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Title: Regional Analysis of the US Groundfish Fishery: Implications of the Extended Fishery Jurisdiction for the Pacific Northwest Fishery

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The Fishery Conservation and Management Act of 1976 took effect on March 1, 1977. By this Act the United States extended its management over fisheries to 200 nautical miles from shore. Extended fishery jurisdiction was expected to promote industry development and expand the contribution of the fishing industry to the economies of the coastal regions. Benefits to the Pacific Coast groundfish industry have, however, been less than were expected when the Act was passed.

A spatial equilibrium model was formulated for the broader United States interregional/international groundfish market. Two steps were involved: First, a system of simultaneous econometric equations was estimated for each of the three product forms--fresh and frozen cod, ocean perch, and flounder fillets. Second, regionalized forms of these equations were collapsed into simple equations and combined with transportation and storage costs in a larger mathematical programming model. The resulting

quadratic programming (QP) problem was then solved (for each product) for the competitive equilibrium quantities demanded and supplied, prices, and product movements.

Two objectives were achieved: A model was formulated that accounts for most of the relevant factors influencing the United States groundfish market; and the multi-regional nature of this market was established. The estimated price and income elasticities were similar to those suggested by earlier studies, and the estimated product movements were consistent with survey data in the Pacific Northwest.

The various policies evaluated in this study (using the spatial equilibrium model) suggest mixed blessings to the Pacific Coast groundfish industry. There is no evidence to suggest that harvesting some average quantities uniformly throughout the year would improve industry revenues. In general, increasing Pacific Coast landings by 30 percent (or more) would depress wholesale revenues but substantially increase fleet revenues. On the other hand, both wholesale and fleet revenues would increase if at least 80 percent of the increase in landings could be sold in markets outside the region. This suggests that an industry policy aimed at expanding landings on the Pacific Coast will improve revenues for all industry participants only if access to outside markets also takes place.

Regional Analysis of the US Groundfish Fishery: Implications of the Extended Fishery Jurisdiction for the Pacific Northwest Fishery

by

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Typed by Dodi Reesman for Richard Adu-Asamoah

DEDICATION

To My Parents

Akora, Maame, "Esie Ne Kagya Nni Aseda"

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CHAPTER I

INTRODUCTION

Many coastal nations of the world (including the United States of America) have extended their jurisdiction over the economic resources of the oceans to 200 miles seaward. Extended Fishery Jurisdiction (EFJ) gained momentum in the 1970s, and was perceived (among other things) to enhance the ability of maritime nations to enforce various regulations, and control fishery activities within their jurisdiction. Foreign fishing fleets have become the target of many such regulations and controls. In many instances the perceived benefits (both immediate and long term) included: (1) a larger share of the harvest going to the coastal nations, (2) increased revenue from trade as a result of a coastal nation's increased participation in foreign trade, and (3) other political and socio-economic advantages.

Trade becomes a very important issue under EFJ. Maritime nations which are now harvesting more than what domestic consumption can absorb must look to foreign markets in order to sell their excess supplies. Those now harvesting less must import. Successful entry into foreign markets and/or the ability to sustain already established markets may become a major problem. Differences exist in the structures of domestic and foreign markets. The implication is that the factors that determine prices, supply and consumption may also vary. An understanding of these factors is relevant for a successful market entry and/or to maintain market share.

Since the late 1960s groundfish products have become increasingly important in the U.S.A. food-fish market. While American waters have large stocks of groundfish species, the bulk of groundfish supply in the U.S. market has historically come from imports. The U.S.A. domestic groundfish landings (on the Atlantic and Pacific Coasts) have been erratic and, in most cases, traditional species have been overfished while opportunities still exist for many underutilized species. Given the situation of the groundfish industry in the U.S.A., especially in the coastal states of Washington, Oregon, and California, it is uncertain whether increased investment in the fishery would be profitable, even over the long run. When the U.S.A. extended its fishery jurisdiction to 200 miles, it expected that landings by American fishermen would increase. Fishermen may, however, not want to increase landings at all times. Any attempts to expand the harvesting activity on all target species at the same time could overburden existing markets. They may also strain existing facilities and force prices and revenues down.

While the foreign nations that traditionally export groundfish products to the U.S.A. (mainly Canada, Norway, Iceland, and Denmark) may also increase their landings, and hence their exports to the U.S.A., increased U.S. imports may very well depend on the U.S. domestic market situation. Advances in transportation and storage technologies have also allowed interstate movement of groundfish-for-food to an extent which did not exist before. The U.S. foreign trade in groundfish products has also experienced significant structural change. With increased imports and the potential for increased domestic production, several policy proposals have been made, including measures to increase domestic production and strategies to expand the domestic market.

The Rationale for the Study

The Pacific Northwest groundfish resource has yet to reach its full economic potential for the United States since the coastal fishery jurisdiction was extended 200 miles from shore about a decade ago. Foreign competition, trade policies, and regulations on domestic fishermen have been blamed for many of the problems facing the industry. There is interest in harvesting policies that reflect marketing considerations. It has been suggested that quotas could be set on an annual basis or broken into quarters, trimesters, or other time periods; which type and the timing of the quota period can have significant implications for the market share sustained by domestic fishermen relative to imports and for the price received for the product. Seasons can also affect the sites where landings occur which, in turn, affect price and market share originating in various locations.

A broad objective of this study is to simulate and evaluate how various policies affect prices, the share of domestic versus foreign production in the U.S. market, and revenue distribution to the U.S. fishermen and wholesalers. The selected proposed policies all aim at improving production and market conditions. Since these policies are not currently in existence, it was decided to simulate the groundfish market by estimating various demand and supply relationships. It would then be possible to see how this simulated market would respond to the implementation of these policies. If the simulated market approximated actual market conditions in the absence of these policies, one could have some confidence in the predictions about conditions in the presence of such policies.

Specific Objectives of Study

The specific objectives of the current research effort include:

(1) Estimation of demand and supply equations to reveal the economic and other factors which influence the U.S. groundfish fillets market.

(2) The establishment of the multi-regional nature of the current market, and evaluation of the current Pacific Northwest production strategies with respect to fishermen's and wholesaler's revenues.

(3) Evaluation, through experimentation, of the impact of certain production and marketing strategies on fishermen's and wholesaler's revenues. These strategies are discussed below as experiments 1-3.

Experiment 1: Uniform Monthly Landings

The current harvesting regime allows for fluctuations in landings dictated by variations in seasonal stock abundance, biological and environmental factors, and restrictions placed on fishermen by management authorities. Experiment 1 is designed to study the effect of harvesting the 12-month average quantities uniformly throughout the year. This approach will smooth out the wide fluctuations in landings, and ensure a constant flow of raw product to processing plants.

Experiment 2: Increased Pacific Northwest Landings

The Pacific Fishery Management Council has estimated that there is room for about 30 percent expansion of production of most Pacific Coast groundfish species. These estimates, as discussed later, are based on historical landings and estimates of the maximum sustainable yield. The assumption here is that under EFJ, the major traditionally exploited groundfish species (and many underexploited species) could experience a 30 percent expansion over the 1972-1981 average landings. This scenario does not suggest where the increased production could be sold. The quadratic programming formulation in this study will, however, distribute the new production levels based on the demand and supply relationships and the cost of shipping between pairs of demand and supply centers.

Experiment 3: Increased Landings with Marketing Strategy

The Pacific Coast states (Washington, Oregon, and California) have usually been the market for groundfish produced in the region. Before 1980, the markets were all to the west of the Rockies, especially central and southern California. In the early 1980s, the widow rockfish fishery was developed and this enabled West Coast dealers to sell high quality products in markets east of the Rockies throughout the year. This promising market position has eroded since 1983 due to a decline in rockfish landings. There has also been competition from Canada, New Zealand, and the New England states of the

U.S.A. Many participants in the Pacific Coast groundfish industry believe that the ability to compete in markets beyond this region is essential to industry expansion involving increased landings. It appears that an aggressive marketing strategy aimed at markets outside the Pacific Coast, especially during the winter months when the New England landings are low, will be required. To study the effect of such an extended market access, the third experiment allows the increase in Pacific Coast production to be sold in the Southwest and the Great Lakes through the appropriate modification of the original programming formulation. Access to outside markets is crudely represented by forcing shipments from the Pacific Northwest to the Southwest and the Great Lakes. This approach is adopted because the other ways (shifting the intercept or slope coefficients, or both, of the target regions' demand equations) do not guarantee shipments from the Pacific region to satisfy the demand in the two regions. The procedure adopted ensures that the aggressive advertisement by Pacific Coast dealers leads to the sale of products in the target markets by displacing similar quantities from other regions. A 30 percent expansion of the Pacific Coast production is assumed for the winter months of December, January, and February. The increment in production is now sold in the Pacific coast, the Southwest, and the Great Lakes markets.

Organization of the Study

Chapter I gives a brief introduction to this research effort and outlines the specific objectives of the study. Chapter II presents a review of the literature on economic studies of groundfish markets and industry in the U.S. In Chapter III, the theoretical framework for this study is discussed. Chapter IV presents the conceptual model and discusses the specific model formulations. Chapter V discusses the scope of this study and attempts to highlight the specific characteristics of the submarkets included in the broader groundfish fillets market defined in this study. This chapter also discusses the data, their sources, and some specific methodologies adopted to generate other relevant data. Chapter VI discusses the econometric estimation procedures and validation. A summary of the results is presented and discussed in this chapter. In Chapter VII, some inferences are drawn based specifically on the results and the implications for policy are discussed.

CHAPTER II

LITERATURE REVIEW

Traditionally, demand analyses have formed the basis of most studies into groundfish product markets in the U.S.A. Such studies have concentrated on one or more levels of the product market, that is, ex-vessel, wholesale and retail markets. Most of the empirical studies have been done at the disaggregated species level while a few have defined an aggregate product, namely, groundfish. Pioneering research on groundfish markets, and especially groundfish demand, may be attributed to Bell, Farrell, Hazelton, Lampe, Nash, Norton, and Waugh (Table 1).

Whatever the market level studied, and the level of aggregation, analyses of groundfish markets have addressed a wide range of issues including the impact of (a) institutional changes, (b) market changes, (c) regional characteristics, (d) product characteristics, and (e) foreign and domestic trade policies, etc. A few studies have been influenced by theoretical considerations, the availability and quality of data, and an improved understanding of specific market behaviors. The empirical studies so far documented range from simple single-equation demand relationships to sophisticated simultaneous multi-equation models, incorporating many market

Table 1. Summary of Selected Empirical Demand Studies and Their Estimated Price and Income Elasticities, for Groundfish Species.

Author and Source	Species	Geographic Area	Period and Time Interval	Market Landings	Form of Equation	Econometric Approach (4)	Elasticity of Demand: Price (1)	Elasticity of Demand: Income (2)
Bell (1968)	Yellowtail Flounder	New England	1957-67 monthly	Landings	log-linear inverse	OLS	-2.29*	1.97*
	Large Haddock	New England	1957-67 monthly	Landings	log-linear inverse	OLS	-2.17*	0.46*
	Small Haddock	New England	1957-67 monthly	Landings	log-linear inverse	OLS	-2.19*	-0.33
	Cod	New England	1957-67 monthly	Landings	log-linear inverse	OLS	-3.15*	0.10
	Ocean Perch	New England	1957-67 monthly	Landings	log-linear inverse	OLS	-250.0	0.75
	Whiting	New England	1957-67	Landings	log-linear	OLS	-22.22*	32.04*
Waugh in Nash and Bell (1969)	Haddock	Boston Pier	--- monthly	Landings	log-linear inverse	OLS	-3.22*	--
	Scrod	Boston Pier	--- monthly	Landings	log-linear inverse	OLS	-4.33*	--
	Cod	New York Fulton Market	--- monthly	Wholesale	log-linear inverse	OLS	-2.90*	
	Flounder	New York Fulton Market	--- monthly	Wholesale	log-linear inverse	OLS	-10.28*	--

Table 1. Summary of Selected Empirical Demand Studies and Their Estimated Price and Income Elasticities, for Groundfish Species (continued).

Author and Source	Species	Geographic Area	Period and Time Interval	Market Landings	Form of Equation	Econometric Approach (4)	Elasticity of Demand: Price (1)	Elasticity of Demand: Income (2)
Bell in Nash and Bell (1969)	Cod	Boston/New Bedford and Gloucester	--- monthly	Landings	log-linear inverse	OLS	-3.30	-1.98*
	Yellowtail Flounder	New Bedford	--- monthly	Landings	log-linear inverse	OLS	-2.28*	1.76*
	Whiting	Gloucester/ Portland/ Rockland	--- monthly	Landings	log-linear inverse	OLS	-22.73*	27.79*
Lampe and Farrell in Nash and Bell (1969)	Haddock	New England	--- monthly	Wholesale frozen fillet	log-linear	LIML	1.40*	-1.11*
Storey and Lee in Nash and Bell (1969)	Haddock	Holyoke Springfield, Mass.	--- weekly	Retail	linear	OLS		
Farrell and Lampe (1967)	Haddock	New England	1954-62 monthly	Landings all year	log-linear inverse	LIML	-2.22*	--
	Haddock	New England	1954-62 monthly	Retail all year	log-linear inverse	LIML	-32.25*	7.20*
	Haddock	New England	1954-62 monthly	Landings 1st semester	log-linear inverse	LIML	-2.22*	--
	Haddock	New England	1954-62 monthly	Landings 2nd semester	log-linear inverse	LIML	-1.77*	--

Table 1. Summary of Selected Empirical Demand Studies and Their Estimated Price and Income Elasticities, for Groundfish Species (continued).

Author and Source	Species	Geographic Area	Period and Time Interval	Market Landings	Form of Equation	Econometric Approach (4)	Elasticity of Demand	
							Price (1)	Income (2)
	Haddock	New England	1954-62 monthly	Retail 1st semester	log-linear inverse	LIML	4.91*	1.49*
	Haddock	New England	1954-62 monthly	Retail 2nd semester	log-linear inverse	LIML	-4.41*	0.16*
Waugh and Norton (1969)	"Market Cod" (3)	New York Fulton Market	1962-68 monthly	Landings	linear inverse	OLS	-2.73*	2.87*
	"Market Cod"	New York Fulton Market	1962-68 monthly	Landings	log-linear inverse	OLS	-2.74*	3.08*
	"Market Cod"	Boston Pier	1962-68 monthly	Landings	linear inverse	OLS	-5.05*	3.39*
	"Market Cod"	Boston Pier	1962-68 monthly	Landings	log-linear inverse	OLS	-4.36*	2.98*
	"Steak Cod" (3)	New York Fulton Market	1962-68 monthly	Landings	linear inverse	OLS	-1.59*	1.89*
	"Steak Cod"	New York Fulton Market	1962-68 monthly	Landings	log-linear	OLS	-1.84*	2.33*
	Large Cod	Boston Pier	1962-68 monthly	Landings	linear inverse	OLS	-6.10*	3.15*
	Large Cod	Boston Pier	1962-68 monthly	Landings	log-linear inverse	OLS	-5.97*	3.27*
	Haddock	New York Fulton Market	1962-68 monthly	Landings	linear	OLS	--	--

Table 1. Summary of Selected Empirical Demand Studies and Their Estimated Price and Income Elasticities, for Groundfish Species (continued).

Author and Source	Species	Geographic Area	Period and Time Interval	Market Landings	Form of Equation	Econometric Approach (4)	Elasticity of Demand: Price (1)	Elasticity of Demand: Income (2)
	Haddock	New York Fulton Market	1962-68 monthly	Landings	log-linear inverse	OLS	-17.27	30.64
	Large Haddock	Boston Pier	1962-68 monthly	Landings	linear inverse	OLS	-4.24*	2.32*
	Large Haddock	Boston Pier	1962-68 monthly	Landings	log-linear inverse	OLS	-3.39*	1.47*
	Scrod Haddock	Boston Pier	1962-68 monthly	Landings	linear inverse	OLS	-3.58*	2.49*
	Scrod Haddock	Boston Pier	1962-68 monthly	Landings	log-linear inverse	OLS	-4.18*	2.82*
	Whiting	New York Fulton Market	1962-68 monthly	Landings	linear inverse	OLS	-1.41*	2.04*
	Whiting	New York Fulton Market	1962-68 monthly	Landings	log-linear inverse	OLS	-1.76	3.37*
Lee and Storey (1970)	Haddock	Massachusetts	1967	Retail	linear	OLS	-3.00	--
O'Rourke and DeLoach (1971)	Lingcod	California	--- annual	Ex-vessel	log-linear inverse	OLS	-8.27*	3.27*
	Lingcod	Pacific Coast	--- annual	Ex-vessel	log-linear inverse	OLS	--	31.22*
	Lingcod	Pacific Coast	--- annual	Processed	log-linear inverse	OLS	-13.84	-5.79

Table 1. Summary of Selected Empirical Demand Studies and Their Estimated Price and Income Elasticities, for Groundfish Species (continued).

Author and Source	Species	Geographic Area	Period and Time Interval	Market Landings	Form of Equation	Econometric Approach (4)	Elasticity of Demand: Price (1)	Elasticity of Demand: Income (2)
	Flounder	Pacific Coast	--- annual	Ex-vessel	log-linear inverse	OLS	-5.18*	-1.66
	Flounder	Pacific Coast	--- annual	Processed	semi-log inverse	OLS	2.87*	
	Flounder	California	--- annual	Ex-vessel	log-linear inverse	OLS	-2.58*	0.78*

(1) The reciprocal of the direct price flexibility (obtained in inverse demand equation) is the lower absolute limit of the direct price elasticity if it is assumed, for simplicity, that the cross-price effects were close to zero. See Houck (1965) for further discussion.

(2) The income elasticity was calculated by dividing the estimated income flexibility by the estimated price flexibility.

(3) Designation used by the authors probably referred to a market classification of the species.

(4) OLS (Ordinary Least Square); LIML (Limited Information Maximum Likelihood).

(*) Coefficient significant at five percent level. When the coefficient of price flexibility was not satistically significant, the transformation of flexibilities into elasticities includes an additional source of error, by virtue of the residuals being measured vertically in the former case and horizontally in the latter.

SOURCE: Adapted from Paez (1981).

levels, foreign trade aharacteristics, and many product forms.

Demand and market analyses of groundfish products in the U.S. date back to the late 1960s. In 1968 the Division of Economic Research of the Bureau of Commercial Fisheries organized a session which sought to document the major research efforts into groundfish markets up to this time. Some of the more interesting studies (in terms of methodology, analytical framework, and findings) which are relevant to the current study are reviewed below.

Farrell and Lampe (1967) have analyzed the New England haddock products market, emphasizing the ex-vessel, wholesale, retail, inventory, and imports and their interdependence. They estimated demand and supply equations for the various market levels in a system of ten log-linear equations using limited information maximum likelihood procedures. Using monthly data for the period 1954 to 1962 they estimated two sets of equations. This gave rise to two sets of estimates: yearly estimates and half-year estimates. The half-year estimates exhibited greater market activity in the first half of the year, and only the ex-vessel and retail markets gave rise to statistically significant estimates for the relevant variables. The increased consumption activity that these researchers observed for the ex-vessel and retail equations, for the first half of the year, was explained by the observance of

Lent by Catholics in the New England subregion.

Bell and Hazelton (1967) contains a summary by Nash of the results of earlier demand studies on about 20 fish products conducted within the Bureau of Commercial Fisheries. The Bureau's Division of Economics had conducted various studies on demand for all fish and shellfish, and also for some individual species. The results as reported by Nash revealed various characteristics of the fish product market which guided most of later research, and even the current research effort. For example, when all fish and shellfish were considered as an aggregate product, demand was found to be price inelastic. However, the demand for individual species was found to be price elastic. For fresh flounder fillets, the elasticity was estimated to fall between -4.0 and -6.0 for the period 1950 to 1963. The price elasticity of demand was estimated as -3.5 for frozen flounder fillets for the period 1954-1963. Fresh and frozen haddock elasticity of demand was estimated as -1.4 for the period 1954-1964. As demonstrated by the elasticity values, the estimates were found to follow a priori expectations about the estimates at different levels of aggregation. In general, less aggregated products tend to have more substitutes (and vice versa), and therefore show high elasticity values. Income elasticities were also reported for the Bell and Hazelton study: the aggregated product of "fish and shellfish" was shown to be income inelastic (0.65 to 1.00) while the less aggregated product forms were shown to be income elastic (2.5 to 5.9). The studies also showed that meat could be an important substitute for "fish and shellfish" as a group but not for disaggregated products at the species level.

Bell's (1968) study of the impact of Papal-Bishop decree (February 1966) on the demand for fish products in the Northeastern U.S.A. is an example of the influence of institutional changes on the direction and content of research. Log-linear derived inverse demand functions at the ex-vessel level were estimated for various groundfish species using monthly data from 1957 to 1967. Species included in the study were yellowtail flounder, cod, ocean perch, large and small haddock, scallops, and whiting. Landings, total personal income, beginning-of-the-month cold storage holdings, imports, consumer price indexes of meat and poultry (substitute products), weighted average ex-vessel prices of substitute fish products, and two variables designed to account for the Lenten period and for the "Papal-Bishop decree" were postulated to explain the variability in ex-vessel price in an inverse demand relationship. The effect of the explanatory variables were mixed and differed according to species, as can be seen from Table 1. A few interesting results deserve elaboration: the income coefficient was significant only in the flounder and whiting equations. With the exception of the ocean perch equation, the coefficient of the landings variable had the expected negative sign, and was statistically significant. The cold storage coefficient was negative for large haddock, ocean perch, and whiting, while in the flounder and small haddock equations it had a positive sign.

Bell suggested an explanation for the different signs on the coefficients: the negative sign might be due to the stock adjustment or inventory effect; the positive sign on the other hand may be explained by the fact that dealers may buy when prices are low, and sell when prices rise. Also, imports were found to have a negative effect on the ex-vessel prices in the flounder, large haddock, and whiting equations while their effect was positive in the others. Meat and poultry price variables had positive relationships with ex-vessel price. Bell found that after 1966 (that is, after the Papal-Bishop decree) there was a downward shift of the ex-vessel demand for groundfish in the Northeastern U.S.A. This downward shift was explained by Roman Catholics (majority of East Coast dwellers) substituting meat for fish on Fridays during Lent. While these results give some insight into the impact of the decree, positive autocorrelation in the residuals of the estimated equations might make the long-run effect of the decree (as suggested by the model) suspect.

As mentioned earlier much of the research done on groundfish demand was influenced by the increased availability and improved quality of the relevant data. Waugh and Norton (1969) formulated price dependent derived ex-vessel demand functions in order to study price variations among fish products, including groundfish products. This formulation which drew extensively on an earlier work by Waugh, Nash, and Bell (1969) was estimated using monthly data (for the period 1962-1968) in which nominal ex-vessel prices were specified to be dependent on U.S.A. current domestic landings, total personal income, and trigonometric variables selected to account for seasonality in production, and hence in prices. Ordinary least squares (OLS) estimates of the linear and log-linear functions gave reasonable (statistically significant coefficients with expected signs) estimates for most species. This analysis, like earlier ones of its kind, was plagued with positive autocorrelation in the residuals which rendered the long-run use of the estimated relationships questionable. Waugh and Norton also studied the impact of imports on ex-vessel prices of the major groundfish products, including flounder, cod, haddock, pollock, cusk, and hake for the period 1954-1967. Based on the assumptions of the interdependence of domestic prices and imports, they specified a simultaneous equation system in which (a) ex-vessel prices were explained by total supply (that is, the sum of imports and domestic landings) and total U.S.A. personal income; and (b) imports were explained by domestic landings and tariffs. The two stage least squares (TSLS) estimates of the structural equations, for flounder and groundfish, are presented below:

Groundfish Equation:

$$P = -5.0377 + 0.014Q_d - 0.0012Q_m + 0.064Y$$

$$Q_m = 1564.20 - 0.51Q_d - 176.76t$$

Flounder Equation:

$$P = 1.0644 - 0.044Q_d - 0.043Q_m + 0.025Y$$

$$Q_m = 213.901 - 0.0307Q_d - 25.9783t.$$

where P = annual average ex-vessel price;

Q_d = annual domestic landings;

Q_m = annual imports;

Y = index of total personal income; and

t = percent ad valorem tax on all fish.

Labys (1975) reports on empirical studies by Bell et al. (1970) which sought to develop a world-wide model of living marine resources. Groundfish (as a separate fish product) was studied together with ten other fish species, other food-fish, and fishmeal. An objective of this study was to incorporate all the relevant economic and biological factors affecting supply and demand of the major seafood products into one world model. Yearly data covering the period 1948 to 1968 were used to fit the specified equations, which allowed regional production, end-use, and price projections to the year 2000. Supply from regional production activities was estimated by assuming the Schaefer (1956) logistic growth model under both constant and decreasing returns from fishing effort. Ex-vessel demand relationships were specified and estimated for the major groundfish producing and consuming nations of the world: the U.S.A., Canada, Japan, Korea, Denmark, the Netherlands, and France. Table 2 shows the price and income elasticities calculated from double-logarithmic equations for the above-mentioned countries.

The authors reported some inconsistencies with the signs and magnitude of the coefficients used in calculating the elasticities in Table 2, and had to adjust such coefficients accordingly.[1/] Such adjustments were necessary in order to make reasonable projections, over the long-run, about regional consumption behaviors. The adjusted own-price and income elasticities are presented in Table 3.

Most of the groundfish market research in the early 1970s were influenced by the changing characteristics of the markets for groundfish species and products, and perhaps, a better understanding of how the various product

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1/ See Labys (1975) pages 291 to 329 for an elaborate discussion of these inconsistences and the adjustment procedures (a) through (g).

Table 2. Regression Results of Groundfish Demand Equations by Selected Countries (in logarithms)

Country	Constant	Price Elasticity	Income Elasticity	R^2	D-W	Period
U.S.A.	-2.0145 (-6.7514)	0.1014 (0.7541)	0.8518 (9.1877)	0.84	2.23	1948-1968
Japan	-1.6923 (-3.4357)	0.2767 (0.7008)	1.0467 (6.5060)	0.83	1.05	1956-1967
Canada	6.6006 (0.4757)	-3.6297 (-0.7904)	-1.2045 (-0.2481)	0.30	2.37	1953-1966
Korea[a/]	2.2774 (1.6845)	0.7873 (0.8476)	-1.0595 (-1.6433)	0.25	1.33	1956-1967
Denmark[b/]	-3.9025 (-4.1255)	-0.3016 (-0.4763)	1.9469 (5.8995)	0.83	0.93	1956-1967
France[b/]	-10.3194 (-1.5965)	-7.1220 (-1.8019)	6.5998 (2.7293)	0.46	2.76	1956-1967
Netherlands	6.9719 (-4.8273)	-0.0783 (-0.2316)	2.6716 (4.6651)	0.88	1.86	1956-1967
United Kingdom	-4.1534 (-2.1125)	-1.3952 (-1.6296)	2.1924 (2.5550)	0.55	2.06	1955-1966

a/ Japanese price data were used in the equation.

b/ U.S. price data were used in the equation.

Dependent variable is per capita consumption of groundfish in round weight.

Notes: Prices are ex-vessel deflated by the individual country's CPI and converted into U.S. cents per pound by the exchange rates.

Income is deflated by the individual country's CPI and converted into U.S. dollars per capita by the exchange rates

T-values in parentheses.

Source: Labays (1975).

Table 3. Groundfish Equations Used for Making Projections

Country	Constant	Price Elasticity	Income Elasticity
		(logarithms)	
United States	-1.0919	-1.0	0.8518
Canada	-2.7681	-1.0	1.211
Denmark	-2.3922	-1.3952	1.9469
France	-4.4452	-1.3952	2.1924
Netherlands	-3.9736	-1.3952	2.1924
United Kingdom	-4.1534	-1.3952	2.1924
Japan	-0.9106	-1.0	1.0467
Korea	-1.1102	-1.0	1.0467

SOURCE: Labys (1975).

markets worked.

Lee and Storey (1970) may have unintentionally demonstrated the difficulty encountered in analyses at the retail market level, and why many groundfish studies in the earlier years had concentrated on the ex-vessel and wholesale markets. They estimated two demand equations for fresh haddock fillets using weekly data for the period 1964 to 1968. The data used came from five major retail outlets in Massachusetts. The quantity demanded was postulated to be explained by own (haddock) retail price, retail prices of competing fish products (mainly swordfish, halibut, flounder, and cod), and total store sales. Also, dummies were introduced to account for (a) special sale price periods, and (b) quantity of shellfish and other finfish sold. Though this study showed a high own-price elasticity for fresh haddock fillets, serious multicollinearity problems with this specification rendered the results unsatisfactory. Perhaps, better results could have been obtained if the various retail outlets for fresh haddock fillets (institutional, retail chains, etc.) had been identified and separately analyzed.

O'Rourke and DeLoach (1971) have studied the fresh and frozen fish and shellfish for California and the Pacific Coast, for the main market levels (from dockside operations through retailing). The study which analyzed extensively the ex-vessel price of 12 finfish and shellfish products also analyzed derived ex-vessel demand for lingcod and flounder. Annual ex-vessel prices were postulated to be influenced by the regional landings and California per capita income. OLS estimates for the log-linear specification showed high (greater than 1.0) absolute price elasticities of demand for lingcod and flounder. The income elasticities, however, were negative and statistically not significant from zero. The income elasticities were positive for the other species. An inference drawn from the results of this study was that California fishermen could increase their revenues by selectively increasing the production of target species, and that sustained increases in revenues to the fishermen would result if production of all target species was not increased at the same time.

Research into groundfish markets in the late 1970s, and in the 1980s, has focused on aspects of the industry and market likely to be affected by the widespread declaration of Extended Fisheries Jurisdiction by the world's coastal nations.

Bockstael (1976), in her dissertation attempted to expand the conceptual base of earlier studies by estimating, among other relationships, U.S. supply and demand equations for frozen groundfish products at the import level. As part of her econometric analyses of the fresh and frozen groundfish fillets and frozen blocks markets, she sought to explain the interaction of consumer demand, imports, and domestic landings in determining ex-vessel and wholesale prices. OLS and TSLS estimates of a block recursive system of equations were obtained for the various market levels, using monthly data for the period 1964 to 1974. A noticeable expansion of the earlier studies was the explicit specification of four linear relationships to explain supply of, and demand for, imported frozen fillets and blocks. Results of the TSLS estimates for some specifications are presented in Table 4. From these results, one would conclude that this modeling exercise was generally successful. Both the demand for, and the supply of the imported frozen groundfish products were reasonably explained by the selected explanatory variables. Most of the equations estimated, especially those for groundfish fillets, had the right signs for the relevant coefficients which were also statistically significant at the 95 percent level.

Bockstael's work revealed that the U.S. import demand for fillets was influenced by the product's own import price, U.S. domestic wholesale price for fillets, the quan-tity of fillets in cold storage, the expected rate of apparent disappearance in the U.S., seasonality where March to May was distinguished from other months, and a variable (ICNAF) denoting seasonal closing by the International Commission for the Northwestern Atlantic

Table 4. U.S. Supply and Demand of Frozen Groundfish Fillets and Blocks Estimated by Bockstael (1976) Using TSLS and Linear Equations, Monthly Data, 1964-1974.

Equation and Variable		Coefficient Value and Significance	Variable Definition (1)
	Constant	11.71*	IMPZ = monthly imports of frozen fillets
$IMPZ^D_t$	PIZ_{t-3}	-0.70*	Monthly weighted average import frozen fillet price
	PWZ_{t-3}	0.03*	Monthly weighted average wholesale frozen fillet price
(Demand of	HZ_{t-3}	-0.20*	1st month cold storage holdings of frozen fillet
Frozen Fillet)	DISZ	1.05*	Twelve month moving avereage of disappearance rate of frozen fillets
	S1	1.21	Dummy = 1, for Dec.-Jan.-Feb.; zero, otherwise
	S2	3.99*	Dummy = 1, for Mar.-Ap.-May; zero, otherwise
	S3	-0.13	Dummy = 1, for June-July-August; zero, otherwise
	ID	2.88*	Anticipatory variable for ICNAF closings
	Constant	-9.66	IMPB = monthly imports of blocks
$IMPB^D_t$	PIB_{t-3}	-0.06	Monthly weighted average import block price
	PSP_{t-3}	0.38	Monthly weighted average wholesale stick-portions price
(Demand of	HS_{t-3}	-0.23*	1st month cold storage holdings of stock-portions and locks
Blocks)	DISP	1.03*	Twelve month moving average of disappearance rates of stock portions
	S1	-0.25	Dummy = 1, for Dec.-Jan.-Feb.; zero, otherwise
	S2	2.62*	Dummy = 1, for Mar.-Ap.-May; zero, otherwise
	S3	3.17*	Dummy = 1, for June-July-August; zero, otherwise
	Constant	-3.05*	IMPZ = monthly imports of frozen fillet
$IMPZ^S_t$	PIZ_{t-3}	0.69*	Monthly weighted average import frozen fillet price
	PIB_{t-3}	-0.15	Monthly weighted average import blocks price
(Supply of	WGZ_{t-3}	-3.93*	Monthly West German price of Cod frozen fillet
Frozen Fillet)	WLD	0.16(E-05)	Three month moving average of groundfish catch in Iceland, United Kingdom, Canada, Norway, Denmark
	DD	-10.47*	Dummy for dollar devaluation DD = 1.01/1964 to 09/1973, zero otherwise
	SQ	2.38*	Dummy for quota SQ = 1, January, April, July, October; zero otherwise
	Constant	29.66*	IMPB = monthly imports of blocks
$IMPB^S_t$	PIB_{t-3}	0.60*	Monthly weighted average import blocks price
	PIZ_{t-3}	0.23	Monthly weighted average imports frozen fillet price
(Supply	WGB_{t-3}	-5.26*	Monthly West German price of Cod blocks
of Blocks)	WLD	0.29(E-04)*	Three month moving average of groundfish catch in Iceland, United Kingdom, Canada Norway, Denmark
	DD	-14.01*	Dummy for dollar devaluation DD = 1.01/1965 to 09/1973; zero otherwise

(*) Statistically significant at 95 percent level.
(1) Endogeneous variables: IMPZ, IMPB, PIZ, PIB, and t = monthly observations.

SOURCE: Bockstael (1976).

Fisheries. The demand for frozen blocks equations weresuccessful in explaining the variability in the dependent variable. The supply of both fillets and block imports was postulated to be influenced by import prices, world landings, West German domestic wholesale prices, a variable representing the devaluation of the U.S. dollar, and another variable accounting for quotas when applied to frozen fillets. Three month lags on prices were used to better capture the rigidity in contractual arrangements in international trade. The demand elasticities for fresh and frozen fillets were estimated to be -6.21 and -3.71 respectively. Demand for sticks and portions at the retail level did not show statistical significance with own price, and Bockstael attributed this to the use of wholesale price as a proxy for retail price. Only fresh groundfish fillets exhibited statistically significant income elasticity, which was estimated as +2.26. In general, Bockstael found that the log-linear specification of the retail demand equation resulted in more credible estimates than the strictly linear relationship.

Wang, Dirlam, and Norton (1978) reported the findings of research in which demand analysis of the Atlantic groundfish was the focus. This research effort was particularly aimed at updating research on groundfish using the most recent data, and estimated demand relationships at the disaggregated species level. Species considered were cod, haddock, and yellowtail flounder. The purpose was to estimate relationships that would aid decision-making in groundfish management as expressed in the groundfish plan. The derived ex-vessel demand for cod, haddock, and flounder was specified as a price dependent relationship with the arguments being New England landings of the various species, retail prices (own-price and prices of substitutes), total landings of cod, haddock, and flounder, and inventory levels. The OLS estimates were used as approximations based on the assumption that simultaneous error was negligible. Some reported results in this study are presented below for comparison with other similar studies. Also presented are some price elasticities (price flexibilities).

A summary of the results shows that, at the ex-vessel market level, the demand is price elastic for all the species concerned: cod (-2.17), haddock (-8.33), yellow-tail (-2.27). They also found the cross-price flexibility (with respect to landings) of demand to be -0.14 for cod and -0.38 for haddock. The income flexibility of demand for yellowtail flounder was found to be 1.492.

Paez (1980) has discussed a simultaneous equation model for the international market for groundfish blocks. Her aim was to "evaluate the more relevant forces affecting the import demand and export supply of groundfish blocks." Applying data from 1964 to 1978 to the model, she obtained results that were consistent with earlier studies. She also estimated the U.S. price elasticity of import demand at -2.00, while the elasticity of import demand in the rest of the world was -6.00. The elasticity of Canadian export supply was estimated at 0.30 while the export supply elasticities were 0.60 and 1.58 for Iceland and Norway respectively.

Tsoa, Schrank, and Roy (1982) have attempted to model the U.S. demand for groundfish in an effort to assess, among other things, the implications of an expanded U.S. fishery following the U.S. extension of its jurisdiction over fishery resources. They estimated a reduced form of a system of inventory-adjustment, price-expectations equations, which noticeably is a deviation from the traditional supply and demand relationships usually specified for this market. They concluded that "income and price elasticities are perverse" and, as a result, expansion of U.S. demand was limited and expected benefits from EFJ would not be realized without substantial changes in the U.S. market structure. The Tsoa et al. specification while commended for this new approach of viewing the U.S. groundfish market, has met some criticisms. Constructive criticisms have been registered by Lin, Johnston, and Rettig (1986) and Crutchfield (1986). These criticisms are important, especially for the current study which seeks to estimate explicitly inventory demand and supply, and import supply equations in a simultaneous equations system. Crutchfield criticizes the aggregation of fresh and frozen groundfish products into a single product, since he believes that fresh and frozen groundfish represent two separate products with unique market characteristics. Both Lin et al. and Crutchfield prefer that imports are explicitly accounted for in the specification. In fact, the Lin et al. modification of the Tsoa et al. specification to include import supply equations (aimed at arriving at a "more complete model" (Lin et al., 1986)), has greatly influenced some specifications in the current study. The suggested inadequacies of the Tsoa et al. model render some of their conclusions inappropriate.

Wang (1984) adopted a partial adjustment model to analyze some aspects of the New England groundfish ex-vessel prices. The focus of Wang's study was the impact of imports on ex-vessel prices of various species of groundfish, including cod, cush, haddock, hake, pollock, yellowtail flounder, and other flounders. Zellner's seemingly unrelated regression procedures were applied to monthly data to estimate the specified equations. Reasonable estimates were obtained, and these allowed the author to make inferences about the ex-vessel market for the selected species of groundfish, and the impact of fresh fish imports. Wang found fresh fish imports to depress New England ex-vessel prices. The price-import flexibility was found to be less than one in all species for both the short-run and the long-run. A ten percent reduction in imports was found to raise ex-vessel prices by 0.8 to 4.0 percent. The study also revealed a price-landing flexibility of less than one for all species (Table 5), and the price adjustment factor was less than one in all cases (Table 6).

Crutchfield (1985) has developed an extensive econometric model of the New England groundfish market. Among other things, this model was specified to determine the relationships among product prices, landings, imports of groundfish products, and other economic factors relevant to explaining consumer demand such as income and prices of competing products. Elasticities were calculated which made it possible to draw some relevant inferences. The model also allowed the author to investigate the implications of choosing certain policy instruments (mainly tariffs and quotas) to restrict imports, and the impact of changes in domestic production on the U.S. groundfish market. A comparison of the results of this study was made with the results of some earlier studies (Bockstael and Tsoa et al.) and it seemed that the Crutchfield model was able to capture most of the important characteristics of the U.S. groundfish market.[2/] Table 7 shows that

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2/ For details see Crutchfield (1985).

Table 5. Price-Landing Flexibility, Monthly 1974-1984.

Species	Price-Landing Flexibility[a] Short-Run	Long-Run
Cod	0.50	0.50
Haddock	0.50	0.50
Hakes	0.20	0.33
Pollock	0.16	0.21
Cush	0.26	0.29
Yellowtail Flounder	0.42	0.54
Other Flounders[b]	0.40	0.56

[a] Measured at sample means.

[b] All flounders except yellowtail flounders.

Table 6. Mean Lag of Price Adjustments: $(1-\lambda)/\lambda$.

Species	Mean Lag
Cod	0
Haddock	0
Hakes	0.67
Pollock	0.33
Cusk	0.10
Yellowtail Flounder	0.29
Other Flounders[a]	0.42

[a] All flounders except yellowtail flounder.

Source: Wang (1984): Tables 5 and 6.

Table 7. Comparison of Results: Crutchfield (1985), Bockstael (1977), Tsoa et al. (1982).

	Crutchfield	Bockstael	Tsoa, Schrank, and Roy
1. Ex-vessel Price Flexibility	-0.36	-0.67	----------
2. Fresh Fillet Retail Demand Elasticity	-4.66	-6.21	---------
3. Frozen Fillet Retail Demand Elasticity	-1.11	-3.71	----------
4. Fish Sticks/Portions Demand Elasticity	-0.10 a/	-0.50 a/	----------
5. Frozen Fillet Import Demand Elasticity	-0.54	-0.07	-0.40 to -0.61 b/
6. Frozen Block Import Demand Elasticity	-0.99	-0.06 a/	-2.89 b/
7. Frozen Fillet Import Supply Elasticity	0.16	0.69	----------
8. Frozen Block Import Demand Elasticity	0.75	0.60	----------

a/ Not significant at 95 percent confidence level.

b/ Reported as "wholesale demand price elasticity," derived from demands for frozen inventories.

similarities and/or differences exist among the results of the various studies. Such modeling efforts and their findings are of interest in the current studies, especially, the specification of the domestic wholesale demand and import supply equations. In most cases, Crutchfield found that domestic landings and ex-vessel prices were interdependent. Consequently, a broader conclusion could be drawn, namely, the domestic fishery is susceptible to changes in exogenous economic and biological factors.

Though this modeling effort by Crutchfield appears more elaborate than any other so far documented, the level of aggregation is high enough to obscure some typical market behaviors such as species preferences and substitution.

CHAPTER III

THEORETICAL FRAMEWORK

Spatial Equilibrium Models

The recent form in which most spatial equilibrium models are specified is essentially an outgrowth of traditional econometric market models and mathematical (linear) programming spatial models. The beginnings of spatial equilibrium models (from now on referred to as SEM) can be traced to the early work of Enke (1951) and Samuelson (1952).

Since 1952 various formulations, expansions, and applications of the basic spatial equilibrium concept have been adopted by many investigators, especially to analyze and evaluate international trade systems. Takayama and Judge (1971) reformulated the basic spatial equilibrium problem from the linear programming framework suggested by Samuelson into a quadratic programming (QP) problem. A characteristic of the QP formulation is that it allows price and/or quantities to be endogenously determined. Very few applications of this concept have been made to the fishing industry in the U.S.A. Notable among the few applications in fishery studies is the approach adopted by Charbonneau and Marasco (1975) to study the fresh and frozen oyster markets in the U.S.A. Earley (1985) has investigated the role of some selected regulations, especially transportation, on the distribution of West Coast (U.S.A.) groundfish using a partial SEM. The two studies mentioned above which employ SEM to fisheries markets draw extensively on the work and suggestions of Lee and Seaver (1971).

Most applications of SEM have been confined to agricultural products and markets. Applications to livestock feed economies by Fox (1953) and Fox and Taeuber (1955) is an early extensive application of this concept in an analytical framework. In spite of the concern that SEM is essentially a tool for normative use (Lee and Seaver, 1977), Bawden (1966) has discussed the applications of the concept to analyze the implications of certain international trade policy issues, such as import duties and levies, quotas, and export subsidies. Much theoretical and conceptual work is still emerging, but this is restricted to refining the basic concept, simplifying the original algorithm for easy understanding and expanding the theoretical scope of application. The works of Martin (1981) and Willett (1983) are typical examples.

In a formulation that represents a competitive market structure, three basic components are usually identified. These are:

(1) A system of equations that describe the aggregate demand for the product of interest in all specified

demand centers, and the aggregate supply of the product at each specified supply source.

(2) A set of product flow activities, which indicate product distribution over space.

(3) A set of theoretically sound equilibrating conditions.

The system of aggregate demand and supply equations is similar to, and imply, the structure of a traditional market model. However, the equilibrium process is differently represented. Here the equilibrium is represented through the identification of the profits to be realized from the flow of the products. The excess of price differential between any two points in the market system (usually between a supply source and a demand point) less transfer costs, forms the basis for arriving at equilibrium. Using the equation systems, the flow activities, and equilibrium conditions, mathematical programming can be used to assure profit maximization in the broader commodity market. The programming algorithm allows products to be distributed over all relevant points until demand and supply in every spatially separated market is satisfied. This process of arriving at a competitive market equilibrium is what makes SEM more appealing than other analytical procedures for evaluating policies. The equilibrium conditions and most other definitional equations may be altered to impose specific constraints on target model parameters.

The Spatial Equilibrium Problem

The original spatial equilibrium problem, as stated by Enke (1951), involved trade in a homogeneous product between two or more regions, separated spatially but not isolated. These regions were assumed to have known or estimable demand and supply functions, and known transfer (transportation plus handling) costs between all possible pairs. Under the above assumptions, the stated problem was one of determining equilibrium quantities produced and consumed, and prices at both supply sources and demand centers resulting from optimal distribution of the commodity among regions.

A geometric representation of the interregional trade relations, as described above, is provided in Figure 1. This representation is a modification of the original problem developed by Samuelson (1952). Figure 1 provides a framework for discussing three basic phases of a commodity market, namely:

(1) No trade (all production and consumption are domestic).

(2) Trade with zero transfer costs.

(3) Trade with positive transfer costs.

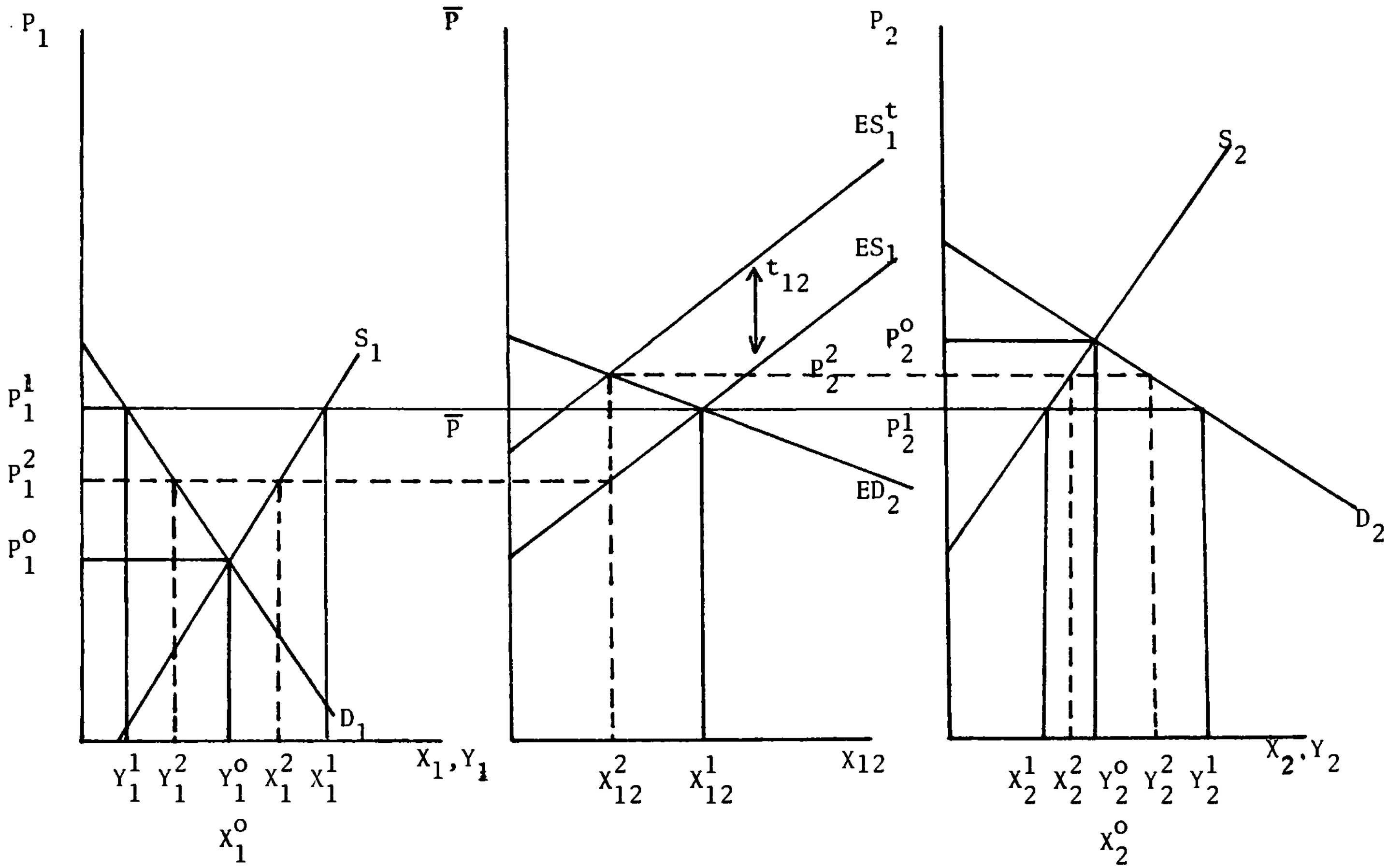

Figure 1. A Geometric Representation of Interregional Trade.

The first phase depicts a situation where each region produces and consumes the product of interest. Production decisions are only those designed to satisfy the domestic market. Equilibrium quantities (produced and consumed) and prices are established by the forces of demand and supply existing only in the particular region. This represents a situation where there is no incentive to trade. In the two-region system represented in Figure 1, (P_1^0, X_1^0, Y_1^0) and (P_2^0, X_2^0, Y_2^0) represent equilibrium situations as established in regions 1 and 2 respectively, through the operation of the respective demand and supply relationships. In fact, P_1^0 may not be equal to P_2^0, and in this case $P_2^0 > P_1^0$.

The second phase develops trade without the introduction of transfer costs. While this phase provides an exposition that enhances understanding of the basic theory of trade, it is oversimplified and unrealistic. Figure 1 develops a framework for trade in a situation where region 1 has a comparative advantage in the production of the homogeneous product, or supply in region 1 is much higher than the region's domestic consumption can absorb. On the other hand, at prices below the pre-trade equilibrium price in region 2 (P_2^0) there is excess demand for the product. This is represented by the negatively sloping line ED_2 in the middle graph of Figure 1. Similarly, at prices above the pre-trade equilibrium in region 1 (P_1^0) there is excess supply of the product. This is represented in the middle graph of Figure 1 by ES_1. The interaction between ES_1 and ED_2 establishes equilibrium trade relationships such that prices are equalized in both regions, that is, $P_1^1 = \bar{P} = P_2^1$. Under trade without transfer costs, P_2^1 (trade) is less than P_2^0, and P_1^1 (trade) is greater than P_1^0. This translates into obvious gains to producers in region 1 and gains to consumers in region 2, and a loss to consumers in region 1 while producers in region 2 lose. There is a welfare implication, the relevance of which is only established by the relative net gain or loss (due to price change) in each region of the market system. The quantity that region 2 purchases from region 1 (established along ED_2) is the excess demand observed for prices below the pre-trade equilibrium. At the trade equilibrium, this quantity is equal to the quantity that region 1 offers for sale to region 2. At $\bar{P} = P_1^1 = P_2^1$, region 1 produces X_1^1, consumes Y_1^1, and sells X_{12}^1 to region 2. Region 2, on the other hand, produces X_2^1, consumes Y_2^1, and therefore has to purchase X_{12}^1 from region 1 to satisfy its excess demand.

The introduction of transfer cost into the model may be achieved with an upward and parallel shift (to the original curve) of the excess supply curve (now ES_1^t) such that the perpendicular distance between ES_1 and ES_1^t is the transfer cost rate. With this introduction, the quantity traded is reduced. Price in the importing region (region 2) rises relative to the pre-transfer-cost price, but it is still less than the no-trade situation. On the other hand, price in region 1 falls below the pre-transfer-cost price but it is still higher than the no-trade equilibrium price. Production in region 1 falls to X_1^2 while demand in region 1 increases to Y_1^2 due to the decline in prices. Production in region 2 is higher than the previous phase (X_2^2) but consumption in region 2 also falls to Y_2^2, because prices are now higher than the pre-transfer--cost price. Quantities imported from region 1 now decline to X_{12}^2.

The concept of spatial equilibrium as presented in the trade literature has always stressed the welfare implications of trade versus no trade. For instance, the existence of an equilibrium in SEM has always been associated with the maximization of the gains from trade among all the participants in trade. While an explicit expression of an objective to maximize some welfare function finds appeal in the mathematical specification of the spatial price determination problem, such welfare considerations are only a part of the focus of this study. Of a greater interest, however, is the competitive determination of quantities and prices resulting from the optimal allocation of products among competing producing and consuming regions. It is assumed in the current study that each participant in trade seeks to maximize some net gain function. Thus the aggregate of all such maximized functions may represent the "value" of trade for participating regions under competitive market assumptions. When the gains from trade are maximized, the only difference between trade with and without transfer costs is that the prices at consuming and supply centers differ by the transfer cost in the former. That is, $P_2^1 - P_1^1 = 0$ (no transfer costs), but $P_2^2 - P_1^2 \leq t_{12}$ (transfer costs are considered). The above price relationships suggest that it is possible to obtain equilibrium without trade taking place, in which case $P_2^2 - P_1^2 < t_{12}$.

Competitive Spatial Price Determination (Quadratic Programming Model) in Quantity Domain

The graphical exposition given in the previous section introduces some equilibrating conditions relevant to the mathematical formulation of a programming model. These conditions are:

(1) Prices are equalized.

(2) Demand in a region is made up of the sum of product flows to that region from its own production, and from supply of all other sources. Also the supply from a region is the sum of the supply to itself, and the supply to all other regions.

For example, in the two region situation let Y_j (j=1,2) be the demands in regions 1 and 2 respectively, and X_i (i=1,2) be the supply in the two regions. Let X_{ij} be the flow of product from supply sources i to a demand point j. Then condition 2 states that:

$$Y_j = X_{ij} \quad (i = j = 1) \tag{1}$$

$$X_i = X_{ij} \quad (i = j = 2) \tag{2}$$

and

$$Y_j = \sum_{i}^{n} X_{ij} \quad (j = 2,\ i = 1,2) \tag{3}$$

$$X_i = \sum_{j}^{n} X_{ij} \quad (i = 1;\ j = 1,2) \tag{4}$$

(3) Equilibrium prices and quantities must lie on the defined supply and demand functions.

For simplicity of presentation it is assumed that n consuming and producing regions are involved in trade, and that these regions have known demand and supply functions. In practice, some consuming regions may not produce and vice versa.

Let the regional demand and supply be represented as price-dependent relationships:

$$\text{DEMAND:} \quad P_j = a_j - b_j Y_j \quad (j=1,2,\ldots,n) \tag{5}$$

$$\text{SUPPLY:} \quad P_i = c_i + d_i X_i \quad (i=1,2,\ldots,n) \tag{6}$$

where P_j and P_i are demand and supply prices respectively; Y_j and X_i are demand and supply quantities respectively;

a_j and c_i are intercept values of the demand and supply functions respectively; and $a_j > 0$, $c_i \lesseqgtr 0$, b_j and d_i are the slope coefficients of the demand and supply equations respectively, and $b_j > 0$, $d_i > 0$.

For all demand centers, the demand matrix may be represented by:

$$P_Y = A - BY$$

or

$$(P_j) = (a_j) - (b_j)(Y_j) \tag{7}$$

where

$P_Y = (P_j)$ is an n-element vector of demand prices

$A = (a_j)$ is an n-element vector of demand intercepts

$B = (b_j)$ is an n-element vector of demand slopes

$Y = (Y_j)$ is an n-element vector of demand quantities

Similarly, for all supply regions

$$P_X = C + DX$$

or

$$(P_i) = (c_i) + (d_i)(X_i) \tag{8}$$

where (P_i), (c_i), (d_i) and (X_i) have interpretation corresponding to the demand expressions. For each region $(j=i)$, the gain function may be represented by

$$g(Y_j, X_i) = \int_{Y_j^0}^{Y_j^1} (a_j - b_j Y_j) dY_j - \int_{X_i^0}^{X_i^1} (c_i + d_i X_i) dX_i \tag{9}$$

The right-hand side of equation (9) is essentially the sum of consumer and producer surplus. For all the n demand and supply regions, the total gain function may be represented by:

$$
\begin{aligned}
G(Y,X) &= \sum_{i=j=1}^{n} g(Y_j, X_i) \\
&= \sum_{j=1}^{n} \left(\int_{Y_j^0}^{Y_j^1} (a_j - b_j Y_j) dY_j \right) - \sum_{i=1}^{n} \left(\int_{X_i^0}^{X_i^1} (c_i + d_i X_i) dX_i \right)
\end{aligned}
\tag{10}
$$

where Y_j^0 and Y_j^1 are the pre- and post-trade demand quantities (without transfer costs), and X_i^0 and X_i^1 are pre- and post-trade supply quantities respectively. Equation (10) compares to the graphical presentation above when the areas under the excess demand and excess supply curves, and bounded by the price line, are maximized. Evaluating the integrals throughout all ranges of Y and X for the $j^{\underline{th}}$ demand region and the $i^{\underline{th}}$ supply region (i=j) yields the results below:

$$g(Y_j X_i) = k_j + a_j Y_j - \tfrac{1}{2} b_j Y_j^2 - k_i - C_i X_i - \tfrac{1}{2} d_i X_i^2 \tag{11}$$

where k_j and k_i are constants of integration. For all j demand regions and all i supply regions, then

$$
\begin{aligned}
g(Y,X) &= \Sigma\, g(Y_j, X_i) \\
&= \sum_{j=1}^{n} (k_j + a_j Y_j - \tfrac{1}{2} b_j Y_j^2) \\
&\quad - \sum_{i=1}^{n} (k_j + C_i X_i + \tfrac{1}{2} d_i X_i^2)
\end{aligned}
\tag{12}
$$

Using the notations in equations (7) and (8),

$$G(Y,X) = K + A'Y - C'X - \tfrac{1}{2}Y'RY - \tfrac{1}{2}X'HX \qquad (13)$$

where $R = (b_j)_{n \text{ by } n}$ and $H = (d_i)_{n \text{ by } n}$.

Transfer costs may now be introduced for all routes permitting product flow from a supply region i to a demand region j (including i=j). Let t_{ij} represent the unit cost of transferring a unit of the commodity from region i to region j such that $t_{ij} = 0$ for (i=j). Let X_{ij} represent the trade flow between the pair of regions (any i and j including i=j). Then, the total transfer cost for all trade flows will be given by:

$$\sum_{i=1}^{n} \sum_{j=1}^{n} t_{ij}X_{ij} = T'x \qquad (14)$$

where $T = (t_{ij})_{1 \text{ by } n^2}$ and $x = (X_{ij})_{1 \text{ by } n^2}$. T'x is exogenously determined and subtracts from the gains of the regions engaged in trade. The net value of total gain, NG, due to trade is specified as the objective function in a programming problem. A quadratic programming formulation results and, after dropping the constants of integration, the objective is to maximize

$$NG(Y,X,x) = A'Y - C'X - \tfrac{1}{2}Y'RY - \tfrac{1}{2}X'HX - T'x \qquad (15)$$

subject to the equilibrating conditions described earlier. Under these conditions, post-trade equilibrium quantities may be estimated in a mathematical programming model:

(1) Demand in a region is equal to trade flow to that region, and no excess demand is allowed.

$$Y_j \le \sum_{j=1}^{n} X_{ij} \quad \text{for all j, including (j=1)} \tag{16}$$

(2) Production in a region equals trade from that region, with the possibility of excess supply.

$$X_i \ge \sum_{i=1}^{n} X_{ij} \quad \text{for all i including (i=j)} \tag{17}$$

Again, when all trading regions are considered, the above conditions may be represented by the following matrices:

$$(Y_j) \le (\sum_{j=1}^{n} X_{ij}) \text{ or } G_Y x \ge Y \tag{18}$$

and

$$-(X_i) \le (\sum_{i=1}^{n} X_{ij}) \text{ or } G_X x \ge X \tag{19}$$

Where G_Y is an n by n^2 matrix of ones with the following configuration:

$$\begin{array}{ccccc} 1 & \ldots & 1 & \ldots & 1 \\ \cdot & & \cdot & & \cdot \\ \cdot & & \cdot & & \cdot \\ 1 & & 1 & & 1 \end{array}$$

G_X is also an n by n^2 matrix of ones with the following configuration:

$$\begin{array}{llllll} -1 & -1 & \ldots\ldots. & -1 & & \\ & -1 & -1 & \ldots\ldots. & -1 & \\ & & -1 & -1 & \ldots\ldots. & -1 \end{array}$$

The complete mathematical programming model may be represented by:

Maximize $NG(Y,X,x)$

$$= A'Y - C'X - \tfrac{1}{2}Y'RY - \tfrac{1}{2}X'HX - T'x \tag{20}$$

subject to

$$G_Y x \geq Y$$

$$G_X x \geq -X \tag{21}$$

and

$$Y,X,x \geq 0.$$

The above formulation satisfies the three quantity conditions, and the non-negativity condition (because such quantity conditions are explicitly included in the model specification). However, this formulation does not guarantee that the price and optimal supply and demand conditions are met. Applying the Kuhn-Tucker conditions to a Lagrangian formulation of the above problem will demonstrate whether or not such (price and optimal supply and demand) conditions are met. Equations (20) and (21) may be combined into the following problem:

Maximize $Z(Y,X,x,\lambda_Y,\lambda_X)$

$$= A'Y - C'X - \tfrac{1}{2}Y'RY - \tfrac{1}{2}X'HX - T'x + \lambda_Y' (G_Y x - Y) + \lambda_X'(G_X x + X) \tag{22}$$

where $\lambda_Y = (\lambda_j)_{nx1}$ and $\lambda_X = (\lambda_i)_{nx1}$ are the Lagrangian multipliers associated with the demand and supply constraints respectively. The elements of λ_Y and λ_X may be interpreted as the shadow prices for the demand (λ_Y) and supply (λ_X) constraints, and they are also the equilibrium prices at demand centers and supply points respectively. In the next subsection, the Kuhn-Tucker necessary conditions for Z in equation (22) are derived and the interpretations relevant to the current study are discussed. All vectors are evaluated at their optimum values, and the second expression of each necessary condition is the complementary slackness condition.

<u>Kuhn-Tucker Necessary Conditions for Equation (22)</u>

$$\frac{\partial Z}{\partial Y} = A - RY - \lambda_Y \le 0; \quad \left(\frac{\partial Z}{\partial Y}\right)Y = 0 \tag{23}$$

$$\frac{\partial Z}{\partial X} = -(C + HX) + \lambda_X \le 0; \quad \left(\frac{\partial Z}{\partial X}\right)X = 0 \tag{24}$$

$$\frac{\partial Z}{\partial x} = -T' + G_Y'\lambda_Y + G_X'\lambda_X \le 0; \quad \left(\frac{\partial Z}{\partial x}\right)x = 0 \tag{25}$$

$$\frac{\partial Z}{\partial \lambda_Y} = G_Y x - Y \ge 0; \quad \left(\frac{\partial Z}{\partial \lambda_Y}\right)\lambda_Y = 0 \tag{26}$$

$$\frac{\partial Z}{\partial \lambda_X} = G_X x + X \ge 0; \quad \left(\frac{\partial Z}{\partial \lambda_X}\right)\lambda_X = 0 \tag{27}$$

Let λ_Y be the optimal market demand prices, and λ_X the optimal market supply prices. From equation (23), if the optimum solution shows that $Y > 0$, then $\frac{\partial Z}{\partial Y} = 0$ and $A - RY = \lambda_Y$. The regional optimum price must be on the demand curve, and this implies that the demand condition is satisfied. On the other hand, if $Y = 0$ then $\frac{\partial Z}{\partial Y} \leq 0$ and $A-RY \leq \lambda_Y$.

From equation (24), if the optimum solution indicates that $X > 0$, then $\frac{\partial Z}{\partial X} = 0$, and $(C + HX) = \lambda_X$, thus satisfying the optimum supply condition. If, however, $X = 0$, then $\frac{\partial Z}{\partial X} \leq 0$ and $C + HX \geq \lambda_X$.

Equation (25) indicates that, if at the optimum solution $x > 0$, then $\frac{\partial Z}{\partial x} = 0$. This implies that $G_Y^{'}\lambda_Y + G_X^{'}\lambda_X = T$ (that is, if trade flow is positive, then the difference in prices between a demand region and a supply region is the transfer cost). This satisfies the needed price condition. It can also be verified that when $x = 0$ is the optimum solution, $\frac{\partial Z}{\partial x} \leq 0$, and $\lambda_Y - \lambda_X \leq T$.

From equation (26), if $\lambda_Y > 0$ (that is, demand prices are positive), $\frac{\partial Z}{\partial \lambda_Y} = 0$ implying that there is no excess demand or excess supply. However, when $\lambda_Y = 0$ (demand prices are equal to zero), $\frac{\partial Z}{\partial \lambda_Y} \geq 0$ so that $G_Y x \geq Y$, suggesting that excess supply may exist under this condition.

Equation (27) has a similar interpretation to equation (26). When $\lambda_X > 0$ is the optimum solution, $\frac{\partial Z}{\partial \lambda_X} = 0$ so that $-G_X x = X$. This suggests that at positive optimum supply prices, excess supply does not exist. However, excess supply is possible if $\lambda_X = 0$ and $G_X x \geq -X$ (since $\frac{\partial Z}{\partial \lambda_X} \geq 0$). Thus, from the foregoing discussions of the derived Kuhn-Tucker conditions, the solution to equations (20) and (21), the primal problem, satisfies the required quantity conditions (equations (26) and (27)). The dual of the same problem, however, satisfies the optimum demand and supply conditions (equations (23) and (24)), and the optimum price conditions (equation (25)).

Theoretical and Empirical Problems With Spatial Equilibrium Modeling

The literature on spatial equilibrium models identifies some shortcomings of this analytical procedure. For the purposes of the current study, and to simplify the discussion, the problems associated with SEM are divided into two groups: theoretical and empirical.

Theoretical shortcomings discussed here relate to the assumptions underlying the specification of the econometric and programming phases of the model:

(a) It is assumed that the product traded is homogeneous. All production and supply sources should supply a homogeneous product to all demand centers, and consumers should demand that product without differentiation of sources of supply. This problem is, however, not unique to SEM. Traditional econometric specifications also encounter similar product homogeneity assumptions, which are also very difficult to satisfy. In general, if products could be differentiated in any way, they are appropriately specified as substitutes in the consumer's bundle of consumption goods.

(b) Cross-hauling is not possible in the basic SEM specification. This is because the model does not allow regions in deficit to transfer products to other regions, and regions with excess supply do not import. This basic problem can, however, be avoided by introducing appropriate constraints that allow only specified supply levels, and direction and quantity of some shipments.

(c) Changes in transportation costs introduced into the programming model lead to abrupt rather than smooth adjustments in the trade matrix. Transportation rates used in SEM are usually average values over the specified period of the analysis. In interregional analysis, weekly or even monthly observed rates within the period of analysis may not deviate significantly from the average over the period. Therefore changes in these rates may give rise to a reasonably smooth adjustment in the trade matrix.

The empirical problems are two-fold: First, there are usually serious deficiencies in the data needed to adequately specify the necessary behavioral relationships. There are also difficulties in obtaining reliable data on transfer costs.

A second empirical shortcoming is that specification errors arise because these models usually capture only a portion of the market for the commodity of interest. A serious problem with specification is that most formulations exclude cross-price effects, weather and other exogenous effects, and price expectations in the demand and supply equations. It has also been discussed in the literature that it is impossible to incorporate time lags and other nonquantitative institutional arrangements into the model. While it may be difficult to explicitly include the above factors at the programming phase, such factors may be accounted for at the econometric phase. When the SEM is specified to include endogenous price or quantity relationships, lagged variables and their effects can be incorporated in the econometric estimation of such demand and supply equations. Nonquantitative institutional arrangements are difficult to incorporate even in the most carefully specified econometric relationships. When dummy variables are used to capture such institutional arrangements, their effect (depending on specification) is registered in changes in the intercept coefficient, a variation in the slope coefficient or a change in both coefficients. Thus, lags and nonquantitative arrangements, if properly specified in the econometric relationships used in SEM, can be implicitly introduced into a SEM. The only immediate disadvantage, however, is that certain important policy variables such as income or export earnings cannot be readjusted within the model to accommodate sharp changes in the size and direction of trade.

Another problem with the SEM is that the generated trade matrix tends to have many more zero elements than does the actual trade matrix. This problem reflects the inability to include all trading regions in the model specification. It also reflects the assumed allocation procedure, and the magnitudes of the econometric and transportation parameters. The situation, in this case, is improved by a better understanding and representation of the market system.

As indicated earlier, most of the problems discussed above are not necessarily unique to SEM. The decision to adopt this analytical framework in the current study, despite the inherent problems, is influenced by the various positive attributes which other analytical procedures lack. The two phases of the SEM formulation require, first, the econometric estimation of demand and supply equations. In the next two sections, the theoretical derivation and discussion of these functional forms are presented.

Demand

Utility Maximization and Demand Functions

Commodity demand equations are usually estimated by applying the theory of consumer demand. For most empirical work other assumptions, in addition to those usually dictated by the theory, are included which specifically relate to the problem of interest. Assumptions about consumer behavior may be incorporated into the theory of demand through the specification of an appropriate utility function. The types of assumptions introduced reflect the empirical considerations, and they represent restrictions which result in systems of demand equations that can be estimated with assembled historical (time series) data on prices, consumption levels, income, and other relevant variables. Thus, the specification of a demand equation, derived from the formulation of a utility maximization problem, primarily assumes the existence of a utility function. Once the form of the utility function is specified, the analytical assumptions or properties, are conveniently chosen to give an equation form which is theoretically and empirically acceptable. The utility function measures the level of satisfaction that an individual experiences as a result of consuming a particular bundle of goods and services (defined earlier as commodities). Implicit in this definition is a time dimension, that is, consumption is measured as a flow: the amounts of commodities consumed per unit of time.

In general, the utility function is maximized subject to a budget constraint, that is,

$$\text{Maximize } U = U(Y) \tag{28}$$

subject to

$$P'Y = I \tag{29}$$

where $Y = (Y_i)$ is an n-element vector with its elements defined to include the consumer's complete choice set of the levels of the commodities consumed per unit of time. P is also an n-element column vector of prices, and I is consumer income. The equality of expenditure (P'Y) to consumer income, I, suggests that the consumer income is fully allocated among the commodities in the consumer's choice set. For most practical purposes, P and I are assumed to be positive, and the consumer considers them as given. The implication is that consumers cannot influence the price they pay for the commodities purchased and, within the data period considered, incomes do not vary. The utility function presented in equation (28) is defined to satisfy certain assumptions. It is:

(1) a strictly increasing function,

(2) strictly quasi-concave, and

(3) twice continuously differentiable.

The maximization process (equations (28) and (29)) is carried out by the Lagrangian method through the relationship below:

$$L(Y,\mu) = U(Y) - \mu(P'Y-I) \tag{30}$$

where μ is the Lagrangian multiplier, and is interpreted as the marginal utility of income. Differentiating the above function with respect to Y_i and μ gives the first order condition for the constrained utility maximization problem:

$$U_Y = \mu P = 0; \; P'Y - I = 0 \tag{31}$$

U_Y is the vector of the derivatives of the utility function with respect to Y_i ($i=1,2,\ldots,n$) such that:

$$U_i = \frac{\partial U}{\partial Y_i} > 0 \quad (i = 1,2,\ldots,n) \tag{32}$$

The second partial derivatives are made possible by the continuity and differentiability assumptions mentioned earlier. By Young's Theorem, the second partial derivatives of the utility surface are symmetric; that is,

$$U_{ij} = \frac{\partial^2 U}{\partial Y_i \partial Y_j} = \frac{\partial^2 U}{\partial Y_j \partial Y_i} = U_{ji} \tag{33}$$

While the second derivatives, U_{ij} ($i=j$), show the rates of change of the first partial derivatives, U_{ij} ($i \neq j$) describes how marginal utility changes with consumption levels of other commodities. Also the second order conditions for maximization may be written as

$$X'VX \leq 0 \tag{34}$$

for all X such that $P'X = 0$.

The Hessian, V, is an n^2-element matrix represented by

$$V = (U_{ij}) \qquad (i,j=1,2,\ldots,n) \tag{35}$$

The second order condition (equation (34)) is assured by the strict quasi-concavity assumption of the utility function.

The first order conditions for maximization (equation (31)) gives rise to n+1 equations in 2n+2 variables. These variables include n prices, n quantities, μ, and income, I. Application of the implicit function theorem1/ allows the system of equations to be solved for unique values of $Y = (Y_i)$, and μ in terms of prices and income, that is,

$$\begin{aligned} Y_i &= Y_i(P_1,\ldots,P_n,I) \\ \mu &= \mu(P_1,\ldots,P_n,I). \end{aligned} \tag{36}$$

The demand equation, $Y_i(\cdot)$ has important theoretical and practical attributes: it describes the allocative behavior of the consumer when he/she is confronted with a set of positive prices and fixed income. $\mu(\cdot)$ represents the consumer's evaluation of increases to income (marginal utility of income) and, as indicated in equation (36), it

1/ Chiang, pp. 218-227, gives a simple discussion of this theorem.

> "An equation of the fprm $F(y,X_1,\ldots,X_n)=0$ defines an implicit function $y=f(X_1,\ldots,X_n)$ if F has continuous partial derivatives $F_Y,F_1,\ldots,F_n$, such that at any point $(Y_0,X_{10},\ldots X_{n0})$ satisfying F, F_Y is non-zero, and that there exists an n-dimensional neighborhood, N in which Y satisfies F for every $(X_1,\ldots,X_n)$ in that neighborhood. The implicit function $f(\cdot)=0$ will be continuous and also have continuous partial derivatives $f_1,\ldots,f_n$.

has prices and the fixed income level as arguments.

A number of important considerations surround the derivation and form of the demand equations (36). Notable among them are a set of underlying restrictions known as the Homogeneity Condition, Engel Aggregation Condition, Cournot Aggregation Condition, Symmetry Condition, and the Slutsky Condition. A simplified interpretation of these conditions is that they provide the properties normally associated with demand equations. Barten (1967, 1968) has discussed the implications of the exact meaning of these conditions for empirical research.

An important aspect worth considering is that the demand equations discussed above are designed to explain individual consumer behavior. Consistency in aggregation must therefore be assumed if aggregate equations are to explain market demand. Another aspect of the analysis worth noting is that the generalized model implied by the demand equations (36) and their restrictions would stipulate that the demands for all commodities are interrelated. In addition, several other assumptions regarding separability are necessary in order to explain demand for one or only several commodities considered together. The fulfillment of these conditions and assumptions is normally assumed in bridging the gap between the above theoretical model and the empirical equations which are estimated in commodity demand studies. Usually, the equations that are estimated for a single commodity are of the form which includes the prices of the commodity of interest, prices of only one or two complementary or substitute commodities, income, and possibly other explanatory variables, referred to here as Z.

$$Y_i = y(P_i, P_j, \ldots, P_k,\ I,\ Z,\ U) \tag{37}$$

U is a stochastic disturbance term which is usually added to the statistical estimation. The requirements for U are that it be free from autocorrelation, and have constant variance.

Properties of Demand Functions

While the restrictions on the demand functions are easily established through the derivatives of the maximization function, economists have usually found it convenient and more useful to express these restrictions in elasticities.

Let the direct and cross-price elasticity of demand, E, be represented by the following n by n matrix:

$$E = \overline{Y}^{-1}\ Y_P \overline{P} = (e_{ij}) \tag{38}$$

$\overline{Y}$ and $\overline{P}$ are nxn diagonal matrices with the diagonal elements taking on values of the vectors Y and P respectively, and $Y_P = \frac{\partial Y}{\partial P}$. In general, the elasticities of demand with respect to prices are represented by

$$e_{ij} = \frac{\partial Y_i}{\partial P_j} \cdot \frac{P_j}{Y_i} \quad \text{for } (i,j=1,2,\ldots,n) \tag{39}$$

Income elasticities, η, for the n commodities can also be computed as

$$\eta = \bar{Y}^{-1} Y_I \bar{I} \tag{40}$$

where η is an n-element column vector of income elasticities and $Y_I = \frac{\partial Y}{\partial I}$.

As in equation (39), the income elasticity for the i^{th} commodity is given by:

$$\eta_i = \frac{\partial Y_i}{\partial I} \cdot \frac{I}{Y_i} \qquad (i=1,2,\ldots,n) \tag{41}$$

To derive the properties, one needs to compute the proportion of total expenditure that is allocated to each commodity, that is,

$$W = I^{-1}\bar{P}Y = I^{-1}\bar{Y}P = (W_i) \tag{42}$$

where W is an n-element column vector of expenditure proportions, and

$$W_i = I^{-1}(P_iY_i) = P_iY_i/I \qquad (i=1,2,\ldots,n) \tag{43}$$

Also, a column vector of ones, S' = (1, 1, ..., 1)', is introduced for convenience.

<u>Engel Aggregation Condition</u>

This condition states that the weighted (where the weights are the commodity expenditure proportions) sum of the income elasticities is equal to unity. Multiply equation (40) by W, then

$$W'\eta = (I^{-1}P'\overline{Y})(I\overline{Y}^{-1}Y_I) = P'Y_I = 1 \tag{44}$$

That is, $\Sigma\ W_i\eta_i = 1\ (i = 1,2,\ldots,n)$.

Cournot Aggregation Condition

Premultiply E by W, then

$$\begin{aligned} W'E &= (I^{-1}P'\overline{Y})(\overline{Y}^{-1}Y_P\overline{P}) \\ &= I^{-1}P'Y_P\overline{P} = I^{-1}(-Y')\overline{P} = -W' \end{aligned} \tag{45}$$

since $\frac{\partial Y}{\partial P} = Y_P$ is negative. That is, $\Sigma\ W_ie_{ij} = -W_j$.

Thus the Cournot Aggregation Condition expresses the weighted column sum of the price elasticities (the $j^{\underline{th}}$ column of E) as the negative of the expenditure proportion on the $j^{\underline{th}}$ commodity.

Symmetry Condition

Consider that $[W(E + \eta W')] = (E' + W\eta')\overline{W}$.

$$\begin{aligned} \text{The RHS} &= [\overline{P}Y_P'\overline{Y}^{-1} + (I^{-1}\overline{P}Y)(IY_I'\overline{Y}^{-1}]I^{-1}\overline{PY} \\ &= I^{-1}\overline{P}Y_P'\overline{P} + I^{-1}\overline{P}YY_P'\overline{P} \\ &= I^{-1}\overline{P}(Y_P + Y_IY')\overline{P} \\ &= \overline{W}(E + \eta W') \end{aligned} \tag{46}$$

Equation (46) is usually specified as

$$W_i(e_{ij} + \eta_iW_j) = W_j(e_{ji} + \eta_jW_i) \quad (i,j=1,2,\ldots,n)$$

or

$$e_{ij} = W_j/W_i e_{ji} - W_j(\eta_i-\eta_j) \qquad (i,j=1,2,\ldots,n) \qquad (47)$$

This suggests that the matrix of cross-price elasticities is symmetric.

Homogeneity Condition

$$\begin{aligned} \text{Consider that } E\cdot S &= \bar{Y}^{-1}Y_p\bar{P}S \\ &= \bar{Y}^{-1}Y_pP \\ &= \bar{Y}^{-1}(-Y_I I) \\ &= -\eta \qquad (48) \end{aligned}$$

Thus, the homogeneity condition shows that the representative consumer does not exhibit money illusion: commodity purchases are influenced by relative prices and income.

Slutsky Condition

Economists have traditionally used estimated demand systems to evaluate changes in prices and income. As has been suggested earlier, the demand for a particular commodity in the consumer's choice set is related to the demand for the other commodities in the set. Application of the Slutsky condition allows one to decompose the effects of these changes.

Consider the equation:

$$\frac{\partial Y_i}{\partial P_j} = \mu U_{ij} - \frac{\mu}{\delta\mu/\delta I} \cdot \frac{\partial Y_i}{\partial I}\frac{\partial Y_j}{\partial I} - Y_j\frac{\partial Y_i}{\partial I} \qquad (49)$$

$$(i,j=1,2,\ldots,n)$$

$U_{ij} \in U^{-1}$ is the $(i,j)^{\underline{th}}$ element of the inverse of the Hessian. Equation (49) can be decomposed into three interpretable terms.[2/]

i) U_{ij} has been referred to as the "Specific Substitution Effect" (Theil, 1975) and it shows that the utility that a consumer gets from consuming a commodity i, is a function of the consumption levels of other commodities, j.

ii) $-\frac{\mu}{\mu/I} \cdot \frac{\partial Y_i}{\partial I} \cdot \frac{\partial Y_j}{\partial I}$ may be interpreted as the "General Substitution Effect" (Houthakker, 1960), and it shows that all goods in the consumer's choice set compete for an increment in his/her budget.

iii) $-Y_j \frac{\partial Y_i}{\partial I}$ defines the income effect.

The short discussion above suggests that the total effect of a price change, $\partial Y_i/\partial P_j$, is decomposed into a specific substitution effect, a general substitution effect, and an income effect.

Let $U_{ij} - [\mu/(\partial \mu/\partial I)](\partial Y_i/\partial I)(\partial Y_j/\partial I) = K_{ij}$ be the total substitution effect. Then,

$$\frac{\partial Y_i}{\partial P_j} = K_{ij} - Y_j(\partial Y_i/\partial I) \qquad (i,j,=1,2,...,n) \qquad (50)$$

which defines the "Slutsky Equation," and suggests that

2/ Johnson, Hassan, and Green (1984) discuss these properties in some detail.

the total effect of a price change can be partitioned into two effects: the substitution effect, K_{ij}; and the income effect $[-Y_j(\partial Y_i/\partial I)]$.

Supply

Unlike commodity demand, the nature of commodity supply is more diverse because of the different conditions under which production can take place. This diversity in the conditions which influence production may provide the starting point of an attempt to present an economic and statistical theory that explains commodity supply. The theory of commodity supply expresses a general response of producers to a number of causal determinants existing both within and outside the commodity market. The modern theory of supply recognizes the following broad classes of determinants:

i) Economic,

ii) Ecological,

iii) Technological,

iv) Institutional, and

v) Uncertain.

Needless to say, the above-mentioned determinants are even more relevant to the commodities being studied in the current analysis. A brief discussion of each will establish the relevance of these factors to the current study.

Economic

Economic determinants of supply, as explained by the modern theory of production, relate to the acquisition of factors of production, and the sale of intermediate and/or final products in the market. The market prices of inputs and the prices that producers receive for their products, therefore, feature prominently in this process. Other factors that might also be included are fixed and quasi-fixed factors. For the various stages of groundfish fillets production, these other factors may include vessels and on-board equipment, and processing and storage facilities, etc.

Ecological

For the fishery under consideration, ecological factors that may influence production, and hence supply, include weather, stock abundance, and other environmental factors. Geographical conditions may include the fertility of the traditional fishing grounds and minimization of environmental damage. Ecological factors have one characteristic in common: they are largely unpredictable, or just not understood.

Technological

Until recently, economists had doubted the ability of technology to produce noticeable effects on supply in the short-run. Both the short-run and the long-run effects of the changes in technology have been found to be relevant, because a process of diffusion can be observed when supply innovations are introduced. In general, the impact of innovations on commercial production (and hence supply) will vary depending on the nature of the industry under consideration. Specifically, innovations in the fishing industry may require substantial capital outlay if related to the vessels and some on-board heavy equipment. They may also be less expensive if they are restricted to small equipment purchases, or slight equipment modification.

Institutional

Institutional determinants of supply may relate to the nature of the commodity policies, barriers to international and domestic interregional trade, and even the social structure under which the production activity is organized. Some of these factors are quantifiable and their effects may be analyzed easily in a complete commodity model. Other factors are not easily quantifiable, but even in these cases appropriate dummy variables can be used to capture their effect in a supply relationship.

Uncertain

Situations of uncertainty in the commodity market are usually represented through the formulation of expectations. The producer or supplier forms expectations about future prices in his/her decision to put a particular commodity and quantity on the market. Expectations per se are difficult to incorporate directly into a commodity model. As such, certainty equivalents are usually used to transform expectational variables. Certainty equivalents that have been used in empirical work include extrapolative equivalent, adaptive equivalent, and rational equivalent. Extrapolative equivalent formulation assumes that future values of a variable relate to its past value; adaptive equivalent formulation indicates that previously perceived errors are taken into account; and rational equivalent suggests that prices are predicted by considering all relevant economic information.

Just as the demand function derives from a set of utility maximization conditions under budgetary constraint, the supply function stems from the maximization of profits for a producing unit subject to the production function constraint. For a production unit the above conditions are satisfied if competitive equilibrium is established such that the real cost of an input factor is equal to its marginal productivity. The supply function is clearly distinguished from a production function (which describes the technical relationship between output and various inputs) in that, it is concerned with the response of output to one or more prices.

In general, a static supply function which is formulated to describe commodity supply behavior is of the form,

$$Y_t = y(P_{it}, W_{jt}, U_t) \qquad \begin{matrix} i=1,2,\ldots,m \\ j=1,2,\ldots,n \end{matrix} \tag{52}$$

where P_{it} is an m-element vector of commodity own price, and prices of inputs to the production process or prices of other commodities closely related in production. W_{jt} is an vector of noneconomic determinants. These may include technological or institutional factors, and U_t is a stochastic disturbance term with the usual statistical properties.

As noted earlier, the firm's production function describes its technological possibilities while the supply function describes the firm's economic behavior. Profit maximization subject to a production function constraint, when input and output prices are considered to be given by the production unit, is a convenient starting point in the derivation of the supply function. For a firm that produces only one product using several inputs, it is assumed that the problem facing the firm may be expressed mathematically by:

$$\pi(P,W) = \text{Max } PY - W \cdot X \tag{52}$$

subject to the production function

$$Y = f(X) \tag{53}$$

where P is the scalar price of the output Y, $W = (W_i)$ is a vector of input prices, and $X = (X_i)$ is a vector of inputs. Substituting for Y, from equation (53),

$$\pi(P,W) = \text{Max } P\, f(X) - W \cdot X \tag{54}$$

Using calculus, the first order conditions for the single-output multi-input profit maximization problem are

$$\frac{\partial \pi(\cdot)}{\partial X_i} = P\, \frac{\partial f(X^*)}{\partial X_i} = W_i \qquad (i=1,2,\ldots,n) \tag{55}$$

Following the earlier discussion of this equation, equation (55) shows that the value of marginal product of each factor used in the production of Y must be equal to its own price. For the $i^{\underline{th}}$ input (assuming all other inputs are held constant), equation (55) gives rise to a simple two-dimension relationship which may be graphically represented as in Figure 2. The profit function is given by $\pi = PY - W \cdot X$ and this gives rise to the level sets (for fixed output price, P, and input prices, W) $Y = \pi P^{-1} + WP^{-1} \cdot X$ which is a straight line. πP^{-1} is the vertical intercept of the isoprofit line and represents the real level of profits. WP^{-1} is the slope of the isoprofit line and represents the real wage of the input factor used in production. A profit maximizing production unit seeks to locate a point on the production set that gives the maximum level of profits. In Figure 2 this point is indicated by the point of tangency of the isoprofit line and the

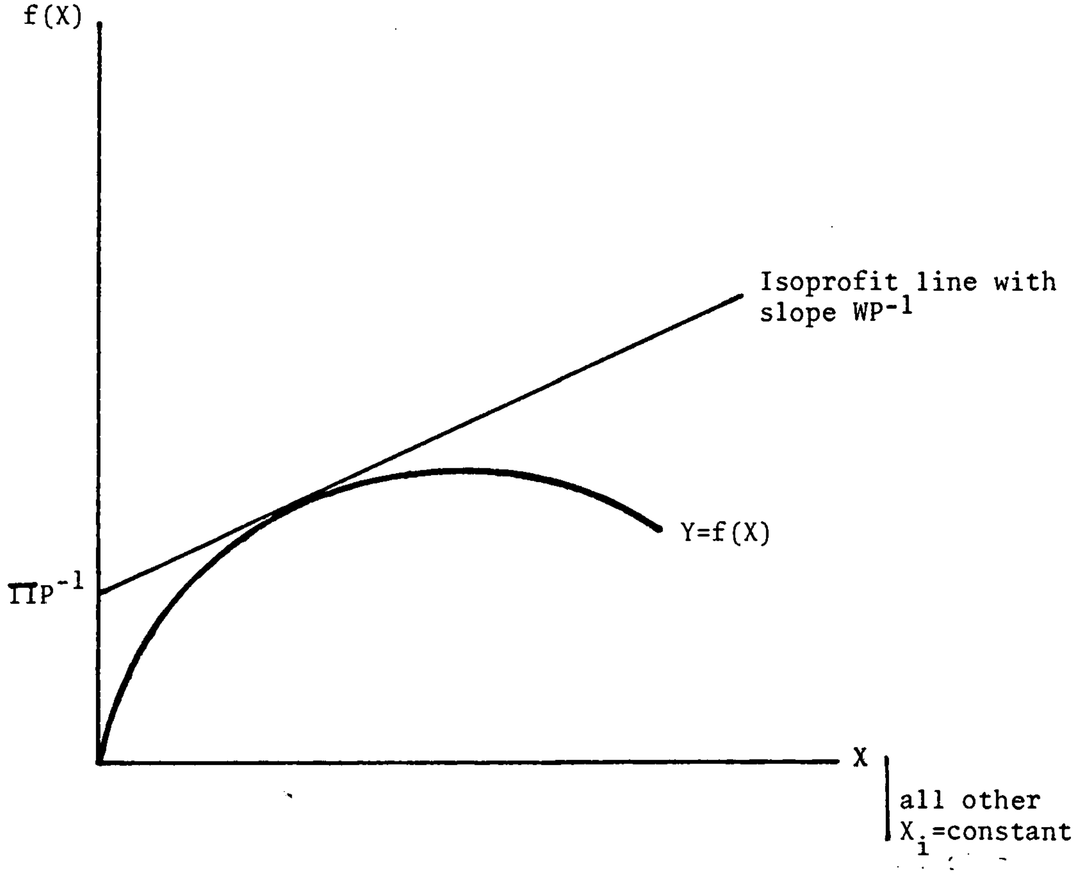

Figure 2. Maximum Profit Determination.

production set; that is

$$\frac{df(X^*)}{dX} = WP^{-1}$$

where f(X*) represents the maximum production set.

The first order conditions and the production function can be used to derive two sets of important relationships, provided that the second order conditions for profit maximization are satisfied. These relationships are:

(1) The output supply functions:

$$Y = y(P, W) \tag{56}$$

(2) The input demand functions:

$$X = x(P, W) \tag{57}$$

By definition, the output supply function represents the quantity of the output, Y, that is supplied given the product's own price and prices of inputs (equation (56)). Similarly, the input demand functions indicate the quantity of input factors acquired (for production) as a function of the input's own price, the prices of competing and/or complement inputs, and the product price (equation (57)).

A set of properties (restrictions) can be derived for equations (56) and (57) similar to those discussed for the product demand functions. Important among these restrictions are:

(1) the sign conditions,

(2) the symmetry conditions, and

(3) the homogeneity conditions.

The derivation of these conditions is achieved through the differentiation of equations (56) and (57).

Sign Conditions

From equation (56),

$$\frac{\partial Y}{\partial P} = \frac{\partial^2 \pi}{\partial P^2} > 0, \tag{58}$$

that is, the supply curve is upward sloping. This is so because the profit function $\pi(\cdot)$ is convex in product price, P.

From equation (57),

$$\frac{\partial X_i}{\partial W_i} = - \frac{\partial^2 \pi}{\partial W_i^2} < 0, \tag{59}$$

that is, the input demand curves are downward sloping. This is also possible due to the convexity of $\pi(\cdot)$ in the input prices, $W = (W_i)$ $(i=1,2,\ldots,n)$. The signs on some other derivatives are not so obvious. For example, no a priori assumptions can be made about the sign on: (a) the derivative of the input factor, X_i, with respect to other input prices W_j $(i \neq j)$, and output price, P. Also an obvious sign cannot be assumed for the response of quantity of output supplied, Y, to changes in input prices $W = (W_i)$. Equations (58) and (59) describe the sign conditions for the product supply and input demand curves.

Symmetry Conditions

From equation (57),

$$\frac{\partial X_i}{\partial W_j} = - \frac{\partial^2 \pi}{\partial W_i \partial W_j} = - \frac{\partial^2 \pi}{\partial W_j \partial W_i} = \frac{\partial X_j}{\partial W_i} \quad (i \neq j)$$

that is,

$$\frac{\partial X_i}{\partial W_j} = \frac{\partial X_j}{\partial W_i} \tag{60}$$

Equation (60) shows that the change in the $i^{\underline{th}}$ input with respect to a change in the $j^{\underline{th}}$ input price is equal to the change in the $j^{\underline{th}}$ input with respect to the $i^{\underline{th}}$ input price.

From equations (56) and (57),

$$\frac{\partial X_i}{\partial P} = - \frac{\partial^2 \pi}{\partial P \partial W_i} = - \frac{\partial^2 \pi}{\partial W_i \partial P} = - \frac{\partial Y}{\partial W_i},$$

that is

$$\frac{\partial X_i}{\partial P} = - \frac{\partial Y}{\partial W_i} \tag{61}$$

Equation (61) states that the change in the $i^{\underline{th}}$ input with respect to a change in output price is equal to the negative of the change in output with respect to a change in the $i^{\underline{th}}$ input price. Equations (60) and (61) describe the symmetry conditions.

Homogeneity Conditions

The homogeneity conditions state that the input demand functions and the output supply function are homogeneous of degree zero. This means that if all input and output prices are changed simultaneously, and in the same proportion, the demand for inputs or the supply of output will not change. These conditions, like those derived for product demand functions, find more useful and convenient interpretation when expressed as elasticities, that is,

$$\sum_{j=1}^{n} \frac{\partial X_i}{\partial W_j} \cdot \frac{W_j}{X_i} + \frac{\partial X_i}{\partial P} \cdot \frac{P}{X_i} = 0. \tag{62}$$

Also,

$$\sum_{j=1}^{n} \frac{\partial Y}{\partial W_j} \cdot \frac{W_j}{Y} + \frac{\partial Y}{\partial P} \cdot \frac{P}{Y} = 0. \tag{63}$$

In a typical empirical work, factors other than output and input prices may influence input demand, and output supply (as discussed earlier).

CHAPTER IV

CONCEPTUAL MODEL

Introduction

A conceptual model is now appropriate as the next step towards estimating the relevant relationships identified in the chosen analytical framework. The information about the broader product market (for fresh and frozen groundfish fillets) needed for this kind of analysis are: demand and supply equations for the selected regions of interest, inventory relationships, and transfer and storage costs. Historical data on prices, supplies, and consumption are assembled for the estimation of a hypothesized econometric model. With the estimated relationships as inputs, a mathematical programming approach is used to approximate competitive market conditions more fully. The two steps incorporate most of the characteristics of a competitive market necessary to determine competitive equilibrium prices and quantities (supplied, demanded, and traded) among spatially separated (but not isolated) regional markets for groundfish.

Thus, two models are developed to analyze the various aspects of this multiregional groundfish market likely to be affected by policies under the U.S. extended fisheries jurisdiction. Model 1 is essentially a set of simultaneous equations for the U.S.A. regional/international groundfish market. The model is formulated to include supply and demand equations for the selected species of groundfish, and for each region identified as either a supply source and/or a demand region. Model 2, as mentioned above, incorporates this set of simultaneous equations into a larger mathematical programming model. The solution to the second model then gives rise to competitive equilibrium prices, quantities demanded and supplied, and optimal product distribution.

The limitations usually placed on studies of this nature by the scarcity of the appropriate time series data are not completely eliminated in this analytical framework. The data problems discussed earlier, some of which appear to be unique to the analytical procedure chosen, are not fully resolved. However, the flexibility inherent in the procedure for analyzing the impact of exogenously determined policy instruments (for which time series data are not available, and therefore cannot be included in a meaningful econometric analysis) makes it appealing for addressing the issues defined in the objectives of the current study. Monthly data for the estimation of the specified demand and supply relationships are obtained from secondary sources as discussed later under "Data and Sources." The data limitations briefly mentioned above have substantially influenced most of the econometric specifications. It is hoped that specification errors are minimal or nonexistent, and that rigor is not compromised with oversimplification. The credibility of the results of the solution to the quadratic programming specification is enhanced by the rigor and acceptable specification of the econometric model, and the researcher's ability to compute reliable transfer costs.

Econometric Model

For the purposes of this study participants in the broader multi-region market are divided into two main groups: "Suppliers" and "Consumers." Suppliers are defined to include all sources of supply of groundfish to the U.S. domestic market. These include U.S. domestic production (from the Atlantic and Pacific, including Alaska, coasts) and foreign production. Foreign sources of supply are subdivided into two broad areas, namely, Canada and Europe (here defined to include Iceland, Norway, Denmark, etc.). The demand side is defined to exclude explicit specification of quantity-demanded equations in regions outside the U.S. (i.e., Canada and Europe). Given that the objective of the current study is to focus on the U.S. regional markets (though consideration is given to both domestic and foreign factors influencing these markets) only the demands in the U.S. are explicitly specified. As indicated earlier, such demands (as they exist in U.S. regions) are satisfied by supply from both domestic and foreign sources. Supplies from foreign sources may therefore be classified as shipments to the U.S. from Canadian and European excess supply of the products of interest. The U.S. demand is further subdivided into quantities demanded for current or immediate consumption in all specified regions (i.e., the total apparent consumption for the U.S.), and demand for inventory. The demand for inventory is defined as the demand for end-of-period holdings and is hypothesized to be a functional relationship involving both economic and non-economic factors. A predetermined supply of inventory (beginning-of-period inventory) may be algebraically derived from the end-of-period inventory relationship. All these relationships are specified for a homogeneous[1/] product: fresh and frozen fillets of the particular groundfish species under consideration. Model specification and estimation are at the wholesale market level.

Based on the assumptions of a competitive multi-regional market for a homogeneous groundfish product, a system of behavioral and identity equations can be constructed which characterize the operation of the market. Such a formulation establishes a competitive global market price, quantities offered for sale by the major suppliers, quantities purchased by consuming regions, and the levels of regional supply and demand. For the current study,

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1/ The same groundfish species from different supply sources are assumed to be homogeneous. This suggests that these products are perfect substitutes in both demand and supply. The assumption may cause serious specification problems but the benefits may outweigh the costs.

some domestic supply regions may not be identified as major demand regions, and vice versa. An algebraic representation of the conceptual simultaneous equation system (MODEL 1) involves a system of seven behavioral equations and three identities. These equations (in their general forms) are described below:

$$X_r = X(P_r = P,\ Z,\ U_1) \tag{64}$$

$$S^* = S^*(P,\ P^*,\ U_2) \tag{65}$$

$$P^* = P^*(P_{-j},\ U_3) \tag{66}$$

$$S = S(S^*,\ S_{-j},\ U_4) \tag{67}$$

$$MC = f(PC,\ PE,\ V,\ U_5) \tag{68}$$

$$ME = g(PE,\ PC,\ W,\ U_6) \tag{69}$$

$$M = h(P^{exv},\ PC,\ PE,\ U_7) \tag{70}$$

$$P = P^{exv} + M \tag{71}$$

$$\Sigma\ X_r = X \tag{72}$$

$$X + S = MC + ME + L + S_{-1} \tag{73}$$

where the variables have the following interpretation:

X_r = Region r's (U.S.) wholesale demand for fresh and frozen groundfish fillets.

S^* = Desired level of end-of-period inventory in period t (one month).

P* = Expected wholesale price at the beginning of the next period t+1.

S = Actual level of end-of-period inventory in period t.

P = Actual wholesale price observed at the beginning of the period t.

MC = Quantities of fillets imports arriving in the U.S. in period t from Canada.

ME = Quantities of fillets imports arriving in the U.S. in period t from Europe.

M = U.S. wholesalers' market margin.

Z = All other exogeneous variables which influence wholesale demand for fresh and frozen fillets.

P_{-j} = Lagged actual prices.

S_{-j} = Lagged actual inventory at the end-of-period.

L = Domestic (U.S.) landings converted to fillet weight.

PC = Average import price of fresh and forzen fillets from Canada.

PE = Average import price of fresh and frozen fillets from Europe.

V = All other exogenous factors influencing import supply from Canada.

W = All other exogenous factors influencing import supply from Europe.

U = A disturbance term accounting for unexplained variation in the dependent variable of an equation.

X_r, S*, S, P*, P, MC, ME, X, M, P^{exv} are the endogenous variables of the system of equations, and the rest are exogenous (predetermined, lagged endogenous, exogenous and lagged exogenous). While this model formulation has attributes of an econometric specification of a trade model, it may be better classified as a multi-regional market model. The derived structural equations, after substituting for nonobservable desired and expected variables, may be represented as below.

X (this will be explained later) is assumed to be the actual quantity demanded for consumption within a period of one month, so that (X+S) is the sum of the *ex ante* demands for current consumption and inventory. In equation (64), national average wholesale price is used as a proxy for regional price because such regional price data are not available. Equation (67) does not really explain why S is not equal to S* ($S \neq S^*$) but it does permit actual levels of ending inventory to be affected by the variables P and P* which are assumed to influence demand (inventory levels). Equations (68) and (69) also need to be explained in some detail. In the U.S. under perfect competition PC = PE. The price in Europe (as opposed to the price in the U.S. of product from Europe) may affect the willingness of Canada to ship to the U.S. Similar arguments can be made for the ME equation for Europe. It is also possible that if PC measures prices in Canada, for high levels of PC, products might be directed from the U.S. market back to the Canadian market. MC measures the quantity of the Canadian product coming to the U.S.--an excess supply relationship. ME also measures supply to the U.S. from excess supply in Europe.

A Priori Assumptions About Quantity-Price Relationships in the Conceptual Model

The conceptual econometric model presented above assumes a competitive market in which the sum of the quantities demanded in all specified demand regions (in any one month) is equal to the total apparent disappearance of that particular product during that month. Also, in equilibrium, total fresh and frozen fillets demanded (demand for current consumption plus demand for inventory including carry-over) is assumed to be equal to the total quantities supplied (the sum of Canadian import supply, European import supply, domestic production, and inventory supply at the beginning of the period).

Quantities supplied (from both domestic and foreign sources) are specified as functional relationships of own price, and the coefficient of price in these relationships is hypothesized to have a positive sign. The suggested supply relationships are expected to be price inelastic (but not perfectly inelastic). Equations that fall into this category (for the purposes of the current study) include: the import supply equations for products from Canada and Europe.

Regional consumption is represented by demand equations in which the quantity demanded is hypothesized to have a negative relationship with the product's own price. These demand equations may be elastic or inelastic, however, perfect price elasticity is not expected for the demand relationships featured. The relationships for inventories (supply and demand) need some elaboration. Incorporating inventory behavior in an analysis of this nature may present some serious specification problems. In the U.S., there are several market intermediaries whose operations fall between the ex-vessel market and the retail market for a groundfish product: some of these may be identified as processors, processor-wholesalers, wholesalers, brokers, and others vaguely classified as speculators. For the purposes of the current study, all such groups will be referred to as dealers. What makes specification of inventory relationships interesting is that each of the above-mentioned groups may keep inventories for different reasons. It is suggested that some or all dealers may keep inventories for transaction, precautionary, or speculative reasons. Of course, one's understanding of the market and its operation at the time of decision-making will determine which one or which combination of the above reasons may influence inventory-holding. Assuming that the decision to hold inventory is not so clearly determined by any one reason (but by a combination of them) a quantity-dependent inventory demand equation may have an ambiguous (unrestricted in sign) sign on the coefficient of price. In general, if the current price is much lower than the expected future price, more inventory will be held in the current period. On the other hand, if the current prices are very high and there is no reason to expect still higher prices in the future, current inventories will be depleted and carry-over inventories will decline. However, the interplay of the three reasons for keeping inventory does not always lead to a predictable sign on the coefficient of price. For the purposes of the current analysis, demand for inventory will be defined to include purchases to build up inventory by the end of the period specified for the data, that is, one month. This suggests that current lower prices, and anticipated higher prices in the future, will encourage inventory build-up. The sign on the coefficient of price in a quantity-dependent equation is expected to be negative.

Inventory supply is defined to include beginning inventory as of the first of the month. For all practical purposes this will be equal to the end-of-period inventory (demand) for the previous period (equation (67)). However, the driving force is no longer low current prices, but is derived from expected higher future prices with expectations formed in the previous period. Equation (67) may be solved, algebraically, for the beginning inventory relationship. For internal consistency and simplicity, actual prices are those observed at the beginning of the month (the data period). From equation (65) therefore, $\frac{\partial S^*}{\partial P^*} > 0$ and $\frac{\partial S^*}{\partial P} < 0$.

From (66) $\frac{\partial P^*}{\partial P_{-1}} > 0$.

From (67) $\frac{\partial S}{\partial S^*} > 0$ and $\frac{\partial S}{\partial S_{-1}} > 0$.

Then $\frac{\partial S}{\partial S^*} \frac{\partial S^*}{\partial P^*} \frac{\partial P^*}{\partial P_{-1}} > 0$.

So that $\frac{\partial S}{\partial P_{-1}} > 0$.

But $\frac{\partial S}{\partial S^*} \quad \frac{\partial S^*}{\partial P} < 0$; so $\frac{\partial S}{\partial P} < 0$.

That is, actual ending inventory for this period is negatively related to this period's price but positively related to last period's price. This seems a bit strange but comes from the way price expectations are formed in this specification (66). (But note:

$$\frac{\partial S}{\partial S_{-1}} \frac{\partial S_{-1}}{\partial S^*_{-1}} \frac{\partial S^*_{-1}}{\partial P_{-1}} = \frac{\partial S}{\partial P_{-1}} < 0$$

where

$$\frac{\partial S}{\partial S_{-1}} > 0, \ \frac{\partial S_{-1}}{\partial S^*_{-1}} > 0, \ \frac{\partial S^*_{-1}}{\partial P_{-1}} < 0.)$$

Demand

Traditional empirical commodity demand analyses have sought to do one of two things:

(1) Many demand equation estimations have aimed at developing relationships that explain how consumers allocate their fixed incomes among the various commodities that they consume. At the center of such an analysis is the individual consumer, who is assumed to have an identifiable utility function that has certain characteristics or properties.

(2) The second type of demand analysis has sought to develop an empirically sound, and theoretically acceptable explanation for the aggregate demand for a commodity. Underlying these analyses are still the aspects of consumption behavior as discussed in the earlier chapters.

The second classification is the object of the current estimation effort, and the aim is to estimate U.S. regional demand (for current consumption) and U.S. inventory demand equations. The wholesale demand for groundfish fillets faced by regional dealers is a derived demand for input (in this case fresh and frozen fillets supplied to dealers in a particular region) in the final product market. Dealers add time, place, and form values to the products that they handle, and thus create a more-valued product through the production of marketing services. A general assumption, however, is that the physical quantity purchased by the dealers does not change in the production process. Dealers seek to maximize profits subject to the production of the relevant marketing services. Expressed mathematically (see equations (52) and (53)), this implies that dealers maximize:

$$(P_Y \cdot Y) - (P_1X_1 + P_2X_2 + P_3X_3) \qquad (74)$$

subject to

$$F = F(Y, X_1, X_2, X_3). \qquad (75)$$

A Lagrangian equation, Z, may be formulated to maximize:

$$Z = [(P_Y \cdot Y) - (P_1X_1 + P_2X_2 + P_3X_3) + \lambda(F(Y, X_1, X_2, X_3))] \qquad (76)$$

where:

Z = Lagrangian function

P_Y = Price paid by retailers for the final product.

P_1 = Average price paid to exporting regions and domestic producers (acquisition price).

P_2 Average wage rate.

P_3 = Price of other materials used in the dealers' production process.

Y = Final product form (fresh and frozen fillets) available through the provision of marketing services.

X_1 = Wholesale quantities purchased for current consumption (that is, apparent consumption).

X_2 = Units of labor used in production by dealers.

X_3 = Units of other materials used in production.

F = Single-product multi-input production function for final product form.

The first order conditions give rise to the demand for an input facing wholesale dealers in the groundfish fillets market (see equation (57)):

$$X_1 = f(P_Y, P_1, P_2, P_3) \tag{77}$$

Equation (77) suggests that the demand for fresh and frozen groundfish fillets by U.S. regional dealers (and hence the demand facing the wholesalers) is a function of: (a) the dealers' average acquisition price; (b) the wholesale price paid by retailers, and (c) other input prices (mainly labor and materials).

Following the theoretical considerations discussed (Chapter III) for utility maximization subject to a budgetary constraint, the price paid by retailers, and consumer disposable income are legitimate arguments of the product demand function facing dealers. The average wholesale price of fresh and frozen fillets is used in the equation as a proxy for the price paid at all wholesale and institutional levels, and for all uses. Regional or economic area personal disposable income is used as income in the wholesale demand function. Equation (77) may be modified to read:

$$X_1 = f(P_{Y1}, P_{Y2}, \ldots, P_{Yn}, P_1, P_2, P_3, I) \tag{78}$$

where $P_{Y1} = P_Y$, and P_{Yj} $(j=2,\ldots,n)$ are substitute and complement product prices facing groundfish retailers. It is assumed that the final product price, P_{Y1} will account for the cost of production (including input acquisition) and will therefore reflect the influence of P_1, P_2, and P_3. These three variables are excluded for the above reason and data limitations.

The availability of substitute fish products and other protein sources will influence the wholesale demand for the product of interest. The wholesale price of competing fish products and the price of poultry may therefore be included as arguments to account for the influence of substitutes or complements. Also, the level of beginning inventory is hypothesized to influence wholesale demand, especially when inventories contribute substantially to regional supply. In general, high beginning-of-month inventory levels will relate positively to the wholesale demand.

The lagged dependent variable may also help to explain dealers' purchases in a particular period. Such a variable may either explain the habitual purchases of dealers over the entire period of study or account for a lag in actual purchases which is designed to satisfy current supply commitments by regional dealers. Seasonal characteristics of domestic production, imports, and inventory movements may also influence prices which may, in turn, influence quantities supplied and purchased. Monthly dummies are therefore included to capture the effects of seasons.

Based on the above discussions, the wholesale demand function facing the regional dealers may be modified again (subscripts are dropped for clarity):

$$X = X(P,\ PSF, PP,\ INV,\ X_{-1},\ I,\ D_K) \tag{79}$$

where

X = Regional monthly demand facing dealers.

P =Average price of product paid by retailers and institutional consumers at the beginning of the month.

PSF= Average monthly wholesale price of substitute fish product.

PP = Average monthly wholesale price of poultry.

INV= Beginning-of-period inventory.

X_{-1}= Lagged value of X

I = Total regional personal income.

D_K = Monthly dummy variables (K = 1, 2, ..., 11)

Equation (79) is estimated as a linear relationship:

$$X = a_0 + a_1P + a_2PSF + a_3PP + a_4INV + a_5X_{-1} + a_6I + \Sigma_K d_K D_K + U_t \quad (80)$$

where D_1 = 1 for February
0 otherwise

D_2 = 1 for March
0 otherwise, etc.

and U_t is a disturbance term.

Inventory Demand Equations

As indicated earlier, it is often difficult to define and explain groundfish inventory behavior satisfactorily. This is because groundfish fillets inventories in the U.S. may be held by one or more groups of market participants. These groups may hold inventories for different purposes, some of which may overlap between groups. In the U.S., groups that are known to have held inventories at one time or another include processors, and a combination of dealers, importers, brokers, wholesalers, and speculators. The data on groundfish fillets inventory include commercial stocks held for various reasons. These inventories only crudely reflect the motives of the major groups of stockholders, and this makes both theoretical and empirical studies of inventory behavior very difficult. The inventory behavior assumed in the current study reflects the behavior of all participants in the market who have the motive for holding inventories, and also have the facilities to do so.

The inventory demand equation developed in this study is a demand for end-of-period inventory. It is specified to reflect partial adjustment towards a desired ending inventory. This suggests that dealers may not have complete control over their stock holdings, in the sense that actual ending inventories may not be equal to the desired levels. The desired ending inventory levels are postulated to be a linear function of current actual (beginning-of-period) prices, and prices expected at the beginning of the next period. This is expressed, mathematically, as (from equation (65)):

$$INV_t^* = b_0 + b_1 P_t + b_2 P_t^* \quad (81)$$

where

INV_t^* = desired ending inventory in period t.

P_t = actual average observed beginning of period wholesale price.

P_t^* = Average expected wholesale price at the beginning of period t+1.

INV_t^* and P_t^* are not observable. However, certain assumptions can be made concerning their functional relationships that will allow them to be included in the specification of an estimable equation. First, expected prices are defined under the assumption that inventory holders follow extrapolative expectations. Expected prices are therefore a function of previous actual price plus or minus a fraction of the previous price change, that is (from equation (66)):

$$P_t^* = P_{t-1} + \beta(P_{t-1} - P_{t-2}) \quad (0 \leq \beta \leq 1) \tag{82}$$

Second, the concept of partial inventory adjustment adopted in the current study follows one first specified by Goodwin (1968):

$$INV_t - INV_{t-1} = \varphi(INV_t^* - INV_{t-1}) \quad 0 \leq \varphi \leq 1 \tag{83}$$

where

INV_t = actual ending inventory in period t.

INV_{t-1} = actual ending inventory lagged one period.

P_{t-1} = actual average wholesale price lagged one period.

$(P_{t-1}-P_{t-2})$ = Change in wholesale price in the period previous to t.

β = coefficient of price change.

φ = coefficient of adjustments.

The remaining variables have the same meaning as before.

Combining equations (81), (82), and (83), an estimable equation specified in observable variables may be derived:

$$INV_t = \varphi(b_0 + (b_1+b_2)P_t + b_2\beta\Delta P_t) + (1-\varphi)INV_{t-1}$$
$$= \varphi b_0 + \varphi(b_1+b_2)P_t + \varphi\beta b_2\Delta P_t + (1-\varphi)INV_{t-1}$$

$$INV_t = \alpha_0 + \alpha_1 P_t + \alpha_2 \Delta P_t + \alpha_3 INV_{t-1} + \sum_{k=1}^{n} d_k D_K + U_t \quad (84)$$

where U_t is a disturbance term, and the expression $\sum_{k=1}^{n} d_K D_K$ is the summed effect of seasonality as introduced through production and prices.

Supply

The supply relationships developed in this study, like the demand relationships, also follow the traditional derivation of supply functions. In general, producers and suppliers seek to maximize profit, subject to some production function constraint. Similarly, it can be said that foreign suppliers seek to maximize net foreign exchange earnings subject to various production and trade restrictions.

Import Supply Equations

Supplies of groundfish products from foreign sources are assumed to come from excess supply in the exporting countries. For the purposes of the current study, two exporting regions are identified: Canada and Europe. Import supply is hypothesized to be explained by variations in import prices, U.S. wholesale prices, past import quantities (reflecting long-term political or economic arrangements), and exchange rates (value of currency of exporting region per U.S. dollar). A linear import supply equation for Canadian groundfish fillets is represented by:

$$MC_t = f(P_t, PC_t, PE_t, ERC_t, MC_{t-1}, D_K, U_t) \qquad (85)$$

Similarly, supply from European sources is represented by:

$$ME_t = f(P_t, PE_t, ERE_t, MC_{t-1}, D_K, U_t) \qquad (86)$$

where

MC = import supply from Canadian sources.

ME = import supply from European sources.

MC_{t-1} = lagged Canadian import supply.

ME_{t-1} = lagged European import supply.

PC = import price of Canadian product.

PE = import price of European product.

ERC = Canadian exchange rate.

ERE = European exchange rate (Icelandic exchange rate is used as proxy).

The remaining variables have the same interpretations as before.

In formulating the above import supply equations (85) and (86) consideration is given to the fact that institutional constraints existing in both exporting and importing regions may prevent the international market from operating efficiently. For example, quotas and tariffs may introduce aspects of trade arrangements that are far from efficient. Also seafood trade prices may be agreed upon at an earlier date than when the product is delivered. This could have a bearing on the effects of changes in exchange rates. There may also be limitations placed on trade by the inadequacy of appropriate modes of transportation.

U.S. Ex-Vessel Demand

The ex-vessel demand equation is actually the demand for domestically produced products. Landings are treated as exogenous in the short run. In the long run, fishermen may change their response to changing prices. They may also change their target species in response to changing relative prices and changing revenues. Responding to changing prices and revenues this way is much more limited in the short run when fishermen cannot alter vessel capacity or vessel power. Also, landings may be influenced by variations in stock abundance, weather, and other environmental factors that cannot be controlled by the fisherman or processor. In the absence of a useful biological production relationship that can be incorporated in the ex-vessel demand specification, this demand relationship is represented as a price-dependent equation. The ex-vessel demand is derived from the ex-vessel/wholesale price spread relationships included in the conceptual model:

$$P_t^{exv} = P(P_t,\ PC_t,\ PE_t,\ L_t,\ U_t) \tag{87}$$

where the variables have the same interpretation as before.

U.S. Domestic Supply

The supply from U.S. domestic production is assumed to be price-inelastic. Many exogenous factors, which are beyond the control of fishermen, influence landings in the U.S. The production of fillets from such landings is assumed to bear a constant relationship to the quantities and quality of the raw fish landed. Fishing is seasonal in nature, and it is expected that the fixed (1972-1981 monthly average) quantities produced domestically will vary by the month.

Ex-Vessel/Wholesale Price Spread and Ex-Vessel Elasticities

Both wholesale and retail markets represent links in the chain of specialized institutions and agencies that affect the marketing process. The prices at these market levels are linked by specific marketing charges which, for groundfish products, may include the cost of processing, packaging, storage, transportation, and a margin for profits.

While traditional demand theory has usually neglected the spread of prices between identifiable market levels, it is evident that many public policy decisions have occasionally been influenced by marketing margins. It appears, therefore, that economic analyses of factors influencing prices will be incomplete without a look at marketing margins. George and King (1971) maintain that "...the lack of understanding of the nature of margins and their behavior on the market seriously limits our understanding of demand theory."

In this study, marketing margins and the theoretical relationships that they give rise to are included to offer a way of estimating elasticities at the ex-vessel level from knowledge of wholesale market relationships, and the estimated spatial equilibrium prices and quantities.

The concept of dockside-wholesale price spread implied in this study is the difference between the wholesale price of the processed product (wholesale suppliers' share) and the payment to the fishermen, as returns for the harvesting of the raw fish product (fisherman's share). An initial problem of specifying an ex-vessel/wholesale price spread arises because different methods of setting prices exist for the different product forms, and also the term "wholesale suppliers" involves diversified groups with different motives and aspirations. It is assumed that the price spreads in the groundfish product market are determined by the combined operation of "absolute" and "percentage" price margins. Further, it is assumed that margins are a linear function of ex-vessel prices; that is,

$$M = a + bP^{exv} \tag{88}$$

and

$$P^{W} = P^{exv} + M \tag{89}$$

where P^{W} (=P in earlier equations) and P^{exv} are wholesale price and ex-vessel price, respectively, of the product. M is the corresponding market margin.

From equations (88) and (89),

$$\begin{aligned} P &= P^{exv} + a + b\,P^{exv} \\ &= a + (1 + b)P^{exv} \end{aligned} \tag{90}$$

$$P^{exv} = -\frac{a}{(1 + b)} + \frac{1}{(1 + b)}\,P$$

$$P^{exv} = \alpha + \beta\,P \tag{91}$$

where $\alpha = -a/(1+b)$ and $\beta = 1/(1+b)$.

It is possible to derive parameters at the ex-vessel level from knowledge of the wholesale market level, especially from the regional demand specifications outlined earlier. For example, a derived demand equation for the wholesale marketing group (brokers, wholesalers, processors, etc.) is generally specified as (equation (79)):

$$Q = f(P,\ PSF,\ PP,\ INV,\ Q_{-1},\ I,\ D_K) \tag{92}$$

The elasticity at the wholesale level "e" is defined by:

$$e = \frac{\partial Q}{\partial P} \cdot \frac{P}{Q} \tag{93}$$

The elasticity that can be obtained from a derived demand equation at the ex-vessel level "E" is:

$$E = \frac{\partial Q}{\partial P^{exv}} \cdot \frac{P^{exv}}{Q} \tag{94}$$

Now $$\frac{\partial Q}{\partial P^{exv}} = \frac{\partial Q}{P} \cdot \frac{\partial P}{\partial P^{exv}} \tag{95}$$

so

$$E = \frac{\partial Q}{\partial P} \cdot \frac{\partial P}{\partial P^{exv}} \cdot \frac{P^{exv}}{Q} \tag{96}$$

From equation (91) $\dfrac{\partial P}{\partial P^{exv}} = \dfrac{1}{\beta_j}$

Then $$E = \frac{1}{\beta_j} \cdot \frac{\partial Q}{\partial P} \cdot \frac{P^{exv}}{Q} \tag{97}$$

Multiply and divided the RHS of (97) by P, then

$$E = \frac{1}{\beta_j} \cdot \frac{\partial Q}{\partial P} \cdot \frac{P}{Q} \cdot \frac{P^{exv}}{P}$$

$$E = \frac{1}{\beta_j} \cdot e \cdot \frac{P^{exv}}{P} \quad \text{(from equation (93))}$$

E can be estimated from knowledge of β_j, e, P^{exv}, and P, and the necessary inferences at the ex-vessel level can be drawn.

Summary of the Structural Equations

The earlier chapters explain the reasons for estimating the econometric model. Essentially, the econometric model determines the relationships between product prices, domestic landings, import supply, and other factors which are relevant for explaining the demand for groundfish products and inventory adjustments.

The model is specified as a system of seven behavioral equations and three identities for each of the product (species) markets identified for the purposes of this study. The structural equations derived from the system of behavioral and identity equations specify the most important relationships characterizing the broader groundfish market. These equations represent wholesale and ex-vessel demands, inventory adjustments, and import supplies. The individual equations discussed below should be regarded as general across species. While the list of variables appearing in each product model is comprehensive, modifications to individual equations are made which involve reshuffling of variables among equations. This is done in an attempt to specify unique equations for the different product markets. Thus, the variables included in each equation are suggested by both economic theory and the unique characteristics of the product market. For example, the demand for a groundfish product is considered to be a function of the product's own price, prices of substitutes and/or complements, and per capita income. Also, a change in income variable may be added to test the possibility that wholesale purchases of these products might be deferred if income temporarily declines, or they might be speeded up if income temporarily increases.

The Cod Fillets Wholesale Market

Wholesale Demand:

$$CCF = (WPC,\ Y_{-1},\ CHY,\ BI,\ CCF_{-1},\ D_1,\ \ldots,\ D_{11}) \tag{98}$$

Inventory Demand:

$$E_I = (WPC,\ CHWPC,\ BI,\ D_1,\ \ldots,\ D_{11}) \tag{99}$$

Canadian Supply:

$$CIS = (IPC,\ IPE,\ WPC,\ EFJ,\ D_1,\ \ldots,\ D_{11}) \tag{100}$$

European Supply:

$$EIS = (IPE,\ IPC,\ WPC,\ EFJ,\ FLD,\ D_1,\ \ldots,\ D_{11}) \tag{101}$$

Domestic U.S. Ex-Vessel Demand:

$$EPC = (WPC,\ IPC,\ IPE,\ LC,\ Y,\ EFJ,\ D_1,\ \ldots,\ D_{11}) \tag{102}$$

Where EPC and WPC are average ex-vessel and wholesale prices of cod fillets, respectively; IPC and IPE are average import supply price of cod fillets from Canada and Europe, respectively; Y and CHY are per capita income and change in per capita income, respectively; CCF is cod fillets consumption; EI and BI are end-of-month and beginning-of-month inventory, respectively; LC and FLD are U.S. landings of cod and rest of the world production of groundfish (cod, ocean perch, and flounders), respectively; CIS and EIS are Canadian and European import supply, respectively; EFJ is dummy for U.S. 200-mile extended fisheries jurisdiction; $D_1,\ldots,D_{11}$ are seasonal dummies, D_1 = February, D_{11} = December; CHWPC is the change in wholesale price; and -1 indicates a one month lag of a variable.

<u>The Ocean Perch Fillets Wholesale Market</u>

Wholesale Demand:

$$COPF = (WPOP, WPP, Y_{-1}, CHY, B_1, COPF_{-1}, D_1, \ldots, D_{11}) \quad (103)$$

Inventory Demand:

$$EI = (WPOP, CHWPOP, BI, D_1, \ldots, D_{11}) \quad (104)$$

Canadian Supply:

$$IPC = (CIS, EIS, WPOP, EPOP_{-1}, EFJ, D_1, \ldots, D_{11}) \quad (105)$$

European Supply:

$$IPE = (EIS, CIS, WPOP, EPOP_{-1}, EFJ, D_1, \ldots, D_{11}) \quad (106$$

Domestic U.S. Ex-Vessel Demand:

$$EPOP = (WPOP, CIS, Y, LOP, EFJ, D_1, \ldots, D_{11}) \quad (107)$$

Where EPOP and WPOP are average ex-vessel and wholesale prices of ocean perch fillets, respectively; COPF is monthly ocean perch fillets consumption; CHWPOP is the change in ocean perch wholesale price; WPP is average wholesale price of poultry; and LOP is U.S. domestic landings. The other variables have similar interpretation as before when applied to ocean perch fillets.

<u>The Flounder Fillets Wholesale Market</u>

Wholesale Demand:

$$CFF = (WPF, WPC, Y_{-1}, CHY, BI, CFF_{-1}, D_1, \ldots, D_{11}) \quad (108)$$

Inventory Demand:

$$EI = (WPF, CHWPF, BI, D_1, \ldots, D_{11}) \quad (109)$$

Canadian Supply:

$$IPC = (CIS, BI, CFF_{-1}, WPF, EFJ, D_1, \ldots, D_{11}) \quad (110)$$

European Supply:

$$IPE = (EIS, WPF, FLD, EFJ, D_1, \ldots, D_{11}) \quad (111)$$

Domestic U.S. Ex-Vessel Demand:

$$EPF = (WPF, CIS, EIS, Y_{-1}, LF, EFJ, D_1, \ldots, D_{11}) \quad (112)$$

Where EPF and WPF are average ex-vessel and wholesale prices, respectively; CFF is the monthly consumption of flounder fillets; CHWPF is the change in flounder fillets wholesale prices; and LF is U.S. landings of flounders. The other variables have similar interpretation as before when applied to flounder fillets.

The domestic wholesale demand for cod fillets is hypothesized to be a function of the average wholesale price of cod, lagged per capita income, change in personal income, beginning-of-the-month inventory, and consumption in the previous period. Domestic groundfish is sold mainly as fresh fillets. Some domestically produced fillets may go into freezing during peak landing periods, and sold later as frozen products. These quantities are not well documented. The proportion of total disappearance that comes from domestic production is relatively small. Most of the cod fillets consumed in the U.S. comes from frozen products, mainly supplied from imports. A portion of the import supply is sold for immediate consumption while a substantial amount goes into cold storage. Like domestic freezings, the proportions of imported groundfish fillets that go into various uses are not separately documented. Very often frozen fillets are restored to "fresh" condition by a careful and slow thawing process and sold as fresh fillets. The quantities treated this way are not exactly known. Due to the uncertainties surrounding the proportions of truly fresh and frozen products consumed in any particular month, the product definition of "fresh and frozen fillets" is adopted for the purposes of this study. Since fresh and frozen products command different prices in the market place, an average of these prices (average wholesale price) is used.

The wholesale demand (disappearance) is a derived demand facing dealers and other intermediaries. Since most of the products handled by intermediaries can be stored over the short run, the change in income variable is introduced to determine the effect of temporary changes in per capita income on the demand facing dealers. The data period (one month) is short enough to expect that the previous month's income, rather than the current income, and the immediate past consumption levels can be expected to influence demand. Also, beginning inventory will influence the amount of the product available for consumption during the month. Beginning inventory and per capita income (and other variables to be discussed later) are included to serve as demand shifters.

The end-of-month inventory is hypothesized to depend on the wholesale price facing dealers, the change in wholesale price, and beginning-of-month inventory. Underlying this specification is the inventory adjustment-price expectations relationships discussed earlier.

The foreign supply equations for cod fillets are specified as quantity-dependent relationships. The Canadian and European import supplies are hypothesized to depend on the domestic wholesale price, the export price in the exporting nation, the export prices in the competing nation, and a binary dummy which is introduced to capture the specific effects of the U.S. 200-mile extension of fisheries jurisdiction. In addition the European supply is hypothesized to depend on the rest of the world landings of groundfish (cod, flounders, ocean perch).

The ex-vessel demand equation is actually the demand for domestically produced cod, and landings are treated as exogenous in the short run. In the long run, fishermen and processors may change their response to changing prices. Fishermen may also change their target species in response to changing relative prices and changing revenues. Responding to changing prices and revenues, this way, may not be possible in the short run when vessel capacity cannot be altered and/or fishing power cannot be improved. Also, landings may be influenced by seasonal variations in species abundance, weather, and other factors that fishermen and processors cannot control. In the absence of a useful biological relationship that can be incorporated in the ex-vessel demand, the ex-vessel demand is represented as a price-dependent relationship. Ex-vessel price is hypothesized to be a function of domestic wholesale price, Canadian and European export prices, U.S. domestic landings, per capita income, and a binary dummy for the U.S. extended fisheries jurisdiction.

Monthly dummies representing seasonality in supply and demand are introduced in all equations, and they play the role of intercept shifters.

The structural equations for the ocean perch fillets market are derived in the same way as the cod fillets equations. The wholesale fillets demand is hypothesized to be a function of the product's own price, the price of a substitute protein source (poultry), per capita income lagged one month, change in income, and beginning-of-month cold storage. The inventory demand equation expresses end-of-month cold storage as a function of wholesale price, change in wholesale price and beginning-of-month cold storage. The import supply relationships are specified differently. The foreign exporters of groundfish fillets appear to have less flexibility with quantities of ocean perch fillets (and flounder fillets) exported to the U.S. than they have with the quantities of cod fillets exported. As a result, there seems to be less variability in export quantities than in the export supply prices. The import supply equations are therefore represented as price-dependent relationships. The Canadian supply of ocean perch fillets to the U.S. market is hypothesized to be a function of the export quantities, the supply of a competing foreign source (Europe), the U.S. wholesale price, lagged import supply price, and a binary dummy introduced to capture the effects of the U.S. 200-mile extended fisheries jurisdiction. The European import supply is also represented as a price-dependent relationship. European import supply price is hypothesized to be a function of the quantity supplied, the supply of a competing foreign source (Canada), the U.S. wholesale price, one month lag of the export price, and a binary dummy for the U.S. extended fisheries jurisdiction. For the same reasons discussed for ex-vessel demand for domestically produced cod, the ex-vessel demand for ocean perch is represented as a price-dependent relationship. The ex-vessel price of ocean perch is hypothesized to be a function of the wholesale price, the Canadian supply, the U.S. per capita income, domestic landings, and a binary dummy for the U.S. extended fisheries jurisdiction. In all cases, monthly dummies (intercept shifters) are introduced to capture seasonal effects.

The structural equations for flounder fillets are similar to those of ocean perch fillets. The U.S. domestic wholesale demand is hypothesized to be a function of the wholesale price, the price of a substitute product (cod fillets), per capita income lagged one period, change in income, beginning-of-month cold storage, and the immediate past consumption level. The end-of-month inventory is also hypothesized to be a function of the wholesale price, change in wholesale price, and beginning-of-month inventory. The import supplies from Canada and Europe and the domestic ex-vessel demand are expressed as price-dependent relationships. The Canadian import supply price is hypothesized to be a function of the quantity supplied, beginning-of-month cold storage in the U.S., one month lag of apparent disappearance in the U.S., the U.S. wholesale price, and a binary dummy for the U.S. extended fisheries jurisdiction. The European import supply price is also hypothesized to be a function of the quantity supplied, the wholesale price in the U.S., the rest of the world production of groundfish, and a binary dummy for the

U.S. extended fisheries jurisdiction. An increase in groundfish production by the rest of the world should depress the price that exporters can expect U.S. importers to pay. The ex-vessel price is hypothesized to be a function of the wholesale price, the quantities supplied from foreign sources, lagged U.S. per capita income, domestic landings, and a binary dummy for the U.S. extended fisheries jurisdiction. As in the case of the other structural equations, monthly dummies are used to shift the intercept coefficients of each equation for each month of the year.

In general, one would expect prices at the wholesale level to exhibit less variability than at the ex-vessel level. This is due to the presence of inventories which tend to stabilize wholesale prices over the long run. Ex-vessel prices also tend to follow the wide variability in landings dictated by the seasonal variability in stock abundance.

CHAPTER V

THE SCOPE OF THE STUDY AND DATA REQUIREMENTS

The study area is defined to include three separate, but not isolated, markets for the major groundfish species. For simplicity and convenience, the three broad regions identified for the current study are: the U.S.A., Canada, and Europe. The U.S. groundfish market is the focus of this study, however, this market is largely influenced by imports from Canada and Europe. European exports to the U.S. market have usually come from Iceland, Norway, and Denmark. Occasionally, data on European supply may include small quantities from the Netherlands, the United Kingdom, Japan, and South Korea. The U.S., Canada, and the European nations mentioned above have been major producers and consumers of fish and shellfish products during the study period.

For the purpose of the current study the U.S. is partitioned into eight consuming regions: Oregon, Washington, California, New England, Mideast, Southeast, Southwest, and the Great Lakes. Inventories are held in New England. The respective regional centers are Portland, Seattle, Los Angeles, Boston, New York City, Miami, Dallas, and Chicago. The supply regions are defined to include Oregon, Washington, New England, California, Alaska, Canada, and Europe. The selected regional supply centers are Portland, Seattle, Boston, San Francisco, Anchorage, Atlantic Canada, and Iceland, respectively.

The U.S. Pacific Coast Groundfish Fishery

The U.S. market place has, until recently, considered the northeast Pacific groundfish products to be inferior to those of other oceans (Pacific Fishing, 1981). There has also been the suspicion that the Pacific Coast fishery is not capable of meeting adequate quality standards, and that suppliers in this region do not comprise a reliable segment of the U.S. food-fish products industry. The target species in this region have included many species of rockfish (the dominant being Pacific Ocean perch), dover sole, flounder sole, other soles (mainly petrale), lingcod, Pacific cod, and sablefish. Pacific Ocean perch is currently recovering from overfishing in both the Pacific Northwest and Alaskan waters. The seasonal availability and density distribution of stocks in the Pacific suggest that consumer choices are limited by what is available to sellers. Product presentation and enhancement, therefore, become crucial to the West Coast fisherman and processor. Most participants in the Pacific Coast groundfish fishery believe that the single most important impediment to industry expansion is the lack of markets (Pacific Fishing, 1981). The most important market is southern California where about 75 percent of the coastal population resides. Estimates by the Pacific Fishery Management Council (PFMC) seem to suggest that the supply of the valuable groundfish species off the California, Oregon, and Washington Coasts is limited. Specifically, PFMC estimates of maximum sustainable yields indicate that there is room for just about 35 percent overall increase in landings of the dominant commercial species. The U.S. Fishery Conservation and Management Act of 1976 extended the U.S. fishery zone to 200 miles with effect from March 1, 1977. It would appear that the Pacific Coast groundfish industry has not benefited from the extension of fisheries jurisdiction to the extent that was expected at the time the Act was passed.

Data and Sources

The data used in this study were obtained mainly from secondary (published) sources or derived from secondary data for the period January 1972 to September 1981. The "Food Fish Market Review and Outlook" (Current Economic Analysis F13 to F33, by the U.S. Department of Commerce) is the source of most of the quantity and price data. Monthly data assembled from this source include the New England landings of the species of interest, national cold storage holdings, apparent disappearance, wholesale prices (for frozen fillets), ex-vessel prices (average for Atlantic Coast ports), and average import supply prices (as quoted at the major ports of entry).

Pacific Coast fillets production data by species are not available on a monthly basis. The National Marine Fisheries Services (NMFS) publications give only aggregated annual information on fillets. Even these annual summaries have been found to be of "uneven quality due to possibly unrepresentative sampling in some states" (Thompson, 1986) especially California. In the absence of reliable published data on the Pacific Coast production of fillets (cod, ocean perch, flounders) an alternative approach is adopted. The appropriate data are derived from published data on species landings by states. The information on landings is available through PACFIN's Monthly Commercial Groundfish Landed (catch in round weight) by state. PACFIN's data are compiled from landings data collected by (1) The Alaska Department of Fish and Game, (2) Oregon Department of Fish and Wildlife, (3) Washington Department of Fisheries, and (4) California Department of Fish and Game.

By assuming that fish are processed into fillets in the same month that they are landed (this assumption is usually valid for most groundfish species including cod, ocean perch, and flounders) the published round weight is converted to fillet weight. The round weight (in 1000 pounds) is multiplied by an appropriate conversion factor (Wang, Dirlam, and Norton; 1978): 0.325 for cod, 0.351 for ocean perch, and 0.341 for flounders.

The state/regional personal income data are obtained from the Bureau of Economic Analysis publication entitled "State Personal Income: Estimates for 1929-1982." State and regional populations are also obtained from the same source. The U.S. import supplies of groundfish from Canada and from other sources (mainly European) are obtained from the Fishery Market News Report (B-31) of various months for the period 1972-1981. The exchange rate series are obtained from the IMF Monthly Bulletin (various years). Foreign landings are represented by a proxy, obtained by adding the total import supply of the three species analyzed in the study.

Data on transport rates between regions are not available for groundfish species. However, there is reason to believe that groundfish products are transported across the U.S. in a similar fashion as fresh and frozen fruits and vegetables. Boles (1977, 1979) has prepared comprehensive cost estimates and estimation procedures for trucking fresh fruits and vegetables across the U.S. These estimates have been adopted with the appropriate modifications. Using Boles' estimation procedures and the highway distances between the selected major cities, the rates per pound per mile between city pairs are calculated (Appendix A). "Pacific Fishing" (1980) gives estimates of transport rates from Atlantic Canada ($0.04/ pound) and Europe (Iceland) ($0.07/pound) to the East Coast of the U.S. These rates are adjusted by the appropriate transportation index. It is assumed that cold storage holdings are kept at a fixed cost of $0.003 per pound per month, and at a variable cost of $0.0015 per pound per month.

Specific Methodology for Deriving Consumption Data

As indicated in the earlier chapters, the use of quadratic (in the objective function) programming to solve for the U.S. interregional/international equilibrium for fresh and frozen groundfish fillets requires three basic inputs. These are: (1) production (supply) and demand regions must be defined in such a way that states within a region share the same production or consumption characteristics, (2) appropriate demand and supply functions should be determined for each specific demand and supply region, and (3) transportation rates must be calculated for each pair of supply and demand regions.

The continental U.S. is divided into eight consumption regions with each region comprising states that are similar in their consumption patterns of food-fish products. Other factors used to determine unique total regional consumption include population and disposable income. Each demand region is then represented by a single demand point (a city) based on the concentration of a region's population and economic activity. Supply sources are divided into domestic and foreign regions. These supply regions are determined by grouping together states (and countries) that have similar production characteristics. Aspects of production considered include similar production costs and similar philosophy of organizing production and marketing. Each supply region is also represented by a single production center. From a theoretical point of view, these regional demand and supply functions should be determined so that a framework may be established in which demand and supply could interact.

Regional demand functions could be estimated by an appropriate econometric procedure using data that are unique to the specific regions. Unfortunately, detailed data on consumption levels by regions are not available for extended periods. Time series data collected on the hypothesized form of the demand function include only national consumption data. However, enough information exists for deriving reasonable average per capita regional consumption for the products of interest. Capps (1982) has derived estimates of average expenditure on fish and shellfish which reflect differences in consumption in specific U.S. regions. Of relevance to the current study is the suggested credibility of such estimates. For instance, expenditures in producing regions such as the Northeast (including New England), and the West (mainly the Pacific Coast states of Washington, Oregon, and California) have been estimated to be higher than those of the other (nonproducing) areas in the U.S. The West and the Northeast appear to have expenditure levels that are much higher (in absolute terms) than the U.S. national average. Other areas (mainly non-producing but consuming regions) have lower expenditure levels than the national average. These suggested differences in expenditure between the regions are assumed to correspond to the differences in consumption among regions. They form the basis for deriving unique regional consumption levels from the observed national consumption (apparent disappearance) data. A basic assumption for adopting the Capps estimates of regional differences in consumption is that the wholesale consumption of fresh and frozen groundfish fillets follow the pattern of fish and shellfish consumption revealed in that survey. Also, it is assumed that demand beyond the survey period has not undergone any significant structural change. The actual procedure adopted in the derivation of regional consumption is similar to that discussed in George and King (1971) for the U.S. regional food consumption, and that adopted by Thatch, Share, and Edelberg (1985) for the Northeast U.S. fresh peaches market.

The Capps study identifies four different consumption regions in the continental U.S.A.: The Northeast, the North Central, the South, and the West. Mean expenditures were derived for these regions and for the U.S. Regional consumption indexes are derived by dividing the regional mean expenditures (and the national mean) by the U.S. mean expenditure values. By multiplying the U.S. average monthly per capita consumption values by the appropriate regional index, regional monthly per capita consumption data are obtained. This way, the U.S. per capita consumption data are multiplied by unity, as indicated in Table 8. Unique total regional consumption figures are derived by multiplying the per capita regional consumption figures by the respective regional population figures. The resulting data are unique to the region's specified in the current study because they distinguish between producing and nonproducing areas, and reflect regional consumption patterns.

Table 8. Derivation of Consumption Indexes.

Region	Number of Households	Mean Expenditures	Consumption Index (CI)
US	10,294	2.81	2.81/2.81 = 1.0000
North-east	2,749	3.32	3.32/2.81 = 1.1815
North Central	2,571	2.31	2.31/2.81 = 0.8221
South	2,950	2.72	2.72/2.81 = 0.9680
West	2,024	2.91	2.91/2.81 = 1.0356

SOURCE: Indexes are computed by author from mean expenditures--Capps (1982, Table 6).

CHAPTER VI

RESULTS

Econometric Estimation Procedures and Results

Two stage least squares (TSLS) estimation procedures are used to estimate each set of structural equations. The TSLS procedure is chosen because it allows for less cumbersome (compared to some more sophisticated estimation procedures) correction procedures for serially correlated error terms in the presence of lagged dependent variables as explanatory variables. In this case the particlar specifications of the structural equations have greatly influenced the choice of estimation procedures. The TSLS has less complicated measures of good fit for the individual equations and for the econometric model as a whole.

It should be noted that the R^2 and the t-ratios of the second stage of the TSLS do not have the traditional interpretation or represent appropriate measures of good fit. For the current econometric modeling effort, the root mean square percent error (RMSPE) is adopted as a measure of good fit. The t-ratios are also adjusted[1/]

1/ The standard errors used to compute the t-ratios of the coefficients of the second-stage regression of the TSLS are "corrected" by multiplying each of them by the ratio of the OLS standard deviation to the second-stage standard deviation of the TSLS. See Gujarati (1978), Appendix 18A.2 for a discussion of this approach.

through a correction of the standard errors of the second stage equations. Where lagged dependent variables are included as explanatory variables, and serial correlation is suspected, a correction is made for first-order serially correlated errors in the presence of such lagged endogenous variables using procedures suggested by Fair (1970).

The estimation results are reported in equations 1 through 15 (Appendix B). The parameters for the various structural demand and supply equations are reported together with the adjusted t-ratios. The other measure of good fit, RMSPE, is used in its traditional role to test the performance of the model. It is a measure of how closely each endogenous variable tracks its corresponding historical data series. In this respect a small value (close to zero) for RMSPE is an acceptable indicator of good fit.

For theoretical consistency, it is useful to compare the magnitude and sign of estimated coefficients with a priori expectations when interpreting the results of econometrically estimated models. Theoretically, it is expected that the own-price coefficients of the demand functions will be negative and those of the supply functions positive. Economic theory predicts demand curves to slope downward and supply curves upward. In the reported equations the own-price coefficients for the demand and supply functions have the theoretically correct signs.

Though some of the own-price coefficients are not statistically significant (using the adjusted t-ratios as reference at the 95 percent confidence level, two-tail), in general, these results are comparable to those obtained for econometric estimates of similarly structured models of these product markets.

The coefficients of income in the cod and flounder demand equations have the expected positive signs (considering these products as normal goods) with the coefficient in the cod equation being statistically significant. The income coefficient in the ocean perch demand equation is negative and statistically insignificant. It is not unusual to observe negative income elasticities for groundfish species. Similar results have been obtained by Bell (1968, 1969), Lampe and Farrell (1969), O'Rourke and DeLoach (1971), and Crutchfield (1985). The coefficient of change in income is positive and statistically significant in the cod demand equation. This suggests that wholesale purchases (demand faced by dealers) might be speeded up if income temporarily increased. The coefficient of change in income in the ocean perch demand equation is negative, and statistically significant. This also suggests that a temporary decline in income would defer purchases of ocean perch fillets. The coefficient of change in income in the flounder demand equation is positive and statistically insignificant. This coefficient also suggests speeded, but small, purchases when income temporarily increases.

Earlier specifications of the cod fillets model suggest that the other fish products (ocean perch and flounder fillets) and poultry are neither good substitutes nor do they seem to be complements for cod fillets. However, poultry appears to be a good substitute for ocean perch fillets as indicated by a statistically significant positive coefficient of poultry price in the ocean perch demand equation. It can also be observed that cod fillets appear to be a good substitute for flounder fillets. This is suggested by the statistically significant positive coefficient of cod price in the flounder demand equation.

Estimated Elasticities

The own-price coefficients in the demand and supply equations form the basis for estimating own-price elasticities for the major species and the selected regions. The specific forms of the wholesale demand equations estimated suggest that the elasticities derived from the unadjusted coefficients will be for the short run. Defining the wholesale price elasticity of demand as $e = \frac{\delta Q^d}{\delta P} \cdot \frac{\bar{P}}{\bar{Q}^d}$, and using the regional averages of P and Q in the initial programming solution (Tables 13, 15, and 17), the elasticities in Table 9 are obtained. The ex-vessel/wholesale price relationships developed in Chapter IV are used to derive the ex-vessel prices and price elasticities of

Table 9. Estimated Wholesale Price Elasticities for Major Groundfish Species.

	Cod	Ocean Perch	Flounders
Oregon	-1.063	-0.614	-0.456
Washington	-1.041	-0.632	-0.441
California	-1.102	-0.661	-0.429
U.S.A.	-1.146	-0.598	-0.755
Inventory Demand	-0.155	-0.245	-0.094
Inventory Supply	0.208	0.244	0.120
Canadian Supply	0.890	0.549	0.016
European Supply	0.455	0.384	0.008

Source: Computed by author from Appendices B, D, F, and H.

demand. These elasticities are presented in Table 10. The estimated ex-vessel prices are presented in Table 13 for cod. By assuming that the wholesale and ex-vessel price elasticities of demand estimated for the initial programming solutions are the true estimates for the selected products and regions, they are used as the basis for estimating ex-vessel prices under the various experiments:

$$\bar{p}^{exv} = \left(\frac{E_0}{e_0}\right)^{\beta_j} \cdot \bar{P}$$

where $\bar{p}^{exv}$ = average ex-vessel price

E_0 = base ex-vessel price elasticity of demand

e_0 = base wholesale price elasticity of demand

β_j = coefficient of wholesale price in the ex-vessel/wholesale price equation

$\bar{P}$ = estimated average wholesale price for an experiment.

The wholesale and ex-vessel price elasticities of demand for cod fillets are greater than unity (elastic). The wholesale price elasticities of demand for ocean perch and flounders are less than unity (inelastic) while the corresponding ex-vessel price elasticities are greater than unity (elastic).

The coefficients of the income variable form the basis for estimating the regional income elasticities for the three products of interest. The income elasticities are defined as:

Table 10. Estimated Ex-Vessel Price and Income Elasticities for Major Groundfish Species.

	Cod	Ocean Perch	Flounders
EX-VESSEL			
Oregon	-2.901	-3.156	-2.355
Washington	-2.839	-3.233	-2.294
California	-3.007	-3.335	-2.240
U.S.A.	-3.128	-3.426	-4.234
INCOME			
Oregon	0.413	-0.205	0.359
Washington	0.433	-0.225	0.375
California	0.488	-0.247	0.390
U.S.A.	0.457	-0.228	0.579

Source: Computed by author from Appendices B, D, F, and H, and Table 9.

$$\eta_Y = \frac{\delta Q^d}{\delta Y_t} \cdot \frac{\bar{Y}_t}{\bar{Q}^d}$$

Using the averages of the regional incomes, $\bar{Y}_t$, and the averages of the regional demand quantities from the initial programming solution, the income elasticities in Table 10 are obtained. All the income elasticities are less than unity (inelastic). This suggests that quantities demanded of the target products are not highly responsive to disposable income.

The demand and supply elasticities for domestic (U.S.) inventories, and the price elasticities of import supply (Canadian and European) have also been estimated for the three species using the approach adopted for the regional elasticities of demand. These elasticities are presented in Table 9. As expected, these estimated elasticities suggest that the supply of imports is price inelastic for fillets of all species. In general, the estimated elasticities in this study are comparable in magnitude and sign to those estimated in earlier studies by Crutchfield (1985), Bockstael (1977), and O'Rourke and DeLoach (1971).

<u>The Programming Solutions and Dicussion</u>

A summary of the spatial equilibrium solutions is presented in Tables 11 through 18. From these results, dealers' wholesale revenues by state are calculated by multiplying the total 12-month quantities by the 12-month average price. The estimated revenues for the three target states of Oregon, Washington, and California are summed to obtain the regional (Pacific Northwest) revenues under various scenarios. The results under initial solution reflect the current production and market structures. The other headings indicate the results of the various experiments discussed in Chapter I. The initial solution (quantities supplied and demanded, prices and shipments) reflects the particular formulation of the programming model discussed earlier. The slope of the supply and demand equations, and the cost of shipping between pairs of supply and demand centers determine the magnitudes of the elements of the solution matrix. The initial solutions suggest that the Pacific Coast production is consumed in the same region.

Model Validation

Validation of the results of the quadratic programming solution is achieved by comparing the product flows with survey data, and the estimated supply and demand quantities with observed product disposition data. These validation procedures are adopted because of the difficulty in obtaining other relevant information for a more rigorous test of the model.

Earley (1985) reports the results of a National Marine Fisheries Service (NMFS) survey in 1981. The survey covered total groundfish (of which cod, ocean perch, and flouders are only a fraction) movements in the Pacific Northwest (Appendix I). Since these survey data contain more species than are considered in this research, they do not offer a direct opportunity for comparison. However, the percentages of the total product shipped to different demand centers from various production points provide a basis for comparison. Table 11 contains information compiled from Appendix I for the purposes of comparing with results of the current research (initial solution).

The three species studied in the current research are the dominant commerical species in the Pacific Coast fishery. Most of these species landed in the Pacific states are therefore sold in the region. For example, Oregon sells about 98 percent of its cod, ocean perch, and flouders in Oregon and Washington. Washington State sells about 97 percent of its production of these species in Washington and Oregon. California produces very little of these species. The other species that are produced in abundance in California are more important to the state's economy, and as a food-fish source. The percentages of cod, ocean perch, and flounders consumed in Oregon/ Washington, and in California reflect the true proportions of these species in the total groundfish production as indicated by the survey data. The spatial analysis indicates that Oregon supplies its domestic market and also Washington and California. Washington State supplies its

Table 11. Percent Groundfish Shipments by State in the Pacific Northwest.

To	From		
	Oregon	Washington	California
Oregon/ Washington	97.6 (30.0)*	96.8 (22.9)	31.6 (7.4)
California/ Hawaii	2.4 (54.6)	3.2 (44.6)	32.1 (81.3)
Other U.S.	0.0 (14.7)	0.0 (20.8)	36.3 (2.2)
Foreign	0.0 (0.7)	0.0 (11.7)	0.0 (9.1)
Total	100.0 (100.0)	100.0 (100.0)	100.0 (100.0)
Percent Cod, Ocean Perch, Flounders to Total Groundfish	5.5	9.6	0.2

* Values in parentheses are from NMFS survey, 1981. Other values are from the initial solution of SEM.

Source: Computed by author from Appendices C, E, G, and I.

own market and markets in Oregon and California. California, on the other hand, supplies its own market, markets of Oregon and Washington, and other U.S. markets. Oregon and Washington do not supply other U.S. markets according to the results of this study. The estimated zero product flow to other markets actually reflects the concentration of the market for the Pacific Coast cod, ocean perch, and flounders in the Pacific Northwest. The positive product flows from the two states observed for the survey data reflect shipments of groundfish species other than the three featured in the current study.

A comparison of the initial solution to the quadratic programming problem with observed data is found in Table 12. In deriving the regional consumption data 15 percent of the national apparent consumption data was allocated to regions not included in this study, and also to cover losses during shipment and spoilage. Taking these adjustments into consideration, the results of this research effort are consistent with the observed percentage disposition of total groundfish (cod, ocean perch, and flounders) supply.

Considering the nationwide disposition of groundfish fillets, the three experiments discussed in this study do not lead to an observable change in the status quo as far as the sources of U.S. supply are concerned. This is not surprising: it has been discussed in Chapter V that Pacific Coast production forms only a small fraction of

Table 12. Percent Yearly Disposition of U.S. Supply of Groundfish Fillets (cod, ocean perch, flounders).

	Supply				Use	
	Beginning Stocks	Landings	Imports	Total	Ending Stocks	Apparent Consumption
Observed Data	529.3 (62.9)	106.6 (12.7)	205.7 (24.4)	841.6 (100.0)	536.4 (63.7)	305.2 (36.3)
Initial Solution	416.5 (57.1)	106.6 (14.6)	206.6 (28.3)	729.6 (100.0)	465.4 (63.8)	264.2 (36.2)
Experiment 1	418.8 (57.2)	106.6 (14.6)	206.5 (28.2)	731.9 (100.0)	466.2 (63.7)	265.7 (36.3)
Experiment 2	418.7 (57.1)	108.0 (14.7)	206.0 (28.1)	732.7 (100.0)	466.4 (63.7)	266.3 (36.3)
Experiment 3	418.7 (57.1)	108.0 (14.7)	205.9 (28.1)	732.7 (100.0)	466.5 (63.7)	266.2 (36.3)

Source: Compiled by author: Observed data: Food Fish Market Review and Outlook, 1981. Others: Computed from Appendices C through H.

the total U.S. domestic production of the major groundfish species. As can be deduced from Table 12, a 30 percent increase in the Pacific Coast production leads to only about a 1.3 percent increase in total U.S. domestic production. Consequently, the impact of a 30 percent increase in Pacific Coast production may not be as dramatic on the national market as it would on the regional market.

A casual look at the results of the policy experiments would give the impression that the QP model is insensitive to these experiments. Given the validation of the model as discussed above, insensitivity to these experiments may be caused by two aspects of the model: (a) quantity levels at which these experiments are conducted are too low to register any significant impact; and (b) collapsing (at the mean values) the econometric equations into simple price-quantity equations in the final model may create a stabilizing effect. If this is the case, some parameter values should be set at their extreme rather than their mean values.

The quantity levels chosen for the experiments suggest that a certain range of values are needed to register dramatic changes in the solution matrix. Sensitivity analysis performed on experiment 2 suggests that except in the case of ocean perch, an increase of 25 percent (and below) in the Pacific Coast landings has no effect on the Pacific Coast market (that is, the original initial solution matrix is not altered). On the other hand an increase of 30 percent or more affects the distribution matrix of all species. A 30 percent increase in the Pacific Coast landings was selected because: (i) this value is realistic given the current discussions within the Pacific Fishery Management Council (PFMC); and (ii) this value registers, at least, some change in the solution matrix and also offers a common basis (across species) for discussion. Sensitivity analysis was also conducted on experiment 3. Here, it was noted that at least 80 percent of the increase in landings need to be shipped out of the Pacific Coast in order to change the solution matrix at all from experiment 2. For the discussion of policy experiment 3, 85 percent of the increase in Pacific Coast landings is shipped to the Southwest and the Great Lakes. This base percentage across all species offers a common ground for comparison and discussion. In the sections that follow the initial solutions are discussed for each product form.

<u>Cod</u>

Oregon's demand is met by the state's own production and shipments from Washington and Alaska (Appendix C). Washington State is mainly supplied by production within that state. California's demand is satisfied by the state's domestic production, supply from Alaska, and shipments from New England holdings of cold storage and production. Cold storage holdings at the end of the month are furnished by imports from Canada and Europe and carry-over inventories. New England demand is met mainly by production in the region while the Mideast is exclusively supplied by European sources. The Southeast is supplied by New England sources (domestic production and cold storage holdings). The Southwest demand is satisfied by shipments from New England production while European sources supply the Great Lakes. The 12-month total demand for cod fillets in Oregon is estimated at 1,031.75 thousand pounds. These quantities are demanded at an average wholesale price of 23.06 cents per pound (Table 13, initial solution). Washington State consumption during the 12-month period is estimated at 1,645.19 thousand pounds. The corresponding average wholesale price is estimated at 22.57 cents per pound. California is the major groundfish consuming state on the Pacific Coast of the U.S. The 12-month total demand is estimated at 9,134.79 thousand pounds. The average wholesale price corresponding to this quantity is estimated at 23.71 cents per pound.

Ocean Perch

The movement of ocean perch fillets (Appendix E) follows a similar pattern as cod fillets. Oregon, Washington, and California are supplied by production in the Pacific Northwest, New England, and shipments from cold storage holdings. New England is supplied by produc

Table 13. Cod: Equilibrium Wholesale Quantity (Q)* Demanded, Prices (P)** and Revenues Under Various Experiments.

Region	(1) Initial Solution	(2) Uniform Landings	(3) Increased Landings	(4) Marketing Strategy
Oregon				
Q	1031.7487	1035.5597	1051.7831	1035.7811
P	23.0588	22.9835	22.5216	22.9507
Revenue	237908.87	238007.86	236878.38	237719.01
Washington				
Q	1645.1856	1646.0321	1676.4510	1651.4787
P	22.5722	22.5576	22.0349	22.4640
Revenue	371354.58	371305.34	369404.30	488051.54
California				
Q	9134.7890	9134.6159	9220.2038	9160.6941
P	23.7113	23.7118	23.4608	23.6353
Revenue	2165977.20	2165981.90	2163133.60	2165157.50
Shipment to the Southwest				
Q				255.0000
P				25.0636
Revenue				6391.22
Shipment to the Great Lakes				
Q				255.0000
P				20.8436
Revenue				5315.11
Total Revenue	2775240.70	2775295.10	2769416.30	2890928.10

* Q is in 1000 pounds fillets weight.
** P is in 1967 cents per pound (revenues are in 1967 dollars).

Source: Computed by author from Appendix D.

tion in the region, and import supply from Canada and Europe. The inventory demand is satisfied by carry-over cold storage holdings, and supplies from Canada and Europe. The Mideast demand is satisfied by European sources and domestic inventory supply. The demand of the South is met from Canadian import supply and domestic inventories while the Great Lakes region is supplied by European sources and inventories. The initial programming solution suggests that Oregon consumes about 616.90 thousand pounds of ocean perch fillets at about 39.00 cents per pound (Table 14). Washington's demand is about 940.10 thousand pounds at 39.20 cents per pound, and California consumes about 5.40 million pounds of ocean perch fillets at about 40 cents per pound.

Flounders

To a large extent the product flow patterns (Appendix G) observed for flounder fillets resemble those suggested by the initial programming solution for ocean perch fillets. The initial solution suggests that Oregon consumes about 1.60 million pounds of founder fillets in a 12-month period at an average price of about 37.00 cents per pound (Table 17). Washington consumes about 2.60 million pounds at about 36.40 cents per pound in the same 12-month period. The suggested demand in California is about 15.4 million pounds and these are purchased at an average price of 36.2 cents per pound.

Table 14. Cod: Ex-Vessel Quantities (Q)*, Prices (P)**, and Revenues Under Various Experiments.

Region	(1) Initial Solution	(2) Uniform Landings	(3) Increased Landings	(4) Marketing Strategy
Oregon				
Q	43.875	43.875	57.038	57.0381
P	9.500	9.469	9.279	9.455
Revenue	4168.12	4154.48	5292.28	5393.12
Washington				
Q	1810.738	1810.738	2353.960	2353.960
P	9.500	9,494	9.274	9.455
Revenue	172027.35	171916.90	218313.31	222564.56
California				
Q	4.800	4.800	6.240	6.240
P	9.500	9.501	9.400	9.467
Revenue	456.02	456.03	586.56	590.74
Total Revenue	176651.49	176527.41	224192.15	228548.42

* Q is in 1000 pounds fillets weight.
** P is in 1967 cents per pound (revenues are in 1967 dollars).

Source: Computed by author from Appendix D.

Table 15. Ocean Perch: Equilibrium Wholesale Quantity (Q)* Demanded, Prices (P)** and Revenues Under Various Experiments.

Region	(1) Initial Solution	(2) Uniform Landings	(3) Increased Landings	(4) Marketing Strategy
Oregon				
Q	616.8952	616.7625	626.7302	616.9422
P	38.9619	38.9756	37.9499	38.9471
Revenue	240354.09	240386.88	237843.48	307479.14
Washington				
Q	940.0627	932.7525	954.5933	940.1360
P	39.1627	39.6447	38.2047	39.1579
Revenue	368153.94	369786.93	364699.51	435273.87
California				
Q	5357.3420	5381.8310	5384.1940	5384.2220
P	39.7086	39.4339	39.4074	39.4071
Revenue	2127325.50	2122265.90	2121770.90	2121765.70
Shipment to the Southwest				
Q				195.0000
P				35.9371
Revenue				70077.35
Shipment to the Great Lakes				
Q				195.0000
P				32.9207
Revenue				64195.37
Total Revenue	2735833.50	2732439.70	2724313.90	2864518.80

* Q is in 1000 pounds fillets weight.
** P is in 1967 cents per pound (revenues are in 1967 dollars).

Source: Computed by author from Appendix F.

Table 16. Ocean Perch: Ex-Vessel Quantities (Q)*, Prices (P)**, and Revenues Under Various Experiments.

Region	(1) Initial Solution	(2) Uniform Landings	(3) Increased Landings	(4) Marketing Strategy
Oregon				
Q	747.279	747.279	971.463	971.463
P	4.862	4.863	4.735	4.861
Revenue	36328.97	36342.42	46001.67	47222.80
Washington				
Q	323.622	323.622	495.437	495.485
P	4.862	4.921	4.743	4.861
Revenue	16732.88	15926.73	23496.57	24083.17
California				
Q	8.065	8.065	10.485	10.485
P	4.862	4.828	4.825	4.825
Revenue	392.08	389.37	505.85	505.85
Total Revenue	52453.93	52658.52	70004.09	71811.82

* Q is in 1000 pounds fillets weight.
** P is in 1967 cents per pound (revenues are in 1967 dollars).

Source: Computed by author from Appendix F.

Table 17. Flounders: Equilibrium Wholesale Quantity (Q)* Demanded, Prices (P)**, and Revenues Under Various Experiments.

Region	(1) Initial Solution	(2) Uniform Landings	(3) Increased Landings	(4) Marketing Strategy
Oregon				
Q	1595.115	1595.877	1604.025	1597.857
P	36.561	36.522	36.112	36.423
Revenue	583182.02	582849.39	579248.72	661740.40
Washington				
Q	2555.443	2555.728	2569.843	2559.724
P	36.351	36.342	35.887	36.213
Revenue	928936.75	928807.78	922244.70	1006724.00
California				
Q	15389.230	15390.900	15413.540	15414.390
P	36.217	36.208	36.084	36.079
Revenue	5573548.20	5572737.10	5561805.40	5561388.60
Shipment to the Southwest				
Q				237.0000
P				35.223
Revenue				83477.33
Shipment to the Great Lakes				
Q				237.0000
P				32.086
Revenue				76044.53
Total Revenue	7085667.00	7084394.20	7063299.80	7229853.00

* Q is in 1000 pounds fillets weight.
** P is in 1967 cents per pound (revenues are in 1967 dollars).

Source: Computed by author from Appendix H.

Table 18. Flounders: Ex-Vessel Quantities (Q)*, Prices (P)**, and Revenues Under Various Experiments.

Region	(1) Initial Solution	(2) Uniform Landings	(3) Increased Landings	(4) Marketing Strategy
Oregon				
Q	748.666	748.666	973.267	973.267
P	13.875	13.860	13.705	13.823
Revenue	103878.90	103765.86	133387.15	134532.68
Washington				
Q	847.044	847.044	1101.157	1101.157
P	13.875	13.872	13.698	13.823
Revenue	117529.05	117499.40	150836.49	152207.43
California				
Q	39.219	39.219	50.985	50.985
P	13.874	13.872	13.824	13.822
Revenue	5441.72	5440.07	7048.22	7047.30
Total Revenue	226849.67	226705.33	291271.86	293787.41

* Q is in 1000 pounds fillets weight.
** P is in 1967 cents per pound (revenues are in 1967 dollars).

Source: Computed by author from Appendix H.

CHAPTER VII

INFERENCES AND POLICY IMPLICATIONS

A number of observations can be made from the estimated econometric model. The two prominent ones are: (1) Import supplies coming into the U.S. are not very responsive to price; it appears that exporters take whatever price they can get for their products. This implies that foreign suppliers may have a substantial capacity to absorb the effect of U.S. initiated policies designed to increase the export price of foreign producers. Trade barriers in the form of moderate tariffs and import quotas designed to increase the price of the imported products in the U.S. may not lead to reasonable improvements in domestic prices. It is assumed in this study that Canadian and European producers target the U.S. market and effort is made to, at least, maintain their respective market shares. It appears, therefore, that only a substantial decline in export margins (crudely defined here as the difference between unit production cost and export price) will lead to declining exports to the U.S. by the foreign producers.

(2) The ex-vessel demand is price elastic. This suggests that any exogenous change in domestic landings will affect both ex-vessel prices and revenues. Specifically, an increase in landings beyond current levels will depress ex-

vessel prices but increase total fleet revenues, and vice versa. In the case of decreased landings, however, the increase in ex-vessel prices that result will not be enough to increase revenues. As can be deduced, these conclusions have implications for policy in situations where the target species in the Pacific Northwest either are recovering from overfishing (example, ocean perch) or are not fully exploited (cod, flounders, etc.). A reduction in fishing effort aimed at encouraging the recovery from overfishing will, at first, increase prices but reduce fleet revenues. The increased landings that are made possible in the future (when recovery is complete) will lead to increased fishermen's revenues. If landings can be increased for currently underexploited species, total revenues to fishermen may be substantially improved beyond the present levels.

Cod Fillets

The initial solution suggests that Pacific Coast intermediaries dealing in cod fillets may make about $2.8 million in total revenues, during a 12-month period (Table 13). Fishermen's revenues are estimated at $177,000 (Table 14) in the same period.

In general, a uniform harvesting regime depresses the average yearly wholesale price, and hence the ex-vessel price. The distribution of uniform monthly landings, however, allows the Pacific Coast intermediaries to make a small gain (about 0.002 percent, Table 19) in total revenues. Fishermen's revenues decline by about 0.07 percent (Table 19). Oregon and Washington experience price decline but increased consumption under this harvesting regime. On the other hand, California experiences increased prices and declining consumption. This situation may be explained by the fact that California's demand for this product is mainly satisfied by supplies from sources outside the state. Specifically, under this regime, there are more shipments from Alaska than from Washington to California.

Increased landings depress both wholesale and ex-vessel prices in the Pacific Northwest region, and this leads to increased consumption (Table 13). The structure of the programming model allows the increase in landings to be consumed only in the Pacific Coast states. This leads to lesser amounts being imported from Alaska into the region. The increase in consumption is not large enough to offset the decline in wholesale prices. Wholesale revenues fall by about 0.21 percent (in relation to the initial solution). The decline in ex-vessel price is offset by the increased purchases at the dockside. A 30 percent increase in landings leads to about a 26.9 percent increase in fishermen's revenues (Table 19).

In general, increased landings with the marketing strategy described in Chapter I also depresses both wholesale and ex-vessel prices, but to a lesser degree

Table 19. Changes in Pacific Coast Revenues From Different Policies in Relation to the Status Quo.

Region	(1) Initial Solution	(2) Uniform Landings	(3) Increased Landings	(4) Marketing Strategy
	(2-1)	(3-1)	(4-1)	(4-3)
WHOLESALE				
Cod	54.40 (0.002)	-5824.40 (-0.210)	115687.40 (4.169)	121511.80 (4.388)
Ocean Perch	-3393.80 (-0.124)	-11519.60 (-0.421)	128685.26 (4.704)	140204.86 (5.146)
Flounders	-1272.80 (-0.018)	-22367.20 (-0.316)	144186.00 (2.035)	166553.20 (2.358)
EX-VESSEL				
Cod	-124.08 (-0.070)	47540.66 (26.912)	51896.93 (29.378)	4356.27 (1.943)
Ocean Perch	204.59 (0.390)	17550.16 (33.458)	19357.88 (39.905)	1807.73 (2.582)
Flounders	-144.34 (-0.064)	64422.19 (28.399)	66937.74 (29.508)	2515.55 (0.864)

Source: Computed by author from Tables 11-16.

Numbers in parentheses indicate percent.

than without such a strategy. With a 30 percent increase in landings in the Pacific Northwest, this experiment (marketing outside the region) suggests a 29.4 percent increase in fishermen's revenues (about two percent more than without a marketing strategy, Table 19). The same experiment suggests that dealers' revenues will increase by about 4.2 percent (about 4.4 percent more than increased landings without a marketing strategy, Table 19).

Ocean Perch

The current production and marketing structures lead to about $2.74 million in total revenues to the Pacific Northwest dealers, and about $52,454 in total revenues to fishermen. Uniform landings lead to increased revenues to both dealers and fishermen in Oregon and Wasshington when compared to the existing harvesting schedules. Dealers and fishermen in California, on the other hand, experience losses under the uniform harvesting strategy. Overall, however, dealers incur about 0.124 percent losses while fishermen gain about 0.4 percent in total revenues (Table 19). Increased landings, as expected, depress prices and improve consumption. A 30 percent increase in ocean perch landings over current average levels, will lead to wholesale revenue losses of about 0.42 percent while fishermen experience total revenue gain of about 33.50 percent. Under increased landings with access to outside markets, both wholesalers and fishermen gain in revenues though California dealers still experience losses under this scenario. Such losses are expected because California fishermen harvest smaller quantities of this species and the state's demand is satisfied by supply from the other regions. Overall, Pacific Coast dealers gain about 4.7 percent in revenues over current production and marketing strategies while fishermen's gains are about 40 percent (Table 19).

Flounder Fillets

Gross sales of Pacific Coast dealers for the 12-month period is about $7.1 million while revenues to fishermen are about $226,849.67 (Tables 17 and 18). Uniform harvesting strategies lead to losses to Pacific Coast dealers (about 0.02 percent) and fishermen (about 0.064 percent) (Table 19). Increased landings lead to losses at the wholesale market level (about 0.32 percent) while fishermen gain (about 28.4 percent) under this scenario. Access to markets outside the Pacific Coast brings gains to both Pacific Coast dealers (about 2.03 percent) and fishermen (about 29.5 percent) (Table 19).

Summary

A spatial equilibrium model (SEM) seems to represent, reasonably, the U.S. interregional/international groundfish market.

The econometric estimates in this study are comparable to those of earlier studies. The estimated elasticities lead to inferences that are supported by both theory and the specific characteristics of the broader groundfish market.

The ability to incorporate into the model aspects that reflect efficient product flows among producing and consuming regions enables one to draw some inferences about product distribution, which a strictly econometric analysis does not. The analyst may not always have enough reliable data to estimate and draw reasonable inferences from a more complete econometric model. In such situations, a carefully specified econometric model can be combined with other relevant variables (for which time series or adequate survey data do not exist) in a SEM. Since most policy variables do not have data over an extended period, the SEM approach provides a better (than econometric procedures) alternative for gaining insight (even if only qualitative) into the effects of many real-world policies. The current modeling effort has clearly demonstrated the flexibility that a SEM offers. The model allows the effects of a policy variable to be transmitted throughout the market system so that more can be learned about the effects of a policy instrument than in other analytical procedures. The effects of combinations of policies can also be studied in a single model. The current applications of SEM to the U.S. broader groundfish market suggest three things.

(1) The particular model formulation allows segments of the broader market to be targeted for policy experiments.

(2) A carefully specified SEM can explain the current market status.

(3) A SEM can simulate, at least qualitatively, the effects of planned or anticipated policies and thus serve as a guide to future decision-making.

Some interesting observations can be made from Table 19. The changes in total revenues, from different policies, with respect to the revenues under the status quo present some insight into industry performance under these policies. Many of the inferences that can be drawn, based on these results, may appear to deviate from the general views that fishermen and processors may have. For example, many processors and fishermen believe that allowing continuous landings of some average quantity will lead to a continuously regulated supply of raw fish to processing plants operating under normal conditions throughout the year. The problems of critical lean seasons when most plants remain idle could be avoided. Also the levels of spoilage during peak leandings, when plants are overworked, could be reduced. Thus by avoiding peak season spoilage, and reducing plant idle time when fishermen fish all year round, revenues are expected to improve. In general, the current model does not support this view. In fact the status quo may be preferred to a uniform landings policy, as suggested by column (2-1) in Table 19.

Industry participants expect an increase in landings over current levels to increase revenues for both dealers and fishermen. The model suggests that under this scenario, wholesale revenues are less than the status quo but ex-vessel revenues increase substantially. The general views of industry participants are understandable since such views may be based on only a subset of all the factors relevant to drawing the most objective inferences.

The first two experiments in this study suggest a mixed blessing to the Pacific Coast groundfish industry. Such qualitative inferences, as can be drawn in this study, make economic sense. The magnitudes and signs of the wholesale and ex-vessel price elasticities (Table 9) indicate that given the specific characteristics of the model, these results are reasonable and, in fact, expected. The revenues estimated for uniform landings assume constant prices. They do not consider the cost of adopting such a policy. They do not take into account any price movements likely to be triggered by the new harvesting regime. The revenues estimated for increasing Pacific Coast landings also assume constant prices. They also do not reflect the costs (direct or indirect) of investment to obtain the increase in landings. On the other hand, the model accounts for the interaction with other regional markets whose specific activities have to be assumed in order to draw the appropriate conclusions.

The elastic ex-vessel demand leads to increased fleet revenues as discussed earlier. Under increased landings with marketing strategy, both wholesale and ex-vessel revenues for all species (and hence total groundfish) are greater than revenues under the status quo. Column (4-3) in Table 19 indicates the effect of access to outside markets when landings are increased by 30 percent. For all species and for all market levels, revenues to the industry are more than those of a policy which seeks production expansion without a marketing strategy. Experiment III, therefore, suggests that if increased landings in the Pacific Coast groundfish fishery is an industry policy, gains to the industry may be assured only if access to outside markets also takes place. While the flexibility and power of this modeling approach has been demonstrated (at least qualitatively) in this study, the availability of more and better data would allow one to refine the basic structure of the model. This would enable the researcher to draw more powerful quantitative inferences to enhance the current discussions.

The policy experiments discussed in this study are not exhaustive for this model specification. Other relevant policy instruments could be appropriately quantified and subjected to analysis. Some policy instruments that may provide interesting insight include: percent changes in transportation rates along a particular route or several routes, specific import quotas on products imported from Canada and Europe, tariffs on imported products, etc. These are policies that may be relevant to the groundfish industry under extended fishery jurisdiction. It may also be interesting to know how sensitive the initial solution is to the location of supply and demand points. Such a sensitivity analysis may give some insight into product disposition strategies which may improve overall industry revenues and/or profits. For the sake of demonstrating applications to the model, the author chose to concentrate on the three policy instruments discussed in this study. Afterall an objective of this study was to formulate a model that would allow easy adaptation to a wide range of policy studies. The flexibility found in the model specification allowed the author to subject a single or multiple policy instruments to analysis and evaluation in a single problem formulation. The choice of policies was influenced by the current debate on potential policies for industry enhancement.

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APPENDICES

Appendix A:

Transport Rates Between Pairs of Supply/Demand Regions($/Ib)

DEMAND/ \ /SUPPLY	Oregon	Washin-gton	New England	Calif-ornia	Alaska	Canada	Europe
OREGON Portland	0.0000	0.0073	0.0948	0.0212	0.0563	0.1348	0.1943
WASHINGTON Seattle	0.0073	0.0000	0.0894	0.0261	0.0563	0.1294	0.1943
NEW ENG. Boston	0.0948	0.0894	0.0000	0.0896	0.1500	0.0400	0.0716
CALIF-ORNIA Los Ang.	0.0326	0.0374	0.0871	0.0143	0.0563	0.1271	0.1943
MID EAST N.Y.C.	0.0855	0.0844	0.0085	0.0870	0.1500	0.0400	0.0716
SOUTH-EAST Miami	0.0994	0.0987	0.0456	0.0906	0.1000	0.0856	0.1900
SOUTH-WEST Dallas	0.0599	0.0616	0.0524	0.0519	0.1000	0.0924	0.1943
GREAT LAKES Chicago	0.0622	0.0611	0.0305	0.0637	0.0783	0.0705	0.0808

SOURCE: Derived from the equation: $Y = 0.3009 + 0.001708M$
where Y = $/100Ibs of payload
M = Fully loading miles(assumed 31500Ibs in a Carlot and allowed for Backhauling)

COST OF OPERATING REFRIGERATED TRUCKS FOR HAULING FRESH FRUITS AND VEGETABLES by Patrick P. Boles for the E.R.S (USDA)

COLD STORAGE HOLDINGS IN NEW ENGLAND (BOSTON) at $0.0015/Ib/month
FIXED COST OF HOLDING INVENTORY $0.0030/Ib/month

Values are adjusted by the Transportation Index:
1967 = 100.00
1979 = 180.80
1981 = 147.00

Appendix B: Tables of Econometric Results (January, 1972 to September, 1981; 117 Observations).

Equation 1: Wholesale Demand for Cod Fillets
Dependent Variable: CCF: Consumption of Cod Fillets

VARIABLE	PARAMRTER ESTIMATE	ADJUSTED T-RATIO	VARIABLE LABEL
INTERCEPT	0.039474	1.7348	
WPC	-0.001274	-2.5426*	Ave. Whsle Price: Cod Fillets
Y_1	0.075240	0.8796	Per Capita Income Lag 1 Month
CHY	0.449971	2.3564*	Change in Income
BI	0.357211	4.0348*	Beginning of Month Inventory
CCF_1	0.061827	0.6653	Cod Consumption Lag 1 Month
D1	0.006855	0.9259	Dummy Variable: February
D2	0.023222	2.9971*	Dummy Variable: March
D3	0.017055	2.1668*	Dummy Variable: April
D4	0.007970	1.0262	Dummy Variable: May
D5	0.013216	1.7541	Dummy Variable: June
D6	0.006313	0.8491	Dummy Variable: July
D7	-0.006235	-0.8289	Dummy Variable: August
D8	0.000991	0.1362	Dummy Variable: September
D9	-0.003881	-0.5062	Dummy Variable: October
D10	-0.008319	-1.1157	Dummy Variable: November
D11	-0.007112	-0.9618	Dummy Variable: December

RMS percent error: 0.3600

Equation 2: U.S. Cod Fillets Inventory Demand
Dependent Variable: EI: End of Month Inventory: Cod Fillets

VARIABLE	PARAMETER ESTIMATE	ADJUSTED T-RATIO	VARIABLE LABEL
INTERCEPT	0.030520	2.7428*	
WPC	-0.000476	-1.7694	Ave. Whsle Price: Cod Fillets
CHWPC	-0.003668	-2.4651*	Change in Cod Whsle Price
BI	0.873847	18.6203*	Beginning of Month Inventory
D1	-0.002169	-0.5058	Dummy Variable: February
D2	0.002634	0.6275	Dummy Variable: March
D3	-0.007479	-1.5285	Dummy Variable: April
D4	-0.008131	-1.9371	Dummy Variable: May
D5	-0.014315	-3.1667*	Dummy Variable: June
D6	-0.016529	-3.2674*	Dummy Variable: July
D7	-0.007084	-1.7101	Dummy Variable: August
D8	-0.015492	-3.5407*	Dummy Variable: September
D9	-0.005618	-1.3048	Dummy Variable: October
D10	-0.001694	-0.3504	Dummy Variable: November
D11	0.000892	0.2066	Dummy Variable: December

RMS percent error:0.1300

* Implies significance at the 95% confidence level.

Equation 3: Canadian Import Supply of Cod Fillets
Dependent Variable: CIS : Supply of Canadian Cod Fillets

VARIABLE	PARAMETER ESTIMATE	ADJUSTED T-RATIO	VARIABLE LABEL
INTERCEPT	0.036414	5.7531*	
IPC	0.000273	0.7743	Import Price: Canadian Cod
IPE	0.000648	1.9324	Import Price: European Cod
WPC	-0.001639	-3.1749*	Ave Whsle Price: Cod Fillets
EFJ	-0.004093	-1.9148	Dummy: US Extd. Fish. Jurisdn.
D1	0.004328	1.4855	Dummy Variable: February
D2	0.011574	3.9688*	Dummy Variable: March
D3	0.001058	0.3632	Dummy Variable: April
D4	0.003066	1.0511	Dummy Variable: May
D5	0.009345	3.1966*	Dummy Variable: June
D6	0.006094	2.0805*	Dummy Variable: July
D7	-0.004206	1.4384	Dummy Variable: August
D8	0.003505	1.2016	Dummy Variable: September
D9	-0.000458	-0.1526	Dummy Variable: October
D10	-0.002391	-0.7896	Dummy Variable: November
D11	-0.002678	-0.8877	Dummy Variable: December

RMS percent error:0.3900

Equation 4: European Import Supply of Cod Fillets
Dependent Variable: EIS : Supply of European Cod Fillets

VARIABLE	PARAMETER ESTIMATE	ADJUSTED T-RATIO	VARIABLE LABEL
INTERCEPT	0.002965	0.2719	
IPE	0.000358	0.7066	Import Price: European Cod
IPC	-0.000550	-1.0318	Import Price: Canadian Cod
WPC	-0.000194	-0.2485	Ave Whsle Price: Cod Fillets
FLD	0.386242	8.1899*	Foreign Landings: Groundfish
EFJ	0.002398	0.7391	Dummy:US Extd. Fish. Jurisdn.
D1	0.002062	0.4617	Dummy Variable: February
D2	0.000154	0.0341	Dummy Variable: March
D3	0.009966	2.2564*	Dummy Variable: April
D4	0.005931	1.3453	Dummy Variable: May
D5	-0.002947	-0.6460	Dummy Variable: June
D6	-0.006841	-1.4883	Dummy Variable: July
D7	-0.008308	-1.7625	Dummy Variable: August
D8	-0.009882	-2.0312*	Dummy Variable: September
D9	-0.012570	-2.6284*	Dummy Variable: October
D10	-0.010497	-2.2711*	Dummy Variable: November
D11	-0.003809	-0.8346	Dummy Variable: December

RMS percent error: 0.4600

Equation 5: Exvessel Demand for US Domestic Cod Fillets
Dependent Variable: EPC: Exvessel Price for Domestic Cod

VARIABLE	PARAMETER ESTIMATE	ADJUSTED T-RATIO	VARIABLE LABEL
INTERCEPT	6.768812	4.9597*	
WPC	0.118378	1.2020	Ave. Whsle Price: Cod Fillets
IPC	-0.025715	-0.3803	Import Price: Canadian Cod
IPE	-0.199911	-2.7647*	Import Price: European Cod
LC	-0.220183	-6.5668*	U.S Domestic Cod Landings
Y	0.048147	6.6495*	Per Capita Income
EFJ	-0.346407	-0.9150	Dummy:US Extd. Fish. Jurisdn.
D1	0.109430	0.2101	Dummy Variable: February
D2	0.611505	1.1724	Dummy Variable: March
D3	-1.497090	-2.7925*	Dummy Variable: April
D4	-3.580432	-6.2406*	Dummy Variable: May
D5	-3.235602	-5.9023*	Dummy Variable: June
D6	-2.919428	-5.5595*	Dummy Variable: July
D7	-2.133839	-4.0512*	Dummy Variable: August
D8	-1.944387	-3.7254*	Dummy Variable: September
D9	-1.446159	-2.6910*	Dummy Variable: October
D10	-1.259889	-2.3328*	Dummy Variable: November
D11	0.239689	0.4465	Dummy Variable: December

RMS percent error: 0.1140

Equation 6: Wholesale Demand for Ocean Perch (OP) Fillets
Dependent Variable: COPF: Consumption of Ocean Perch Fillets

VARIABLE	PARAMETER ESTIMATE	ADJUSTED T-RATIO	VARIABLE LABEL
INTERCEPT	0.020118	1.5409	
WPOP	-0.000332	-1.0080	Ave. Whsle Price: OP Fillets
WPP	0.001159	4.7247*	Ave. Whsle Price: Poultry
Y_1	-0.022310	-0.6201	Per Capita Income Lag 1 month
CHY	-0.174660	-2.3958*	Change in Income
BI	0.075636	2.6196*	Beginning of Month Inventory
COPF_1	0.152063	1.7020	OP Consumption Lag 1 Month
D1	-0.001814	-0.6019	Dummy Variable: February
D2	0.004182	1.3248	Dummy Variable: March
D3	-0.008012	-2.4579*	Dummy Variable: April
D4	-0.006203	-1.9149	Dummy Variable: May
D5	-0.003001	-0.9462	Dummy Variable: June
D6	-0.007971	-2.6000*	Dummy Variable: July
D7	-0.004960	-1.6041	Dummy Variable: August
D8	-0.001336	-0.4669	Dummy Variable: September
D9	-0.006700	-2.2013*	Dummy Variable: October
D10	-0.008689	-3.0326*	Dummy Variable: November
D11	-0.008948	-3.1428*	Dummy Variable: December

RMS percent error: 0.2400

Equation 7: U.S. Ocean Perch Fillets Inventory Demand
Dependent Variable: EI: End of Month Inventory: OP Fillets

VARIABLE	PARAMETER ESTIMATE	ADJUSTED T-RATIO	VARIABLE LABEL
INTERCEPT	0.011951	1.1554	
WPOP	-0.000369	-1.0951	Ave. Whsle Price: Ocean Perch
CHWPOP	0.003818	2.9803*	Change in Whsle Price
BI	0.957745	32.7519*	Beginning of Month Inventory
D1	0.015324	4.6452*	Dummy Variable: February
D2	0.014372	4.4584*	Dummy Variable: March
D3	0.009326	2.8052*	Dummy Variable: April
D4	0.004357	1.2936	Dummy Variable: May
D5	-0.002434	-0.6967	Dummy Variable: June
D6	0.000597	0.1688	Dummy Variable: July
D7	-0.013447	-3.7300*	Dummy Variable: August
D8	-0.007812	-2.4712*	Dummy Variable: September
D9	-0.010159	-3.1540*	Dummy Variable: October
D10	-0.005159	-1.6176	Dummy Variable: November
D11	-0.001264	-0.3984	Dummy Variable: December

RMS percent error: 0.2100

Equation 8: Canadian Import Supply of Ocean Perch Fillets
Dependent Variable: IPC: Import Price: Canadian Ocean Perch

VARIABLE	PARAMETER ESTIMATE	ADJUSTED T-RATIO	VARIABLE LABEL
INTERCEPT	-9.623691	-5.0963*	
CIS	0.034496	2.4710*	Supply of Canadian OP Fillets
EIS	-0.067883	-1.2055	Supply of European OP Fillets
WPOP	1.214139	20.1983*	Ave. Whsle Price: OP Fillets
EPOP_1	0.428986	3.1455*	OP Exvessel Price Lag 1 Month
EFJ	-0.367621	-0.9593	Dummy:US Extd. Fish. Jurisdn.
D1	0.951158	1.6665	Dummy Variable: February
D2	2.005249	3.4281*	Dummy Variable: March
D3	0.677686	1.1840	Dummy Variable: April
D4	1.021842	1.8043	Dummy Variable: May
D5	0.256816	0.4545	Dummy Variable: June
D6	0.795273	1.3746	Dummy Variable: July
D7	0.414529	0.7063	Dummy Variable: August
D8	0.106010	0.1730	Dummy Variable: September
D9	0.267480	0.4433	Dummy Variable: October
D10	0.434334	0.7443	Dummy Variable: November
D11	0.721983	1.2444	Dummy Variable: December

RMS percent error: 0.0440

Equation 9: European Import Supply of Ocean Perch Fillets
Dependent Variable: IPE : Import Price: European OP Fillets

VARIABLE	PARAMETER ESTIMATE	ADJUSTED T-RATIO	VARIABLE LABEL
INTERCEPT	-12.00522	-4.6864*	
EIS	0.038809	0.5080	Supply of European OP Fillets
CIS	0.066831	3.5288*	Supply of Canadian OP Fillets
WPOP	1.282341	15.7253*	Ave. Whsle Price: OP Fillets
EPOP_1	0.460586	2.4894*	Ave. OP Exvessel Price: U.S.
EFJ	-0.569246	-1.0950	Dummy:US Extd. Fish. Jurisdn.
D1	1.267572	1.6371	Dummy Variable: February
D2	2.018973	2.5443*	Dummy Variable: March
D3	1.121329	1.4442	Dummy Variable: April
D4	0.682517	0.8884	Dummy Variable: May
D5	-0.396302	-0.5170	Dummy Variable: June
D6	-0.016833	-0.0214	Dummy Variable: July
D7	-0.315395	-0.3961	Dummy Variable: August
D8	-1.018339	-1.2249	Dummy Variable: September
D9	-0.880177	-1.0753	Dummy Variable: October
D10	-0.599322	-0.7571	Dummy Variable: November
D11	0.313959	0.3988	Dummy Variable: December

RMS percent error: 0.0650

Equation 10: Exvessel Demand for Domestic Ocean Perch Fillets
Dependent Variable: EPOP: Exvessel Price of Domestic Ocean Perch

VARIABLE	PARAMETER ESTIMATE	ADJUSTED T-RATIO	VARIABLE LABEL
INTERCEPT	3.373681	2.2061*	
WPOP	0.024267	0.5909	Ave. Whsle Price: OP Fillets
CIS	-0.039251	-4.4408*	Supply of Canadian Ocean Perch
Y	0.010425	2.7789*	US Per Capita Income
LOP	-0.345325	-5.4119*	U.S. Domestic OP Landings
EFJ	0.433336	1.3437	Dummy:US Extd. Fish. Jurisdn.
D1	0.250353	0.6472	Dummy Variable: February
D2	1.326010	3.0844*	Dummy Variable: March
D3	0.657430	1.5957	Dummy Variable: April
D4	0.899050	2.0463*	Dummy Variable: May
D5	1.019503	2.2490*	Dummy Variable: June
D6	0.890716	2.0207*	Dummy Variable: July
D7	0.800108	1.8942	Dummy Variable: August
D8	0.712551	1.7174	Dummy Variable: September
D9	0.576418	1.4008	Dummy Variable: October
D10	0.047293	0.1209	Dummy Variable: November
D11	-0.050663	-0.1311	Dummy Variable: December

RMS percent error: 0.1490

Equation 11: Wholesale Demand for Flounder Fillets(FF)
Dependent Variable: CFF: Consumption of Flounder Fillets

VARIABLE	PARAMETER ESTIMATE	ADJUSTED T-RATIO	VARIABLE LABEL
INTERCEPT	0.024802	2.2463*	
WPF	-0.000679	-3.4057*	Ave. Whsle Price: FF
WPC	0.000788	2.7659*	Ave. Whsle Price: Cod Fillets
Y_1	0.101185	1.8276	Per Capita Income Lag 1 Month
CHY	-0.063393	-0.5101	Change in Income
BI	0.064859	1.1410	Beginning of Month Inventory
CFF_1	0.256149	2.5574*	Consumption Lag 1 Month
D1	-0.003025	-0.7390	Dummy Variable: February
D2	0.004161	0.9759	Dummy Variable: March
D3	-0.000686	-0.1639	Dummy Variable: April
D4	0.001193	0.2705	Dummy Variable: May
D5	0.004679	1.0679	Dummy Variable: June
D6	0.000591	0.1403	Dummy Variable: July
D7	0.004241	0.9805	Dummy Variable: August
D8	0.005058	1.2169	Dummy Variable: September
D9	0.010266	2.3121*	Dummy Variable: October
D10	0.001886	0.4299	Dummy Variable: November
D11	0.000041	0.0098	Dummy Variable: December

RMS percent error: 0.3900

Equation 12: U.S. Flounder Fillets Inventory Demand
Dependent Variable: EI: End of Month Inventory: Flounder Fillets

VARIABLE	PARAMETER ESTIMATE	ADJUSTED T-RATIO	VARIABLE LABEL
INTERCEPT	0.007443	1.4355	
WPF	-0.000124	-1.6042	Ave. Whsle Price: FF
CHWPF	-0.000052	-0.3119	Change in Flounder Whsle Price
BI	0.945365	33.2379*	Beginning of Month Inventory
D1	-0.004946	-2.3262*	Dummy Variable: February
D2	-0.009312	-4.2688*	Dummy Variable: March
D3	-0.006747	-3.1932*	Dummy Variable: April
D4	-0.003067	-1.3425	Dummy Variable: May
D5	0.000861	0.3783	Dummy Variable: June
D6	0.003231	1.4952	Dummy Variable: July
D7	0.002707	1.1917	Dummy Variable: August
D8	0.003289	1.5299	Dummy Variable: September
D9	0.000986	0.4279	Dummy Variable: October
D10	0.003338	1.5300	Dummy Variable: November
D11	0.003461	1.5829	Dummy Variable: December

RMS percent error: 0.1100

Equation 13: Canadian Import Supply of Flounder Fillets
Dependent Variable: IPC: Imprt Price: Canadian Flounder Fillets

VARIABLE	PARAMETER ESTIMATE	ADJUSTED T-RATIO	VARIABLE LABEL
INTERCEPT	13.62099	5.0181*	
CIS	0.39459	1.5243	Supply of Canadian FF
BI	-0.23918	-2.1360*	US Beginning of Month FF Inv.
CFF_1	-0.21058	-1.2520	US FF Consumption Lag 1 Month
WPF	-1.31276	-1.9636	Ave. Whsle Price of FF: US
EFJ	3.16456	5.7602*	Dummy:US Extd. Fish. Jurisdn.
D1	-0.03089	-0.0433	Dummy Variable: February
D2	-0.26379	-0.3764	Dummy Variable: March
D3	-0.20128	-0.2847	Dummy Variable: April
D4	-0.34086	-0.4749	Dummy Variable: May
D5	-0.72919	-0.9285	Dummy Variable: June
D6	-0.75856	-0.9849	Dummy Variable: July
D7	-0.60602	-0.7577	Dummy Variable: August
D8	-0.41623	-0.5507	Dummy Variable: September
D9	-0.19995	-0.2520	Dummy Variable: October
D10	-0.20005	-0.2530	Dummy Variable: November
D11	-0.19169	-0.2616	Dummy Variable: December

RMS percent error: 0.1500

Equation 14: European Import Supply of Flounder Fillets
Dependent Variable: IPE: Import Price: European Flounder Fillets

VARIABLE	PARAMETER ESTIMATE	ADJUSTED T-RATIO	VARIABLE LABEL
INTERCEPT	7.78171	2.8833*	
EIS	0.99554	5.1152*	Supply of European FF
WPF	-0.26836	-0.4368	Ave. Whsle Price of FF: US
FLD	-0.28187	-3.3302*	Foreign Landings: Groundfish
EFJ	-1.70647	-3.9448*	Dummy:US Extd. Fish. Jurisdn.
D1	0.21694	0.3047	Dummy Variable: February
D2	0.43568	0.6094	Dummy Variable: March
D3	0.24407	0.3512	Dummy Variable: April
D4	0.53066	0.7543	Dummy Variable: May
D5	1.38745	1.8289	Dummy Variable: June
D6	1.15789	1.5599	Dummy Variable: July
D7	1.02743	1.3445	Dummy Variable: August
D8	0.60635	0.7848	Dummy Variable: September
D9	0.01131	0.1488	Dummy Variable: October
D10	-0.01826	-0.0253	Dummy Variable: November
D11	0.15369	0.2170	Dummy Variable: December

RMS percent error: 0.4600

Equation 15: Exvessel Demand for Domestic Flounder Fillets
Dependent Variable: EPF: Exvessel Price of Domestic Flounders

VARIABLE	PARAMETER ESTIMATE	ADJUSTED T-RATIO	VARIABLE LABEL
INTERCEPT	13.68222	3.7348*	
WPF	0.07343	1.1831	Ave. Whsle Price: FF
CIS	0.07201	1.6155	Supply of Canadian FF
EIS	-0.04085	-1.2578	Supply of European FF
Y_1	0.00348	0.2059	Per Capita Income Lag 1 Month
LF	-0.54016	-7.1135*	U.S. Dom. Flounders Landings
EFJ	2.22807	2.2122*	Dummy:US Extd. Fish. Jurisdn.
D1	1.88355	1.4676	Dummy Variable: February
D2	2.56414	2.0797*	Dummy Variable: March
D3	-0.35274	-0.2869	Dummy Variable: April
D4	-2.07044	-1.5953	Dummy Variable: May
D5	-3.20648	-2.4211*	Dummy Variable: June
D6	-3.47729	-2.6778*	Dummy Variable: July
D7	-3.29983	-2.4113*	Dummy Variable: August
D8	-2.97574	-2.2481*	Dummy Variable: September
D9	-1.73174	-1.2398*	Dummy Variable: October
D10	-2.56954	-1.9395	Dummy Variable: November
D11	-3.35250	-2.6336*	Dummy Variable: December

RMS percent error: 0.2040

Appendix C: Regional Equilibrium Cod Fillets Flows (1000 Pounds Fillet Weight)

INITIAL SOLUTION:

FROM	OREGON	WASHING-TON	CALIFOR-NIA	NEW ENGLAND	INV. SUPPLY	ALASKA	CANADA	EUROPE
TO OREGON	43.88	426.96	0.00	18.60	0.00	541.91	0.00	0.00
WASHINGTON	0.00	1372.20	0.00	0.00	0.00	171.73	101.25	0.00
CALIFORNIA	0.00	97.07	4.80	830.47	3524.86	4678.38	0.00	0.00
NEW ENGLAND	0.00	0.00	0.00	5198.45	0.00	0.00	1276.31	0.00
INV. DEMAND	0.00	0.00	0.00	1544.66	194250.17	802.70	18824.70	22946.47
MID-EAST	0.00	0.00	0.00	125.80	0.00	0.00	0.00	18920.51
SOUTHEAST	0.00	0.00	0.00	16063.60	3498.05	0.00	0.00	0.00
SOUTHWEST	0.00	0.00	0.00	7521.97	0.00	165.92	0.00	0.00
GREAT LAKES	0.00	0.00	0.00	0.00	0.00	0.00	0.00	19305.17

UNIFORM LANDINGS:

FROM	OREGON	WASHING-TON	CALIFOR-NIA	NEW ENGLAND	INV. SUPPLY	ALASKA	CANADA	EUROPE
TO OREGON	43.87	231.43	0.00	0.00	0.00	759.26	0.00	0.00
WASHINGTON	0.00	1501.53	0.00	0.00	0.00	144.50	0.00	0.00
CALIFORNIA	0.00	77.78	4.40	1147.88	3047.56	4308.30	548.70	1168.32
NEW ENGLAND	0.00	0.00	0.00	5193.76	0.00	0.00	1280.90	0.00
INV. DEMAND	0.00	0.00	0.00	2411.84	194696.23	0.00	21145.20	18946.46
MID-EAST	0.00	0.00	0.00	115.27	2342.16	0.00	0.00	18879.27
SOUTHEAST	0.00	0.00	0.00	16082.34	3478.88	0.00	0.00	0.00
SOUTHWEST	0.00	0.00	0.40	7448.89	0.00	238.84	0.00	0.00
GREAT LAKES	0.00	0.00	0.00	0.00	0.00	0.00	0.00	19304.85

Appendix C: (continued)

INCREASED LANDINGS:

FROM	OREGON	WASHINGTON	CALIFORNIA	NEW ENGLAND	INV. SUPPLY	ALASKA	CANADA	EUROPE
TO OREGON	57.04	480.91	0.00	18.60	0.00	494.83	0.00	0.00
WASHINGTON	0.00	1403.46	0.00	0.00	0.00	171.73	101.25	0.00
CALIFORNIA	0.00	555.08	6.24	786.99	3147.24	4725.46	0.00	0.00
NEW ENGLAND	0.00	0.00	0.00	5209.96	0.00	0.00	1276.31	0.00
INV. DEMAND	0.00	0.00	0.00	1624.16	194427.45	802.70	18780.88	22810.20
MID-EAST	0.00	0.00	0.00	125.80	0.00	0.00	0.00	18960.52
SOUTHEAST	0.00	0.00	0.00	15997.45	3610.75	0.00	0.00	0.00
SOUTHWEST	0.00	0.00	0.00	7540.56	0.00	165.92	0.00	0.00
GREAT LAKES	0.00	0.00	0.00	0.00	0.00	0.00	0.00	19343.92

MARKETING STRATEGY:

FROM	OREGON	WASHINGTON	CALIFORNIA	NEW ENGLAND	INV. SUPPLY	ALASKA	CANADA	EUROPE
TO OREGON	57.04	450.86	0.00	18.60	0.00	508.88	0.00	0.00
WASHINGTON	0.00	1378.49	0.00	0.00	0.00	171.73	101.25	0.00
CALIFORNIA	0.00	100.10	6.24	835.64	3508.10	4711.41	0.00	0.00
NEW ENGLAND	0.00	0.00	0.00	5212.70	0.00	0.00	1276.31	0.00
INV. DEMAND	0.00	0.00	0.00	1597.65	194260.23	802.70	18770.42	19468.80
MID-EAST	0.00	0.00	0.00	125.80	0.00	0.00	0.00	17656.66
SOUTHEAST	0.00	0.00	0.00	16223.12	3396.20	0.00	0.00	3563.88
SOUTHWEST	0.00	255.00	0.00	7290.00	0.00	165.92	0.00	1313.41
GREAT LAKES	0.00	255.00	0.00	0.00	0.00	0.00	0.00	19098.17

Appendix D: Equilibrium Quantity* Demanded and Price** of Cod Fillets Under Various Experiments.

		INITIAL SOLUTION	UNIFORM LANDINGS	INCREASED LANDINGS	MARKETING STRATEGY
OREGON	QTY.	1031.75	1035.56	1051.78	1035.78
	PRICE	23.06	22.98	22.52	22.95
WASHINGTON	QTY.	1645.19	1646.03	1676.45	1651.48
	PRICE	22.57	22.56	22.39	22.82
CALIFORNIA	QTY.	9134.79	9134.62	9220.20	9160.69
	PRICE	23.71	23.71	23.46	23.64
NEW ENGLAND	QTY.	6474.76	6474.67	6486.27	6489.01
	PRICE	15.65	15.66	15.59	15.58
INV. DEMAND	QTY.	238368.69	238368.05	217684.61	238463.68
	PRICE	15.90	15.91	15.84	15.83
MID-EAST	QTY.	21337.33	21339.00	21377.34	21386.89
	PRICE	15.97	15.97	15.91	15.89
SOUTHEAST	QTY.	19561.61	19561.22	19608.20	19619.32
	PRICE	20.21	20.22	20.16	20.14
SOUTHWEST	QTY.	7688.29	7688.13	7706.88	7711.31
	PRICE	20.89	20.90	20.83	20.82
GREAT LAKES	QTY.	19305.17	19304.85	19343.92	19353.17
	PRICE	16.89	16.89	16.83	16.81

* QUANTITY IN 1000 POUNDS
** PRICE IN 1967 CENTS PER POUND

Appendix E: Regional Equilibrium Ocean Perch Fillets Flows (1000 Pounds Fillet Weight)

INITIAL SOLUTION:

FROM	OREGON	WASHING-TON	CALIFOR-NIA	NEW ENGLAND	INV. SUPPLY	ALASKA	CANADA	EUROPE
TO OREGON	514.83	0.00	3.31	0.00	85.35	13.41	0.00	0.00
WASHINGTON	194.83	323.62	0.00	53.10	359.63	8.89	0.00	0.00
CALIFORNIA	37.62	0.00	4.76	877.81	4375.55	39.81	0.00	21.79
NEW ENGLAND	0.00	0.00	0.00	1692.76	0.00	0.00	822.94	879.59
INV. DEMAND	0.00	0.00	0.00	0.00	97606.28	0.00	16578.09	7913.74
MID-EAST	0.00	0.00	0.00	0.00	7485.52	0.00	0.00	4397.62
SOUTHEAST	0.00	0.00	0.00	1117.29	11879.20	0.00	194.01	0.00
SOUTHWEST	0.00	0.00	0.00	1024.96	3699.34	0.00	457.20	0.00
GREAT LAKES	0.00	0.00	0.00	1634.07	2115.04	0.00	0.00	6869.33

UNIFORM LANDINGS:

FROM	OREGON	WASHING-TON	CALIFOR-NIA	NEW ENGLAND	INV. SUPPLY	ALASKA	CANADA	EUROPE
TO OREGON	611.96	0.00	0.00	0.00	0.00	4.80	0.00	0.00
WASHINGTON	135.32	323.62	0.00	111.84	310.75	51.22	0.00	0.00
CALIFORNIA	0.00	0.00	8.07	217.71	5149.97	6.09	0.00	0.00
NEW ENGLAND	0.00	0.00	0.00	1734.58	0.00	0.00	780.06	879.59
INV. DEMAND	0.00	0.00	0.00	0.00	97508.83	0.00	16627.42	7940.52
MID-EAST	0.00	0.00	0.00	0.00	7498.68	0.00	0.00	4381.42
SOUTHEAST	0.00	0.00	0.00	1184.42	11349.30	0.00	652.41	0.00
SOUTHWEST	0.00	0.00	0.00	1570.18	3609.59	0.00	0.00	0.00
GREAT LAKES	0.00	0.00	0.00	1581.27	2201.08	0.00	0.00	6833.68

Appendix E: (continued).

INCREASED LANDINGS:

FROM	OREGON	WASHING-TON	CALIFOR-NIA	NEW ENGLAND	INV. SUPPLY	ALASKA	CANADA	EUROPE
TO OREGON	595.07	0.00	2.51	0.00	20.24	8.91	0.00	0.00
WASHINGTON	194.83	489.92	0.00	53.10	207.86	8.89	0.00	0.00
CALIFORNIA	181.56	5.52	7.98	477.81	4390.78	44.31	276.23	0.00
NEW ENGLAND	0.00	0.00	0.00	1692.76	0.00	0.00	823.10	879.65
INV. DEMAND	0.00	0.00	0.00	0.00	97984.58	0.00	16267.80	7850.04
MID-EAST	0.00	0.00	0.00	0.00	7594.26	0.00	0.00	4289.65
SOUTHEAST	0.00	0.00	0.00	1517.29	11480.09	0.00	194.01	0.00
SOUTHWEST	0.00	0.00	0.00	1024.96	3699.70	0.00	457.20	0.00
GREAT LAKES	0.00	0.00	0.00	1634.07	2223.73	0.00	0.00	6761.37

MARKETING STRATEGY:

FROM	OREGON	WASHING-TON	CALIFOR-NIA	NEW ENGLAND	INV. SUPPLY	ALASKA	CANADA	EUROPE
TO OREGON	517.01	0.00	6.78	0.00	32.42	33.22	27.50	0.00
WASHINGTON	194.83	327.44	0.00	53.10	257.64	8.89	98.25	0.00
CALIFORNIA	37.62	0.00	3.71	477.81	4313.63	20.00	531.45	0.00
NEW ENGLAND	0.00	0.00	0.00	1986.98	0.00	0.00	823.11	585.44
INV. DEMAND	0.00	0.00	0.00	0.00	99299.97	0.00	14600.72	8202.04
MID-EAST	0.00	0.00	0.00	0.00	7536.49	0.00	0.00	4347.48
SOUTHEAST	0.00	0.00	0.00	1223.07	10490.64	0.00	1477.74	0.00
SOUTHWEST	111.00	84.00	0.00	1024.96	3504.73	0.00	457.20	0.00
GREAT LAKES	111.00	84.00	0.00	1634.07	2165.41	0.00	0.00	6624.74

Appendix F: Equilibrium Quantity* Demanded and Price** of Ocean Perch Fillets Under Various Experiments.

		INITIAL SOLUTION	UNIFORM LANDINGS	INCREASED LANDINGS	MARKETING STRATEGY
OREGON	QTY.	616.90	616.76	626.73	616.94
	PRICE	38.96	38.98	37.95	38.96
WASHINGTON	QTY.	940.06	932.75	954.59	940.14
	PRICE	39.16	39.64	38.20	39.16
CALIFORNIA	QTY.	5357.34	5381.83	5384.19	5384.22
	PRICE	39.71	39.43	39.41	39.41
NEW ENGLAND	QTY.	3395.30	3394.22	3395.52	3395.53
	PRICE	30.70	30.72	30.70	30.70
INV. DEMAND	QTY.	122098.00	122076.70	122102.40	122102.70
	PRICE	30.85	30.87	30.85	30.85
MID-EAST	QTY.	11883.14	11880.09	11883.90	11883.96
	PRICE	31.30	31.32	31.30	31.30
SOUTHEAST	QTY.	13190.50	13186.13	13191.39	13191.46
	PRICE	35.26	35.28	35.26	35.26
SOUTHWEST	QTY.	5181.50	5179.77	5181.86	5181.88
	PRICE	35.94	35.96	35.94	35.94
GREAT LAKES	QTY.	10618.43	10616.04	10619.17	10619.22
	PRICE	32.93	32.94	32.92	32.92

* QUANTITY IN 1000 POUNDS
** PRICE IN 1967 CENTS PER POUND

Appendix G: Regional Equilibrium Flounder Fillets Flows (1000 Pounds Fillet Weight)

INITIAL SOLUTION:

FROM	OREGON	WASHING-TON	CALIFOR-NIA	NEW ENGLAND	INV. SUPPLY	ALASKA	CANADA	EUROPE
TO OREGON	728.54	0.00	13.13	0.00	318.55	477.56	57.33	0.00
WASHINGTON	20.12	847.04	0.00	0.00	720.65	775.35	192.28	0.00
CALIFORNIA	0.00	0.00	7.16	54.64	5697.16	6909.49	2720.79	0.00
NEW ENGLAND	0.00	0.00	0.00	7420.91	0.00	0.00	1642.18	0.00
INV. DEMAND	0.00	0.00	0.00	0.00	58404.22	0.00	47359.78	0.00
MID-EAST	0.00	0.00	0.00	3226.42	18858.27	0.00	0.00	8174.22
SOUTHEAST	0.00	0.00	0.00	25837.85	3117.60	1422.94	0.00	0.00
SOUTHWEST	0.00	0.00	18.93	7880.34	494.38	3600.84	0.00	0.00
GREAT LAKES	0.00	0.00	0.00	129.82	0.00	0.00	0.00	26977.86

UNIFORM LANDINGS:

FROM	OREGON	WASHING-TON	CALIFOR-NIA	NEW ENGLAND	INV. SUPPLY	ALASKA	CANADA	EUROPE
TO OREGON	748.67	0.00	13.07	0.00	84.64	670.29	79.21	0.00
WASHINGTON	0.00	847.04	0.00	0.00	684.41	861.38	162.89	0.00
CALIFORNIA	0.00	0.00	13.07	155.31	5701.75	6795.27	2725.51	0.00
NEW ENGLAND	0.00	0.00	0.00	6690.41	0.00	0.00	2373.60	0.00
INV. DEMAND	0.00	0.00	0.00	0.00	59141.97	0.00	46625.02	0.00
MID-EAST	0.00	0.00	0.00	3085.87	19007.03	0.00	0.00	8169.21
SOUTHEAST	0.00	0.00	0.00	26627.84	2433.29	1320.99	0.00	0.00
SOUTHWEST	0.00	0.00	13.07	7890.09	554.54	3538.26	0.00	0.00
GREAT LAKES	0.00	0.00	0.00	100.46	0.00	0.00	0.00	26998.75

Appendix G: (continued).

INCREASED LANDINGS:

FROM	OREGON	WASHING-TON	CALIFOR-NIA	NEW ENGLAND	INV. SUPPLY	ALASKA	CANADA	EUROPE
TO OREGON	953.14	1.64	14.50	0.00	204.98	372.44	57.33	0.00
WASHINGTON	20.12	1084.13	0.00	0.00	475.96	797.36	192.28	0.00
CALIFORNIA	0.00	15.39	17.56	54.64	5612.57	6992.60	2720.79	0.00
NEW ENGLAND	0.00	0.00	0.00	6704.00	0.00	0.00	2372.41	0.00
INV. DEMAND	0.00	0.00	0.00	0.00	59266.80	0.00	46540.67	0.00
MID-EAST	0.00	0.00	0.00	3226.42	19033.66	0.00	0.00	8045.08
SOUTHEAST	0.00	0.00	0.00	26533.27	2476.24	1422.94	0.00	0.00
SOUTHWEST	0.00	0.00	18.93	7901.84	494.38	3600.84	0.00	0.00
GREAT LAKES	0.00	0.00	0.00	129.82	0.00	0.00	0.00	27022.81

MARKETING STRATEGY:

FROM	OREGON	WASHING-TON	CALIFOR-NIA	NEW ENGLAND	INV. SUPPLY	ALASKA	CANADA	EUROPE
TO OREGON	731.14	0.00	20.98	0.00	310.80	477.61	57.33	0.00
WASHINGTON	20.12	849.16	0.00	0.00	722.87	775.30	192.28	0.00
CALIFORNIA	0.00	0.00	11.08	54.64	5718.40	6909.49	2720.79	0.00
NEW ENGLAND	0.00	0.00	0.00	7434.69	0.00	0.00	1642.18	0.00
INV. DEMAND	0.00	0.00	0.00	0.00	58541.19	0.00	47267.80	0.00
MID-EAST	0.00	0.00	0.00	3226.42	18802.77	0.00	0.00	8277.57
SOUTHEAST	0.00	0.00	0.00	26038.83	2972.56	1422.94	0.00	0.00
SOUTHWEST	111.00	126.00	18.93	7665.59	494.38	3600.84	0.00	0.00
GREAT LAKES	111.00	126.00	0.00	129.82	0.00	0.00	0.00	26787.37

Appendix H: Equilibrium Quantity* Demanded and Price** of Flounder Fillets Under Various Experiments.

		INITIAL SOLUTION	UNIFORM LANDINGS	INCREASED LANDINGS	MARKETING STRATEGY
OREGON	QTY.	1595.12	1595.88	1604.03	1597.86
	PRICE	36.56	36.52	36.11	36.42
WASHINGTON	QTY.	2555.44	2555.73	2569.84	2559.72
	PRICE	36.35	36.34	35.89	36.21
CALIFORNIA	QTY.	15389.23	15390.90	15413.54	15414.39
	PRICE	36.22	36.21	36.08	36.08
NEW ENGLAND	QTY.	9063.09	9064.01	9076.40	9076.87
	PRICE	30.29	30.28	30.16	30.15
INV. DEMAND	QTY.	105764.00	105767.00	105807.40	105809.00
	PRICE	30.44	30.43	30.31	30.30
MID-EAST	QTY.	30258.92	30262.10	30305.16	30306.77
	PRICE	31.14	31.13	31.01	31.00
SOUTHEAST	QTY.	30378.40	30382.12	30432.45	30434.33
	PRICE	34.85	34.84	34.72	34.71
SOUTHWEST	QTY.	11994.48	11995.96	12015.98	12016.73
	PRICE	35.36	35.35	35.23	35.22
GREAT LAKES	QTY.	27107.69	27099.22	27152.63	27154.19
	PRICE	32.22	32.25	32.09	32.09

* QUANTITY IN 1000 POUNDS
** PRICE IN 1967 CENTS PER POUND

Appendix I: Results of the N.M.F.S. 1981 Survey (Total Groundfish -- Summary: Land, Sea, Air).

FROM / TO	Seattle	Other Washington	Portland	Other Oregon	San Francisco	L. Angeles San Diego	Other California	TOTAL
Oregon Washington	111540	1197900	0	2481930	0	0	1815000	5606370
California Hawaii	568740	1977690	0	4672800	4698540	150810	5797000	17865580
Other U.S.	201630	983400	0	1255980	55110	0	474540	2970660
Foreign	367620	266640	0	155100	0	0	2263140	3052500
TOTAL	1284030	4425960	0	8565810	4753650	150810	10349680	29529940

Values are expressed in process weight.
Source: Adapted from Earley (1985): N.M.F.S. 1981 Primary Market Channels.