



The World's Largest Open Access Agricultural & Applied Economics Digital Library

This document is discoverable and free to researchers across the globe due to the work of AgEcon Search.

Help ensure our sustainability.

Give to AgEcon Search

AgEcon Search

<http://ageconsearch.umn.edu>

aesearch@umn.edu

*Papers downloaded from **AgEcon Search** may be used for non-commercial purposes and personal study only. No other use, including posting to another Internet site, is permitted without permission from the copyright owner (not AgEcon Search), or as allowed under the provisions of Fair Use, U.S. Copyright Act, Title 17 U.S.C.*

No endorsement of AgEcon Search or its fundraising activities by the author(s) of the following work or their employer(s) is intended or implied.

Meat Demand in the UK: A Differential Approach

Panos Fousekis and Brian J. Revell

ABSTRACT

A differential approach is employed to analyze demand for meat in the United Kingdom during 1989-99. Differential demand systems with fixed price effects (Rotterdam and CBS) better explain consumers' retail purchase allocation decisions for beef, lamb, pork, bacon and poultry compared with models containing variable price effects (NBR and differential AIDS). The real expenditure and the Hicksian demand elasticities are generally found to be quite different from earlier studies using AIDS models. A quality change index of meat consumption is constructed from the estimated CBS model estimation results and decomposed into real expenditure, substitution, trend, seasonal and residual effects.

Key Words: *Meat demand, differential approach, model selection, UK.*

The choice of a functional form is at the interface of economic theory and the data. Applied demand studies normally proceed in two steps. First, behavioral assumptions are imposed which lead to a cost or to an indirect utility function. Second, a functional form is selected. Desirable properties of functional forms are parsimony and flexibility (Caves and Christensen; Barnett). The dual approach, which leads to functional forms with such properties, has become very popular in the last 30 years. Researchers, however, have become increasingly aware of two limitations of this approach. First, different dual functional forms often lead to different results even on the same data set (Howard and Shumway). Furthermore, economic theory does not provide any

guide for choosing *ex ante* among competing forms and only a limited basis for *ex-post* evaluation (such as when a model violates an economic law or a strong *a-priori* belief). Second, dual functional forms often fail to generate credible parameter estimates (Diewert and Wales).

In the field of consumer demand analysis the issue of selecting among competing functional forms has been addressed in a number of recent studies (Eales, Durham, and Wessels; Brown, Lee, and Seale; Lee, Brown, and Seale; Barten; Alston and Chalfant; Weather- spoon and Seale). They have demonstrated that a family of competing systems can be generated through alternative parameterisations of Theil's differential system (Theil, 1965 and 1980). Selection among these competing models is possible via simple parameter restrictions. The differential systems are locally flexible (Mountain), linear in parameters, and as parsimonious as the dual systems. It is not surprising therefore that their popularity is rising.

In this paper a differential approach is used

Panos Fousekis is a lecturer in the Department of Agricultural Economics at the Agricultural University of Athens, Greece, and Brian J Revell is Professor of Agricultural and Food Economics and Dean of the School of Management at Harper Adams University College in the UK. No senior authorship has been assigned. The authors thank the editorial reviewers for helpful and constructive comments.

to analyse meat demand in the U.K. As Bansback points out, food demand analysis in general and meat demand analysis in particular are topics that will continue to attract the attention of researchers for the near future. This is not least because the U.K. industry across all species will continue to experience significant changes in the aftermath of the BSE (*bovine spongiform encephalopathy*) crisis, the forthcoming price support reductions under Agenda 2000, and the next WTO negotiations.

A considerable number of meat demand studies conducted in N. America since the late 1980s have adopted dual and differential systems approach (e.g., Kesavan and Buhr; Eales and Unnevehr; Gao and Spreen; Alston and Chalfant; Reynolds and Goddard; Moschini and Meilke). In the EU and the UK there have only been a few studies on meat demand which rely on systems (Tiffin and Tiffin; Laajimi and Albisu; Burton and Young, 1996 and 1992; Chesher and Rees). These studies used the dual approach and the AIDS specification (Deaton and Muellbauer). In none of them was model selection an issue. Their purpose was rather either to estimate wider food demand systems of which meat was a part or to examine the nature of structural change in meat demand. This paper focuses on appropriate model selection in a demand systems context.

The paper is structured as follows. Section 2 presents the theoretical model. Section 3 contains a discussion on the data used for the empirical analysis, the estimation results and comparisons with earlier studies. Section 4 presents a decomposition of the quality change in meat consumption in the UK for the period 1989:1 to 1999:2. Section 5 offers conclusions.

Differential Demand Models

A family of demand systems can be developed from alternative parameterisations of Theil's (1965) differential model

$$(1) \quad w_i d \ln q_i = \theta_i d \ln Q + \sum_{j=1}^n \pi_{ij} d \ln p_j, \\ i, j = 1, 2, \dots, n.$$

In system (1) w_i is the budget share, p_i and q_i are the price and the quantity respectively, $d \ln p_j$ and $d \ln q_i$ are the time rates of change of p_j and q_i , and $d \ln Q = \sum_{i=1}^n w_i d \ln q_i$ is the Divisia volume index of the aggregate quantity demanded. Parameter $\theta_i = p_i(\partial q_i / \partial m)$ is the marginal share, that is the proportion of a unit increase in total outlay m allocated to commodity i while parameter π_{ij} is the compensated price effect (Slutsky term) of a change in the price of the j th commodity on the demand for the i th commodity. The theoretical constraints on system (1) are

$$(2) \quad \sum_{i=1}^n \theta_i = 1,$$

$$\sum_{i=1}^n \pi_{ij} = 0, \quad \text{additivity;}$$

$$(3) \quad \sum_{j=1}^n \pi_{ij} = 0, \quad \text{homogeneity; and}$$

$$(4) \quad \pi_{ij} = \pi_{ji}, \quad \text{symmetry.}$$

The Rotterdam model is a particular parameterisation of the differential system (1) where the demand parameters θ_i and π_{ij} are assumed to be constant. However, there is no strong *a-priori* reason why the marginal shares and the price effects should be held constant. Allowing each θ_i to differ from w_i by a constant β_i results into the CBS (Central Bureau of Statistics) demand system (Keller and van Driel)

$$(5) \quad w_i d \ln q_i = (w_i + \beta_i) d \ln Q + \sum_{j=1}^n \pi_{ij} d \ln p_j, \\ i, j = 1, 2, \dots, n.$$

The CBS system has variable real income, that is, real expenditure effects (variable marginal shares) and constant compensated price effects. For the CBS the requirement that the marginal shares add up to unity is satisfied when $\sum_{i=1}^n \beta_i = 0$.

The differential form of the AIDS model is obtained from (1) if, in addition to $\theta_i = w_i + \beta_i$, it is assumed that $\pi_{ij} = (\gamma_{ij} - w_i(\delta_{ij} - w_j))$, where δ_{ij} is the Kronecker delta. The differential form of the AIDS is thus

$$(6) \quad w_i d \ln q_i = (w_i + \beta_i) d \ln Q \\ + \sum_{i=1}^n (\gamma_{ij} - w_i(\delta_{ij} - w_j)) d \ln p_j, \\ i, j = 1, 2, \dots, n.$$

For this model the additivity condition requires $\sum_{i=1}^n \beta_i = 0$ and $\sum_{i=1}^n \gamma_{ij} = 0$ while homogeneity and symmetry require $\sum_{i=1}^n \gamma_{ij} = 0$ and $\gamma_{ij} = \gamma_{ji}$ respectively. The differential AIDS has both the real income effects and the compensated price effects variable.

A fourth alternative, the NBR (Neves) system, can be developed from (6) by substituting $\theta_i - w_i$ for β_i . The NBR system which has fixed real income effects and variable compensated price effects can be written as

$$(7) \quad w_i d \ln q_i = \theta_i d \ln Q \\ + \sum_{i=1}^n (\gamma_{ij} - w_i(\delta_{ij} - w_j)) d \ln p_j, \\ i, j = 1, 2, \dots, n.$$

The Rotterdam, the CBS, the differential AIDS, and the NBR systems are not nested. Barten shows, however, the general (synthetic) model nests all four:

$$(8) \quad w_i d \ln q_i = (\delta_1 w_i + d_i) d \ln Q \\ + \sum_{j=1}^n (e_{ij} - \delta_2 w_i(\delta_{ij} - w_j)) d \ln p_j, \\ i, j = 1, 2, \dots, n$$

where $d_i = \delta_1 \beta_i + (1 - \delta_1) \theta_i$, $e_{ij} = \delta_2 \gamma_{ij} + (1 - \delta_2) \pi_{ij}$; and δ_1 and δ_2 are two additional parameters. When both δ_1 and δ_2 are zero system (8) reduces to the Rotterdam. When $\delta_1 = 1$ and $\delta_2 = 0$, $\delta_1 = 1$ and $\delta_2 = 1$ and, $\delta_1 = 0$ and $\delta_2 = 1$, it reduces to the CBS, to the differential AIDS, and to the NBR respectively. The theoretical restrictions on (8) are

$$(9) \quad \sum_{i=1}^n d_i = 1 - \delta_1,$$

$$\sum_{i=1}^n e_{ij} = 0, \quad \text{additivity;}$$

$$(10) \quad \sum_{j=1}^n e_{ij} = 0, \quad \text{homogeneity; and}$$

$$(11) \quad e_{ij} = e_{ji}, \quad \text{symmetry.}$$

Table 1a. Budget Shares, Prices and Quantities for the Five Meats^a

	Budget Share	Price ^b	Quantity ^c
Beef	0.29	4.44	22506
Pork	0.144	3.32	14931
Poultry	0.274	2.43	38833
Bacon	0.175	4.18	14474
Lamb	0.117	3.79	10946

^a At the sample mean, 1989:1 to 1999:2.

^b Prices are in Pounds sterling per Kg.

^c Quantities in tonnes per month.

The Likelihood Ratio Test (LRT) for model selection is $LRT = -2(\ln L(\phi^*) - \ln L(\phi))$ where ϕ^* is the vector of parameter estimates of a restricted model (i.e., Rotterdam, CBS, differential AIDS, and NBR), ϕ is the vector of parameter estimates of the synthetic and $L(\cdot)$ is the log value of the likelihood function (Amemiya). Under the null hypothesis that a restricted model best describes the data, the LRT statistic has an asymptotic χ^2 distribution with 2 degrees of freedom, where 2 is the number of restrictions imposed.

Data, Model Selection and Demand Elasticities

The Data

Calendar monthly household purchases and expenditure in the UK for the major species of meat (beef, lamb, pork, bacon, and poultry) were derived from four weekly AGB Taylor Nelson Sofres consumer Superpanel data.¹ The latter comprises a continuous sample of 8000 households. Sample data were available for January 1989 to February 1999.

Table 1a presents the sample mean budget shares, unit prices, and quantities purchased of the five meats. Beef had the highest budget share followed by poultry, bacon, pork and lamb. Beef was also the most expensive meat while poultry had the lowest price and the greatest purchase volume. Table 1b presents sample mean budget shares in different sub-

¹ Supplied by the Meat and Livestock Commission.

Table 1b. Budget Shares at Different Sub-Periods

	Beef	Pork	Poultry	Bacon	Lamb
1989–92	0.32	0.14	0.24	0.17	0.13
1993–95	0.30	0.14	0.27	0.17	0.11
1996–98	0.24	0.15	0.31	0.19	0.11

periods (1989–92, 1993–95, and 1996–98). There was a decrease in the budget share of beef and an increase in the share of poultry. The budget share of pork remained stable while there was a small increase in the budget share of bacon and a small decrease in the share of lamb.

Model Specification and Selection

Since seasonal (monthly) data are used for the empirical analysis, all models include 11 seasonal dummies (for February to December). They also include a constant term to capture possible gradual changes in tastes and preferences. Given that the four competing systems (Rotterdam, CBS, AIDS, and NBR) and the synthetic model automatically satisfy the adding-up restrictions, only four equations were estimated (the lamb equation was dropped).² The theoretical restrictions of homogeneity and symmetry were imposed and the systems estimated using the SURE method (Judge *et al.*) in the TSP4.3 program. Parameter estimates for all five models are available from the authors upon request.³

² The empirical results are robust to the choice of equation to be dropped.

³ An attempt was made to verify whether the 1996 BSE crisis affected allocation decisions. A dummy variable (taking value 0 prior to March 1996 and value 1 afterwards) was initially included in the models. The coefficients associated with this dummy were in all cases completely insignificant and the model selection results were not affected. While this may seem at first surprising, it should be remembered that in differential systems the allocation decisions are not budget shares (as in the AIDS model) but the contributions of each commodity to the change in the Divisia volume index (Theil, 1980). These contributions are given as $f_i = w_i d \ln q_i$. Over the sample period they do not show any outliers or abrupt changes. This explains why the inclusion of the BSE dummy did not affect the empirical results.

Table 2. The Likelihood Ratio Tests

Model	Log-likelihood	Test Statistic ^a
Synthetic	1866.51	—
Rotterdam	1865.05	2.92
CBS	1864.63	3.76
AIDS	1862.38	8.26
NBR	1863.15	6.72

^a The tabulated value is 5.99, at 5 percent level of significance.

Table 2 presents the log values of the likelihood function and the corresponding statistics for model selection. The Synthetic system rejects both the NBR and the AIDS models at the 5-percent level. It fails however to reject at the same level of significance both the Rotterdam and the CBS models.⁴ On purely statistical grounds the Rotterdam offers a slightly better description of the data compared with the CBS. Nevertheless, the latter appears superior to the former on the grounds of economic intuition according to which meat products must be substitutes in consumption (Kesavan and Buhr; Eales and Unnevehr). In particular all cross-compensated price effects for the CBS are positive. For the Rotterdam model, the Slutsky term describing the interactions between beef and lamb is negative (although insignificant), implying complementarity between these two types of meat.⁵ We mention here that Hicksian complementarity between lamb and pork, and lamb and other meats has been reported in the study of Tiffin and Tiffin which relied on a static dual AIDS. Complementarity between lamb and pork has been also reported in the study of Burton and Young (1992) from a dynamic AIDS model. Since both the CBS and the Rotterdam cannot be rejected and the CBS conforms with economic intuition, only results from the CBS are discussed further in this section. It should be emphasised, however, that the parameter esti-

⁴ The parameter estimate for δ_2 is -0.3 with a t-statistic -0.5 , thus rejecting decisively the AIDS and the NBR. The parameter estimate, however, for δ_1 is 0.4 with a t-statistic 1.8 . Because of this, the LRT cannot reject the Rotterdam and the CBS.

⁵ The relevant t-statistic is only -0.2 .

mates from the Rotterdam and the CBS are on the whole very similar.

In the estimated system all compensated own-price effects were negative and statistically significant at the 5-percent level or less. All ten compensated cross-price effects were positive and six of them statistically significant at the 5-percent level or less. From the 55 coefficients associated with the monthly dummies 21 were statistically significant at the 5-percent level or less, three statistically significant at the 10-percent level or less while several others were higher than their respective standard errors. This implies that allocation decisions are affected by seasonal factors. The trend terms, however, were not statistically significant. This is consistent with the relative stability of the allocation variables, $f_i = w_i d \ln q_i$, over time (see Footnote 3). The DW statistics range from 1.91 for the beef equation to 2.48 for the poultry equation. The eigenvalues of the Slutsky matrix $\pi = [\pi_{ij}]$ are -0.42 , -0.22 , -0.18 , -0.12 , and -0.0005 suggesting that the matrix is quasi-concave as stipulated by the economic theory.

Endogeneity, and Homotheticity Tests for the CBS Model

One potential problem with the differential systems is that of endogeneity which may arise when $d \ln Q$ and the disturbance terms in demand equations are not independent of each other (Attfield). To test for endogeneity we resort to the Theory of Rational Random Behavior (Theil, 1980; Duffy) according to which $d \ln Q$ is exogenous when the disturbance terms are proportional to the Slutsky terms. For the CBS model, exogeneity requires $\text{cov}(u_i, u_j) = \lambda \pi_{ij}$, where λ is a factor of proportionality and u 's are the residuals. Here, the regression of the covariances on a constant and the Slutsky terms gives $\text{cov}(u_i, u_j) = -0.26(8.49) - 167.1(48.41)$ with $R^2 = 0.44$ and where the numbers in parentheses are standard errors. The fact that the intercept is insignificant but the slope is not suggests that the residual covariances are indeed proportional to the Slutsky terms. Thus, treating $d \ln Q$

as exogenous appears to be a reasonable approach for this data set.

Preferences over meat products are homothetic when marginal shares are equal to the corresponding budget shares. For the CBS model, homotheticity requires $\beta_i = 0$ for all i . The Wald test (Judge *et al.*) is used to examine homotheticity. The appropriate test statistic is the χ^2 distribution with four degrees of freedom.⁶ The empirical value is 34.01 while the tabulated value at the 5-percent level is 9.46. We therefore conclude that preferences are non-homothetic implying that the budget shares of the meats in the UK differ from their marginal shares or, equivalently, that the budget shares of the individual meats depend on the aggregate expenditure on meat.

Elasticity Estimates from the CBS Model

The expenditure elasticity (η_i) and the compensated price elasticity (η_{ij}) are given as

$$(12) \quad \eta_i = (\beta_i/w_i + 1) \quad \text{and}$$

$$(13) \quad \eta_{ij} = \pi_{ij}/w_i, \quad \text{respectively.}$$

Table 3 presents the expenditure and the compensated price elasticities along with their corresponding standard errors.⁷ The expenditure elasticities of beef, pork, poultry and bacon are very close to unity while that of lamb is low. These results are consistent with the findings of Tiffin and Tiffin. They are different, however, from those of Burton and Young (1996) which indicated expenditure elastic demand for lamb and expenditure inelastic demand for pork and poultry. The Hicksian own-price elasticities are all close to unity. Tiffin and Tiffin found that pork and chicken demand were own-price elastic while lamb demand was inelastic. In contrast Burton and

⁶ We test the null hypothesis $\beta_1 = \beta_2 = \beta_3 = \beta_4 = 0$. If this is true, then $\beta_5 = 0$ as well because from the adding-up condition the constants β sum to zero.

⁷ The variances of the expenditure elasticities are calculated as $\text{Var}(\eta_i) = \text{Var}(1 + \beta_i/w_i) = \text{Var}(\beta_i)/(\bar{w}_i)^2$ while the variances of the compensated price elasticities are calculated as $\text{Var}(\eta_{ij}) = \text{Var}(\pi_{ij})/(\bar{w}_i)^2$, where the symbol bar indicates that the evaluation takes place at the average shares.

Table 3. Expenditure and Hicksian Elasticity Estimates.^a

	Expenditure	Price Elasticities				
	Elasticity	Beef	Pork	Poultry	Bacon	Lamb
Beef	0.996* (0.082) ^b	-0.844* (0.171)	0.017 (0.077)	0.489* (0.101)	0.314* (0.08)	0.023 (0.077)
Pork	0.946* (0.07)	0.034 (0.156)	-1.002* (0.144)	0.504* (0.095)	0.095 (0.113)	0.391* (0.093)
Poultry	1.097* (0.078)	0.518* (0.107)	0.264* (0.049)	-0.983* (0.1)	0.041 (0.05)	0.159* (0.053)
Bacon	1.172* (0.058)	0.521* (0.133)	0.078 (0.093)	0.066 (0.079)	-0.855* (0.132)	0.19* (0.079)
Lamb	0.588* (0.093)	0.057 (0.191)	0.48* (0.114)	0.373* (0.123)	0.284* (0.119)	-1.196* (0.153)

^a Evaluated at the mean sample shares.^b Asymptotic standard error in parentheses.

* Statistically significant at 5 percent or less.

Young (1996) found the demand for lamb to be elastic and the demand for pork and poultry inelastic. Almost all cross-price Hicksian elasticities are smaller than 0.5, confirming the limited substitution possibilities suggested by the studies of Tiffin and Tiffin, and Burton and Young (1996).

The Marshallian (uncompensated) price elasticities are derived from the Hicksian compensated price and the expenditure elasticities using the formula

$$(14) \quad m_{ij} = \eta_{ij} - \eta_i w_j.$$

Table 4 presents the Marshallian price elasticities along with their corresponding standard errors.⁸ Gross complementarity in consumption appears to be the case for the pairs beef and lamb, pork and bacon, and poultry and bacon.

For the proper interpretation of the elasticities presented in Tables 3 and 4, the theoretical framework that underlies the estimated system should be borne in mind. Consumers are assumed to follow a multi-stage approach in allocating aggregate expenditure. In the first

stage, the allocation takes place among broad groups of goods that are separable from each other. In a second stage expenditure within each group is further allocated among the goods making up that group (Theil, 1980; Deaton and Muellbauer). Hence meat is considered as a single composite commodity among others within some primary group, *viz.* food. Given the decisions made in the first stage, UK consumers then allocate the aggregate expenditure on meat to beef, pork, lamb, poultry, and bacon. Thus the price and expenditure elasticities in Tables 3 and 4 should be interpreted as conditional on the first stage decision, that is on the expenditure allocated to meat as a whole.

Quality Change in Meat Consumption and its Decomposition

In economics the term *quality change in consumption* does not involve any outside judgement of what is "good" for the consumer. It measures the desirability of the consumption basket from the consumer's point of view as revealed by his/her behaviour. Commodities for which the marginal share exceeds the corresponding budget share are more attractive to the consumer. Based on this reasoning Theil (1980) proposed the following quality change index (QCI) in consumption in differential form

⁸ The variances of the Marshallian price elasticities are calculated as

$$\begin{aligned} \text{Var}(m_{ij}) = & \text{Var}(\eta_{ij}) + \text{Var}(\eta_i)(\bar{w}_j)^2 \\ & - 2\bar{w}_j \text{Cov}(\eta_{ij}, \eta_i). \end{aligned}$$

Table 4. Marshalian Price Elasticities^a

	Beef	Pork	Poultry	Bacon	Lamb
Beef	-1.332* (0.176) ^b	-0.126 (0.078)	0.216* (0.093)	0.14** (0.082)	-0.093 (0.079)
Pork	-0.241 (0.158)	-1.161* (0.146)	0.245* (0.086)	-0.07 (0.115)	0.281* (0.096)
Poultry	0.199** (0.116)	0.106* (0.052)	-1.284* (0.095)	-0.15* (0.053)	0.031 (0.055)
Bacon	0.181 (0.133)	-0.09 (0.093)	-0.256* (0.072)	-1.06* (0.135)	0.053 (0.082)
Lamb	-0.113 (0.192)	0.396* (0.116)	0.22** (0.112)	0.181 (0.122)	-1.264* (0.157)

^a Evaluated at the mean sample shares.^b Asymptotic standard error in parentheses.

* (**) Statistically significant at the 5- (10-)percent level or less.

$$(15) \quad QCI = d \ln Q^F - d \ln Q,$$

where $d \ln Q^F$ is the Frisch quantity index which weighs quantity changes of individual commodities by the respective marginal shares.

For the CBS model the QCI can be written as

$$(16) \quad QCI = \sum_{i=1}^n \beta_i d \ln q_i.$$

Substituting (5) into (16) and taking into account that each of the estimated equations involves constant terms and seasonal dummies yields

$$(17) \quad QCI = \sum_{i=1}^5 \beta_i (c_i/w_i) + \sum_{i=1}^5 \sum_{h=1}^{11} \beta_i (a_{ih}/w_i) s_h \\ + \sum_{i=1}^5 \beta_i (\beta_i/w_i + 1) d \ln Q \\ + \sum_{i=1}^5 \sum_{j=1}^5 \beta_i (\pi_{ij}/w_i) + \sum_{i=1}^5 \beta_i (u_i/w_i),$$

where $i, j = 1, \dots, 5$ attach to beef, pork, poultry, bacon, lamb and $h = 1, 2, \dots, 11$, to the seasonal dummies. The coefficients c_i are associated with trends and the coefficients a_{ih} with the seasonal (monthly) dummies, denoted as s_h .

Equation (17) decomposes the QCI into a trend effect, a seasonal effect, a real-expenditure effect, a substitution effect and a residual

effect. The real-expenditure effect increases *ceteris paribus* with the dispersion of expenditure elasticities among the commodities in the bundle. The substitution effect *ceteris paribus* becomes positive (negative) when the price of goods for which the marginal share exceeds the respective budget share tends to decrease (increase) relative to the rest of goods. The constant terms in differential demand systems represent trends and the coefficients of seasonal dummies represent seasonal deviations from these trends. The seasonal effect in (17) becomes, *ceteris paribus*, positive (negative) when the seasonal deviations from the trend of the commodities for which the marginal shares exceed the respective budget shares are positive (negative).

Table 5 presents the QCI decomposition for February 1989 to February 1999 as well as for the sub-periods February 1989 to February 1994 and March 1994 to February 1999. Over the whole sample there was a moderate increase in quality in consumption by 0.26 percent per annum. The real expenditure effect is negative largely because the Divisia quantity index has decreased at an annual average rate of 4.5 percent. The substitution effect is negative since the prices of poultry and bacon, for which the expenditure elasticities are greater than unity, have increased faster than the prices of the rest of the other meats. Specifically, the annual average rates of change of poultry and bacon prices have been 4.5 and 3.5 per-

Table 5. The Quality Change Index and its Decomposition

Period	Quality Change Index	Real Expenditure	Components of Quality Change ^a			
			Substitution	Trend	Seasonal	Residual
89:2–94:2	0.54	–0.204	0.23	–0.245	0.48	0.28
94:3–99:2	–0.19	–0.196	–0.31	–0.264	0.42	0.17
89:2–99:2	0.26	–0.168	–0.05	–0.253	0.47	0.26

^a The annual average rates of change have been calculated by multiplying the monthly average rates of change by 12.

cent respectively while the annual rates of change of beef, pork, and lamb prices have been 0.8, 2.2, and 3.4 percent respectively. The seasonal effect is positive because positive and statistically significant coefficients for the monthly dummies prevail in the poultry and bacon equations, where poultry and bacon are the commodities for which the marginal shares exceed the budget shares. Finally, the trend effect is negative since β and c coefficients with opposite signs appear in each estimated equation.

Over the first sub-period, the quality change is positive (annual rate of change 0.5 percent) while over the second sub-period the quality change is negative (annual rate of change –0.2 percent). Given that the real expenditure, the trend and seasonal effects in both sub-periods are very similar, the change in the sign of the QCI from positive to negative must be attributed to the substitution effect. In the first period the substitution effect is positive because the commodity which has the lowest expenditure elasticity (lamb) has by far the highest rate of change in price. In particular, in the first sub-period the annual average rate of increase in lamb price has been 5.7 percent while the annual rates of change of the remaining prices were lower than 3.4 percent. In the second sub-period, however, the largest rates of price change have been those for poultry and bacon (5.5 and 3.8 percent respectively), meats which have the highest expenditure elasticities.

Conclusions

This paper uses a differential demand systems approach in the analysis of five meats (beef, pork, poultry, bacon, and lamb) in the UK for

the period January, 1989 to February, 1999. Statistical tests show that the differential demand models with fixed price effects (the Rotterdam and the CBS models) explain the allocation decisions better compared with models containing variable price effects (NBR and differential AIDS models).

The expenditure elasticities for all meats except lamb are close to unity. This is in agreement with the results reported in the more recent study by Tiffin and Tiffin but contrasts with the earlier findings of Burton and Young. The Hicksian elasticities are, however, quite different from those reported in the aforementioned studies.

Theil's (1980) concept of quality in consumption has been used to calculate a quality change index and to decompose it into real expenditure, substitution, and other effects. It appears that after 1994 the quality change of meat consumption in the UK became negative largely due to the substitution effects induced by the increases in the prices of poultry and bacon relative to the prices of the other meats.

References

- Alston, J., and J. Chalfant (1993). "The Silence of the Lambdas: A Test for the AIDS and the Rotterdam Models". *American Journal of Agricultural Economics* 75:304–13.
- Amemiya, T. (1985). *Advanced Econometrics*. Harvard University Press, Cambridge.
- Attfield, C. (1985). "Homogeneity and Endogeneity in Systems of Demand Equations". *Journal of Econometrics* 27, 197–209.
- Bansback, B. (1995). "Towards A Broader Understanding of Meat Demand". *Journal of Agricultural Economics* 46:287–303.
- Barnett, W. (1983). "Definition of Second Order

- Approximations and of Flexible Functional Forms". *Economic Letters* 12:31–35.
- Barten, A. (1993). "Consumer Allocation Models: Choice of Functional Form". *Empirical Economics* 18:129–58.
- Brown, G., J. Lee, and J. Seale (1995). "A Family of Inverse Demand System and Choice of Functional Form". *Empirical Economics* 20:519–530.
- Burton, M. and T. Young (1992). "The Structure of Changing Tastes for Meat and Fish in Great Britain". *European Review of Agricultural Economics* 19:165–80.
- Burton, M., and T. Young (1996). "The Impact of BSE on Demand for Beef and Other Meats in Great Britain". *Applied Economics* 28:687–983.
- Caves, W., and L. Christensen (1980). "Global Properties of Flexible Functional Forms". *American Economic Review* 70: 322–32.
- Chesher, A., and H. Rees (1987). "Income Elasticities of Demand for Food in Great Britain". *Journal of Agricultural Economics* 38:433–48.
- Deaton, A., and J. Muellbauer (1980). "An Almost Ideal Demand System". *American Economic Review* 70:312–26.
- Diewert, W., and T. Wales (1987). "Flexible Functional Forms and Global Curvature Conditions". *Econometrica* 55:43–68.
- Duffy, M. (1987). "Advertising and InterProduct Distribution of Demand". *European Economic Review* 31, 1051–70.
- Eales, J., and L. Unnevehr (1994). "The Inverse Almost Ideal Demand System". *European Economic Review* 38:101–15.
- Eales, J., C. Durham, and C. Wessels (1997). "Generalized Models of Japanese Demand for Fish". *American Journal of Agricultural Economics* 79:1153–63.
- Gao, X., and T. Spreen (1994). "A Microeconomic Analysis of the U.S Meat Demand". *Canadian Journal of Agricultural Economics* 42:397–12.
- Howard, W., and C. Shumway (1989). "Nonrobustness of Dynamic Dual Models of the US Dairy Industry". *Northeastern Journal of Agricultural and Resource Economics* 18, 18–25.
- Judge, G., R. Hill, W. Griffiths, H. Lutkepohl, and T. Lee (1988). *Introduction to the Theory and Practice of Econometrics*. John Wiley, Chichester.
- Keller, W., and H. van Driel (1985). "Differential Consumer Demand Analysis". *European Economic Review* 27:375–90.
- Kesavan, T., and B. Buhr (1995). "Price Determination and Dynamic Adjustments: An Inverse Demand System Approach to Meat Products in the U.S". *Empirical Economics* 20:681–98.
- Laajaimi, A., and M. Albisu (1997). "La Demand de Viandes et de Poissons en Espagne: Une Analyse Micro-Economique". *Cahiers d'Economie et Sociologie Rurale* 42–43:72–91.
- Lee, J., G. Brown, and J. Seale (1994). "Model Choice in Consumer Analysis: Taiwan 1970–89". *American Journal of Agricultural Economics* 76:504–12.
- Moschini, G., and K. Meilke (1989). "Modelling the Pattern of Structural Change in the U.S Meat Demand". *American Journal of Agricultural Economics* 71:253–61.
- Mountain, D. (1988). "The Rotterdam Model: An Approximation in Variable Space". *Econometrica* 56:477–84.
- Neves, P. (1987). "An Analysis of Consumer Demand in Portugal, 1958–81". *Memoire de Maîtrise en Sciences Economiques*. Université Catholique de Louvain, Louvain-la-Neuve, Belgium.
- Reynolds, A., and E. Goddard (1991). "Structural Change in Canadian Meat Demand". *Canadian Journal of Agricultural Economics* 39:211–22.
- Theil, H. (1965). "The Information Approach to Demand Analysis". *Econometrica* 33:67–87.
- Theil, H. (1980). *The System-Wide Approach to Microeconomics*. University of Chicago Press, Chicago.
- Tiffin, A., and R. R. Tiffin (1999). "Estimates of Food Demand Elasticities for Great Britain". *Journal of Agricultural Economics* 50:140–47.
- Weatherspoon, D., and J. L. Seale Jr. (1995). "Do the Japanese Discriminate Against Australian Beef Imports? Evidence from the Differential Approach". *Journal of Agricultural and Applied Economics* 27(2):536–543.

