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QUALITY/QUANTITY TRADE-OFFS IN THE DEMAND FOR BEEF AND LAMB: A CROSS-SECTIONAL TIME-SERIES STUDY

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Recent studies using apparent consumption data have identified changes in relative prices, incomes and advertising levels as the primary factors underlying the observed decline in demand for red meat during the period 1964-84. In those studies, beef and veal, lamb, chicken and pork were treated as homogeneous goods with single prices. Additional information can be obtained if each of these meats is treated as a heterogeneous aggregate of commodities.

Cuts of beef, veal and lamb were grouped into a set of broad price categories. Changes that have occurred in quality and quantity choice within these categories were analysed, and factors affecting these choices were identified. For each category, cross-sectional elasticities were calculated for quantity demand with respect to own price and for quality and quantity with respect to income. In addition, detailed information was obtained on the effect of demographic factors on the demand for each of these categories of meat.

It was found that changes in prices, and to a minor extent demographic factors, have contributed to the decline in consumption, and that consumers have altered their quality choices among the different groupings of meat cuts over the period. It cannot be concluded, however, that consumers have traded off quality against quantity over the period.

The composition of meat consumption in Australia has altered in recent years, with a decline in the consumption of beef and veal and lamb and an increase in consumption of pork and poultry. Several recent studies using apparent consumption data have focussed on the factors that have led to the shift in consumption. Changes in relative prices and incomes have been identified as the primary factors underlying the consumption shift during the 1960 to 1983 period (Martin and Porter 1985; Chalfant and Alston 1986). Recent Bureau work has identified changes in generic advertising levels as having had an important influence on demand since 1977. Studies using household level data have identified demographic factors such as household size, age of the housekeeper and ethnic origin as having observable although minor effects on the demand for meat and seafood (Bartley, Ball and Weeks 1987). All of these studies, by necessity, have treated beef and veal, lamb, pork and seafood as individually homogeneous commodities with single prices. If these meats are actually heterogeneous from the demand standpoint, inferences drawn from these studies can only be very general.

Additional understanding of the decline in demand for red meat can be obtained if, for example, beef and veal and lamb are examined as heterogeneous aggregates of commodities. By decomposing these meats into individual cuts, changes that have occurred in quality and quantity choice for different categories within individual meats can be analysed. A qualitative study among Newcastle housewives found that quality choice varied with changes in income (McShane 1973). Although McShane found that the quantity of meat consumed by a household was fairly constant with income, it is nevertheless possible that an improvement in the quality of red meat consumed may be accompanied by a reduction in the total quantity.

In this study the quality and quantity relationships of different classes of beef and veal and lamb are estimated, and changes that have occurred in these relationships between the 1960s and 1980s are identified. (Data were not available for a similar disaggregated, time-dependent treatment of other meats.) Real price changes for the different categories are derived after factors affecting quality choice, such as family size and income, have been taken into account. This disaggregated approach enables information on substitutability between categories to be obtained through the cross-price elasticities. The dependence of quantity consumed on price and income, and of quality chosen on income, are calculated for each meat category. The method employed enables the degree of heterogeneity within beef and veal and lamb to be determined, so that the implications of treating these meats as homogeneous commodities can be assessed.

Detailed information can also be obtained on the influence of demographic factors on the demand for particular quality categories of red meat. In particular the effect of age, occupation and ethnic origin on demand for different cuts is examined.

In the next section, the theoretical issues involved in examining quality and quantity choice using cross-sectional data are explained. This is followed by a section describing the data and the variables used in the analysis. The subsequent section provides a brief discussion of methodological considerations. In the final sections results of the price and quantity equations estimated are presented and conclusions drawn.

Theoretical Issues

Faced with a budget constraint a consumer has to choose how to allocate income between competing demands. Initially, it is assumed, the consumer

will allocate income between broad groupings of goods such as food, housing, clothing and transport. After deciding on the allocation of income to food, the consumer faces a secondary allocation decision between individual food items such as meat and vegetables. This allocation procedure is known as two-stage budgeting. In this study it is also assumed that after allocating income to total meat expenditure the consumer makes a subsequent decision to allocate income to an individual meat type or 'commodity class' (using the terminology of Cramer 1973), such as beef and veal, lamb, pork and chicken. The present study is concerned mainly with the subsequent choices of cut and quality within each such 'class'. Therefore, any substitution that may occur between cuts of different meats is ignored. The method does, however, detect any substitutions between - for example - the four categories into which beef cuts have been grouped.

A consumer is faced with two distinct choices - of quality and quantity. In this study it is assumed that the consumer first determines which quality of good will be purchased within any commodity class. Beef and veal are viewed as a commodity class, individual cuts being 'goods'. (In the strict Cramer terminology, goods are homogeneous products. Realistically, however, some level of heterogeneity will be observed within individual cuts; for example, cuts obtained from grain fed and grass fed animals are not identical products.) Second, the consumer decides on the quantity of the commodity. In many instances an increase in household income will lead to an increase in the quality of a good being purchased while the quantity consumed may decline.

The price of any commodity can be viewed as containing both quality and quantity components. To obtain true estimates of the factors affecting the quantity of a commodity demanded, 'quality-adjusted' prices are therefore needed - that is, prices devoid of any quality component. Cross-sectional household expenditure surveys have not provided data on specific attributes of meat quality such as colour, fat content, electrical stimulation and age. In removing quality components of prices, quality attributes are therefore proxied by household characteristics and income, as it is these characteristics that determine quality choice. This approach is taken by Cox and Wohlgenant (1986) in a cross-sectional disaggregated study of vegetable demand. (Purging prices of their quality attributes is a standard technique in the construction of index numbers, where it is the pure inflation component of any price change that is of interest, net of the price effects of any quality changes that may have occurred over time.)

Cramer (1973) demonstrates that the bias created by using unadjusted prices will increase with the qualitative heterogeneity of a commodity. Thus a comparison of regression estimates or elasticities obtained using quality-adjusted prices with those using unadjusted prices will provide an indication of the heterogeneity.

By decomposing expenditure into its component parts of price and quantity, it can be seen that income elasticities of expenditure can be analysed into pure quantity elasticities (these being what are usually termed income elasticities) and quality elasticities. Following Cramer:

$$\text{expenditure} = \text{quantity} \times \text{price};$$

$$\log x = \log q + \log p;$$

$$\frac{d \log x}{d \log y} = \frac{d \log q}{d \log y} + \frac{d \log p}{d \log y}$$

where y is income. Taking price as the measure of quality, this last expression can be read as:

expenditure elasticity	=	quantity elasticity	+	quality elasticity

The quality elasticity is the measure of the extent to which an increase in income will lead to an increase in the quality chosen. (For truly homogeneous goods the quality elasticity would be zero, since no such differential would be available to the consumer.)

The consumer's problem can be expressed in the general form:

Maximise

$$U(q_i, v_i(a_i)) \qquad q_i > 0, \; v_i > 0$$

subject to

$$\sum_i p_i[c_i, b_i v_i(a_i)] \, q_i = y$$

where

- q_i are quantities of commodities,
- v_i are qualities of commodities,
- a_i are commodity attributes,
- y is money income, and
- p_i are total commodity prices, which are functions of
- c_i, pure quantity prices, and
- b_i, quality prices.

A solution to this optimisation problem is the general Houthakker (1952) model:

$$(1) \qquad p_i = c_i + \sum_j b_{ij} a_{ij}$$

$$(2) \qquad q_i = q_i^*(c_i, a_i, y, c_{j \neq i})$$

With the assumption of a distinct separation between the consumer's quality and quantity decisions, equations (1) and (2) can be estimated independently. When the price equation is estimated, the price predictions from the regression, net of the 'true' constant term (that obtained in the absence of any dummy variables), can be interpreted as the quality component of price; the quantity component is then the constant plus residuals. This approach follows Cowling and Rayner (1970), who disaggregated tractor prices into their quality and pure quantity components; more recently, it has been corroborated theoretically by Ladd (1982).

A time-series and regional dimension can be added to the model specification by including dummy variables for survey periods and cities. In general the time dummy provides a measure of the average change in the real price of any meat type, holding constant the quality attributes. This approach is justified for hedonic price equations when (as is the case with beef and veal and lamb) product characteristics have not changed between time periods (Griliches 1971). It is also a standard cross-sectional time-series technique for estimating demand equations. The equations to be estimated take the form:

$$(3) \qquad p_i = c_i + \sum_j b_{ij} a_{ij} + \sum_t d_{it} D_{it}$$

$$(4) \qquad q_i = q_i^*(c_i, a_i, y, c_{j \neq i}, D_i)$$

where D_{it} are period and city dummies.

Data

The data used are from the household meat consumption surveys conducted by the then BAE in Sydney in 1964, in Melbourne in 1967 and in Sydney and Melbourne in 1984. The households were either questioned on a recall basis or were given diaries to itemise expenditure on meat and total food items and quantities consumed. The 1964 survey was conducted on a 50 per cent recall, 50 per cent diary basis, the 1967 survey on a total recall system and the 1984 survey on a total diary basis. The 1964 and 1984 surveys were conducted over a two-week period and the 1967 survey over one week. Detailed information on individual meat cuts was obtained as well as demographic characteristics and income for each household. Households whose income data were not considered reliable have been excluded. The prices used were implicit prices, obtained by dividing expenditure by quantity. (Thus, where a consumer's expenditure on any category is zero, the price to that consumer is indeterminate - see following section.)

The 1984 survey data required weighting to take account of non-responses and to ensure true representation of the populations of Sydney and Melbourne. The weights are the probabilities of inclusion in each sample stratum. To maintain consistency across surveys the earlier surveys have been weighted in a similar manner as far as practicable. (Some data on survey design were not retained from the earlier surveys.) The estimates reported in this study are thus not ordinary least squares estimates but weighted least squares estimates.

Ideally the finest level of disaggregation possible within any commodity class should be used, to reduce the heterogeneity within each group. The commodity class beef and veal was disaggregated into veal and high, medium, low and very low quality beef. Lamb was disaggregated into high and low quality lamb. As a consistent non-arbitrary criterion for assigning cuts to quality categories, weighted mean price was used. The allocation of meat cuts to quality categories is shown in Table 1. (Pork was excluded because there was no correspondence between the cut classifications used in the 1960s surveys and the 1984 survey.)

The demographic characteristics used are detailed in Table 2. Dummy variables A1 to A5 represent the age of the housekeeper: B1 to B6 represent the birthplace of the household head; and C1 to C6 represent the occupation of the household head. The range of demographic variables included has been limited by the range of questions asked in the earlier surveys. It is for this reason that people of Asian origin have not been separated into a distinct category but are included in the B6 group. The best fits were obtained when household size was included as a single variable in the price equations, and was disaggregated into numbers of adults and children in the quantity equations. (The definition of a child differed slightly between surveys: in the 1960s surveys, children included only ages 0-13, but 14-year-olds were included in the 1984 surveys.) Gross weekly income was used as a proxy for household expenditure, since it was the only suitable variable for this purpose common to all of the surveys.

TABLE 1

Grouping of Meat Cuts into Quality Categories

Quality	Cuts
Beef and veal	
High quality beef	Fillet steak
	Rump steak
	Sirloin steak
	Sirloin roast
Medium quality beef	Topside steak
	Round steak
Low quality beef	Blade steak
	Silverside
Very low quality beef	Rib roast
	Brisket
	Minced Steak
	Chuck steak
Veal	All cuts of veal
Lamb	
High quality lamb	Leg chop
	Leg roast
	Chump chop
	Short loin chops
	Cutlets
Low quality lamb	Shoulder roast
	Neck chops

All price variables enter the model specification as the price of a cut relative to 'the price of food', a quarterly index derived from the food component of the consumer price index. (A consistent index for the price of other meats could not be constructed for the total estimation period.) To obtain homogeneity of degree zero in prices and incomes, all price and income variables were deflated by the quarterly consumer price index.

Estimations

Price equations

The price equations were estimated using only observations with determinate implicit prices (that is, removing all zero purchases). Data on each quality category were examined for consistency, and observations more than three standard deviations from the mean were removed. (Houthakker (1952) and Cox and Wohlgenant (1986) used five standard deviations as their limit, but outliers in the data of this study appear to begin at three standard deviations.)

TABLE 2

Variables Representing Economic and Demographic Characteristics

Prices ($/kg)(a)

HB = price of high quality beef
MB = price of medium quality beef
LB = price of low quality beef
VB = price of very low quality beef
V = price of veal
HL = price of high quality lamb
LL = price of low quality lamb

Demographics

Adults = number of persons in the household aged 14 or above (15y in 1984).
Children = number of persons in the household aged 0-13y (14y in 1984).
Household size = adults and children aggregated.
Income = gross weekly household income ($) (a).

Age of housekeeper:

A1 = 1 if 15-24y; 0 otherwise.
A2 = 1 if 25-34y; 0 otherwise.
A3 = 1 if 35-44y; 0 otherwise.
A4 = 1 if 45-59y; 0 otherwise.
A5 = 1 if 60y or over; 0 otherwise.

Birthplace of household head:

B1 = 1 Australia or New Zealand (or Canada or United States, in 1984 survey); 0 otherwise.
B2 = 1 if United Kingdom or Ireland; 0 otherwise.
B3 = 1 if northern Europe; 0 otherwise.
B4 = 1 if eastern Europe; 0 otherwise.
B5 = 1 if southern Europe; 0 otherwise.
B6 = 1 if none of the above; 0 otherwise.

Occupation of household head:

C1 = 1 if professional, technical, administrative or management; 0 otherwise.
C2 = 1 if clerical or semi-clerical; 0 otherwise.
C3 = 1 if sales or services; 0 otherwise.
C4 = 1 if a skilled tradesperson; 0 otherwise.
C5 = 1 if a production process worker; 0 otherwise.
C6 = 1 if none of the above; 0 otherwise.

(a) In constant 1980-81 dollars.

The preferred functional form for the price equations, on both theoretical and empirical grounds, was a semi-log formulation, with income and household size entering in log form. Increases in household size are hypothesised to have the effect of reducing the quality that a household will purchase, but at a declining rate. Increases in real income should lead to an

increase in the quality chosen, similarly at a declining rate. The other demographic variables - age, ethnic origin and occupation - were expected to act as proxies for other factors that influence quality choice.

All price equations were estimated by weighted least squares (using an SAS regression package), with the weights normalised to the number of observations appearing in each equation. The Breusch-Pagan test indicated that some equations showed the possible presence of heteroskedasticity. Attempts to model the form of heteroskedasticity, however, did not produce any appreciable difference in the parameter estimates or standard errors. The regression estimates are reported in Tables 3 and 4.

Quantity equations

To estimate the quantity equations a limited-dependent-variable framework was required. A censored regression model was needed because the quantity demanded by a household of any particular quality category may be zero, causing the distribution to violate the standard regression assumption of normality. If all the observations are used, ordinary least squares will result in biased estimates. The same result will be true if only non-zero observations are used, as

$$E(y_i|y_i > 0) = x'B + E(u_i/u_i > - x'B).$$

The reason for the bias in this case can be expressed using the notation:

$$\lambda(\ ) = f(\ )/F(\ )$$

where $f(\ )$ is a density function and $F(\ )$ is a cumulative distribution function. If σ and β are coefficient matrices, then

$$E(u_i|u_i > 0\ ) = \sigma\lambda\ (x'(B/\sigma))$$

which need not equal zero (see Amemiya 1981).

To obtain unbiased estimates the quantity equations were estimated using a variant of Heckman's two-step estimator procedure. Heckman's procedure uses all observations to compute B/σ and then uses positive observations to run the regression

$$y = x'B + \sigma\lambda(x'(\hat{B}/\hat{\sigma})).$$

In this study the logistic distribution was used to compute the first stage estimator rather than the probit distribution used by Heckman, because of software limitations. Software limitations also precluded the use of the tobit estimator.

A procedure was also required for replacing indeterminate implicit prices (the prices of categories not purchased) with some approximation to the prices actually faced by households. The mean value of real (unadjusted) price and quality-adjusted price of each category, for each city and time period, was used for this purpose.

TABLE 3

Coefficients of Price (Quality) Equations for Beef and Veal Categories

Regressor	High quality beef	Medium quality beef	Low quality beef	Very low quality beef	Veal
	$/kg	$/kg	$/kg	$/kg	$/kg
Intercept	4.90 (30.13)	4.09 (55.40)	3.41 (43.00)	2.73 (35.62)	4.58 (38.22)
Log household size	-0.21 (-4.06)	0.02 (0.76)	-0.05 (-1.97)	0.01 (-0.50)	-0.05 (-1.36)
Log income	0.08 (2.25)	-0.02 (-0.93)	0.04 (2.30)	0.03 (1.85)	0.07 (2.39)
Age					
A2	0.04 (0.46)	0.10 (2.52)	0.03 (0.66)	0.01 (0.17)	0.11 (1.65)
A3	0.11 (1.17)	0.03 (0.71)	0.00 (-)	0.02 (0.39)	0.09 (1.36)
A4	0.03 (0.38)	0.07 (1.76)	0.02 (0.57)	0.02 (0.38)	0.11 (1.81)
A5	0.03 (-0.39)	0.08 (2.14)	-0.03 (-0.81)	0.13 (3.14)	0.15 (2.41)
Birthplace					
B1	0.02 (0.22)	-0.07 (-1.31)	0.16 (3.00)	-0.01 (-0.28)	0.11 (1.29)
B2	-0.08 (-0.60)	-0.15 (-2.57)	0.16 (2.65)	0.04 (-0.60)	0.07 (0.71)
B3	-0.13 (-0.78)	0.07 (-0.96)	0.17 (2.01)	-0.05 (-0.67)	0.22 (1.76)
B4	0.03 (0.19)	0.02 (0.29)	0.20 (2.40)	0.05 (0.62)	-0.15 (-1.16)
B5	0.09 (0.68)	-0.05 (-0.79)	0.19 (2.84)	0.01 (0.13)	0.22 (2.18)
Occupation					
C1	0.11 (1.60)	-0.02 (-0.55)	-0.04 (-1.27)	0.01 (0.32)	0.38 (0.07)
C2	0.19 (2.29)	0.01 (0.17)	-0.02 (-0.57)	0.01 (0.27)	0.06 (0.99)
C3	0.07 (0.79)	-0.03 (-0.62)	-0.06 (-1.47)	-0.01 (-0.25)	0.12 (1.87)
C4	-0.22 (-2.91)	-0.01 (-0.26)	-0.02 (-0.61)	0.03 (0.98)	0.06 (1.08)
C5	0.02 (0.21)	0.00 (-)	-0.02 (-0.41)	-0.04 (-1.03)	-0.12 (-1.79)
Time and place					
T1: Sydney 1964	-0.41 (-2.07)	-0.19 (-2.14)	-0.50 (-5.20)	-0.37 (-4.02)	-1.45 (-10.03)
T2: Melbourne 1967	-0.08 (-0.39)	0.32 (3.52)	0.03 (0.27)	-0.25 (-2.72)	-1.52 (-10.43)
T3: Sydney 1984	0.18 (2.97)	-0.06 (-2.20)	0.32 (10.80)	0.01 (0.49)	0.28 (6.22)
$\bar{R}^2$	0.05	0.14	0.21	0.05	0.47

Figures in parentheses are t-statistics.

TABLE 4

Coefficients of Price (Quality) Equations for Lamb Categories

Regressor	High quality	Low quality
	$/kg	$/kg
Intercept	2.98 (26.58)	2.74 (31.05)
Log household size	-0.04 (-1.20)	-0.06 (-2.17)
Log income	0.05 (1.92)	0.03 (1.27)
Age		
A2	0.00 (-)	0.04 (0.83)
A3	-0.03 (-0.41)	0.04 (0.84)
A4	0.02 (0.27)	0.01 (0.14)
A5	0.02 (0.42)	0.07 (1.40)
Birthplace		
B1	0.17 (2.28)	0.05 (0.81)
B2	0.19 (2.18)	0.03 (0.48)
B3	0.16 (1.38)	0.00 (-)
B4	0.17 (1.43)	0.02 (0.23)
B5	0.26 (2.75)	0.03 (0.44)
Occupation		
C1	-0.04 (-0.81)	0.03 (0.82)
C2	-0.05 (-0.80)	0.01 (0.17)
C3	0.02 (0.29)	-0.03 (-0.64)
C4	0.04 (0.83)	0.02 (0.49)
C5	-0.11 (-1.72)	0.02 (0.31)
Time and place		
T1	-0.22 (-1.65)	-0.15 (-1.45)
T2	-0.31 (-2.26)	0.07 (0.68)
T3	-0.10 (-2.44)	-0.16 (-4.69)
$\bar{R}^2$	0.02	0.06

Figures in parentheses are t-statistics.

Only data from the 1964 and 1984 surveys were used to estimate the quantity equations. As the 1967 survey was undertaken over a week rather than a fortnight, the purchase probabilities obtained from it are not consistent with those from the other surveys.

To assess the importance of price and the extent of commodity heterogeneity and to compute price elasticities, three regressions were run for each quality category, with - respectively - real prices, quality-adjusted prices and no prices. Similar regressions were run for the aggregate commodities, beef and veal and lamb.

The preferred functional form, chosen on the basis of $\bar{R}^2$ values, was a fully linear specification including the hypothesised principal determinants of household meat demand, namely numbers of adults and children and income. These household size variables could not enter the specification in log form because of zero values for number of children. A linear specification of income consistently produced higher $\bar{R}^2$ values, for each quality category, than did a log specification. Dummy variables were again included for age, ethnic origin and occupation and for periods and cities.

Results

Effects on the quality component of price

The regression estimates of each quality category for the price (quality) equations are shown in Table 3 for beef and veal and Table 4 for lamb. Note that the coefficients are measures of the price paid - and hence quality chosen within each meat category. For example, an increase in family size would be expected to have a negative effect on the quality of a commodity chosen by a household, and therefore on the price paid for it. Family size has this expected negative effect on the prices paid for beef cuts in the high and low categories, but no statistically significant effect on the prices paid for medium and very low quality beef or for veal. For lamb, household size has a negative effect on prices paid for cuts in the low quality category but not in the high quality category.

A household would be expected to react to an increase in its income by purchasing a higher quality commodity, thereby paying a higher price. Household income has a positive effect on the prices paid for all beef and veal categories except medium quality beef. It has a positive effect on the price paid for high quality lamb but not on that for low quality lamb. Thus, quality elasticities with respect to income are significantly different from zero for all categories except medium quality beef and low quality lamb.

The influence of demographic factors on prices paid would be expected to vary between meat categories, but no a priori expectations were held as to the direction of their effects. Occupation of the household head has a significant effect on price only for high quality beef and high quality lamb. Consumers in the clerical occupation group pay more for high quality beef, while those in the skilled tradespersons group pay less for cuts in that category. Households of production process workers pay less for high quality lamb.

Increasing age of housekeeper has the effect of increasing the average price paid for medium quality beef; in addition, elderly housekeepers pay higher prices for both very low quality beef and low quality lamb.

Households whose household heads were born in Europe, New Zealand, the United States, Australia or Canada pay more for low quality beef than others do. Those with household heads from southern or northern Europe pay more for veal; those from the United Kingdom or Ireland pay less for medium quality beef. Households with household heads from Australia, the United States, New Zealand, Canada, the United Kingdom, Ireland or eastern Europe pay more for high quality lamb.

When the effects of the quality factors discussed above were removed, the real prices of high quality, low quality and very low quality beef and of veal were seen to have risen between the 1960s and 1984. (Note that the time effects were re-estimated, and are therefore not those shown in the tables.) The real price of medium quality beef was higher in 1967 than in 1964 or 1984. In contrast to beef and veal, the real price of lamb was not found to have increased between the 1960s and 1984, though that of low quality lamb was higher in 1967 than in 1964 or 1984. These results must be qualified, in view of the differences in survey methods and weighting systems employed with the different surveys. Also, these results are not necessarily comparable with those from studies using total commodity carcass weight measures of real price (Bartley, Ball and Weeks 1987). For example,

there has been an increase in bulk buying of lamb over the time period, which has reduced its average price.

In general, based on the $\bar{R}^2$ values, price is poorly explained. The exception is the veal category. This result is consistent with the finding of Cox and Wohlgenant (1986) that US vegetable prices are poorly explained by quality factors.

Factors affecting demand

Three sets of regressions were run to explain quantity of each category consumed (per household), respectively including in the equation unadjusted prices and quality-adjusted prices and excluding prices. F statistics for testing the hypothesis that prices have no effect on quantity demanded are shown in Table 5. The test statistics indicate that all specifications with prices are superior to those without. The differences between the estimates from the equations with unadjusted prices and those with quality-adjusted prices indicate that the bias resulting from using unadjusted prices is substantial. As an illustration, the estimates obtained using unadjusted prices suggest that high quality beef is an inferior good - a result that is not obtained using quality-adjusted prices. The strong bias involved with unadjusted prices suggests that there is a high level of heterogeneity in the commodity groups. For this reason the subsequent discussion will refer only to the results from the regressions with quality-adjusted prices, which are given in Tables 6 and 7.

In all quality categories the coefficient of own price is negative, indicating that price influences demand for all quality categories of beef and veal and lamb. Some cross-price effects are observed in the veal and medium and low quality beef categories, but not between the categories of lamb.

No a priori views were held on the effects of additional adults and children on the quantity consumed of different quality categories. The results suggest that these factors do have different effects on individual categories but are of minor importance. The only statistically significant

TABLE 5

Test of Hypothesis that Prices have no Effect on Quantity Demanded

Meat category	F statistic	
	Unadjusted prices	Quality-adjusted prices
High quality beef(a)	12.4	10.8
Medium quality beef(a)	10.4	9.7
Low quality beef(a)	12.2	13.0
Very low quality beef(a)	18.0	17.7
Veal(a)	18.4	16.8
High quality lamb(b)	30.4	30.6
Low quality lamb(b)	17.6	17.7

(a) Test statistic is distributed $F_{5,1509}$; $F_{5,1509}(0.05) = 2.21$. (b) Test statistic is distributed $F_{2,1085}$; $F_{2,1085}(0.05) = 3.00$.

TABLE 6

Coefficients of Quantity Equations for Beef and Veal Categories(a)

Regressor	High quality beef	Medium quality beef	Low quality beef	Very low quality beef	Veal
	g/fortnight	g/fortnight	g/fortnight	g/fortnight	g/fortnight
Intercept	3 271 (0.70)	3 471 (1.09)	-865 (0.29)	9 123 (2.32)	23 980 (2.65)
Price					
HB	-15 (-2.37)	9 (0.06)	29 (0.37)	-5 (-0.04)	-233 (-1.24)
MB	-79 (0.40)	-406 (-3.08)	93 (0.71)	-64 (-0.38)	-95 (-0.26)
LB	-109 (-0.61)	31 (1.66)	-335 (-5.29)	-234 (-2.17)	-540 (-1.65)
VB	-152 (-0.53)	-146 (-0.95)	-214 (1.26)	-796 (-3.63)	-917 (-2.08)
V	-3 (-0.14)	-44 (-1.10)	-54 (-1.51)	-11 (-0.42)	-392 (-4.06)
Adults	141 (1.56)	112 (0.75)	256 (1.59)	-86 (-0.35)	-176 (-0.95)
Children	254 (1.50)	59 (0.58)	75 (0.91)	-112 (-0.61)	161 (0.91)
Income	2.6 (0.64)	1.8 (1.20)	0.2 (0.07)	1.0 (0.59)	-0.6 (-0.15)
Age					
A2	-203 (-0.35)	521 (1.65)	259 (0.62)	-1 093 (-1.73)	-1 427 (-2.02)
A3	-221 (-0.36)	622 (1.67)	894 (1.96)	-1 038 (-1.55)	-1 109 (-1.42)
A4	23 (0.03)	559 (1.94)	656 (1.13)	-788 (-1.38)	-2 005 (-1.83)
A5	-63 (-0.12)	334 (1.17)	336 (0.76)	-1 365 (-2.37)	-780 (-1.08)
Birthplace					
B1	-359 (-0.63)	-662 (-1.62)	611 (1.98)	-1 121 (-1.19)	-2 282 (-1.58)
B2	-462 (-1.29)	-1 062 (-2.41)	461 (1.32)	-739 (-1.07)	639 (0.51)
B3	-721 (-1.59)	145 (0.21)	-573 (-1.02)	-1 325 (-1.26)	-1 363 (-0.79)
B4	-675 (-1.63)	93 (0.14)	96 (0.19)	917 (1.61)	-6 965 (-1.87)
B5	46 (0.13)	-32 (-0.07)	-397 (-0.52)	-170 (-0.34)	-2 079 (-0.94)
Occupation					
C1	15 (0.08)	-315 (-1.19)	-518 (-1.00)	-215 (-0.99)	-1 486 (-1.98)
C2	-163 (-0.52)	-103 (-0.38)	-343 (-0.76)	-19 (-0.09)	814 (1.22)
C3	388 (1.96)	-181 (-0.64)	129 (0.55)	-489 (-2.33)	1 164 (1.43)
C4	583 (0.88)	198 (0.66)	476 (1.70)	-243 (-1.08)	-1 643 (-1.79)
C5	146 (0.31)	-65 (-0.20)	-456 (-1.06)	-329 (-1.26)	1 834 (2.50)
Time and place					
T3: Sydney 1984	573 (3.09)	760 (1.15)	404 (1.03)	333 (1.52)	1 608 (2.60)
T4: Melbourne 1984	598 (2.19)	984 (1.46)	477 (1.85)	808 (2.15)	1 388 (1.80)
$\bar{R}^2$	0.20	0.24	0.28	0.19	0.29

(a) Using quality-adjusted prices. Figures in parentheses are t-statistics.

result of this kind is that additional adults in a household add to the quantity of high quality lamb consumed.

As in the price equations, the effects of demographic factors on quantity demanded would be expected to differ between quality categories. Occupation of the household head affects the quantity consumed of all quality categories except medium quality beef. Households with a household head in the sales and service occupation group buy more high quality beef

TABLE 7

Coefficients of Quantity Equations for Lamb Categories(a)

Regressor	High quality	Low quality
	g/fortnight	g/fortnight
Intercept	-1 988 (-0.48)	5 393 (2.17)
Price		
HL	-266 (-3.16)	45 (0.57)
LL	-8 (-0.05)	-455 (-4.85)
Adults	276 (4.14)	61 (0.40)
Children	87 (0.72)	94 (0.80)
Income	5.1 (1.75)	-2.0 (-1.05)
Age		
A2	444 (0.62)	-192 (-0.75)
A3	658 (0.94)	125 (0.37)
A4	585 (0.83)	-80 (-0.20)
A5	827 (0.93)	-418 (-0.86)
Birthplace		
B1	558 (0.56)	-468 (-1.02)
B2	193 (0.32)	-679 (-1.40)
B3	-183 (-0.32)	107 (0.12)
B4	-1 636 (-1.48)	457 (0.61)
B5	881 (1.86)	-415 (-0.88)
Occupation		
C1	-362 (-1.84)	-611 (-2.63)
C2	246 (0.99)	126 (0.61)
C3	-317 (-1.49)	-194 (-0.78)
C4	-39 (-0.19)	-138 (-0.56)
C5	838 (1.93)	-177 (-0.58)
Time and place		
T3	408 (1.24)	806 (1.35)
T4	406 (1.41)	313 (1.05)
$\bar{R}^2$	0.26	0.25

(a) Using quality adjusted prices. Figures in parentheses are t-statistics.

than other occupation groups but less very low quality beef. Households of skilled tradespersons consume more low quality beef than others, but - together with those of professional, technical, administrative and management personnel - consume less veal. Households of production process workers consume more veal than those of other occupation groups. Households of professional, technical, administrative and management personnel consume less lamb - of both high and low quality - relative to other occupation groups, while those of production process workers consume more high quality lamb.

Age of the housekeeper is an important influence on a households' consumption of beef and veal. Households with a housekeeper in the age group 25 - 59 consume more medium quality beef than those with a younger or older housekeeper. Households with a housekeeper in the age group 25 - 34 or over 60 consume less very low quality beef than other households. Those with a housekeeper in the age groups 25 - 34 or 45 - 59 consume less veal, and

those with a housekeeper in the age group 35 - 44 more low quality beef, relative to other age groups.

The birthplace of the household head has a significant effect on the consumption of all quality categories except low quality lamb. Households with a household head born in eastern Europe consume less high quality beef and veal than others, but more very low quality beef. Households with a household head born in Australia, New Zealand, Canada or the United States consume more low quality beef than other households, while households with a household head from the United Kingdom or Ireland consume less medium quality beef than others. Those with a household head born in southern Europe consume more high quality lamb than other households.

Removing the effects of changes in real prices, real incomes and demographic factors, it was found that the quantities of high quality beef and of veal demanded increased between the 1960s and 1984. (Again, these are re-estimation results, not shown in the tables.) In 1984, the demand for both l y and very low quality beef was higher in Melbourne than in Sydney. For both the lamb categories there has been a significant increase in the quantity demanded between the 1960s and 1984. These results, again, need to be qualified because of differences in the survey methods and weighting systems employed in the different surveys.

Elasticities

The own-price elasticities are shown in Table 8. For comparison, UK price elasticities obtained from a cross-sectional time-series study over the period 1977-1984 are also shown (Meat and Livestock Commission 1987). The UK study found all beef and veal and lamb cuts to be price-elastic, whereas here only medium quality beef, very low quality beef and veal are price-elastic. These results are consistent with the fewness of significant cross-price elasticities. It would be expected that if the cuts in different quality categories were close substitutes then price elasticities would be high. The high price elasticities reported in the UK study imply that meat cuts are close substitutes there - a result that does not appear to hold in Australia. The results from the present study indicate that a price rise will cause fewer households to move away from the high quality cuts of beef and from lamb of either category than from the lower quality cuts of beef and from veal.

Low quality beef is seen to be a substitute for medium quality beef, with a cross-price elasticity of 0.8. Low quality beef is complementary with very low quality beef, with a cross-price elasticity of -0.55, while both are substitutes for veal, with cross-price elasticities of 1.5 and 1.9 respectively.

Estimates of the quality elasticities with respect to income, shown in Table 9, range from 0.016 to zero, a change in household income having the greatest effect on the price of high quality beef followed by high quality lamb, veal, very low and low quality beef. It is not unexpected that high quality beef and lamb should have higher income elasticities than veal, as the veal category includes a wide range of cuts. The difference between the elasticities of very low and low quality beef is not statistically significant.

The estimated income elasticities are small, and are not statistically significant with the exception of that for high quality lamb which is 0.12. This may be due to measurement error involved in using gross weekly

TABLE 8

Own-price Elasticities

Meat category	Elasticity
Present study	
High quality beef	-0.54
Medium quality beef	-1.09
Low quality beef	-0.91
Very low quality beef	-1.42
Veal	-1.40
High quality lamb	-0.59
Low quality lamb	-0.57
United Kingdom(a)	
Beef	
roasting first quality	-3.05
roasting second quality	-2.83
stewing first quality	-5.81
mince	-2.72
freezer (purchased fresh)	-3.56
freezer (purchased frozen)	-3.83
Lamb	
roasting (excl. shoulder)	-4.09
chops	-3.18
shoulder	-5.16
stewing	-1.39
freezer (purchased fresh)	-4.95
freezer (purchased frozen)	-4.25

(a) Meat and Livestock Commission (1987).

TABLE 9

Quality Elasticities with Respect to Income(a)

Meat category	Elasticity
High quality beef	0.016
Medium quality beef	ns
Low quality beef	0.011
Very low quality beef	0.012
Veal	0.014
High quality lamb	0.015
Low quality lamb	ns

(a) Quality elasticities are calculated as b^*/p^*, where b_i is the coefficient of the log income term in the price equation and p^* is the mean of price. ns, not significantly different from zero.

household income as a proxy for disposable income, which is likely to bias the relevant coefficients downward.

Conclusions

This study has demonstrated that, using disaggregated cross-sectional time-series data, the factors affecting demand for red meat can be analysed more deeply than is possible with aggregate apparent consumption data. The significant differences between the estimates obtained using quality-adjusted price data and unadjusted price data suggest that beef and veal and lamb are highly heterogeneous. Inferences drawn from studies that treat these meats as homogeneous commodities with single prices may be only very general because of the problems inherent in aggregation.

There is no evidence to suggest that, when prices, incomes and the demographic factors included in this study are held constant, demand for red meat has fallen over the period 1964 to 1984 in any of the quality categories considered. However, per capita apparent consumption of beef declined from 49.5 kg in 1964 to 41.1 kg in 1984 (BAE data). This implies that changes in prices, incomes and, to a minor extent, demographic factors underlie this decline in consumption. This result is consistent with results obtained using apparent consumption data (Martin and Porter 1985). The analysis has shown that quality-adjusted real prices have increased significantly over the period, so increases in real price will be a major factor behind the decline. (These results, however, require qualification as the time variable also captures the differences in survey methods and weighting procedures.)

Quality trade-offs have occurred over the period. This is demonstrated by the non-negative quality elasticities for all categories. Higher price elasticities for the lower quality cuts, together with an increase in real prices over the period, also help to account for the movement away from low quality cuts. It cannot be concluded that quality/quantity trade-offs have occurred between quality categories over the period. The insignificant income coefficients suggest there has not been a trade-off of quality for quantity because, with real incomes increasing over the period, there is no suggestion that consumers adjust the quantity they consume of a particular meat category in response to an increase in income. (These results are consistent with the findings of McShane 1973.) The smallness of the measured income effects may, however, be due to measurement error involved in using gross weekly household income as a proxy for disposable income. Changing demographic factors over the period, such as reductions in family size, have also led to an increase in the quality of meat consumed.

Demands for increased quality within particular categories appear to have very low income elasticities. This may suggest that, as incomes rise, consumers do not demand a great deal of additional services with particular cuts of meat.

Other demographic factors, such as age, occupation and ethnic origin, have been shown to have varying effects on the demands for the different quality categories. These effects are of minor importance in their absolute influence on demand, when considered relative to price effects.

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