Supply Response Functions of Two Fish Species in the Arabian Gulf Area

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Abstract

A polynomial distributed lag model was fitted to monthly fish production data from the Arabian Gulf, Saudi Arabia, in order to determine the nature of the lagged output response resulting from a change in fish price. Our results show that the variation in the supply functions of two of the most widely purchased species (*Epinephelus tauvina*, Serranidae and *Scomberomorus commerson*, Scombridae) can be explained by changes in wholesale prices and a binary variable representing the season of the year. The computed price coefficients show the responsiveness of supply to price changes.

Introduction

Fish consumption in the Arabian Gulf area has risen steadily over the past decade. In Saudi Arabia, the estimated total consumption of fish in 1984 was about 87.7 million kg. This is an increase of 256% since 1975. While part of this expansion resulted from an increasing population, *per caput* consumption of fish increased 133% for the same time period. Feidi (1979) estimated that *per caput* consumption of fish in the Gulf region is close to 3 $kg \cdot year^{-1}$, compared to the world average of 13 $kg \cdot year^{-1}$.

Harvesting of the available fish resource depends on the demand for local consumption and export. There is no shortage of protein in the area because the demand for animal protein is satisfied mainly by red meat, which is more popular and often cheaper than fish (Carleton 1980). However, people in Saudi Arabia and neighboring states like to include a certain amount of fish in their diet.

The fishes of the family Serranidae, locally known as hamoor, is one of the largest and the most important groups of fish. In the Arabian Gulf, twenty-two species of groupers, belonging to five genera were described (Randall and Ben Tuvia 1983), of which *Epinephelus tauvina* is one of the most economically important and widely distributed in the Arabian Gulf. The family Scombridae is also recorded in the Gulf waters (Daghestani et al. 1988) with *Scomberomorus commerson* (Canad) being the most abundant especially during the cooler months, when it is the object of an offshore gillnet fishery. These two species are highly valued and are the most marketable fish in the Kingdom of Saudi Arabia, as well as in other Gulf states.

The two sources of fish supply are catches by domestic fishermen and imports from foreign countries. The average weight of domestic catches for 1983-1986 was 44.75 million kg. Imports contributed about 50% of the total supply.

The rapid expansion of the fish market due to human population growth requires estimation of the responsiveness of fish supply to price changes. This type of analysis provides useful information for policymakers in the Gulf states in their attempt to provide an adequate supply of fish to consumers and maintain a reasonable balance between fish production and consumption. The goal of the present study is to specify and estimate the supply response function for *E. tauvina* and *S. commerson*.

Materials and Methods

Monthly data for the period from August 1988 to July 1989 were collected from the Qatif wholesale market, one of the largest fish markets in Saudi Arabia. The data on quantity and wholesale price of *E. tauvina* and *S. commerson*, the two most important species in that market, were used to estimate the supply response functions.

The landings of *E. tauvina* and *S. commerson* in a given time period were hypothesized to be a function of their prices. However, in fish production as in many other products, there is a lagged response to a price change due to the nature of the underlying production process. A general distributed lag model can be written as:

$$Q_t = \delta + \sum_{i=0}^{g} \beta_i P_{t-i} + U_t \quad ...1)$$

where Q_t is the quantity supplied at time t; P_{t-i} is the price at time t-i; g is the number of periods covered by the lag function, U_t is a random variable independent of P_t, having mean zero and constant variance, and β_i are the coefficients of the lag structure; i = 1, 2..., g. Therefore, there are g+1 coefficients to be estimated.

Equation (1) has lagged values of the independent variable (P_{t-i}) which is likely to be correlated. This creates the problem of multicollinearity among the explanatory variables. In such cases, it is possible to estimate the regression coefficients, but the reliability of these estimates is questionable. To avoid this problem Koyck (1954) assumed that the β_i in equation (2) have the following form:

$$\beta_i = a\lambda^i \quad ...2)$$

where $0 \leq \lambda < 1$. In this situation, lesser weights are given to time periods away from the current period and the lower the value of λ, the higher the decay in the weights. In addition, if $\lambda = 0$, then there is no lag structure. Nerlove (1956), Friedman (1957) and Griliches (1967) have discussed the problems encountered when using equation (2). One of these is that the lag formulation is restricted by the geometrical specification. Almon (1965) suggested a more flexible specification *viz* "distribution lags"; the Almon procedure forces a polynomial of one degree less than the lag length in order to obtain a new model with fewer variables than equation (1). This method can avoid the problem of multicollinearity and forces the coefficients to behave in a systematic fashion.

In this paper we utilized the Almon lag technique to specify and estimate a polynomial price lag model for our two fish species. Since the lower order polynomial is appropriate for most econometric studies, we adopt a second-order polynomial for the lag coefficients which can be written as:

$$\beta_i = a_o + a_1{}^i + a_2{}^{i2} \quad ...3)$$

Substituting equation (4) into equation (1) gives:

$$Q_t = \delta + \sum_{i=0}^{g} (a_o + a_1{}^i + a_2{}^{i2}) P_{t-i} + U_t \quad ...4)$$

In order to determine the length of lag (g), several lengths of lag periods were examined and g=5 was found to be the most appropriate in terms of the empirical results. Therefore, equation (4) can then be written when g=5 as:

$$Q_t = \delta + a_oP_t + (a_o + a_1 + a_2) P_{t-1} + (a_o + 2a_1 + 4a_2)P_{t-2} + (a_o + 3a_1 + 9a_2) P_{t-3} + (a_o + 4a_1 + 16a_2) P_{t-4} + (a_o + 5a_1 + 25a_2) P_{t-5} + U_t \quad ...5)$$

Rearranging equation (5) gives:

$$Q_t = \delta + a_o (P_t+P_{t-1} + P_{t-2} + P_{t-3} + P_{t-4} + P_{t-5}) + a_1 (P_{t-1} + 2P_{t-2} + 3 P_{t-3} + 4 P_{t-4} + 5 P_{t-5}) + a_2 (P_{t-1}+4P_{t-2} +9P_{t-3+}16P_{t-4}+25P_{t-5}) + U_t \quad ...6)$$

Table 1. Regression results of the supply response functions for the two most important fish species at the market of Qatif, Saudi Arabia.

Species	Intercept	Dt	Pt	Pt-1	Pt-2	Pt-3	Pt-4	Pt-5	F	R^2	D-W
				Independent variables					Summary statistics		
E. tauvina	-2591.4	-487.24	37.146	20.258	14.539	19.989	36.606	64.393	11.62	0.88	2.17
	(-3.04)	(-3.46)	(2.97)	(2.88)	(2.90)	(3.10)	(3.20)	(3.23)			
S. commerson	-1354.6	-14.875	7.5662	8.0180	8.9171	10.263	12.057	14.298	46.93	0.97	3.30
	(-6.36)	(-1.65)	(5.61)	(5.82)	(5.80)	(6.27)	(7.19)	(7.97)			

t-values are in parenthesis.

We arrived to a set of new variables which can then be estimated to obtain estimates of a's and δ. The β's coefficients of equation (1) would then be obtained by substituting the estimated a's in equation (3). Equation (6) can be expanded to incorporate nonprice variable. Since seasonal changes in supply play an important role in the availability of fish, we have introduced a dummy variable (D_t) which is equal to one during summer and zero during the rest of the year. The technique used in estimating the coefficients of equation (6) was ordinary least-squares (OLS).

Results and Discussion

The results based on the Almon lag formulation are presented in Table 1 for *E. tauvina* and *S. commerson*. All the estimated variables have signs consistent with *a priori* expectations, the fit of both supply equations was good, with $R^2 = 0.88$ and 0.97, respectively. The price variables for lags 0 through 5 were found to be significant in the supply equations for *E. tauvina* and *S. commerson* and at the 5% level on a two-tail t-test. The coefficient associated with the variable for season (D_t) was not significantly different from zero in the case of *S. commerson*, but was significant for *E. tauvina*. The Durbin-Watson statistic was used to test for first-order serial correlation. Such correlation does not appear to be present in either of the supply functions. The null hypothesis $\Sigma\beta_i = 0$ of no relationship was tested by computing the F-test for each regression equation and the results are presented in Table 1. From these values, we may conclude that wholesale prices of *E. tauvina* and *S. commerson* have an important influence on the supply of these fishes.

The significance of the price coefficients were apparently related to the responsiveness of output to prices. The size of the estimated coefficients illustrates the importance of this variable with regard to its impact on the output. In addition, a price change of *E. tauvina* had a much stronger effect on output than did a change in the price of *S. commerson*. A price change of either species at time t has its maximum effect on production five periods later. As shown in the Table, one Saudi Rial kg^{-1} increase in wholesale price of either fish would lead to about 64 t increase in output of *E. tauvina* and about 14 t increase in output of *S. commerson* in the fifth month, while the same increase in prices at time t would lead to about 37 t increase in output of *E. tauvina* and about 7.6 t increase in output of *S. commerson*. These results appear reasonable in view of *a priori* knowledge of the fish industry. The binary coefficient representing the season of the year in the statistical supply function for *E. tauvina* was significant and negative. This implies that the supply of this fish during summer is about 487 t less than in winter months.

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