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Salmon Industry**

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Measuring Market Power in the UK Retail Salmon Industry

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Abstract

This paper presents an investigation into the market structure for three product types of salmon (smoked, fresh and whole salmon) in the UK retail market. Evidence of the potential for market power and pricing conduct is analysed using structural simultaneous system equations based on the Bresnahan (1982) model. The importance of the retail market is recognised given the dominance of supermarket chains which accounted for £1.6 billion sales of seafood and the share of about 87% of all seafood retail sales in 2004 as compared with only 16% in 1988. The results indicate that the system is well represented by the models and that the market is competitive for fresh fillets and whole salmon but retailers exert some market power for smoked salmon. The hypothesis that market power is the same for all three products in the study was rejected; further indicating that retailers may be exercising market power for smoked salmon.

Keywords: Market power, Error correction model, Dynamic demand systems, salmon

JEL Classification: JEL-1, JEL-J

Introduction

Rapid growth of the UK retail sector in the last 20-years has fueled an enormous change in the organization of relationships along the seafood marketing structure. Changes in consumer buying habits with the increased demand for convenience food and the consumption of more meals away from home are frequently cited in the literature as the natural causes of these transformations. These changes have shifted the market from being unsophisticated into being highly technological and concentrated. This concentration has been brought about partly by the substantial growth in the production of intensively farmed salmon in Scotland, and partly by the increased dominance of supermarkets in retail sales. Mergers among supermarket chains and take-overs by multinational retail firms have led to supermarket dominance in the retail trade. Supermarket sales of seafood at £1.6 billion for 2004 was up 9.6% on 2003 figures (Seafish Industry Authority, 2004), and account for about 87% of all seafood retail as compared with only 16% in 1988 (Murray and Fofana, 2002). Growth in supermarket sales has occurred at the expense of market stalls, fishmongers, retail vans and other independent retailers as depicted in Figure 1. Consequently, the supermarket is now the outlet of choice for most consumers, rather than the independent small retailer (e.g. fishmonger).

[Insert Figure 1 here]

The motivations of this paper are closely linked to the developments that have occurred in the fish retailing industry in the last two decades and the dominance of supermarkets in retailing of seafood products in the UK. These developments have raised concerns that supermarkets may be exercising market power. This allegation has been expressed by consumer groups and newspapers such as *Fish Farming Today*, No. 180 November, (2003) and *Sunday Times*, 23 August (1998)). A number of recently published books¹

¹ “Shopped” by Joanna Blythman and “Not on the Label” by Felicity Lawrence
New Economics Foundation – “Clone Town Britain”
<http://www.neweconomics.org/gen/uploads/mrrefr55lroqjwrefpvg525528082004130712.pdf>

about multiple retailers' growth and dominance also document the growing public concern of the spiralling power of the supermarket retail chains.

Concerns over the dominance and potential market power was one of the factors that led the Office of Fair Trading (OFT) in the UK prompted the Competition Commission (CC) to investigate UK supermarket sector, the report of which was released in 2000. The CC's analysis covered both the supermarkets' relationships with suppliers and the extent to which the downstream market was competitive. The investigation included an analysis of price trends over time, international price comparisons, profitability, and consumer satisfaction. The CC concluded that there was no evidence of excess prices or profits, and that the market was 'broadly competitive'. In early 2006, the OFT again referred the retail industry to the CC for more detailed investigation due to further consolidation in the retail market since 2000. The OFT is particularly concerned that increased consolidation and the move by supermarkets into the convenience sector could reasonably be suspected to distort competition and harm consumers.

The question of competition and market power come together in considerations of dominant firms and in the chain they operate. High market concentration and shares are commonly associated with the exercise of market power (Burt and Sparks (2003)). Therefore a concept central to the industrial organization literature is that increased concentration leads to increased market power, while less concentration increases the disciplines on industry's pricing strategy. Disadvantaging competitors by offering lower prices to suppliers provides a benefit that allows dominant firms to increase market share or prices. In the literature a number of possible ways of raising costs can be identified, including supply agreements, exclusive dealing, wage deals, compliance costs, advertising, development service enhancements and vertical integration. All or some of these tactics have been ascribed to the operation of multiple retailers and supermarkets (Smith (2002), Clarke et al. (2002)).

In a recent article, Jaffry, Fofana and Murray (2003) carried out a study of the retail market for fresh salmon fillets in the UK using data for the industry from 1992-2000. Their work was motivated by the recent questions about claims that supermarket chains use their buying power to obtain substantial discounts from suppliers but fail to pass these benefits on to consumers. Using single demand and supply equations, Jaffry et al analysed the chain between the retailers and consumers for the fresh salmon fillets using the New Empirical Industrial Organization (NEIO) methodology. The study revealed that the retail market for fresh salmon fillet is competitive despite the market being highly concentrated. However, the study does not imply that market power is not being applied to other product forms such as smoked salmon fillets or whole salmon at retail level.

Since the late 1980s, application of the NEIO to estimating the extent of market power has become very popular. Recent developments in time series economics have further enhanced empirical investigation of market power using the NEIO methodology. In this methodology, correct specification of the demand process is crucial. While most applications of this method have been restricted to single markets, Cotterill, Dhar and Putsis (2000), Hausman, Leonard and Zona (1994) and Hyde and Perloff (1998), among others have used system demand equations to overcome the theoretical shortcomings of single demand equation in determining market power. Hyde and Perloff (1998) developed cross-markets investigation of market power for meat using a linearised form of AIDS model.

In this paper an economic model of firm conduct similar to that of Hyde and Perloff (1998) is used to measure explicitly the degree of competitive behaviour in the retailing of salmon products in the UK. This approach yields precise, interpretable statistical tests to evaluate the degree of market power in salmon retailing. While the approach used in this paper is similar to that of Hyde and Perloff, it is more robust in that the time series properties of the data are accounted for in the construction of the LAIDS model. The marginal cost equation in this article also differs from that of Hyde and Perloff in that we

included a variable that captures price of capital for retailing and tests are conducted for the legitimacy of the instruments used in the estimation. The modelling approach also differs from previous salmon retail market power studies in the UK that uses single demand models (e.g. Jaffry et al. (2003)).

1. Model formulation

The key to measuring market power using the NEIO methodology is the consistent estimation of demand and cost models. Therefore, we first specify a system demand model estimated and then derive the optimality equations following Hyde and Perloff (1998).

1.1 Demand Systems

The first stage in the estimation of market power is to specify and estimate a model that describes consumer demand. The key to any demand estimation is to specify a model that is both flexible and consistent with economic theory. The linear form of the AIDS has enjoyed great popularity in applied demand analysis due to its consistency and ease of estimation. Starting from a specific cost function with the basic assumption that commodities are weakly separable from non-related goods, the AIDS model gives the share equations in a 3 good system as

$$z_{it} = \alpha_i + \sum_{j=1}^3 \gamma_{ij} \ln p_{jt} + \beta_i \ln \left(\frac{x_t}{p_t} \right) \quad (1)$$

where $z_{it} = \frac{p_{it}q_{it}}{x_t}$ is the budget share of the i^{th} good, p_{jt} are prices of the j^{th} good in the

bundle, x_t is total expenditure on all goods in the system and p_t is the index of prices in time period t. The index of prices p_t is assumed to be a function of commodity prices and is defined as a translog price index of the form:

$$\ln p_t = \alpha_0 + \sum_j \alpha_k \ln p_k + \frac{1}{2} \sum_j \sum_k \gamma_{jk} \ln p_j \quad (2)$$

The linear AIDS model uses the 'corrected' Stone's (1953) price index:

$$\ln p_t^s = \sum z_{it} \ln \left(\frac{p_{it}}{p_i^0} \right)$$

where p_i^0 is the mean of the series used as the base period. To keep the model consistent with economic theory, the parameters are constrained such that the homogeneity, adding-up and symmetry conditions hold. These restrictions are imposed as follows:

$$\begin{array}{lll} \sum_{i=1}^3 \alpha_i = 1 & \sum_{i=1}^3 \gamma_{ij} = 0 & \sum_{i=1}^3 \beta_i = 0 \quad (\text{Adding up}) \\ \sum_{j=1}^3 \gamma_{ij} = 0 & (\text{Homogeneity}) & \gamma_{ij} = \gamma_{ji} \quad i \neq j \quad (\text{Symmetry}) \end{array}$$

Therefore we estimate own price and expenditure elasticities of the three product forms included in the study. The uncompensated own price (ε_{ii}) and income (η_i) elasticities of demand (Green and Alston, 1990) are calculated as follows

$$(\text{Own price}) \varepsilon_{ii} = -1 + \frac{\gamma_{ii}}{z_i} - \beta_i \quad (\text{Expenditure}) \eta_i = 1 + \frac{\beta_i}{z_i}$$

Calculating elasticities, the budget shares are ideally the predicted shares at the estimation point. However, Chalfant (1987) indicated that the use of the corresponding sample share closely approximates the predicted shares, and that these can be used in empirical work.

1.2 Optimality condition

As highlighted by Hyde and Perloff (1998), Bresnahan (1982) showed that a suitable way of generating an entire family of possible equilibria is to equate marginal cost with a measure of *effective* marginal revenue. This is mathematically given as follows

$$MR \equiv p_i + \lambda_i p'_i(q_i) q_i \quad (3)$$

where q is quantity, p is price and the λ term is a parameter to be determined and captures the degree of market power in the industry for all goods $i = 1, \dots, n$. Theoretically, λ term takes a value between 0 and 1 ($0 \leq \lambda \leq 1$) and if λ equals zero perfect competition exists. If λ is equal to 1 the industry behaves as a cartel. Intermediate λ values identify different oligopoly regimes. In general, the optimality condition in (3) can be rewritten for good i as

$$p_i + \lambda_i \frac{\partial p_i}{\partial q_i} q_i = MC(q_i) \quad (4)$$

where $MC(q_i)$ is a formulation for the marginal cost function which is the first derivative of the total cost function. The procedure summarised in equation (4) has been applied in many single market studies (see for example Jaffry et al (2003) and Steen and Salvanes (1998) for specific examples on the application to salmon markets. Hyde and Perloff (1998) generalised equation (4) to study several markets simultaneously. Following the same vein, we generalised equation (4) to study several product markets simultaneously. Some authors have interpreted λ as conjectural variation, in this paper we have followed Perloff (1992) as the wedge between price and marginal cost created by an unknown game.

To extend Hyde and Perloff (1998) analysis, we included a variable, k , which is a proxy index that captures the price associated capital and other utilities faced by all retail outlets

as part of the determinant of marginal costs.² The k variable in the marginal cost equation emphasises the asymmetry in costs that can exist between the incumbent large retail firms and potential entrants in the market. Supermarkets have used this advantage to cut prices to lure customers and by so doing moving away from short run to long run profit maximization objectives. These strategies are designed to increase market share, protect market position in the long run and act as a barrier strategically to deter potential entrants in the industry. The evaluation of competitive markets and market behaviour often focuses on the extent to which one or more firms can sustain a price increase. Firms will find it very difficult to sustain significant long-term price increases if it is easy for new firms to enter a market and provide a substitute product or service. The existence of barriers to market entry will limit such market responses. There are many types of barrier to entry in different markets. Bain (1956) identified absolute cost advantage³ and economies of large scale production that require large capital expenditure as among the general sources of barrier to entry in an industry. Bain argued that a barrier to entry is a structural attribute of a market implying that incumbent sellers can earn more than a normal rate of return without attracting new entrants into the industry. For example, the cost of land is a significant part of costs in the UK. The Competition Commission (2000) reported that the five main supermarkets in the UK paid more to acquire land for development than their counterparts in other European countries. Along these lines the Competition Commission (2000) examined development costs of land in France, Germany, and the Netherlands. The analysis suggests that development costs in the UK were typically 2.5 times higher than in France; 1.6 times higher than in Germany and 2.7 times higher than Netherlands. Therefore k which is an index of the price of capital and other utilities is a key variable in the cost structure of large retail organizations in the UK and it is vital to uncover any anticompetitive behaviour.

² Steen and Salvanes (1998), Park and Weliwita (1999), Jaffrey, Fofana and Murray (2003) included measures of capital cost in the marginal cost equations in determining oligopoly power.

³ Absolute cost advantage is used to describe a number of potential cost advantages that incumbents may have over new entrants, other than economies of scale.

Following Hyde and Perloff (1998), constant returns to scale is assumed so as to allow the possibility of detecting other forms of market structures. In this vein, marginal cost for each good reflects constant returns to scale and is linear in wholesale prices, wages and price of capital as shown in the following equation.

$$MC(q_i) = a_i + b_i v_i + d_i w + e_i k \quad (5)$$

where v_i is the wholesale price of each fish product; w is an index of retail wage costs common for all salmon products and k is a measure of capital cost common to all retail outlets in the industry. a_i, b_i, d_i and e_i are parameters to be estimated. Similar marginal cost representations have also been used by Deodhar and Sheldon (1995) and Hatirl et al (2003).

Taking first differential of the LAIDS model holding total expenditure (x) and other prices $p_j, j \neq i$ constant, the slope of each of the demand curve can be given as follows

$$\frac{\partial p_i}{\partial q_j} = -\frac{p_i}{q_j} \left[\delta_{ij} - \frac{\gamma_{ij}}{z_i} + \beta_i \frac{z_j}{z_i} \right]^{-1} \quad (6)$$

where δ_{ij} refers to the Kronecker delta. In the salmon retail market retailers stock most of the product forms for salmon. In the case where each firm sells all three goods, as we assume that retail firms sell all three products, (4) can be generalised to

$$p_i + \sum_{j=1}^3 q_j \frac{\partial p_j}{\partial q_i} = MC(q_i) \quad (7)$$

Substituting (5) and (6) into the optimality condition (7), with some mathematical manipulations yields the following equation used in the estimation.

$$p_i = \left[a_i + b_i v_i + d_i w + e_i k - \frac{\lambda_i z_i}{q_i} \sum_{i \neq j} \frac{p_j q_j}{\gamma_{ij} - \beta_i z_j} \right] \times \left(1 - \frac{\lambda_i}{1 - \frac{\gamma_{ii}}{z_i} + \beta_i} \right)^{-1} \quad (8)$$

where p_i is the retail price of salmon product i , v_i is the wholesale price, w is an index of the retail wage rates, q is the quantity sold, z is the budget share, γ and β are coefficients from the LAIDS model and a, b, c, d, e and λ are parameters to be estimated. As evident from equation (8), an integral part of the optimality condition which depicts the industry's pricing behaviour is the elasticity concept which is the conduct coefficient (λ). The λ parameter measures a gap created by some unknown game as could be the case in a folk-theorem equilibrium that lies between the collusive and Cournot equilibria (Hyde and Perloff (1998)). Thus the model involves a kind of pseudo-dynamics depicted in a framework that is essentially static.⁴ More recently, the appearance of studies in the literature have tested the validity of static oligopoly models (e.g., Nevo (2001); Hausman and Leonard (2000); Genesove and Mullin (1998); Wolfram (1999)). Most of these studies suggest that the seemingly static oligopoly models yield reasonably accurate predictions of pricing behaviour. The conduct coefficient will reveal what kind of oligopolistic behaviour that characterizes the market, and there is no need to impose any *a priori* restriction on it. That is, it is not necessary to assume a certain conduct beforehand, and test for its propriety. Instead, any behavioural model is *a priori* plausible.

2.0 Data and Empirical Modelling

Salmon retail data for smoked, fillets and whole salmon were collected from Seafish Industry Authority and the production and wholesale data were obtained from Scottish Quality Salmon (SQS).⁵ Quantity-value transformation was used to derive unit prices per kilogram. Asche et al (2001) argues the significant price reductions of new aquaculture species indicates that the markets for these species are not strongly linked to the markets for other products. As perfect substitutes have a constant relative price and close substitutes have highly correlated prices, this suggests that farmed fish does not compete too

⁴Although derived in a static context, these tests provide a valid empirical test of dynamic equilibrium (Worthington (1990)). Consequently we do not introduce any dynamics in the optimality model during estimation.

closely with other goods. Therefore data for substitute products were excluded from the analysis.

Wage (w) in the marginal cost equation is an index of wage costs of retailers, based on a continuous surveys conducted by the UK Office for National Statistics (ONS) in which over 12, 500 samples are selected annually. Price capital variable (k) in the marginal cost equation is an index of rent, which includes maintenance, insurance, ground rent, council tax, water rates, mortgage, building maintenance and an interest payment index; collected from the Office for National Statistics (ONS), UK.

The data available for empirical modelling are monthly figures from January 1992 to December 2003. Table 1 summarises and presents descriptive statistics of the variables used in the estimation procedure.

[Insert Table 1 Here]

Although monthly data were available we follow Genesove and Mullin (1998) in aggregating up to quarterly level. Genesove and Mullin argued that this was to ensure that the estimated elasticity represents the long run elasticity as opposed to short run. In addition, the long run is considered because under imperfect competition, retailers are more likely to establish a price in the long-run rather than short-run profits in mind and to maintain that price for a considerable period of time (Juma, (2004)). Before specifying the most appropriate empirical model the time series properties of the data were reviewed in order to investigate formally whether the long run demand relationships are economically meaningful or merely spurious.

⁵SQS is an industry body that represents Scottish Salmon Growers Association, the Scottish Salmon Board and Scottish Quality Salmon. A new expanded trade association, Scottish Salmon Producer Organisation, was created in 2006 that has taken over the operations of SQS.

First, each of the individual time series is tested for a unit root in the demand equations. Unit root testing was implemented using the Augmented Dickey-Fuller (ADF) test. The tests are conducted with and without a trend term and the results indicated that the constructed series for fresh fillets, whole and smoked fillets were all non-stationary in levels but stationary in first differences, a necessary condition for cointegration.

The second step was to investigate whether both z_i and the vector of explanatory variables in each demand equation are cointegrated. This test was implemented using Johanson's (1988) approach, a vector auto-regressive model. This test is important because the demand model specified would be inappropriate if the variables do not have a long run relationship or are not cointegrated. The results show that there is at least one cointegration vector in the share equation, z_i for each salmon product forms. The results are presented in table 2 below.

[Insert Table 2 Here]

Having found that all variables in the LAIDS model are I(1) and there is at least one cointegrating vector in each of the share equation implies that the LAIDS model must be estimated in a way that accounts for these properties. The estimation of the LAIDS model using integrated data has been addressed using a number of methods. For example, Ng (1995) specifically considers the issue of testing the homogeneity restriction and uses a method in which the empirical distribution of the relevant test statistics are simulated by parameterising the data generating process and using this as the basis for a Monte Carlo exercise. The most commonly used method in fish demand analysis is the Anderson and Blundell (1982) technique as exemplified by Asche et al. (1997). Therefore following Asche et al. we specify our dynamic LAIDS error correction model (LAIDS-ECM) as follows:

$$\Delta_4 z_{it} = \alpha_i + \delta \Delta_4 z_{it-1} + \sum_{k=1}^3 \alpha_{ik} s_{ik} \alpha_{it} + \sum_{j=1}^n \varphi_{ij} \ln \Delta_4 p_j + \beta_i \ln \Delta_4 E + \eta_t \quad (10)$$

where Δ_4 denotes fourth differenced filter (e.g. $\Delta_4 p = p_{it} - p_{it-4}$), $E = \frac{x_t}{p_t}$,

$p_j \dots \Delta_4 z_{it} \dots s_{ik}$ are seasonal dummies, t a linear trend, η_t is the error term. The use of a trend is quite common in demand analysis, for example see Burton and Young, (1996), Asche et al. (1997). The trend term in the equation is assumed to capture several factors. First, marketing of salmon especially by SQS in the media to promote salmon as a healthy diet to counteract negative publicity about salmon farming has intensified since the creation of the industry body. The activities of the industry body and similar organizations that promote oily fish have drawn attention to salmon products. Second, the trend also captures structural shifts in demand and changes in taste.

Like Asche et al., we are not able to separate the trend and the constant terms in equation (10) thus estimated are not interpreted as minimum expenditure on each salmon product. The filter in equation (10) has been argued to control for both deterministic and stochastic seasonal trends in the model (Asche et al., 1997). The fourth difference filter is preferable in with quarterly data to the normal first difference filter because it controls both for seasonal cycles and for unit roots such that the short-run dynamics in the data series are stationary. Following Anderson and Blundell (1983) and Burton and Young (1996), the properties of homogeneity and symmetry are applied in the long-run segment of the model. While symmetry may not hold in the short run, homogeneity holds by the virtue of the adding up properties. One lag was sufficient to account for the dynamics and the effects of habit formation in the model.

3.0 Empirical Results

To accommodate the large number of parameters in equations (8) and (10) and the attendant multicollinearity problems the demand system equations and the system of equilibrium conditions were estimated sequentially.⁶ The demand system (8) was estimated us-

⁶ In all, we attempted to estimate five equations system with demand theoretical restrictions imposed using non linear three- stage least square to achieve maximum efficiency. Unfortunately we were not able to

ing a seemingly unrelated regression (SUR) technique, which accounts for cross-equation contemporaneous correlation and as a result takes into account the optimization process that is essential in any demand system. The demand system is estimated by incorporating the theoretical restrictions of adding-up, symmetry and homogeneity. Following Anderson and Blundell (1982), one equation (we dropped the whole salmon share equation) was dropped to avoid singularity during estimation and the adding-up restriction was used to recover the equation after estimation. The estimated parameters are reported in

Table 3[Insert Table 3 Here]

The model specification is robust and fits the observed data for both product forms as measured by system R-square¹ of 87%. The hypotheses of homogeneity and symmetry conditions implied in economic theory are tested with a Wald test. The computed test statistics for symmetry restriction is 10.4 and the tabulated χ^2 statistics is 3.84 for one degree of freedom, which allowed the rejection of the hypothesis at the 5% level of significance. On the other hand, the homogeneity restriction was accepted at the 5% level of significance. The corresponding computed value of the test statistics for homogeneity is 4.60 and the tabulated χ^2 statistics for 2 degrees of freedom is 5.99. The rejection of the symmetry condition found in this study is not unusual. This implies that empirical demand studies often found that some theoretical restrictions do not hold (Deaton and Muellbauer 1980b, Cozzarin and Gilmour 1998). Cozzarin and Gilmour conducted a survey on these restrictions in empirical demand studies and found homogeneity (symmetry) was tested in 29 of the models and the restriction was rejected 57% percent of the time. A joint test for homogeneity and symmetry were also conducted. The computed test statis-

achieve convergence in that case may be due to large number of parameters to be estimated. However a number of market power studies have used sequential estimation method (e.g. see Steen and Salvanes, (1999); Gohin and Guyomard, (2000); Jaffry et al, (2003).

tics is 6.12 and the corresponding critical value at 5% level of significance is 7.82, which means that we can't reject the null of a joint homogeneity and symmetry restriction.

We use the Lagrange Multiplier (LM) to test for the presence of autocorrelation. In the LM test the null hypothesis of $H_0 : \rho_1 = 0$ (no autocorrelation) is tested against the alternative hypothesis of the presence of autocorrelation. The LM test has a χ^2 distribution with degrees of freedom equivalent to the number of lagged residuals. Using the aforementioned test the computed χ^2 statistics are 0.13 and 0.22 and the tabulated critical is 5.99 for 2 degrees of freedom. The test suggests that there is no problem of autocorrelation detected in both estimated share equations. Following from the results obtained, the results indicate that the system model estimated for retail demand for salmon possess both theoretical properties of homogeneity and symmetry.

The economic content of the LAIDS model is presented in Table 4 in terms of elasticities. The own price elasticities have correct signs (negative) according to the economic theory. Estimates of elasticity in the retail market for different salmon products in the UK are not commonly reported in the literature except for fresh fillets. Compared with earlier studies of salmon market in the UK, the results of this study appear in line with fresh fillets estimates reported in the past. For example Clay and Fofana (1999) and Jaffry et al. (2003) reported own price elasticity estimate values of -0.33 and -0.62 for fresh salmon fillets. It is interesting to note that our calculations indicate that whole salmon is relatively more elastic compared with fresh fillets or smoked salmon. This is typical of unprocessed food, meaning that a slight increase in the price of whole salmon triggers higher than proportionate decrease in demand. Unlike smoked or fresh fillet which are to some degree processed and higher value goods and therefore a slight increase in price would not change demand a great deal. Also worth noting is that the elasticity estimate for fresh salmon fillets appears to be increasing in value with time. This trend indicates the independence of consumers and that the market demand curve is gradually disciplining the

market. That is customers react more strongly in later years to changes in price as compared with earlier years; this is a sign of competitiveness in the industry.

[Insert Table 4 Here]

The own price elasticities for smoked and fresh fillets of -0.88 and -1.02 are not significantly different from (minus) one, implying that consumers almost make proportional responses in the quantity demanded when the prices of these products change. However, the own price elasticity for whole salmon (-1.49) depicts elastic demand. All other things remaining unchanged, if the price of whole salmon in the retail market increases by 10% consumers cut back on the quantity demanded by almost 15%. This adjustment by consumers for whole salmon is not surprising for a product that is unprocessed and mostly displayed on wet fish counters in supermarkets, thus competing directly with other unprocessed fish products. The expenditure elasticities are statistically significant indicating that total expenditure on salmon products is a significant determinant of the demand for all the product forms of salmon that were investigated. However, we note the elasticities estimates are not significantly different from one for smoked fillets and whole salmon. The expenditure elasticity for fresh fillets is, however, greater than one indicating that demand is expenditure elastic. Earlier studies of salmon in the 1980s to mid 1990s typically estimated higher expenditure elasticity values as compared those found in this study. Our estimates are dissimilar from earlier studies due to recent changes in the market and the demand structure for salmon. These changes are fuelled by marked shifts in food consumption patterns due to changing lifestyle of the UK consumer, along with economic, social and demographic changes. Furthermore, the demand system specification and the estimation techniques used in this article are more robust in contrast to many earlier studies when the market was immature. Thus, the results in this study are similar for income to comparable elasticities of Asche et al. (1997), Clay and Fofana (1999) and Jaffry et al. (2003). On the whole, the elasticity estimates are plausible and meaningful and further lend support to the satisfactory nature of the LAIDS-ECM model estimated.

Due to the non-linearity of the system of equilibrium conditions (10), the non-linear three-stage least squares (NL3SLS) procedure with instruments is used for estimation. Initial starting value estimates were obtained in a two-stage estimation procedure using

an instrumental variable method to avoid simultaneity bias. The instruments used were GDP, time trend, UK money supply (M3), quarterly average of UK Banks' base interest rates, UK CPI, index of production by Standard Industry Classification (92) and an index of expenditure on food and non-alcoholic beverages.⁷ Our estimates of the marginal cost equation for each product form and the corresponding market power estimates are presented in Table 5.

A key problem with instrumental variable is that instruments are required which are at least asymptotically uncorrelated with the error term in the regression equation. In order to test the validity of the instruments we used a Sargan (1964) validity test of instruments. Under the null hypothesis, the Sargan statistic is asymptotically distributed as χ^2 with p-k degrees of freedom; and is written down as:

$$S = \Delta\hat{\varepsilon}'W\left(\sum_{i=1}^n W_i' \Delta\hat{\varepsilon}_i \Delta\hat{\varepsilon}_i' W_i\right)^{-1} W'\hat{\varepsilon}_i \quad (11)$$

where W is the chosen matrix of instruments, p indicates the number of columns in W and k the number of parameters to be estimated. The test statistics were 1.98, 1.95 and 8.14 for smoked fillet, fresh fillet and whole salmon marginal cost equations respectively. From the results, we accept the validity of instruments for all the marginal cost equations when compared with the critical value of 9.49 for 4 degrees of freedom and 5% level of significance.

[Insert Table 5 Here]

⁷ GDP, CPI, index of productivity, and Index of expenditure on food and non-alcoholic beverages were collected from the Office for National Statistics. M3 and base interest rate were obtained from the Bank of England.

The model fits the data well with satisfactory R^2 values. An autocorrelation test (DW test) was performed to check for the existence of autocorrelation in each of the marginal cost equation. The results also suggest that no autocorrelation in these equations.

Considering the effects of the retail wage rate on retail marginal cost, these were found to be of minimal impact with those for salmon steak and whole salmon not being statistically significant. This effect was as expected in that the retail wage rate is generally close to the minimum wage. More importantly however is the fact that employees in the retail sector have little influence on their wage rates and are therefore price-takers. With respect to the market power parameters, λ , these were found not to be significant at the 5% significance level for fresh fillet and whole salmon but significant for smoked salmon. More importantly however, is that the market power estimates for fresh fillet and whole salmon are close to zero for us to conclude that the market for these products is near perfectly competitive. However, in relative terms the market power estimate for smoked salmon is significant and of higher magnitude as compared with other two products. This suggests that retailers exercise some degree of market power for smoked fillet. Furthermore, the corresponding Lerner index⁸ for smoked salmon is 0.0127 while the estimated indexes for fillets and whole salmon are 0.0001 and 0.0002 respectively. It can be seen that the Lerner indexes for fresh fillet and whole salmon were negligible and sufficiently close to zero to indicate that they are competitive while the value for smoked salmon was different from zero suggesting some relative degree of market power.

We also tested whether the retail marginal cost function and the market power parameter for each salmon product are identical. The Wald test statistics for identical marginal cost function is 18.54 and the corresponding tabulated value is 12.59 for 6 degrees of freedom and 5% level of significance. The test clearly rejects the hypothesis that the marginal cost

$$^8 L_i = \frac{p_i - MC_i}{p_i} = - \frac{\lambda_i}{\varepsilon_{ii}} ; \text{ where } MC_i \text{ is the marginal cost for salmon product } i.$$

functions of each salmon product are equal. This further shows that there are physical as well as cost differences between the different products of salmon that affects retail marginal costs. The cost differences are reflected in the degree to which each product form is processed, i.e. smoked fillet is highly processed while whole salmon is the least processed. This leads to the existence of different variable cost structures associated with different market structures, higher costs being associated with non-competition. The Wald test statistics for equal market power measure for each product form is 8.44 and the corresponding tabulated value is 7.82 for 3 degrees of freedom at the 5% level of significance. These results further show that the market power estimates for each salmon product are not identical, lending support to the notion that retailers might be exercising some degree of market power for smoked fillet.

Indeed there are reasons in the industry to suggest that retailers of smoked salmon fillet might have some degree of market power. Salmon or indeed fish processing in the UK industry is a mature and conservative one based on traditional practices with some methods of processing still unaltered by recent technological innovations. A survey conducted by the UK Sea Fish Industry Authority in 2000 revealed that close to 40% of primary processors either have no internet web site or do not use computers even in basic tasks in their businesses, such as book-keeping or inventory purposes. Moreover, there has been more consolidation, liquidations and rationalization of salmon smoking firms or activities within firms than any other firms specialising in other forms of processing of salmon.

4.0 Conclusions

Salmon products have now become affordable to the ordinary consumer despite the highly concentrated channels by which the supplies are obtained. In order to gain an understanding of the transformation of the retail sector for salmon products, we applied a new approach in Industrial Economics to the salmon retail market. The methodology, unlike its predecessors, is theoretically more robust. Modeling the formation of prices in the market, we estimated an ECM LAIDS model that is claimed to approximate con-

sumer behaviour. This is the first study to use such a model within a structural econometric framework of firms to test for market power for salmon products in the UK. Applying these models to salmon products at the retail level yields robust demand and marginal cost models with theoretically acceptable model diagnostics, suggesting that the system is well represented. The empirical results were derived with data for 1992-2003 and the results show competitive pricing behaviour in general but that the retailer might have some degree of market power for smoked salmon fillet. Largely the findings from this study support previous findings (Jaffry et al (2003); Steen and Salvanes, (1999)). In addition, our findings support the claims made by supermarkets in the UK, that, regardless of their huge market share and high concentration, retail sales for salmon remain competitive.

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Tables

Table 1: Descriptive Statistics

Variable description	Coefficient	Mean	Standard deviation
Demand equation:			
Budget Share			
Smoke salmon	z_{1t}	0.18	0.04
Salmon fillet	z_{2t}	0.51	0.21
Whole salmon	z_{3t}	0.31	0.22
Price			
Smoke salmon	γ_{11}	13.17	3.37
Salmon fillet	γ_{22}	6.13	0.87
Whole salmon	γ_{33}	3.12	0.62
Expenditure	β	7.90	0.55
Marginal cost equation:			
Wholesale price of smoked salmon	v_1	11.13	2.87
Wholesale price of salmon fillet	v_2	3.63	1.62
Wholesale price of whole salmon	v_3	2.64	0.79
Price of labour (wage index)	w	100.56	8.99
Capital cost (index)	e	190.01	30.36

Table 2: Stationarity and Cointegration Tests for Salmon Retail Products

Variable	Unit root test				Cointegration test	
	Level		First difference			
	Constant in-cluded	Constant + trend Included	Constant included	Constant + trend included	ξ_{Max}	ξ_{Trace}
$Z_{smoked\ fillet}$	-1.94	-0.94	-9.78 ^a	-10.83 ^a	71.8 ^a	117.5 ^a
$Z_{fresh\ fillet}$	-1.64	-0.98	-9.03 ^a	-9.15 ^a	65.0 ^a	108.7 ^a
Z_{whole}	-0.85	-1.71	-7.55 ^a	-7.46 ^a	38.1 ^b	100.70 ^a
LnP_{smoked}	-1.25	-2.17	-5.29 ^a	-5.22 ^a		
$lnP_{fresh\ fillet}$	-2.32	-1.82	-5.06 ^a	-5.06 ^a		
LnP_{whole}	-0.82	-1.68	-6.59 ^a	-6.46 ^a		
$Ln(Exp)$	-0.77	-3.11	-4.70 ^a	-4.61 ^a		

^a significant at 1% level, ^b significant at 5%.

Table 3: Estimated Parameters of an LAIDS-ECM for Retail Salmon Products

Share Equation Variable	Smoked Fillets		Fresh Fillets	
	Parame-	t -ratio	Parame-	t -ratio
α (constant)	0.004	0.11	0.004	0.12
$\Delta_4 z_{i-1}$	0.401 ^b	2.95	0.346 ^b	2.92
Δ_4 Smoked Fillet _t	0.262 ^c	1.62	-0.255 ^b	-1.95
Δ_4 Fresh Fillet _t	-0.520 ^c	-1.47	0.478 ^c	1.68
Δ_4 Whole _t	-0.122	-1.04	0.210 ^b	2.23
Δ_4 Expenditure _t	0.034	0.76	-0.014	-0.38
Δ_4 Smoked Fillet _{t-1}	0.055	0.32	-0.256 ^b	-1.86
Δ_4 Fresh Fillet _{t-1}	0.466 ^c	1.43	-0.362	-1.42
Δ_4 Whole _{t-1}	0.275 ^b	2.08	-0.487 ^b	-4.26
Δ_4 Expenditure _{t-1}	-0.114 ^c	-1.39	0.139 ^b	2.18
Smoked Fillet _{t-5} (z_{t-5})	0.381	0.57	-0.655	-1.23
Fresh Fillet _{t-5} (z_{t-5})	0.647	1.07	-0.769 ^c	-1.60
Whole _{t-5} (z_{t-5})	0.729	1.07	-0.815 ^c	-1.52
Smoked Fillet _{t-5}	0.016	0.68	-0.260	-1.29
Fresh Fillet _{t-5}	-0.260	-1.29	0.730 ^b	3.01
Whole _{t-5}	0.244 ^b	2.14	-0.470 ^b	-3.64
Expenditure _{t-5}	-0.004	1.26	0.139 ^c	1.75
S ₁	-0.008	-0.27	0.007	0.30
S ₂	-0.028	-0.74	0.015	0.50
S ₃	-0.052	-1.27	0.074 ^b	2.12
System R ²	0.87			
R ²	0.53		0.66	

^b significant at 5% level; ^c significant at 10% level

Table 4: Uncompensated Elasticity Estimates for Retail Salmon Products

	Estimate	
	Coefficient	t-ratio
Own price		
Smoked Fillet	-0.88 ^a	-8.65
Fresh Fillet	-1.02 ^a	-11.48
Whole	-1.49 ^a	-6.83
Expenditure		
Smoked Fillet	0.98 ^a	3.75
Fresh Fillet	1.27 ^a	8.21
Whole	0.93 ^a	5.44

^a significant at 1% level

Table 5: Parameter Estimates for Marginal Costs Equations

	Con-	V	W	K	λ	R ²	DW
Smoked Fil-	0.0512 (0.67)	0.440 ^a (1.51)	0.002 (1.12)	-0.0007 ^a (1.30)	-0.0112 ^b (-2.18)	0.79	2.04
Fresh Fillet	-0.004 (-0.11)	0.412 ^b (3.59)	0.001 ^b (2.26)	-0.0004 ^b (2.82)	-0.0001 (0.69)	0.73	1.48
Whole	0.0024 ^a (1.48)	0.144 (1.25)	0.0007 ^b (2.32)	-0.0004 ^b (2.32)	-0.0003 (-0.92)	0.75	1.42

V=wholesale prices; W=index of retail wage; λ =market power measure, K= index of capital cost, DW=Durbin-Watson test statistics; student t-test statistics in parenthesis. ^b significant at 5% , ^c significant at 10% level

Figure

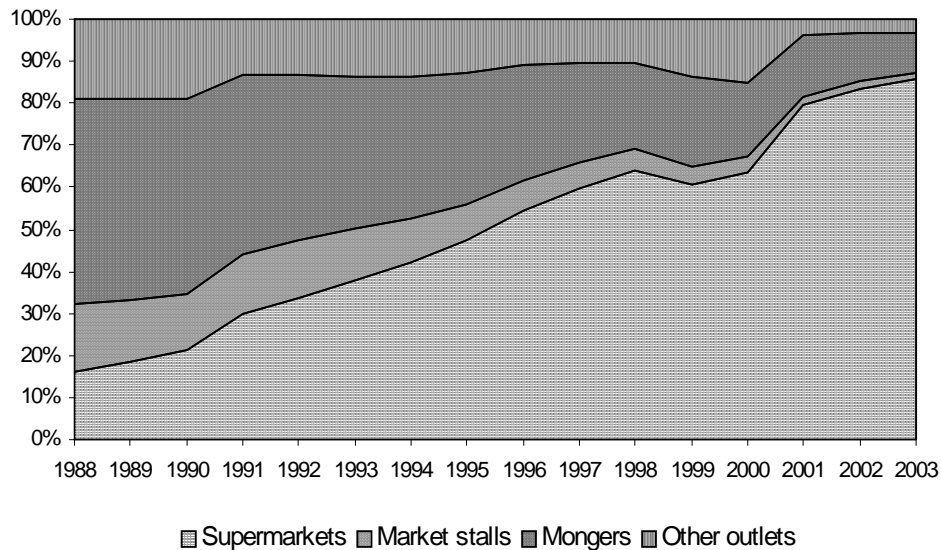


Figure 1: Value of fish sales by outlet