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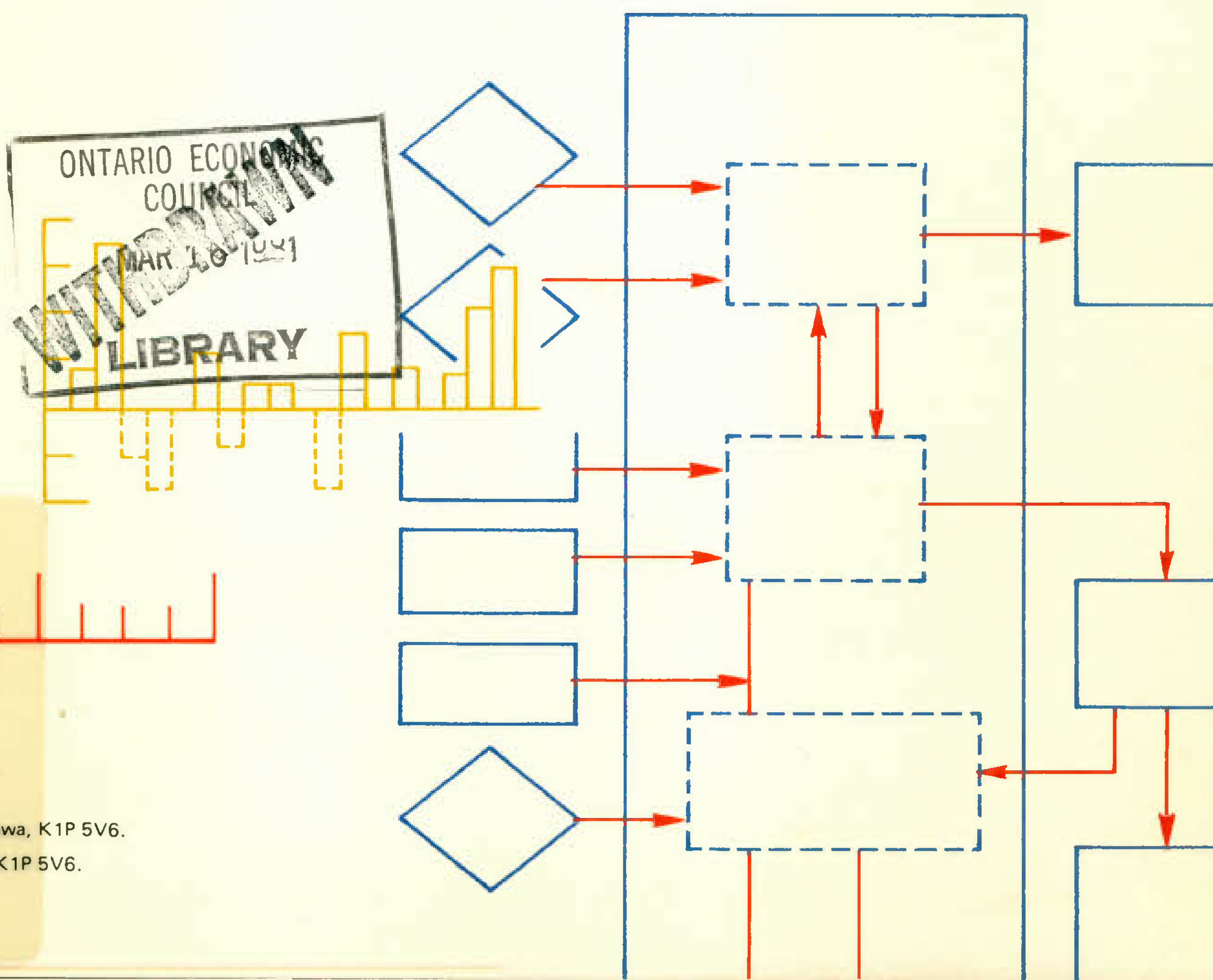

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DISCUSSION PAPER NO. 187

United States Demand for Selected Groundfish Products

by

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Résumé

Produit en guise d'étude documentaire aux fins du rapport que le Conseil économique a publié en 1980 sous le titre Au-delà de la dépendance, ce document présente un modèle visant à évaluer la demande américaine pour les divers produits exportés par l'industrie terre-neuvienne des poissons de fond. Les auteurs arrivent à la conclusion que les élasticités de prix à long terme pour le filet de morue et le filet de sébaste se situent dans les environs de -0,7 tandis que la demande pour le filet de poisson plat et les blocs de poisson congelé est modérément élastique par rapport aux prix. Par rapport aux revenus, l'élasticité de la demande pour ces quatre produits varie de 1,9 dans le cas du filet de poisson plat à 3,7 dans le cas du filet de morue.

Abstract

As a background paper for the Economic Council's 1980 report Newfoundland: From Dependency to Self-Reliance, the authors of this paper have formulated a model to estimate United States demands for the various groundfish products which constitute the major exports of the Newfoundland groundfishery. They conclude that the long run price elasticities for cod fillets and redfish fillets are in the neighbourhood of -0.7 while the demands for flatfish fillets and frozen fish blocks are moderately price elastic. Demands for all four products are income elastic with elasticities ranging from 1.9 for flatfish fillets to 3.7 for cod fillets.

a. Introduction

This paper is concerned with the demand for selected fish products in the United States.[1] It is a background study undertaken for the Economic Council report Newfoundland: From Dependency to Self-Reliance (1980). The chief market for products of the Newfoundland fishery for many years has been the United States and there seems little likelihood that the established pattern of trade will change in the near future. With increased catch made possible by the expansion of national fisheries jurisdiction to the 200 mile limit there is concern over the ability of the U.S. market to absorb increased amounts of Newfoundland fish exports.

Previous econometric studies of the demand for fish products have generally been limited to the estimation of single-equation demand models.[2] The neglect of supply conditions, and the resulting simultaneous equation bias in the estimates, arises from difficulties in specifying the production process of a renewable resource because of gaps in our knowledge of the biological relationships underlying the process. This neglect has been rationalized by the expedient assumption of perfectly inelastic supply, stated explicitly in some cases and remaining implicit in others. However, simultaneous equation bias in the estimates may prevail if supply is in fact not perfectly inelastic.

Although we have not overcome the fundamental difficulty of identifying the supply conditions underlying the U.S. fishery, we estimate a demand equation indirectly by embedding it in an econometric model that presumably reduces the degree of simultaneous equation bias. Moreover, we analyze each fish product separately. In what follows, we first describe the model and our estimating procedure. We then discuss estimates of the structural parameters of the model.

b. The Model

The model, designed to apply to a representative groundfish product, consists of desired stock, stock adjustment, price expectations and demand functions, and a stock-flow identity. We adopt the following notation:

S_t^* = inventories of the fish product desired by U.S. suppliers at the end of time period t

S_t = inventories actually held by U.S. suppliers at the end of time period t

P_t^e = price of the fish product which U.S. suppliers expect, during time period t-1, to prevail in time period t

P_t = price of the fish product

P_t^o = price of a substitute fish product

M_t = total importsof the fish product

Q_t = total production of the fish product

Q_t^d = total demand for the fish product

Y_t = personal income,

all flows and actual prices evaluated for the U.S. during time period t.

We postulate the following relationships:[3]

$$(1)\quad S_t^* = \alpha_o + \alpha_1 P_{t+1}^e$$

$$(2)\quad S_t = S_{t-1} + \lambda_1 (S_t^* - S_{t-1})$$

$$(3)\quad P_{t+1}^e = P_t^e + \lambda_2 (P_t - P_t^e) + \sum_i \theta_i D_{it}$$

$$(4)\quad Q_t^d = \beta_o - \beta_1 P_t + \beta_2 P_t^o + \beta_3 Y_{t-1} + \beta_4 Q_{t-1}^d$$

$$(5)\quad S_t - S_{t-1} \equiv Q_t + M_t - Q_t^d$$

Equation (1) is a desired stock function in which inventories desired by suppliers at the end of the period are determined by the price which they expect to prevail in the next period.[4] Equation (2) allows for a partial adjustment from actual to desired stocks in a single period. An adaptive expectations hypothesis is implied in equation (3). Suppliers are assumed to form their expectations concerning the future price on the basis of the error made in the previous prediction of the current price. To account for seasonal variations in supply, variations which may lead suppliers to expect prices to change even if they made a perfect prediction in the previous period, we include $\sum_i \theta_i D_{it}$ in equation (3). The D_i's represent monthly binary dummy variables, each assuming a value of one for the i^{th} month and zero otherwise.

In equation (4), the quantity demanded of a fish product is a linear function of its price, the price of substitutes in the period, and the level of personal income and the quantity demanded in the previous period. When the time period is a month in length, it is not unreasonable to assume that immediate past income rather than current income determines consumption. The inclusion of quantity demanded in the previous period is predicated on the hypothesis that there is habit persistence in the consumption of fish products. Finally, equation (5) states that, by definition, the change in the stock held during a given period. equals the difference between the supply of and demand for that fish product during the period.[5]

In this system of five simultaneous equations, there are two exogenous variables (P_t^o, Y_{t-1}) and three predetermined variables $(P_t^e, S_{t-1}$ and $Q_{t-1}^d)$. The jointly determined variables are S_t^*, S_t, Q_t^d, P_{t+1}^e, $(Q_t + M_t)$, and P_t. The system is therefore deficient, with six variables and only five equations. This problem arises because there is no specification of how a change in quantity demanded is distributed between changes in inventories on the one hand and changes in total supply (i.e., production plus imports) on the other hand. We estimate a single semi-reduced form equation derived from this five equation system. In general, such single equation estimation generates a simultaneous equation bias. Closing the model, however, would require that we build a U.S. supply model, in which a production function of the U.S. groundfishery is specified. Due to the lack of biological information relevant for the estimation of the production function (or the supply function), we would risk substituting specification errors that are at least as serious as the bias we are trying to overcome.

We now demonstrate how the parameters of the system can be estimated with a semi-reduced form. First, substitute equation (1) into equation (2) to obtain

(6) $$S_t = (1 - \lambda_1)S_{t-1} + \lambda_1 \alpha_1 P_{t+1}^e + \lambda_1 \alpha_o\text{, and hence}$$

(7) $$S_{t-1} = (1 - \lambda_1)S_{t-2} + \lambda_1 \alpha_1 P_t^e + \lambda_1 \alpha_o .$$

Multiplying both sides of equation (7) by $(1 - \lambda_2)$ and then subtracting the result from equation (6), and at the same time inserting equation (3), we obtain

$$(8) \quad S_t = (2 - \lambda_1 - \lambda_2) S_{t-1} - (1 - \lambda_1)(1 - \lambda_2) S_{t-2} + \lambda_1 \lambda_2 \alpha_1 P_t + \lambda_1 \alpha_1 \sum_i \theta_i D_{it} + \lambda_1 \lambda_2 \alpha_o \, .$$

The first difference of equation (8) is

$$(9) \quad S_t - S_{t-1} = (2 - \lambda_1 - \lambda_2)(S_{t-1} - S_{t-2}) - (1 - \lambda_1)(1 - \lambda_2)(S_{t-2} - S_{t-3}) + \lambda_1 \lambda_2 \alpha_1 (P_t - P_{t-1}) + \sum_i \delta_i D_{it} \, ,$$

where $\delta_i = \lambda_1 \alpha_1 (\theta_i - \theta_{i-1})$.

Substituting equations (9) and (4) into (5), we obtain

$$(10) \quad Q_t + M_t = \beta_o - \beta_1 P_t + (2 - \lambda_1 - \lambda_2)(S_{t-1} - S_{t-2}) - (1 - \lambda_1)(1 - \lambda_2)(S_{t-2} - S_{t-3}) + \lambda_1 \lambda_2 \alpha_1 (P_t - P_{t-1}) + \beta_2 P_t^o + \beta_3 Y_{t-1} + \beta_4 Q_{t-1}^d + \sum_i \theta_i D_{it} \, .$$

Alternatively, equation (10) can be rearranged as

$$(11)\quad P_t = \frac{\beta_o}{\beta} - \frac{1}{\beta}(Q_t + M_t) + \frac{2-\lambda_1-\lambda_2}{\beta}(S_{t-1} - S_{t-2})$$

$$- \frac{(1-\lambda_1)(1-\lambda_2)}{\beta}(S_{t-2} - S_{t-3}) - \frac{\lambda_1\lambda_2\alpha_1}{\beta} P_{t-1} + \frac{\beta_2}{\beta} P^o_t$$

$$+ \frac{\beta_3}{\beta} Y_{t-1} + \frac{\beta_4}{\beta} Q^d_{t-1} + \sum_i \delta_i D_{it} ,$$

where $\beta = \beta_1 - \lambda_1 \lambda_2 \alpha_1$.

As long as random error terms are additive in equations (1) through (4), we may simply insert an error term into equation (10) or (11). Equations (10) and (11) represent two versions of a semi-reduced form equation for the system; each can be used to estimate the structural parameters.[6] However, identification of parameters and standard hypothesis tests are simplified when equation (10), instead of equation (11), is estimated. This is because equation (11) is non-linear in all the parameters. Moreover, equation (11) regresses the current price level on its first order lag. Due to the extremely high correlation between price and its lag, the coefficient of determination is always high, and thus gives a misimpression of the performance of the model.[7] Hence, equation (10) is used for estimation.

Although the estimating equation derived above is superficially similar to demand equations used by previous researchers in this area,[8] it is more than simply a demand equation; it is derived from a multi-equation model so specified that each parameter in the equation has a specific role in the model. For example, the coefficient of the lag of the change in inventories implies something about the speed at which price expectations and inventories adjust. Likewise, the coefficient of the price change variable reflects the responsiveness of the desired stock to the expected future price. Hence, equation (10) should not be interpreted as a demand equation.[9]

c. Data

Monthly time series data are more suitable for our purpose than annual data for several reasons. First, the change in inventories over a span of one year conceals much intra-year variation. Second , since prices are gathered on a monthly basis, annual prices are obtained by computing weighted averages of monthly prices. This aggregation process introduces undesirable features.[10] Third, the limited data available make the sample of annual time series quite small, leaving very few degrees of freedom for estimation. Monthly data are therefore used whenever possible.

Our main source of data is the Food Fish Market Review and Outlook (FFMRO), from which we obtain monthly data on the price, domestic production, imports and inventories of various groundfish products from January 1967 to December 1977. We confine our attention to cod, flatfish and redfish fillets, and to fish blocks of various species.

Unfortunately, FFMRO reports on fish blocks as a whole rather than by species. Fish blocks, therefore, can be examined only for all species together. However, a satisfactory monthly weighted average price of fish blocks cannot be computed because of a lack of information concerning the breakdown of fish blocks by species and by month. Nevertheless, an annual weighted average price of United States imports of fish blocks can be found in Fishery Statistics of the United States for the period from 1959 to 1974.

Since domestic production of fish blocks in the United States is a negligible proportion of the total U.S. supply,[11] the import price may be adequate for our purpose.

The prices of groundfish fillets used in this study are wholesale prices of frozen fillets.[12] Data on monthly personal income as well as annual personal disposable income are obtained from Survey of Current Business. Current personal income or personal disposable income deflated by the consumer price index is used to measure the effect of real income on the demand for fish products.

d. Empirical Results

When equation (10) is estimated, we find that the coefficient of $(S_{t-2} - S_{t-3})$, i.e., $(1 - \lambda_1)(1 - \lambda_2)$, is never significantly different from zero. We thus cannot reject the hypothesis that either λ_1 or λ_2 equals one. When $\lambda_1 = 1$, full stock adjustment takes place within the period; when $\lambda_2 = 1$, suppliers' price expectations are not influenced by their previous prediction. Since either case is possible, we define λ_i as whichever of λ_1 or λ_2 is not equal to one, and revise equation (10) as follows:

$$(10') \quad Q_t + M_t = \beta_o - \beta_1 P_t + (1 - \lambda_i)(S_{t-1} - S_{t-2}) + \lambda_i \alpha_1 (P_t - P_{t-1}) + \beta_2 P_t^o + \beta_3 Y_{t-1} + \beta_4 Q_{t-1}^d + \sum_i \delta_i D_{it} + \varepsilon_t ,$$

where ε_t is a random error term.

In the case of fish blocks, annual data are used and thus the binary dummy variables are omitted. Furthermore, in this case, we use current real disposable income rather than its lag as regressor. We also delete Q^d_{t-1} from the equation since habit persistence is unlikely over such a relatively long period. Equation (10") is thus adapted for fish blocks as follows:

$$(10") \quad Q_t + M_t = \beta_o - \beta_1 P_t + (1 - \lambda_i)(S_{t-1} - S_{t-2}) + \lambda_i \alpha_1 (P_t - P_{t-1}) + \beta_2 P^o_t + \beta_3 Y_t + \varepsilon_t .$$

Equation (10') is estimated for fillets of the three species of groundfish. Two methods of estimation are used: ordinary least squares (OLS) and Zellner's method of seemingly unrelated regressions (Zellner's method). Estimates obtained by Zellner's method exhibit greater efficiency, as anticipated, and only these results are reported in Table I. For fish blocks, equation (10") is estimated separately by the OLS method.

In equations (10') and (10"), if the parameter estimates of $(1 - \lambda_i)$ and $\lambda_i \alpha_1$ are not jointly significantly different from zero, we can reject the hypotheses postulated in our equations (1) through (3) (except for those implied by the seasonal dummies). Our estimation would then be equivalent (except for allowance for seasonal variation) to estimation of the demand equation alone. Whether equations (10') and (10") are superior to such an alternative can be tested through the joint null hypothesis $(1 - \lambda_i) = \lambda_i \alpha_1 = 0$. In the three species of fillets equations estimated by Zellner's method, the joint null hypothesis that $(1 - \lambda_i) = \lambda_i \alpha_1 = 0$ yields an F-ratio of 9.1 with 6 and 318 degrees of freedom in the numerator and denominator, respectively. Therefore, we can decisively reject the hypothesis that $(1 - \lambda_i) = \lambda_i \alpha_1 = 0$ and we conclude that our multi-equation approach is superior to the estimation of the demand equation alone. In the case of fish blocks, however, the joint hypothesis of $(1 - \lambda_i) = \lambda_i \alpha_1 = 0$ gives an F-ratio of 3.6 with 2 and 8 degrees of freedom in the numerator and denominator, respectively. The critical F-ratio at a 95 significance level is 4.46. We thus reject the hypothesis that using equation (10") for fish blocks is better than estimating the demand equation alone. This is not surprising since, as discussed previously, annual data are not really suitable to our model.

As can be seen from Table I, all parameter estimates have correct signs and most are significantly different from zero at the 95 percent significance level. For the variable P_t^o, we use the price of flatfish in the cod fillets equation and the price of cod fillets in the flatfish and redfish fillets equations. In the fish blocks equation, the weighted average price of all fillets is used for P_t^o.[13]

As shown in Table I, the estimates of β_1 are all significantly different from zero. We define the short-run price-elasticity of demand for a fish product as

$$\eta^s = -\frac{\partial Q^d}{\partial P} \cdot \frac{P}{Q^d} = \beta_1 \frac{P}{Q^d} .$$

We then use the estimates of β_1 reported in Table I to calculate the value of η^s for the various types of fillets under investigation. Since the demand equation is assumed to be linear, η^s as estimated will vary with P_t/Q_t^d over time. Using the sample mean of P_t/Q_t^d, we compute

Table I

Estimates of the Parameters Using Equations (10') and (10")*

Parameter	Cod Fillets	Flatfish Fillets	Redfish Fillets	Fish Blocks
β_1	.0782 (.0337)	.0680 (.0249)	.0644 (.0182)	2447.8 (1094.7)
$1-\lambda_2$	.2249 (.1233)	.8354 (.1794)	.5712 (.1045)	.4147 (.8593)
$\lambda_2\alpha_1$	.1917 (.1009)	.0399 (.0796)	.0858 (.0959)	9.8756 (3.7221)
β_2	.0326 (.0298)	.0182 (.0250)	.0118 (.0265)	2953.9 (1136.8)
β_3	3.2478 (1.4215)	1.9229 (1.0817)	1.4274 (.8970)	127.28 (30.18)
β_4	.1961 (.0901)	.4771 (.0793)	.1393 (.0876)	
δ_1	1 6397 (.9424)	-1.5941 (.7101)	.6521 (.7355)	
δ_2	.1495 (.9568)	-1.3617 (.7925)	.2793 (.8852)	
δ_3	3.0839 (.9308)	.8992 (.8055)	1.9284 (.8747)	
δ_4	4.8683 (.9938)	-.1570 (.7964)	.4486 (.8901)	
δ_5	1.1880 (1.0245)	.1023 (.7483)	.3526 (.7961)	
δ_6	4.4024 (.9697)	.9210 (.7231)	2.1664 (.7574)	
δ_7	2.5462 (1.0022)	-.0855 (.6981)	2.9291 (.7311)	
δ_8	2.1023 (.9497)	.3557 (.6981)	2.1998 (.7310)	
δ_9	1.8661 (.9365)	.6608 (.6959)	3.4175 (.7327)	
δ_{10}	1.9306 (.9513)	2.0222 (.7253)	1.9435 (.7766)	
δ_{11}	-.1947 (.9470)	-1.0078 (.7247)	-.6562 (.7563)	
$\beta_0 + \delta_{12}$	-17.254 (8.043)	-6.3071 (6.0058)	-3.6952 (5.1059)	-626.16 (175.24)
R^2	.5766	.5606	.6258	.9127
D-W	2.0896	2.2745	2.0124	

* Standard error of the estimate is in parenthesis.

the average price elasticities of demand for each of the three species of fillets and report them in Table II. As shown in Table II, the short-run elasticities are less than one for all species of fillets.

The inclusion of lagged consumption as an explanatory variable in the demand equation renders the equation dynamic and a change in price will not only change the current demand but also cause further changes in future demand. On the basis of the habit persistence hypothesis, as current consumption rises, future consumption will increase in a convergent series. The value of β_4 in our model indicates the impact of current consumption on future demand. For demand to be dynamically stable, the value of β_4 must be smaller than unity, as it is in each of our estimated equations. In addition, except in the redfish equation, all estimates of β_4 are significantly different from zero. We use the estimates of β_1 and β_4 to measure the long-run effect of a change in price on demand.

$$\text{Let} \quad \gamma = \beta_o - \beta_1 P + \beta_2 P^o + \beta_3 Y \quad , \text{ and}$$

rewrite the demand function (equation 4) as the first-order difference equation:

$$Q_t^d = \gamma + \beta_4 Q_{t-1}^d \quad .$$

By repeated substitution, we have

$$\begin{aligned} Q_t^d &= \gamma + \beta_4 (\gamma + \beta_4 Q_{t-2}^d) \\ &= \gamma (1 + \beta_4 + \beta_4^{\,2} + \dots) \quad , \end{aligned}$$

which, if $\beta_4 < 1$, yields:

$$Q_t^d = \frac{\gamma}{1-\beta_4} \quad .$$

The long-term change in quantity demanded resulting from a sustained change in price, ceteris paribus, is therefore:

$$\Delta Q^d = -\frac{\beta_1}{1-\beta_4} \Delta P \quad .$$

We then define the long-run price-elasticity of demand as:

$$\eta^{\ell} = \frac{\beta_1}{1-\beta_4} \cdot \frac{P}{Q^d} \quad .$$

The long-run price-elasticities of demand for the three species of fillets are computed by using the sample mean of P_t/Q_t^d and are reported in Table II. Demand for cod and redfish fillets remain price-inelastic even when the dynamic effects are considered. For flatfish, however, the long-run price elasticity is slightly larger than unity.

In contrast, the demand for fish blocks is found to be price-elastic, the elasticity being estimated as 2.9. Considering the magnitude of the estimates of β_4 in the fillets equations, the long-run effects work themselves out within two or three months. Estimates generated by annual data, therefore, are conceptually comparable to the long-run elasticity estimates generated from monthly data. There remains, however, a substantial difference between the long-run demand elasticities for the three species of fillets and that for the blocks. A possible explanation is that demand for fish blocks is largely industrial or commercial, while demand for fillets is more or less restricted to individual households.[14]

The lack of choice among various types of fillets at retail outlets and perhaps market arrangements concerning supermarket chains may lead to a low degree of substitution between various species of fillets, and therefore to low elasticities.

The lack of choice may also explain why we find that the estimates of β_2 (the cross-price effect) in the fillets equation are not significantly different from zero, implying that the three species of fillets are not good substitutes for one another.[15] With monthly data, habit persistence in household behavior, along with rigid marketing arrangements by supermarkets, may reduce substitutability. On the other hand, the primarily industrial demand for fish blocks is large-scale and is specialized and, therefore, more likely to be sensitive to variations in price. We find in the fish blocks equation, therefore, that the estimate of β_2 as shown in Table I is significantly different from zero. The cross-elasticity of demand for fish blocks, using the price of all fillets as the price of substitutes, is found to be as high as 4.15. Clearly, this result implies that fillets can be regarded as good substitutes for blocks, but, if the implications of the market arrangements discussed above are correct, the converse is not true.

Short-run income elasticities of demand are also reported in Table II. Using the estimates of β_3 as shown in Table I, we find that the income-elasticities are in all cases larger than one, with estimated values ranging from 1.9 for flatfish fillets to 3.7 for cod fillets.

TABLE II

Estimates of Demand Elasticities Using Parameter Estimates

Reported in Table I.

Demand Elasticity \ Product	Cod Fillets	Flatfish Fillets	Redfish Fillets	Fish Blocks
Short run (own price)	.611	.671	.636	-
Long run (own price)	.760	1.282	.739	2.89
Income	3.745	1.925	2.066	2.63

Finally, we turn to the estimates of $(1 - \lambda_i)$ and $\lambda_i \alpha_1$, where λ_i measures either the speed of adjustment in inventories or the adaptivity of price expectations to errors made in the previous prediction, and α_1 indicates the responsiveness of the desired stock to changes in the future expected price. For the adjustments to be dynamically stable, λ_i must be positive and less than one. Each of our estimates of $(1 - \lambda_i)$ satisfies this condition. In addition, α_1 should be positive since, if suppliers expect the price to rise, they react by accumulating inventories. Again, each of our estimates of α_1 satisfies this condition. From the estimates of $(1 - \lambda_i)$ and $\lambda_i \alpha_1$ as reported in Table I, we obtain estimates of α_1 of .247, .242 and .2 for cod, flatfish and redfish fillets, respectively. These estimates of α_1 seem quite reasonable. Although the individual estimates of λ_i and $\lambda_i \alpha_1$ are not all significantly different from zero as shown in Table I, the joint hypothesis of $\lambda_i = \lambda_i \alpha_1 = 0$, as mentioned previously, is rejected for the fillets equations.

e. Conclusion

We have formulated a model of the U.S. demand for various groundfish products. Almost all of the important parameters in our model can be estimated and identified from a single semi-reduced form equation. When monthly data are applied to estimate the structure of the model, the results are quite satisfactory. Our attempt to use annual data in the case of fish blocks is less successful. Better estimates of demand function for fish blocks will probably be obtained if monthly data on fish blocks by species become available.

Our empirical results suggest that the demand for groundfish products in the U.S. is quite income-elastic. An implication of this finding is clearly that imports, production, and prices received by the industry will be influenced strongly by cyclical fluctuations in income. Since the demand for various groundfish fillets are price-inelastic, a recession in the U.S. will exert downward pressure on prices paid for these products if they are to be absorbed by the U.S. market. In addition, producers may be forced to reduce production and thus employment in the fishery.

Likewise, our findings on the price and income elasticities of demand for groundfish products may also cast a pessimistic light on the issue of Extended Fisheries Jurisdiction (EFJ). If EFJ results in an increase in the supply of fish products in the U.S. due to increased domestic production as well as imports, certainly, there will be a drastic reduction in the price of fish products unless U.S. income and, therefore, demand rise substantially. Hence, expected benefits from EFJ will not accrue to the fishery if current market arrangements are maintained.

Notes

[1] As part of a continuing study of the Newfoundland groundfishery, the paper deals only with the groundfish products which are exported in substantial quantities from Newfoundland to the United States. For this reason, the main species of groundfish products included in this study are cod, redfish (ocean perch), and flatfish (by which we mean several species of flounder and sole -- primarily greysole, American plaice, and yellowtail flounder).

[2] Numerous studies using a demand equation alone have been compiled in D.A. Nash and F.W. Bell (1969). For a more recent study of the U.S. demand for groundfish products, see R.A. Holmes and R. Bharath (1976). A multi-equation model for the U.S. shrimp market is adopted in a study by J.P. Doll (1972). Doll's model consists of three demand equations at various market levels, i.e., retail, wholesale and ex-vessel, an equation relating retail to wholesale prices, and a stock balance equation. Again, there is no specification of supply conditions. The shortage of empirical research on fisheries employing econometric models of demand and supply has been emphatically pointed out recently in M. Wilkinson (1979), p. 254.

[3] The first three equations constitute the well-known "Nerlove Model", which has been widely used in studies of agricultural supply. See M. Nerlove (1958), for his original work. For a recent survey of empirical studies using Nerlove's model in agriculture, see H. Askari and J.T. Cummings (1977).

[4] A theoretically more desirable version of equation (1) would specify the desired stock as a function of the difference between the expected rate of return from holding stocks and the interest rate, which is the cost of holding inventory, i.e.

$$S^*_t = \alpha_o + \alpha_1 \frac{P^e_{t+1} - P_t}{P_t} - r_t \quad ,$$

where r_t is the short term interest rate. Unfortunately, such a specification creates a non-linearity which precludes estimation using the method discussed below. Therefore, equation (1) is adopted as an approximation to this specification.

[5] U.S. exports of the groundfish products studied in this paper are almost nil. Hence, U.S. exports are excluded from equation (5).

[6] All parameters in equations (10) and (11) can be identified except for λ_1, λ_2 and the relatively unimportant β_o and δ_{12}. Problems concerning λ_1 and λ_2 are discussed below.

[7] We have found an R^2 in excess of .99 in all cases where equation (11) is estimated.

[8] For references, see footnote 3.

[9] It is interesting to note that in some studies employing single-equation estimation, the estimating equation has been called a "demand equation" even though it is difficult to interpret it as such. In a well-known study, for example, F.W. Bell has estimated a demand equation using price as regressand and domestic production, stocks, imports and other variables as separate regressors. If the estimating equation is a genuine demand equation, quantity consumed, i.e., production plus imports minus the change in inventories, is a more appropriate explanatory variable. See F.W. Bell (1968).

[10] In fact, we estimated equation (10) with annual data even when monthly data are available. The parameter estimates obtained from annual data have larger standard errors and in some cases wrong signs. This is perhaps due to aggregation bias in computing the variable values.

[11] Almost 99 percent of the total U.S. supply of fish blocks was imported during the period under investigation.

[12] A model could have been constructed to incorporate a wholesale as well as a retail market for each product. We believe that the additional complication would not be worthwhile for our purpose unless we are able to specify supply conditions correctly at various market levels. As mentioned previously, Doll, in his study of demand at several market levels, makes no attempt to include supply conditions.

[13] When prices of both alternative species of fillets are included separately in the equation, we find that estimates for the coefficients of the P_t^o 's are not significantly different from zero and have wrong signs in some cases. Therefore, we include the price of only one substitute product in each of the fillet equations. To extract the general inflationary

13 (cont'd)

effects from the prices of fish products, all prices in the fish block equations are deflated by the consumer price index. In the fillets equations, where monthly data are used, we attempted to use product prices deflated by the consumer price index and by the price index of meat, fish and poultry, without success. The parameters are estimated with wrong signs in many cases. Hence, all results reported in Table I for the fillet equations are obtained using undeflated prices.

[14] Local fish plants inform us that fillets exported to the U.S. are sold directly in the supermarkets. Blocks exported to the U.S. are largely purchased by hospitals, restaurants, fast food chains, etc., in the U.S.

[15] Alternatively, one may assert that the reason why the estimates of β_2 are insignificantly different from zero is due to severe multi-collinearity between the prices of various fillets. Our results, however, indicate that the covariances of the estimates as reported in Table I are quite low.

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