades is the diversity of models, variables and assumptions used and the data period, which effectively precludes a straight comparison of like with like. Richardson (1976) exposed the methodological limitations of pre-1975 studies. He mentions for example, ad hoc selection of variables, inconsistent measurement and interpretation of these variables, and inconsistency with or disregard of any underlying utility function. Linear or log estimation was chosen with the aim of optimum fit to the data, or with a desire to interpret the parameters directly as elasticities. Statistical problems affecting time series data such as autocorrelation and multicollinearity were usually ignored. Main *et al*. (1976) succeeded in deriving plausible and mutually consistent estimates from a system of interdependent demand equations, but still without the restrictions which follow from consumer preference theory, as applied in different ways later by Fisher (1979), Murray (1984), Cashin (1991) and Piggott *et al*. (1996).

Grouping or disaggregation of different products within the market can have a major bearing on demand and price analyses. Research into disaggregated models has often been constrained by data limitations. In this regard, the more recent studies are at an advantage, being able to use more detailed data sources.

The above-mentioned estimates have been derived from static models, meaningful over only a small portion of the demand curve: these assume no relationship exists between price changes in a certain period, and longer-run consumer behaviour patterns. O'Sullivan (1977) makes the case for building a dynamic model which could explain the asymmetry in demand response which was a feature of demand for meat in the early 1970s.

In terms of export demand elasticities, econometric estimates are all relatively small when compared to formula-based estimates, and particularly so for the specific markets where quotas have been in place over the sample periods.

4 Conclusions

The Australian meat industry has undergone significant structural change since empirical work commenced in the early 1960s. Particularly important indicators have been the emergence of chicken meat in the 1970s as a major competitor, the intensification of the pigmeat industry, and the growth in exports of beef and lamb. Structural change in consumer tastes and preferences may occur in several ways. For example, the late 1960s saw improvements in efficiency for poultry production through vertical integration and other factors that made for low cost production and as a result prices fell to become the lowest of all meats. Consumers come to expect to pay low prices for chicken and adjust their consumption patterns accordingly. A second factor is the health characteristics of food. The early 1980s questioned the health attributes of red meats and portrayed chicken as the healthy white meat alternative. Chicken gained a further dominant position in consumer diets. Its own-price elasticity is smaller than the other meats because chicken is primarily used in the fast food business and for special occasions.

From the results of the cross-price elasticities reviewed in Tables 1 and 2 it can be seen that beef is a strong substitute for lamb, and to a lesser extent, lamb is a substitute for beef. Pork and chicken also tend to be substitutes for lamb and beef.

The cross-price elasticity estimates reported in Tables 3 and 4 for chicken and pork respectively, show complementary values for these two meats. This complementary relationship is explained by Fisher (1979). He suggests that the quantities of chicken and fresh pork supplied are highly correlated. This is due to the fact that producers of both types of meat rely on cereal grains as a major input into production, which is attributed to their intensive nature. A higher price for cereals may lead to a reduction in supply of both meats and hence an increase in both of their prices. Thus the cross-elasticities represent these two products as complements.

Export demand estimates tend to be relatively large for those studies based on formula calculations, and relatively small and even inelastic for the econometric estimates. This is particularly so for the specific markets where quotas have been in place over the sample periods.

Accurate and reliable information about the responsiveness both of consumers and producers of commodities to changes in market prices is crucial if informed decisions are to be taken in various fields of policy. As detailed in this review, modelling demand response has been one of the major concerns of agricultural economists in Australia as elsewhere, but some gaps remain.

An area for further analysis could be a formal meta-analysis of the domestic market estimates to better separate out the effects on own- and cross-price elasticity estimates of time period, functional form, model specification, and the like.

Another could be an up-to-date study of Australian retail meat demand using modern functional forms and estimation methods.

And finally, in spite of the trade status of the Australian meat industries, there are significant gaps in knowledge about export demand elasticities. Analyses covering export demand by region and by product would seem to be an obvious area for further effort.

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TABLE 1. RETAIL ELASTICITIES OF DEMAND FOR BEEF IN AUSTRALIA

Year of Publn.	Researcher	Market Level	Geographic Coverage	Change in BEEF consumption from a change in the price of				in	Data Period	Data Set	Method	Functional Form
				Beef	Lamb	Pork	Chicken	Income				
1961	Van der Meulen	Retail	Sydney	-0.71	0.49			0.40	A	1948-49 to 1959-60	OLS	Double Log
1961	Taylor	Retail	Aust	-0.96	0.02				A	1950-51 to 1959-60	OLS	Double Log
1963	Taylor	Retail	Aust	-1.03					A	1950-51 to 1959-60	OLS	Double Log
1967	Marceau	Retail	NSW	-1.33					Q	1951 to 1963	OLS	Double Log
1967	Gruen *et al.*	Retail	Aust	-0.96					A	1949-50 to 1964-65	OLS	Double Log
1967	BAE	Retail	Sydney					0.27	XS	1964-65	OLS	
1970	BAE	Retail	Melbourne					0.21	XS	1967	OLS	
1971	Papadopoulos	Retail	NSW	-2.06	-0.23	1.43		0.98	Q	1962(1) to 1970(2)	2SLS	Double Log
1972	Throsby	Retail	Aust	-1.90				0.59	Q	1962 to 1972	2SLS	
1974	Throsby	Retail	Aust	-0.76	0.04			0.22	Q	1962 to 1972	OLS/2SLS	Double Log
1974	Greenfield	Retail	Aust	-1.71				1.23	A	1955 to 1972	OLS	Double log
1976	Main *et al. (s)*	Retail	Aust	-1.41	0.37, 0.03			0.47	Q	1962(1) to 1975(2)	OLS	Double Log
1976	Main *et al. (s)*	Retail	Aust	-1.38	0.39, 0.32			0.43	Q	1962(1) to 1975(2)	SUR	Double Log
1977	Freebairn/Gruen	Retail	Aust	-1.39	0.44			0.51	Q	1962(1) to 1975(4)	OLS	Double log
1977	Freebairn/Gruen	Retail	Aust	-0.90 :1975 (low) prices					Q	1962(1) to 1975(4)	OLS	Linear
1977	Freebairn/Gruen	Retail	Aust	-1.85 :1973 (high) prices					Q	1962(1) to 1975(4)	OLS	Linear
1978	Johnson	Retail	Aust	-1.35 :1962(1)				0.46	Q	1962(1) to 1975(4)	OLS	Box-Cox Functional
1978	Johnson	Retail	Aust	-1.39 :1964(2)				0.46	Q	1962(1) to 1975(4)	OLS	Form
1978	Johnson	Retail	Aust	-1.26 :1966(3)				0.43	Q	1962(1) to 1975(4)	OLS	
1978	Johnson	Retail	Aust	-1.21 :1968(4)				0.38	Q	1962(1) to 1975(4)	OLS	
1978	Johnson	Retail	Aust	-1.23 :1971(1)				0.40	Q	1962(1) to 1975(4)	OLS	
1978	Johnson	Retail	Aust	-1.26 :1973(2)				0.40	Q	1962(1) to 1975(4)	OLS	
1978	Johnson	Retail	Aust	-1.56 :1975(1)				0.44	Q	1962(1) to 1975(4)	OLS	
1979	Fisher	Retail	Aust	-1.19	0.14	0.14	0.04	0.54	Q	1962(1) to 1977(2)	FIML	Modified Translog
1979	Fisher	Retail	Aust	-1.32	0.21	0.16		0.48	Q	1962(1) to 1977(2)	FIML	Double Log
1984	Murray	Retail	Aust	-1.95	0.32	0.19	0.09	1.18	A	1949-50 to 1978-79	SUR	AIDS
1984	Murray	Retail	Aust	-1.42	0.15	0.13	0.01	0.93	A	1949-50 to 1978-79	SUR	Translog

TABLE 1. (cont) RETAIL ELASTICITIES OF DEMAND FOR BEEF IN AUSTRALIA

Year of Publn.	Researcher	Market Level	Geographic Coverage	Change in BEEF consumption from a change in the price of				in	Data Period	Data Set	Method	Functional Form
				Beef	Lamb	Pork	Chicken	Income				
1984	Murray	Retail	Aust	-1.62	0.12	0.08	-0.03	1.37	A	1949-50 to 1978-7	SUR	Indirect Addilog
1985	Dewbre *et al*	Retail	Aust	-0.98	0.23	0.05	-0.03	0.37	A	1964-65 to 1982-83	OLS	double log
1985	Martin/Porter	Retail	Aust	-1.13	0.06	0.63	0.19	0.68	Q	1962(1) to 1983(1)	OLS	Double Log
1987	Alston/Chalfant	Retail	Aust	-1.11	0.26	0.75	0.46	0.15	Q	1968(1) to 1983(1)	OLS	Double Log
1987	Alston/Chalfant	Retail	Aust	-0.42	0.37	0.29	0.02	1.61	Q	1968(1) to 1983(1)	OLS	Double Log
1991	Cashin (p)	Retail	Aust	-1.24	-0.02	-0.20	-0.19	1.65	Q	1967(1) to 1990(2)	SUR	LA-AIDS
1991	Cashin (p)	Retail	Aust	-0.82	-0.11	-0.02	-0.36	1.38	Q	1982(1) to 1990(2)	SUR	LA-AIDS
1992	Harris/Shaw	Retail	Aust	-0.92				0.26	A	1962 to 1988	SUR	LA-AIDS
1996	Piggott *et al.*	Retail	Aust	-0.42	0.43	0.13	-0.14	1.82	Q	1978(3) to 1988(4)	OLS	Double Log
2000	Vere *et al*	Retail	Aust	-1.38	0.64	0.37		0.33	Q	1970(1) to 1996(4)	2SLS	Linear

OLS: Ordinary Least Squares, 2SLS: 2-stage Least Squares, SUR: Seemingly Unrelated Regression, FIML: Full Information Maximum Likelihood Estimates
Q: Quarterly data, A: Annual data, XS: Cross-section data, AIDS: Almost Ideal Demand System
(s): Sheepmeat and Lamb estimate respectively, (p) Pigmeat and pork estimates respectively

TABLE 2. RETAIL ELASTICITIES OF DEMAND FOR LAMB IN AUSTRALIA

Year of Publn.	Researcher	Market Level	Geog. Coverage	Change in LAMB consumption from a change in the price of Lamb	Beef	Pork	Chicken	in Income	Data Period	Data Set	Method	Functional Form
1961	Van der Meulen	Retail	Sydney	-1.18	0.91			0.23	A	1948-49 to 1959-60	OLS	Linear
1963	Taylor	Retail	Aust	-1.82					A	1950-51 to 1959-60	OLS	Double log
1964	Taylor	Retail	Aust	(f) -0.49	(f) 0.31				A	1950-51 to 1959-61	OLS	Double log
1967	Marceau	Retail	NSW	-2.07	0.48			0.14	Q	1951 to 1963	OLS	Double log
1967	Gruen *et al.*	Retail	Aust	-1.55	0.50			0.83	A	1949-50 to 1964-66	OLS	Double log
1971	Papadopoulos	Retail	NSW	-1.30	0.87	0.21		0.26	Q	1962(1) to 1970(2)	OLS	Double log
1976	Main *et al. (s)*	Retail	Aust	-1.25, -1.68	0.53, 0.71	0.91, 0.86		-0.49, 0.03	Q	1962(1) to 1975(2)	OLS	Double log
1976	Main *et al. (s)*	Retail	Aust	-1.24, -1.89	0.50, 0.64	0.84, 0.91		-0.51, -0.14	Q	1962(1) to 1975(2)	SUR	Double log
1979	Fisher	Retail	Aust	-1.58	0.47	0.33	-0.12	0.09	Q	1962(1) to 1977(2)	FIML	Modified Translog
1979	Fisher	Retail	Aust	-1.66	0.72	0.37		0.03	Q	1962(1) to 1977(2)	FIML	Double log
1981	Griffith/Vere	Retail	Aust	-1.33	0.95	0.60		0.09	Q	1966(1) to 1979(4)	OLS	Linear
1981	Griffith/Vere	Retail	Aust	-1.61	1.10	0.87		0.25	Q	1966(1) to 1979(4)	2SLS	Linear
1984	Murray	Retail	Aust	-1.29	0.50	0.12	-0.11	0.85	A	1949-50 to 1978-79	SUR	AIDS
1984	Murray	Retail	Aust	-1.35	0.51	0.22	0.02	0.80	A	1949-50 to 1978-79	SUR	Translog
1984	Murray	Retail	Aust	-1.50	0.61	0.08	-0.03	0.76	A	1949-50 to 1978-79	OLS	Indirect Addilog
1985	Martin/Porter	Retail	Aust	-1.88	0.68	0.53	0.70	-0.13	Q	1962(1) to 1983(1)	OLS	Double log
1985	Dewbre *et al*	Retail	Aust	-1.43	0.50	0.07	0.13	0.21	A	1964-65 to 1982-83	OLS	Double log
1987	Alston/Chalfant	Retail	Aust	-1.39	0.70	0.42	0.51	0.39	Q	1968(1) to 1983(1)	OLS	Double log
1987	Alston/Chalfant	Retail	Aust	-1.33	1.06	0.20	0.28	0.85	Q	1968(1) to 1983(1)	OLS	Double log
1988	Vere/Griffith	Retail	NSW	-0.82	0.63	0.33		-0.67	Q	1966(1) to 1986(4)	OLS	Double log
1991	Cashin (p)	Retail	Aust	-1.33	0.51	0.25	0.05	0.53	Q	1967(1) to 1990(2)	SUR	LA-AIDS
1991	Cashin (p)	Retail	Aust	-0.99	-0.02	0.10	0.26	0.77	Q	1982(1) to 1990(2)	SUR	LA-AIDS
1996	Piggott *et al.*	Retail	Aust	-1.26	0.68	0.11	0.47	0.43	Q	1978(3) to 1988(4)	OLS	Double log
2000	Vere *et al*	Retail	Aust	-1.54	0.87	0.38	0.74	0.22	Q	1970(1) to 1996(4)	2SLS	Linear

OLS: Ordinary Least Squares, 2SLS: 2-stage Least Squares, SUR: Seemingly Unrelated Regression, FIML: Full Information Maximum Likelihood Estimates
Q: Quarterly data, A: Annual data, AIDS: Almost Ideal Demand System
(s): Sheepmeat and Lamb estimate respectively, (p) pigmeat and pork estimates respectively, (f) price flexibilities

TABLE 3. RETAIL ELASTICITIES OF DEMAND FOR PORK IN AUSTRALIA

Year of Publn.	Researcher	Market Level	Geog. Coverage	Change in PORK consumption from a change in the price of: Pork	Beef	Lamb	Chicken	in Income	Data Period	Data Set	Method	Functional Form
1967	Gruen *et al.*	Retail	Aust.	-2.19				2.80	A	1952-53 to 1968-70	OLS	Double log
1967	Hill	Retail	Aust.	-1.20					A	1948-49 to 1961-62	OLS	Double log
1970	Pender/Erwood	Retail	Aust.	-3.29	1.85 (a)			1.50	A	1952-53 to 1968-69	OLS	Double log
1971	Papadopoulos	Retail	NSW	-3.99	5.36	0.65		-0.26	Q	1962(1) to 1970(2)	OLS	Double log
1976	Main *et al. (s)*	Retail	Aust.	-1.50	0.53	0.20, 0.69	-0.51	-0.21	Q	1962(1) to 1975(2)	OLS	Double log
1976	Main *et al. (s)*	Retail	Aust.	-1.89	0.41	0.38, 0.73	-0.61	-0.44	Q	1962(1) to 1975(2)	SUR	Double log
1979	Fisher	Retail	Aust.	-0.95	1.00	0.70	-0.27	0.04	Q	1962(1) to 1977(2)	FIML	Modified Translog
1979	Fisher	Retail	Aust.	-1.40	1.13	0.78		0.20	Q	1962(1) to 1977(2)	FIML	Double log
1984	Murray	Retail	Aust.	-1.38	0.52	0.19	-0.07	1.06	A	1949-50 to 1978-79	SUR	AIDS
1984	Murray	Retail	Aust.	-1.87	0.56	0.40	-0.19	1.70	A	1949-50 to 1978-79	SUR	Translog
1984	Murray	Retail	Aust.	-1.85	0.61	0.12	-0.03	1.06	A	1949-50 to 1978-79	OLS	Indirect Addilog
1985	Martin/Porter	Retail	Aust.	-1.09	0.38	0.09	-0.28	0.25	Q	1962(1) to 1983(1)	OLS	Double log
1985	Dewbre *et al*	Retail	Aust	-1.34	0.36	0.18	0.16	0.31	A	1964-65 to 1982-83	OLS	Double log
1987	Alston/Chalfant	Retail	Aust.	-1.02	0.36	0.18	-0.23	-0.24	Q	1968(1) to 1983(1)	OLS	Double log
1987	Alston/Chalfant	Retail	Aust.	-1.12	0.47	0.20	-0.31	0.26	Q	1968(1) to 1983(1)	OLS	Double log
1991	Cashin (p)	Retail	Aust.	-0.83	0.24	0.22	0.14	0.23	Q	1967(1) to 1990(2)	SUR	LA-AIDS
1991	Cashin (p)	Retail	Aust.	-1.20	0.42	0.36	-0.32	0.31	Q	1982(1) to 1990(2)	SUR	LA-AIDS
1996	Piggott *et al.*	Retail	Aust.	-0.87	0.43	0.17	0.27	0.15	Q	1978(3) to 1988(4)	OLS	Double log
2000	Vere *et al*	Retail	Aust	-1.59	0.41		0.65	0.12	Q	1970(1) to 1996(4)	2SLS	Linear

OLS: Ordinary Least Squares, 2SLS: 2-stage Least Squares, SUR: Seemingly Unrelated Regression, FIML: Full Information Maximum Likelihood Estimates
Q: Quarterly data, A: Annual data, AIDS: Almost Ideal Demand System
(s): Sheepmeat and Lamb estimate respectively, (p) pigmeat and pork estimates respectively, (a) index of all other meat prices

TABLE 4. RETAIL ELASTICITIES OF DEMAND FOR CHICKEN IN AUSTRALIA

Year of Publn.	Researcher	Market Level	Geog. Coverage	Change in CHICKEN consumption from a change in the price of				in Income	Data Period	Data Set	Method	Functional Form
				Chicken	Beef	Pork	Lamb					
1970	Paton	Retail	Aust.	-1.31			0.42		A	1954 to 1969	OLS	Double log
1979	Fisher	Retail	Aust.	-0.23	0.28	-0.27	-0.25	0.20	Q	1962(1) to 1977(2)	FIML	Modified Translog
1979	Fisher	Retail	Aust.	-0.16				0.16	Q	1962(1) to 1977(2)	FIML	Double log
1984	Murray	Retail	Aust.	-1.14	-0.19	0.01	0.02	1.34	A	1949-50 to 1978-79	SUR	AIDS
1984	Murray	Retail	Aust.	-0.65	0.26	-0.06	0.08	0.57	A	1949-50 to 1978-79	SUR	Translog
1984	Murray	Retail	Aust.	-0.40	0.61	0.08	0.12	-0.49	A	1949-50 to 1978-79	OLS	Indirect Addilog
1985	Martin/Porter	Retail	Aust.	-0.31	0.18	-0.15	0.00	0.34	Q	1962(1) to 1983(1)	OLS	Log difference form
1985	Dewbre *et al*	Retail	Aust	-0.77	0.12	0.02	0.06	0.29	A	1964-65 to 1982-83	OLS	double log
1987	Alston/Chalfant	Retail	Aust.	-0.31	0.12	-0.01	0.08	-0.93	Q	1968(1) to 1983(1)	OLS	Double log
1987	Alston/Chalfant	Retail	Aust.	-0.37	0.21	-0.14	0.08	0.17	Q	1968(1) to 1983(1)	OLS	Double log
1991	Cashin (p)	Retail	Aust.	-0.47	0.03	0.26	0.12	0.06	Q	1967(1) to 1990(2)	SUR	LA-AIDS (a)
1991	Cashin (p)	Retail	Aust.	-0.23	1.07	-0.11	0.99	1.11	Q	1982(1) to 1990(2)	SUR	LA-AIDS (a)
1996	Piggott *et al.*	Retail	Aust.	-0.46	0.34	0.23	-0.10	0.18	Q	1978(3) to 1988(4)	OLS	Double log

OLS: Ordinary Least Squares, SUR: Seemingly Unrelated Regression, FIML: Full Information Maximum Likelihood Estimates
Q: Quarterly data, A: Annual data, AIDS: Almost Ideal Demand System
(p) Pigmeat and Pork estimate respectively

TABLE 5. FARM AND WHOLESALE ELASTICITIES OF DEMAND FOR BEEF IN AUSTRALIA

Year of Publn.	Researcher	Market Level	Geographic Coverage	Change in BEEF demand from a change in the price of Beef	Data Period	Data Set	Method	Functional Form
1967	Marceau	Saleyard	NSW	-0.50	Q	1951 to 1963	OLS	Double Log
1973	Papadopoulos	Saleyard	NSW	(f) -0.41	A	1961 to 1972	OLS	Linear
1973	Papadopoulos	Saleyard	VIC	(f) -0.44	A	1961 to 1972	OLS	Linear
1973	Papadopoulos	Saleyard	QLD	(f) -0.05	A	1961 to 1972	OLS	Linear
1973	Papadopoulos	Saleyard	SA	(f) -0.26	A	1961 to 1972	OLS	Linear
1973	Papadopoulos	Saleyard	TAS	(f) -0.39	A	1961 to 1972	OLS	Linear
1977	Freebairn/ Gruen	Wholesale	Aust	-0.39 1975 (low) prices	Q	1962 to 1972	OLS	Linear 1975
1977	Freebairn/ Gruen	Wholesale	Aust	-1.31 1973 (high) prices	Q	1962(1) to 1975(2)	OLS	Linear 1973
1977	Freebairn/ Gruen	Saleyard	Aust	-0.27 1975 (low) prices	Q	1962 to 1972	OLS	Linear 1975
1977	Freebairn/ Gruen	Saleyard	Aust	-1.19 1973 (high) prices	Q	1962(1) to 1975(2)	OLS	Linear 1973
1980	Harrison/ Richardson	Saleyard	Aust	(f) -0.34 (table quality)	Q	1966(1) to 1979(4)	2SLS	Linear
1980	Harrison/ Richardson	Saleyard	Aust	(f) -0.25 (manufact. quality)	Q	1966(1) to 1979(4)	2SLS	Linear
1992	Harris/Shaw	Saleyard	Aust	-0.37	A	1962 to 1988	SUR	LA-AIDS

OLS: Ordinary Least Squares, 2SLS: 2-stage Least Squares, SUR: Seemingly Unrelated Regression
Q: Quarterly data, A: Annual data, AIDS: Almost Ideal Demand System (f)
flexibility.

TABLE 6. EXPORT ELASTICITIES OF DEMAND FOR BEEF IN AUSTRALIA								
Year of Publn.	Researcher	Market Level	Geographic Coverage	Change in BEEF export demand from a change in the price of	Data Period	Data Set	Method	Functional Form
				Beef				
1973	Papadopoulos	export	US	-32.00	A	1970	formula	
1977	Freebairn/ Gruen	export	"other markets"	-1.27	A	1970/71 to 1975/76	OLS	Double log
1978	Parton	export	all	[-1.0,-2.0] (high price)	A	na	assumed	
1978	Parton	export	all	[-0.25,-1.0] (low price)	A	na	assumed	
1979	Scobie/Johnson	export	all	-10.30	A	1965	formula	
1979	Cronin	export	all	-67.00 (free market)	A	late 1970s	formula	
1979	Cronin	export	all	-4.00 (govt. intervention)	A	late 1970s	formula	
1985	Dewbre *et al*	export	US (non-quota)	-1.70 (saleyard price level)	A	1961/62 to 1982/83	OLS	Double log
1985	Dewbre *et al*	export	non-US Pacific	-1.00 (saleyard price level)	A	1961/62 to 1982/83	OLS	Double log
1992	Harris/Shaw	export	all	[-0.64,-0.88,-1.37] (SR,MR,LR)	A	1962 to 1988	SUR	LA-AIDS
2000	Vere *et al*	export	US	-0.99	Q	1970 to 1996	2SLS	Linear
2000	Vere *et al*	export	Japan	-0.05	Q	1970 to 1996	2SLS	Linear

OLS: Ordinary Least Squares, SUR: Seemingly Unrelated Regression, AIDS: Almost Ideal Demand System
Q: Quarterly data, A: Annual data
SR: short run (1 year), MR: medium run (5 years), LR: long run (10 years)