Marine Resource Economics, Volume 23, pp. 215–227
Printed in the U.S.A. All rights reserved

0738-1360/00 $3.00 + .00

A Demand Analysis of the UK Canned Tuna Market

SHABBAR JAFFRY
University of Portsmouth Business School

JAMES BROWN
Ministry of Fisheries, New Zealand

Abstract *This study provides an analysis of the retail level demand for canned tuna in the UK using four-weekly scanned data for the period 1995–99. The role of product medium is analysed, looking at the interactions between the traditional tuna in brine and oil and the more recent value added tuna in sauces. A system of demand equations is estimated using the dynamic almost ideal demand system (AIDS) model. All products are demonstrated to have negative and inelastic own price elasticities. Tuna in brine and sauce is shown to be a normal good, while tuna in oil was demonstrated to be a luxury good. Tuna in oil was indicated as being a substitute for tuna in sauce.*

Key words Demand, tuna, scanner data.

JEL Classification Code Q21.

Introduction

Processed food products are often presented in such a way that the product medium is the most important difference between product types and subsequently a major influence on consumer choices. In this article, the role of product medium is analysed, as opposed to the more traditional choice between product forms. When the consumer purchases a can of tuna with a particular use for it in mind, the medium may be the dominating factor, as the type of medium cannot be changed but the product form can. For example, tuna steak can be broken up into chunks and further into flakes if preferred, but a sauce cannot be transformed into brine. An empirical analysis is carried out for tuna in different product mediums available in the UK market. The canned tuna market, which was once traditionally dominated by low-value products, is now experiencing competition from higher-value products, such as tuna in 'sauces' (including mayonnaise, vegetable mixes, *etc*.), which have emerged as convenience foods.

To investigate the importance of product medium, scanner data collected at UK

Shabbar Jaffry is a reader in the Department of Economics, University of Portsmouth Business School, Richmond Building, Portland Street, Portsmouth, UK PO1 3DE, email: shabbar.jaffry@port.ac.uk. James Brown is Senior International Adviser, Ministry of Fisheries, ASB Bank House, 101-103 The Terrace, P O Box 1020, Wellington, New Zealand, email: james.brown@fish.govt.nz

This article is produced as part of the project, "Market-driven incentive structures for sustainable fisheries management (Missfish)," funded by the European Commission (EC) FAIR Programme (CT98 4255). The authors thank project leader Helen Pickering and project team members for their help throughout the research. We also thank Asghar Zaidi for his critical comments on earlier drafts of the paper.

retail supermarkets is used. Scanner data is becoming increasingly available for investigation of consumer behavior. These data sets have a substantially different structure from the type of datasets that are normally used in demand analysis. In particular they are less aggregated, so that one can investigate the relationship between very similar products and at times even different brands of the same product. So far, this has only been exploited for seafood products to a limited extent. Some recent exceptions include investigation into demand for canned tuna focusing into the dolphin-safe issue using scanner data (Wallstrom and Wessells 1995; Wessells and Wallstrom 1999) and study of the effect of dolphin-safe labelling for canned tuna in the USA (Teisl, Roe, and Hicks 2002). While this may not be too surprising given that much seafood is sold as fresh or unlabeled, there is still a number of important market segments that scanner data can shed light on.

Despite tuna being amongst the most important species in the world's fisheries, little formal investigation is done and limited knowledge is available about the demand structure for it. Wessells and Wilen (1994) and Johnson, Durham, and Wessells (1998) include a demand equation for tuna in an AIDS system investigating seafood demand in Japan. Bose and McIlgrom (1996) investigate market integration for different tuna species also in Japan. Unlike this study, however, which is based on retail price data, many of these other studies are derived demand studies. Canned tuna is not only amongst the most important product forms for this fish, but is also the most important canned fish product in the world and the EU, both in terms of value and volume of production (Suanzes-Carpegna 1998; US International Trade Commission 1998). Global production has steadily increased in the past 20 years from 600,000 MT to 1.4 million MT. The canned tuna market is also very important in the UK. Despite having no canned tuna industry, the UK has become a significant consumer of canned tuna, being the world's second largest importer after the USA at 108,000 MT in 1999 (Globefish 1999a), at a market value of $US 270M (Spruyt 2000).

In the UK, canned tuna is the most important fish purchased at retail level by volume, exceeding that of any other specie, whether canned, frozen, or fresh. Canned tuna accounts for the largest value and volume share of the canned fish market, in which it has experienced the highest growth in the last five years. The canned tuna market in the UK is highly competitive and has undergone substantial changes in the past decade. Whilst the UK consumer has remained very price conscious, the diversity of products has increased in the last decade, with value added products accounting for an increasing share of the market.

The article presents empirical findings of a study of canned tuna demand in the UK using four-weekly scanned data for the period 1995–2000, with particular attention given to the role of product medium, through conducting a demand analysis of retail level sales data. The demand system used is the dynamic almost ideal demand system (AIDS) of Anderson and Blundell (1983, 1984), estimated using full information maximum likelihood methodology. Performing a demand analysis enables one to determine the relationships and interactions between the various groups within the canned tuna market and hence provide a greater understanding of the structure and characteristics of the market. It is therefore useful for both policy makers and stakeholders in the market, for example processors, wholesalers, and retailers.

Adjustment costs for seafood demand have received some attention in the literature (Wessells and Wilen 1994; Asche 1997; Asche, Salvanes, and Steen 1997), and when investigated, it appears that there are adjustment costs present for most seafood products. This generates interest in using scanner data, as it contains not only more disaggregated information, but also contains products that list informational content on labels which develops habit formation.

Application of the AIDS to describe food markets and expenditure structures, including those of fish, has been extensive since its formulation. Examples of its application to the demand of fish include Jaffry, Pascoe, and Robinson (1999) and Burton and Young (1992) in the UK where changes in tastes of fish and meat were studied, and Wellman (1992), who considered price and income elasticities and substitution between fish and other protein products. Furthermore, Wellman (1992) also accounted for demographic effects, including age, sex, and geography, finding them all to be significant. Wessells and Wilen (1994); Eales, Durham, and Wessells (1997); and Eales and Wessells (1999) studied demand for fish in Japan. Asche (1996); Asche, Salvanes, and Steen (1997); and Asche, Bjørndal, and Salvanes (1998) analysed the demand structure for salmon in the EU. More relevant to this study, Teisl, Roe, and Hicks (2002) used AIDS methodology to determine the market effect of the dolphin-safe eco-label in the US, incorporating seafood, luncheon meat, and red meat in the system.

The paper begins with a detailed discussion of the UK market for canned tuna, with preliminary analysis of the retail sales data set. The demand theory (AIDS of Deaton and Muellbauer [1980a]) and methodologies employed in this analysis are then described, followed by the econometric specification of AIDS. The data source and grouping procedure is presented, together with the results of the analysis. The results are then discussed and conclusions are subsequently drawn.

The UK Canned Tuna Market

Canned tuna is the most important canned fish product in the UK. The total UK canned fish retail market is valued at US$519M, with canned tuna accounting for 52% of this at US$270M, followed by canned salmon (19%). Canned tuna is also the most important fish purchased at retail level by volume, being greater than any other species canned, frozen, or fresh (Spruyt 2000).

In terms of growth, the canned tuna market has outperformed the canned fish market since 1995, both in terms of volume and value. The canned tuna market grew 18% by 8,000 tonnes to 59,000 tonnes, while the canned fish market grew by 2% to 93,000 tonnes. Over the same period canned tuna grew by 25% in value to US$270M, whereas total canned fish sales increased by 9% to US$519M, with increases in the period 1997–99 being largely due to increases in salmon retail prices in 1997 and tuna in 1998 (Spruyt 2000).

This growth has been in spite of a fluctuating, sometimes significant, increase in retail price per volume of canned tuna. Prices were relatively stable between early 1995 and early 1997 at around £2.60/kg, as illustrated in figure 1, after which they increased to a high of £3/kg in 1999 and then fell to a low of £2.56/kg in early 2000. These changes in retail prices reflect the low landings and subsequently high raw material prices associated with the 1997 El Niño (FAO 1998).

The UK canned tuna market is comprised of approximately 70% retail sizes (typically 185g, 200g / 6.5-7 oz.) and 30% foodservice, catering, or institutional sizes (mainly 1.8 kg) (Spruyt 2000). Tuna has traditionally been consumed cold in sandwiches and salads, although it has increasingly been promoted in cooking recipes, helping fuel the increased demand over the last decade. It should be noted that almost the entire UK market is for skipjack tuna, with the average consumer being unaware of the differences between species. Only very recently has yellowfin tuna begun to emerge in the market due to a fall in its price.

Canned tuna is typically of the form flake, chunk, or steak. The market used to be dominated by tuna steak in oil, although the less expensive chunks and flakes grew in market share to 40% in 1993 (Josupeit 1993). At the same time, while oil was still the dominant medium, it was also reported that the market value share of

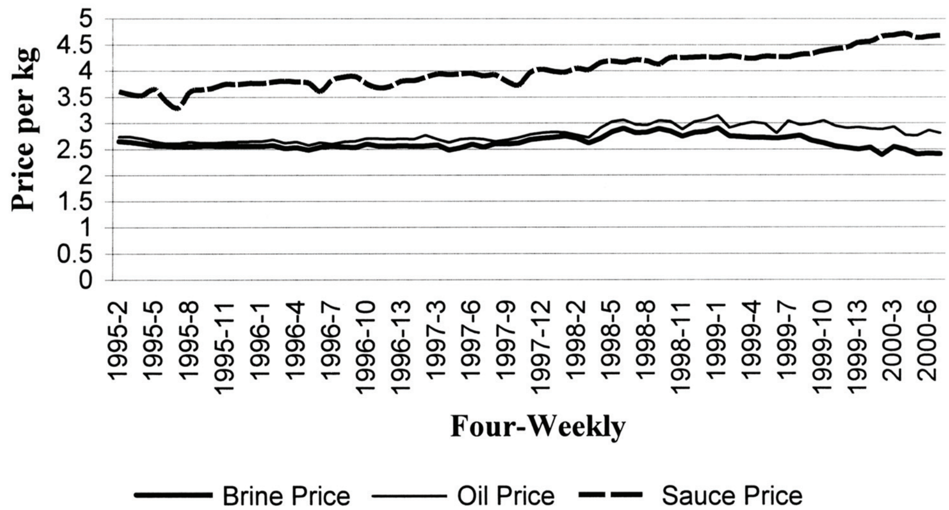

Figure 1. Average Monthly Retail Prices of Canned Tuna in the UK (£/kg)

canned tuna in brine had increased to an estimated 20–25%. Analysis of the retail sales data reveals that these trends have continued. Since 1995 the market value share of tuna steak has declined from 33–22%, while the share of less expensive tuna chunks increased from 57–69%. It should be noted that these changes in market share may not be due only to the product form but also to the medium.

Canned tuna in brine has increased in value share from 60–66%, so dominating the market, while tuna in oil has decreased from 30% in 1995 to 22% in 2000. Tuna in water, olive oil, and sauces have all increased their value share by approximately 1% each over the same period to 5%, 2%, and 6%, respectively. These trends illustrate the considerable changes that the canned tuna market has undergone in the last decade. While the UK consumer has continued to remain very price conscious with regards to the standard canned tuna in oils and brine, canned tuna has increasingly become value added, as illustrated in figure 2, by the increase in diversity of product mediums.

To provide a more detailed understanding of the structure and characteristics of the UK retail market for canned tuna, we estimate demand functions for canned tuna grouped by medium, as considered here. Performing a demand analysis enables one to determine the relationships and interactions between the various groups within the canned tuna market. It is especially useful to determine how these relatively new value-added products behave in the market in relation to the traditional tuna in brine and oil; that is, how demand of the different products responds to changes in prices and income. Conducting a demand analysis is therefore useful for both policy makers and those involved in the market.

Demand Theory and Methodology

The AIDS of Deaton and Muellbauer (1980a) has been the most common functional form in demand system specification since the early 1980s and will be used here. The AIDS model is formulated in terms of budget shares of the second stage of the

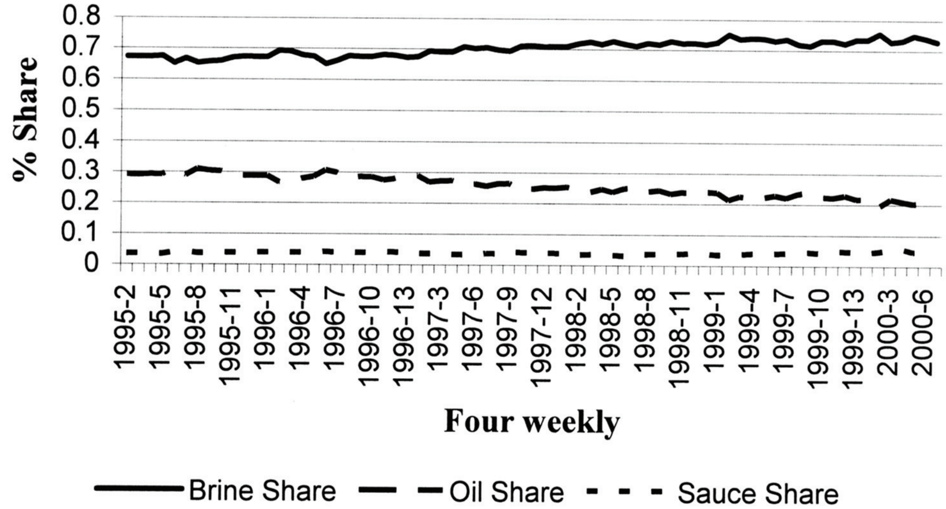

Figure 2. Conditional Budget Shares of Canned Tuna (%)

budgeting process, with each demand equation expressed as:

$$w_{it} = \alpha_i + \sum \gamma_{ij} \ln p_{jt} + \beta_i \ln\left(\frac{X_t}{P_t}\right), \tag{1}$$

where $w_{it} = p_{it}q_{it}/X_t$, X is the expenditure on all goods in the system and

$$\ln P_t = \alpha_0 + \sum \alpha_i \ln p_{it} + \frac{1}{2}\sum_i \sum_j \gamma_{ij} \ln p_{it} \ln p_{jt}. \tag{2}$$

The AIDS is linear except for the translog price index, $\ln P_t$. This used to be typically dealt with by approximating the translog price index using a Stone price index to make the system linear $\ln P_t^* = \Sigma_i w_{it} \ln p_{it}$, as suggested by Deaton and Muellbauer (1980a). Since then, however, Moschini (1995) demonstrated the Stone index to be inappropriate, as it caused the estimated parameters to be inconsistent. This problem was attributed to the fact that the Stone price index does not satisfy what Diewert terms the commensurability property; that is, it is not invariant to the unit of measurement for the prices. Moschini (1995) subsequently suggested the Laspeyre version of the Stone index:

$$\ln P_t^S = \sum_i w_{it}^0 \ln\left(\frac{p_{it}}{p_i^0}\right), \tag{3}$$

where the superscript 0 denotes a base period, which was further suggested to be the mean.

In accordance with economic theory, the parameters of the demand equations must satisfy the following restrictions:

Adding up: $$\sum_i \alpha_i = 1, \quad \sum_i \gamma_{ij} = 0 \quad \sum_i \beta_i = 0 \tag{4}$$

Symmetry: $$\gamma_{ij} = \gamma_{ji} \tag{5}$$

Homogeneity: $$\sum_i \gamma_{ij} = 0. \tag{6}$$

The adding up restriction requires that the marginal propensity to spend on each good sums to unity and that the net effect of a price change on the budget is zero. This restriction is automatically imposed on the data by deleting one share equation prior to estimation and calculating the coefficients of this equation on the basis of the adding up restriction. This process also serves to overcome the problem of the covariance matrix being singular. The homogeneity and symmetry restrictions are both imposed on the estimated parameters. The homogeneity restriction implies that the prices and total expenditure are homogeneous of degree zero. It assumes that prices and expenditure play no role in determining the budget constraint so that the units of measurement have no effect on the consumers' perception of opportunity. That is, a doubling of all prices and income would have no effect on quantities demanded. The symmetry restriction implies that the compensated price responses are symmetric so that consumer choices are consistent.

If the data indicates it is appropriate, trend and seasonal dummies can also be introduced. Incorporating seasonal dummies is most easily done by introducing them as shifts on the constant term. Deaton and Muellbauer (1980a) also note that the trend variable can be interpreted as a change in tastes.

The elasticities from AIDS are given as:

Uncompensated: $$\varepsilon_{ij} = \frac{\gamma_{ij}}{w_i} - \beta_i \frac{w_j}{w_i} - \delta \tag{7}$$

Compensated: $$\varepsilon^*_{ij} = \frac{\gamma_{ij}}{w_i} + w_j - \delta, \ \delta = 1, \ i = j, \ \delta = 0, \ i \neq j, \tag{8}$$

where $\delta = 1$ for own price elasticity ($i = j$), and $\delta = 0$ for cross price elasticity ($i \neq j$). Expenditure elasticity is specified as:

$$\eta_i = 1 + \frac{\beta_i}{w_i}. \tag{9}$$

Econometric Specification

In most of the earlier demand studies, habit formation was given as a main reason for introducing dynamics in consumer demand models. Pollak (1970) argued that contractual obligations or imperfect information might also cause some adjustment time to any changes in prices or consumer expenditure. General dynamic structures have, therefore, been used in demand studies more recently. The error correction specification suggested by Anderson and Blundell (1983, 1984) nests all the general dynamic specifications. Their general dynamic specification is normally operationalised by transforming demand systems, including AIDS, into an autoregressive distributed lag model by including lags of all the variables in the demand system. This is later transformed into an error correction type framework of Davidson *et al*. (1978). This methodology allows one to test for the other restricted specifications; *i.e*., habit formation. Veall and Zimmermann (1986) and Anderson and Blundell (1983, 1984) have shown that the hypothesis of restrictive specification is rejected in favour of the more general dynamic specification.

Following the Deaton and Muellbauer (1980a, b) AIDS methodology and given the time series data on budget shares, prices, and per capita total expenditure, Anderson and Blundell (1984, 1983) proposed the estimable functional form of the dynamic AIDS model and is given by:

$$\Delta w_t = A\Delta\tilde{z}_t - B\left[w_{t-1} - \prod{}^{n}(\Theta)z_{t-1}\right] + \varepsilon_t, \tag{10}$$

where w_t is the vector of budget shares, z_t vector contains prices and expenditure, the time trend vector of $\tilde{z}_t$ refers to the z_t without the constant term, Δ represents the first difference operator, and ε_t is the vector of disturbances. These are assumed to be independent and identically distributed over time. The A vector contains the short-run parameters and B is a vector of speed of adjustment. The parameters of interest in this article are the long-run parameters and are contained in $\Pi(\Theta)$. The own, cross price, and expenditure elasticities reported below are calculated using these long-run parameters.

To avoid the singularity implicit in the system, one equation is omitted and one share deleted from the lagged shares vector. According to Anderson and Blundell (1983, 1984), the adding up restriction implies that there is no loss of identification in the long-run structure, irrespective of which equation is omitted. In this article, a dynamic AIDS model of an error correction nature explained above has been estimated.

Data

Data Source

For the demand analysis, time series scanner data was obtained from Information Resources Incorporated Infoscan® retail data. This data is generated by scanned sales from a representative sample of stores from the UK. The data series is on a four-weekly basis from February 1995 to December 1999 inclusive. Moreover, the data is progressively broken down by manufacturer, brand, form, medium, and size. For each of these sub-groups, data includes sales by value, volume, and number of units. Average unit and volume price is also given for each group. Despite the data differentiating between private and retailers' brands, all retail brands were grouped together for reasons of confidentiality.

Although a rich data set, there were a number of limitations. The value sales and average volume and unit price included all retailer price reductions, but not manufacturer's coupons. The average prices reported were calculated from value sales divided by volume sales and were not necessarily the price that consumers paid, but the average of all transactions in that time period. For the purpose of the analysis these discrepancies are assumed to be negligible. Further assumptions were also made for the purpose of grouping the data for analysis.

Grouping of Data

Considering the data by product form for preliminary analysis, there were a total of 92 products at the form level. These were described as flake (23), steak (11), chunk (36), solid (3), "other" (16), slice (1), rondelet (1), and fillet (1). As it was not known what the "other" forms were, they were grouped together with the miscellaneous slice, rondelet, and fillet. Solid was grouped with steak, as they are similar products, if not identical.

At the medium level there were 202 products,[1] which were grouped as brine (77), sauces (45) and oil (80). The groups "oil" included vegetable, sunflower, flora, and soya oil and what was described simply as "in oil." It was not possible to distinguish between oil types for those labelled as "in oil" and there was little difference in prices; thus, it was considered permissible to group all these oils together. The group "sauces" covered a range of mediums, including mayonnaise, vegetable mixes, a variety of sauces (*e.g.,* tomato, curry), and again what was specified as "other." These were grouped on the basis that, although they were different from each other, they were value-added products that would often have been consumed on their own, as opposed to in a sandwich or salad in the same manner as the other mediums. Sauces were thus expected *a priori* not to be close substitutes to the other product mediums so were allocated their own group.

For the purpose of the demand analysis, it was decided to treat the market in terms of product medium, as opposed to product form, for a number of reasons. Firstly, there is a larger proportion of "other" forms than there are "other" mediums. Also, "other" forms are mainly in "other" mediums, which are typically more expensive. This means that if a demand analysis was conducted for product form, any conclusions drawn could be attributed to the product medium as opposed to its form, and these conclusions would have little meaning or application, as it is not known what the "other" forms actually are. To further support the choice to analyse tuna by medium, the purchasing decision-making process of the consumer was considered. On the basis that a consumer purchases a can of tuna with a use for it in mind, the medium may be the dominating factor, as the type of medium cannot be changed but the product form can. For example, tuna steak can be broken up into chunks and further into flakes if preferred, but a sauce cannot be converted into brine. This is not to say that there would be no difference between steak and flake, say, as price and water content do differ, but that for the purpose of our analysis medium was considered to be the most rational way by which to group and analyse the data.

With the data treated in the three groups, brine, sauce, and oil, elasticities were estimated using the methodology described previously.

[1] There are more types of product medium than forms due to each product form being available in several different mediums.

Empirical Results

The AIDS system was first estimated in static form (results are not presented here).[2] The static model showed that there was serial correlation in each equation, and it was also present in the whole system. The LM test against autocorrelation gives the test statistic: $\chi^2(2) = 24.01$, $\chi^2(2) = 14.13$, $\chi^2(4) = 38.61$ for brine and sauce equations and the system, respectively. The null hypothesis of no autocorrelation is rejected at the 1% level of significance in both equations and the system. This confirms earlier studies and justifies the dynamic specification of the model. The static model was also tested for homogeneity and symmetry restrictions. The LM test of the null of homogeneity and symmetry produced a test statistic $\chi^2(3) = 115.49$. The null of homogeneity and symmetry in the equations was rejected at the 1% level of significance.

Due to the reason explained above, the dynamic model of Anderson and Blundell (1983, 1984) was estimated. The diagnostic test results of dynamic specification are presented in table 1. The regression evaluation tests involved *F*-tests for the hypothesis that the *i*-period lag ($F_{k=i}$) is zero; that there is no serial correlation present (F_{ar}, against 5th-order autoregression); that there is no autoregressive conditional heteroskedasticity (F_{arch}, against 4th-order); that there is no heteroskedasticity (F_{het}); and lastly, a test for normality (χ^2nd).

Both equations in the system have a high R^2. Small σ (residuals standard deviation) values are also observed in all the equations. The system diagnostic tests show that there is no serial correlation in the system and no non-normality in errors. There is no serial correlation in any of the equations individually. There is no autoregressive conditional heteroskedasticity present in any of the equations or in the overall system. On the basis of these diagnostic test results, it is concluded that the system is well specified.

The theoretical restrictions of homogeneity and symmetry were tested on the dynamic model in sequence. The homogeneity restriction on both equations together was imposed and tested. The LR test of the homogeneity restriction in the system produced a test statistic of $\chi^2(3) = 1.77$. The null hypothesis of homogeneity in these equations was not rejected at the 1% level of significance. The test of the symmetry

Table 1
Model Evaluation Diagnostics

Statistic	Brine Equation	Sauce Equation	System
Lag length = 4			
R^2	0.981	0.942	
σ	0.007	0.002	
$F_{ar}(5, 36)$	1.729	0.970	
F_{arch} (5, 31)	0.282	0.978	
χ^2_{nd} (2)	0.715	2.835	
System			
$F_{ar}(125, 83)$			1.134
χ^2_{het} (630)			643.60
χ^2_{nd} (10)			9.148

[2] All the estimations were carried out using PcGive V 9.

restriction gave a test statistic of $\chi^2(3) = 2.85$. The null of symmetry in the long-run parameters was also not rejected at the 1% level of significance. The parameters in the long-run equations[3] are given in table 2. The standard errors for the estimated parameters reported in parentheses.[4] All the coefficients in table 2 are statistically significant at the 1% level of significance.

Using the restricted equations presented in table 2, the own (7), income (9), and cross price (7) elasticities were estimated. These calculations are performed using mean normalised prices, normalising prices to one point and evaluating the elasticities at this point. This makes the elasticity formulas easier to calculate, although the justification for this point is not better than any other point (Asche and Wessells 1997). The elasticities of the oil equation were subsequently calculated on the basis of the adding up restrictions (4).

All own price elasticities are found to be negative, as expected (table 3). The own price elasticities show that all product forms are price inelastic. While the expenditure elasticity of brine and sauce show that they are normal goods ($\eta_i = 0.96$ and 0.34, respectively, $0 < \eta_i < 1$) as anticipated, oil appears to be a luxury good ($\eta_i = 1.35$, $\eta_i > 1$). Oil and sauce appeared to be substitutes of one another ($\varepsilon_{ij} > 0$). Tuna in brine is demonstrated to be a complement of tuna in sauce and oil ($\varepsilon_{ij} < 0$).

In accordance with economic theory, the negative price elasticities of all the products mean that as their prices increase the expenditure on them decreases. As they are inelastic, price increases would lead to proportionately smaller decreases in

Table 2
Long-run Parameters

	Lpbo	Lpso	Lrexp	Trend
Brine equation	0.265	–0.130	–0.027	0.002
	(0.030)	(0.000)	(0.010)	(0.000)
Sauce equation	–0.130	0.067	–0.059	0.000
	(0.018)	(0.018)	(0.010)	(0.000)

Notes: Lpbo, Lpso are log of brine price minus oil price and log of sauce price minus oil price, respectively, and Lrexp is log of group total expenditure. Trend is a linear deterministic trend. Standard errors are reported in the parentheses.

Table 3
Long-run Own, Cross, and Expenditure Uncompensated Elasticities

	Brine	Sauce	Oil	Expenditure
Brine	–0.571	–0.193	–0.194	0.959
Sauce	–1.008	–0.194	0.860	0.342
Oil	–0.769	0.219	–0.796	1.346

[3] Following Engle and Granger (1987), the residuals from the both equations were tested for stationarity and were found to be stationary (results not presented here but available on request).
[4] Chambers 1993; Asche 1996; Attfield 1997; and Asche, Steen, and Salvanes 1997 use Engle and Granger (1987) tests to confirm that their estimated demand relationships are long-run relationships.

value demanded and, therefore, an increase in sales revenue. Income increases, however, do not result in uniform changes in expenditure for all goods. Being a luxury good, the expenditure on tuna in oil increases by a proportionately larger amount than any demand increases for tuna. The apparently complementary nature of tuna in brine, sauce, and oil suggests that an increase in price of one would lead to a decrease in consumption of the other. An increase in the price of tuna in sauce, however, would cause an increase in the consumption of tuna in oil due to them being substitutes.

Discussion and Conclusions

In this article the UK retail market for canned tuna is analysed, estimating the elasticities of tuna in different mediums. A dynamic AIDS model was estimated using the full information maximum likelihood estimation method.

The model fitted the data well in terms of passing the misspecification tests and the own price elasticities having the correct signs and magnitudes. Furthermore, the theoretical restriction homogeneity was imposed and symmetry based on demand theory was tested and the model did not reject the restriction. Brine and sauce were found to be normal goods as expected. Tuna in oil appeared to be a luxury good. The cross price elasticities indicated that brine was a complement of both tuna in oil and sauce, which was not expected. The cross price elasticity of sauce for oil suggests them as substitutes.

The inelastic own price elasticities would be encouraging for producers and retailers of canned tuna, as price increases would lead to proportionately smaller decreases in value demanded and hence an increase in revenue. The luxury nature of canned tuna in oil would also be welcomed, as an increase in income would lead to a proportionately larger increase in expenditure. In trying to capitalise on these characteristics, however, the close substitution of sauce for oil could be important in pricing strategies, as a change in the price of oil would lead to a shift in demand to sauce. This could also have implications for policy makers implementing management measures that may affect the price of these goods in the retail market.

Considering those cross price elasticities that contradict *a priori* expectations, it is difficult to perceive under what circumstance tuna in brine would be a complement for tuna in oil or sauce. One could speculate that a consumer's decision to purchase canned tuna of any medium is influenced by an initial inspection of the price of tuna in brine, the most basic and numerous canned tuna product, but this is unlikely. One could thus conclude that these elasticities should be interpreted with caution.

The unexpected elasticities could also suggest that the system being analysed was not a complete market. While the diagnostic results and restriction tests all appear to show the model not to be misspecified, it is possible that the groups within the system interact outside the defined market. Tuna in sauce, for example, is a value-added product so it may compete with and be influenced by products such as value-added pasta dishes. Josupeit (1993) notes the importance of the canned salmon market in developments of the UK canned tuna market, but was not included in this analysis due to the unavailability of data. The two products are substitutes for one another, as reflected by their positions together on the supermarket shelves, although the less easy-to-use nature of canned salmon makes it unpopular with some consumers (Josupeit 1993). There have been a number of significant changes in the canned salmon market in the last decade. Since 1990 there has been a downward global trend in canned salmon production, reflecting the decline in wild salmon production, which is the main raw material for canned salmon (Globefish 1999b). This was borne out as increases in canned salmon retail prices in the UK in 1997 (Spruyt 2000).

Indeed, in their work to determine the market effect of the dolphin-safe eco-label in the USA, Wallstrom and Wessells (1995) incorporated salmon into their demand analysis, and Teisl, Roe, and Hicks (2002) included seafood, luncheon meat, and red meat. In both cases the alternative products were demonstrated to be substitutes of canned tuna. Although canned tuna is perceived by US consumers to be a lower quality product than UK consumers, these studies serve to illustrate that other products, including canned salmon, would ideally be included in such an analysis of the UK canned tuna market.

References

Anderson, G.J., and R.W. Blundell. 1983. Testing Restrictions in a Flexible Demand System: An Application to Consumers' Expenditure in Canada. *Review of Economic Studies* 50:397–410.

___. 1984. Consumer Non-Durables in the U.K.: A Dynamic Demand System. *Economic Journal* 94:35–44.

Asche, F. 1996. A System Approach to the Demand for Salmon in the European Union. *Applied Economics* 28:97–101.

___. 1997. Dynamic Adjustment in Demand Equations. *Marine Resource Economics* 12:221–37.

Asche F., T. Bjørndal, and K.G. Salvanes. 1998. The Demand for Salmon in the European Union: The Importance of Product Form and Origin. *Canadian Journal of Agricultural Economics* 46(1):69–81.

Asche, F., K.G. Salvanes, and F. Steen. 1997. Market Delineation and Demand Structure. *American Journal of Agricultural Economics* 79(1):139–50.

Asche, F., and C.R. Wessells. 1997. On Price Indices in the Almost Ideal Demand System. *American Journal of Agricultural Economics* 79:1182–85.

Attfield, C.L.F. 1997. Estimating a Cointegrating Demand System. *European Economic Review* 41:61–73.

Bose, S., and A. McIlgrom. 1996. Substitutability among Species in the Japanese Tuna Market: A Cointegration Analysis. *Marine Resource Economics* 11:143–56.

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.

Chambers, M.J. 1993. Consumers' Demand in the Long Run: Some Evidence from UK Data. *Applied Economics* 25:727–33.

Davidson, J.E.H., D.F. Hendry, F. Srba, and S. Yeo. 1978. Econometric Modelling of the Aggregate Time-Series Relationship between Consumers' Expenditure and Income in the United Kingdom. *Economic Journal* 88:661–92.

Deaton A.S., and J. Muellbauer. 1980a. An Almost Ideal Demand System. *American Economic Review* 70:312–26.

___. 1980b. *Economics and Consumer Behaviour*. Cambridge, UK: Cambridge University Press.

Eales, J., C. Durham, and C.R. Wessells. 1997. Generalized Models of Japanese Demand for Fish. *American Journal of Agricultural Economics* 79:1153–63.

Eales, J., and C.R. Wessells. 1999. Testing Separability of Japanese Demand for Meat and Fish within Differential Demand Systems. *Journal of Agricultural and Resource Economics* 24:114–26.

Engle, R.F., and C.W.J. Granger. 1987. Cointegration and Error Correction: Representation, Estimation and Testing. *Econometrica* 55:251–80.

FAO. 1998. *Update on FAO's Activities in Relation to the 1997/98 El Niño.* July. Rome: FAO www.fao.org/news/1998/elnin2-e.htm (accessed June 2000).

Globefish. 1999a. *Commodity Update: Tuna*. 1999. www.globefish.org/index.php?id=215

___. 1999b. *Commodity Update: Salmon*. 1999. www.globefish.org/index.php?id=4437

Jaffry, S., S. Pascoe, and K. Robinson. 1999. Long-run Price Flexibilities for High Valued UK Fish Species: A Cointegration Systems Approach. *Applied Economics* 31:473–81.

Johnson, A., C.A. Durham, and C.R. Wessells. 1998. Seasonality in Japanese Household Demand for Meat and Seafood. *Agribusiness* 14(4):337–51.

Josupeit, H. 1993. Canned Tuna Markets in Europe. *FAO/GLOBEFISH Research Programme*, Vol. 15. Rome, Italy: FAO.

Moschini, G. 1995. Units of Measurement and the Stone Price Index in Demand System Estimation. *American Journal of Agricultural Economics* 77:63–8.

Pollak, R.A. 1970. Habit Formation and Dynamic Demand Functions. *Journal of Political Economy* 78(4):745–63.

Spruyt, N. 2000. Private Label Products v/s Supermarket Brands in the UK Market. *Infofish Tuna Trade Conference*, Bangkok, Thailand, 25-27 May 2000.

Suanzes-Carpegna, D.V. 1998. *Report on the Fish Canning Industry and Aquaculture in the European Union Committee on Fisheries*. European Parliament Committee on Fisheries, 21 April 1998, a4-0137/98.

Teisl, M.F., B. Roe, and R.L. Hicks. 2002. Can Eco-labels Tune a Market? Evidence from Dolphin-safe Labelling. *Journal of Environmental Economics and Management* 43(3):339–59.

US International Trade Commission. 1998. Industry & Trade Summary, Canned Fish, Except Shellfish. USITC Publication 3083.

Veall, M.R., and K.F. Zimmermann. 1986. A Monthly Dynamic Consumer Expenditure System for Germany with Different Types of Households. *Review of Economics and Statistics* 68:256–64.

Wallstrom, P., and C.R. Wessells. 1995. Analysis of U.S. Consumer Demand for Canned Tuna: Impact of Dolphin-safe Controversy. *International Cooperation for Fisheries and Aquaculture Development, Proceedings of the 7th Biennial Conference of the International Institute of Fisheries Economics and Trade*, D.S. Liao, ed., pp. 264–76. Keelung, Taiwan, R.O.C.: National Taiwan Ocean University.

Wellman, K.F. 1992. The US Retail Demand for Fish Products: An Application of the Almost Ideal Demand System. *Applied Economics* 24:445–57.

Wessells, C.R., and P. Wallstrom. 1999. Modeling Demand Structure Using Scanner Data: Implications for Salmon Enhancement Policies. *Agribusiness: An International Journal* 15:449–61.

Wessells, C.R., and J.E. Wilen. 1994. Seasonal Patterns and Regional Preferences in Japanese Household Demand for Seafood. *Canadian Journal of Agricultural Economics* 42:87–103.