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The Demand For Wet Fish in Great Britain

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Abstract *Conventional empirical demand systems normally take prices to be exogenous, and determine the quantities demanded. Although this is logical for the individual consumer, at the market level the aggregate quantity traded may be exogenously determined, while the price vector changes to ensure the markets clear. It is suggested that this alternative scenario is particularly attractive for foodstuffs, and especially for wet fish, the commodity under consideration. An empirical analysis of the demand for wet fish in the UK using both the direct and indirect Translog models suggest that in this market, quantities are determining prices rather than the other way round. Furthermore, the two models provide widely different estimates of consumer preferences. This would suggest that more attention should be paid to the direction of causality in markets when undertaking formal demand analysis.*

Keywords Inverse demand systems, wet fish, causality.

The cornerstone of neo-classical demand theory is the concept of the utility function. It is assumed that the observed consumption decisions of consumers can be rationalized in terms of the outcome of maximising the utility function subject to some budget constraint. For any given budget and set of commodity prices, explicit knowledge of the utility function allows the analyst to identify key variables, such as income and price elasticities. Thus the aim of much empirical demand analysis is to explicitly (or implicitly) identify the un-observable form and parameters of the utility function. These will not be a function of the market structure through which goods are obtained ie. in a direct utility function, the level of utility attained depends solely on the quantities of the commodities consumed. Thus, nowhere in the literature is it suggested that the level of utility achieved by a consumer as a result of consuming a bundle of goods will differ if that bundle has been imposed by a rationing system, or if an identical bundle is chosen through a free market system. This is an extreme case, but it will be equally true that, in a market system, the optimization process of the individual consumer will be unchanged whether or not the market supply of the good is perfectly elastic or perfectly inelastic. Each consumer will behave as a price taker, and, for a particular price vector, derive their demand for commodities. At the *market* level there is a difference: if supply is perfectly elastic at a particular price, then market demand is simply given by the summation of the individual demands evaluated at that price. If the supply is perfectly inelastic, then the sum of the individual demands will be constrained to equal that exogenous supply, and it is the price vector that will change in order to ensure this. Thus, the market structure (in the sense of what should be considered exogenous) will have no implications for the form of the optimality conditions of the consumer, but will have implications for any empirical analysis that utilises market level data, as the variables that will be considered as exogenous will be different.

The majority of empirical demand analysis that uses complete systems has been conducted on the basis that prices are exogenous, implying a perfectly elastic supply curve (an example involving fish is given by Young, 1982). Given the econometric complexity of most systems, it is perhaps not surprising that researchers have avoided the difficulties in determining both price and quantity simultaneously, but it is by no means clear why the Gordian knot has so resolutely been cut in this way, in particular when the commodities under consideration are foodstuffs. In this case, given the nature of the production process, a more reasonable assumption would seem to be that supply is exogenous, and thus prices are determined within the market (Deaton and Muellbauer, (1980) p. 81). There have been some studies that have followed this approach, for example, Houthakker, (1960), Christensen and Manser, (1977). The particular concern of this paper is the implication of using the alternative assumptions about market level exogeneity on the evaluation of consumer preferences.

In the analysis of demand relationships for fish, inverse demand equations appear to be predominate (see Nash and Bell, (1969) and Schrank *et al.*, (1988)) but the analysis has been almost entirely restricted to ad-hoc, single equation studies (an exception is the work by Barten and Bettendorf, (1989)). The reason for this appears to be the computational cost of estimating such systems, and the increase in parameters as the number of categories of fish increase. Neither of these arguments are valid, and in particular, the number of parameters in systems can be significantly reduced by: 1) imposing the parameter restrictions implied by the theory, which is the main reason for their use, 2) invoking separability assumptions which restrict the number goods within a system.

Although the latter may seem contentious, implicitly it is also widely used in ad hoc studies as the number of alternative prices/quantities included in any specification is usually small. It seems to attract attention in formal demand systems because an explicit statement of the separability assumption has to be made, but this transparency should be viewed as an advantage.

The final reason for preference to be given to ad hoc systems is that their nature allows some form of dynamic response to be incorporated easily. This is not the case in formal systems, where even ad hoc extensions that attempt to retain the formal properties (usually at equilibrium) lead to significant estimation difficulties (*eg* Anderson and Blundell, 1982). It is also not clear that an unspecified 'adjustment' mechanism is the most appropriate model for any dynamic response in food demand systems, whereas models of structural change in tastes would appear to present a better way forward (*eg* Burton and Young, 1992, Moschini and Meilke, 1989).

In this paper, consumer preferences with respect to wet fish are to be investigated, and here in particular it would seem appropriate to investigate the implications of assuming that supply is exogenous, especially when using relatively high frequency data. The results from a conventional, quantity dependant, demand system will also be presented in order to allow comparisons to be made between the two approaches. It should be emphasised that the assumptions made about the supply of fish are at the two extremes: either perfectly elastic or perfectly inelastic. Neither are likely to be 'true,' but it seems important to investigate the implications of either choice, given that the assumption of a perfectly elastic supply curve is usually adopted in formal demand systems unquestioningly.

Theory

The models used are the direct and indirect translog, as outlined in Christensen *et al.* (1975). In the direct translog, a direct utility function is specified of the form

$$-\ln(U) = \alpha_0 + \Sigma_i\alpha_i \ln(X_i) + 0.5\Sigma_i\Sigma_j\beta_{ij} \ln(X_i) \ln(X_j) \quad i,j = 1..n \qquad (1)$$

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

$$\alpha_i + \Sigma_j\beta_{ij} \ln(X_j) - [\Sigma_j\alpha_j + \Sigma_i\Sigma_j\beta_{ij}\ln(X_j)] \frac{P_iX_i}{M} = 0 \qquad (2)$$

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

$$W_i = \frac{\alpha_i + \Sigma_j\beta_{ij}\ln(X_j)}{-1 + \Sigma_j\beta_{mj}\ln(X_j)} \qquad (3)$$

where W_i is the share of expenditure spent on good i, and $\beta_{mj} = \Sigma_i\beta_{ij}$. It is also necessary to impose some normalization rule on the parameters, as the utility function is homogeneous of degree one, and the first order condition homogeneous of degree zero, in the parameters. The normalization used is that $\Sigma_j\alpha_j = -1$. Although the parameters are not invariant to the rule used, all elasticities and test statistics are (for a proof of this, see Christensen and Manser, pp 50–51).

The direct demand functions are derived from the indirect translog utility function

$$\ln(V) = \alpha_0 + \Sigma_i\alpha_i\ln(p_i) + 0.5\Sigma_i\Sigma_j\beta_{ij}\ln(p_i)\ln(p_j) \quad i,j = \ldots. n \qquad (4)$$

where $p_i = P_i/M$. Using Roys' identity the budget shares can be derived.

$$W_i = \frac{\alpha_i + \Sigma_j\beta_{ij}\ln(p_j)}{-1 + \Sigma_j\beta_{mj}\ln(p_j)} \qquad (5)$$

Equations 3 and 5 bear a close resemblance to each other, but it is important to remember that the translog function *is not self-dual* and therefore they do not represent the same preferences. This would be the case only if $\beta_{ij} = 0$ for all i,j, as the direct and indirect utility functions then collapse to the double log form, which is self-dual. From an econometric viewpoint, these are competing models, containing alternative assumptions about the source of exogeneity in the market, a point that was emphasised in Christensen and Manser, but which seems to have been lost on others (*e.g.* Bewley 1986, McLaren 1982).

Data

The analysis has been conducted for the consumption of wet fish only. Restricting the analysis to these goods implies some multi-stage budgeting procedure in the allocation of total expenditure. Although this is a common assumption, made to reduce the number of goods included in any one system, in the current context it has to be made with some caution, as one is assuming that consumption of wet fish is independent of the consumption of frozen fish. Some support for this separability assumption at the consumer level is given in Lessor *et al.* (1982) where it is argued that wet and frozen fish are viewed as quite different products, based on the need for different preparation and cooking techniques. It poses more of a problem at the market level as presumably there could be re-allocation of the product between end uses, but as stated earlier, the intention is to investigate the implications of the alternate assumptions of exogeneity: more complex methodologies are discussed in the concluding section.

Both direct and indirect demand systems have been estimated for the period 1980:2 to 1986:2, using quarterly data reported in the Sea Fish Industry Authority (SFIA) documents 'Household Fish Consumption in Great Britain.' It would be preferable to employ data of a higher frequency as this would make the exogeneity assumptions more plausible. Monthly data is available on landings, but the current data set provides the best indication of consumption within the UK. Quantities and expenditures are identified for 15 types of fish, with some further disaggregation within types by form of presentation (*i.e.* whole, fillets and steaks). For the purpose of the analysis the data has been aggregated into four groups:

White	:-Cod, Saithe, Haddock, Hake.
Smoked White	:-Smoked Cod, Smoked Haddock.
Fat	:-Herrings, Kippers, Mackerel, Smoked Mackerel.
Other	:-Plaice, Skate, Lemon Sole, Whiting, Rock Salmon.

The fish types are not homogeneous within the groups, but these were chosen in consultation with economists at SFIA. The shares of total expenditure accounted for by each group are reported in Table 1.

Table 1
Group Shares of Expenditure: 1980:2–1986:2

	Max.	Mean	Min.
White	0.547	0.499	0.466
White Smoked	0.139	0.123	0.099
Fat	0.106	0.086	0.064
Other	0.322	0.292	0.247

Estimation

Before estimation, the exogenous data series in each model were normalised. Thus, in equation 3, the quantities (X_j) were normalised to have a value of 1 in 1986:2, and in equation 5 the prices and income were normalised to have a value of 1 in 1986:2. Again, these transformations will change the parameter values, but not the estimated elasticities. The reason for indexing the series in this manner is it ensures the point of approximation is related to the observable data set. It also greatly eases the calculation of the elasticities.

Given that adding up holds within the data, and will hold within the estimation, the residual variance covariance matrix will be singular if all 4 share equations within a system are estimated together. The standard procedure is to exclude one equation, and then recover the non-estimated parameters using the adding up constraint. The alternative used here is to estimate each system twice, excluding a different equation each time. The common parameters and the log likelihood value should be invariant between the two, thus providing a check on the computer coding.

The parameter values are reported in Table 2 below. Note that symmetry has been imposed, with the restrictions that $\beta_{ij} = \beta_{ji}$, $i > j = 1 \ldots . n$, although these may not be valid restrictions for *some* utility functions that generate demand equations in the form of 3) and 5) (see Simmons and Weiserbs 1979). An effort was made to test both the symmetry conditions, and adding up, (*i.e.* $\beta_{mj} = \Sigma\beta_{ij}$) but extending the parameter set in this way caused the estimation to fail due to matrix singularity. Thus we had to proceed with these restrictions as given.

The Theil U(2) statistics reported in Table 3 indicate that the direct model significantly out-performs the indirect model. These results appear to give support to the idea that the demand for wet fish should be modelled within the context of an exogenous market supply. However, inspection of the bordered Hessian derived from the direct utility function reveals that the signs of the principle bordered minors do not alternate, so that the second order sufficient condition for a maximum is not satisfied (Chiang, p385). Although this is only a sufficient, and not necessary, condition, and hence the resulting failure to satisfy it does not preclude the possibility of a maximum being identified, derivation of the price and income elasticities reveals that not all of the compensated own price substitution effects are negative (Table 4). This clearly makes it difficult to interpret the direct translog model as a conventional demand system. The indirect translog generates elasticities that are conventionally acceptable (Table 5), and which are very similar to results obtained for Great Britain using conventional AIDS and Rotterdam demand systems for fish demand under different classifications in Young and Burton (1987, 1988).[1] The results are also of the same order of magnitude to those reported by Tsoa *et al.* (1982) for the US.[2]

Given the direct translog's predictive ability, it was decided to re-specify it, in an effort to retain this ability while producing a model consistent with economic theory. The simplest adjustment is to impose explicit additivity on the utility function, which yields 6 parameter constraints of the form $\beta_{ij} = 0$ for $i \neq j$, and

[1] e.g. own price elasticities of −0.65 for cod, −0.59 for plaice, −0.87 for all 'white' fish and—1.30 for 'fat' fish.
[2] e.g. long run own price elasticities of −0.46 for cod and −1.04 for flat fish.

Table 2
Estimation Results for Direct and Indirect Translog Models

Parameter	Direct	Indirect	Direct (Additive)
α_1	−0.4719	−0.4690	−0.4746
	(0.002)	(0.010)	(0.002)
β_{11}	−0.1366	−1.1069	−0.4626
	(0.175)	(1.038)	(0.027)
β_{12}	0.0931	−0.2866	
	(0.037)	(0.275)	
β_{13}	0.0602	−0.4143	
	(0.037)	(0.237)	
β_{14}	0.2557	−0.5014	
	(0.117)	(0.624)	
α_2	−0.1310	−0.1325	−0.1311
	(0.001)	(0.005)	(0.001)
β_{22}	−0.0960	−0.0052	−0.1109
	(0.015)	(0.183)	(0.003)
β_{23}	0.0213	−0.0084	
	(0.010)	(0.055)	
β_{24}	0.0512	−0.2439	
	(0.031)	(0.207)	
α_3	−0.0918	−0.0906	−0.0916
	(0.001)	(0.005)	(0.001)
β_{33}	−0.0467	0.0111	−0.0546
	(0.011)	(0.045)	(0.006)
β_{34}	0.0415	−0.0671	
	(0.029)	(0.093)	
α_4	−0.3053	−0.3079	−0.3027
	(0.001)	(0.009)	(0.002)
β_{44}	−0.1864	−0.6296	−0.2976
	(0.095)	(0.378)	(0.031)

(standard errors in parenthesis)
Commodity Coding: 1 = White 2 = Smoked White 3 = Fat 4 = Other

the estimated parameters from this model are reported in Table 2 above. The imposition of these constraints generates a (small sample adjusted) log likelihood test statistic of 16.5, so the restrictions would be accepted at a relatively high significance level (99%). The second order conditions for a maximum are satisfied, and the elasticities are reported in Table 6. The income elasticities are broadly similar between the indirect and the additive direct system, with 'Fat' fish necessities, and the 'Other' group (containing the relatively more expensive flat fish) a luxury. The major switch is in 'Smoked White,' which is a luxury in the indirect specification, and a necessity in the direct system. More dramatic differences occur between the price elasticities in the two systems. The direct model has substantially higher own price elasticities, with the 'White' and 'Other' groups

Table 3
Theil U(2) Statistics

	Direct	Indirect	Direct (Additive)
White	0.267	0.577	0.275
White Smoked	0.088	0.666	0.130
Fat	0.230	0.578	0.245
Other	0.295	0.601	0.319

1966 version, using changes.

having particularly large values, with corresponding large cross price effects between the two goods. This degree of substitution between fish is perhaps justifiable, given the extreme level of dis-aggregation and similarity of the goods analyzed. What is of more concern is the fact that similar effects are not apparent in the results for the indirect system.

Christensen and Manser also found there to be some diversity in the elasticities generated by direct and indirect demand systems applied to the same data set, but in their case the alternative results could be considered as compatible with each other, which is not the case with the current results. The cause of the divergence is problematic. Both systems are intended to represent second order approximations to the underlying utility or cost function, and although not self-dual, it would be surprising if the complete disparity in representation of the utility function were due solely to divergences in the approximation implied by the two systems. The difference cannot be attributed to the error of simply deriving the elasticities for the direct model by inverting the corresponding flexibility, as the elasticities for the direct demand system have been derived correctly, by inverting the full matrix of own and cross flexibilities (Anderson, 1990). The significance of the assumption made about the direction of causality at the market level would therefore seem to be highlighted by these results. This feature also appears in the table of elasticities reported by Nash and Bell (1969) where the own price elasticities generated by quantity dependant systems are generally small (in absolute size) compared with those generated by price dependant systems, irrespective of species or region covered. Note that this result occurs despite the fact that the elasticities for the price dependent models are derived by inverting single flexibilities (Houck, 1965), and again suggests that the direction of causality assumed

Table 4
Estimated Elasticities, Direct Translog

	with respect to								
		Price (total)				Price (compensated)			
Group	Income	P1	P2	P3	P4	P1	P2	P3	P4
1	0.49	0.70	0.23	0.08	−1.48	0.92	0.29	0.13	−1.30
2	0.67	0.73	−10.30	0.90	7.86	1.04	−10.10	0.96	8.11
3	−0.28	0.79	1.42	−2.95	1.03	0.65	1.37	−2.97	0.95
4	2.32	−3.18	3.21	0.07	−2.40	−2.07	3.48	0.28	−1.70

Commodity Code 1 = White 2 = White Smoked 3 = Fat 4 = Other
Details of formulae used for generating elasticities and flexibilities are available from the author on request.

Table 5
Estimated Elasticities, Indirect Translog

		with respect to							
		Price (total)				Price (compensated)			
Group	Income	P1	P2	P3	P4	P1	P2	P3	P4
1	0.85	−0.95	0.07	0.41	−0.37	−0.55	0.18	0.49	−0.11
2	1.67	−0.15	−1.50	−0.42	0.40	0.63	−1.28	−0.27	0.92
3	0.49	2.26	−0.45	−1.60	−0.79	2.49	−0.39	−1.55	−1.55
4	1.90	−0.68	0.25	−0.26	−0.40	−0.17	0.39	−0.16	−0.06

Commodity Code 1 = White 2 = White Smoked 3 = Fat 4 = Other

at the market level has important implications for the inferred consumer behaviour.

Although the simulation performance is reduced as compared with the unconstrained direct translog, this appears to be a fairly small effect, and it is still a substantial improvement as compared with the unconstrained indirect translog (Table 3).

The elasticities themselves are of interest, in that they allow some comparison of the preferences implied by the two models, but within the direct translog models the flexibilities are also important, as they reveal the changes in prices that will occur as a result of changes in the exogenous supply of wet fish. These are reported in Table 7 for the additive model. These are all negative, as expected, and the restrictive nature of the additivity assumption is apparent, with the cross effects of a change in quantity j being the same for all prices i ($i \neq j$). They are also largely in line with the own quantity flexibilities reported by Barten and Bettendorf for Belgium.

Conclusions

Most empirical studies of the demand for foodstuffs that use formal systems have concentrated on elaborating consistent representations of consumer preferences, while ignoring the market structure through which such preference manifest themselves. We have argued that individual consumer preferences will be independent of the market structure, but that the means to identify aggregate demand functions is not. In particular, the assumption that the supply of goods is infinitely elastic leads to a quantity dependent formulation of the demand system being used in

Table 6
Estimated Elasticities, Direct Translog (Additive)

		with respect to							
		Price (total)				Price (compensated)			
Group	Income	P1	P2	P3	P4	P1	P2	P3	P4
1	1.04	−20.70	0.76	0.14	18.50	−20.20	0.88	0.24	18.80
2	0.17	3.13	−6.41	0.02	3.04	3.20	−6.34	0.04	3.09
3	0.06	1.19	0.05	−2.47	1.16	1.23	0.06	−2.47	1.18
4	1.57	28.80	1.14	0.21	−31.20	29.50	1.33	0.36	−30.80

Commodity Code 1 = White 2 = White Smoked 3 = Fat 4 = Other

Table 7
Estimated Flexibilities, Direct Translog (Additive)

	with respect to Quantity			
Group	Q1	Q2	Q3	Q4
1	−0.48	−0.11	−0.05	−0.30
2	−0.46	−0.26	−0.05	−0.30
3	−0.46	−0.11	−0.49	−0.30
4	−0.46	−0.11	−0.05	−0.31

Commodity Code 1 = White 2 = White Smoked 3 = Fat
4 = Other

empirical work. A competing hypothesis would be that supply is perfectly inelastic, implying that the correct formulation of the demand curves would be price dependent with exogenous quantities. If an assumption has to be made in order to avoid price and quantity being simultaneously determined, a priori the latter would seem more reasonable in the case of food. This proposition has been investigated for the case of the demand for wet fish using the direct and indirect translog models. In terms of its ability to reproduce the observed market data, the direct model, in which quantities are assumed exogenous, far out performs the indirect model, even when additivity restrictions are imposed on the direct model alone. Furthermore, the form of the demand curves implied by the two models show considerable differences, with much greater responsiveness to price changes revealed by the direct translog model. These results should be tempered with caution given the separability assumptions invoked, and the possibility that the assumption of a perfectly inelastic supply curve may be as questionable as the conventional assumption of one that is perfectly elastic. The next stage of the analysis should perhaps consider extending the data to include frozen fish and using formal tests of exogeneity, in the manner of Bronsard *et al.* (1984). However, it does appear that accurate measurement of consumer preferences cannot be expected if the aggregate structure of the market is simply assumed away.

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