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Title: SUBSTITUTIONAL RELATIONSHIPS BETWEEN RAINBOW TROUT AND PANSIZE SALMON: A MARKET DEMAND ANALYSIS

Abstract approved: Richard S. Johnston

The fundamental objective of this analysis was to isolate and identify the factors governing the demand for domestically produced rainbow trout in a representative west coast market, and assess the impact on that demand, if any, of the introduction of pansize salmon. The approach taken in this market demand study was to identify those variables hypothesized to determine supply and demand for rainbow trout. Several testable hypotheses concerning the anticipated relationships were specified. It was hypothesized that a negative relationship would exist between the price of trout at the brokerage level and the quantity demanded at that level. Conversely, the price of trout at the wholesale level was hypothesized to be positively correlated with the quantity of rainbow trout demanded at the brokerage level. Further, the signs on the coefficients of variables accounting for the wholesale prices of substitute items were expected to be
negative, while comparable prices at the brokerage level should be positive, based upon the hypothesis. It was hypothesized that the presence of Japanese trout in the market place would have a negative impact on the quantity of domestically produced trout demanded. Personal disposable income was hypothesized to be positively correlated with the quantity of trout demanded. Expectations were that seasonal factors tend to cause trout demand to fluctuate cyclically.

An econometric simultaneous equations model was specified from which estimates of the parameters of the demand equation were obtained using Two Stage Least Squares techniques. A recognition of the limitations associated with the available data set necessitates the emphasizing of the preliminary nature of these results.

Data on quantities and prices of rainbow trout and equivalent price series for hypothesized substitutes were obtained through personal interviews with market participants and close observers thereof.

The results of the study, while preliminary, tend to support the original set of hypotheses concerning the interrelationships between quantity of domestic trout demanded and own-price, the price of close substitutes and seasonal demand fluctuations. Somewhat unexpectedly, the regression seems to have uncovered a negative income/quantity demanded relationship for rainbow trout. This raises some interesting questions which might best be addressed in terms of hypotheses for future analysis.
Substitutional Relationships Between Rainbow Trout and Pansize Salmon: A Market Demand Analysis

by

Lewis Everett Queirolo

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Date thesis is presented December 13, 1976
Typed by Clover Redfern for Lewis Everett Queirolo
I wish to express my most sincere appreciation to several individuals without whose counsel and assistance this thesis would have been infinitely more difficult. In particular, I would like to acknowledge Dr. Richard S. Johnston for his advice, support, and service as major professor throughout my term of study in this department. His sincere concern for my well being, both academically and personally deserve the respect and admiration I hold for him.

I should also like to acknowledge Dr. William G. Brown for his insights and recommendations concerning econometric methods and techniques. His subtle wit and personal support have been greatly appreciated.

A special thanks must be given Dr. John A. Edwards for that seemingly always open office door and the patient counsel to be found inside.

I wish also to express my appreciation to Dr. Roger G. Petersen for serving on my Committee.

It is impossible to acknowledge everyone who contributed to the thesis which follows. But without the support, love, and sacrifices of my wife, Susan, and my daughters, Chelcee and Ryanne, the investment of time and effort embodied in this Masters degree would have been quite impossible. In a real sense this degree belongs to all four of us.
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The world's oceans have long provided a rich and varied source of food protein for human consumption. Historically, the United States and Canada have concentrated their respective fishing efforts and resources, at least in the North Pacific, upon a select few species. Among the most economically important of these have been the anadromous salmonids, spawned and hatched out in freshwater streams, maturing in the saltwater environment of the open ocean and ultimately returning to complete the cycle in the freshwater streams of their origin. But as Brown, Larson, Johnston, and Wahle (1976) have noted,

Increasing demands over the years for the utilization of rivers and streams for hydroelectric power, irrigation, flood control, navigation, waste disposal and other purposes, have presented severe hazards to the anadromous fish... (pp. 1).

As a result natural runs of these several species have declined dramatically while pressures for increased resource exploitation have mounted. Techniques for management of this resource and alternative means of increasing depleted stocks have become high priority issues in both countries. But inherent in such efforts have been numerous political and economic stumbling blocks.
and Pontecorvo (1969) noted,

The viscous and continuous political infighting that has plagued the conservation authorities from Alaska to the Columbia River is eloquent testimony to the participant's awareness of economic consideration in fishery management.

The common property phenomenon and wide ranging migratory nature of these species add an international dimension to the conservation and management struggle surrounding natural and/or hatchery-enhanced runs.

Possible alternative sources of food fish which have been receiving increased attention recently include aquaculture, or perhaps more properly mariculture in the case of salmon species and salt-water species. These range from shellfish production, either on estuarine beds or floating rafts, to ocean ranching of salmonids, which entails releasing fry, in the case of Pink's and Chum's, and smolts, in the case of Coho's and Chinook's, into the sea. They feed and mature as would native runs of their species, returning to release sites as part of their natural biological, reproductive cycle, where they may then be harvested.

However, for the purposes of this study, the use of the term "aquaculture" is intended to describe the much more restrictive fish culture technique wherein the organism is hatched, reared, and ultimately harvested under the constant control and management of the production facility's staff. In the case of salmon, the fish remain as
private property on the "farm" site throughout their life, thus avoiding the common property dilemma facing ocean ranching operations. In addition, theoretically, this high density impoundment culture technique can provide a continuously harvestable stock of marketable product and, of perhaps equal importance to the institutional-restaurant trade, a uniformity of product size and quality lacking in commercially harvested ocean runs.

A brief review of the history of salmon aquaculture might be helpful at this point. *A Workshop on Salmonid Aquaculture: A Summary Report*, Washington Sea Grant Project (1973), indicates,

Since 1895, natural runs of Pacific Northwest salmon and trout have been supplemented by runs of hatchery reared fish. Because of growing demand for high quality fish in U.S. and foreign markets, researchers have looked in recent years to developing propagation methods such as net-pen rearing, ocean ranching, and lagoon rearing in attempts to find more effective and possibly more economical alternatives to traditional hatchery methods. The results of their experiments have stimulated considerable interest from management agencies, research institutions, private investors and the public.

In reality salmonid aquaculture is not a new phenomenon. Trout have been reared in closely managed environments for more than one hundred years and the first "farm" in the Northwest was established in 1909 (Klontz and King, 1975). But in terms of anadromous species the concept of managed food fish production is a relatively new development. By the late 1960's most of the technical and political groundwork (Kane, 1970) had been laid to permit the development
of salmon aquaculture on a commercially feasible and potentially economically viable scale. The first production operation began in the Puget Sound area of Washington state and by the spring of 1972 the initial crop of pansize or mini salmon were harvested. Since that time the industry has grown in scope, both geographically and methodologically, to encompass operations in Oregon, Idaho, and Canada as well as several additional production sites in Washington state. Investors have ranged from large national and international corporations such as Union Carbide, Ralston-Purina, and Weyerhauser to fishermen's cooperatives and several consolidated Indian tribes (Deloria, 1975). The rearing techniques have been as numerous and varied as the companies in the industry.

Presently several fundamentally important questions concerning the economic feasibility of the pansize salmon product remain unanswered. Thus the ultimate future of this phase of the salmon aquaculture industry is still unresolved. However, it is abundantly clear that resolution of these issues is of critical importance both for the members of the industry and the salmon fisheries in general.
II. PROBLEM STATEMENT

Aquaculture, the process of rearing fish and shellfish in high density, closely managed habitats for purposes of human consumption, has been likened to the feed lot concept of livestock production (Lannan, 1975). But unlike its agricultural counterpart, aquaculture, and for that matter fisheries products generally, have received very little attention in the way of objective quantitative demand analysis, as discussed in the introduction. Legislative and administrative decisions which may have long range repercussions upon the food fish industry have often been made without a full appreciation for the economic impact they entail. In most cases this has been due primarily to the fact that the information necessary for informed decisions simply was not available.

Knowledge of the nature of demand for a product would be invaluable, not only in terms of allocating scarce resources efficiently on the part of public decision makers, but equally as well to members of the industry and potential entrants, in the process of making sound investment, management, and production decisions.

Intense production of aquatic organisms on a scale capable of providing sufficient stocks of marketable product requires substantial capital investment and, by its nature, faces very high production costs (Richards, Mahnken, Tanonaka, 1972). An understanding of the
dimensions of current and potential demand and the substitutional relationships governing market performance would provide insight into the effects on total revenue associated with various price and output levels for aquaculturally produced food fish products.
Some preliminary work on the economic and market potential of the so-called, "pansize" or "mini" salmon had generated a great deal of interest and guarded enthusiasm among those in and around the aquaculture industry. Most of this early research centered upon the technology and cost of production associated with salmon aquaculture. However, some work on product marketability was undertaken. Test marketing of the "single serving" salmon product took place in the east and midwest as well as in California. The character of most of this market work emphasized a non-quantitative "opinion poll" format, wherein the new product was evaluated on the basis of several criteria by brokers-wholesalers, institutional buyers, and restaurant managers and chefs. The results indicated a very rosy future for pansize salmon, but astute observers noted the danger in relying too heavily upon these preliminary results. As the Evaluation of the Commercial Feasibility of Salmon Aquaculture in the Puget Sound, undertaken by Jack A. Richards, Conrad V. M. Mahnken and George K. Tanonaka of NMFS (1972) pointed out, "There is no established market for this new, unique product--'plate size' salmon" (p. 13). As a result no hard data on performance of the product in the market place were available upon which to make sound public and private policy and investment decisions concerning such issues as licensing,
enhancement programs, water use, discharge levels of waste and investment in appropriate monitoring programs, etc. The need for quantitative economic analysis of potential consumer demand for the product was clear. As pansize salmon received wider exposure in the market place the data would, it was assumed, be forthcoming.

As mentioned earlier, the initial commercial pilot project designed to rear "mini" salmon was undertaken by Ocean Systems, Inc. in the Puget Sound, Washington. The first harvest of marketable product was expected in the spring of 1972. Since that time several other production facilities have been constructed, both in the Puget Sound area and elsewhere in Washington State and Oregon. Thus by July of 1975, when this study was in its formative stages, the expectation was that sufficient time series and/or cross-sectional data to do a quantitative demand study would be available.

Because of the reasonably close proximity of Oregon Aqua Foods Inc., of Newport, Oregon, to Oregon State University and the close working relationship of "Ore-Aqua's" founder, Dr. John R. "Jack" Donaldson, with this institution, contact, exploring the possibility of obtaining cooperation and project input from the aforementioned firm, was made. Mr. Robert Cantrell, business manager of Oregon Aqua Foods, was both interested and most cooperative. However, after several visits to the company's Newport facility it became apparent that the available production, price, and shipments data were
insufficient to support a meaningful statistical analysis.

In the course of developing testable hypotheses for the pansize salmon study, it became apparent that rainbow trout was perceived by pansize salmon producers to be one of the strongest potential substitutes for the new product in the marketplace. Because data limitations prevented direct estimation of the demand for pansize salmon, it was felt that using rainbow trout, a widely distributed, well-established aquaculturally produced food fish, as a close proxy for pansize salmon might permit the observation and identification of the forces governing the performance of both products in the marketplace. It was under this assumption that the focus of this study shifted to an estimation of the demand for rainbow trout and the impact, if any, which the arrival of pansize salmon in the market had on that demand.

Because trout has been aquaculturally produced and marketed in the U.S. for more than 106 years (Klontz and King, 1975), it was assumed that copious amounts of data would be available and that some demand analyses had probably already been done. However, after an exhaustive search it became clear that neither assumption was correct. Thus the current study is a pioneering effort in the estimation of the demand for rainbow trout. It is also somewhat unique in attempting to explore the impact of a "new" product on the demand for an "established" one.
An indepth historical survey of the trout aquaculture industry is beyond the scope of this thesis. An excellent compendium of aquaculture in the United States is available for interested readers in, *Aquaculture in Idaho and Nationwide*, Idaho Department of Water Resources, Klontz, and King, 1975. For clarity sake however, a few highlights of the evolution and character of that industry must be made.

The state of Idaho is responsible for 90% of the nation's total production of rainbow trout. Estimated total trout output, in Idaho, by 1980 is expected to reach 39 million pounds and contribute nearly $50 million to the state's economy (Klontz and King, 1975). The industry itself is comprised of a relatively few trout producing companies, most of which are located within a ten mile radius of Buhl, Idaho (see Figure 1). Among the some 14 companies and 28 production facilities, the industry is dominated by three major integrated operations accounting for 80% of the total output.

The potential for cooperative marketing and promotional activities appear obvious. Nonetheless, every attempt at such coordination has resulted in varying degrees of failure. The industry might best be described in terms of intense personal rivalries bordering on physical violence in some cases. Even in the best of circumstances, highly price-competitive behavior has characterized this industry throughout the post World War II period. Demand analysis
Figure 1. Geographic distribution of Idaho food fish production facilities. Source: Aquaculture in Idaho and Nationwide, 1975, Idaho Department of Water Resources.
and market research has, for the most part, been lacking as a result of apprehension on the part of producers to provide accurate detailed production data. Klontz and King (1975) noted in their recent study,

The food animal industry unlike hard-goods industries, must move their product when it is a certain size or it becomes a financial liability—it keeps on growing and must be fed to keep it presentable for the consumer. Current (marketing) practices are inadequate to promote increased sales of food fish over the counter or in restaurants. The primary problem with marketing (in Idaho trout aquaculture) is that it has been guided by production rather than the other way around (p. 69).

Sensitive to the increasing awareness on the part of industry members of the need for market analysis and yet conscious of their historical behavior, project members sought initial contacts within or around the Idaho food fish industry. The first and surely the most cooperative source of ongoing information concerning the industry in general, was Dr. G. W. Klontz of the University of Idaho. In addition to providing a wealth of background information, Dr. Klontz was instrumental in identifying and, in several instances, actually introducing key individuals within the industry. With his assistance an on-site visit was arranged with one of the major producers for early January, 1976. However, a number of unforeseen events prevented the scheduled meeting from taking place. It rapidly became clear that the data being sought would not be available from the primary sources, i.e., the major Idaho producers, at this time.
Subsequently, contact was established with Mr. Robert Erkins, who had been instrumental in the growth and development of Thousand Springs Trout Farm, Inc. into one of the three most significant trout operations in Idaho. Currently, Mr. Erkins co-authors the fisheries industry publication, "The Gruber-Erkins Newsletter," and is no longer directly affiliated with Thousand Springs. However, his insight and experience proved to be invaluable. After an extensive conversation at his home in Bliss, Idaho, during which the project was discussed in some detail, Mr. Erkins suggested that the most likely source of available data on price and quantities would be through the brokerage network within the trout marketing system. It was hoped that brokerage firms, being somewhat closer to the process of marketing a product, could be persuaded to provide the aggregate shipments data and price lists necessary to successfully carry out the analysis. Trout, while a valuable food product, actually accounts for a relatively small percentage of a brokers gross sales volume, and for this reason relinquishing sales data would be less apt to evoke concern. Although it was made clear from the start that all results of this study would be made public, it was also pointed out that specific data would be held in strictest confidence and only marketwide aggregate figures would be incorporated within the published results.

The exact location for the demand study was, at this time, still an unresolved issue. It seemed clear that, for the purposes of this
study, a market should be identified in which trout and its closest hypothesized substitutes, namely commercially harvested ocean salmon and aquaculturally produced pansize salmon, were most consistently in close competition for the consumer's dollar. Because of the limited distribution of the pansize salmon product and resource constraints associated with the research project, a west coast outlet seemed most desirable. Seattle and Portland were rejected on several counts, perhaps chief among them being the availability of large quantities of trout and salmon readily accessible to sport fishermen from the two metropolitan areas. Erkins indicated that both Seattle and Portland were traditionally "poor" trout markets in terms of consistent sales volume. San Francisco had seemed a highly promising market based upon its worldwide reputation as a seafood capitol and the fact that pansize salmon had been introduced there early in the test marketing stage. But despite these facts Erkins suggested avoiding San Francisco. Apparently, in part because of its reputation and the substantial tourist trade, San Francisco is frequently a "dumping ground" for excess stocks and for this reason is not perceived to be a representative market. Los Angeles, on the other hand, seemed free of the possible biases associated with the Seattle, Portland, or San Francisco markets and additionally represented a substantially larger potential consuming population than did any one of the other three. It was Mr. Erkings' impression that Los Angeles also
represented the market in which ocean run salmon, pansize salmon, and rainbow trout had been most consistently available over the longest continuous series of years. This conclusion was later verbally supported by several other sources, including those who were currently producing pansize salmon. This information suggests that the Los Angeles market might best serve as the target area for the project.

Bear in mind that the initial purpose of this study centered on pansize salmon. As the preceding section has attempted to demonstrate, this goal could be satisfied only indirectly. Thus, the principal objective of this research became an effort to isolate and identify the forces governing the demand for rainbow trout and the impact upon that demand of changes in the price of several potential substitutes. Of obvious interest was the impact on the demand for trout of the appearance of pansize salmon in the market.

Most specifically, the study intends to (1) develop a model of the structure of the Los Angeles market which identifies the factors hypothesized to influence the demand for rainbow trout, (2) estimate the magnitudes of own-price, cross-price, and income elasticities associated with rainbow trout in this market and (3) assess the potential impact of various pricing and marketing strategies upon total revenue of brokers and ultimately producers, of rainbow trout.
As mentioned earlier, very little has been done in terms of identifying criteria and evaluating techniques for assessing the impact of a "new" product in a highly competitive market situation. A significant objective of this study, then is to seek to establish an analytical framework within which a unique new product, namely pansize salmon, might be quantitatively evaluated in terms of market impact and potential, despite the lack of substantial data on historical or cross-sectional market performance.

Preliminary contacts were made with brokerage firms in the Los Angeles market serving as representatives of the major Idaho trout producers on the basis of a list of distributors provided by Mr. Erkins. Dr. William Jensen, who has been a participant in and a close observer of the Pacific coast fishing industry, was instrumental in establishing contact between industry representatives and project members.

Despite the efforts by Mr. Erkins and Dr. Jensen to lay the appropriate introductory groundwork, the project's reception was mixed. While some data were immediately made available, several of the most significant brokerage houses either flatly refused to cooperate or required express permission from their Idaho producers prior to releasing data. Thus the study seemed to have come full circle. Despite this resistance and armed with at least some hard data and the impression that a significant portion of the market was
therein represented, analysis began.

It quickly became apparent however that substantial portions of the market were not being accounted for within the available data and a second round of information search was undertaken. Subsequently two of the principal suppliers of the Los Angeles market, namely Clear Springs Trout Company and Thousand Springs Trout Farm, Inc., had agreed to release data on their shipments into southern California. At this point it was believed that 80-90% of the trout entering L.A. were being accounted for by the data acquired in L.A. and that just promised. Unfortunately, before the data from Clear Springs Trout Company could be obtained a fire destroyed one of the buildings at the company's Idaho production and processing facility and all sales records were lost.

While Clear Springs is currently the world's largest trout producer, their participation in the Los Angeles market has been very recent, spanning only two to three years. Thus, it was felt that the loss of data on that portion of the market, while a most regrettable incident, would not significantly hamper the analysis. Further, data which represent the most recent market participation on the part of Clear Springs Trout Company have been provided by Mr. Larry Cope, general manager of the Idaho operation, and could be utilized for validation of the model.
IV. THE MARKET

The market distributional network referred to in this analysis is geographically identical to the standard metropolitan statistical areas, (SMSA's), of Los Angeles, Orange, Ventura, Riverside, and San Bernadino counties, California, as set forth by the United States Bureau of Census (see Figure 2). This specific group of counties in the Southern California basin is also referred to by the Bureau of Statistics as the Los Angeles standard consolidated statistical area, (SCSA), the dark shaded area in Figure 2, and may be referred to by either title within the body of this study. It was noted in the course of data preparation that delineations of SMSA's have tended to fluctuate over time and therefore appropriate care has been taken to assure consistency in the statistics incorporated in this analysis.

Through interviews with representatives of several of the major brokerage firms in the Los Angeles area it became apparent that this combination of standardized areas described closely, and most satisfactorily, the boundaries within which trout arriving in L.A. were distributed. Brokers in San Luis Obispo area serve territories to the north and San Diego distributors are significant agents in the extreme south. Some overlapping does occur at the margins, and in one case an L.A. broker reportedly was handling the Las Vegas trade for the trout farm his firm represents, but, generally speaking, the vast
Figure 2. California standard metropolitan statistical areas.
majority, perhaps greater than 95%, of the rainbow trout entering through the Los Angeles based brokerage houses are distributed and consumed within the geographic boundaries described above.

The dimensions of the Los Angeles SCSA, in terms of a potential consuming population, are substantial as the population and personal disposable income figures in Table 1 denote. However, indications are that a consistent marketing program or strategy for exploitation and development of this potential market has been lacking historically. Industry sources explained that, traditionally, as the demand for rainbow trout increased in the Colorado resort market, incidently the largest single trout market in the U.S. during the heavy tourist season, the producers had characteristically pulled their product out of Los Angeles, and other lesser markets, in order to accommodate the Colorado trade. This, obviously, disrupted supplies of the product and alienated customers, thereby necessitating a complete rebuilding of the L.A. distribution network for rainbow trout each year. The phenomenon continued until the early to mid 1960's when some of the Idaho producers began to recognize the inherent costs and inefficiencies of such a supply strategy and ceased the practice. Additional production capacity resulting in increased supplies of rainbow trout also contributed to the elimination of this historical pattern.
Table 1. Estimated total population of selected California counties 1970-75 and adjusted gross and median income for selected California counties (1975).

<table>
<thead>
<tr>
<th>County</th>
<th>July 1, 1970</th>
<th>July 1, 1971</th>
<th>July 1, 1972</th>
<th>July 1, 1973</th>
<th>July 1, 1974</th>
<th>July 1, 1975</th>
</tr>
</thead>
<tbody>
<tr>
<td>Los Angeles</td>
<td>7,047,100</td>
<td>7,071,200</td>
<td>6,988,900</td>
<td>6,966,200</td>
<td>6,955,500</td>
<td>6,970,000</td>
</tr>
<tr>
<td>Orange</td>
<td>1,431,600</td>
<td>1,471,000</td>
<td>1,526,700</td>
<td>1,592,300</td>
<td>1,653,500</td>
<td>1,694,900</td>
</tr>
<tr>
<td>Riverside</td>
<td>461,400</td>
<td>474,000</td>
<td>488,500</td>
<td>501,600</td>
<td>514,200</td>
<td>526,600</td>
</tr>
<tr>
<td>San Bernadino</td>
<td>685,200</td>
<td>689,500</td>
<td>690,500</td>
<td>691,400</td>
<td>694,600</td>
<td>698,300</td>
</tr>
<tr>
<td>Ventura</td>
<td>381,400</td>
<td>389,800</td>
<td>404,200</td>
<td>415,200</td>
<td>427,000</td>
<td>438,200</td>
</tr>
</tbody>
</table>

Gross - ($1,000) Median

Adjusted gross and median income for selected California counties (1975):

<table>
<thead>
<tr>
<th>County</th>
<th>Gross</th>
<th>Median</th>
</tr>
</thead>
<tbody>
<tr>
<td>Los Angeles</td>
<td>$28,735,988</td>
<td>$ 9,121</td>
</tr>
<tr>
<td>Orange</td>
<td>7,202,367</td>
<td>10,684</td>
</tr>
<tr>
<td>Riverside</td>
<td>1,584,552</td>
<td>8,544</td>
</tr>
<tr>
<td>San Bernadino</td>
<td>2,146,000</td>
<td>9,364</td>
</tr>
<tr>
<td>Ventura</td>
<td>1,571,157</td>
<td>10,605</td>
</tr>
</tbody>
</table>

Rainbow trout enter the Los Angeles market in several forms including, fresh or fresh-frozen, dressed or boned. However, data limitations preclude estimating separate demand relationships for each. Thus this study will, by necessity, aggregate these groups and estimate the demand for rainbow trout in total, ignoring the particular form the product takes. Interpretation of the results, thus, will require one to be sensitive to this limitation. The single exception to this format will be in the case of trout categorized as "large". As has been explained in the preceding chapter, once trout reach optimal market size they must be harvested or very soon they become too large to command a premium price in the market place. Historically this has occurred periodically and these "large" trout have been offered for sale at greatly reduced prices, usually in significantly larger shipments than are characteristic for the "prime" product. For the purposes of this demand analysis these "large" trout are hypothesized to be highly price competitive substitutes for the smaller sized fish. When referring to the premium product the term "rainbow trout" will be used. "Large" trout will be so identified henceforth.

The current Los Angeles distribution network, as it relates to rainbow trout, might be represented by a flow chart such as the one in Figure 3. Notice, with the exception of imported Japanese trout, all the trout entering the Los Angeles market are the product of the "far west" or "mountain" states, these being dominated far and away
Figure 3. Los Angeles rainbow trout distribution network.
by the Idaho "farms". While there are trout production facilities in several eastern states, most notably North Carolina and Pennsylvania, indications are that none of their product reaches the Los Angeles market. There are rainbow trout production facilities in the state of California as well. However, there is no competition between these trout and the Idaho product. The California fish are ultimately destined for fee fishout ponds, not the retail consumption market, according to California Department of Fish and Game representatives.

Thus, as the flow chart indicates, the rainbow trout are marketed by brokerage representatives for the producers. Historically, each of the "farms", has secured a single broker in the Los Angeles market to handle the distribution of its product. These relationships, between producer and broker, have been subject to

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1For the sake of accuracy it should be noted that rainbow trout are produced in relatively significant numbers in Montana, Colorado, and Wyoming. Several other western states have production facilities but do not produce sufficient quantities of product to merit attention. But the volume of output of all of the above mentioned producers is so minor when compared to the Idaho industry's production that for purposes of this analysis the term "Idaho rainbow trout" will be used interchangeably with the term "domestically produced rainbow trout". Conservative estimates of Idaho's dominance of the industry put the portion of total national production of rainbow trout reared and harvested in Idaho at 90-95% (Klontz and King, 1975). The proportion of domestically produced rainbow trout distributed in the L.A. market originating in Idaho is even higher. Therefore, no attempt will be made to differentiate between Idaho, Montana, Colorado, and Wyoming trout entering L.A. The volume of non-Idahoan, but domestically produced trout has historically been very insignificant when they appeared at all, at least over the period observed in this analysis.
fluctuation or turnover over time. However, characteristically, there appears to have been a "one to one" relationship between producer and broker, at any point in time.

As the Los Angeles rainbow trout market has been dominated, historically, by primarily three to five Idaho trout companies, so too the number of brokerage firms handling the product have been dominated by three to five significant brokerage houses. Industry estimates place the portion of the total L.A. market served by the three principal "farms", and therefore the three principal brokers, at 85-90%, with the remaining 10-15% divided among half-a-dozen other producers. These percentages have fluctuated somewhat over time; however, they are essentially indicative of the relative influences in the L.A. market until very recently.

Again referring to the flow chart, the small number of brokerage houses, acting as exclusive representatives of their particular producer, service a substantially more numerous intermediate or wholesale level of the market. Purchases by these wholesalers, historically, have tended to fluctuate between brokers, i.e., between "farms", as the availability of a particular producer's product varies. However, again, at any one time a wholesaler probably only distributes a single "farm's" product.

At the next level are the final consumption purveyors. As will be explained in more detail in the following section, this level of the
domestic rainbow trout distribution network is primarily an institution-restaurant trade. The number of these establishments, either serving rainbow trout or as potential markets for the product, is staggering in a megalopolis the size and character of the Los Angeles SCSA. Historically, these retailers have born the brunt of the supply fluctuations described above in terms of relatively highest costs incurred as a result of the loss of supply. And, perhaps as a result of this, indications are that, at least some of these establishments, maintain an interlocking supply relationship with several wholesalers serving different Idaho producers. This may cease to be the case as supplies become more stable but over the period of this analysis some of this behavior was reported to be persisting.

The majority of the over-the-counter retail trade has traditionally been met by imported trout, primarily from Japan. However, some few domestic rainbow trout do pass through the primary distribution network and arrive at the market outlet purveyor. Additional Idaho rainbow trout bypass the broker-wholesaler-retailer network and are purchased directly from Idaho producers by "food chain" buyers for ultimate distribution to their local retail outlets. Safeway is reportedly the prime example of this behavior in the L.A. market area. However, the volume of domestically produced trout which arrive in the over-the-counter market is quite small, at present: perhaps no more than 5% of the total volume of rainbow trout
entering Los Angeles. Japanese trout, as was mentioned, account for
the remaining volume and may be distributed through either of these
two alternative systems.

Beyond the L. A. market, as detailed above, Idaho rainbow trout
are marketed throughout the United States and there are tentative
plans to investigate the potential of export markets, especially
Europe. Thus these external markets constitute important potential
shifters in the supply of rainbow trout available in the Los Angeles
market. This will become more obviously significant in terms of the
economic model which will be specified in the following section.
V. A PRELIMINARY DEMAND ANALYSIS OF RAINBOW TROUT IN THE LOS ANGELES MARKET

Per capita consumption of edible food fish products has remained approximately constant over the post W. W. II years. Most available sources place the figure at between 10 and 11 pounds per capita annually. "But whether per capita consumption increases or not, an increased demand for food fish, as for all foods, must come in the future as the population explosion continues" (Bell, Hazelton, p. 23). If projections are correct, the population of the United States will soon reach the 225 million mark. The impact upon total consumption, assuming constant per capita consumption, will result in an additional 385 million pounds of edible fish being required just to accommodate this growth (Bell and Hazelton, 1967).

At present a majority of the fish products, both edible and industrial, being consumed in the United States are imported. Generally this trend has been on the increase in recent years as indicated by Figures 4 and 5. Perhaps more dramatically, the market value of these imported fish products has more than doubled over the last decade (see Figure 6). Batie (1974) noted "It is not immediately clear why this should be so. The United States is one of the largest seafood markets in the world, and U.S. fishermen have an obvious geographic advantage in meeting this demand." Imports have characteristically enjoyed a price advantage relative to their U.S.
counterparts. However, at least in the case of rainbow trout, the quality of the imported product has been somewhat lower. As a result indications are that the two trout products, domestic rainbow trout and imported trout, have traditionally found their way into different consumptive markets. As noted in a preceding section, while some domestically produced rainbow trout ultimately arrive in the meat display or frozen food counter of retail markets, indications are that the overwhelming majority of the "prime" quality domestic product reaches the consumer through the restaurant-institutional system, while imported trout generally account for the bulk of the over-the-counter trade. Very recently, U.S. importation of foreign produced trout, historically dominated by the Japanese but also including significant shipments from Denmark, have been declining as a result of increased demand for trout within Japan and some European countries, and because of disease problems in Danish stocks (Robinson, 1972). It would therefore appear reasonable to assume that some future market adjustment in the domestic product's distribution may be inevitable.

\[2\] It has been observed and verified through industry sources that upwards of 90-95% of all domestically produced rainbow trout are consumed within the restaurant-institutional trade. Therefore references made above to "retailers" are intended to identify restaurants, institutions, and their suppliers, at the level immediately below wholesale, when appropriate "market outlets" refer to retail food stores such as grocery or seafood outlets.
In an effort to isolate and identify the factors governing the movement of rainbow trout within and between the several levels of the Los Angeles distribution network, a preliminary economic model has been hypothesized.

If one accepts the existence of consumer utility functions and further accepts that consumers act to maximize their own utility subject to budget constraints, then certain consumer demand behavior can be anticipated, at least to the extent that they constitute testable hypotheses. The relationships responsible for the retail performance of rainbow trout in the L.A. market, based upon the above assumption, can be expressed in terms of the functional interaction between the quantity of trout in the market, its own price, the prices of close substitutes and/or complements and the personal disposable income of the potential consuming public. The hypothesized specification of the retail segment of the economic model can be expressed, using the notation in Foote (1958, p. 8) as:

\[
\begin{align*}
Q_d^c & : P_r^c, P_{cpss}^c, P_{csvb}^c, Y, D_2, D_3, D_4 \\
\end{align*}
\]

or alternatively in per capita terms, where "N" stands for population:

\[
\begin{align*}
\frac{Q_d^c}{N} & : P_r^c, P_{cpss}^c, P_{csvb}^c, Y/N, D_2, D_3, D_4 \\
\end{align*}
\]
and assuming the identity,

\[ Q_{ct}^d = Q_{rt}^s = Q^{\text{total}} \]

where,

- \( Q_{ct}^d \) or \( Q_{ct}^d / N \) = (per capita) quantity of rainbow trout demanded by L.A. consumers at the final consumption level
- \( P_{ct}^r \) = price of rainbow trout from retailer to consumer
- \( P_{c\text{pss}}^r \) = price of pansize salmon from retailer to consumer
- \( P_{c\text{svb}}^r \) = price of other food protein substitutes from retailer to consumer
- \( Y \) or \( Y / N \) = (per capita) personal disposable income in the Los Angeles SCSA

\( D_2, D_3, D_4 \) = binary variables included to account for seasonal shifts in consumer demand on a quarterly basis.

All variables, excluding \( D_2, D_3, \) and \( D_4 \), have time subscripts where the time interval is one month.

Based upon the assumptions and hypothesized relationships stated above it is expected that, by specifying quantity demanded as the endogenous or dependent variable and the other variables in the equation as exogenously determined, the sign of the coefficient on the "own-price" variable, \( P_{ct}^r \), will be negative. By including "own-price" of rainbow trout as a predetermined variable in the model, the
assumption is made that forces beyond the scope of the L.A. market
work to determine the price in L.A. For example, Los Angeles, while
a significant market, is only one of several market areas into which
producers can ship trout. To some extent then the price in L.A.
might be assumed to be dependent upon the price/quantity relationships of these other markets. The signs of the coefficients for the
price of substitutes, including $P_{c}^{ss}$ and $P_{c}^{svb}$, would be
expected to be positive, as would the sign of coefficients on personal
disposable income.

The second distributional level accounts for the wholesale to
retail movement of rainbow trout in Los Angeles. As in the preced-
ing equation the quantity of rainbow trout, total or per capita, is
treated as an endogenous variable and is specified to be a linear
function of the price of rainbow trout paid to the wholesaler, the price
of rainbow trout received by the retailer, the price of substitute food
proteins confronting the retailer as well as the prices the retailer
could command for these same substitute items, and some variable
accounting for retail costs associated with including rainbow trout on
the menu, e.g., menu inserts, table tents or other specific promo-
tional costs. In addition, because some product does move into
"market outlets" a variable accounting for associated "market outlet"
costs has been included. Thus the economic specification of this
second stage becomes:
The Preliminary Economic Model for the Wholesale to Retail Level

\[ Q_{rt}^{w_d} : P_{rt}^{w_t}, P_{ct}^{r_t-1}, P_{rsvb}^{w_t}, P_{csvb}^{r_{t-1}}, I, C_t \]

where:

- \( Q_{rt}^{w_d} \) or \( Q_{rt}^{w_d} / N \) = (per capita) quantity of rainbow trout demanded by retailers at wholesale
- \( P_{rt}^{w_t} \) = price of rainbow trout to retailer at wholesale
- \( P_{ct}^{r_t} \) = price received for rainbow trout by retailer
- \( P_{rsvb}^{w_t} \) = price of substitute seafood items to retailer at wholesale
- \( P_{csvb}^{r_{t-1}} \) = price received for substitute seafood items by retailer
- \( I \) = some index of costs associated with featuring rainbow trout as a menu item
- \( C \) = costs associated with maintaining fresh and fresh frozen fish in a meat display case of an over-the-counter retail outlet.

Note the inclusion of the subscript \( t \) for each variable in the economic model. As before, \( t \) equals the one month interval; thus variables subscripted \( t-1 \) are lagged by one month. The rationale for this decision is discussed on pages 38 and 39.
The third level of distribution in the L.A. market is that of broker to wholesaler. It is this stage of the marketing network which will be most closely scrutinized in this analysis. This decision was made primarily on the basis of two criteria, the first being the need to limit the scope of the research to accommodate time and resource constraints. The second, and perhaps more utilitarian reason, was some initial indication of availability of cooperation from Los Angeles brokers and wholesalers and the subsequent contribution of primary data on this facet of the distribution network. However, as discussed in the following section, data problems surfaced even at this level, requiring the adoption of an intermediate strategy to solicit much needed additional cooperation from industry sources.

As has been alluded to above, the initial series of efforts at data acquisition were not wholly successful. It became apparent, rather quickly, that significant portions of the total quantity of rainbow trout entering the Los Angeles market were not being accounted for by the data in hand. Confirmation of this suspicion came when, in a subsequent phone conversation with Mr. Erkins, he noted the sources that had provided data constituted perhaps no more than 35% of the total product movement in this market during the period 1964 through 1975, under consideration.

It was decided that the data currently being withheld might be obtained if those in possession of the missing information had a
clearer understanding of what the analysis intended to do and how critical to the study's success their participation was. As a means to this end a single equation model was specified and coefficients estimated using ordinary least squares technique, and utilizing a much shorter time series for which approximately 90% of the market was represented by the data, namely May, 1972, through December, 1975, in hopes that the results might be used as a descriptive tool in an effort to secure wider cooperation on the part of industry members.

It was recognized that the results of this model's analysis would, very likely, be unsatisfactory in terms of describing the actual behavior within the market, as a result of the incomplete data set and brevity of the time series. However, as a first approximation, given the obvious problems just cited, and recalling that the principal reason for this first stage of the analysis was to demonstrate the general thrust of the investigation, the time and energy invested seemed completely justified.

The economic model itself is described below. The equation specifies quantity of rainbow trout demanded by Los Angeles' wholesalers as the dependent variable. All other variables are assumed to be pre-determined. Price paid and received by wholesalers for rainbow trout and prices of hypothesized substitute food proteins, are deflated by the WPI (wholesale price index) for "Farm products, processed foods and feeds," U.S. Bureau of Labor Statistics. In
addition, prices at the wholesaler to retailer level are lagged by one time period in order to assess the validity of the following hypothesis. The analysis is seeking to identify the derived demand curve for the wholesale segment in the marketing structure. It is reasonable to assume, it is hypothesized, that planning decisions, at the wholesale level, are made in light of the most recent price information available. In essence, the wholesaler is demanding trout as an "input factor" to his final product. Whether he processes, repacks, or simply distributes the product, the analysis is fundamentally the same. Thus the wholesaler is confronted with several sets of prices when making decisions concerning trout. They include the cost of rainbow trout he must pay to obtain the "input", the price he is able to command for rainbow trout from retailers and the prices and costs associated with substitute inputs, i.e., alternate seafood products. This is the thought process which led to the decision to incorporate a lag in the price variables of this equation. An additional benefit associated with this "first approximation" process was an opportunity to scrutinize the resulting output in order to identify additional hypotheses which might then be more fully explored using the more complete data set.
The Preliminary Economic Model for the Broker to Wholesale Level

The economic model specified was as follows:

\[
Q^\text{wt}_d: P^\text{wt}_b, P^\text{rt}_w, P^\text{rms}_w, P^\text{wfrgt}_b, P^\text{rpss}_w, P^\text{tm}_w, D_3, D_4, Y, D^\text{int}
\]

and assumes the identity:

\[
Q^\text{wt}_d = Q^\text{wt}_s = Q^\text{total}
\]

recalling the colon in read "depends on", a comma is read "and",

\[Q^\text{wt}_s = \text{quantity of rainbow trout supplied by producers to the L. A. market}
\]

\[Q^\text{wt}_d = \text{quantity of rainbow trout demanded by L. A. wholesalers at brokerage level}
\]

\[P^\text{wt}_b = \text{price of rainbow trout from broker to wholesaler}
\]

\[P^\text{rt}_w = \text{price of rainbow trout from wholesaler to retailer}
\]

\[P^\text{tm}_w = \text{price of rainbow trout from wholesaler to market outlets}
\]

\[P^\text{rms}_w = \text{price of medium salmon from wholesaler to retailer}
\]

\[P^\text{wfrgt}_b = \text{price of "large" trout from broker to wholesaler}
\]

\[P^\text{rpss}_w = \text{price of pansize salmon from wholesaler to retailer}
\]
\[ Y = \text{personal disposable income in the L. A. (SCSA); not deflated} \]

\[ D^{imt} = \text{binary variable indicating presence or absence of imported trout in market} \]

\[ D_2, D_3, D_4 = \text{binary variables included to account for seasonality shifters on quarterly basis.} \]

All variables have "time" subscripts, where the time interval is one month, except \( D_2, D_3 \) and \( D_4 \). The perceived need to include both \( P_{\text{wt}} \) and \( P_{\text{rt}} \) in the equation has been addressed above.

The remaining variables in this model and for that matter, subsequent specifications, were included on a variety of grounds.

The price of rainbow trout at the market outlet level was included in this preliminary model on the assumption that \( P_{\text{wt}} \) would be accounting for shifts in demand resulting from changes in consumer demand for rainbow trout over the counter. This shift could potentially cause a significant change in \( Q_{\text{wt}} \) and necessitate price and allocation adjustments throughout the market.

Through discussions with seafood wholesalers in L. A. it was determined that "medium salmon" probably served as one of the closest substitutes for rainbow trout in this market. This hypothesis was implicitly incorporated into the model by the inclusion of \( P_{\text{rms}} \).
Once again, in order to account for a hypothesized substitutional relationship, this time at the same broker to wholesaler level, the variable $P^{wtr}_{b}$ was included in the model. Large trout appear in the market place periodically and usually in very large volume. Thus, if these two trout products are substitutes for one another, a shift in demand for rainbow trout should be detectable in conjunction with the flood of large trout onto the market place.

The inclusion of the price of pansize salmon has been discussed in some detail already. Suffice it to say, pansize salmon in terms of its relationship to rainbow trout is a very important issue in this analysis.

The inclusion of personal disposable income in a wholesale demand model is intended to account for the very significant influence retail demand has on the derived demand at wholesale. Y also tends to reflect the general economic condition of the potential consuming public which is targeted to be the final consumptive market for this product.

$D^{int}$ appears as a binary variable in the model to reflect the potential influence of Japanese trout, as a demand shifter, upon total quantities of domestic rainbow trout moving through the Los Angeles distribution network.

Finally, a series of three dummy or binary variables are included to detect any significant seasonal shift in demand on a
quarterly basis. Several preceding studies on seafood demand have tentatively identified seasonal demand fluctuations owing to a variety of factors including religious holidays, traditional non-seafood main course dishes, i.e., Thanksgiving turkey or Christmas ham, etc. Industry members are divided as to the significance and timing of such seasonal shifts in demand for rainbow trout in the L.A. market. Thus, the need to attempt to isolate the seasonality factor appears justifiable and desirable.

Implicit in the identity equation \( Q^w_d = Q^w_s = Q^{\text{total}} \) is the assumption that no stocks of rainbow trout are held at any of the market levels in L.A. or that they are constant over time.

The econometric model, estimated coefficients, t statistics, and elasticity values can be found in Appendix A.

The most obvious result of the O.L.S. estimation was that only slightly more than half of the variance associated with the dependent variable, 56%, was being explained by the variables in the model, based upon the observed data available. This would seem to reaffirm the contention that the data being withheld would be of significant importance to a complete evaluation of the problem. It is, however encouraging to observe that the signs on all coefficients are consistent with hypothesized relationships between the endogenous variable and each of the predetermined variables.
The entering F value for the complete regression indicated that the regression was significant at the .975 level with 10 and 24 degrees of freedom. That is, the hypothesis that all the $\beta$ coefficient values equal zero was rejected. The observed F value for the complete regression was 3.2093 and the critical value was 2.64.

Elasticities were calculated at the means and the results should only be interpreted as meaningful for small incremental changes about those mean values. 3

Variables accounting for the influence of hypothesized substitute goods in this model include the price of medium salmon to retailers, the price of "large" trout to wholesalers, and the price of pansize salmon to retailers. Of these potential substitutes only pansize

3"Price elasticity of demand or elasticity of demand is the proportional change in the consumption of a good divided by the proportional change in the price of the good" (Ferguson and Gould, 1975, p. 46).

$$\frac{\partial Q}{\partial P} = \eta = \frac{\partial Q}{\partial P} \frac{P}{Q}$$

"Cross-price elasticity of demand measures the relative responsiveness of quantity demanded of a given commodity to changes in the price of a related commodity" (Ibid., p. 103).

$$\frac{\partial Q_x}{\partial P_y} / \frac{Q_x}{P_y} = \epsilon_{xy} = \frac{\partial Q_x}{\partial P_y} \frac{P_y}{Q_x}$$

"Income elasticity of demand is the relative responsiveness of quantity demanded to changes in income" (Ibid., p. 104).

$$\frac{\partial Q}{\partial Y} = \eta_{\text{income}} = \frac{\partial Q}{\partial Y} \frac{Y}{Q} .$$
salmon failed to enter the equation at a statistically significant level, as indicated by calculated t-values. Medium salmon and "large" trout appear to be strong substitutes for rainbow trout. The cross-price elasticities associated with rainbow trout and each of these substitute commodities indicate an "elastic" relationship. In the case of medium salmon the variable \( P_{w}^{rms} \) represents what the wholesaler "receives" for selling medium salmon. Thus the elastic cross-price relationship implies that, for example, a 1% increase in the price received by the wholesaler for medium salmon will result in a greater than 1% decrease in the quantity of rainbow trout he will demand from the broker, ceteris paribus. The variable \( P_{b}^{wfrgt} \) represents what the wholesaler must "pay" for the commodity. The positive elastic relationship, in this case, indicates that, for example, a 1% increase in the price the wholesaler faces for "large" trout will result in a greater than 1% increase in the quantity of "rainbow" trout he demands, ceteris paribus.

The variables representing own-price did not enter the equation at statistically significant levels. However, the signs on the

---

4 If the cross-price elasticity of demand > 1 the relationship is said to be "elastic". That is, for example, a 1% change in the price of commodity \( Y \) will result in a greater than 1% change in the quantity of \( X \) demanded, ceteris paribus. The relative direction of these changes depends upon the specific relationships which exist between the two commodities, i.e., substitutional, complementary or independent.
coefficients and magnitudes of the elasticities are consistent with expectations.

Personal disposable income appears as a significant explanatory variable in the analysis of wholesale demand. The resulting estimated elasticity indicates that the relationship between quantity of rainbow trout demanded by wholesalers and personal disposable income in the Los Angeles SCSA is positive. Indeed, the demand for rainbow trout appears to be income elastic. That is, as personal disposable income for this area increases by, for example, 1.0% the quantity of rainbow trout demanded by wholesalers will increase by 2.47% ceteris paribus.

Certain writers have suggested that commodities can be classified as "necessities" and "luxuries" on the basis of income elasticity. If income elasticity is very low (certainly less than one), quantity demanded is not very responsive to changes in income. Consumption remains about the same irrespective of income level. This suggests that the commodity in question is a "necessity". On the other hand, an income elasticity greater than one indicates that the commodity is more or less a "luxury" (Ferguson and Gould, 1975).

According to Ernst Engels, the income elasticity of demand for food as a general category is very low, but specific items might very well be perceived as "luxury" goods. This result tends to lend credence to information received from industry sources concerning consumption patterns for rainbow trout. The general impression has been that Idaho rainbow trout is a premium food product primarily
consumed as a luxury item within the restaurant and institutional distribution network. Interestingly, this consuming market is exactly identical to the "targeted market" identified in the promotional strategy of the pansize salmon producers. Further, the descriptive term "luxury food item" appears in some of the pansize salmon literature.
VI. FURTHER ANALYSIS AND HYPOTHESIS GENERATION

Despite solid assurances of cooperation from key industry sources, the previously mentioned data, upon which further analysis had been anticipated, have not been forthcoming. As a result of this unfulfilled commitment by one or two of the most significant trout producers the remainder of this analysis is limited to hypothesis generation in hopes that, perhaps, future studies might succeed in obtaining critical data and proceed to quantitatively evaluate the merits of the several hypotheses presented below.

As was explained in the preceding chapter, it had been hoped that a demonstrative presentation of a simple model might serve as a tool with which to persuade others to contribute data. Thus the single equation, quantity dependent model was estimated using ordinary least squares techniques. However, it had been strongly felt that the more correct specification of the Los Angeles market would require a system of equations to account for the simultaneous determination of price and quantity in the market. The assumption implicit in the single equation model is that price is somehow determined outside the model. For example, one explanation might be that Idaho producers set a price and then allow the market to define an equilibrium quantity at that price. Another explanation is that the price in the L.A. market in preceding periods determines the quantity available for
distribution through the marketing network in the time period being observed.

Subsection A: The Money Illusion, a Simultaneous Equations Model

None of these alternative explanations seemed very satisfactory based upon the results of extensive investigation and interviews with industry sources. In fact, every indication was that rainbow trout characteristically has been a highly price-competitive commodity in the Los Angeles market. This observation led to the specification of a simultaneous equation system in which it was implicitly hypothesized that the price of rainbow trout and equilibrium quantity are interdependent and, thus, simultaneously determined in the market place. That is, both own-price and quantity are endogenous variables. As has been discussed earlier, the remainder of the price variables in this specification are assumed to be predetermined.\(^5\) This follows from the assumption that the quantity of rainbow trout demanded by

\(^5\) Foote (1958) defines an endogenous variable \"as one that is correlated with the unexplained residuals in the structural equation in which it appears,\" while a predetermined variable \"is independent of the unexplained residual in the structural equation in which it appears\". Kmenta (1971, p. 532) notes that \"predetermined variables can be subdivided into exogenous and lagged endogenous variables. The values of the exogenous variables are completely determined outside the system under consideration, whereas the values of the lagged endogenous variables are represented by the past values of the endogenous variables of the model\".
wholesalers in time "t" depends, not only upon the current price
of rainbow trout and its hypothesized substitutes at the brokerage
level, but also upon the most recent available information concerning
wholesale to retail prices. This implies a lag, in this case one time
period, in the several price series accounting for substitutes and
own-price behavior in the wholesale to retail sector.

The system of structural equations for this particular
specification include:

\[ Q_{t}^{wt} = a_{0} + a_{1}P_{t}^{wt} + a_{2}P_{t}^{rms} + a_{3}P_{t}^{wfrt} + a_{4}P_{t}^{rt} + a_{5}P_{t}^{rt} + a_{6}Y_{t} + a_{7}D_{t}^{imt} + a_{8}D_{t} + a_{9}D_{t} + a_{10}D_{t} \]

\[ Q_{t}^{wt} = \beta_{0} + \beta_{1}P_{t}^{wt} + \beta_{2}P_{t}^{wnt} + \beta_{3}T \]

\[ Q_{t}^{wt} = Q_{t}^{wt} = Q_{t}^{total} \]

in aggregate, or alternatively, in per capita terms the system
becomes:

\[ \frac{Q_{t}^{wt}}{N_{t}} = a_{0} + a_{1}P_{t}^{wt} + a_{2}P_{t}^{rms} + a_{3}P_{t}^{rt} + a_{4}P_{t}^{rt} + a_{5}Y/N_{t} + a_{6}D_{t}^{imt} + a_{7}D_{t} + a_{8}D_{t} + a_{9}D_{t} + a_{10}P_{t}^{wfrt} \]
\[
\frac{Q^{wt}_{s}}{N_{t}} = \beta_0 + \beta_1 P^{wt}_{b_t} + \beta_2 P^{wnt}_{b_t} + \beta_3 T
\]

\[
\frac{Q^{wt}_{s}}{N_{t}} = \frac{Q^{wt}_{d}}{N_{t}} = \frac{Q^{total}_{trout}}{N_{t}}
\]

where the variables in the demand equations are specified as before (see V, page 40 and 41), and \( N_t \) = population of Los Angeles SCSA in time \( t \).

The supply equation contains, in addition to \( P^{wt}_{b_t} \):

\[ Q^{wt}_{s} \text{ or } \frac{Q^{wt}_{s}}{N_{t}} = \text{quantity of rainbow trout supplied to brokers for sale in L.A. in time } t, \text{ in total or per capita terms} \]

\[ P^{wnt}_{b_t} = \text{price of rainbow trout from broker to wholesaler in time } t \text{ for the Fulton Fish Market, New York (deflated)} \]

\[ N_t = \text{population of Los Angeles SCSA in time } t \]

\[ T = \text{variable "time" accounting for supply shifters not otherwise observable given the available data.} \]

All prices were deflated by the W.P.I. for "Farm products, processed foods and feeds," U.S. Bureau of Labor Statistics. Two runs were made using, in the first, a non-deflated income variable, \(^6\) and

\(^6\)By specifying the model in terms of a non-deflated personal disposable income variables, either per capita or total, the implicit argument might be framed in terms of a behavioral model. It can be
in the second an income variable deflated by the consumer price
index (CPI), U.S. Bureau of Economic Analysis.

The identity \( Q_d^{wt} = Q_s^{wt} = Q_{\text{trout}}^{\text{total}} \) specifies an equilibrium
condition in which quantities supplied are exactly equal to quantities
demanded. As noted earlier, all available information indicates that
no significant stocks of rainbow trout are held at any of the three
marketing levels in the L.A. distribution network. Stocks do appear
to exist at production/processing sites from which shipment orders
originating in L.A. can be met within 24 hours of receipt, according
to industry sources.

In the supply equation the inclusion of the New York Fulton Fish
Market price series for rainbow trout was intended to account for Los
Angeles supply shifts resulting from price fluctuations in alternative
market areas. The variable \( T \) represents time and as explained
above was intended to account for supply shifting forces at work in the
market which are not otherwise observable given the data limitations
discussed earlier. The rationale for the inclusion of the demand
equation variables has been described in the preceding section and
readers are referred there for further clarification.

Hypothesized that consumers determine their consumptive patterns,
in the short run, principally upon their perceived or "nominal"
income. That is, "money illusion" tends to dominate short term
consumptive behavior.
While it would have been possible at this point to estimate coefficients for both the demand and supply equations using one of several econometric estimation techniques, for the purpose of this analysis, only the demand equation was actually quantitatively evaluated. The results of both the deflated and non-deflated income specifications can be seen in Appendix B and C respectively. A two stage least squares technique was employed in order to account for the simultaneity of own-price and quantity in the hypothesized model.

This method was selected over alternative techniques on the basis of several criteria, chief among them being the suitability of 2SLS as an estimation method for an over identified equation. In addition,

7 An equation is said to be over-identified, "when the number of the unrestricted coefficients exceeds the number of the restricted parameters and there is no unique solution" (Kmenta, 1971, p. 540). The criteria for determining identification of an equation includes rank and order conditions. The order condition requires that the total number of exogenous variables \((K^*)\) excluded from the equation of interest must be at least as great as the total number of endogenous variables \((G^\Delta)\) in the given equation minus one. Or,

\[
K^* \geq G^\Delta - 1
\]

If \(K^* = G^\Delta - 1\) the equation is exactly identified
If \(K^* > G^\Delta - 1\) the equation is over-identified
If \(K^* < G^\Delta - 1\) the equation is under-identified.

The rank condition is somewhat more complex. However in essence, the rank condition requires that there be at least one independent equation for each endogenous variable in the system.

In this case the rank condition is satisfied, however, the demand equation is over-identified on the basis of the order condition.
the ready availability of the two stage least squares technique package on the available electronic data processing system increases the cost of using one of the alternative, more mathematically cumbersome methods of estimation. In addition none of these alternative methods demonstrate a clear advantage over two stage least squares, according to Kmenta (1971).

A third case can be made for employing two stage least squares in as much as it "does not require complete knowledge of the whole system; all that is required is a listing of all predetermined variables and their sample values" (Kmenta, 1971, p. 562).

The results of the simultaneous models were somewhat disappointing. In the first case, non-deflated \( Y \), price of rainbow trout from broker to wholesaler was regressed against all the predetermined variables in the model in the first stage. This process yielded a predicted own-price, \( \hat{P}_{b_t}^{wt} \), broker to wholesaler, which was then included as an explanatory variable, in place of the observed \( P_{b_t}^{wt} \), in the second stage estimation of the demand equation with per capita quantity of rainbow trout as the dependent variable.  

\[ \]  

Subsequent to the above cited per capita specification the model was re-evaluated with the substitution of "total" for "per capita" demand and income figures. The results of this run were similar to those reported above. Where the two specifications do vary slightly, the per capita appeared to be the superior delineation by \( R^2 \) criteria.
The first stage regression was highly significant with the 25.8910 F-statistic for the total regression exceeding the critical F value by a magnitude of more than eight, at the .05 level, with 11, 25 degrees of freedom. The $R^2$ for the first stage was .9139.

The second stage regression in which per capita quantity was the dependent variable, yielded somewhat less encouraging results. The F-statistic for the complete regression, 3.3681; with 10, 25 d.f., exceeded the critical F value 2.24; $\alpha = 0.05$. Furthermore, the signs on several of the coefficients in the second stage regression were not consistent with the previously hypothesized relationships. An example is the relationship between rainbow trout demanded and the price of pansize salmon at the wholesale to retail level. Pansize salmon has been hypothesized, from the inception of this study, to be a strong potential substitute for rainbow trout in the market place. Pansize salmon does enter the second stage equation at a statistically significant level based upon the t-statistic. However, the sign on the coefficient of pansize salmon is positive, thus implying that as the price received by the wholesaler for supplying pansize salmon to his retail customers rises, the quantity of rainbow trout he, the wholesaler, will demand will increase as well. This is clearly inconsistent with the expected relationship. More disturbing than this inconsistency is the "incorrect" sign on the coefficient predicted for own-price from broker to wholesaler. This variable enters the equation at a
significant level, based again upon the associated t-statistic. However, contrary to the inverse or negative price/quantity relationship expected, a positive relationship emerged. The price of rainbow trout from the wholesaler to retailer in time $t-1$ failed to enter the model at a significant level. Dropping this variable on grounds that $P_{wt}$ and $P_{rt}^{w_{t-1}}$ are highly intercorrelated, thereby making it difficult to sort out the separate effects of each, failed to change the estimated sign of the coefficient on $P_{wt}^{w_{t-1}}$. The Durbin-Watson statistic, used as a mechanism for assessing auto-regressive tendencies in the data, is in the indeterminant range in this case, 1.6932.

The personal disposable income variable, non-deflated, entered the regression at a highly significant level and with the expected positive sign on the coefficient. However, care must be taken in interpreting the significance of this result based upon the accompanying coefficients. The remaining exogenous or explanatory variables included in this specification failed to enter the equation at significant levels. However, their exclusion from the model in subsequent runs only tended to aggravate the problems and substantially reduce the regressions' significance.
Subsection B: A Simultaneous Equations Model Expressed in "Real" Price and Income Parameters

The alternative specification of this simultaneous, quantity-dependent model included only a single modification. This involved, as noted above, the use of a deflated personal disposable income figure, \( Y^* \) or \( Y^*/N_t \), rather than the nominal income figure, \( Y \) or \( Y/N_t \), used previously. The model was specified, as was the previous one, in both "total" and "per capita" terms, for purposes of comparative analysis. The results of the "per capita" run were only slightly different from the "total" equation results and thus only the per capita results are addressed directly in this subsection. Again, complete results of this specification are included in Appendix C.

Once more the two stage least squares technique was employed. In the first stage own-price (broker to wholesaler) was regressed against all of the predetermined variables in the system of equations, this time including a deflated per capita disposable income variable, in place of the nominal income variable. The resulting predicted price, \( \hat{P}_{wt} \), was introduced into the second stage quantity dependent equation, in place of the observed \( P_{wt} \), as an explanatory variable. The remainder of the predetermined variables are identical to those contained in the preceding model except for the substitution of the deflated per capital disposable income variable, identified above. The results were very interesting.
In the first stage estimation the regressions significance, based upon the F-statistic, and the "goodness of fit" or explanatory capacity, based upon the $R^2$ statistic, were very slightly reduced from the same figures in the preceding model. The $R^2$ declined from .9193 to .9098 and the F-statistic for the total regression, first stage, dropped from 25.891; (11, 25 d.f.) to 22.9266; (11, 25 d.f.). However, it was the second stage results which caused the greatest interest. While the second stage F-statistic and $R^2$ did improve marginally, and the Durbin-Watson statistic remained virtually unchanged, there was a substantial difference in the individual significance of several variables based upon their t-values and the signs of their respective coefficients, when compared to the earlier model. Specifically, every variable except that accounting for fourth quarter seasonality shifts in demand, entered the second stage regression at significant levels. Under this formulation, the price of large trout at the brokerage level appears to be positively correlated with the dependent variable. It also would seem to be a highly significant explanatory variable with regard to the variation observed in quantity of rainbow trout demanded. That is, for example, as the price of large trout falls at the brokerage level, presumably due to an increase in supply, wholesalers tend to substitute away from rainbow trout, thus reducing the quantity of rainbow trout demanded, ceteris paribus. This is precisely the relationship hypothesized and from a
comparative standpoint, just the opposite of the results of the preceding model. Recall that $P_{wfrgt}^{bt}$ in the first model failed to enter the regression at a statistically significant level. Similarly, the price received by wholesalers for pansize salmon entered the second regression at a highly significant level and, unlike the results of the first model, $P_{w}^{\text{TPSS}}_{t-1}$ did so with the expected negative sign. Thus the implicit relationship, in this second case, between the price of pansize salmon, wholesale to retail, and the quantity of rainbow trout demanded by the wholesale sector, is one of substitute input factors into the wholesalers' production function. For example, as the price of pansize salmon the wholesaler can command from the retail level decreases, he will tend to substitute away from pansize salmon and increase his demand for rainbow trout, ceteris paribus.

The presence of Japanese trout in the Los Angeles market does appear to have some negative influence upon the quantity of rainbow trout demanded, based upon the results of this second specification. Once again, this is contrary to the results of the regression of the first model, but consistent with a prior expectation inasmuch as the influence, while statistically significant, appears to be rather negligible in absolute terms. This might be interpreted as accounting for some of the fluctuation in the small quantities of domestic rainbow trout which pass through the distribution network to the "market outlet" level where they interact with the less expensive Japanese
product. If the imported fish were readily available, and at the characteristically lower per unit price, then it might be expected that "market outlet" purveyors would substitute away from the more costly domestic product. When supplies of Japanese trout tighten, the void is filled by increased demand for domestic product. This would surely have some observable effect on levels of demand for rainbow trout within the L.A. distribution network. As the preceding chapters have attempted to establish, the magnitude of the effect would be expected to be relatively insignificant. In a sense, the demand relationship specified above may be seen as the sum of two demands, namely "market outlet" and "food service", with the former involving relatively small quantities of Idaho trout. The Japanese import variable may account for shifts in the "market outlet" demand.

The prices of rainbow trout, both $P_{b_t}^{wt}$ (first stage predicted), from broker to wholesaler and $P_{w_{t-1}}^{rt}$ from wholesaler to retailer, enter the regression at statistically significant levels. Furthermore, in contrast to the earlier specification, they do so with the hypothesized signs on their coefficients. The price of rainbow trout received by the wholesaler is positively correlated with the quantity of rainbow trout demanded at the brokerage level. As the price the wholesaler is able to command for the product increases, for example, the quantity he demands from the broker will similarly increase, ceteris paribus.
The predicted price of rainbow trout at the brokerage level is a very significant explanatory variable, both in terms of the t-value and the magnitude of the variables' coefficient, in this quantity-dependent second stage. The relationship, as hypothesized, is negative, implying that, as the price of rainbow trout at the broker to wholesaler level increases (decreases) the quantity of rainbow trout demanded will respond in the opposite direction.

The binary variables intended to account for seasonal shifts in demand do, in two of the three cases, enter the regression at significant t levels. The second quarter of the calendar year appears to reflect a period during which consumption of rainbow trout is on the decline. This seems to be in agreement with industry perceptions. The first quarter characteristically is "the" big seafood season as the Lenten period is observed. Following the end of the religious observance there tends to be some adjustment away from fish, in favor of alternative food protein items. Thus a more complete specification might have included consideration of these items explicitly. The decline in demand for rainbow trout in this period probably reflects a more general downward trend in seafood consumption. The third quarter binary variable also enters the equation at a significant level and would appear to reflect a moderate upturn in demand following the second quarter decline. The fourth quarter failed to enter the equation at a statistically significant level.
Unexpectedly the two remaining variables, namely the price of medium salmon, wholesaler to retailer, and deflated per capita personal disposable income, while entering the regression at statistically significant levels, do so with "erroneous" signs. That is, in the case of the price of medium salmon, an hypothesized substitute for rainbow trout, the coefficient is significantly different from zero and positive. This is contrary to the substitutional hypothesis.

Per capita personal disposable income, deflated, enters the regression with a negative sign. There are several possible explanations for this result. The negative coefficient may be the result of statistical problems within the data. It is, of course, not theoretically inconceivable that, over some range, rainbow trout is, in fact, an inferior good. Ignoring the layman's negative connotation of the term "inferior good", the economic implications are, simply stated, that as income increases the satiation point for the consumption of rainbow trout decreases. This is not so difficult to imagine when one recalls that income can be perceived as a proxy for "all other goods". In this sense for example, as a consumer increases consumption, including that of alternative food proteins such as beef, pork, poultry and other seafoods, the utility he obtains from consuming rainbow trout may be diminished over some range. Alternatively perhaps, over the long run, recalling the very short time series available for use in this analysis, one might hypothesize the true relationship is
actually positive. Thus if sufficient data are available one would, in fact observe a positive income/quantity relationship.

In any event, the presence of the "unexpected" coefficients on these two variables casts a shadow on the reliability of the remaining signs and coefficients. Nonetheless, in light of the serious, and at the present unresolvable, data problems the results of this specification are quite encouraging. Any final resolution of the model's validity must await the broader participation and cooperative support, in terms of data provision, of the Idaho food fish industry. Perhaps the responsibility for the absence of broader industry collaboration can be traces to a failure to make clear the project's goals and objectives. Furthermore, as has been mentioned previously, while oligopistic in structure the history of intense price rivalry of this industry may have contributed to the reluctance by making the perceived costs very high relative to the potential benefits.

Subsection C: A Single Equation Price Dependent Alternative Specification

The preceding model specifications are consistent with the vast majority of available information obtained throughout the interview, data acquisition segment of this study concerning the L.A. market. Further, the preceding models are consistent with the theoretical framework hypothesized within this analysis. They are also based on
the best estimates of the Los Angeles market structure in terms of the author's perceptions of that distribution network. However, in response to a somewhat divergent view of the L.A. market, on the part of one of the Idaho producers interviewed, and in an effort to examine the validity of all available leads, a third model was specified and quantitatively evaluated. In this case the price of rainbow trout at the brokerage level was identified as the dependent variable in a single equation model. The quantity of rainbow trout entering L.A. was assumed to be a predetermined variable under this specification. The basis for this assumption was drawn from an interview, mentioned above, during which the L.A. market was described as a traditional dumping ground for excess supplies of rainbow trout, from domestic farms. In essence the prices in alternative U.S. markets determine the quantities which will ultimately find their way into the Los Angeles distribution network under this specification. Once the producers have determined the magnitude of their shipments to alternative markets the remainder of the available supply is either used to replenish stocks or is shipped into L.A. where it is sold for whatever the product will bring.

This argument seemed somewhat inconsistent with the history of highly price competitive market behavior in L.A., cited earlier in this study. However, at this stage of the analysis the primary goal was one of hypothesis-generation. Completeness required that this
specification be explored. The exact specification of this equation is as follows:

$$p_{wt}^b = a_0 + a_1 \frac{Q_t}{N_t} + a_2 \frac{Y}{N_t} + a_3 P_{w_{t-1}}^{rpss} + a_4 P_{w_{t-1}}^{rms} + a_5 P_{w_{t-1}}^{rt} + a_6 D_2 + a_7 D_3 + a_8 D_4$$

where the variables are as specified in the preceding subsection.

A complete presentation of the results of the ordinary least squared (OLS) regression appear in Appendix D. Briefly, however, the model does yield some interesting results. For example, the price that wholesalers received in the preceding period, $t-1$, is a highly significant explanatory variable in terms of accounting for the variation associated with the brokers price of rainbow trout in time $t$, based upon the $t$-statistic. Further, this relationship is positive, as one would expect to observe based upon the hypothesized interaction of the two price variables. The price of pansize salmon from wholesaler to retailer also enters the regression at a highly significant level, again based upon the $t$-statistic at a .90 value. The negative coefficient on pansize salmon's price is also consistent with the expected substitutional relationship. That is, as the price of pansize salmon received by the wholesaler increases, for example, the wholesaler should substitute away from rainbow trout, in favor of the
more profitable pansize salmon, *ceteris paribus*, thus necessitating a reduction in the price of rainbow trout by the broker in order to move the available supply.

Per capita quantity demanded of rainbow trout, while entering the regression at a significant level, does so with a positive coefficient. This is contrary to the expected or hypothesized relationship between the predetermined quantity variable and the broker to wholesale price of rainbow trout. The positive sign on the coefficient would imply that as supplies of rainbow trout increased (decreased), into the Los Angeles market, the price of rainbow trout would likewise increase (decrease). This is inconsistent with both the predictions of the economic theoretical constructs and the generally asserted perceptions of the workings of the L. A. market held by those of its participants surveyed.

Similarly, the relationship between per capita personal disposable income, and the dependent variable implied by the negative sign on the former's coefficient is not consistent with expectations. Seasonality appears not to be a significant explanatory factor in this specification based upon the OLS results. This is particularly interesting in light of the very strong opinion to the contrary held by the industry member who's statements prompted this particular model configuration. Despite the somewhat improved $R^2$, .77, and the consistent coefficients on most of the variables in this price dependent
model, it remains the opinion of the author that the quantity dependent, simultaneous price/quantity model, specified in the preceding subsection, most nearly approximates the actual Los Angeles distribution network's behavior.

However, this can be explored further when and if subsequent research is done in this field, and assuming industry members provide adequate support in terms of cooperation and data accessibility.
VII. SUMMARY AND CONCLUSIONS

Because not all of the major participants in the Los Angeles market were willing or able to provide needed data, it has not been possible to provide a thorough description of that distribution network. Despite these data limitations however, an initial effort has been made to quantitatively approximate and statistically evaluate the market for rainbow trout and the role of its hypothesized substitutes, including among them, pansize salmon. In light of the results of the analysis discussed in Chapter VI some interesting and potentially significant observations can be made. Several models were examined. The results of testing the hypotheses of two of these models, namely the alternative simultaneous equations specifications, are particularly interesting. In the first model, two stage least squares techniques were used to estimate the parameters of a quantity-dependent demand equation. This equation included, predicted own-price (broker to wholesaler) deflated, price of trout (wholesale to retail) lagged one period and deflated, the prices of several substitutes also lagged and deflated, personal disposable income, non-deflated, and several binary variables accounting for seasonality and the presence of Japanese trout in the market place. (All prices were deflated by the Wholesale Price Index for Farm Products, Processed Foods and Feeds.)
The second specification is identical to the first with the single exception that the personal disposable income variable is deflated by the Consumer Price Index. As the reader may observe, the substantial improvement in the second simultaneous equations specification over the first, as measured by the $R^2$, $F$ and $t$ statistics, resulting, as just mentioned, exclusively from the deflation of the income variable, gives rise to several interesting questions. If, for example, one had chosen to specify the first simultaneous model totally in terms of "nominal" figures, instead of incorporating deflated prices and non-deflated income variables, would the results have been more closely akin to those obtained in the second model? It seems reasonable, since under the assumption of the first model, the consumer behaves under a "money illusion" concerning his relative economic well being. When the analyst looks at monthly purchases, as in this analysis, the significance of "real" income and "real" prices may be diluted because the consumer is not able to fully perceive and internalize these "real" changes in his relative economic status. Perhaps then, in a future specification one might attempt to incorporate a lag of one or more time periods in order to attempt to account for this adjustment to "real" parameters on the part of the consumer. Alternatively, perhaps by aggregating the data in such a way as to minimize the influence on consumptive behavior of this adjustment period, one might be more successful in isolating the
actual demand relationships at work in the market place. The use of longer observation periods, quarterly or semi-annual increments, might also reduce the impact of non-quantifiable influences which may distort short run behavior, but which have no long run influence on consumer demand. Evaluation of these modifications of the basic simultaneous equations model, presented above, must await additional inputs in terms of historical time series data on the product.

Based upon the results of the analysis several conclusions might be inferred. To begin with, there seems to be a very strong substitutional relationship implied, by the results of the simultaneous equations model, between rainbow trout and pansize salmon. Data limitations prevent a quantitative estimation of the magnitude of this relationship. However, the existence of such an interaction between the two aquaculturally produced food fish perceived by industry members in the earliest stages of this analysis, seems to be confirmed. Further, seasonality appears to be an influencing factor in the demand for rainbow trout.

In terms of the second model, Japanese trout appear to have only a marginal influence on the demand for rainbow trout. However, as the imported product becomes more scarce in the U.S. market, domestically produced trout will probably come under increasing demand to fill the void. This may be expected to amplify the competitive interaction between "food service" and "market outlet"
consumers for the domestic product.

Beyond this, the analysis of this market relationship must await more complete data series. It is the fervent hope of the author that this study serves primarily to identify critical issues, ask the relevant questions, and pose provocative alternative explanations as a means of informing all interested parties of the potential benefits forthcoming if such questions can be objectively answered. In line with this, it seems indisputably clear that further research into the market behavior and potential of aquaculturally produced food proteins, and particularly that of rainbow trout and pansize salmon which have generated so much recent interest, cannot be too soon in coming.
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APPENDICES
APPENDIX A

For the convenience of the reader the economic model appearing on pages 40 and 41 is reproduced below as are the definitions of the model's components.

The economic model specified was as follows:

\[ Q_{d}^{wt} : P_{b}^{wt}, P_{w}^{rt}, P_{w}^{rms}, P_{b}^{wfrgt}, P_{w}^{rpss}, P_{tm}, D_{2}, D_{3}, D_{4}, Y, D_{int} \]

and assumes the identity:

\[ Q_{d}^{wt} = Q_{s}^{wt} = Q_{total} \]

recalling the colon is read "depends on", a comma is read "and",

\[ Q_{s}^{wt} = \text{quantity of rainbow trout supplied by producers to the L.A. market} \]

\[ Q_{d}^{wt} = \text{quantity of rainbow trout demanded by L.A. wholesalers at brokerage level} \]

\[ P_{b}^{wt} = \text{price of rainbow trout from broker to wholesaler} \]

\[ P_{w}^{rt} = \text{price of rainbow trout from wholesaler to retailer} \]

\[ P_{tm} = \text{price of rainbow trout from wholesaler to market outlets} \]

\[ P_{w}^{rms} = \text{price of medium salmon from wholesaler to retailer} \]

\[ P_{b}^{wfrgt} = \text{price of "large" trout from broker to wholesaler} \]

\[ P_{w}^{rpss} = \text{price of pansize salmon from wholesaler to retailer} \]
\[ Y = \text{personal disposable income in the L.A. (SCSA); not deflated} \]

\[ D_{\text{int}} = \text{binary variable indicating presence or absence of imported trout in market} \]

\[ D_2, D_3, D_4 = \text{binary variables included to account for seasonality shifters on quarterly basis.} \]

The econometric equation actually estimated using Ordinary Least Squares is as follows:

\[
Q_{\text{wt}}^{\text{wt}} = a_0 + a_1 P_{\text{wt}}^{\text{rt}} + a_2 P_{\text{wt}}^{\text{rms}} + a_3 D_2 + a_4 D_3 + a_5 D_4 + a_6 Y_t \\
+ a_7 D_{\text{int}} + a_8 P_{\text{bt}}^{\text{wt}} + a_9 P_{\text{bt}}^{\text{wfrgt}} + a_{10} P_{\text{wt}}^{\text{rpss}} + a_{11} P_{\text{bt}}^{\text{mt}} + \mu
\]

where variables are defined as indicated in the economic model, the present month is \( t \), the preceding month \( t-1 \) and \( \mu \) is a stochastic error term.

The results of the analysis are:

\[
Q_{\text{wt}}^{\text{wt}} = -24414 + 7675.2 P_{\text{wt}}^{\text{rt}} - 12907 P_{\text{wt}}^{\text{rms}} + 2395.5 D_2 + 3935.0 D_3 \\
- 5912 \begin{array}{c} \cdot 258 \end{array} - 1.143 \begin{array}{c} \cdot 258 \end{array} + 17.571 D_{\text{int}}^{\text{int}} - 2374200 P_{\text{bt}}^{\text{wt}} + \\
5039.3 D_4 + 0.0060099 Y + 1.571 D_{\text{int}}^{\text{int}} - 2374200 P_{\text{bt}}^{\text{wt}} + \\
(2.65) (3.65) (0.043) (-0.797) 2.47 -1.17
\]
\[ + 3054400P_{wfrg}^{t} + 42822P_{rpss}^{t} + 758580P_{mt}^{t-1} \]
\[ (1.67) \quad (1.43) \quad \cdot \cdot \cdot \quad (.392) \]
\[ 1.22 \quad .00488 \]
\[ R^2 = .562 \]

where the t-values are in parenthesis below the coefficients, and single-tailed tests were used. The elasticities are immediately below the t statistics. The t-values are statistically significant at the 90% level with 25 degrees of freedom if they exceed the critical value 1.316. The 95% significance level critical t is 1.708.

The period of analysis is May 1972-December 1975, inclusive. The number of complete observations with which the analysis was carried out totals 36.

The least squares assumptions made with regards to \( \mu \), in this specification, as well as the error terms in the subsequent alternative formulations include:

1. \( E(\mu_i) = 0 \)
2. \( E(\mu_i^2) = \sigma^2 \)
3. \( E(\mu_i \mu_j) = 0; \quad (i \neq j) \)
4. Each explanatory variable is nonstochastic with values fixed in repeated samples.
5. The number of observations exceeds the number of coefficients to be estimated.
6. No exact linear relation exists between any of the explanatory variables.

For purposes of testing one additional assumption is required.

7. \( \mu_i \) is normally distributed where the subscript \( i \) indicates the \( i \)th observation of the error term.
APPENDIX B

The first simultaneous equation's specification included a non-deflated personal disposable income variable as explained in Chapter VI, Subsection A. The specification of this system was as follows:

\[
\frac{Q_{d_{wt}}}{N_t} = a_0 + a_1 P_{b_{wt}} + a_2 P_{w_{t-1}}^{rms} + a_3 P_{w_{t-1}}^{rps} + a_4 P_{w_{t-1}}^{r} + a_5 Y/N_t
\]

\[+ a_6 D_{int}^{imt} + a_7 D_2 + a_8 D_3 + a_9 D_4 + \lambda + a_{10} P_{w_{bt}}^{wt} \]

\[
\frac{Q_{s_{wt}}}{N_t} = \frac{Q_{d_{wt}}}{N_t} = \frac{Q_{total_{s}}}{N_t}
\]

where the variables in the demand equations are specified as before, (see V, page 40 and 41 or Appendix A, page 75), and \( N_t \) = population of Los Angeles SCSA in time \( t \), and \( \lambda \) and \( \theta \) are stochastic error terms.

The supply equation contains, in addition to \( P_{b_{wt}} \):

\[
Q_{s_{wt}}^{wt} \text{ or } \frac{Q_{s_{wt}}^{wt}}{N_t} = \text{quantity of rainbow trout supplied to brokers for sale in L.A. in time } t, \text{ in total or per capita terms}
\]
\( p_{b_t}^{wnyt} \) = price of rainbow trout from broker to wholesaler in time \( t \) for the Fulton Fish Market, New York (deflated)

\( N_t \) = population of Los Angeles SCSA in time \( t \)

\( T \) = variable "time" accounting for supply shifters not otherwise observable given the available data.

All prices were deflated by the W. P. I. for "Farm products, processed foods and feeds", U.S. Bureau of Labor Statistics.

The results of the analysis of this general specification are presented below in the "per capita", as opposed to "total", form. This decision was based on the fact that, for all practical purposes, the two specifications just mentioned, yield identical results.

The results of the first stage regression are:

\[
p_{b_t}^{wt} = 0.0094 + 0.00439 p_{rt}^{rt} + 0.000537 p_{rms}^{rms} - 0.00157 D_t^{int} \\
(3.19) (4.72) (0.742) (-1.17)
\]

\[
+ 0.000709 D_3 + 0.00138 D_4 + 0.000736 T - 0.00018 D_t^{int} \\
(0.474) (1.103) (3.31) (-0.747)
\]

\[
+ 0.244 p_{wfgt}^{wnyt} - 0.00595 p_{rps}^{rps} - 0.0000000002Y/N_t + 0.1077 p_{b_t}^{wnyt} \\
(2.57) (-3.40) (-3.34) (0.897)
\]

\( R^2 = 0.919 \)

F-statistic = 25.891; 11, 25 d.f.
In the second stage estimation of the demand equation, \( P^w_t \) is included as an explanatory variable and yields:

\[
\frac{Q_{d,t}}{N_t} = -0.00406 - 0.00179P_{rt} - 0.00453P_{rms} - 0.000958D^2_{t-1} \times (-2.10) \times (-0.695) \times (-0.523) \times (-0.578)
+ 0.0000933D^3_{t-1} - 0.00159D^4_{t-1} + 0.000000135D^{int}_{t} + 0.0894P^{wfr gt}_{t} \times (0.471) \times (-0.949) \times (0.039) \times (-0.419)
+ 0.0461P^{rps s}_{t} \times (1.36) \times (3.43) \times (1.21)
\]

\( R^2 = 0.573967 \)

\( F\text{-statistic} = 3.368; \ 10, 25 \text{ d.f.} \)

\( \text{Durbin-Watson Statistic} = 1.693 \)

where the \( t\)-values are in parenthesis below the coefficients. The \( t\)-values are statistically significant at the 90% level with 25 degrees of freedom if they exceed the critical value 1.316, using a single-tailed test.

The period of analysis is May 1972-December 1975, inclusive.
APPENDIX C

As explained in the chapter on model development, the simultaneous equation's specification was quantitatively evaluated in two alternative forms depending upon whether the income variable was deflated by the C.P.I. or not. Appendix B contains the results of the non-deflated specification. The deflated personal disposable income specification appears below. Once again the model has been evaluated in both "per capita" and "total" or aggregate terms. The results are not sufficiently different to warrant inclusion of both. The "per capita" results are given below.

In the second stage $\hat{P}_{bt}$ is included as an explanatory variable and yields:

$$
Q_{dt}^{wt} = \frac{.0256 + .00922P_{rt}^{wt} + .00113P_{rms}^{wt} - .000342D_t + .00038D_t}{N_t} \\
+ .00011D_t^4 - .0000515D_t^{imt} + .7179P_{wtrgt}^{wrt} - .0969P_{rpss}^{wrt} \\
- .000000631Y_{*}^{wtn} - 2.125P_{bt}^{wt} \\
(-3.75) \\
(-2.68) \\
R^2 = .578107 \\
F\text{-statistic} = 3.4257; 10, 25 \\
Durbin-Watson Statistic = 1.674
$$
where the t-values are in parenthesis below the coefficients. The critical t-value is 1.316 at the 90% level with 25 degrees of freedom, noting once again the use of a single-tailed test.

In the first stage the regression yielded the following:

\[
\hat{P}_t^{\text{wt}} = .01196 + .00337P_{rt} + .000863P_{rms}^w - .000134D_2 + .00011D_3^w \\
(2.68) \quad (2.79) \quad w_t-1 \quad (.974) \quad w_t-1 \quad (-.950) \quad (.708)
\]

\[
+ .0000764D_4 - .0000089T - .0000171D_{int}^t + .3193D_{wfgt}^t \\
(.578) \quad (-1.16) \quad (-.656) \quad (3.45)
\]

\[
- .0486P_{rss}^t + .1253P_{wny}^t - .000000316Y^*/N_t \\
(-2.67) \quad (.960) \quad (-2.71)
\]

\[
R^2 = .9098
\]

\[
F\text{-statistic} = 22.926; 11, 25 \text{ d.f.}
\]

where the t-values are in parenthesis below the coefficients. The t-values are statistically significant at the 90% level with 25 degrees of freedom if they exceed the critical value 1.316. The period of analysis is May, 1972-December, 1975, inclusive. Note that \(Y^*/N_t\) is the deflated per capita personal disposable income for time \(t\). L.A. SCSA.
APPENDIX D

For the third alternative specification being considered, namely the price of rainbow trout dependent single equation model, ordinary least squares (OLS) technique has been employed to estimate the coefficients. The results are as follows:

\[
P_{bt}^{wt} = .00242 + .00622P_{rt}^{t} + .0036P_{rms}^{t} - .0000252D_{2}^{t} - .000174D_{3}^{t}
+ .0000852D_{4}^{t} - .06765P^{rps}^{t} + .22803Q_{d}^{wN}^{t} - .000369Y^{N}^{t}
\]

\[R^2 = .770\]
\[F\text{-statistic} = 14.29; 8, 34 \text{ d.f.}\]
\[Durbin-Watson \text{ Statistic} = 1.599\]

where the t-values are in parenthesis below the coefficients. The critical t-value at the 90% confidence level with 32 degrees of freedom is 1.311.

The period of analysis is May 1972-December 1975, inclusive.