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ABSTRACT

A recursive model of the price formation process in the marketing system for oysters in the Chesapeake Bay was developed. The model explained over 90 percent of the annual variation in the retail price, wholesale price, and the ex-vessel price of oysters. Disposable income and the consumer price index for fish sigificantly influenced the retail price of oysters; the retail price, landings in the Chesapeake Bay, and marketing costs significantly influenced the ex-vessel price of oysters. The impact of oyster consumption on the retail price, the impact of landings from outside the Chesapeake Bay on the wholesale price, and the impact of landings in the Chesapeake Bay on the ex-vessel price were not statistically different from zero.

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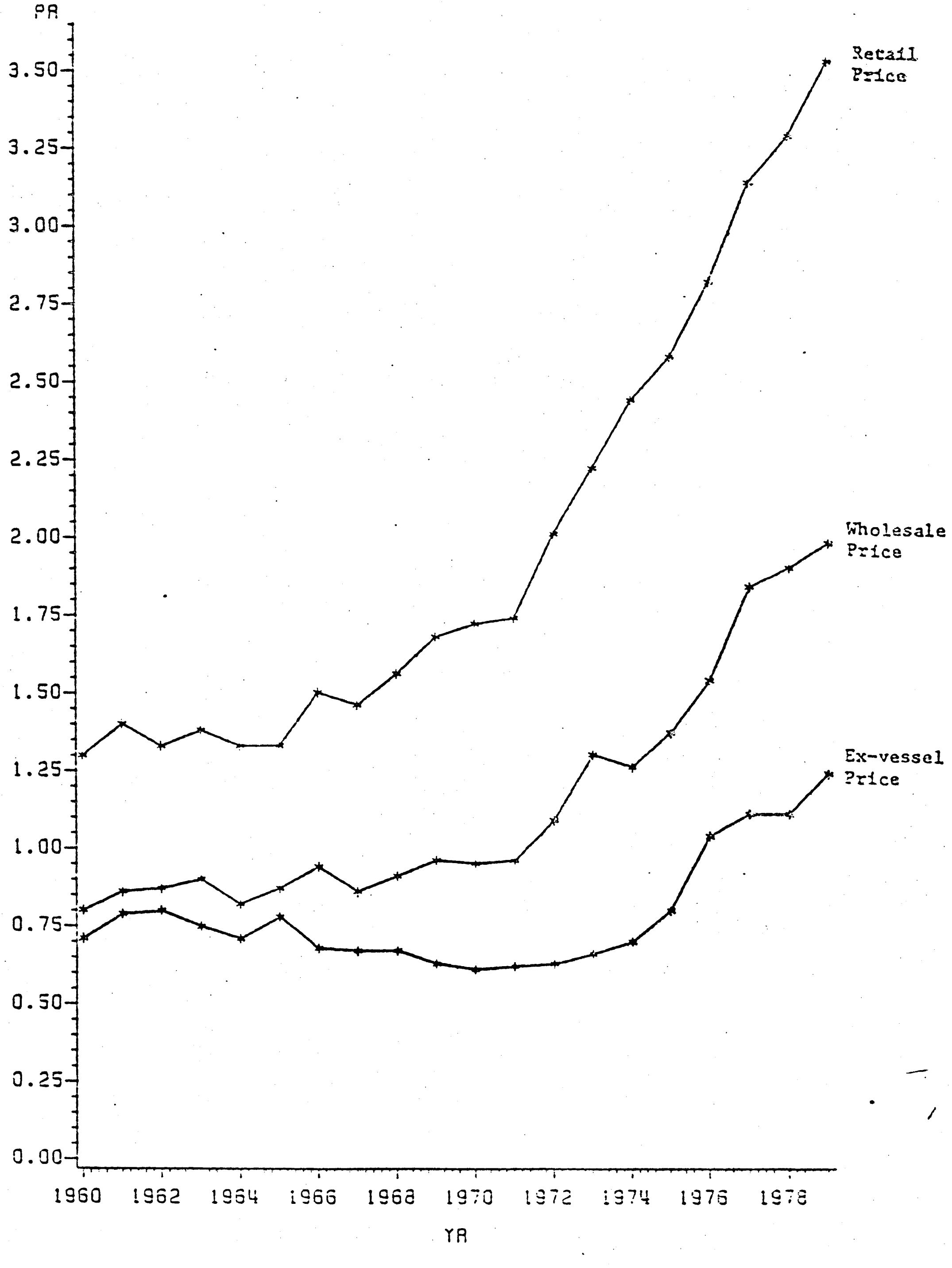
Background

Since the early 1900s, the oyster fishery has been a major industry in the Chesapeake Bay area of Maryland and Virginia. Historically, it has been a stable source of employment and income as well as a symbol of the economic and social vitality in the coastal region. Additionally, the Chesapeake Bay region accounts for 40 to 50 percent of total U.S. oyster production [Shellfish Market Review (1981)].

Although oyster production in the Chesapeake Bay has remained relatively stable since 1960, the harvest has never again reached what it had been prior to that time [Fishery Statistics of the United States, 1950-1976]. Over the past twenty years, a relatively stagnant harvesting sector has coexisted with a relatively prosperous processing sector. Annual ex-vessel (dockside) price, wholesale price, and retail price data for oysters for the 1960-79 period support this inference (Figure 1). Ex-vessel prices did not change appreciably from 1960 to 1975; in fact from 1966-1974, ex-vessel prices were actually below the 1960 level. In contrast with ex-vessel price trends, wholesale prices rose slowly until 1970 and then began to increase substantially. Similarly, retail prices have risen, with minor fluctuations, continuously since 1960. By 1976, the wholesale and the retail prices were at least double their respective 1960 levels. These price trends have resulted in rising gross marketing margins between the harvesting sector and the processing sector. The gross marketing margins between

Figure 1. Retail, Wholesale, and Ex-Vessel Prices for the Period 1960-1979



Source: <u>Shellfish Market Review</u>

the processing sector and the retail sector have remained relatively constant.

Since the economic potential of the Chesaeake Bay oyster fishery depends in part on the price formation process in the marketing system, it is important to understand the factors affecting ex-vessel, wholesale, and retail prices. With such information, public and private decision makers will be better able to identify actions which may be taken to improve the situation for oyster harvesters. However, no analyses have been conducted to examine ex-vessel, wholesale, and retail prices of oysters in the Chesapeake Bay. The purpose of this study is to determine the nature and the magnitude of the factors affecting the prices at the various marketing levels.

The Model

The relationship among ex-vessel, wholesale, and retail prices depends on consumer demand, producer supply, and the cost of marketing inputs [Gardner (1975), Heien (1980)]. From communications with oyster industry personnel in the Chesapeake Bay [Virginia Institute of Marine Science, Virginia Marine Resource Commission and Marine Products Commission], it was hypothesized that: (1) retail prices are influenced by consumer demand, not by wholesale prices or ex-vessel prices; (2) wholesale prices are based on retail prices, marketing costs, and producer supply; and (3) ex-vessel prices are determined by wholesale prices and producer supply. A schematic diagram of the hypothesized price formation process in the marketing system for oysters in the

Chesapeake Bay is depicted in Figure 2.

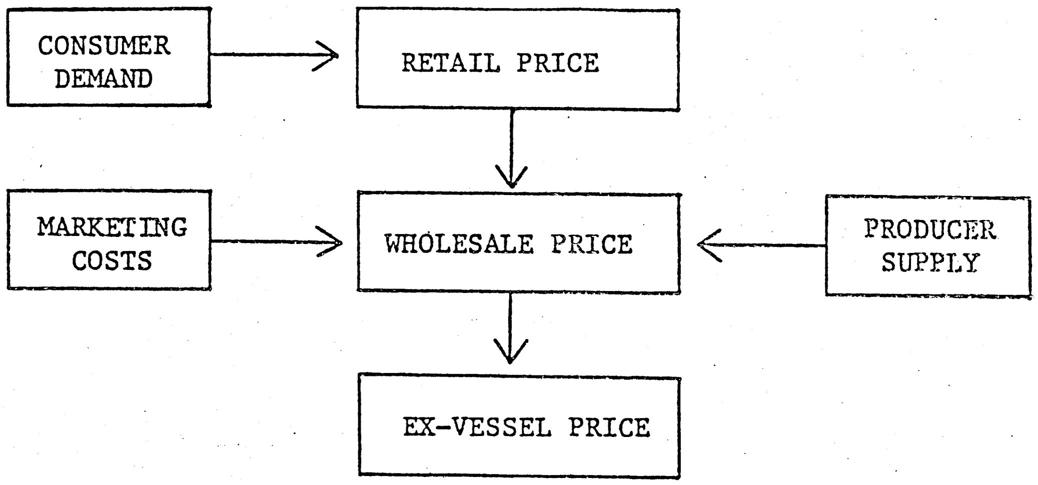


Figure 2.

Based on this information from oyster industry leaders, a recursive model consisting of three structural equations was formulated:

$$PR = \beta_{10} + \beta_{11}C + \beta_{12}Y + \beta_{13}CPIF + \beta_{14}YR + e_1$$

$$PW = \beta_{20} + \beta_{21}YR + \beta_{22}L + \beta_{23}I + \beta_{24}IIGS + \beta_{25}PR + e_2$$

$$PEV = \beta_{30} + \beta_{31}L + \beta_{33}PW + e_3$$

where: PR = nominal retail price of oysters (standards) at Baltimore, MD $/pound

C = total annual consumption of oysters in millions of pounds

Y = nominal total disposable personal income in the United States in billions of dollars

CPIF = consumer price index of fish (1967 = 100)

YR = year

PW = nominal wholesale price of oysters (standards) at Norfolk, VA, $/pound

L = landings in the Chesapeake Bay, millions of pounds

I = imports from the South Atlantic and the Gulf, millions of pounds

IIGS = index of intermediate goods and services (1967 = 100)

PEV = nominal ex-vessel price of oysters, weighted average of value of Maryland and Virginia landings in $/pound

e_1, e_2, e_3 = disturbance terms for the respective equations

The data base used consists of annual observations for the period 1960 to 1979. The condition of triangularity necessary for the use of the recursive system is met, that is, the Jacobian of the transformation connecting the disturbance terms with the endogenous variables is triangular and equal to one.

It is hypothesized that in the retail price equation, the coefficient on consumption, β_{11}, is negative to reflect the usual inverse relation to price. The coefficient on income, β_{12} , is hypothesized to be positive reflecting the fact that oysters are normal goods. CPIF is an index used to measure the prices of substitute food finfish and shellfish products. As such, it is hypothesized to be positively related to the retail price of oysters. In light of Figure 1, it is hypothesized that the coefficient on year, a trend indicator, is positive.

At the wholesale level, it is hypothesized that landings and imports have inverse impacts on the wholesale price. Therefore, the coefficients, β_{22} and β_{23}, are expected to be negative. Since landings and imports have been relatively stable over the 1960-79 period, they serve as exogenous variables in this recursive system. Marketing costs are a function of transport cost, labor cost, overhead cost, and packaging [Bundy and Williams (1978)]. Transport cost is the cost incurred in moving oysters from dockside to shucking/packing houses and from the shucking house to wholesale and/or retail outlets. Overhead cost includes fixed fees such as taxes, unemployment insurance, advertising, and utilities. The unavailability of time series data on particular cost components led to the use of the index of intermediate goods and services (IIGS) as a proxy variable for marketing costs. IIGS is an index developed by the USDA to measure trends in marketing costs for the food processing sector, as such, it can be assumed to be an accurate representation of costs in the oyster processing sector. Marketing costs are hypothesized to be positively related to the wholesale price. It is hypothesized that β_{25}, the coefficient of PR, is positive to reflect the consumer demand for oysters. Again, in light of Figure 1, the coefficient on the trend indicator is hypothesized to be positive.

According to economic theory, the coefficient on landings, β_{31}, in the ex-vessel price equation should be negative, reflecting an inverse relationship between producer supply and ex-vessel price. The coefficient on PW, β_{33}, is hypothesized to be positive to reflect the wholesale demand for oysters. On the basis of Figure 1, since ex-vessel prices decreased from 1964 to 1974 before increasing substantially after 1975, *a priori*, no expectation is made for the relationship between the trend indicator and the ex-vessel price.

Empirical Results

Attempts to estimate the recursive model using the method of ordinary least squares were plagued by serious multicollinearity problems. The presence of multicollinearity was confirmed by examining the pairwise correlation matrix of predetermined variables, by examining the relative magnitudes of the eigenvalues and eigenvectors of the correlation matrix of predetermined variables, and by examining the Variance Inflation Factors (VIFs). Small eignvalues associated with large elements of eigenvectors pinpoint the predetermined variables that participate in the multicollinearity [Hoerl and Kennard (1970)]. The VIFs are the diagonal elements of the inverse of the correlation matrix of predetermined variables. Those elements with VIFs greater than ten were considered to be severely correlated [Capps and Semprevio (1981)]. Thus, for the retail price equation, an eigenvalue of 0.0019 and VIFs of 37.07 for year, 332.25 for disposable income, and 175.44 for the consumer price index of fish and for the wholesale price equation, an eigenvalue of 0.0039 and VIFs of 142.36 for retail price and 118.71 for the index of intermediate goods and services were considered indicative of severe multicollinearity. However, no evidence of a severe problem was detected for the ex-vessel price equation; therefore, it was estimated using ordinary least squares.

The use of ridge regression is one method of reducing the effects of multicollinearity [Hoerl and Kennard (1970)], thereby making it possible to partition the separate effects of the various factors influencing the price at each level of the marketing chain. The selection of the k-values for the retail and wholesale price equations was made on the basis of the mean squared error (MSE) for the estimated parameter coefficient vector and on the basis of the Ridge Trace [Hoerl and Kennard (1970)]. A drawback to this procedure rests on the fact that the selection of k-values is subjective. The k-value selected for the retail and wholesale price equations was k = 0.20. The MSE for the estimated parameter coefficient vector was minimized for both equations at this k-level.

The estimated equations for retail, wholesale, and ex-vessel prices were:

$$PR = -48.07 + \underset{(0.0038)}{0.0249\ YR} + \underset{(0.000027)}{0.00064\ Y} + \underset{(0.00025)}{0.0042\ CPIF} - \underset{(0.0042)}{0.00093\ C}$$

$$k = 0.20 \qquad MSE = 0.1330 \qquad R^2 = .981$$

$$PW = -15.94 + \underset{(0.0029)}{0.0086\ YR} + \underset{(0.014)}{0.197\ PR} - \underset{(0.0061)}{0.0161\ L} - \underset{(0.0053)}{0.0067\ I} + \underset{(0.00024)}{0.0028\ IIGS}$$

$$k = 0.20 \qquad MSE = 0.0684 \qquad R^2 = .966$$

$$PEV = 51.72 - \underset{(0.0053)}{0.026\ YR} + \underset{(0.0857)}{0.752\ PW} - \underset{(0.0058)}{0.0074\ L}$$

$$k = 0.00 \qquad MSE = 0.201 \qquad R^2 = .909$$

where all variables are previously defined and where the standard errors for the parameter estimates are given in parentheses.

The model explained 98 percent of the annual variation in the retail price, better than 96 percent of the annual variation in the wholesale price, and approximately 91 percent of the annual variation in the ex-vessel price. The signs of the estimated coefficients in each of the price equations conformed to theoretical expectations. The level of significance chosen was $\alpha = .10$. Except for oyster consumption, all variables in the retail price equation were significant. In the wholesale price equation, only imports from the South Atlantic and the Gulf were not statistically significant and in the ex-vessel price equation, only landings in the Chesapeake Bay were not statistically significant.

From the retail price equation, a one billion dollar increase in disposable income would increase the retail price of oysters by 0.064¢ per pound. A one unit change in the consumer price index of fish would increase the retail price of oysters by 0.42¢ per pound. The impact of oyster consumption on the retail price of oysters was not statistically different from zero. In order to make meaningful comparisons of the relative impact of these variables, flexibilities were computed at the sample means. A one percent change in disposable income would lead to a 0.249 percent change in the retail price of oysters, and a one percent change in the consumer price index of fish would lead to a 0.310 percent change in the retail price of oysters. The retail own-price flexibility of oysters, the percentage change in the retail price associated with a one percent change in oyster consumption, was -0.036. Consequently, this measure implies that the retail price of oysters in the Chesapeake Bay is inflexible, and therefore, increasing total revenue to retailers could be accomplished by increasing oyster consumption.

At the wholesale level, a one dollar change in the retail price of oysters would lead to a 19.7¢ per pound change in the wholesale price in the same direction. A one million pound change in Chesapeake Bay landings would lead to a 1.61¢ per pound change in the wholesale price in the opposite direction and one unit change in the IIGS would result in a 0.28¢ per pound change in the wholesale price in the same direction. The impact of imports from the South Atlantic and the Gulf was not statistically different from zero. Again, to make comparisons of the relative impact of various variables on the wholesale price, flexibilities were computed at the sample means. A one percent change in the retail price of oysters would result in a 0.323 percent change in the wholesale price and a one percent change in the index of intemediate goods and services would result in a 0.341 percent change in the wholesale price. The wholesale own-price flexibility of oysters was -0.319, and the wholesale cross-price flexibility of oysters was -0.142. The respective flexibility coefficients indicate that the wholesale price of oysters is somewhat irresponsive to changes landings and imports. However, the wholesale price is more responsive to changes in landings in the Chesapeake Bay than to changes in imports from the South Atlantic and the Gulf.

At the ex-vessel price level, a one dollar per pound increase in the wholesale price of oysters would increase the ex-vessel price by 75.2¢ per pound. The impact of landings on the ex-vessel price of oysters was not statistically different from zero. At the sample means, a one percent change in the wholesale price of oysters would lead to a 1.099 percent change in the ex-vessel price indicating the sensitivity of the ex-vessel price to changes in the wholesale price. The ex-vessel own-price flexibility of oysters in the Chesapeake Bay was -0.215; whereas, the wholesale own-price flexibility was -0.319. Thus, the wholesale price is slightly more sensitive to changes in landings in the Chesapeake Bay than is the ex-vessel price. On the basis of the estimated flexibilities, increasing the total revenue to oyster harvesters and to wholesalers could be accomplished by increasing landings of oysters in the Chesapeake Bay.

Concluding Comments and Future Research Considerations

The recursive model presented a realistic and adequate description of the price formation process for oysters in the Chesapeake Bay. The model explained over 90 percent of the annual variations in the retail price, the wholesale price, and the ex-vessel price of oysters. Disposable income, the consumer price index for fish, and the trend indicator were statistically significant variables in influencing the retail price of oysters. The retail price, Bay landings, marketing costs, and the trend indicator were statistically significant variables in influencing the wholesale price of oysters. The wholesale price and the trend indicator were statistically important factors for the ex-vessel price of oysters. However, oyster consumption did not have a significant impact on the retail price, imports did not have a significant impact on the wholesale price, and Bay landings did not have a significant impact on the ex-vessel price.

This study, although a useful initial step does not present, by any means, an exhaustive analysis. For example, in order to perform analyses of alternative management strategies, the ex-vessel price relationship should be integrated with bieconomic models that attempt to simulate the Chesapeake Bay fishery. Additionally, future analyses should examine the interdependencies among the oyster fishery and other fisheries. The existence of economic interdependencies among fisheries involving different species has been hypothesized by Crutchfield (1973). Strand and Matteucci (1977) have provided empirical evidence for the existence of short-term economic interrelations between the Virginia oyster and blue crab fisheries. Further, additional analyses should partition the aggregate Chesapeake Bay landings into Maryland landings and Virginia landings to consider potential state differences in oyster harvest. Finally, due to the seasonal nature of the oyster harvest in the Chesapeake Bay, future analyses should consider the effects of seasonality on ex-vessel, wholesale, and retail prices of oysters. These additional research efforts should pay huge dividends to policy-makers and management agencies, such as the Tidewater Administration of Maryland and Virginia Marine Resources Commission, who have regulatory authority over the Chesapeake Bay oyster fishery.

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