

An Empirical Investigation of Price-quantity Relations of the Quota Species of Australia's South East Fishery

S. Bose (Australian Maritime College)

Abstract. An inverse system framework is followed in this paper to analyse the process of price formation in the Sydney Fish Market for the quota species of Australia's South East Fishery. The log-linear version is supported by the data and the system is estimated using the seemingly unrelated regression (SUR) technique. In all but one case, own-price flexibility coefficients were observed to satisfy the theoretical expectation of the general price-quantity relations and to be less than one in absolute value, which indicates an inflexibility of real wholesale prices to their corresponding quantities. It is also found that the majority (13 out of 16) of the quota species may be classified as normal goods. The impact of structural change in the fishery, as a result of the introduction of the quota system, on the prices of quota species is also examined, and it is observed that the quota management system has significantly affected the price of twelve out of the sixteen species.

Key words: Australia, multi-species fishery, inverse demand, exogeneity, structural change

1. INTRODUCTION

Analysis of demand in fisheries is of great importance for a number of reasons. First, parameter estimates of the market demand function can be used to calculate the magnitude of consumer surplus, which is a measure of net economic benefits to consumers purchasing seafood and thus plays an important part in the formulation of welfare policy for the appropriate groups in the market (Bockstael (1977)). In addition, estimates of price elasticity under the direct demand system and/or price flexibility under the indirect demand system are useful for determining the change in consumer surplus that could be generated by other factors. Second, in calculating gross (or net) revenue one has to rely on market price. Thus a sound knowledge of price formation in fisheries is helpful to predict the net benefits to the fisher, which are of great importance to design policies relevant to rent capture in fisheries (Grafton (1995)). Third, in recent years consumer sovereignty has been conceived as the hub of the general marketing philosophy in contemporary business milieu. Consequently, understanding the behaviour of the end-users and satisfying their needs is one of the major goals of marketing research in general. The market research fulfils the managers' need for up-to-date knowledge about the market and its actors. It also helps specify and provide marketing managers with the essential information to reduce uncertainty in the decision making process (Bockstael (1984) and Prochaska (1984)). Fourth, in a somewhat different but related context, market research is prerequisite for undertaking successful marketing strategies, for

satisfying the criteria for sustainability of the related industry (Widerberg (1994)), and also for attaining information on consumer preferences. Last but not least, demand analysis under a variable price framework is important to locate the economic reference point - the maximum economic yield (MEY) - which is one of the objectives of present-day fisheries management (Anderson (1986), Sylvia (1994)).

2. REVIEW OF RELATED STUDIES

The information on the demand parameters for the SEF quota species is very limited. The existing empirical studies on fish markets in Australia can be divided into two groups based on pre- and post quota management regimes. The existing market studies before the introduction of quota management system are as follows. In a case study, Smith and Reid (1991) have investigated the distributional efficiency of eight selected species from the South East Fishery by testing whether there is any significant difference between the net price obtained from the Sydney and the Melbourne Fish Markets. It is found that, under the prevalent supply constraints, the allocation of those selected species between the markets is generally consistent with the profit maximisation strategy.

MacIntosh et al. (1988) have studied the weekly auction-retail price spreads for fifteen fish species (nine of them are under the current quota management system) and two crustacea categories covering the period from October 1982 to June 1986. They found

that the auction prices are highly variable in nature. They also noticed the seasonal impact on price spread behaviour. Pascoe et al. (1987) considered the price determination of fish and shellfish in the Sydney seafood market using a separate model for each of the categories covering the period from January 1980 to June 1986. The model for fish consists of a supply equation, a price equation, an import equation and an identity that represents the market equilibrium condition. It is assumed that the supply is influenced by non-price factors, such as weather conditions, patterns of fish behaviour and net expected returns and hence treated as exogenous to the system. The demand function for fish follows the inverse demand framework and includes own-quantity, quantity of shellfish, real income, fish imports, real price of meat and seasonal dummies as explanatory variables. It is found that own-quantity, the quantities of shellfish, and the seasonality in demands are the significant factors influencing the average price of fish.

On the other hand, a fish market study after the quota management system was recently carried out by Smith et al. (1998). Smith et al. (1998) have studied the processes of price formation in the Sydney fish market for fourteen SEF quota species. The study was divided into two main parts. In the first part, using an inverse demand single-equation framework, the price of target species was expressed as a function of own-quantity, quantity of other closely related species, number of buyers and the day of the week. They also examined the price-quantity relationship in a disaggregated manner by incorporating size grades of individual species into its corresponding price equation. It is found that prices of selected major species are mostly influenced by their corresponding quantity on sale. The second part of the study by Smith et al. (1998) is devoted to price-quality relationships for five quota and four non-quota species.

Realising the importance of information on market prices this study mainly aims at investigating the process of price formation for the SEF quota species at the Sydney Fish Market. Additionally, this study also investigates if there is a significant impact of structural change due to the introduction of quota system on the prices of quota species.

3. THE FISHERY

The South-East fishery (SEF), formerly known as the South-East Trawl fishery (SETF), is one of the oldest and most valuable (approximately A\$ 57.6 million, at point-of-first-sale estimates of 1996) commercial multi-species fishery in Australia (Caton et al. (1997)). The fishery extends from Barranjoey Point in New South Wales (NSW) around Tasmania and west to Cape Willoughby in South Australia. As evidenced by the dollar value of the fishery, it plays an important role in the food economy of the country by supplying fresh fish to two major national seafood markets - the Sydney Fish market and the Melbourne Fish market - for

domestic consumption. It also earns foreign exchange by supplying fish to satisfy a part of export market demand. Thus the fishery is an important component of the national fishing industry. It should be mentioned that the SEF is one of the major sources of supply of fish to the Sydney and Melbourne Fish Markets.

About 100 commercial species are utilized by the trawl sector of the fishery of which 16 species were brought into the quota management system by introducing individual transferable quotas (ITQs) on 1 January 1992, and more than 80% of the landing catch weight belongs to those quota species (Caton et al. (1997)). These quota species are Blue-eye trevalla (*Hyperoglyphe antarctica*), Blue grenadier (*Macruronus novaezelandiae*), Blue warehou (*Seriola lalandi*), Gemfish (*Rexea solandri*), School whiting (*Sillago flindersi*), Jackass morwong (*Nemadactylus macropterus*), John dory (*Zeus faber*), Ling (*Genypterus blacodes*), Mirror dory (*Zenopsis nebulosus*), Ocean perch (*Helicolenus sp.*), Orange roughy (*Hoplostethus atlanticus*), Redfish (*Centroberyx affinis*), Royal red prawn (*Haliporoides sibogae*), Silver trevally (*Pseudocaranx dentex*), Spotted warehou (*Seriola punctata*) and Tiger flathead (*Neoplatycephalus richardsoni*).

4. SYDNEY FISH MARKET

The New South Wales Fish Marketing Authority, which is a financially independent statutory body, was constituted in April 1964, as the result of the Fisheries and Oyster Farm Act of 1935 and its subsequent amendments in the years 1945 and 1963. The Marketing Authority was responsible for maintaining, administering, and operating the orderly marketing system through the Sydney Fish Market that was the hub of this system. In October 1994, the former Sydney Fish Market became a private joint venture company - the Sydney Fish Market Pty Limited - with equal shares between the Sydney Fish Market Tenants and Merchants Pty Limited and, the catching sector through a holding company and unit trust.

The main objectives of this fish market are to: a) ensure an orderly marketing of seafood products, b) ensure a fair return to the suppliers, c) provide best quality fresh seafood to the consumers, d) encourage foreign suppliers, e) ensure industry regulations are best practiced by the fishers, f) achieve allocative efficiency, and g) implement environmental best practice.

In 1989, a computerised auction system was introduced to the Sydney Fish market. This revolutionary step was justified on the ground of significant auction time reduction with two auctions happening at once as well as the outcome of minimizing price uncertainty by stabilizing the prices of fish products. This so called Fair Auction Selling Technology (FAST) follows the Dutch auction system. There are 260 bidder terminals in the grandstand that are connected with the computer.

Buyers are officially registered into the auction system by entering their personal identification number. Each buyer can participate in either or both auctions simultaneously using two bid buttons in each terminal connected with two auction clocks A and B.

A brief description of the identification number, position on the auction floor, number of crates, weight of each crate, species identification and source, and size and processing status of the lot currently on sale appears directly below the clock. The auction clocks thus clearly displays all the required information for the buyer as the auction proceeds. Although the auction is 'silent' not 'oral' as all are bidding by computer, the auctioneer still plays an important role in initial reserve price setting, providing further descriptions of the lots that are on sale, and the overall maintenance of the auction. In the initial price setting process the suppliers are also able to take part in setting a floor price below which the Sydney Fish Market will not sell their product. Most fish caught by fishers in NSW is first handled through one of 22 fishermen's cooperatives.

The market opens at 6pm Monday to Thursday, and 4pm Sunday to receive fish products from the suppliers for the next day's auction that begins at 5.30am during each weekday. The product can also be delivered till 9am for auction on the same day. On average about 200 buyers attend the daily auction. A progressive as well as a final comprehensive report is available to provide information on current market activities and the sellers are supplied with the daily market report which carries all the necessary information. Furthermore, the market provides up-to-the-minute information on ongoing auction sale through an interactive voice system directly from the auction floor (Anon 1996b).

The market ensures the best quality seafood to the end users as the quality assurance officers and auctioneers employed by the Sydney Fish Market authority routinely check the quality of fish and seafood products being auctioned. To ensure the industry's operations are best practice the marketed products are also inspected by the State's fisheries industry inspector before auction. In the case of the international seafood trade the Australian Quarantine and Inspection Service (AQIS) undertakes the quality control tasks. The market also plays an important role in the seafood marketing process through its seafood school.

5. DATA SOURCE

This study considers only fresh and unprocessed fish. Data on monthly quantity sold through the auction for 16 quota species were obtained from the Sydney Fish Marketing Authority covering the period March 1990 – December 1996. The monthly series of income and consumer price index (CPI) are calculated from the quarterly figures of State's Gross Domestic Product and CPI using the method of straight line interpolation. Lack of 'fresh and whole' fish export data and the

unavailability of separate data on import for 'fresh and whole' quota species makes it rather difficult to consider export and import explicitly into the demand analysis. The descriptive statistics for quota species of all forms (processed and unprocessed) and types sold through auction at Sydney Fish Market for the period March 1990 – December 1996 are presented in Table 1.

6. THE MODEL AND ESTIMATION

In an excellent survey Brown and Deaton (1972), have outlined the models used prior to 1970's in applied analysis of consumer demand both as a single-equation and as a system frameworks. The two commonly held approaches in empirical estimation of demand function are as follows. First, specify a particular utility function and derive the demand functions for the commodities involved through the constrained maximisation procedure. This procedure automatically satisfies the general restrictions associated with demand analysis. Second, specify the demand function that seem appropriate for the problem at hand and impose restrictions to ensure theoretical plausibility (Phlips 1974).

In an special survey on seafood demand and market analysis Wessells and Anderson (1992) have highlighted different approaches used by researchers in analysing seafood markets since the early 1960's. In the existing literature researchers have adopted both the single-equation or system approach in analysing seafood demand.¹

Use of linear and/or log-linear specifications are very common in demand studies. But there is no *a priori* reason to choose one form over the other and also to restrict to these particular choices. In this study a more generalised procedure known as Box-Cox (1964) transformation has been used to select the appropriate functional form. The results of the likelihood-ratio (LR) test suggest that the log-linear model is appropriate. Another major problem in the applied demand analysis is that the required data are not available to permit flexibility in procedures and sophistication in functional specifications. Bearing this limitation in mind, this study estimates the following log-linear inverse demand system:

¹ The single-equation framework has been adopted by Kusumastanto and Jolly (1997), Mickwitz (1995), Hanna (1992), Nowak (1992), Roy et al. (1991), Houston et al. (1989), Lin et al. (1988), Bird (1986), DeVoretz (1982), Allan (1972), and Bell (1968). On the other hand, Asche (1996), Burton (1992), and Wellman (1992), Tsoa et al. (1991), Ioannides and Whitmarsh (1987) have followed the system approach. The simultaneous equation approach has been followed by Angrist et al. (1995), Roy et al. (1992) and Bockstael (1977).

$$\ln P_{it} = a_i + \sum_{j=1}^{16} b_{ij} \ln Q_{jt} + g_i \ln Y_t + u_{it};$$

$$i = 1, 2, 3, \dots, 16 \quad (1)$$

where, P_t , Q_t and Y_t represent real weighted average price, total quantity sold, and real income respectively. The term ' u_t ' is the white noise residual. To capture the anticipated seasonal influences monthly dummy variables are also added to equation (1). As mentioned earlier that in the beginning of 1992 a quota management system was introduced in the fishery in the form of Individual Transferable Quota (ITQ) for 16 major species. To examine if there is any significant affect of this output control on the market prices, a structural dummy variable is included in each individual equation of the system. All variables except dummies are expressed in logarithms.

It is important to note that in this system approach quantities of fish species and income of the consumers are treated as exogenous variables. The choice of price dependent model is not uncommon in seafood demand analysis (Jaffry et al. (1999), Burton (1992), Barten and Bettendorf (1989), Ioannides and Whitmarsh (1987)) The theoretical properties of the inverse demand are derived by Anderson (1980). The robustness of the assumption of exogeneity of quantity supplied was examined for each individual species separately following a test procedure proposed by Hausman (1978). Based on the test results, treating supply as exogenous is not unrealistic in this particular case at hand.

In an inverse demand framework, if the variables are expressed in logarithms then the estimated coefficients are generally interpreted as own- and cross-price flexibilities. The price flexibility is a measure of responsiveness of prices and is defined as the percentage change in the price of a commodity due to 1% change in its own quantity demanded or that of other related commodities and variables. The reciprocal of the own-price flexibility is not in general the same as the own-price elasticity as it depends on the significance of the cross flexibility coefficients in the estimated model (Houck 1965). But Houck (1965) has mentioned that the reciprocal of the own-price flexibility in general constitutes the lower limit (in absolute sense) of the own-price elasticity estimates.

The system is estimated using the seemingly unrelated regression technique developed by Zellner (1962) and iterated to convergence. Use of this system approach is justified by the fact that it provides a theoretical framework to deal with the issue of interdependencies among quota species. The system is tested for symmetry using the likelihood-ratio (LR) test that follows a χ^2 distribution with degrees of freedom equal to the number of restriction (120) imposed. The test value (284.55) is compared with the tabulated χ^2 value 129.56 (with 100 d.f.) at the 5% level of significance.

Based on this test value the null hypothesis is rejected at the 5% level of significance thereby suggesting that the symmetry condition should be imposed while estimating the system.

7. RESULTS²

With the symmetry condition imposed, the nature of the relationship between the dependent and independent variables is summarised in Table 2. It is found that own-price flexibility parameters in all cases but Ocean Perch (OP) are negative and significant at the 5% level and thereby conform to theoretical expectation. Also, all own-price flexibility coefficients are less than one in absolute value thereby indicating an inflexibility of real weighted average wholesale prices of species to their own quantities. The price-quantity relations are also examined using scatter diagrams for each species (not reported here). The scatter plots show a negatively inclined pattern thereby illustrating the own price-quantity relations. In the case of Ocean Perch (OP), the apparent contradiction between the model results and the pattern of price-quantity relation in the scatter plot is, perhaps, due to the problem of multicollinearity. It should also be noted that in the case of the exogeneity test for OP a similar price-quantity relation appears and the regression results did not satisfy the normality test of the residuals.

In addition, in the inverse demand framework a cross-price flexibility coefficient in a particular price equation for species 'i' measures the percentage change in the price of species 'i' due to 1% change in the quantity demanded of the species 'j' ($i \neq j$), other things being constant. It is found that at least one cross-price flexibility coefficient is significant in each price equation. In six price equations, it is found that five or more cross-price flexibility coefficients are significant.

The majority (13 out of 16) of the quota species may be classified as normal goods as the price responses with respect to changes in income are positive for those species. The prices of ten species show a significant seasonal variation in different parts of the year. The structural change in the fishery that occurred in the beginning of 1992 due to the introduction of quota management system has significant impact on the prices of twelve out of sixteen species.

8. CONCLUSION

An inverse demand system framework has been followed in this study to analyse the process of price formation in the Sydney Fish Market for the South East Fishery quota species. It should be mentioned that for some species the Sydney Fish Market is not a dominant

² Due to space limitations, detailed of the results are not reported here but they are available from the author upon request.

market outlet. Therefore the findings of this study for those species will be applicable only to the extent to which they are sold in that market. Price is found to be generally inflexible with respect to the quantity landed as the absolute value of the own price-flexibility is less than one (coefficient values ranging from -0.75 to -0.23, excluding Ocean Perch). In most cases, the estimated cross-price flexibility coefficients are very small in magnitude. Thus any management measures that changes the level of landings of the quota species would, perhaps, change the level of revenue in the same direction in most of the cases. Furthermore, the significance of the cross-price flexibility coefficient along with the cross-price elasticity of supply (Bose et al. (2000)) should be taken into account to examine the likely impact of any proposals to remove some quota species from the system on both the demand and supply sides of the market.

The estimated results reveal significant seasonal factors which should be taken into account in the revenue calculating process and for forecasting market prices of quota species. Also, any future change in management regimes should take into consideration the likely impact of any such change on market prices in order to predict the trend in revenue. It should also be mentioned that the information on the price formation of quota species is useful in analysing the demand for quota for individual species as they are theoretically positively related to each other. In other words, a rise in price of a species causes a rise in the price of quota in that species, other things being equal (Campbell (1995)). Finally, to provide adequate quantitative assessment of the price determination for the quota species, future research works will require explicit as well as better quality time series data on exports, imports, retail and the other wholesale (the Melbourne Fish Market) market activities of quota and other closely related non-quota species.

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Table 1: Descriptive Statistics for Quota Species at Sydney Fish Market, 1990-1996*

Species	No. of Entry	Average Weight (kg)	Average Value (\$)	Average Minimum Price(\$/kg)	Average Maximum Price (\$/kg)
School Whiting (WH)	6085	338.70	563.14	1.77	2.55
(St. Deviation)		444.63	616.33	1.08	1.21
Silver Trevally (ST)	8692	477.22	696.87	1.48	2.18
(St. Deviation)		725.32	945.34	0.79	1.26
John Dory (JD)	8276	208.34	1246.26	5.10	7.05
(St. Deviation)		270.41	1634.53	2.59	2.55
Tiger Flathead (TF)	9035	818.18	1668.19	1.95	2.85
(St. Deviation)		1204.91	2156.29	1.00	3.77
Redfish (RF)	6733	1356.04	1539.45	1.40	2.12
(St. Deviation)		2085.59	1974.72	0.86	1.10
Jackass Morwong (MR)	5051	872.99	2002.38	2.43	3.20
(St. Deviation)		1399.10	2726.84	0.97	0.97
Blue Warehou (BW)	1765	438.98	722.81	1.87	2.06
(St. Deviation)		748.99	1112.45	0.87	2.68
Ling (LN)	8370	319.41	1176.91	3.66	4.26
(St. Deviation)		472.77	1626.35	1.20	1.09
Gemfish (GF)	4773	303.26	1150.30	4.13	4.75
(St. Deviation)		801.71	2482.94	1.63	1.53
Mirror Dory (MD)	4526	373.50	810.37	1.91	2.60
(St. Deviation)		823.95	1594.68	1.14	1.15
Blue Eye (BE)	4883	252.60	1451.92	5.02	5.79
(St. Deviation)		400.23	2482.09	2.25	2.30
Spotted Warehou (SW)	2833	748.59	1065.68	1.58	1.96
(St. Deviation)		1134.60	1473.52	0.89	2.18
Ocean Perch (OP)	6577	237.14	721.19	2.44	3.49
(St. Deviation)		306.32	992.27	1.48	1.64
Royal Red Prawn (RRP)	1272	939.43	3246.23	3.37	4.16
(St. Deviation)		1149.52	3843.87	1.21	1.15
Blue Grenadier (BG)	1242	307.09	667.96	2.47	2.79
(St. Deviation)		582.98	1099.20	1.02	0.98
Orange Roughy(OR)	728	1611.79	4128.98	2.88	3.18
(St. Deviation)		3614.03	8463.55	1.75	1.74

Note: * All forms (processed and unprocessed) of quota species at the auction floor during the period 1990-96 have been considered in calculation.

Table 2: Summary Results for the Quota Species.

Species	Nature of Own Relation	Significant Cross-relation with other species	Income coefficient significant?	Structural change significant?	Seasonal pattern significant?
School Whiting (WH)	Negative*	BW ⁺	No	No	No
Silver Trevally (ST)	Negative*	BW ⁺ , TF ⁻ , LN ⁻	No	Yes	Yes
John Dory (JD)	Negative*	BE ⁺ , OP ⁺ , MD ⁻	Yes	Yes	Yes
Tiger Flathead (TF)	Negative*	ST ⁻ , MD ⁻ , OP ⁻	Yes	Yes	Yes
Redfish (RF)	Negative*	BW ⁻ , SW ⁻ , OR ⁻	Yes	No	Yes
Jackass Morwong (MR)	Negative*	BW ⁻ , SW ⁻ , OP ⁻ , BG ⁻ , LN ⁻	Yes	Yes	Yes
Blue Warehou (BW)	Negative*	RF ⁻ , MR ⁻ , MD ⁻ , OP ⁻ , LN ⁻ , BG ⁻ , ST ⁻ , MR ⁻ , BW ⁻ , GF ⁻ , MD ⁻ , OP ⁻ ,	No	No	Yes
Ling (LN)	Negative*	RRP ⁻	No	Yes	Yes
Gemfish (GF)	Negative*	SW ⁺ , LN ⁻	No	Yes	No
Mirror Dory (MD)	Negative*	BW ⁻ , TF ⁻ , JD ⁻ , BG ⁻ , LN ⁻	Yes	No	Yes
Blue Eye (BE)	Negative*	JD ⁺ , RRP ⁺	No	Yes	No
Spotted Warehou (SW)	Negative*	RF ⁻ , MR ⁻ , GF ⁻ , OP ⁻ , BG ⁻ , JD ⁺ , TF ⁻ , MR ⁻ , BW ⁻ , LN ⁻ , SW ⁻ ,	Yes	Yes	No
Ocean Perch (OP)	Positive*	RRP ⁺	No	Yes	Yes
Royal Red Prawn (RRP)	Negative*	BE ⁺ , LN ⁻ , OP ⁺	Yes	No	No
Blue Grenadier (BG)	Negative*	MR ⁻ , BW ⁻ , MD ⁻ , SW ⁻	No	Yes	No
Orange Roughy(OR)	Negative*	RF ⁻	No	Yes	No

Note: '+' and '-' signs indicate the nature of relationships. '*' indicates significant relationship.