Australian Journal of Agricultural Economics, Vol. 23, No. 3 (December 1979), pp. 220-230.

THE DEMAND FOR MEAT — AN EXAMPLE OF AN INCOMPLETE COMMODITY DEMAND SYSTEM*

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Equations describing the demand for beef and veal, mutton, lamb, pork and chicken are estimated using the full information maximum likelihood estimator. Elasticity estimates are presented and the double logarithmic model is compared with a demand system which is derived from the indirect translog utility function. Estimates of the direct price and income elasticities are not particularly sensitive to model specification but the estimated cross-price elasticities are sensitive to the choice of functional form. The results indicate that the double logarithmic specification may be less satisfactory than the alternative presented in cases where restrictions on the parameters are imposed during estimation.

Introduction

Generally speaking, agricultural economists have specified demand functions in a pragmatic way. In the case of the demand for meat, most of the work done in Australia has been on a commodity by commodity basis using a single equations approach.[1] Main et al. (1976), in their study of the demand for beef, mutton, lamb and pork, used a system of seemingly unrelated regression equations but did not explicitly use any of the useful restrictions from the theory of demand in the estimation of their system.

One of the major problems associated with estimating a series of equations to describe the demand for the various types of meats is that the prices of commodities such as mutton and lamb are highly correlated. For example, Main et al. (p. 202) noted that the correlation between the prices of mutton and lamb in the data employed in their study was 0.87. One way of alleviating the effect of this correlation on parameter estimates is to impose some restrictions on the parameters during estimation. In the case of a system of demand equations, one set of restrictions which may be imposed are those which follow from utility theory. The aim of this study was to estimate the parameters of two different systems of demand equations for meat, making use of some *a priori* constraints on the estimated coefficients. The systems examined are the familiar double logarithmic formulation and a modified version of the indirect translog demand system.

Some Implications of Utility Maximisation

The models presented in this paper have been developed within a static framework. The maximisation of a static utility function subject

[1] One exception is the work by Reynolds (1978).

* This is a revised version of a paper presented at the 23rd Annual Conference of the Australian Agricultural Economics Society, Canberra, February 1979. Helpful comments by Keith Campbell, Russ Reynolds and the *Journal* referees are gratefully acknowledged.

to a budget constraint leads to a number of important restrictions on the parameters in a demand system. One of three approaches can be followed. If a utility function is specified, then all the relevant restrictions can be inferred from the solution of the maximisation problem. The second possible approach is to specify an indirect utility function, that is, a relationship which specifies utility as a function of prices and expenditure, and then to derive the related demand system using Roy's identity (see Phlips 1974, p. 29). Finally, the demand system itself may be specified directly with relevant theoretical restrictions added. The direct approach has the major drawback that the nature of the underlying utility function is not immediately obvious from the form of the demand system itself. In using the double logarithmic formulation the third approach is adopted. The main reason for testing the double logarithmic form is its popularity among agricultural economists.

The three basic sets of restrictions on the parameters of a demand system which can be established from the solution of a utility maximisation problem are the homogeneity restriction, the Slutsky symmetry condition and Engel aggregation. A full discussion of these restrictions can be found in Phlips (1974). Because the demand systems discussed in the present paper are incomplete in the sense that they do not contain a full set of commodities, the Engel aggregation restriction does not apply and is not discussed further.[2]

The homogeneity condition states that the demand system is homogeneous of degree zero in prices and income (or expenditure). This is equivalent to saying that consumers do not suffer from money illusion. In terms of elasticities, the restriction implies that

(1) $\Sigma_j \eta_{ij} = -\mu_i;\ j = 1, ..., K$

where η_{ii} = direct price elasticity of demand,
η_{ij} = cross price elasticity of demand,
μ_i = income elasticity of demand, and
K = number of goods in the system.

The Slutsky equation decomposes a price change into its substitution and income effects. Slutsky established the relationship

(2) $\partial q_i/\partial p_j = k_{ij} - q_j\, \partial q_i/\partial y$

where k_{ij} is the substitution effect and q, p, and y represent quantity, price and income, respectively. The substitution effect of a price change is symmetrical, that is, $k_{ij} = k_{ji}$. However, because of the income effect, the cross-price elasticities, η_{ij} and η_{ji}, are not symmetrical. Re-expressing equation (2) in elasticity form and noting that the substitution effect is symmetrical gives

(3) $\eta_{ij} = \eta_{ji} w_j/w_i + w_j\,(\mu_j - \mu_i)$

where w_i and w_j are the relative budget shares of goods i and j. The symmetry condition implies that there is some consistency in consumer behaviour between commodities. An approximation to the symmetry relation is often used in empirical work. If it can be assumed that the

[2] For a system in which y is defined as total expenditure, the Engel aggregation restriction requires that $\Sigma_i w_i \mu_i = 1$. A further restriction, the Cournot aggregation condition, holds if the other restrictions are satisfied. The Cournot aggregation restriction requires that $\Sigma_i w_i \eta_{ij} = -w_j$. For cases such as those considered in the present paper, where not all goods are defined and where disposable income is substituted for total expenditure, the aggregation conditions do not hold.

income elasticities for goods i and j are approximately equal or that the expenditure share, w_j, is close to zero, then the term to the right of the plus sign in equation (3) can be deleted. The resulting equation is known as the Hotelling-Jureen relationship.

The homogeneity condition provides K restrictions on the parameters. The number of restrictions implied by the symmetry condition is $K(K - 1)/2$ and, together, homogeneity and symmetry imply a total of $(K^2 + K)/2$ restrictions on the parameters of the system.

Extra restrictions on the parameters of demand systems result from the specific form of the utility function. For example, a common assumption in the case where broad groups of goods are being studied is that the utility function is additive, that is, that the utility provided by the consumption of one good is independent of the consumption of any other good. This particular assumption implies that the cross-price derivatives are proportional to the income derivatives (see Phlips 1974, pp. 60-2). Additivity is not a particularly sensible restriction to impose in the case of a study of the demand for meat because the marginal utility associated with the consumption of one type of meat is likely to be affected by the quantities of other meats consumed. However, if the theory of demand is valid and the demand functions are double logarithmic, then the underlying utility function is linear logarithmic and therefore additive (see Christensen et al. 1975, p. 367). Fortunately, a full set of interactions can be allowed for in a double-logarithmic demand system if the restrictions are enforced at the sample means rather than globally. However, this case illustrates the dangers involved in specifying demand systems directly without reference to utility theory.

The Demand for Meat

In the present study, the demand system consists of five relationships describing the aggregate demand in Australia for beef and veal, mutton, lamb, pork and chicken. The basic specification of the model may be written compactly as

$$(4) \qquad Q' = \Pi X' + V'$$

where

Q' = g:t matrix of t observations on each of g endogenous quantity variables;

X' = g+5 : t matrix of observations on the prices of beef and veal, mutton, lamb, pork, chicken and food other than meat, income and three additive seasonal dummy variables;

Π = a matrix of parameters to be estimated; and

V' = g:t matrix of disturbances.

The quantity variables were expressed in terms of quantities consumed per head. Demand theory deals with individual consumers and, because of the aggregation problem, the implications of the theory do not carry over exactly to aggregate demand functions. However, the only practical way of overcoming this problem is to think of the consumption per head as representing demand by a representative consumer whose behaviour is described by the theory. Hicks (1956, p. 55) has noted that:

> The statistical information on consumers' behaviour, which is available to us, always relates to the behaviour of groups of individuals — such, for instance, as the consumers of a particular commodity in a particular region. It is always material of this character which we have to test; and indeed it is material of this kind which we want to test, for the preference hypothesis only acquires a *prima facie* plausibility when it is applied to a statistical average. To assume that the representative consumer acts like an ideal consumer is a hypothesis worth testing; to assume that an actual person, the Mr. Brown or Mr. Jones who lives round the corner, does in fact act in such a way does not deserve a moment's consideration.

In taking this position, errors due to aggregation are accepted. However, Houthakker and Taylor (1970, p. 200) have commented that, in their opinion, 'of all the errors likely to be made in demand analysis, the aggregation error is the least troublesome'.

It was assumed that the quantity variables were endogenous and that the prices at retail were predetermined. Main et al. (1976, p. 198) have suggested a number of reasons why they believe this to be a reasonable assumption. Among these reasons is the suggestion that, because of price levelling and averaging by retailers, consumers face prices which fluctuate much less than saleyard prices. However, quantities coming into the market may have some effect on retail prices and, therefore, the estimates of the parameters in the models presented may contain some simultaneous equations bias.

Data

The data comprise 62 quarterly observations for the period 1962(1) to 1977(2). Apparent consumption of each type of meat in each quarter was calculated by subtracting exports and changes in stocks from production. Production statistics are published in *The Meat Industry Australia* by the Australian Bureau of Statistics (ABS). Retail prices of various cuts of meat prevailing in Australian capital cities are published in *Average Retail Prices of Selected Food Items* (ABS). Weighted prices were obtained by applying the weights used in the construction of the consumer price indexes. The price series for food other than meat was derived using the meat price indexes and the index of the price of food which is used as part of the overall consumer price index. A detailed description of the data base can be found in Main et al. (1976) or Reynolds (1978).[3]

Estimation of the double logarithmic model

It was assumed that the disturbances were from a multivariate normal error structure and estimates were derived using the full information maximum likelihood procedure. The restrictions on the parameters were imposed explicitly at the time of estimation.[4] In the case of the double logarithmic model, the equations are homogeneous of degree zero in prices and income if the restriction given in equation (1) is applied directly to the coefficients on the nominal prices and income. The symmetry restriction (3) was applied in the case of the double logarithmic model. Measures of the goodness-of-fit of the equations

[3] The greater proportion of the data used in the present study was compiled by Russ Reynolds of the Bureau of Agricultural Economics.

[4] The model was estimated using the Wymer (1977*a*) RESIMUL package.

and the system were obtained using the statistics developed by Carter and Nagar (1977).[5] Tests for serial correlation among the errors were conducted equation by equation using the estimated correlogram.

The estimates of the parameters of the model are shown in Table 1. Because of the form of the model, the estimated coefficients may be interpreted as elasticities. Inspection of Table 1 shows that the coefficients on the chicken price variable in the mutton and lamb equations are relatively small compared to their estimated standard errors. Apart from this, there was evidence of autocorrelation within two equations in the double logarithmic system. When compared with the approximate standard errors, the first-order autocorrelation coefficients for the pork and chicken equations were large. However, there was no evidence of higher order serial correlation. The autocorrelation may have been due to one of a number of forms of misspecification or measurement error. The serial correlation among the residuals from the chicken equation was probably due largely to measurement error. The first 20 quarterly observations in the poultry consumption series were estimated from annual data by imposing the average seasonal pattern estimated for the data from later years.

Because the autocorrelation was probably due to errors in the data, a statistical method of correcting the problem was sought. A general procedure that may be used to fit a first-order autoregressive process to the disturbances in a simultaneous equations model and to test for the presence of autocorrelation has been outlined by Hendry (1971) and employed by Moffatt and Ryland (1978). For their model, Moffatt and Ryland assumed that the disturbances were generated by the process[6]

$$(5) \qquad V' = RV_1' + U'$$

where R = g:g matrix of autocorrelation coefficients, and
U′ = g:t matrix of serially uncorrelated disturbances.

Combining equations of the form (4) and (5) results in an autoregressive model of the form

$$(6) \qquad Q' = RQ_1' + \Pi X' - R\Pi X_1' + U'$$

In the case of the meat model, it was not feasible to fit the system represented by equation (6) because the transformation added a further 25 parameters to the system. Because the autocorrelation appeared to be confined to the pork and chicken equations (the fourth and fifth equations), it was assumed that the matrix, R, contained zero elements everywhere except for the values r_{44} and r_{55} in the leading diagonal. The resulting model was estimated excluding those variables whose coefficients were smaller than their respective asymptotic standard errors. The results are presented in Table 2. The estimates of the autocorrelation coefficients were 0.59 and 0.99 for the pork and chicken equations, respectively. The revised estimate of the income elasticity for chicken is more consistent with expectations than the original coefficient. However, the results suggest that there are no significant cross-price effects between chicken and the other meats. It is unlikely

[5] Thanks are due to George Ryland, who provided the computer program for the calculation of these statistics.

[6] A subscript k on V_k' indicates that the order of lag on the vector is k.

TABLE 1

The Demand for Meat: Estimates of the Complete Set of Elasticities Using the Double Logarithmic Model[a]

	Dependent variable				
	q_B	q_M	q_L	q_P	q_C
p_B	−1.27 (11.29)	0.84 (2.55)	0.64 (5.57)	0.90 (4.73)	0.73 (4.89)
p_M	0.12 (2.31)	−1.45 (3.48)	0.37 (2.14)	−0.25 (1.08)	−0.09 (0.55)
p_L	0.19 (5.38)	0.72 (2.20)	−1.76 (10.01)	0.28 (1.29)	−0.06 (0.43)
p_P	0.13 (4.64)	−0.22 (1.04)	0.13 (1.29)	−1.26 (5.27)	−0.28 (2.41)
p_C	0.11 (5.10)	−0.07 (0.45)	−0.02 (0.31)	−0.27 (2.34)	−0.64 (5.82)
p_{OF}	0.20 (1.67)	1.55 (3.46)	0.59 (3.19)	0.51 (1.45)	−1.08 (4.08)
y	0.52 (9.27)	−1.37 (9.17)	0.05 (1.00)	0.09 (1.09)	1.42 (22.21)
D_1	0.14 (3.76)	−0.52 (6.76)	−0.08 (3.62)	0.14 (3.93)	0.27 (8.98)
D_2	0.31 (8.01)	−0.57 (6.73)	−0.03 (1.39)	0.20 (5.01)	0.43 (13.19)
D_3	0.14 (3.88)	−0.36 (4.85)	0.00 (0.14)	0.13 (3.80)	0.20 (7.03)
Constant	1.94	2.66	1.47	0.31	−1.45
R^2	0.83	0.86	0.92	0.83	0.97
R^2 (System)					0.92

[a] Numbers in parentheses are asymptotic t values. The subscripts $_B$, $_M$, $_L$, $_P$, $_C$, and $_{OF}$ represent beef, mutton, lamb, pork, chicken and food other than meat, respectively. D_1, D_2 and D_3 are additive seasonal dummy variables.

that this is actually the case. It is possible that this effect is due to the restrictive nature of the double logarithmic specification. In an attempt to overcome this problem, a more flexible functional form was tested.

An alternative functional form

A general form for both the utility function and the indirect utility function has been suggested by Christensen, Jorgensen and Lau (1975). Their indirect translog utility function leads to a demand system of the following form.

$$p_i q_i / y = \frac{\alpha_i - \Sigma_j \beta_{ij} \ln (p_j/y)}{\Sigma_k \alpha_k + \Sigma_k \Sigma_j \beta_{kj} \ln (p_j/y)} \tag{7}$$

An attempt was made to estimate the model represented by equation (7) in its nonlinear form. The Wymer (1977*b*) package ASIMUL, which calculates pseudo full information maximum likelihood estimates of a general nonlinear system of equations, was used in an effort to obtain estimates of the parameters. Unfortunately, the nonlinear system

TABLE 2

The Demand for Meat: Estimates of Elasticities from the Double Logarithmic Model Corrected for Autocorrelation[a]

	Dependent variable				
	q_B	q_M	q_L	q_P	q_C
p_B	—1.32 (12.12)	0.96 (3.06)	0.72 (8.79)	1.13 (5.80)	
p_M	0.14 (2.81)	—1.17 (2.97)	0.23 (1.58)	—0.70 (2.72)	
p_L	0.21 (8.55)	0.46 (1.65)	—1.66 (10.85)	0.78 (3.83)	
p_P	0.16 (5.70)	—0.63 (2.68)	0.37 (3.83)	—1.40 (6.51)	
p_C					—0.16 (4.98)
p_{OF}	0.32 (3.04)	1.83 (5.54)	0.30 (3.04)		
y	0.48 (8.52)	—1.45 (8.45)	0.03 (0.76)	0.20 (1.55)	0.16 (4.98)
D_1	0.13 (3.63)	—0.54 (6.04)	—0.07 (4.64)	0.22 (4.41)	
D_2	0.31 (7.89)	—0.60 (6.11)	—0.04 (2.40)	0.20 (4.29)	0.08 (6.15)
D_3	0.14 (3.78)	—0.32 (3.70)		0.08 (2.47)	0.02 (1.35)
Constant	2.01	2.98	1.34	—0.09	0.00
R^2	0.84	0.84	0.94	0.85	0.99
R^2 (System)					0.97

[a] Numbers in parentheses are asymptotic *t* values.

had to be abandoned before reliable estimates were obtained because the nonlinear system was approximately 50 times more expensive to solve than the linear systems.

The expression on the left-hand side of equation (7) is the budget share of good *i*, w_i. The budget shares must add up to unity in a complete model. The form of the function on the right ensures that the adding up restriction is satisfied. However, in the present study, the adding up restriction is irrelevant and for the purposes of estimation it is convenient to linearise the function by assuming that the denominator on the right-hand side of the expression is equal to unity.

The modified form of equation (7) is homogeneous of degree zero in prices and income. The symmetry restriction implies that $\beta_{ij} = \beta_{ji}$. These restrictions were imposed directly during estimation.

The elasticity estimates from the modified translog model are presented in Table 3. The R^2 values for the beef, mutton, lamb, pork and chicken equations were 0.83, 0.94, 0.95, 0.93 and 0.83, respectively. The system's R^2 was 0.90. First-order autocorrelation again appeared to be a problem in the pork and chicken equations. This was corrected using the same transformation as applied to the double logarithmic model. The resulting estimates are given in Table 4. The R^2 values for the five equations in the autoregressive model were 0.84, 0.93, 0.96, 0.94 and 0.93, respectively. The system's R^2 value was 0.93. The transformation effectively eliminated all of the within-equation autocorrelation.

TABLE 3

Elasticity Estimates from the Modified Translog Model[a]

Product	Elasticity with respect to the price of						Elasticity with respect to income
	Beef	Mutton	Lamb	Pork	Chicken	Other food	
Beef	—1.20 (10.58)		0.11 (4.21)	0.08 (4.40)	0.08 (4.59)	0.36 (2.89)	0.58 (10.07)
Mutton		—1.22 (5.81)	0.59 (2.64)		0.15 (1.46)	1.45 (8.25)	—0.97 (9.72)
Lamb	0.36 (4.21)	0.31 (2.64)	—1.55 (12.50)	0.07 (1.18)	—0.14 (2.71)	0.82 (6.07)	0.14 (4.31)
Pork	0.52 (4.40)		0.14 (1.18)	—1.25 (6.02)	—0.44 (4.46)	0.91 (3.36)	0.11 (1.61)
Chicken	0.57 (4.59)	0.17 (1.46)	—0.30 (2.71)	—0.44 (4.46)	—0.63 (6.04)	—0.85 (3.60)	1.48 (24.45)

[a] Numbers in parentheses are asymptotic t values.

TABLE 4

Elasticity Estimates from the Modified Translog Model Corrected for Autocorrelation[a]

Product	Elasticity with respect to the price of						Elasticity with respect to income
	Beef	Mutton	Lamb	Pork	Chicken	Other food	
Beef	—1.19 (10.68)		0.14 (5.73)	0.14 (6.00)	0.04 (1.38)	0.33 (2.63)	0.54 (9.11)
Mutton		—1.12 (4.96)	0.49 (2.00)	—0.48 (2.56)	0.23 (1.88)	1.69 (7.59)	—0.81 (7.16)
Lamb	0.47 (5.73)	0.25 (2.00)	—1.58 (11.17)	0.33 (3.78)	—0.12 (2.52)	0.56 (4.47)	0.09 (2.52)
Pork	1.00 (6.00)	—0.52 (2.56)	0.70 (3.78)	—0.95 (4.44)	—0.27 (2.70)		0.04 (0.48)
Chicken	0.28 (1.38)	0.27 (1.88)	—0.25 (2.52)	—0.27 (2.70)	—0.23 (2.31)		0.20 (5.70)

[a] Numbers in parentheses are asymptotic t values.

Inspection of Tables 3 and 4 indicates that quite marked changes in the parameter estimates for equations (4) and (5) arose as a result of the correction for autocorrelation. This is particularly the case for the chicken equation where the estimate of the income elasticity fell from 1.48 to 0.20. The new estimate is below the estimate of the income elasticity for beef and veal but above that for the other meats. Both the double logarithmic model and the modified translog model give rise to estimates of the direct price elasticity of the demand for chicken which are much smaller in absolute value than the estimated direct price elasticities for the other meats. This is consistent with the fact that a large quantity of chicken is consumed either as 'fast-food' or on special occasions.

A limited number of the cross-price elasticities obtained from both the double logarithmic and the translog models were negative. Although these effects are contrary to expectations, they are persistent given both changes in specification and estimation procedure. For example, Main et al. (1976) obtained a negative cross-price effect between pork and mutton using quite a different model and estimation procedure. Simultaneous equations bias may have been the reason for at least some of the cross-price elasticities possessing negative signs. It is conceivable, for example, that the quantities of pork and chicken supplied are correlated because both industries rely heavily on one type of feed, namely cereal grains. If this effect is significant, then there would be a tendency for increases in the prices of both commodities, as a result of reductions in supply, to occur together. The effect would be measured in the demand system as negative cross-price elasticities between chicken and pork.

No attempt was made to test the restrictions imposed on the parameters in the demand systems. In the final model specifications, there were two sets of restrictions, one set derived from demand theory and the other set resulting from the autoregression in the error structure. It was not possible to test the hypothesis that the symmetry and homogeneity conditions were consistent with the observations because both sets of restrictions occurred in the model simultaneously.

The advantages in terms of degrees of freedom associated with the use of the restrictions are obvious. For example, an unconstrained version of the double logarithmic model would contain 50 parameters (excluding the constant terms) compared with 35 in the constrained system. However, a completely unconstrained system could be estimated one equation at a time so the degrees of freedom question would not necessarily arise. But, in an unconstrained system, the effects of multicollinearity are likely to be severe, especially when the goods under consideration are closely related. As an illustration of the results that can be obtained using single-equation methods, the ordinary least-squares estimates of the equations from the double logarithmic model are presented in Table 5. (Variables were excluded from the equations if their respective coefficients were not significant at the 90 per cent level.) Inspection of Table 5 shows that all of the direct price elasticity estimates are smaller in absolute value than would be expected, that there are fewer statistically significant cross-price elasticities than were observed in the complete system and that the estimated income elasticity for beef and veal is negative. These inconsistencies are all likely to be due to the effects of a high degree of multicollinearity.

Conclusion

Both the double logarithmic and the modified translog models resulted in similar estimates of the direct price and income elasticity

TABLE 5

The Demand for Meat: OLS Estimates of the Double Logarithmic Model[a]

	Dependent variable				
	q_B	q_M	q_L	q_P	q_C
p_B	−0.85		0.90	0.98	2.03
	(−7.02)		(11.77)	(5.40)	(18.51)
p_M		−0.51			−0.87
		(−2.30)			(−10.66)
p_L			−1.54		
			−18.83)		
p_P		1.19	0.49	−0.75	
		(2.15)	(4.04)	(−6.61)	
p_C		0.42		−0.25	−0.39
		(1.72)		(−2.07)	(−5.70)
p_{OF}	2.03	−4.22	0.32		0.68
	(8.34)	(−4.04)	(1.26)		(4.54)
y	−0.16	0.25	−0.06		0.26
	(−1.26)	(1.24)	(−0.66)		(4.32)
D_1		−0.12	−0.08	0.13	
		(−1.93)	(−4.14)	(3.78)	
D_2	0.09		−0.06	0.19	0.07
	(2.42)		(−2.32)	(5.55)	(3.46)
D_3				0.14	0.05
				(3.99)	(3.33)
Constant	−1.94	13.85	0.75	0.86	−8.49
	(−3.11)	(9.14)	(1.45)	(1.32)	(−18.43)
R^2	0.81	0.85	0.94	0.80	0.99
D.W.	2.39	2.12	1.83	1.11	1.03

[a] Numbers in parentheses are t values.

for the various meats, although the size and significance of the cross-price effects appeared to be dependent on model specification. This result may have occurred because of the restrictive nature of the double logarithmic specification. Although the double logarithmic model is easy to implement, its use may not be justified where a demand system containing closely related goods is estimated subject to the restrictions from the demand theory, even when these restrictions are enforced at the sample means.

References

Carter, R. A. L. and Nagar, A. L. (1977), 'Coefficients of correlation for simultaneous equations systems', *Journal of Econometrics* 6(1), 39-50.

Christensen, L. R., Jorgensen, D. W. and Lau, L. J. (1975), 'Transcendental logarithmic utility functions', *American Economic Review* 65(3), 367-83.

Hendry, D. F. (1971), 'Maximum likelihood estimation of systems of simultaneous regression equations with errors generated by a vector autoregressive process', *International Economic Review* 12(2), 257-72.

Hicks, J. R. (1956), *A Revision of Demand Theory*, Oxford University Press, Oxford.

Houthakker, H. and Taylor, L. D. (1970), *Consumer Demand in the United States 1929-1970*, Harvard University Press, Cambridge, Mass.

Main, G. W., Reynolds, R. G. and White, G. M. (1976), 'Quantity-price relationships in the Australian retail meat market', *Quarterly Review of Agricultural Economics* 29(3), 193-211.

Moffatt, D. J. and Ryland, G. J. (1978), Estimation of commodity demand systems, Paper presented to the Australian Agricultural Economics Society Conference, Sydney, February.

Phlips, L. (1974), *Applied Consumption Analysis*, North Holland, Amsterdam.

Reynolds, R. G. (1978), Retail demand for meats in Australia: a study of the theory and application of consumer demand, M.Ec. thesis, University of New England, Armidale.

Wymer, C. R. (1977*a*), *Computer Programs: RESIMUL Manual*, International Monetary Fund, Washington, D.C.

——— (1977*b*), *Computer Programs: ASIMUL Manual*, International Monetary Fund, Washington, D.C.