THE RETAIL DEMAND FOR DEMERSAL FRESH FISH IN GREAT BRITAIN

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ABSTRACT

Over the past 20 years, the demand for fish has changed markedly. The species prevalent in the consumption mix has altered to reflect the greater availability of farmed species such as salmon, and the decline in some of the more common marine-caught demersal species such as cod. This paper examines the retail demand for fish in the Great Britain, focusing on fresh demersal fish species. A three-stage demand model using a nested family of differential demand systems is tested and estimated from time series data of meat, fish and fish products in the UK. Both conditional and unconditional expenditure, own and cross price elasticities of demand are derived from the parameter estimates. There is strong evidence of between species interaction in consumption, both as substitutes and complements, justifying the demand system approach to analysis. Differences between conditional and unconditional elasticities suggest that consumers make decisions on the basis of aggregate fish groups and only then select amongst the individual categories or species on the basis of price.

Keywords: Retail demand; fish; differential demand systems, conditional and unconditional elasticities

INTRODUCTION

Many of the early studies of fish demand in the 1980's and early 1990s as summarised by Rodgers [1], relied on ex-vessel or wholesale data. They reported very low price flexibilities of demand, which implied very high retail price elasticities frequently in excess of $|2|$, and somewhat above those normally associated with staple food items. These arose largely from methodological approaches that adopted either *ad hoc* single equation and/or time-series estimation of the demand relationships, and omitted many potential competing products and demand inter-relationships.

Burton and Young [2,3,4] in their series of studies on the UK demand for fish, on the other hand, found own price elasticities for cod, haddock and plaice of less than unity[b]. Furthermore, a more recent study based on National Food Survey data [4] of the demand for meat and fish reported statistically significant retail own price elasticity estimates for fresh and frozen fish also less than unity in magnitude. The crucial point is that these latter studies adopted a demand systems approach to modeling and estimation and have produced elasticity estimates that are of more intuitively "believable" orders of magnitude, and comparable with those obtained in demand studies of other food products. However the former studies were based on small numbers of observations, and the latter dealt with fish at an aggregate level.

This study differs in that it examines the retail demand for fish at a series of different levels of aggregation (or disaggregation), and focuses ultimately on inter-species retail demand relationships for demersal fish. As it is based on almost ten years of monthly data unlike earlier studies, the estimates are also both robust and credible. Finally, the study also addresses the issue of appropriate model selection within the complete demand systems approach.

THE EMPIRICAL MODELS AND THE DATA

The Budgeting Stages

This study utilizes a three-stage budgeting model with an assumed preference or purchase decision structure as given in Figure 1. In Stage 1[c], total consumption of meat and fish is divided into six broad commodity groups

- Red Meats (beef, lamb and pork)
- Poultry,
- Bacon,
- Total Fresh Fish,
- Frozen Natural Fish, and
- Total Processed Fish

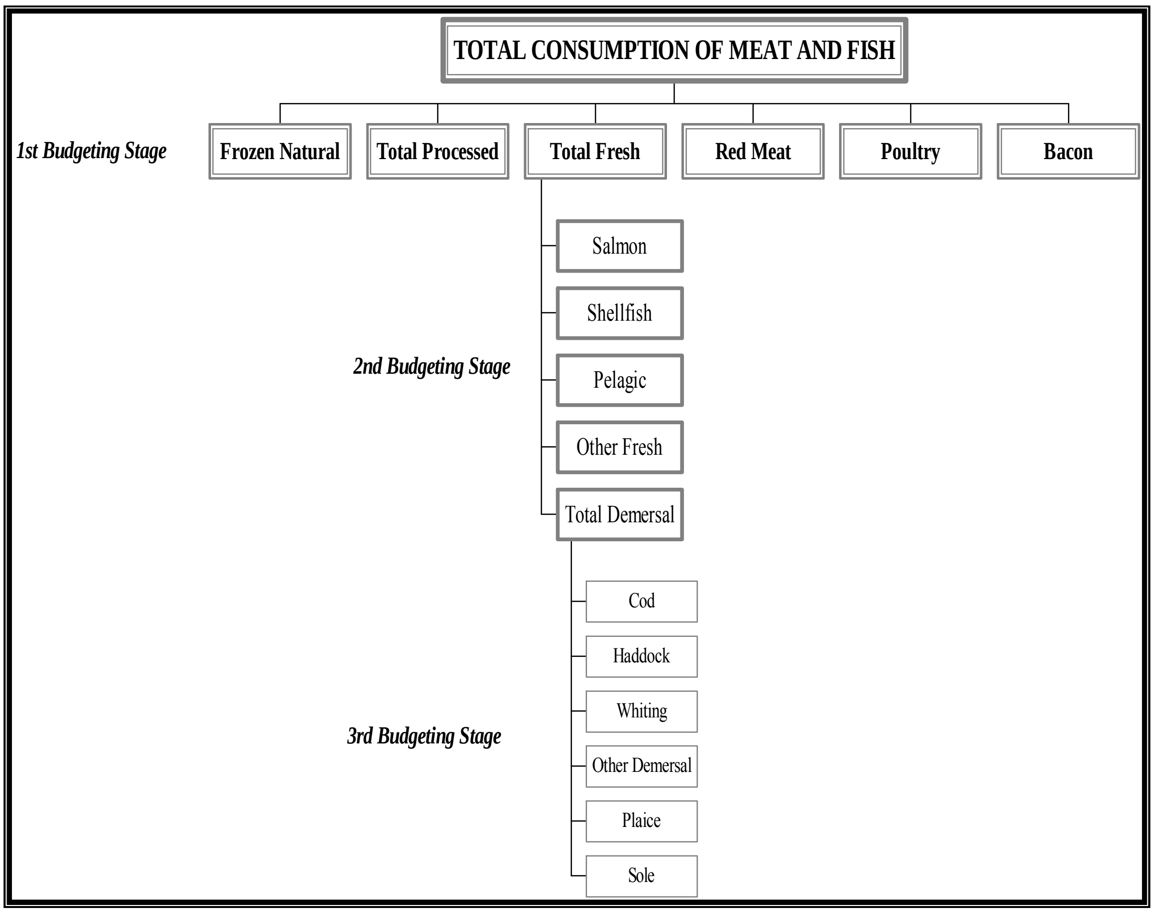

Figure 1 Assumed Consumer Purchase Decision Tree

In Stage 2, expenditure on Total Fresh Fish is allocated into

- salmon,
- shellfish,
- total pelagic species,
- total demersal fish species and
- all other fresh fish.

Finally, in Stage 3, expenditure on demersal species is further disaggregated into

- cod,
- haddock,
- whiting,
- other demersal,
- plaice, and
- sole.

Given the assumed decision tree, in the first and the third budgeting Stages there are 6-equation systems, while in the Stage 2 there is a 5-equation system.

Calendar monthly household purchases and expenditure in Great Britain (GB) were derived from four weekly data[d]. Unit values (prices) were derived by dividing expenditures by the respective quantities. Comparable sample data series for all of the variables were available from February 1992 to November 2001. Table I shows that red meats accounted for almost 39% of expenditure shares in Stage 1, with poultry and bacon a further 47%. Consumers spent less than 15% of Stage 1 animal meat proteins expenditure on fish.

Table I Expenditure Shares in Stage 1 Animal Meat Proteins Consumption

Statistics	Frozen Natural Fish	Total Processed Fish	Total Fresh Fish	Red meat	Poultry	Bacon
Average	**0.6%**	**9.1%**	**4.9%**	**38.7%**	**34.6%**	**11.9%**
Min	0.4%	7.2%	3.7%	33.5%	31.0%	10.6%
Max	0.9%	10.9%	6.0%	44.5%	40.5%	13.7%

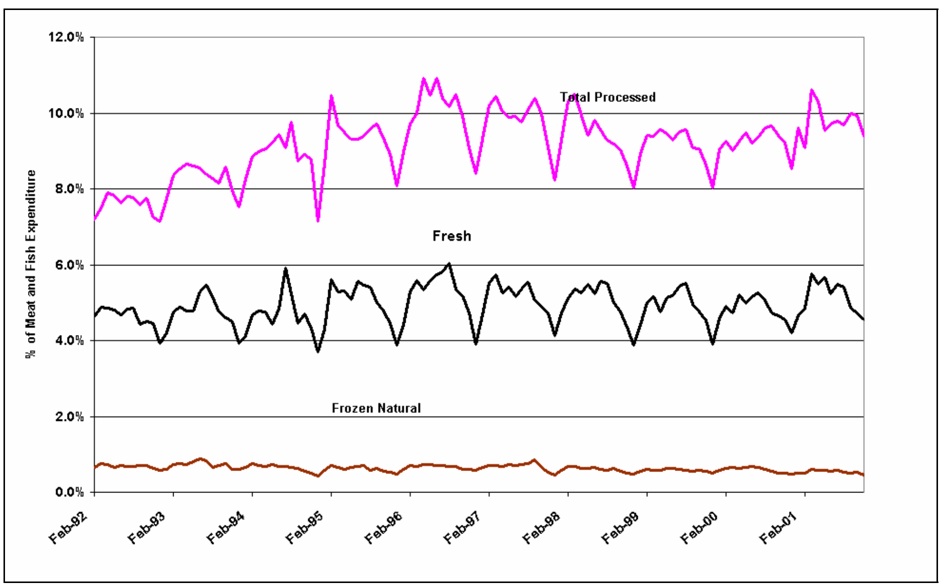

Figure 2. Trends in Stage 1 fish consumption expenditure

Figure 2 shows that expenditure shares on both fresh and frozen unprocessed fish remained stable over the decade, though there was a slight increase in the expenditure share of processed fish, particularly during the period 1992-97.

Stage 2 expenditure shares are shown in Figure 3 and reveals a decline in the share of demersal species within the fresh fish subsystem from 65% to 40 %, and increases in salmon and to a lesser extent shellfish expenditure shares, both reflecting the growth of aquaculture, with the former rising from 5% to over 20% of consumer spending on fresh fish.

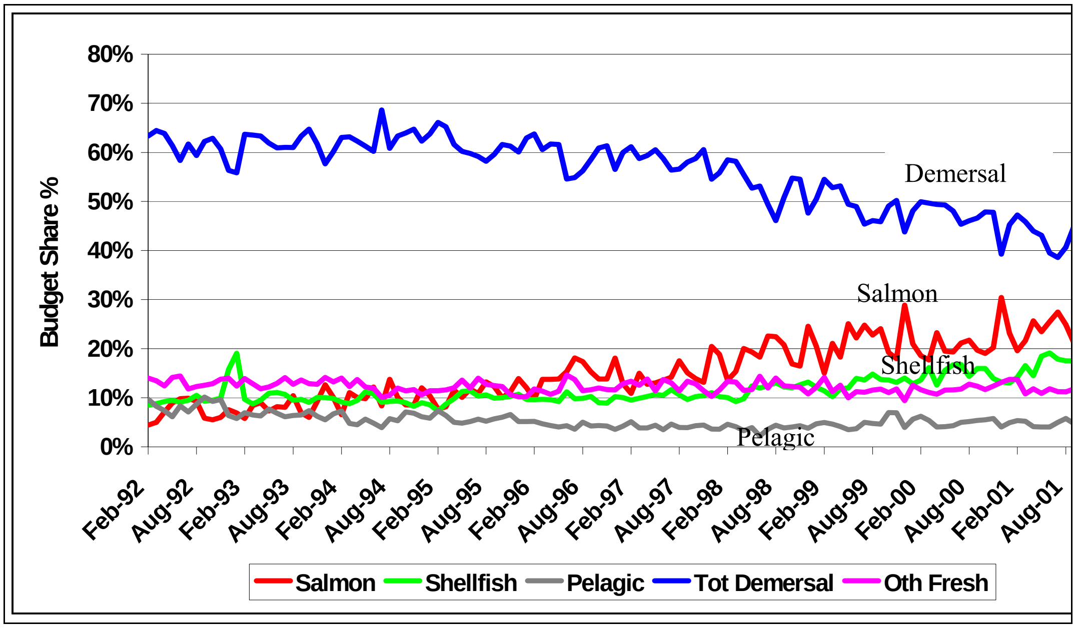

Figure 3. Stage 2 expenditure shares for fresh fish

Figure 4 presents the Stage 3 demersal fish expenditure subsystem and reveals the dominance of cod and haddock in consumer spending..

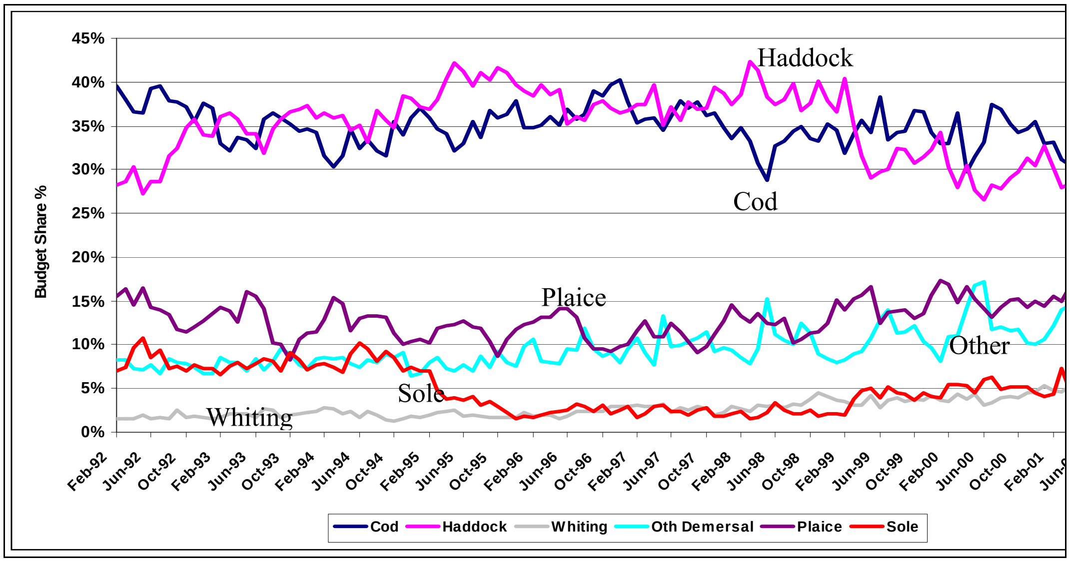

Figure 4. Stage 3 expenditure shares for demersal species

The expenditure share of haddock initially increased but decreased after 1996, largely driven by volume reductions. Cod, on the other hand, despite a declining volume since 1997, maintained its expenditure share. The expenditure shares of other demersal species, plaice and whiting exhibited exhibit upward trends while that for sole decreased initially but has increased in the latter part of the study period.

Weak Separability and Conditional Elasticities

An assumption commonly used in applied demand analysis is that of *weak separability* [6,7]. This involves examining a sub-system of a more complete (food) product system, and excluding other goods from the analysis. The use of the assumption is justified because estimation of structural demand systems involving a large number of equations is not feasible in many data sets that are typically available for empirical work[e]. The resulting degrees of freedom problem may severely affect the statistical properties of an estimated demand model. Weak separability thus makes estimation of intrinsically large systems possible but neglects potential interconnections among goods belonging to different sub-sets. Pollak and Wales [10] termed the demand functions within a sub-system as conditional ones and the resulting elasticity estimates as ***conditional*** elasticities. They are derived under the assumption that a price change within the subgroup of products does not affect the subgroup's budget/expenditure share of the total for all commodities[f]. ***Unconditional*** elasticities are derived from a demand system which involves all relevant commodities. The conditional and unconditional elasticities will furthermore, generally be different. It is the unconditional elasticities that are naturally of greater interest for policy analysis, but as indicated above, in a multi-commodity framework, data restrictions might preclude their direct estimation, and hence the need for the multi-stage approach.

To solve this problem of estimating unconditional elasticities directly, correction formulae for the *conditional* elasticities have been derived from multi-stage budgeting [11,12,13,14]. The simplest way to present the correction formulae for the unconditional elasticities is to consider a two-stage budgeting process. Let l be the total number of goods interest. Suppose also that these goods can be divided into two mutually exclusive and exhaustive sub-sets, denoted by A and B, involving m and n goods, respectively (with $l=m+n$). The Marshallian demand function, q^*_{Ai} for good i in A is

$$q^*_{Ai} = g_{Ai}(p_{A1}, \ldots.., p_{Am}, p_{B1}, \ldots.., p_{Bn}, x) \qquad \text{(Eq.1)}$$

where p stand for prices and x for total expenditure on all goods. Under weak separability a change in the price of one good in the sub-set A, affects the demand for all goods in the sub-set B in exactly the same manner. Furthermore, weak separability makes it possible to divide the problem into several Stages.

At the first stage, total expenditure is allocated between groups A and B. This requires replacing all commodity prices and quantities within each group with a single price and a single quantity index. Following {6,14], the first-stage demand function for group A can be written as

$$q_A = g_A(P_A, P_B, x)\,, \qquad \text{(Eq.2)}$$

where q_A is expressed as real expenditure (at base year prices) and the Ps are the respective sub-group price indexes.

Weak separability is a necessary and sufficient condition for the second stage of the two-stage budgeting process. At the second stage, each group's expenditure function is minimized conditional on the utility level implied by the first-stage demand function (Eq.2). The resulting demand function for good i within group A is

$$q_{Ai} = g_{Ai}(p_{A1}, \ldots.., p_{Am}, x_A)\,, \qquad \text{(Eq.3)}$$

where x_A is the expenditure allocated to A in the first-stage.

Eq.1 and Eq.3 are the unconditional and conditional Marshallian (uncompensated) demand functions, respectively. Given weak separability, the two allocations, where the first stage is defined by Eq.2 and the second stage is defined by Eq.3 yield identical results to an allocation made in one step (that is, the allocation resulting from Eq.1. However, the numerical values of the conditional and unconditional elasticities may be different..

Starting with the expenditure elasticities, let E_{AiA} be the conditional expenditure elasticity for good *i* in A, and E_A the expenditure elasticity for group A. Then the unconditional expenditure elasticity, E_{Ai}, for good *i* is calculated as

$$E_{Ai} = \frac{\partial \ln g^*_{Ai}}{\partial \ln x} = \frac{\partial \ln g_{Ai}}{\partial \ln x}\frac{\partial \ln x_A}{\partial \ln x} = \frac{\partial \ln g_{Ai}}{\partial \ln x}\frac{\partial \ln g_A}{\partial \ln x} = E_{AiA}E_A. \qquad \text{(Eq.4)}$$

A change in total expenditure affects the allocation to group A through Eq.2 (first-stage decisions). The change in the allocation to group A affects the demand for good *i* through Eq.3 (second-stage decision). The total effect (expressed as the unconditional expenditure elasticity) is the product of the first- and the second-stage expenditure elasticities.

Turning to the price elasticities, let e_{Aij} be the uncompensated conditional price elasticity between goods *i* and *j* in group A, and e_{AA} be the uncompensated own-price elasticity for group A[g]. Then, the uncompensated unconditional price elasticity, e_{AiAj}, is derived using the chain rule in (3) as

$$e_{AiAj} = \frac{\partial \ln g^*_{Ai}}{\partial \ln p_{Aj}} = \frac{\partial \ln g_{Ai}}{\partial \ln p_{Aj}} + \frac{\partial \ln g_{Ai}}{\partial \ln x_A}\frac{\partial \ln x_A}{\partial \ln P_A}\frac{\partial \ln P_A}{\partial \ln p_{Aj}} = e_{aj} + w_{AjA}E_{AiA}(1+e_{AA}), \qquad \text{(Eq.5)}$$

where w_{AjA} is the expenditure share of good *j* in the second-stage problem, that is,

$$w_{AjA} = p_{Aj}q_{Aj}/x_A. \qquad \text{(Eq.6)}$$

The change in the price of good *j* has two effects: a direct one and an indirect one. The direct effect works through Eq.3 and it is the change in the demand for good *i* holding expenditure on group A constant. The indirect effect arises because the change in the price of good *j* changes the price of the aggregate good A. This affects the expenditure allocated to group A (through Eq.2) and, in turn the demand for good *i* (through Eq (3)). The direct effect and the indirect effect together constitute the total effect of a change in the price of good *j* on the demand for good *i*. Finally, the unconditional compensated price elasticities can be calculated as

$$\varepsilon_{AiAj} = \varepsilon_{aj} + w_{AjA}E_{AiA}\varepsilon_{AA}. \qquad \text{(Eq.7)}$$ [h]

Differential Demand Systems and Model Specification

In the field of consumer demand analysis the issue of selecting among competing functional forms has been addressed in a number of studies [15,16,17,18]. It has been demonstrated that a family of competing systems can be generated through alternative parameterizations of ***Theil's differential system*** [19]. Selection among these competing models is possible via simple parameter restrictions. The differential systems are locally flexible, linear in parameters and as parsimonious as the dual systems [20].

Theil's differential model can be written as:

$$w_i d\ln q_i = \theta_i d\ln Q + \sum_{j=1}^{n} \pi_{ij} d\ln p_j, \quad i,j = 1,2,......n. \qquad \text{(Eq.8)}$$

in which w_i is the budget share, p_i and q_i are the price and the quantity respectively, $dln\ p_j$ and $dln\ q_i$ 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 synthetic system which nests within it 4 commonly used models[i] can be written as:-

$$w_i d\ln q_i = (\delta_1 w_i + d_i) d\ln Q + \sum_{j=1}^{n} (e_{ij} - \delta_2 w_i(\delta_{ij} - w_j)) d\ln p_j, \quad i,j = 1,2,......n \qquad \text{(Eq.9)}$$

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 (Eq.9) reduces to the Rotterdam demand system. 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 (Eq.9) are

$$\sum_{i=1}^{n} d_i = 1-\delta_1, \quad \sum_{i=1}^{n} e_{ij} = 0, \ \text{additivity}; \quad \sum_{j=1}^{n} e_{ij} = 0, \ \text{homogeneity; and} \quad e_{ij} = e_{ji}, \ \text{symmetry.}$$

Selecting the appropriate system is through the Likelihood Ratio Test (LRT) given as LRT=-2(ln(φ*)-lnL(φ)) 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(•) is the log value of the likelihood function. 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.

Since seasonal (monthly) data were used in the empirical analysis, all models also included 11 seasonal dummy variables; and a constant term, the latter in order to capture any trend in tastes and preferences. All systems were estimated using the SURE [23] method in the TSP 4.3 program in which one equation within each system was dropped for estimation and its coefficients subsequently retrieved through the imposed restrictions.

THE EMPIRICAL RESULTS

Given the limitations on space, we do not present the full set of estimated parameters for each stage model or the complete sets of conditional and unconditional compensated and uncompensated elasticities, but focus mainly on the derived unconditional uncompensated elasticity estimates, as these are the most useful in the context of policy, market analysis and promotion.

Stage 1

LRT rejected both the differential AIDS and the NBR at the 5 percent level or less. It did not reject the Rotterdam and the CBS models. Given that the value of the log-likelihood function for the CBS, however, was closer to that of the Synthetic system only results from the CBS are discussed further in this sub-section.

The CBS model performed reasonably well. The coefficients of determination ranged from 0.51 for Frozen Natural Fish to 0.90 for Poultry, which are quite high given that the model has been estimated in the differential form. Unconditional elasticity estimates are presented in Table II.

Table II: Unconditional Expenditure and Marshallian Price Elasticities for Stage 1

	Expenditure Elasticities	**Frozen Natural**	**Processed**	**Fresh**	**Red meat**	**Poultry**	**Bacon**
Frozen Natural	**0.662***	**-0.158**	0.422	0.244*	-0.759	-0.388	0.553
Total Processed	**0.733***	0.023	**-0.549***	0.075	0.182	-0.306*	-0.158*
Total Fresh	**0.317***	0.028*	0.177	**-0.400***	-0.260	0.035	0.103
Red meat	**1.035***	-0.018*	0.015*	-0.068*	**-0.627***	-0.229*	-0.105*
Poultry	**1.163***	-0.014*	-0.120*	-0.036*	-0.306*	**-0.566***	-0.099*
Bacon	**0.918***	0.026	-0.138*	0.013*	-0.296*	-0.204*	**-0.316***

* Significant at least at 5% level.

At the aggregate level, fish demand appears expenditure inelastic, with processed fish having the highest expenditure elasticity of the fish categories, and that of fresh fish the lowest at 0.32. Fish demand is also own price inelastic. Net complementarity or non-substitutability (though not strongly significant) also appears to exist for the pairs frozen natural fish-red meats and-poultry, processed fish-poultry and bacon, and fresh fish-red meats.

Stage 2

Estimation and testing of the Synthetic system rejected all the restricted models at the 5 percent level or less. Therefore, only results from the Synthetic are discussed further in this sub-section. The Synthetic model performed reasonably well with coefficients of determination ranging from 0.57 for shellfish to 0.92 for other fresh fish. The estimated equation system showed a significant positive trend in the underlying demand for salmon, and declining consumer preferences for pelagic and demersal fresh fish.

Table III presents the conditional expenditure and Marshallian price elasticities for Stage 2, revealing that for a given share of Stage 1 expenditure on fresh fish, the main commodity aggregates are net complements[j] with relatively low own price elasticities. The expenditure elasticity for demersal species is also just below unity, implying a less than proportionate expansion in demand as incomes rise.

Table III: Conditional Expenditure and Marshallian Price Elasticities for Stage 2

	Expenditure Elasticities	**Salmon**	**Shellfish**	**Pelagic**	**Total Demersal**	**Other Fresh**
Salmon	**1.752**	**-0.511**	-0.01	0.033	0.006	-0.186
Shellfish	**0.721**	-0.082	**-0.362**	0.000	-0.231	-0.047
Pelagic	**0.839**	0.008	-0.013	**-0.404**	-0.351	-0.079
Tot Demersal	**0.947**	-0.101	-0.074	-0.039	**-0.659**	-0.071
Other Fresh	**0.653**	-0.064	-0.036	-0.025	-0.174	**-0.354**

Table IV presents the comparable unconditional expenditure and Marshallian price elasticities for the Stage 2 analysis. The unconditional expenditure elasticities are substantially lower than the conditional ones, as they reflect a small unconditional expenditure elasticity for the Stage 1 fresh fish reference group. All Stage 2 species are expenditure inelastic, although that for salmon is higher than for demersal species. The unconditional uncompensated own-price elasticities are bigger in magnitude than the compensated conditional estimates and all aggregate species remain as gross complements. Demersal fish have the largest unconditional own-price elasticity of the Stage 2 group. Salmon, which is price inelastic, clearly has become a staple fish consumption product and is less price responsive than demersal fish, which would normally be considered as the traditional fish products purchased by UK consumers.

Table IV: Unconditional Expenditure and Marshallian Price Elasticities for Stage 2:

	Expenditure Elasticities	Salmon	Shellfish	Pelagic	Total Demersal	Other Fresh
Salmon	**0.556***	**-0.616***	-0.091*	-0.004	-0.385*	-0.272*
Shellfish	**0.229***	-0.125*	**-0.395***	-0.015	-0.393*	-0.082
Pelagic	**0.266***	-0.042	-0.052	**-0.422***	-0.538*	-0.120
Total Demersal	**0.300***	-0.158*	-0.118*	-0.059*	**-0.871***	-0.117*
Other Fresh	**0.207***	-0.103*	-0.067	-0.038	-0.320*	**-0.386***

* Significant at least at 5% level.

Stage 3

The Synthetic system rejected all the restricted models at the 5 percent level or less. Therefore, only results from the Synthetic model are discussed further in this sub-section. The Synthetic model performed reasonably well, with the coefficients of determination ranging from 0.67 for plaice to 0.91 for cod.

Table V presents the conditional expenditure and the Marshallian elasticity estimates at Stage 3. Plaice and other demersal fish are expenditure elastic while the expenditure elasticities of cod, haddock and sole are very close to unity. All own and cross-price elasticities are less than unity. The cross-price elasticities for cod are small but positive (indicating limited net substitutability with other fresh white fish species, especially haddock). There is also weak substitutability of haddock , other demersal and plaice for whiting. All other demersal species appear as complements.

Table V: Conditional Expenditure and Marshallian Price Elasticity Estimates for Stage 3

	Expenditure Elasticities	Cod	Haddock	Whiting	Oth Demersal	Plaice	Sole
Cod	**0.996**	**-0.823**	0.123	0.005	0.028	0.059	0.002
Haddock	**0.962**	-0.091	**-0.698**	-0.011	-0.055	-0.083	-0.025
Whiting	**0.527**	-0.004	0.016	**-0.552**	0.02	0.046	-0.052
Oth Demersal	**1.104**	-0.162	-0.247	-0.01	**-0.532**	-0.099	-0.13
Plaice	**1.145**	-0.118	-0.287	-0.007	-0.078	**-0.787**	-0.031
Sole	**0.976**	0.018	-0.18	-0.042	-0.09	-0.061	**-0.621**

Table VI presents the corresponding unconditional expenditure and uncompensated price elasticity estimates. All expenditure elasticities are substantially less than unity. This must be attributed to the fact that the reference expenditure elasticities in the first two stages (total fresh and total demersal categories) are also relatively small. The unconditional Marshallian elasticities shown in the table reveal cod as own-price elastic, while haddock has unitary price elasticity. Whiting has the lowest own-price elasticity, while the price elasticities for the other demersal, sole and plaice categories range from –0.62 to –0.92. All species in the sub-group appear now to be unconditional gross complements. It is also interesting to note that the unconditional price elasticities for cod, haddock and plaice are all above the equivalent elasticity for salmon (in stage 2).

Table VI: Unconditional Expenditure and Marshallian Price Elasticities for Stage 3

	Expenditure Elasticities	Cod	Haddock	Whiting	Other Demersal	Plaice	Sole
Cod	**0.299***	**-1.126***	-0.179*	-0.020*	-0.055*	-0.053*	-0.041*
Haddock	**0.289***	-0.383*	**-0.990***	-0.034*	-0.135*	-0.191*	-0.066*
Whiting	**0.159***	-0.164*	-0.144	**-0.565***	-0.024*	-0.014	-0.075*
Oth. Demersal	**0.331***	-0.497*	-0.582*	-0.037*	**-0.624***	-0.223*	-0.177*
Plaice	**0.344***	-0.466*	-0.634*	-0.035	-0.174*	**-0.915***	-0.080*
Sole	**0.293***	-0.278*	-0.475*	-0.066*	-0.172*	-0.170*	**-0.663***

* Significant at least at 5% level.

CONCLUSIONS

The study shows that arbitrary specification of a particular model (eg AIDS, Rotterdam etc) may be inappropriate, and that different specifications may be required for different stages of the analysis. The derivation of unconditional elasticities from the different Stage model parameter estimates is also laborious and complex. It is, therefore, useful to assess whether the effort is justified. This is perhaps best done by comparing the magnitudes of the conditional and unconditional elasticities at the various budgeting Stages.

The unconditional expenditure elasticities for the commodities in Stage 2 are less than one third of the respective conditional ones. The unconditional Marshallian own-price elasticities are higher than the corresponding conditional ones for all commodities. All commodities in Stage 2 appear as gross complements on the basis of the unconditional elasticities - something that is not the case for the conditional estimates. The unconditional expenditure elasticities in the Stage 3 are less than one third the magnitudes of the respective conditional ones whilst the unconditional Marshallian price elasticities are considerably higher than the conditional ones. Furthermore, all unconditional Marshallian elasticities suggest cross complementarity which is again not the case for the conditional estimates. Overall, the empirical results suggest that there are notable differences between unconditional and conditional elasticities both in terms of magnitude as well as in terms of the implied relationships between commodities (complementarity/non-substitutability vs.substitutability). Hence the use of conditional elasticities for policy analysis purposes could lead to quite misleading inferences.

The unconditional elasticities derived at both Stages 2 and 3 suggest that the demand for the sub-groups of fish categories and species identified behave as complements with respect to price changes. This tends to support the hypothesis that there is an underlying similarity/homogeneity in the species or categories which make up the sub-groups defined, and that consumers first choose processed, fresh or frozen fish or meat. They do not discriminate between types of fresh fish at this point in the decision process. Hence, all specific fresh fish categories and/or species are considered by consumers to be complements i.e. homogeneous. Having made the decision to purchase fresh fish, then within-sub-group species choices are made on the basis of relative prices. It is this phenomenon that the conditional Hicksian (compensated) elasticities estimates will reflect. In particular the results underline that there is substitutability at each stage amongst the principal fish sub-groups or species at given levels of expenditure shares.

According to the Stage 1 analysis, the fresh, frozen natural, and processed fish categories are all expenditure and price inelastic. They are also gross substitutes in consumption but the substitution possibilities among them are not very high (all cross-price elasticities are less than 0.5). Frozen natural fish is a gross complement for red meats and poultry, processed fish is a gross complement for poultry and bacon, and fresh fish a gross complement to red meats.

In Stage 2, the salmon, shellfish, pelagic, total demersal, and other fresh fish categories were all be expenditure and price inelastic. They were also cross complements to each other. In Stage 3, all cod, haddock, whiting, other demersal, plaice and sole, were found to be quite expenditure inelastic and all except cod and haddock, price inelastic. All Stage 3 species are gross complements. Changes in the prices of cod and haddock appear to exercise considerable influence on the demand for other fish species, while changes in the prices of plaice and sole cause limited expenditure reallocations.

The direct policy implications of this retail demand study are quite limited, if only for the important reason that there is little if no fisheries related policy that is addressed specifically at retail demand in the UK or EU. However, there are some broader implications for the long-term development of the sector. Given the income inelasticity of demand for fish at all three stages of analysis, any growth in total consumer expenditure on meat and fish will result in a less than proportionate impact on the quantity of fish purchased. In other words, the fishing and fish-processing sectors are likely to become a smaller part of the total food economy unless they can benefit from export demand growth for their products.

Retail demand has also been shown to be unconditionally price inelastic at all stages of analysis, with the exception of cod in Stage 3. This implies that any underlying upward tendency in price will generally lead to an increase in expenditure/revenue for that category of product all other things being equal. From a marketing and promotional perspective, the general price inelasticity suggests that price discounting is unlikely to be a useful retailing strategy –at least if the aim is to increase sales turnover. In terms of the demersal fresh species, cod and plaice consumption are likely to be the most responsive to any price changes, with cod and haddock the strongest substitutes once the consumer has made the decision to buy fresh demersal fish.

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ENDNOTES

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[b] In absolute value, but with a negative sign in actuality signifying a normal inverse quantity-price relationship.

[c] This approximates (as it excludes dairy products) to an animal proteins demand system.

[d] Taylor Nelson Sofres (TNS) Superpanel data were employed in the study. The Superpanel comprised of between 8-10,000 households over the sample period making scan-data records of their purchases on a 4 weekly basis. TNS raise and convert thee panel purchase data to time series estimates of aggregate GB consumption by volume and value for food products, including processed, fresh and frozen fish, meat and meat products and ready meals.

[e] Even with the theoretical conditions of symmetry and homogeneity imposed *a priori*, the number of free price parameters to be estimated increases quadratically with the number of goods in a system while the number of effective observations increases only linearly [8,9].

[f] i.e. conditional upon the assumption that the sub-system being analysed is weakly separable from other sub-systems. Hence, this assumption implies that the marginal rate of substitution among goods in one-subset is independent from the consumption of goods in another sub-set.

[g] We generally distinguish between compensated (or Hicksian) and uncompensated (or Marshallian) demand curves and their associated elasticities. This is to reflect the fact that a (relative) price change between two goods will not only involve a *substitution* effect (i.e.. movement around an indifference curve), but an *income* effect also with a movement to another indifference curve. The total effect of a price change (with both income and substitution effects) is measured by the Marshallian or uncompensated elasticity. If we adjust for the income effect, we would measure the pure substitution effect and this is represented by the compensated or Hicksian elasticity

[h] The above formulae can (with some notational difficulties) be generalized to any number of stages. In the three-stage system considered in the present study one first has to consider Stages 1 and 2 two as a two-stage budgeting process. This will yield unconditional elasticities for the sub-commodities in Stage 2. Next, one considers Stages 2 and 3 as a two-stage budgeting process again. Utilizing the unconditional elasticities from Stage 2 in the relevant formulae will yield the unconditional elasticities for commodities in Stage 3.

[i] Viz. Rotterdam Model, Differential AIDS, NBR Neaves[21] and CBS[22].

[j] It is worth noting that the equivalent Hicksian elasticities show inter-species substitutability