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THE DETERMINATION AND FORECASTING OF MEAT PRICES IN THE UK

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WP 90/07

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(1) Introduction

There are a number of pieces of work that have been developed in the past that are concerned with price determination in the meat sector. One can criticise the suitability of this earlier work for price forecasting on three grounds. Firstly, the inverse demand systems that have typically been estimated have used ad-hoc specifications, without reference to the constraints on functional form and parameter values that may be derived from the well established economic theory of commodity demand. Secondly, such systems may not provide the relevant information for those interested in the operation of the market, in terms of periodicity or commodity coverage. Thirdly, if a model is to be of value as a forecasting tool then it must be capable of generating such forecasts easily and efficiently. Ideally an ex ante forecast should require a minimum number of exogenous variables to be generated (consistent with an adequate representation of market behaviour).

The intention of this work is to provide such a forecasting tool for monthly meat prices at the producer level, using an inverse demand system that utilises the constraints implied by theory.

(2) A Note on Methodology

Five meat commodities are identified within the model, Steer Beef, Other Beef, Mutton and Lamb, Bacon and Ham, and Pork. Beef is dissaggregated in this way because the beef intervention system has been restricted to steer beef (over our estimation period of 1982:7 to 1988:12) and it is envisaged that the impact of intervention will be different for the two classifications.

In disaggregating beef in this way several assumptions have to be made about how the beef market works. These are, as follows,

Assumptions

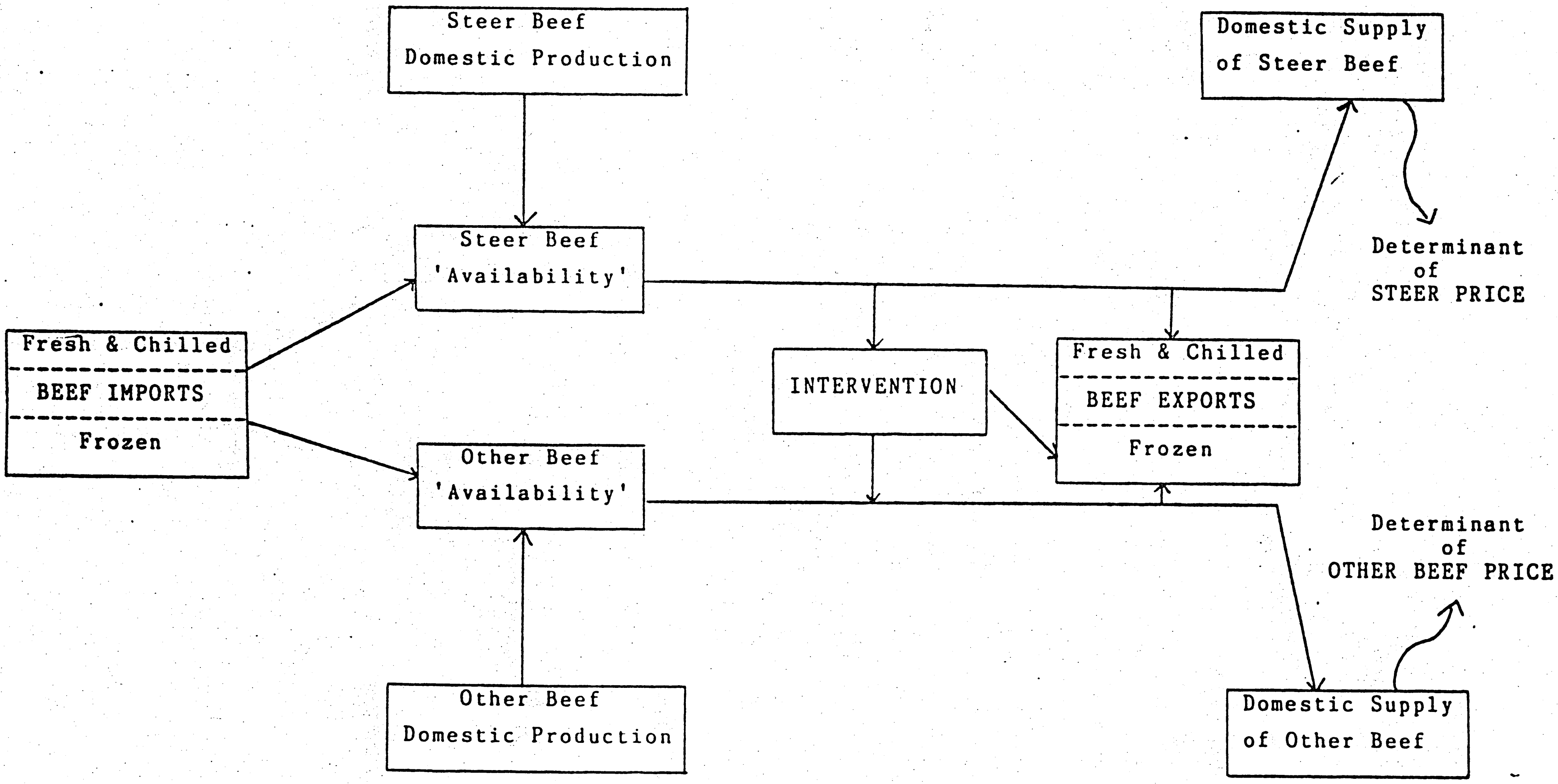
(i) Intervention purchases reduce steer beef supply only.

(ii) Monthly sales from intervention can be split into domestic and those destined for the export market by a set coefficient. This coefficient is obtained from the total figures for 1987. This is done because a monthly breakdown of intervention sales data is not available.

(iii) Domestic intervention sales increases the supply of 'other beef'. This is because these sales have an end use restriction whereby they can be only used in products that normally use low quality beef.

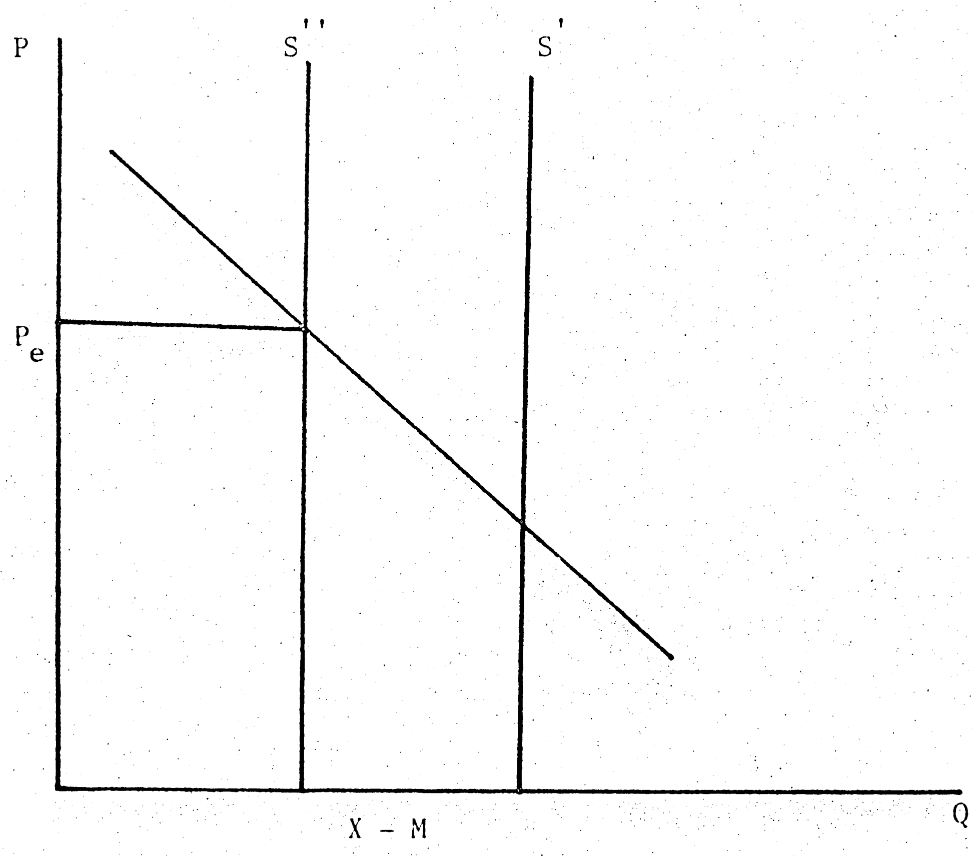
(iv) Exports and imports of beef are disaggregated in the following way: Fresh and chilled imports and exports effect the steer beef supply and frozen imports and exports effect the supply of other beef. This is because fresh and chilled beef is deemed to be of superior quality to frozen beef, and thus seemed the most appropriate way to disaggregate traded beef. This specification was decided on, following consultation with MLC economists.

These assumptions about the flow of beef within the market are best illustrated in the following diagram.


Steer Beef
Domestic Production
Steer Beef
'Availability'
Fresh & Chilled
BEEF IMPORTS
Frozen
Other Beef
'Availability'
Other Beef
Domestic Production
INTERVENTION
Fresh & Chilled
BEEF EXPORTS
Frozen
Domestic Supply
of Steer Beef
Determinant
of
STEER PRICE
Determinant
of
OTHER BEEF PRICE
Domestic Supply
of Other Beef

The derivation of the estimated demand system that we will be using (at the farm gate level) is based on the direct translog utility function developed by Christensen, Jorgenson and Lau (1975). Formal maximisation of this function can lead to a system of <u>inverse</u> demand equations, with prices being determined by the quantities of the meat traded onto the market (more detail is given in section 2). This rationalization of the market clearing mechanism is the opposite to that usually employed in the estimation of formal demand systems, but has been commonly employed in ad-hoc models of commodity demand (e.g. Agriculture Canada (1980), Hallam (1981), Heien (1975), Heien (1976), Maclaren (1978)). The assumption that the quantity of meat available for supply onto the market is exogenous is tenable given the monthly data periodicity and the biological nature of the production process. We are also assuming that imports and exports of meats, and all intervention sales, are exogenously determined in the model to give us a net supply, or domestic supply figure for each meat onto the market. As we shall see below intervention purchases are treated endogenously. In terms of a conventional supply and demand diagram then, we are assuming a perfectly inelastic supply of meat moving on to the market where total demand is constrained to equal the exogenous suppy, with the price vector changing to ensure this. The simple diagram below illustrates this.

<u>DIAGRAM TWO</u>



With this type of market structure we use inverse demand functions to explain the determination of prices where the price of a meat i can be regarded as a function of the supply of meat i, and other meats j as well as income M. i.e.

$$P_i = f(X_i, X_j, M, U_t)$$

However, prices are determined by the actual supply onto the market, and the possibility of sales into intervention mean that for steer beef there may be a divergence between available supply and actual supply. The model therefore includes an explanation of the level of sales of steer beef into intervention stores as we shall see later. This inclusion means that, for steer beef only, the model determines the price of steer beef, the supply of steer beef onto the market and intervention sales simultaneously. The other prices are then determined by the quantity supplied onto the market of each meat (i.e. domestic production + imports - exports).

(3) <u>Data</u>

Monthly data (i.e. four weekly months) was collected for the model for the estimation period 7/82 to 12/88. The majority of the data was collected from Meat and Livestock Commission (MLC) publications, and unless otherwise stated all data should be presumed to have arisen from those publications. The publications used were as follows,

(1) The UK Handbook

(2) The UK Weekly Market Survey (issues from 6/82 to 12/88)

(3) Data files at the MLC headquarters.

Where appropriate the numbers used above will indicate where individual series were collated. For a more detailed listing see Appendix One.

Data on intervention operations was obtained from Intervention Board for Agricultural Produce (IBAP) yearbooks, and press notices of the IBAP. Data on exports and imports was obtained from Her Majesty's Custom's and Excise figures from summary sheets at the MLC.

The data collected was usually of the deadweight type (apart from the price data for pigs), because this is the part of the market in which intervention operations occur. There are however strong connections between the deadweight and liveweight markets for beef and other meats so it seems appropriate to assume that using deadweight (or liveweight) data is a fair representation of the whole market environment, and does not bias the model in any way.

We will now go on to outline the data that was collected in five sections (i) supply data (ii) import and export data (iii) intervention data (iv) price data and (v) other data, before presenting the generated variables to be used in modelling in Section (vi). It should be noted that all data was adjusted to give a standard 4 week month to retain consistency in the model and all data is for the UK unless otherwise stated.

(i) **Supply Data**

Production figures in tonnes of meat were collected from sources (1) and (3). The following series were collected.

PRODBV - production of beef and veal

PRODML - production of mutton and lamb

PRODP - production of pork

PRODBH - production of bacon and ham

* All figures were converted into four weekly months (i.e. five weekly month figures were multiplied by 4/5).

In order to disaggregate beef into steer and other beef, data was also collected on the numbers of animals marketed at sample deadweight centres. This gives us the following four series.

HNO - number of heifers marketed at sample deadweight centres

CNO - number of cows marketed at sample deadweight centres

BNO - number of bulls marketed at sample deadweight centres

SNO - number of steers marketed at sample deadweight centres

This data was collected from summary sheets at the MLC i.e. source (3), and was not adjusted in any way, as it's use as we shall see further on is only to determine the share of beef split between steer and other beef.

(ii) **Import and Export Data**

Trade data in tonnes of meat was collected from summary sheets at the MLC as previously stated. The following series were collected.

BMF - Imports of beef (Frozen)

BMFC - Imports of beef (Fresh and Chilled)

BXF - Exports of beef (Frozen)

BXFC - Exports of beef (Fresh and Chilled)

MLM - Imports of mutton and lamb

MLX - Exports of mutton and lamb

PM - Imports of pork

PX - Exports of pork

BHM - Imports of bacon and ham

BHX - Exports of bacon and ham

As this data appears as calendar month data it was transformed into 4 weekly months by multiplying the figure by 28/number of days in a particular month. In the PHOENIX forecasting model this is done automatically, when one forms the X_1 variables shown below.

(iii) **Intervention Data**

Intervention operations data in tonnes of meat was collected from IBAP yearbooks and press notices. The following series were collected.

INTBUY - purchases of beef into intervention

INTSALBI - Sales of 'bone-in' beef out of intervention

INTSALBL - Sales of 'bone-less' beef out of intervention

The following series were generated from this data:

INTSALES = sales of beef from intervention (adjusted to bone-in equivalents for consistency)

$$= \text{INTSALBI} + \frac{\text{INTSALBL}}{0.69}$$

This was done in order to form a total figure for intervention sales. The coefficient 0.69 is a boning-out coefficient calculated from 1982-87 data.

INTDOM = Domestic sales of beef from intervention

$$= \frac{30}{51} * \text{INTSALES}$$

INTEX = Export sales of beef from intervention

$$= \frac{21}{51} * \text{INTSALES}$$

This was done in order to split intervention sales into domestic and exported. The coefficient a/51 is based on 1987 intervention sales figure. All data was left in calendar month figures.

The following series were also collected.

INTPR = Intervention price of beef (p per kg dw) = Price of R4L steers or the lowest heavy grade steers (pre 1984). Price of carcase equivalent i.e. hindquarter price is divided by 1.2 and forequarter price by 0.8 to achieve this. Source:2

FD = A dummy variable = 1 when intervention was occurring on forequarter beef; 0 otherwise.
(nb if forequarter buying is in operation for most of a single month FD = 1). Source:2

HD = A dummy variable = 1 when intervention was occurring on hindquarter beef; 0 otherwise Source:2

MD = A dummy variable = 1 when intervention was occurring on carcasses; 0 otherwise Source:2

RT = A dummy variable = 1 when triggering has switched off R grade intervention; 0 otherwise Source:2

UT = A dummy variable = 1 when triggering has switched off U grade intervention; 0 otherwise Source:2

(iv) **Prices Data**

The following series were collected on prices, and their sources indicated

AMPS = Average market price of sheep (GB) (p per kg dressed carcass weight) Source 1

PORKP = Auction market price of porkers (England and Wales) (p per kg liveweight) Source 1

CUTTP = Auction market price of cutlers (England and Wales) (p per kg liveweight) Source 1

BACOP = Auction market price of baconers (England and Wales) (p per kg liveweight) Source 1

HPR = Heifer price from sample deadweight centres (p per kg deadweight) Source 3

CPR = Cow price from sample deadweight centres (p per kg deadweight) Source 3

BPR = Bull price from sample deadweight centres (p per kg deadweight) Source 3

SPR = Steer price from sample deadweight centres (p per kg deadweight) Source 3

(v) **Other Data**

Other data series generated were as follows

TIME - Time trend = 1 in period 1 (i.e. January 1982) and increasing by 1 each month

JANDUM - Dummy variable = 1 in 198i:1 ; 0 otherwise

FEBDUM - Dummy variable = 1 in 198i:2 ; 0 otherwise

. . . . .

. . . . .

DECDUM - Dummy variable = 1 in 198i:12; 0 otherwise

The following 'seasonal dummies' were then created

D1 = Spring dummy = MARDUM + APRDUM + MAYDUM

D2 = Summer dummy = JUNDUM + JULDUM + AUGDUM

D3 = Autumn dummy = SEPDUM + OCTDUM + NOVDUM

(vi) **Generated Data**

From the data outlined above we generated the following variables for use in the model.

PRICES OF EACH COMMODITY

P1 = Mutton and lamb price = AMPS

P2 = Steer beef price = SPR

P3 = Other beef price = $\frac{(CPR*CN) + (HPR*HN) + (BPR*BN)}{(CN+HN+BN)}$

P4 = Bacon and ham price = $\frac{(CUTTP + BACOP)}{2}$

P5 = Pork price = PORKP

DOMESTIC SUPPLIES OF EACH COMMODITY

X1 = Domestic supply of mutton and lamb

= PRODML - MLX + MLM

X2 = Domestic supply of steer beef

$$= \left(PRODBV * \frac{SN}{SN+CN+BN+HN}\right) - BXFC + BMFC - INTBUY$$

X3 = Domestic supply of other beef

$$= \left(PRODBV * \frac{CN+BN+HN}{SN+CN+BN+HN}\right) + INTDOM - (BXF-BMF-INTEX)$$

X4 = Domestic supply of bacon and ham

= PRODBH - BHX + BHM

X5 = Domestic supply of pork

= PRODP - PX + PM

A further domestic supply variable which will be used in the model is,

X2N = X2 + INTBUY

i.e. the domestic supply of steer beef without intervention purchases being removed.

INCOME VARIABLE

An income variable M also needs to be generated where,

$$M = \sum_i P_i X_i$$

BUDGET SHARE VARIABLES

This allows for the generation of the budget shares which form the endogenous variables in our model. The budget shares W_i are generated as follows:

$$W_i = \frac{P_i X_i}{M}$$

(4) The Direct Translog Model

The model used in our estimation as stated previously is the direct translog, as outlined in Christensen et al (1975). In the direct translog, a direct utility function is specified of the form

1) $-\ln(U) = \alpha_0 + \sum_i \alpha_i.\ln(X_i) + \frac{1}{2}.\sum_{ij}\sum \beta_{ij}.\ln(X_i).\ln(X_j) \quad i,j=1....n$

where X_i is the quantity of commodity i consumed. Maximization of utility subject to the budget constraint $\Sigma P_i X_i = M$ yield first order conditions of the form

2) $\alpha_i + \sum_j \beta_{ij}.\ln(X_j) - [\sum_j \alpha_j + \sum_{ji}\sum \beta_{ij}.\ln(X_j)].P_i.X_i/M = 0$

These conditions are independent of the market structure that is assumed, and in theory could be used to generate direct or indirect demand functions. In fact, the specification of 2) lends itself to indirect demand functions of the form

3) $W_i = \dfrac{\alpha_i + \sum_i \beta_{ij}.\ln(X_j)}{-1 + \sum_j \beta_{mj}.\ln(X_j)}$

where W_i is the share of expenditure spent on good i, and $\beta_{mj} = \sum_i \beta_{ij}$. It is also necessary to impose some normalization rule on the parameters, as the utility function is homogeneous of degree one, (and hence the first order condition homogeneous of degree zero), in the parameters. The normalization used is that $\sum_j \alpha_j = -1$. Although the parameters are not invariant to the rule used all elasticities and test statistics are.

Given the generated data, we identify five indirect demand functions of the form shown above.

Only m-1 equations need to be estimated for a complete econometric model (i.e. 4 in this case) the standard procedure being to exclude one equation and determine the non-estimated parameters using the adding up constraint (when it is imposed). We however applied an alternative approach of estimating the system of equations twice excluding a different equation each time. This allowed us to check our estimation procedures as the common parameters and log likelihood values should be invariant between the two estimations.

Of course the model we are using only explains how budget shares are determined by changes in supply, and not prices: the variable we wish to determine. However when we come to simulate the model we can recover values for the price of the commodity using the predicted share and the exogenous values of quantity of the good and income i.e.

$$P_i = \frac{W_{is}.M}{X_i} \qquad i=1,2,\ldots.n$$

where W_{is} = simulated value of W_i.

Thus from the direct translog model, we can observe how well price movements are explained given supply/consumption levels. Forecasting of future price movements can be done by obtaining forecasts for M and X_i, and ex-post forecasting can be done quite simply where series for M and X_i are readily attainable.

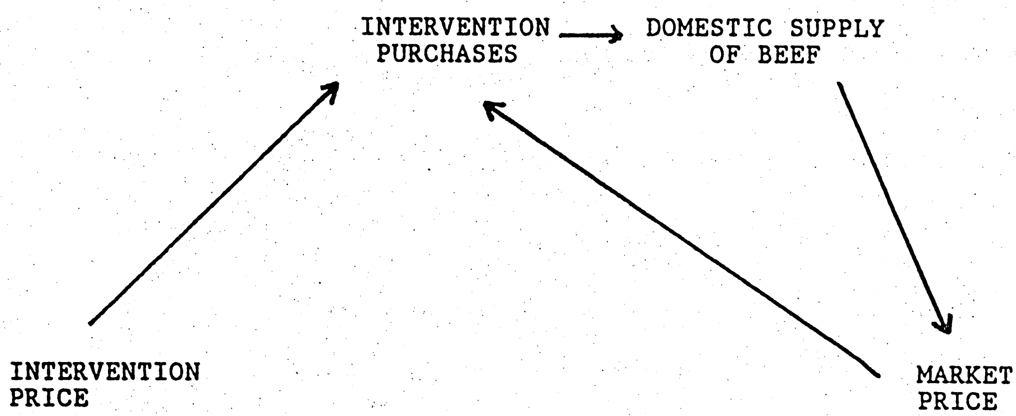
Before we go on to estimate the above set of equations, and further specifications of the model we will first of all outline how we overcome one of the major inconsistencies in the model: that of the endogeneity of intervention buying.

(5) <u>Intervention Buying</u>

One problem apparent in the assumption of an exogenous supply is, can intervention purchasing be regarded as being exogenous? The answer is obviously no, as previously stated, even though it is said wholesalers and deadweight centres tend to sell fixed amounts into intervention somewhat regardless of price conditions in the market (from consultation with representatives from MAFF); and that there is a time lag in offering beef for intervention and it being accepted (usually several days); because there will obviously be some relationship between intervention purchases and the strength (or weakness) of beef prices in relation to the intervention price, when businesses stand to gain or lose money depending on their dealings in the market and with the Intervention Board.

There are then market linkages which are more complicated than just an exogenous domestic supply of beef, and an endogenous market supply. These linkages are best illustrated in the following diagram.

DIAGRAM THREE : Market Linkages



It was decided then to make intervention buying (INTBUY) endogenous in the model, making the model simultaneous in nature. In order to do this the technique of Two Stage Least Squares using instrumental variable estimation was used.

One problem in the estimation of an equation for intervention buying is to take account of the triggering mechanism which has been in operation during 1988 (March to December for R3 and R4L, and July to August for U2, U3 and U4). This triggering has come about due to the 'tightening-up' of intervention arrangements and large increases in steer beef prices. In our model, we take account of it very crudely via the use of dummy variables, which seemed the only appropriate way without unduly complicating the estimation. We also have to assume that whatever portion of a steer (be it forequarter, hindquarter or carcase) is purchased into intervention the effect on physical supply is the same. There is nothing wrong with this assumption except that purchasing in different categories of beef will probably effect market price in different ways, and this point then is obviously ignored. Data availability prevented the construction of a model where hindquarters and forequarters could appear as different products, which would obviously have been the way of capturing the different price effect of different intervention buying regimes. Thus, although hindquarters account for what is the high value portion of a beef animal the effect on price of buying one tonne of hindquarter beef into intervention is exactly the same in our model as buying in one tonne of forequarter beef.

The following equation then was formed which allows us to construct an instrumental variable for INTBUY :- INTBUYI.

$$4)\quad \ln INTBUY = E1 + E2.FD + E3.HD + E4.MD + E5.\ln \frac{P2^*}{INTPR_{(t-1)}} + E6.\ln (INTBUY_{(t-1)}) + E7.RT$$

Where, P2* is an instrumental variable for P2. For definition of the other variables see section (1). The instrument P2* chosen for P2 was P2(t-1), which seemed to be a good choice given the static nature of steer beef prices over the estimation period. The static nature of beef prices also made it difficult to estimate an econometric equation which would give reasonable simulated values of P2, whilst having a specification that could be justified by its test statistics (e.g. t statistics on dependent variables). P2(t-1) on th other hand proved to be a very close approximation to P2.

The reason behind the above specification is as follows: when the different arrangements are in place (i.e. forequarter, hindquarter or carcase buying in) it is expected that different quantities of beef will go into intervention i.e. when hindquarter buying occurs generally less beef goes into intervention than when forequarter buying or carcase buying is in operation; and when carcase buying is in operation more still is purchased. There are then dummy variables in the equation to account for changes in intervention buying when different buying in operations exist. There is also a dummy variable in the equation to take account of the effect of the triggering mechanism on intervention buying. The dummy variable UT for grade U triggering was excluded in the final specification because it was found to be insignificant according to its standard error and associated t-statistic.

A lagged dependent variable was thought to be a necessary variable in the equation as wholesalers/abattoirs tend to follow a pattern in their selling into intervention, and it is said sell in quantities regardless of market conditions (MAFF). A lagged dependent variable then was seen as an appropriate and simple way of capturing this practice. Obviously, however the amount being sold into intervention will depend on market conditions and the relationship between market price (P2) and intervention price (INTPR). A variable then relating P2 to INTPR was constructed in the form shown to take account of this.

One problem with the equation is that it does not take the intervention triggering system into account in a very formal manner. One method was tried, to take account of the triggering system by constructing the following variable $IPROP^2$ where,

5) $$IPROP^2 = \ln \frac{P2_{(t-1)}}{INTPR_{(t-1)}} * \ln \frac{P2_{(t-1)}}{INTPR_{(t-1)}}$$

which would allow for INTBUY to reduce if the margin between P2 and INTPR became large enough for the triggering system to come into operation. This variable was however, highly insignificant when its standard error/t-statistic was observed. It was therefore excluded from the intervention buying equations.

The equation then was estimated over the period 1982:7 to 1988:12 using ordinary least squares and, the following results obtained.

E1	=	2.888	(5.67)	
E2	=	0.5084	(2.49)	$R^2 = 0.72$
E3	=	-0.3252	(1.60)	
E4	=	0.8626	(3.92)	$\bar{R}^2 = 0.70$
E5	=	-7.1837	(4.54)	Durbin-Watson = 1.85
E6	=	0.4933	(6.46)	
E7	=	0.3511	(2.19)	DF = 71

t statistics in parenthesis.

This shows a reasonably good fit ($\bar{R}^2 = 0.70$) with all variables being significant (all can be strongly accepted at the .05 level of significance i.e. $t^{0.05} = 2.0$) apart from E3 (which can only be accepted at the .20 level of significance i.e. $t^{0.2} = 1.296$).

In order to test for serial correlation where a lagged dependent variable is found the Durbin h test has to be used, where

6) $h = (1-0.5d)\sqrt{\{n/(1-n\ Var(B))\}}$

where d is the durbin-watson statistic

n is the number of obsevations

Var(B) is the estimated variance of the coefficient attached to the lagged dependent variable

(Pindyck and Rubinfeld (1981)).

The test for first-order serial correlation is done directly using the normal distribution table. From our equation h = 0.9. At the 5 per cent level, the critical value of the normal distribution is 1.645. Since 0.9 is less than 1.645, we cannot reject the null hypothesis of no serial correlation. As a result the use of ordinary least-squares estimation is deemed to be satisfactory.

The instrumental variable INTBUYI can then be formed by taking the exponential of the simulated series for ln(INTBUY).

A generated U2 statistic of 0.66051 (1969 using changes) also suggests that the equation simulates well.

(6) **Estimation**

When the instrumental variable INTBUYI is used in the estimation so the replacement for INTBUY a new income term M2 has to be used where,

$$M2 = \sum_{i=2} P_i X_i + P2(X2N - INTBUYI) \qquad (5.8)$$

The following system of budget share equations can then be formed using INTBUYI

(7)

$$W_i = \frac{P_i X_i}{M2} = \frac{\alpha_i + \sum_{j\neq 2} B_{ij} \ln(X_j) + B_{i2} \ln(X2N - INTBUYI)}{-1 + \sum_{j\neq 2} B_{mj} \ln(X_j) + B_{m2} \ln(X2N - INTBUYI)}$$

Before estimation however the exogenous data series i.e. the quantities X_j (including X2N-INTBUYI) were normalized to have a value of 1 is the last period 1988:12 i.e. each series of X_j was divided by its value in the final period. These transformations change the parameter values, but not the test statistics and estimated elasticities (for a proof of this, see Christensen and Manser 1977). This normalization eases greatly the calculation of elasticities and flexibilities.

The following identity must also be used when estimating the set of budget share equations,

$$P2 = \frac{W2 * M2}{(X2N-INTBUYI)}$$

In our estimation we also carried out one further transformation of the equations, which enabled the model to estimate with greater efficiency. This was to divide all the X_j (including X2N - INTBUYI) apart from X5, in the numerator of each equation by X5, allowing a simpler specification of the parameters. The following system of budget share equation is then formed.

(8)

$$W_i = \frac{\alpha_i + \sum_{j\neq 2 or 5} B_{ij} \ln(X_j/X5) + B_{i2} \ln\left(\frac{X2N-INTBUYI}{X5}\right) + B_{mi} \ln(X5)}{-1 + \sum_{j\neq 2} B_{mj} \ln(X_j) + B_{m2} \ln(X2N-INTBUYI)}$$

The B_{m1} parameter attached to ln(X5) in the numerator is recovered from the fact that

$$B_{m1} = B_{11} + B_{12} + B_{13} + B_{14} + B_{15} \qquad (i=1,2,....5)$$

One might argue that the parameters of the utility function may in fact change over time given seasonal changes in tastes, and changes in the perception of goods leading to changes in tasks over time. We will then estimate the budget share equations with a time trend and seasonal dummies. The following budget share equations are then generated.

(9)

$$W_1 = \frac{\alpha_1 + \sum_{j\neq 2or5} B_{1j} \ln(X_j/X5) + B_{12} \ln\left(\frac{X2N-INTBUYI}{X5}\right) + B_{m1} \ln(X5)}{-1 + \sum_{j\neq 2or5} B_{mj} \ln(X_j) + B_{m2} \ln(X2N-INTBUYI)}$$

$$\frac{+ \sum_K \Sigma_{1K}.D_K + æ_1 \ln(t)}{+ \sum_K \Sigma_{mK}.D_K + æ_m \ln(t)}$$

where D_K is a dummy variable = 1 in period K, 0 otherwise

K = 1,2,3 i.e. we have D_1 D_2 and D_3 as specified in section (1)

t = time trend

The reason for having D_1, D_2 and D_3 as specified in section (1) was that these specification test captured the seasons they are chosen to represent i.e. spring, summer and autumn. The model then, was estimated (i.e. 4 equations plus the identity) as a system using the technique of Full Information Maximum Likelihood,

> "....a 'system method' in which we estimate the parameters of all equations simultaneously using all information in the model."
>
> Maddala (1979)

After estimating the model, the first stage was to analyse the results to check if a maxium of utility had been attained. This is done by checking the second-order conditions.

(7) Checking the Second-Order Conditions

Inspection of the bordered Hessian derived from the direct utility function reveals that the signs of the principle bordered minors alternate, and so the second-order sufficient condition for a maximum is satisfied (see Appendix Two). As a result of this, all of the compensated own price substitution effects (not reported here) are negative. However, we have only checked for a maximum at the point of normalization i.e. 1988:12, and it is possible that at other/different points of normalization a maximum is not obtained. This is analogous to the movement along an indifference curve, where at one point we may be on a point of concavity but at another point not so. We thus checked the bordered Hessian at different points of normalization; which meant re-estimating the whole model normalising at these different points. We checked the first point 1982:7 the mid point 1986:9; and 1988:9, 1988:6, and 1988:3; the points at which further estimates had to be done in order to calculate elasticities and flexibilities (see section 9). At all of these points the second-order sufficient condition for a maximum was satisfied, indicating that we have a model specification which produces results consistent with demand theory.

We will now go on then to discuss the results of our estimation for our chosen model.

(8) **Results from the Estimation**

The parameter values for the chosen model are reported in the following table.

Table 3

Parameter		
α_1	-0.165	(0.025)
θ_{11}	-0.03	(0.013)
θ_{12}	0.002	(0.009)
θ_{13}	0.036	(0.009)
æ$_1$	0.003	(0.009)
B_{11}	-0.119	(0.027)
B_{12}	0.008	(0.016)
B_{13}	0.004	(0.017)
B_{14}	0.008	(0.007)
B_{15}	0.014	(0.012)
α_2	-0.272	(0.017)
θ_{21}	0.014	(0.015)
θ_{22}	0.002	(0.012)
θ_{23}	0.005	(0.015)
æ$_2$	0.01	(0.007)
B_{22}	-0.159	(0.037)
B_{23}	0.08	(0.044)
B_{24}	0.029	(0.015)
B_{25}	0.042	(0.024)
α_3	-0.267	(0.018)
θ_{31}	0.011	(0.015)
θ_{32}	0.003	(0.012)
θ_{33}	0.008	(0.015)
æ$_3$	0.006	(0.007)
B_{33}	-0.148	(0.034)
B_{34}	0.014	(0.012)
B_{35}	0.015	(0.018)

α_4	-0.106	(0.006)
θ_{41}	0.003	(0.005)
θ_{42}	-0.001	(0.005)
θ_{43}	-0.01	(0.007)
$æ_4$	0.004	(0.003)
B_{44}	-0.03	(0.021)
B_{45}	0.102	(0.031)
α_5	-0.191	(0.012)
θ_{51}	0.007	(0.009)
θ_{52}	0.003	(0.008)
θ_{53}	-0.013	(0.012)
$æ_5$	0.008	(0.005)
B_{55}	0.025	(0.05)

There was some evidence of serial correlation in the estimated equations as was reflected in the durbin-watson statistics. This may be corrected for using the Cochrane-Orcutt method, but when it was tried the estimated parameter values remained fairly constant, and this type of correction makes a simulation of the complete model overly complex. It was decided therefore to proceed without correcting for serial correlation.

The calculation of the elasticities and flexibilities is outlined in Appendix Two. In order to generate flexibilities and elasticities for each quarter/season, the model had to be re-estimated, each time normalizing at the first point of the quarter i.e. for quarter 1 at March 1988. The values for A_i then used in the calculation of elasticities and flexibilities are generated from the following expression:

$$A_i = \frac{\alpha_i + \Theta_{iK} + æ_i \,.\, \ln(t)}{-1 + \Theta_{HK} + æ_H \,.\, \ln(t)}$$

where,

$t = 84$

A matrix of price elasticities (total) for each quarter is then generated, and a matrix for flexibilities is obtained by inverting this matrix. The following two tables (Tables 4 and 5) illustrate the elasticities and flexibilities generated from the model.

Commodity Code

1 = Mutton and lamb

2 = Steer beef

3 = Other beef

4 = Bacon and ham

5 = Pork

Table 4 : **Elasticities for the Direct Translog Model, by Season**

Quarter 4 (December, January, February)

with respect to

Group	Income	Price (total)				
		1	2	3	4	5
1	2.101	-2.629	0.444	0.057	-0.190	-0.082
2	1.087	0.503	-5.134	3.302	0.265	0.109
3	1.143	0.238	3.115	-3.959	-0.142	-0.343
4	-0.153	0.071	1.017	0.020	-3.982	3.412
5	0.362	0.204	0.307	-0.297	1.702	-2.506

Quarter 3 (September, October, November)

with respect to

Group	Income	Price (total)				
		1	2	3	4	5
1	1.664	-2.400	-0.137	0.536	-0.256	0.089
2	0.262	0.153	-3.789	2.326	0.204	0.079
3	2.074	0.437	2.364	-3.508	0.024	-0.525
4	-0.726	-0.058	0.966	0.862	-8.745	8.411
5	0.821	0.294	-0.001	-0.457	4.320	-5.185

Quarter 2 (June, July, August)

with respect to

Group	Income	Price (total)				
		1	2	3	4	5
1	1.675	-2.408	0.610	-0.192	-0.337	0.069
2	1.849	0.583	-5.247	3.225	0.282	-0.009
3	0.682	0.076	2.922	-3.663	-0.077	-0.330
4	-0.947	-0.181	1.522	0.255	-8.909	8.347
5	0.766	0.230	0.279	-0.598	4.526	-5.311

Quarter 1 (march, April, May)

with respect to

Group	Income	Price (total)				
		1	2	3	4	5
1	1.220	-2.073	0.056	0.288	-0.398	0.249
2	0.590	0.218	-5.682	3.912	0.190	0.259
3	1.965	0.239	3.817	-4.678	0.019	-0.663
4	-1.949	-0.335	1.273	1.179	-14.440	13.921
5	1.579	0.395	0.196	-0.954	7.741	-8.538

Table 5 : Flexibilities for the Direct Translog Model, by Season

Quarter 4

with respect to quantity

Group	1	2	3	4	5
1	-0.386	-0.050	-0.054	0.056	0.093
2	-0.111	-0.418	-0.351	-0.007	0.018
3	-0.097	-0.309	-0.520	0.043	0.120
4	-0.151	-0.290	-0.181	-0.605	-0.811
5	-0.136	-0.216	-0.109	-0.412	-0.953

Quarter 3

with respect to quantity

Group	1	2	3	4	5
1	-0.421	-0.015	-0.072	0.059	0.095
2	-0.082	-0.456	-0.317	0.013	0.046
3	-0.087	-0.280	-0.487	0.082	0.176
4	-0.153	-0.276	-0.227	-0.548	-0.873
5	-0.144	-0.206	-0.150	-0.461	-0.931

Quarter 2

with respect to quantity

Group	1	2	3	4	5
1	-0.422	-0.052	-0.035	0.065	0.098
2	-0.098	-0.383	-0.340	0.024	0.059
3	-0.071	-0.276	-0.531	0.075	0.150
4	-0.148	-0.321	-0.174	-0.549	-0.853
5	-0.147	-0.265	-0.108	-0.471	-0.923

Quarter 1

with respect to quantity

Group	1	2	3	4	5
1	-0.485	-0.025	-0.053	0.057	0.083
2	-0.076	-0.401	-0.345	0.024	0.051
3	-0.068	-0.295	-0.478	0.090	0.174
4	-0.135	-0.294	-0.212	-0.539	-0.874
5	-0.139	-0.244	-0.149	-0.495	-0.924

As can be seen from Table Five some of the income elasticities are somewhat peculiar, notably for steer beef, which in quarters 1 and 4 is a normal good, in quarter 3 an inferior good and in quarter 2 a luxury good. Sheep meat is a luxury good throughout; other beef is a luxury good for 3 quarters; pork is a normal good throughout, and bacon and ham is an inferior good throughout. These relationships are somewhat strange given the nature of the commodities i.e. one would expect them to all have income elasticities showing them to be normal goods or luxuries (in each quarter), but it must be remembered that these are not true income elasticities as we are only regarding income spent on meats, and so to draw too strong a conclusion to their meaning is not appropriate). There are also quite a few complementary relationships between commodities as shown by the price elasticities especially between commodities 3 and 5 and 1 and 4 (as shown by negative elasticities in most quarters for ε_{35}, ε_{53}, ε_{14} and ε_{41}), although one should in practice examine the compensated price elasticities to assess this, which are given by the expression

$$\varepsilon^*_{ij} = \varepsilon_{ij} + n_j w_j$$

where

ε^*_{ij} = compensated price elasticity

ε_{ij} = uncompensated price elasticity

n_j = income elasticity

w_j = budget share (at point of normalization)

This transformation does however still leave some complimentary relationships for certain meats, which is somewhat curious.

For the direct translog model, we are more concerned (given the structure of the model) with price flexibilities, as they reveal the changes in prices brought about by changes in the exogenous supply of a meat commodity. The flexibilities generated by our model are as stated in Diagram Six.

Some of the flexibilities are rather counter intuitive, notably f_{14}, f_{15}, f_{24}, f_{25}, f_{34} and f_{35} which are all positive (albeit small in value) whereby an increase in the supply of commodity 4 or 5 will lead to an increase in the price of commodities 1, 2 and 3. In our estimation we did find that estimating 'sensible' flexibilities for pork, and bacon and ham was difficult using different model specifications, and even aggregating the two commodities together did not solve this problem. As will be seen later the model also does not simulate very well for these two commodities.

The other flexibilities in the matrices however are seemingly quite plausible. They do not vary greatly from one quarter to the next, as would be expected, and are negative. It is also worth noting that given the closeness of commodities 2 and 3, and 4 and 5 we observe plausible values for flexibilities where the following are throughout similar in value:

f_{21} and f_{31}

f_{22} and f_{23}

f_{32} and f_{33}

f_{22} and f_{32} Although less so

f_{23} and f_{33}

f_{12} and f_{13}

f_{41} and f_{51}

f_{42} and f_{52}

f_{43} and f_{53}

f_{44} and f_{54}

f_{45} and f_{55}

f_{42} and f_{43}

f_{52} and f_{53}

f_{42} and f_{52} Although less so

f_{43} and f_{53}

i.e. we would expect for instance an increase in the supply of steer beef (commodity 2) to have a similar impact on both steer price and other beef price (commodity 3).

It is also true that the positive flexibilities we have illustrated also show this pattern i.e. the following are similar in value

f_{14} and f_{15}

f_{24} and f_{25}

f_{34} and f_{55}

These factors then, convey that we have to some extent captured the market structure of the U.K. meat sector, although obviously we have some rather tenuous values i.e. positive cross-price flexibilities.

We can also calculate elasticities and flexibilities removing the effect of tastes i.e. setting t = 7 (the first period value for t) in the formula for A_1 where,

$$A_1 = \frac{\alpha_1 + \Theta_{1K} + æ_1 \,.\, \ln(t)}{-1 + \Theta_{MK} + æ_M \,.\ln(t)}$$

This however had a very minute effect on the elasticities and flexiilities, and as such we have not reported them here. As we shall see in the next section tastes have had a very small effect on the budget shares and prices of meats over our estimation period.

We will now go on to show the results of the model simulation, which will illustrate the models explanatory power.

There were two sub-models used in the simulation the first being simultaneous; and the second recursive (using simulated values for certain endogenous variables). These are illustrated below where the recovered parameters from the estimation shown in Table 3 were used in the simulation.

<u>Sub-Model 1</u> (simultaneous)

(10)

$$W_2 = \frac{\alpha_2 + \sum_{j\neq 2or5} B_{1j} \ln(X_j/X5 + B_{22} \ln(\underline{X2N\text{-}INTBUY}/X5) + B_{m2} \ln(X5)}{-1 + \sum_{j\neq 2} B_{mj} \ln(X_j) + B_{m2} \ln(X2N\text{-}INTBUY) +}$$

$$\frac{+ \sum_K \theta_{2K}\, D_K + æ_2 \ln(t)}{+ \sum_K \theta_{mK}.D_K + æ_m \ln(t)}$$

(11)

$$P2 = \frac{W2 \times M}{(X2N-INTBUY)}$$

(12)

$$INTBUY = \exp(E1 + E2.FD + E3.HD + E4.MD + E5 \ln(\frac{P2}{INTPR}) + E6 \ln(INTBUY(t-1)))$$

Here it is clearly seen that we have a simultaneous model, with the endogenous variables W_2, P_2 and INTBUY occurring as explanatory variables in at least one of the other equations, and all equations having one endogenous variable in the right-hand side. The model is also dynamic in that the simulated values for INTBUY from the previous period appear as the lagged values for INTBUY in the current period.

<u>Sub-Model 2</u> (Recursive with endogenous variables in right hand side

i = 2

(13)

$$W_1 = \frac{\alpha_1 + \sum_{j \neq 2 or 5} B_{1j} \ln(X_j/X5) + B_{12} \ln(\frac{X2N-INTBUY}{X5}) + B_{m1} \ln(X5)}{-1 + \sum_{j \neq 2} B_{mj} \ln(X_j) + B_{m2} \ln(X2N-INTBUY)}$$

$$\frac{+ \sum_K \theta_{1K}.D_K + æ_1 \ln(t)}{+ \sum_K \theta_{mK}.D_K + æ_m \ln(t)}$$

(14)

$$P_1 = \frac{W_1 \times M}{X_1}$$

The Theil U2 statistics (1969 using changes) generated by the simulation for both the static and dynamic models are shown below in Table 6. These indicate the model's explanatory power more precisely.

TABLE SIX : Theil U2 Statistics (1969 using changes)

VARIABLE	STATIC MODEL U2 STATISTIC	DYNAMIC MODEL U2 STATISTIC
W1	0.65204	0.65357
W2	0.56754	0.67514
W3	0.30587	0.27175
W4	0.99153	1.02486
W5	1.24329	1.28670
INTBUY	0.50622	0.65357
P1	0.72992	0.73236
P2	1.44564	1.30477
P3	1.57191	1.40750
P4	2.02536	2.10130
P5	1.94393	2.00757

Commodity code: 1 = mutton and lamb, 2 = steer beef, 3 = other beef, 4 = bacon and ham 5 = pork.

This version of the U2 statistic has a range between o and infinity, where anything less than one is generally regarded as a good fit. A value of 1 indicates naive expectations i.e. of $P_{t+1} = P_t$.

As can be seen from the Theil U2 statistics, the model performs well for the budget shares and for INTBUY, with all U2 statistics below 1, apart from for W5. In fact the equations for W1, W2, W3 and INTBUY perform very well indeed. The equations for W4 and W5 perform less well, though not badly by any means.

When, however we view the U2 statistics for prices, we see that the model performs less well. It seems that the errors in the budget share simulations (i.e. $W_{1,s} - W_1$) are accentuated in the simulations for prices, but what has in fact happened is a rescaling by the income term M, which makes seemingly small errors in terms of budget shares into much larger ones in terms of prices. This then has the effect of making the price simulations look somewhat less acceptable. For P2 and P3 the actual series are very static in nature , whereas the simulated values in fact show a seasonal type pattern, over accentuating the movements in prices.

As stated previously throughout our modelling it was difficult to achieve sensible results for pork and bacon and ham, and given their seemingly somewhat random movement in prices it was difficult to achieve reasonable simulation values. Aggregating the two commodities for instance could not overcome this problem.

The results however are reasonable for prices, and by no means unacceptable.

(9) Forecasting with the Model

In this section then, we will present the results of ex poste forecasts carried out over the period 1989:1 to 1989:10. It is worth pointing out that this particular model can also be used for ex ante forecasting once values of the exogenous variables in the model have been predetermined/forecasted. The principle requirements are the quantities of meat supplied/available for consumption, the level of the beef intervention price, and the total expenditure on all meats.

Given the drastic changes that have occured in the beef intervention system during 1989, and the high level of beef market prices relative to intervention prices leading to very low levels of intervention buying during 1989, it was felt the model may not perform very well, with the simplistic intervention equation specified. However, we proceeded to carry out forecasting keeping the intervention buying equation, using actual values of the exogenous variables specified in the intervention buying equation, the actual values for the domestic supply (X_i) variables and the actual value for income M (where M $= \Sigma P_i.X_i$). The model then was simulated dynamically over the forecast period and, the forecast values for budget shares, prices and intervention purchases were then compared with their actual values over the forecast period.

The following Theil U2 statistics (1969 using changes) were generated shown below in Table 7.

TABLE 7 : THEIL U2 STATISTICS (1969 USING CHANGES) FOR THE FORECAST PERIOD (1989:1 TO 1989:10)

VARIABLE	U2 STATISTIC STATIC SIMULATION	DYNAMIC SIMULATION
W1	1.045	1.052
W2	0.449	0.487
W3	0.290	0.245
W4	0.826	0.764
W5	1.280	1.193
INTBUY	0.820	1.130
P1	0.820	0.825
P2	0.927	1.073
P3	0.935	0.824
P4	1.503	1.399
P5	1.735	1.623

Commodity code: 1 = mutton and lamb, 2 = steer beef, 3 = other beef, 4 = bacon and ham, 5 = pork.

As we can see the model performs well in generating forecasts of the endogenous variables with most Theil U2 statistics having values near to unity and the highest (that for pork price) being only 1.74 for the static simulation (for further explanation of Theil U2 statistics see section 8). In actual fact the model performs better for the forecast period than it did for the estimation period 1982:7 to 1988:10. These results then are encouraging, and allow us to assert that the model seems to form an adequate representation of the U.K. beef and meats market, and in so doing allows us to forecast with some accuracy, future meat prices. This is obviously dependent upon the accuracy, or otherwise of the forecasted exogenous variables in the model if one wishes to carry out ex ante forecasting, but if this is achievable forecasting is straightforward and possibly reasonably accurate.

(11) Conclusions and Summary

In this chapter we have used our knowledge of the red meat market to construct an econometric model which uses the theory of neo-classical demand. The direct translog model used provided a means for capturing how market prices (for red meats) are determined at the market level.

In our modelling we took into account the endogenous nature of intervention buying operations and made the model simultaneous using instrumental variables and two-stage least squares estimation procedures.

For our chosen model we have presented elasticities and flexibilities, which led us to believe we had to some extent captured the workings of the UK red meat sector, and the mechanism of price determination. The simulation results showed, that although the model worked very well for budget shares it worked less well for prices. This may be because although our model looks complex it is quite simple in nature, having very few independent variables, making it difficult to explain price determination in a quite limited means. We must however stress that we feel we have captured the basic mechanisms and causality relationships in the red meat market in our model. When the model was used for forecasting it performed quite well, again leading us to the conclusion that we had captured the workings of the UK red meat market. Of course improvements could be made by say including chicken if reasonable data could be obtained, and by maybe trying to disaggregate beef in a different manner (i.e. steer and heifer beef).

APPENDIX ONE: DATA

Sources:

(1) The Uk Handbook (1987-89) MLC.

(2) The Uk Weekly Market Survey (Various issues 6/82 - 12/88) MLC.

(3) Data Files (1982-88) MLC.

(4) Intervention Board for Agricultural Produce Yearbook (issues from 1982-1989) IBAP.

(5) Press Notices IBAP.

(6) Her Majesty's Customs and Excise figures. Summary sheets. MLC.

All data on a monthly basis from June 1982, to December 1988 (and for the forecast periods).

Series Name	Sources
AMPS	1
APRDUM	-
AUGDUM	-
BACOP	1
BHM	6
BHX	6
BMF	6
BMFC	6
BNO	3
BPR	3
BXF	6
BXFC	6
CNO	3
CPR	3
CUTTP	1
D1	-
D2	-
D3	-
DMX	-
FD	2
FEBDUM	-
HD	2
HNO	3
HPR	3
INPRO	Transformed Variable
INTBUY	4,5
INTDOM	Transformed Variable
INTEX	Transformed Variable
INTPR	2
INTSALBI	4,5
INTSALBL	4,5
INTSALES	Transformed Variable
JANDUM	-
JULDUM	-
JUNDUM	-
LINTBUY	Transformed Variable
M	Transformed Variable
MARDUM	-
MAYDUM	-
MD	2
MLM	6
MLX	6
NOVDUM	-
OCTDUM	-
P1	Transformed Variable
P2	"

Series Name	Sources
P3	Transformed Variable
P4	"
P5	"
PM	"
PORKP	1
PRODBH	1,3
PRODBV	1,3
PRODML	1,3
PRODP	1,3
PX	6
RT	2
SEPDUM	-
SNO	3
SPR	3
TIME	-
UT	2
W1	Transformed Variable
W2	"
W3	"
W4	"
W5	"
X1	"
X2	"
X2N	"
X3	"
X4	"
X5	"

APPENDIX TWO: ELASTICITIES AND FLEXIBILITIES

(See, Burton (1988) Christensen and Manser (1977).)

The price flexibilities for the direct translog model can be derived directly as follows,

$$n_{ij} = -\delta_{ij} + \frac{d\ \ln(W_i)}{d\ \ln(P_j)} = -\delta_{ij} + \frac{B_{ji}/W_i + \sum_i B_{ij}}{-1 + \sum_j\sum_i B_{ij}\ \ln(P_j)}$$

where δ_{ij} is the Kronecker delta

= 1

0 otherwise

The derivation of the price elasticities for the direct translog model has to use the bordered Hessian matrix; where if the elasticities are calculated at the point of normalization of the exogenous variables (where X_i=1 i.e. in 1988.12 the derivation becomes far easier.

The bordered Hessian H is defined as:

$$H = \begin{vmatrix} 0 & -P_1 & -P_2 & .. & .. & -P_n \\ -P_1 & U_{11} & U_{12} & .. & .. & U_{1n} \\ -P_2 & U_{21} & U_{22} & .. & .. & U_{2n} \\ .. & .. & .. & .. & .. & .. \\ .. & .. & .. & .. & .. & .. \\ -P_n & .. & .. & .. & .. & U_{nn} \end{vmatrix}$$

$$U_{ij} = \frac{d^2U}{dX_i\ dX_j}$$

If X_i, X_j = 1 then $U_{ij} = A_i\ \delta_{ij} - B_{ij}$

$U_i = -A_i$

where $A_i = \dfrac{\alpha_i + \Theta_{ik}. + a_i.\ln(t)}{-1 + \Theta_{mk}. + a_m.\ln(t)}$

t = value in final period.

Thus for the 5 commodity case we are estimating

$$H = \begin{vmatrix} 0 & -P_1 & -P_2 & -P_3 & -P_4 & -P_5 \\ -P_1 & A_1-B_{11} & -B_{12} & -B_{13} & -B_14 & -B_{15} \\ -P_2 & -B_{12} & A_2-B_{22} & -B_{23} & -B_{24} & -B_{25} \\ -P_3 & -B_{13} & -B_{23} & A_3-B_{33} & -B_{34} & -B_{35} \\ -P_4 & -B_{14} & -B_{24} & -B_{34} & A_4-B_{44} & -B_{45} \\ -P_5 & -B_{15} & -B_{25} & -B_{35} & -B_{45} & A_5-B_{55} \end{vmatrix}$$

If we define the matrix M as

$$M = \begin{vmatrix} -M & P_1 & P_2 & .. & .. & .. & P_n \\ 0 & U_1 & 0 & 0 & .. & .. & 0 \\ 0 & 0 & U_2 & 0 & 0 & .. & 0 \\ 0 & 0 & 0 & U_3 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & U_n \end{vmatrix}$$

Or in the 5 commodity case applying the restriction $U_i = -A_i$.

$$M = \begin{vmatrix} -M & P_1 & P_2 & P_3 & P_4 & P_5 \\ 0 & -A_1 & 0 & 0 & 0 & 0 \\ 0 & 0 & -A_2 & 0 & 0 & 0 \\ 0 & 0 & 0 & -A_3 & 0 & 0 \\ 0 & 0 & 0 & 0 & -A_4 & 0 \\ 0 & 0 & 0 & 0 & 0 & -A_5 \end{vmatrix}$$

We can form E the matrix of income elasticities and uncompensated price elasticities as follows

$$E = H^{-1}.M$$

The income elasticity of the ith good is given by the (i+1,1) element of E i.e. $n_i = E(i+1,1)$. The price elasticity of the ith good with respect to the jth price is given by the (i+1, j+1) element of E

i.e. $n_{ij} = E(1+j, j+1)$

Compensated price elasticities (n^*_{ij}) can be retrieved via the Slutsky equation

$$n^*_{ij} = n_{ij} + W_j n_i$$

An alternative way of deriving the price flexibilities for the direct translog model has been derived by Houck (1965) where the matrix of own and cross flexibilities F is equal to the inverse of the matrix of own and cross price elasticities P

$$F = P^{-1}$$

This is in fact the way we calculated our flexibilities as we had already constructed the bordered Hessian matrix to test for a maximum.

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