# Impact of U.S. Wholesale Demand for Canned Sardines on Market Accessibility of Potential Gulf of Mexico Products

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*ABSTRACT—Significant resources of small fish, which are potentially marketable in the form of canned sardines, are available from Gulf of Mexico waters. To determine the potential for entry into the established U.S. canned sardine market, three product groups, which comprise the market, are analyzed at the wholesale level to determine their demand characteristics. Results indicate that opportunities for entry exist, especially for products that are similar to imports in terms of package and quality.*

## Introduction

Exploitable populations of small pelagic fishes occur in the northern Gulf of Mexico. Of these, coastal herrings, generally of the family Clupeidae, are dominant, including the Spanish sardine, *Sardinella aurita*; Atlantic thread herring, *Opisthonema oglinum*; round herring, *Etrumeus teres*; and scaled sardine, *Harengula jaguana*. Also exploitable is the anchovy, *Anchoa* spp., several species of scad, *Decapturas* spp., and the Atlantic bumper, *Chloroscombrus chrysurus*.

Use of these pelagic fishes is now minimal, with the exception of Gulf menhaden, *Brevoortia patronus*. Reintjes[1] has reported that several of these species can support larger fisheries than are being conducted. There was a temporary industrial fishery for thread herring near Fort Myers, Fla., in the late 1960's which shut down with a ban on purse seining (Kinnear and Fuss, 1971). The Food and Fiber Institute at Mississippi State University and the National Marine Fisheries Service have experimented with curing, canning, and smoking of several of these species of fish for human consumption. Perkins[2] indicated that a number of products were suitable for the marketplace, especially the canned Spanish sardine.

Canning is an accepted utilization method for small pelagics. The entire U.S. production of canned sardines is concentrated in Maine and utilizes immature Atlantic herring, *Clupea harengus harengus*. In 1980, 86 percent of the Maine product was packed in soy oil. The major sources for imported sardines are Norway, Peru, Portugal, Japan, and Canada (in order of importance), with a high concentration of Peruvian and Norwegian imports. The majority of Norwegian and Canadian imports utilize immature Atlantic herring, while other countries utilize the pilchard or sardine.

The traditional Maine pack consists of one layer of medium to large sardines in soy oil, though there has been some diversification of pack medium in recent years, most notably a mustard sauce pack. The majority of Maine sardines are packed in standard 3¾-ounce cans.

The imports in oil are usually packed in brisling, sild, or soy oils. Imports not in oil are usually packed in such media as mustard sauce, tomato sauce, brine, or cream sauces. There are no standard can sizes for imports; sizes range from a 125 rectangular Dingley[3] can to a 425 round no. 1 tall can (Lanier, 1981).

In this paper we examine the U.S. wholesale demand characteristics of three sardine groups by independently estimating their respective price functions. An empirical model is used to extrapolate pertinent economic information relating to market accessibility for potential Gulf of Mexico producers.

This paper is based on the assumption that product differentiation exists among domestic sardines, imported sardines in oil, and imported sardines not in oil. The price functions are reduced form equations that reflect demands faced by producers and importers and derived from wholesalers. However, we have examined demand at one particular market level and demand for a given good is ultimately derived from the aggregate of individual consumer demand curves.

## Industry Structure of Domestic Producers

All U.S. sardine processors are currently located in Maine. A sizeable sardine fishery and industry existed in California until the catch declined dramatically in the early 1960's. In 1973 California banned all sardine fishing.

All 14 plants in Maine process most of their product in soy oil. Experts on the Maine sardine industry and sardine processors agree that the annual volume

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[1]Reintjes, J. W. 1979. A review of clupeoid and carangid fishery resources in the Western Central Atlantic. Food Agric. Organ., U.N., WECAF study, 30 p.

[2]Perkins, G. B. 1981. Economic assessment of a potential sardine fishery in the Gulf of Mexico. Rep. Food Fiber Inst., Miss. State Univ., 22 p.

[3]Mention of trade names or commercial firms does not imply endorsement by the National Marine Fisheries Service, NOAA.

of sardine production is a useful criterion for classifying the size of a plant: A plant which produces <50,000 cases[4] can be considered small, a medium-sized plant produces 50,000-100,000 cases, and a large plant produces ≥100,000 cases. Using this criterion, there were five small plants, five medium plants, and four large plants operating in Maine in 1980. Although the distribution of generic plant sizes was fairly uniform, the concentration of production was not. The four largest plants produced 46 percent of the total production, while the eight largest plants produced 78 percent of total production.

Hu et al.[5] discovered that the average cost of producing a case of sardines was about $4.50 higher for a small plant than for a large plant owing to higher unit costs for fish and cans. In fact, in some instances small plants were selling their product at a price less than their total cost per unit[6].

## Market Characteristics of Canned Sardine Imports

In 1979 the import market was about evenly divided between oil-packed sardines and other packs. Oil packs were supplied mainly by Norway (47 percent), Canada (14 percent), Portugal (15 percent), Yugoslavia (9 percent), and Spain (5 percent) (Lanier, 1981). Other packs, predominantly tomato sauce, were supplied by Peru (45 percent), Norway (22 percent), Japan (13 percent), and Mexico (12 percent) (Lanier, 1981). From 1961 to 1977, South Africa and Namibia dominated the not-in-oil pack, averaging about 50 percent of the import total. However, their resource was over-exploited and exports shrank to minimal levels. This enabled Peru to emerge quickly as the leading supplier of the not-in-oil pack to the United States.

**Table 1.—Canned sardine prices in actual cents per pound at the pre-wholesale level (USDOC, 1976-83; 1961-75).**

| | | Imports | |
|---|---|---|---|
| Year | Domestic | Not in oil | In oil |
| 1961 | 30.75 | 12.36 | 38.51 |
| 1962 | 37.88 | 14.30 | 41.05 |
| 1963 | 34.42 | 15.72 | 48.18 |
| 1964 | 33.51 | 15.70 | 47.81 |
| 1965 | 36.43 | 15.43 | 47.56 |
| 1966 | 39.25 | 16.16 | 48.87 |
| 1967 | 47.37 | 17.29 | 46.48 |
| 1968 | 47.65 | 18.43 | 46.34 |
| 1969 | 47.17 | 21.05 | 45.70 |
| 1970 | 59.49 | 27.53 | 46.43 |
| 1971 | 48.78 | 26.75 | 50.39 |
| 1972 | 65.34 | 33.34 | 54.88 |
| 1973 | 67.37 | 34.46 | 64.77 |
| 1974 | 86.52 | 37.39 | 74.90 |
| 1975 | 95.80 | 68.60 | 87.86 |
| 1976 | 98.02 | 48.52 | 88.22 |
| 1977 | 115.78 | 51.17 | 97.21 |
| 1978 | 135.16 | 59.54 | 105.19 |
| 1979 | 147.57 | 60.64 | 120.98 |
| 1980 | 159.29 | 60.17 | 132.97 |
| 1981 | 143.82 | 70.37 | 137.80 |
| 1982 | 157.21 | 61.71 | 135.55 |
| 1983 | 166.66 | 68.82 | 123.87 |

**Table 2.—Variable Specification.**

| Notation | Specification |
|---|---|
| *PM* | Average annual price of canned Maine sardines paid by wholesalers in cents per pound. |
| *PO* | Average annual price of imported sardines in oil paid by wholesalers in cents per pound. |
| *PNO* | Average annual price of imported sardines not in oil paid by wholesalers in cents per pound. |
| *QM* | Annual per capital quantities of the Maine pack demanded by wholesalers in pounds. |
| *QO* | Annual per capita quantities of imports in oil demanded by wholesalers in pounds. |
| *QNO* | Annual per capita quantities of imports not in oil demanded by wholesalers in pounds. |
| *PT* | Average annual price of canned tuna paid by wholesalers in cents per pound. |
| *PS* | Average annual price of canned salmon paid by wholesalers in cents per pound. |
| *Y* | Per capita gross disposal income. |

## Market Structure and Price Analysis

Canned Maine sardines are generally marketed through brokers in metropolitan areas, while imported sardines are generally marketed through wholesalers. For ease of analysis we will assume that brokers and wholesalers together constitute the wholesale sector of the canned sardine market.

Import prices tend to be lower than domestic prices at the pre-wholesale level (Table 1) and higher at the retail level. Hu et al.[5] stated that this difference is due partly to an ad valorum tax (not reflected in pre-wholesale prices), but mostly to a perception of higher quality for the imports. Small sardines in oil command a higher price than medium/large sardines in oil. This price differential is attributable to a perception of higher quality for the small sardine. The not-in-oil pack is priced considerably lower than the oil pack at the pre-wholesale level, ranging from 32 percent of the oil pack in 1961 to 56 percent in 1983.

## Economic Model of Wholesale Demand

The model presented here establishes the nature of demand for canned sardines as derived from wholesalers. The rationale for observing this market segment is that this is the set of demand curves new producers would face as they try to enter the existing market for canned sardines.

The applicability of this model is twofold: 1) It can be used as a policy-making tool that allows institutions to measure the effects of public policy decisions (e.g., taxes, tariffs, quotas, etc.) on sales revenues, tax revenues, and general measures of consumer and producer surpluses, and 2) it can provide general indications of the ability of new firms to enter existing markets by examining price flexibilities in regard to demand.

To determine the demand characteristics of the pre-wholesale market, three functional form equations were specified:

$$PM = f(-QM, +PT, +PS, +PO, +PNO, \pm Y)$$

$$PO = f(-QO, +PT, +PS, +PM, +PNO, \pm Y)$$

$$PNO = f(-QNO, +PT, +PS, +PM, +PO, \pm Y)$$

In specifying the equations (Table 2) we assumed that the pre-wholesale

[4]One case = 23.4 pounds net.
[5]Hu, T. W., D. M. Dressel, and D. R. Whitaker. 1983. The Maine sardine industry. Saltonstall-Kennedy Rep. 83-9-WO, 39 p. Dep. Econ., Penn. State Univ., University Park.
[6]If variable cost per unit is less than selling price per unit, it is advantageous for the firm to keep producing because it can cover a portion of its fixed cost at least in the short run. Total cost = fixed cost plus variable cost.

prices were endogenous variables determined by the market system. We further assumed that the inverse demand function, where price is a function of quantity demanded, was applicable, similar to the case of price dependent agricultural commodities (Tweeten, 1975). In general, the supplies of canned sardines are assumed to be primarily determined by abundance of fish stocks and thereby are assumed to be predetermined. The model utilizes 23 years of annualized data, 1961-83 inclusive.

The model is general in scope and is limited to product groups, not individual products; e.g., two-layered Norwegian sardines packed in brisling oil are included with one-layered Canadian sardines packed in soy oil. Data limitations prevented separation of the Maine pack into oil and not-in-oil packs. Since the Maine pack has been predominantly packed in oil, we would expect it to be more like the oil pack as opposed to the not-in-oil pack vis-a-vis its demand characteristics. The estimation of quantity-dependent demand equations to measure wholesale demand was also considered in our research. Preliminary results indicated that producers and importers did not react to predetermined prices by adjusting their inventories and/or production as evidenced by the inability of exogenous variables to adequately explain variations in quantities demanded.

## Exogenous Variables and Apparent Economic Relationships

The exogenous variables that are assumed to have a causal effect on prewholesale prices are per capita quantities demanded at the wholesale level, real prices of substitute goods at the prewholesale level, and real disposable income per capita. Quantities demanded are deflated by population size to preclude demographic effects (Table 3). Prices are deflated by the GNP implicit price deflator to preclude inflationary effects (Table 4).

Table 3.—Per capita demand for canned sardines in pounds (USDOC, 1976-83; 1962-75).

| | Imports | | | | | | |
|---|---|---|---|---|---|---|---|
| Year | In oil | % | Not in oil | % | Domestic | % | Total (100%) |
| 1961 | 0.152 | 39 | 0.079 | 20 | 0.162 | 41 | 0.394 |
| 1962 | 0.175 | 32 | 0.109 | 20 | 0.256 | 47 | 0.541 |
| 1963 | 0.105 | 25 | 0.114 | 27 | 0.195 | 47 | 0.416 |
| 1964 | 0.104 | 30 | 0.128 | 36 | 0.120 | 34 | 0.353 |
| 1965 | 0.111 | 30 | 0.121 | 33 | 0.137 | 37 | 0.370 |
| 1966 | 0.120 | 27 | 0.173 | 40 | 0.142 | 32 | 0.437 |
| 1967 | 0.129 | 32 | 0.136 | 33 | 0.141 | 35 | 0.406 |
| 1968 | 0.142 | 30 | 0.152 | 32 | 0.185 | 38 | 0.480 |
| 1969 | 0.135 | 40 | 0.090 | 27 | 0.111 | 33 | 0.337 |
| 1970 | 0.167 | 53 | 0.062 | 20 | 0.087 | 27 | 0.317 |
| 1971 | 0.150 | 43 | 0.091 | 26 | 0.103 | 30 | 0.345 |
| 1972 | 0.198 | 40 | 0.136 | 28 | 0.157 | 32 | 0.493 |
| 1973 | 0.170 | 40 | 0.148 | 35 | 0.102 | 24 | 0.421 |
| 1974 | 0.173 | 32 | 0.186 | 43 | 0.109 | 25 | 0.433 |
| 1975 | 0.085 | 33 | 0.058 | 23 | 0.110 | 43 | 0.255 |
| 1976 | 0.123 | 35 | 0.124 | 35 | 0.106 | 30 | 0.354 |
| 1977 | 0.117 | 36 | 0.110 | 33 | 0.101 | 31 | 0.329 |
| 1978 | 0.110 | 33 | 0.111 | 33 | 0.112 | 33 | 0.334 |
| 1979 | 0.101 | 29 | 0.119 | 34 | 0.128 | 37 | 0.349 |
| 1980 | 0.080 | 26 | 0.145 | 48 | 0.079 | 26 | 0.304 |
| 1981 | 0.079 | 20 | 0.161 | 40 | 0.158 | 40 | 0.399 |
| 1982 | 0.060 | 21 | 0.154 | 53 | 0.073 | 25 | 0.289 |
| 1983 | 0.073 | 36 | 0.077 | 38 | 0.051 | 25 | 0.202 |

Table 4.—Canned sardine prices in deflated cents per pound at the pre-wholesale level (USDOC, 1976-83; 1961-75).

| | | Imports | |
|---|---|---|---|
| Year | Domestic | Not in oil | In oil |
| 1961 | 44.35 | 17.83 | 55.54 |
| 1962 | 53.65 | 20.25 | 58.14 |
| 1963 | 48.03 | 21.93 | 67.22 |
| 1964 | 46.05 | 21.57 | 65.70 |
| 1965 | 49.00 | 20.76 | 63.96 |
| 1966 | 51.14 | 21.06 | 63.67 |
| 1967 | 59.92 | 21.87 | 58.79 |
| 1968 | 57.73 | 22.33 | 56.14 |
| 1969 | 54.35 | 24.25 | 52.66 |
| 1970 | 65.05 | 30.10 | 50.77 |
| 1971 | 50.81 | 27.86 | 52.49 |
| 1972 | 65.34 | 33.34 | 54.88 |
| 1973 | 63.71 | 32.58 | 61.24 |
| 1974 | 75.18 | 32.49 | 65.08 |
| 1975 | 76.59 | 54.85 | 70.24 |
| 1976 | 74.07 | 36.66 | 66.66 |
| 1977 | 82.67 | 36.54 | 69.41 |
| 1978 | 89.85 | 39.58 | 69.93 |
| 1979 | 90.30 | 37.10 | 74.03 |
| 1980 | 89.27 | 33.72 | 74.53 |
| 1981 | 73.53 | 35.97 | 70.45 |
| 1982 | 75.81 | 29.75 | 65.36 |
| 1983 | 77.39 | 31.96 | 57.52 |

In theory, we would expect quantity-price relationships to be negative, price of substitutes-price relationships to be positive, and income-price relationships to be positive for normal goods and negative for inferior goods[7].

Preliminary plots suggested a lack of linear relationships, and therefore variables were transformed into natural logs before the price functions were estimated. The log-log form yields estimated coefficients that are price flexibilities or a percentage change in price caused by a 1 percent change in an exogenous variable.

## Hypotheses

The following hypotheses were tested in the null form:

1) The exogenous variables independently have no causal effect on the endogenous variable (two-tailed t-test),

2) the exogenous variables collectively have no causal effect on the endogenous variable (f-test), and

3) there is no autocorrelation present in the model (Durbin-Watson test).

The t-tests and f-tests were tested at the 0.10 significance level[8], and the Durbin-Watson statistic was tested at the 0.01 significance level. The estimated structural equations (in natural logarithms) are:

$$PM = -6.09 + \underset{(0.35)}{0.030\ QM} + \underset{(1.47)}{0.310\ PO} + \underset{(0.92)}{0.142\ PNO} + \underset{(0.42)}{0.064\ PS} + \underset{(0.30)}{0.068\ PT} + \underset{(3.58)}{0.973^{*}\ Y} \quad (1)$$

$$d = 2.41 \qquad F_{(6,16)} = 18.74^{*} \qquad R^2 = 81.6$$

$$PO = 3.36 - \underset{(-8.51)}{0.369^{*}\ QO} - \underset{(-0.88)}{0.066\ PNO} + \underset{(1.61)}{0.184\ PM} + \underset{(1.95)}{0.145^{*}\ PS} + \underset{(5.12)}{0.561^{*}\ PT} - \underset{(-3.06)}{0.461^{*}\ Y} \quad (2)$$

$$d = 1.87 \qquad F_{(6,16)} = 20.97^{*} \qquad R^2 = 84.5$$

[7]Inferiority and normality are descriptive of the income elasticity of demand for a good. It is possible that a good will be inferior for one consumer and superior for another consumer. A good that is income inferior exhibits a proportional decline in consumption as consumptive income increases. Conversely, a normal good exhibits a proportional increase in consumption as consumptive income increases.

[8]An asterisk (*) indicates significance at the 0.10 level.

$$PNO = -9.90 - 0.289^{*}\,QNO + 0.357\,PO + 0.128\,PM$$
$$(-3.29) \qquad (1.21) \qquad (0.42)$$
$$+ 0.272\,PS + 0.398\,PT + 0.926^{*}\,Y \qquad (3)$$
$$(1.49) \qquad (1.59) \qquad (2.49)$$
$$d = 1.49 \qquad F_{(6,16)} = 18.55^{*} \qquad R^2 = 82.7$$

## Test Results

1) The null hypothesis that states exogenous variables independently have no causal effect on the endogenous variable is accepted for all variables in equations (1), (2), and (3) which are not significant at the 0.10 level.

2) The null hypothesis that states the exogenous variables collectively have no causal effect on the endogenous variable is not accepted for each equation.

3) The null hypothesis that states there is no autocorrelation present in the model is accepted for each equation.

## Interpretations

### Price Function for Maine Sardines

All signs of estimated coefficients are consistent with economic theory with the exception of quantities demanded which is positive but statistically insignificant. The equation says that quantity demanded has no significant effect on price and income has a significantly positive effect on price. The equation offers an explanation of the variance of price over time ($R^2 = 81.6$), and the overall equation is significant ($F$-ratio). This equation may be used to forecast Maine sardine prices, but it does not give us an indication of the ability of new firms to enter the canned sardine market and compete with the Maine sardine. To measure the impact of increased supplies on total revenues accruing to this product group, a significant measure of price flexibility with respect to quantity demanded is required.

The equation says that prices are not determined by wholesale market demand; i.e., there is no significant relationship between price and quantity changes. Maine producers are pricemakers at this market level, not pricetakers, and there is an absence of interaction among Maine sardine brokers and imported sardine wholesalers.

We cannot interpret the positive income effect on price as meaning Maine sardines are an income normal good; e.g., increases in income levels will increase quantities demanded. To this end, the following quantity-dependent demand equation was estimated:

$$QM = 9.10 + 0.250\,PM + 0.338\,PO - 0.153\,PNO$$
$$(0.35) \qquad (0.53) \qquad (-0.33)$$
$$+ 0.918\,PT - 2.03^{*}\,Y \qquad (4)$$
$$(1.51) \qquad (-2.19)$$
$$d = 2.27 \qquad F_{(6,16)} = 4.03^{*} \qquad R^2 = 45.2$$

This quantity-dependent equation says that Maine sardines are income inferior products; i.e., a 1 percent increase in real disposable income will cause a decrease in quantity demanded of 2.03 percent.

### Price Function for Imports in Oil

All signs of estimated coefficients are consistent with economic theory with the exception of price of imports not in oil which is negative and statistically insignificant. The overall equation is significant, and a high level of variation in price is explained by the exogenous variables ($R^2 = 84.5$).

A price flexibility of demand (percentage change in price caused by a 1 percent change in quantity demanded) of less than one (ignoring the negative sign) implies a price elastic demand. In general, the reciprocal of price flexibility with respect to quantity is equal to the true value of price elasticity of demand only if the cross-price flexibilities are zero (Meinken et al., 1956). The price flexibility with respect to demand for imported sardines in oil is $-0.369$ and implies a price elasticity of demand of $-2.710$. This means that a 1 percent increase in quantity demanded will cause a decrease in price of 0.369 percent. When price flexibility of demand is less than one, as in this instance, an increase in quantities supplied to the market will yield an increase in total sales revenues (price $\times$ quantity) to the sum of the firms competing in the market.

Salmon and tuna are significant but weak substitutes for imported sardines in oil. A 1 percent increase in the price of salmon will cause an increase in the price of imported sardines in oil of 0.145 percent; a 1 percent increase in the price of tuna will cause a 0.561 percent increase in the price of imported sardines in oil.

Price flexibility with respect to income is negative for imported sardines in oil at $-0.461$. This means a 1 percent increase in income will cause a decrease of $-0.461$ percent in price. When this estimated coefficient is negative it infers that the product is an income inferior good.

### Price Function for Imports Not in Oil

All signs of estimated coefficients are consistent with economic theory. The overall equation is significant, and the level of correlation is high at $R^2 = 82.7$.

The price flexibility of the product with respect to quantity is measured at $-0.289$, which implies an elasticity of $-3.460$. As for imported sardines in oil, further quantities added to the market will increase gross revenues to the sum of the firms in the market. In fact, a lower price flexibility and higher demand elasticity will enable this product group to increase its total revenues at a

faster rate than in-oil sardine group.

Price flexibility with respect to income is positive at 0.926 for the not-in-oil pack, meaning that a 1 percent increase in the level of real income per capita will cause the price of imported sardines not in oil to increase 0.926 percent. In general, when this measure of price flexibility is positive, the product is regarded as income normal.

## Summary and Conclusions

Clearly, stock sizes of several coastal herrings in the northern Gulf of Mexico can support larger fisheries, and an accepted method of utilizing small pelagics is by canning. If a decision is made to can these fish, there may be opportunities for entrance into the U.S. canned sardine market. There are two distinct segments of the canned sardine market which are not interdependent: The domestic Maine sardine segment and the imported sardine segment.

The domestic segment exhibits noncompetitive price determination where prices and quantities are not related. The imported segment exhibits competitive pricing which is determined in the marketplace and derived from consumer demand.

The ability for Gulf of Mexico producers to compete in the market with a product similar to the Maine pack will depend solely on arrangements between themselves and wholesalers. It is questionable whether Gulf producers can successfully compete with Maine producers, given the large quantities and unpredictable prices indicative of the Maine pack. Gulf producers would most likely have to approximate the scale of plant of the large Maine producers to be sufficiently cost-effective to enter the market with this type of product. Furthermore, domestic brokers may be reluctant to respond to lower price offerings, should they occur, because Gulf producers still have to prove that they could meet broker supply requirements.

Regression results for the estimation of demand for imported sardines indicate that the market may be receptive to the entry of products that are similar to imports. Both product groups in the import segment exhibit elastic demand, which results in increased gross revenues to the sum of the firms competing as more quantities of goods are sold. Entry into this segment of the market depends highly on product quality or perception of quality.

There are several ways to market a quality pack; e.g., wrapping the can in paper, using premium names/labels, packing in different can sizes and shapes. The production of two-layered packs using small fishes, if available, would be preferred over the one-layer pack, since a higher quality is attached to the smaller sardines. Typical oil pack prices respond negatively to increases in income, while the prices of the typical not-in-oil pack respond positively. Thus, we conclude that Gulf canned sardine production should be oriented toward a not-in-oil pack, especially for the one-layered product.


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