A MAIDS Model of Irish Meat Demand

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Abstract: This paper estimates the demand for meats in Ireland using the newly developed *Modified Almost Ideal Demand System* or MAIDS model of Cooper and McLaren (1992). This model nests the Almost Ideal System as a special case and also permits a simple statistical test of neo-classical demand theory. The empirical analysis rejects the Almost Ideal model but the neo-classical regularity conditions on consumer behaviour are not rejected. Own-price responses are highly elastic in all cases save chickenmeat which is found to be completely inelastic. Expenditure elasticties for all meats are estimated to be close to unity .

I INTRODUCTION

T here is a fairly extensive literature on the estimation of consumer demand systems in Ireland (prominent examples include, Madden (1993), Conniffe and Hegarty (1980), O'Riordan (1975, and 1976). These studies were principally concerned with the demand for broad aggregates of goods. An exception is the paper on the demand for alcohol by Thom (1984). To date there are only three published studies on the demand for meats in Ireland (Cowan and Herlihy (1982), Buttimer and O'Neill (1973) and Casey (1973)). These studies are of the traditional single-equation type and hence do not imbed or test the restrictions implied by neo-classical consumer theory. Thus the main motivation for our paper is to estimate for the first time a consumer demand system for Ireland for the principal meats which provides

an estimation framework for invoking the restrictions of neo-classical theory.

A problem which has inflicted many of the consumer demand systems which have been published in Ireland, and indeed elsewhere, is that while they imbed or test many of the restrictions of neo-classical consumer theory such as adding-up, symmetry and homogeneity they do not confront what is perhaps the most important theoretical restriction of the theory, namely, the condition that the consumers' expenditure function be concave in prices. Up to now those demand systems which can readily imbed this restriction (for example, the CES and LES) imply many other restrictions on demand responsiveness which make them undesirable as a modelling apparatus a priori. The AIDS model of Deaton and Muellbauer (1980) is a case in point. This demand system has now almost become *de rigueur* in the analysis of consumer behaviour. Yet as is well known the curvature conditions are only satisfied in the neighbourhood of the point of approximation.[1] In principle it is possible to impose the curvature requirements on the AIDS model in the manner, for example, of Conniffe and Hegarty (1980). However, the procedure is very difficult to implement.

The recent development of the *Modified Almost Ideal Demand System (MAIDS)* by Cooper and McLaren (1992) provides an alternative approach which has considerable appeal. The MAIDS model allows us to determine the adherence to the curvature conditions by using a simple log likelihood test. Moreover, their model implies the AIDS specification can be tested as a special case. Thus another motivation for this paper is to present a estimate of the MAIDS model for meat demand in Ireland which allows us to explicitly determine the adherence to the curvature requirements of utility maximising consumers.

The plan of our paper is as follows. Section II sets out the version of the MAIDS model which we use to estimate the parameters of Irish meat demand. Section III documents the results of the econometric analysis and the various hypothesis tests which were conducted. Section IV sets out the price and expenditure elasticties and Section V concludes the paper.

II A MAIDS MODEL OF IRISH MEAT DEMAND

At least two separability structures suggest themselves in the creation of a demand model for meats. We could invoke the well-known two-stage budgeting assumption (as in Thom (1984)) whereby it is assumed that the

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1.   While we focus on the AIDS\MAIDS model in this paper we do not imply that it is the best practice. There are other modelling approaches which could equally have been considered, for example, the *Rotterdam* system (see Alston and Chalfant (1993) for a comparative test of model performance).

consumer first allocates her expenditure between aggegate meats and "other goods" and then allocates her expenditure on aggregate meats between the different types of meat, namely, beef, sheepmeat, pigmeat and chicken. The demand function for each meat is expressed as a function of individual meat prices and expenditure on meats. The alternative approach is to assume a single-stage allocation of total consumer expenditure between the individual meats and "other" goods. The latter specification is less restrictive in terms of consumer behaviour as two-stage budgeting requires weak-homogenous separability in respective of the meats and other goods. The demand function for each meat under this assumption is written as a function of individual meat prices, the price of "other goods" and *total* consumer expenditure. In the case of our empirical application the latter separability structure is also consistent with the availability of data on Irish meat demand. As we outline in Appendix 1, while we are unable to generate meat expenditures we are able to construct individual meat price indices and total consumer expenditure is published on an annual basis.

The properties of the Deaton and Muellbauer (1980) AIDS model are well known and has been applied extensively in the modelling of meat demand in other countries. The form which is usually estimated is approximately linear and has been termed the *Linear Approximate (LA)* or LA-AIDS model after Blancifirti and Green (1983).[2] While the LA-AIDS model facilities the imposition of many of the restrictions of demand theory, the adherence of empirical demand systems to the monotonicity and especially concavity restrictions — the curvature conditions — of the expenditure function has proved troublesome. As it is not possible to impose the curvature restrictions with a simple restriction on the parameters of the empirical model the usual procedure is to conduct *ex post* tests for non-violation. Such tests are cumbersome to implement especially if they are carried out at each observation. Moreover, they are not statistical tests and the analyst is always left in a quandry when the conditions are "almost" satisfied. The curvature conditions can be imposed *ex ante* on the LA-AIDS model by implementing procedures suggested by, for example, Conniffe and Hegarty (1980), Jorgenson and Fraumeni (1981) and Chalfant, Gray and White (1991). These procedures are, however, difficult to implement. An alternative approach would be to employ a demand system which respected the curvarture conditions over a wider range of prices and expenditure and yet which still preserved all the properties and simplification of the LA-AIDS. Such a model has recently been proposed by Cooper and McLaren (1992) which they term the *Modified*-AIDS or MAIDS model. We propose to apply this model in the estimation of Irish

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2. It should be noted that this approach may lead to parameter bias, especially in micro data (Pashardes, 1993).

meat demand. The MAIDS model which we estimate with adding-up, symmetry and homogeneity imposed is given by

$$W_i = \frac{\alpha_i + \sum_j \gamma_{ij} \ln p_j + \beta_i \ln(X/P)}{1 + \beta \ln(X/P)}; \ i, j(i \neq j) = 1, \ldots, n$$

$$\ln P = \sum_i W_i \ln p_i \qquad\qquad\qquad (1)$$

$$\sum_i \alpha_i = 1; \ \sum_i \gamma_{ij} = 0; \ \gamma_{ij} = \gamma_{ji}(i \neq j); \ \sum_j \gamma_{ij}; \ \sum_i \beta_i = \beta; \ \sum_i \delta_i = 0$$

where,
W denotes the expenditure shares of the individual meats relative to total consumer expenditure; p denotes the prices of individual meats and "other goods"; X denotes total (nominal) consumer expenditure; P denotes the price index of all consumer goods; the Greek letters are the parameters to be estimated.

The MAIDS model will adhere to the curvature conditions implied by demand theory provided (see Cooper and McLaren (1992) and McLaren *et al.* (1995)).

$$0 \leq \beta \leq 1$$

This requirement permits us to statistically test our estimated model for compliance with the curvature condition over this interval. The AIDS model is of course a special case when

$$\beta = 0.$$

Given data constraints we were unable to estimate the parameters of the demand system in the usual expenditure share form. We also considered it prudent to include a trend term in the denominator. Thus the model we actually estimated was as follows:

$$q_i = \left(\frac{X}{p_i}\right)\left(\frac{\alpha_i + \sum_j \gamma_{ij} \ln p_j + \beta_i \ln(X/P) + \delta_i T}{1 + \beta \ln(X/P)}\right); \ i, j(i \neq j) = 1, \ldots, n$$

$$\ln P = \sum_i W_i \ln p_i \qquad\qquad\qquad (2)$$

$$\sum_i \alpha_i = 1; \ \sum_i \gamma_{ij} = 0; \ \gamma_{ij} = \gamma_{ji}(i \neq j); \ \sum_j \gamma_{ij}; \ \sum_i \beta_i = \beta; \ \sum_i \delta_i = 0$$

where,

q is the per capita[3] consumption of individual meats and T is a time trend which could capture *inter alia* changes in "tastes", structural shifts and possible misspecified dynamics.

The introduction of the time trend renders our MAIDS model only approximately valid since it is apparent that with a positive coefficient on the trend term the shares could ultimately exceed unity, while a negative coefficent would see the shares becoming negative. The possibility of such outcomes emerging beyond the sample period cannot be ruled out but as long as this behaviour does not emerge within sample we can still have confidence in the approximate validity of our estimated model.

It is convenient to calculate the elasticties at the point of normalisation of all price and expenditure variables.[4] We chose 1990 — the last year of our sample — as the point of normalisation since we considered more up-to-date elasticities the more relevant for policy analysis. With normalisation we obtain the Marshallian or uncompensated own-price elasticities as

$$\eta_{ii} = -1 + \frac{\gamma_{ii} - \beta_i(\alpha_i + \delta_i T)}{\alpha_i + \delta_i T} + \beta(\alpha_i + \delta_i T) \tag{3}$$

The cross-price elasticities are

$$\eta_{ij} = \frac{\gamma_{ij} - \beta_i(\alpha_j + \delta_{jT})}{\alpha_i + \delta_{iT}} + \beta(\alpha_j + \delta_{jT}) \tag{4}$$

Expenditure elasticities are

$$\eta_{ix} = 1 + \frac{\beta_i}{\alpha_i + \delta_i T} - \beta \tag{5}$$

3.   Two features of our estimation approach should be noted. First, prices are assumed to be exogenous which we justify on the assumption that Irish meat prices are determined in our export markets. Second, our stochastic specification involves the appendage of a multivariate normal stochastic component to the deterministic equations which reflects standard practice in the estimation of demand systems up to now. However, it is worth pointing out that Conniffe (1993) and McLaren *et al.* (1995) have recently criticised this approach and recommend alternative procedures.

4.   See Alston and Green (1990) for a discussion on the appropriate manner of calculating elasticties in models such as ours.

314 THE ECONOMIC AND SOCIAL REVIEW

III DATA AND ESTIMATION OF THE MAIDS MODEL

A considerable effort had to be expended to generate the required data needed to estimate the model and the details are set out in Appendix 1. For the econometric estimation we had 68 effective observations comprising 17 time-series observations from 1974 to 1990 on each of the four meats. Given symmetry and linear homogeneity, the system in Equation (4) requires the estimation of 23 parameters. The system was estimated using the maximum-likelihood procedure in the *Time Series Processor (Version 4.3)* package. Initial experimentation revealed that the own-price elasticity of demand for chicken to be not significantly different from zero and this restriction was subsequently imposed in the estimation.[5]

The results of the estimation of Equation (4), where all right-hand-side variables are normalised to 1990=1 prior to taking logarithms, are given in Table 1.

Table 1: *MAIDS Model Parameter Estimates of Irish Meat Demand*[a]

| Constant | Relative Prices[b] | | | | Con. Expenditure | Trend |
	Beef	Mutton	Pigmeat	Chicken		
.0028	−.0005	.0039	.0041	−.0009	.0068	.0003
(0.36)	(−.15)	(3.45)	(1.10)	(−.77)	(1.16)	(0.62)
.0155		−.0031	−.0031	−.0002	.0030	−.0007
(4.11)		(−3.65)	(−2.55)	(−0.31)	(1.55)	(−3.20)
.0401			−.0010	−.0055	.0102	−.0016
(3.89)			(−.22)	(−3.75)	(1.62)	(−2.58)
.0098				-.--[c]	.0026	−.0003
(2.81)				(-.--)[c]	(1.21)	(1.45)
β=0.6828						
(2.56)						

Single equation statistics:

	Beef	Mutton	Pigmeat	Chicken
R^2	0.86	0.91	0.84	0.95
DW	1.78	1.15	1.69	1.40

t-ratios in parentheses.
[a] = the equation for "other goods" is not being displayed.
[b] = meat prices are defined relative to "other goods".
[c] = coefficient restricted such that the own-price elasticity of chicken equals zero at the 1990 data point.

5. The imposition of this restriction did not materially affect the other coefficient estimates. However, what it did do was to enable us to obtain stable estimates using the maximum likelihood estimator. In the absence of this restriction we were only able to obtain robust estimates using a non-linear SURE procedure.

The key parameter in terms of the adherence of our estimates to the curvature conditions is the β estimate which we find to be 0.68 with a t-ratio of 2.56 which implies that the curvature requirements are not violated. We also ran the AIDS version of Equation (2), that is, setting $\beta = 0$. A likelihood-ratio test strongly rejects the AIDS model at the 5 per cent confidence level.

The trend parameters, which we interpret as capturing a combination of "taste" and structural changes in demand and possible misspecified dynamics, are significant and negative only in respect of mutton and pigmeat. Bearing in mind our previous comments about the possibility of the shares behaving pathologically with large values of T, it is comforting to note that we find no evidence of such behaviour within sample.

The Marshallian elasticity estimates are given in Table 2.

Table 2: *MAIDS Elasticity Estimates of Irish Meat Demand, 1990*

Meat	Relative Prices				Con. Expenditure
	Beef	*Mutton*	*Pigmeat*	*Chicken*	
Beef	−1.07	0.50	0.53	−0.12	1.19
	(−2.25)	(3.19)	(1.12)	(−0.76)	(2.01)
Mutton	1.16	−1.89	−0.93	−0.05	1.21
	(3.35)	(−7.62)	(−2.47)	(0.32)	(2.88)
Pigmeat	0.32	−0.24	−1.04	−0.42	1.10
	(1.08)	(2.55)	(−2.93)	(−3.58)	(3.23)
Chicken	−0.20	−0.02	−1.17	0.00 [a]	0.88
	(0.77)	(−0.23)	(−3.54)	(-.--) [a]	(2.57)

t-ratios in parentheses.
[a] = restricted to equal zero.

With the exception of chicken, we find that demand is own-price elastic with an exceptionally high parameter evident for mutton. As mentioned previously we could not reject a zero own-price elasticity of demand for chicken. Expenditure elasticities exceed unity in three cases with chicken having a value of about 0.9. The cross-price effects are interesting. Beef appears to substitute with mutton and pigmeat but not with chicken. Beef is a stronger substitute for mutton than the obverse. But pigmeat is suggested to be a complement to mutton consumption. Beef is a substitute for pigmeat but the relationship is stronger in the other direction. Pigmeat is complementary to both mutton and chicken consumption. In the chicken relation the only strong cross-price effect which emerges is the implied high level of complementarity between chicken demand and pigmeat.

It might be of interest to point out that the AIDS model, which was

rejected by our data, tended to produce much higher own-price but lower expenditure elasticities.

Our main findings of relatively high own-price and expenditure elasticities are broadly consistent with the international literature as is apparent from Table 3 which reproduces the results from a number of selected studies which employ a broadly similar methodology to our own.

Table 3: *Meat Demand Elasticity Estimates from Selected Studies*

Study[a]	UK	FR	US1	JAP	US2	AUSL	CAN	US3
				Own-price Elasticities				
Beef	−1.66	−0.76	−0.96	−1.89	−1.05	−0.42	−0.96	−0.51
Mutton/Lamb	−1.42	−0.77	−	−	−	−1.33	−	−0.10
Pigmeat	−1.03	−0.48	−0.76	−0.76	−0.84	−1.12	−0.73	−0.73
Chicken	−0.90	−0.86	−0.98	−0.59	−0.10	−0.37	−0.91	−0.39
				Expenditure Elasticities				
Beef	1.32	0.89	1.22	1.83	1.39	1.61	1.61	0.97
Mutton/Lamb	1.07	1.52		−	−	0.85	−	1.26[*]
Pigmeat	0.79	1.44	0.78	0.53	0.85	0.26	0.58	1.04
Chicken	0.98	1.77	0.78	1.60	0.21	0.17	0.97	0.77

* other "red" meats.
a: UK=Burton and Young (1992).
  FR=Fulponi (1989).
  US1=Christensen and Manser (1977).
  JAP=Hayes, Wahl and Williams (1990).
  US2=Moschini and Meilke (1989).
  AUSL=Alston and Chalfant (1987).
  CAN=Chalfant, Gray and White (1991).
  US3=Wellman (1992).
The studies of Christensen and Manser (1977) and Alston and Chalfant (1987) employ the *Translog* and *Modified Translog/AIDS* specifications respectively while the remaining papers use the AIDS model.

IV CONCLUDING COMMENTS

This paper has presented, for the first time, a system-based estimation of the demand for meat in Ireland. Our paper is also unique to the extent that we estimate the MAIDS model of Cooper and McLaren (1992) which allows us to statistically test the validity of the AIDS specification and also to determine whether the estimated model adheres to the requisite curvature restrictions implied by neo-classical theory. Our empirical estimates strongly support the MAIDS model and reject the special case AIDS version. Moreover, our results do not violate the curvature requirements.

Our main findings reveal relatively high own-price and expenditure elasticities. These findings are also consistent with the international literature.

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APPENDIX A1: DATA DEFINITIONS

Meat consumption (q_i)

Data on per capita meat consumption (kilograms) were obtained from the Irish Statistical Bulletin (ISB, March 1986) for the years 1974-1984. As this series was discountinued in 1984 we used data produced by the Food and Agricultural Organisation (FAO) for the years 1985-1990. The FAO and ISB data overlap for 1983 and 1984 and as there is close agreement between the series the data for 1985-1990 should be consistent with that for the earlier period. Beef and sheepmeat consumption consists of carcass meat, poultry-meat includes uncooked chicken only and pigmeat comprises pork and bacon consumption, excluding cooked ham.

Meat prices $(Ln(P_{ij})$; $i, j = 1,...,n-1)$

As no retail price series are published for the meat aggregates used in our analysis (that is, beef, sheepmeat, pigmeat and poultrymeat) these had to be constructed. The prices for these meat aggregates were obtained as follows:

Beef: The Central Statistics Office (CSO) publish quarterly national average retail prices (including VAT) for the principal cuts of beef, namely, round steak, sirloin and rib steak. These series tend to be highly correlated but we thought it preferable to utilise as much information as was available by compiling a price index. We first aggregated the quarterly prices to annual values. Then we derived a price index as

$$Ln(PB) = \sum s_i * Ln(PBC_i) \qquad (1)$$

where,

PBC$_i$ = price of the ith beef cut; and

s$_i$ = expenditure weight for the ith beef cut. These weights are unpublished but the CSO kindly made available a set of weights derived for November 1982.

Sheepmeat: A similar procedure was employed here. The principal price cuts used in compiling the index in the manner of Equation (1) were: leg, loin chops, gigot chops, neck and liver.

Pigmeat: The price of pigmeat is an aggregate of pork and bacon price cuts. An index of *pork* prices was obtained by aggregating the retail prices of leg, loin, shoulder and porksteak again in the manner of Equation (1). The *bacon* retail price index was defined for back rashers, streaky rashers and ham. Finally, the pork and bacon price indices were aggregated into an index of *pigmeat* prices using the CSO published weights for each type of pigmeat which are based on the 1987 Household Budget Survey (HBS).

Poultrymeat: No official retail price series are published for Ireland. However, time series estimates of the retail price of uncooked chicken were kindly supplied by the *Irish Poultry Processors Association.*

All consumer goods' price (Ln(P))

We used Ln(CPI) as a proxy for Ln(P) in Equation (1) of the text.

"Other" goods' price (Ln(p$_n$))

In the context of our study "other" goods comprise all consumer goods except our four meats. We obtained a proxy for this price simply as

$$Ln(p_n) = Ln(CPI) - S_m * Ln(p_m) \qquad (2)$$

where,

p$_n$ = the price of "other" goods;

p$_m$ = the price of meat which is obtained by aggregating the prices of the four meats in our study; and

S$_m$ = the expenditure share of our four meats in total consumer expenditure as published by the CSO based on the 1987 Household Budget Survey.

Nominal consumer expenditure (X)

This series was obtained from the National Income and Expenditure Accounts (ESRI databank).