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DEMAND RELATIONSHIPS FOR VEGETABLES:

A Review of Past Studies

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DEMAND RELATIONSHIPS FOR VEGETABLES: A REVIEW OF PAST STUDIES

by

Carole Frank Nuckton

PREFACE

This report is a sequel to Demand Relationships for California Tree Fruits, Grapes, and Nuts: A Review of Past Studies.[1/] Like the former report, this one brings together in summary form much of what is known empirically about the demand for agricultural commodities of major importance in California. In a survey of this nature, no attempt has been made to evaluate or criticize the studies.

The report on tree fruits, grapes, and nuts has proved valuable to researchers in determining what has been done in a particular commodity area, what methodologies have been used, and in what areas original or updated research is most needed. Neither that report nor this one is intended as a substitute for turning to the original studies themselves. On the contrary, through this medium the researcher is able to turn more quickly to the studies of particular relevance to his/her interest.

1/ By Carole Frank Nuckton. Giannini Foundation of Agricultural Economics Special Report, University of California, Division of Agricultural Sciences Special Publication No. 3247, August 1978.

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INTRODUCTION

Estimates of relationships between prices and quantities sold, and other factors affecting levels of demand are essential ingredients of economic analyses pertaining to agricultural commodities. Information about such estimates is scattered through a wide range of articles and research studies. This report compiles and summarizes the current state of knowledge concerning demand relationships for vegetables. It is similar to a 1978 report: *Demand Relationships for California Tree Fruits, Grapes, and Nuts: A Review of Past Studies*.1/

Selection of the studies to be included in this report involved first a searching and then a sorting process. From all studies gathered in a particular commodity area, those of special methodological interest or particular empirical interest were abstracted. All other studies in the group were referenced with a short descriptive paragraph in a "related studies" section for each vegetable or vegetable group. Summary

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tables present flexibility or elasticity estimates from the studies as well as other information, concisely reported. Due to the fact that quite a few of the studies included more than one vegetable or even many types of vegetables, the report is divided into three sections:

1. A short section in which studies of demand for vegetables in aggregate was estimated.

2. A section in which many vegetables were included in one study.

3. A third and major section presenting demand studies for a single vegetable. Various groupings were considered--e.g., leafy green, root and tuberous--but it was thought simpler to present the vegetables in alphabetic order. Some of the studies in this section also include more than one vegetable so that overlapping categorization prohibited any but the alphabetic arrangement. For those studies including more than one vegetable, abstracts will appear under the vegetable section coming first alphabetically, and then they are cross-referenced under the other vegetables covered. If elasticity or flexibility estimates were made, they will appear in each of the respective vegetable summary tables.

In some of the commodity areas, a great deal of research has been done. For several of the vegetables, however, there were no published studies to be found. Notice in the alphabetic listing several vegetables, important to California agriculture, are missing: artichokes, broccoli, cauliflower, garlic, and spinach. It is equally as important for the user of this report to notice the need for updating or even for an initial study in one commodity area as it is for him/her to review what has been done in another. A few studies of historical interest have been included in this report, even though the estimates themselves would probably not be applicable today.

It is important to keep in mind while studying the summaries, the proportion of the particular crop that is produced in California. As a general rule, if California produces only a small proportion of the nation's crop, then demand for the California product will be more elastic than for the total product. Table 1 presents California production of each vegetable as a percentage of total U.S. production of that vegetable. The information in Table 1 can be referred to and used in conjunction with the demand estimates for each of the vegetables as they appear throughout the report.

While the emphasis is on California vegetables, the report includes studies done in many other states, even demand studies for the product of another state (Hawaiian vine vegetables, Michigan celery, New Mexico's lettuce). An initial requirement for inclusion in the report is that the commodity be of importance in California as well. Table 1 also includes farm-level sales value for each vegetable in 1977.

The Abstracts

Included in each of the abstracts are:

1. The full reference.

2. The scope of the demand analysis. The study may analyze, for example, the national demand for a California product, the demand in a specific consumer market for a product grown elsewhere in the nation, the demand for a commodity to the processing market, etc.

3. The purpose of the study as stated by the author. The studies were undertaken for a variety of reasons, among them: aiding

TABLE 1: California Vegetables: Share of U.S. Production and Gross Sales Value, 1977

	California Share of U.S. Production	Value
	-percent-	-million dollars-
Asparagus	50.9	42.8
Beans		
Dry	18.0	81.6
Green Lima	58.2	16.6
Snap	3.9	9.6
Brussels Sprouts	74.3	12.8
Cabbage	7.9	16.1
Carrots	46.9	77.4
Celery	70.7	96.4
Corn, Sweet	1.8	9.9
Cucumbers	10.4	15.2
Lettuce	74.1	305.0
Melons	58.0	62.4
Onions	29.4	46.7
Peas	2.4	2.1
Peppers, Bell	28.1	19.0
Potatoes	6.2	124.9
Strawberries	80.2	168.4
Tomatoes		
Fresh	35.5	154.0
Processing	85.8	426.2

Source: California Statistical Abstract, 1978, Table G-21, pp. 93-94.

in establishing the orderly marketing of a commodity, evaluating the impact of various public policies, forecasting future prices, estimating margins, examining interregional competition, understanding intraseasonal, demand, etc.

4. The observational interval (weekly, monthly, annual, etc.) and the period of analysis for time series studies. For cross-sectional analyses, the year or years in which the observations were made are indicated.

5. Specification and estimation procedure. The report includes a spectrum of models from the simplest of price forecasting equations to complex simultaneous systems including retail demand, derived demands, supply response and market allocation equations to fresh, processed, or frozen markets.

In some of the more complete studies, the theoretical underpinnings are examined thoroughly, preliminary to the empirical derivations. Also, in some studies the results of the demand analysis are used in a further application such as in a quadratic programming model or in forecasting future prices. Neither the theoretical analyses preliminary to the demand estimation nor the applications succeeding it are included in this report. Also, information given about the product other than demand, such as production, yield, costs, or supply is not reviewed here. It is possible that abstracting one aspect of a work, removing this aspect from its context, may misrepresent some of the studies. The reader, therefore, must keep in mind that the empirical demand estimates presented in this report may not have been the main thrust of the study being reviewed. This report is not intended as a substitute for detailed analysis of the original research report.

6. Estimation results. Whenever possible, the equations or a representative equation of the study are presented. A danger in abstracting some of the more complex econometric models is that the reviewer is open to misinterpreting the analysis or to reporting results that the author may not consider the most consequential. An attempt has been made to present the equation or equations that the author indicated as the best result--if it was so indicated. Exhibited in conjunction with the equation, if these were given in the study, are the R^2 or $\bar{R}^2$ value, the t-statistics or the standard errors of the coefficients, and the Durbin-Watson statistic. For estimation procedures other than the ordinary least squares, however, the meaning of the above statistics is somewhat distorted. The author may, therefore, have chosen not to report them.

The Summary Tables

Following the abstracts of selected studies in each commodity group are found tables that summarize empirical results in a concise way. It will be useful at this point for the reader to refer to one of the summary tables (Beans, page 49) as the columns are explained, one by one. The first column gives the last name of the author or authors and the date of the study. The second column indicates the geographical area covered by the dependent variable. Thus a price forecasting equation for a California vegetable would have "California" in the second column even though it is U.S. demand for the California product that is being estimated.

The next two columns are the time period covered by the study and the observational interval used. Frequently, when monthly observational intervals have been used, intraseasonal estimates are obtained. If the study uses cross-sectional analysis, instead of time series, this will be noted in the "observational interval" column. The year or years in which the observations were made will be indicated in the "time period" column.

Columns indicating the form of the equation and the method of estimation appear next on the tables. Among the studies reported in the summary tables, five forms for estimation were used: linear, double log, semilog, first differences of the variables, and the first differences of the logs. Any equation of the form: $Y = a + b_1X_1 + \ldots + b_nX_n$, where neither Y nor any of the X's are in logarithms of the natural units, is denoted "linear." This does not mean that some of the variables themselves may not be ratios, proportions, or in per capita terms, or that the equation may not be a polynomial of some degree other than one. One study is linear, but in the first differences of the variables. By "double log" is meant that the dependent variable and all the explanatory variables are in logarithmic form, usually, but not necessarily, to the base e. "Semilog" is used to denote an equation in which at least one variable on the right hand side is in logarithmic form, whereas the dependent variable is in natural units. First differences of the logarithms are used in a few of the models.

In some cases the studies contain other models besides the ones reported in the tables. One cannot tell from the table alone, for example, whether the author had also used two stage least squares or a double log form if ordinary least squares in linear form is reported. As in the abstracts, we have endeavored to present the results that the author indicated as best. If both linear and double log forms were estimated, but there was no clear choice between them statistically or theoretically, and if the elasticities or flexibilities based on the linear form were not calculated in the study, then for convenience, the double log results were chosen for the summary table. The "market level" column is important to keep in mind while studying the estimates. The farm level demand is generally more inelastic than the processor, wholesale, or retail levels. The product column is included to distinguish between estimates for the total crop and those for a specific market--fresh, canned, frozen, etc.

The remaining columns present the demand estimates in the form of either flexibilities or elasticities[1/]--price, income, and the cross effect. The latter will be footnoted in the tables in order to indicate

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1/ The price flexibility is defined as the percentage change in price with respect to a one percent change in quantity. Similarly, the income flexibility is the percentage change in price for a one percent change in income. The cross flexibility is the percentage change in price for a one percent change in the quantity of some other product--usually considered a substitute. In some studies, however, a cross-price effect rather than a flexibility is estimated. The column will be labeled therefore "cross effect" rather than "cross flexibility." The three elasticities are the percentage change in quantity with respect to a one percent change in own price, in income, and in the price of another good or goods, respectively.

the specific cross relationship that has been measured. [Many studies of agricultural commodities assume that quantity is determined by factors outside the model. Price, therefore, is taken as the dependent variable and a price flexibility rather than an elasticity is estimated.] It is not, however, correct to invert the flexibility in order to get an elasticity estimate; this is sometimes done, but can only be taken as a rough approximation of the elasticity.

Whenever flexibilities are presented in the tables, the reader may assume, in general, that price was the dependent variable in the equation; whereas, the elasticities were usually based on some measure of quantity. It was not felt necessary, therefore, to add an additional column to the table indicating whether it was quantity or price that was being explained by the regression.

When an equation referred to in the table is linear, then the corresponding elasticities or flexibilities are computed at the means of the variables unless otherwise indicated in a footnote to the table.

Related Studies

Immediately following the summary tables for each commodity or commodity group is a section entitled "Related Studies." Full references are given and a one- or two-sentence comment about each study. These additional references should prove useful to those who wish to go more deeply into the background of a commodity.

The Author Index

At the conclusion of the report is found a complete index by first author's and other authors' last names. The page numbers refer to each place in the report where a study by the author is mentioned--either an abstract, in a summary table, or in the related studies section.

A Word of Caution

One must remember that the elasticities and flexibilities exhibited in the tables represent various attempts to estimate the actual value. The estimates will change considerably for differing time spans, for alternative choices of variables, for various functional forms and methods of estimation. It is not legitimate, therefore, to appropriate one of these numbers as *the* flexibility or *the* elasticity. Rather, the numbers can be taken as general indicators. If several different studies find the nationwide elasticity for a commodity less than one (in absolute value), one can say with some confidence that demand for that product is inelastic.

Abbreviations

Several abbreviations have been used throughout the report and will be introduced here:

OLS = ordinary least squares;

TSLS = two state least squares;

3SLS = three stage least squares;

USDA = United States Department of Agriculture;

ERS = Economic Research Service;

ESCS = Economics, Statistics, and Cooperatives Service;

R^2 or $\bar{R}^2$ = the coefficient of determination, unadjusted and adjusted, respectively;

DW = the Durbin-Watson statistic;

wrt = with respect to.

DEMAND STUDIES FOR VEGETABLES, AGGREGATED

Abstract

BEN C. FRENCH. *Some Characteristics of Demand for Frozen Vegetables.* California Agricultural Experiment Station, Giannini Foundation of Agricultural Economics, Research Report No. 266, September 1963.

Scope: U.S. frozen vegetables including asparagus, Brussels sprouts, snap beans, lima beans, broccoli, cauliflower, cut corn, peas, and spinach.

Purpose: To develop quantitative estimates of demand relationships that may be used "as guides to processors and others in formulating marketing policies and programs" and also used "in models of interregional competition and economic projections of importance to the industry." p. 1.

Observational Interval: Annual.

Period of Analysis: 1947 through 1962.

Specification and Estimation Procedure: Because of multicollinearity among prices of frozen vegetables (trending downward during the period of analysis) and per capita consumption and income (both upward), it was impossible to separate the effects on consumption of price changes from those of income changes. Accordingly, cross-section estimates of the income-consumption relationship for families in different income classes were used as a parameter in the time series analysis. Three sources of cross-section data were used: a 1950-51 Bureau of Labor Statistics study, a 1955 USDA household food consumption study, and regional sales surveys appearing in the trade magazine, *Quick Frozen Foods*, in 1958, 1959 and

1960. Income elasticities from all three sources were derived and compared. The estimates based on the 1955 USDA study were considered best for use in the time series analysis.

Six alternative empirical specifications were made of the general model:

$$P_F = b_0 + b_1Q_F + b_2Q_R + b_3Q_C + b_4\log I + b_5T + u$$

where: F, R, and C refer to frozen, fresh, and canned, respectively; price (P), quantity (Q), and income (I) are in per capita terms; and T is a trend variable. The version reported below assumes that the b_2, b_3, and b_5 coefficients are zero and incorporates the income elasticity just discussed, into the estimation.

In addition, some analysis was done on individual vegetable prices:

1. The ratios of the annual prices of individual vegetables to the arithmetic means of all vegetable prices.

2. The differences between annual prices of individual vegetables and the arithmetic means of all vegetable prices.

3. The annual relative share of total vegetable expenditures held by each type of vegetable.

<u>Estimation Results</u>:

$$P_F = 39.93 - \underset{(.331)}{3.106}\,(Q_F - 9.62\log I) + U \qquad R^2 = .87 \qquad DW = 1.51$$

where:

P_F = FOB price, deflated by the Consumer Price Index, cents per pound;

Q_F = per capita annual consumption, pounds;

I = index of per capita income (1959 = 100).

(The standard error is in the parenthesis).

"A final estimate of the demand relationships suggests that at recent levels of consumption the price flexibility for frozen vegetables is in the neighborhood of -2.0." p. 56.

Related Studies; Vegetables, Aggregated

Brandow, G. E. *Interrelations Among Demand for Farm Products and Implications for Control of Market Supply.* Pennsylvania Agricultural Experiment Station, Bulletin No. 680, August 1961. The complete demand model had several parts: retail-level demand, farm-level demand for domestic food use derived from retail demand, industrial and export demand, total demand for food and cotton, and finally the demand for feed grains and oilseeds. Vegetables were considered as a group. The retail-level elasticity estimate was -.30; farm level, -.10.

Cromarty, William A. "An Econometric Model for United States Agriculture." *Journal of the American Statistical Association,* Vol. 54, No. 287, September 1959, pp. 556-577. Agriculture as an economic sector was disaggregated into 12 commodity groups in order to examine major supply, demand, and price relationships within agriculture and between agriculture and the nonfarm sector. Two linear demand equations were estimated by OLS for the vegetable group for the period 1929 through 1953, and from these equations the following price elasticities were derived as the reciprocal of the flexibilities: fresh, -1.706; processed, -5.714.

Fox, Karl A. *The Analysis of Demand for Farm Products.* USDA, Technical Bulletin No. 1081, 1953. "The study presented, in terms of simple diagrams, demand-supply structures for a number of farm products . . ." including livestock and crops. The diagrams were of help in determining whether a single-equation or simultaneous-equation method is required to measure U.S. consumer demand for the product. Many statistical demand equations for 1922 through 1941 were presented and discussed. Price flexibilities based on the vegetable equations are presented here.

Commodity	Effect on Price of a One Percent Change in:	
	Production	Disposable Income
Potatoes	-3.51	1.20
Onions	-2.27	1.00
Truck crops for the fresh market	-1.03	.81

Nerlove, Marc. "Distributional Lags and Estimation of Long-Run Supply and Demand Elasticities: Theoretical Considerations." *Journal of Farm Economics,* Vol. XL, No. 2, May 1958, pp. 301-311; and Marc Nerlove and William Addison. "Statistical Estimation of Long-Run Elasticities of Supply and demand." *Journal of Farm Economics,* Vol. XL, No. 4, November 1958, pp. 861-880. Although the coefficient of price (short-run elasticity) for vegetables in U.K., 1921-1938, was not significantly different from zero and the long-run elasticity of demand could therefore not be calculated, the study is nevertheless of considerable methodological interest. The first paper advances the hypothesis that the long-run elasticity of demand cannot be estimated directly. The function that is usually estimated is merely a line through a series of different short-run demand curves. It is neither the short- nor the long-run demand. Using a distributed lag model, however, the recovery of long-run elasticities from the estimated equation becomes feasible. Statistical supply analysis was also performed for 20 fresh market vegetables in the U.S.

DEMAND STUDIES FOR SEVERAL TYPES OF VEGETABLES

Abstracts

RICHARD M. ADAMS, WARREN E. JOHNSTON, and GORDON A. KING. *Some Effects of Alternative Energy Policies on California Annual Crop Production.* California Agricultural Experiment Station, Giannini Foundation of Agricultural Economics, Research Report No. 326, September 1978.

Scope: Cropping patterns under alternative assumptions for ten California vegetable crops (broccoli, cantaloupes, carrots, cauliflower, celery, lettuce, onions, potatoes, fresh tomatoes, and processing tomatoes) and nine field crops.

Purpose: ". . . to evaluate the price, quantity, acreage, and 'welfare' effects of changes in statewide and subregional energy restraints, in increased energy costs, and in product demand levels." p. 7.

Observational Interval: Annual.

Period of Analysis: 1955 through 1972.

Specification and Estimation Procedure: For use in the quadratic programming model, slope coefficients and flexibility estimates from 27 linear, OLS price forecasting equations from Adam's Ph.D. dissertation were used.

Estimation Results:

Summary of Vegetable Price-Forecasting Equations[a/]

Vegetable	Adjusted intercept[b/]	Slope coefficient with respect to California production[c/]	Price flexibility with respect to California production, 1967-72
Broccoli			
Early spring	15.30	-1.520	-0.21
Fall	12.47	-3.280	-0.29
Cantaloupes			
Spring	9.54	-1.038	-0.19
Summer	8.23	-0.281	-0.36
Carrots			
Winter	9.19	-1.107	-0.41
Early summer	6.30	-0.901	-0.43
Late fall	6.00	-0.649	-0.11
Cauliflower			
Early spring	16.00	-5.670	-0.50
Fall	15.00	-4.030[d/]	f/
Celery			
Winter	10.06	-1.660	-0.81
Spring	9.59	-1.795	-0.69
Early summer	7.14	-1.099	-0.32
Late fall	7.08	-0.419	-0.63
Lettuce			
Winter	9.08	-0.314	-0.22
Early spring	12.23	-1.226	-0.33
Summer	7.09	-0.202	-0.10
Fall	10.31	-0.518	-0.41
Onions			
Late spring	5.36	-0.408[d/]	f/
Late summer	3.02	-0.072	-0.14
Potatoes			
Winter	4.53	-0.695	-0.65
Late spring	5.50	-0.148	-1.21
Early summer	5.38	-1.260	-1.22
Late summer	5.45	-1.227	-1.24
Fall	5.40	-0.442[d/]	f/
Tomatoes			
Processing	68.00	-2.480[e/]	-0.27
Tomatoes - fresh			
Early spring	15.88	-3.170	f/
Early summer	15.79	-0.575	-0.14
Early fall	16.63	-0.468	-0.18

a/ Summarized from Richard M. Adams. A Quadratic Programming Approach to the Production of California Field and Vegetable Crops Emphasizing Land, Water, and Energy Use. Unpublished Ph.D. dissertation, University of California, Davis, Sept. 1975.

b/ Independent variables, other than "California production" were evaluated at mean levels and added to the intercept term, resulting in a general price-forecasting equation of the form: $Pc_i = a_i + d_i Qc_i$. Units of the intercept terms are in dollars per cwt. for all vegetables, excluding processing tomatoes, which is in dollars per ton. The intercept was then "adjusted" to ensure consistency of 1972 prices and quantities; i.e., to ensure that 1972 quantity levels resulted in approximate 1972 prices when used in the price-forecasting equation framework.

c/ Units of the slope coefficients are million cwt. for all vegetables, except processing tomatoes, which is expressed in million tons.

d/ Due to statistical insignificance of the estimated slope coefficient, the incorporated slope coefficient is derived from other season price-flexibilities for the same crop, at relevant price and quantity levels.

e/ Slope coefficient derived from King, Jesse, and French--reviewed in this report.

f/ Price-flexibility not calculated due to use of other season slope coefficients.

O. P. BLAICH. *Strength-of-Demand for 120 Market Categories of Food, 1957-1961.* University of California Agricultural Extension Service, April 1963.

Scope: Estimates of the "strength-of-demand" for all foods: vegetables, fruit, nuts, assorted animal products, and starches and sugars for the United States were made.

Purpose: ". . . to satisfy a wide variety of needs for information relating to the medium long-run demand for food and its many component items. The material should be adaptable to the needs of farmers, marketers of farm products, suppliers of farm inputs, and consumers." p. i.

Observational Interval: Annual.

Period of Analysis: 1957 through 1961.

Specification and Estimation Procedure: Strength-of-demand attempts to measure shifts of the demand curve due to changes in consumer income, tastes, and prices of substitutes or complements, as opposed to movements along the curve due to changes in the quantity of the product available. If the exact relationship between price and quantity were known, then a price-quantity observation to the right of the curve would represent a strong demand shift; to the left, a weak one.

Estimates of the elasticities of demand for each of the vegetables were taken from other sources. Since statistical estimates of demand relationships are never exact, a range was constructed for use in the strength-of-demand formula resulting thereby in a range for the strength also (S' . . . S").

S expressed as a proportion and in per capita terms was calculated using:

$$S = \frac{\Delta q}{q} - \frac{-e\Delta p}{p}$$

where:

S represents the measure of strength-of-demand;

Δq measures the observed change in quantity during an interval of time;

Δp represents the observed change in price during the same interval of time; and

e is the elasticity of demand.

For convenience, the S range was given a letter rating where:

A = strong demand $S' \geq 0$, $S'' > S'$;

B = indeterminate $S' < 0$, $S'' > 0$;

C = weak demand $S' < S''$, $S'' \leq 0$.

Since S was calculated in per capita terms, S = 0 could still reflect a strong demand for the product in view of the expected population growth of the United States during the 1960's.

<u>Estimation Results</u>:

Estimation results:

Fresh Vegetables: Strength-of-Demand at the Farm Level, Trend of Prices, Trend of Per Capita Consumption, United States, 1957-1961

Item	1957-61 Average Per Cent Change in 1/		Suggested Range of Price Elasticity		Strength-of-Demand Range		Rating
	Price	Per Capita Con-sumption	From	To	From	To	
Asparagus	+ 3.8	- 4.0	-0.1	-2.0*	- 3.6	+ 3.6	B
Artichokes	- 2.3	+10.1	-0.1	-2.0*	+ 9.9	+ 5.5	A
Lima Beans	- 1.0	+ 3.3	-0.8	-2.2	+ 2.5	+ 1.1	A
Snap Beans	- 0.8	- 3.0	-0.8	-2.2*	- 3.6	- 4.8	C
Beets	- 5.1	-10.0	-0.1	-2.0*	-10.5	-20.2	C-
Broccoli	+ 6.0	- 5.0	-0.1	-2.0*	- 4.4	+ 7.0	B
Brussels Sprouts	- 3.5	0.0	-0.1	-2.0*	- 0.4	- 7.0	C
Cabbage	- 2.4	- 1.8	-0.3	-0.7	- 2.5	- 3.5	C
Cantaloupe	+ 0.2	- 1.8	-0.4	-1.2	- 1.7	- 1.6	C
Carrots	- 0.1	- 2.5	-0.1	-2.0*	- 2.5	- 2.7	C
Cauliflower	+ 5.5	- 5.5	-0.2	-1.0*	- 4.4	0.0	C
Celery	- 7.4	- 2.0	-0.3	-0.9	- 4.2	- 8.7	C
Sweet Corn	- 0.4	+ 0.4	-0.2	-0.8	- 0.3	- 0.1	C
Cucumber	+ 1.0	- 0.3	-0.7	-2.1	+ 0.4	+ 1.8	A
Eggplant	- 0.8	0.0	-0.1	-2.0*	- 0.1	- 1.6	C
Garlic	-10.1	+ 7.1	-0.1	-1.0*	+ 6.1	- 3.0	B
Kale	+ 5.6	0.0	-0.1	-2.0*	+ 0.6	+11.2	A
Lettuce	- 2.4	+ 0.5	-0.2	-3.0	0.0	- 6.7	C
Onions	- 1.3	0.0	-0.2	-0.6	- 0.3	- 0.8	C
Green Peas	+ 1.8	-12.5	-0.2	-0.8	-12.1	-11.1	C-
Green Peppers	- 3.9	+ 3.0	-0.7	-2.0	+ 0.3	- 4.8	B-
Spinach	+ 2.4	- 5.0	-0.1	-2.0*	- 4.8	- 0.2	C
Tomatoes	+ 1.4	+ 0.7	-2.3	-6.5	+ 3.9	+ 9.8	A

* The estimates of elasticity marked with an asterisk are based largely on judgment.

1/ The least squares trend calculated as a percent of the five-year mean.

Frozen Vegetables: Strength-of-Demand at the Farm Level, Trend of Prices, Trend of Per Capita Consumption, United States, 1957-1961

Item	1957-61 Average Per Cent Change in 1/		Suggested Range of Price Elasticity		Strength-of-Demand Range		
	Price	Per Capita Consumption	From	To	From	To	Rating
Asparagus	+6.5	+ 7.7	-0.2	-2.5*	+ 9.0	+24.0	A+
Beans, Snap	-0.8	- 1.7	-0.8	-2.5*	- 2.3	- 3.7	C
Beans, Lima	+1.2	- 1.3	-0.8	-2.5*	- 0.3	- 1.7	C
Carrots	-3.7	+ 7.7	-0.2	-2.5*	+ 7.0	- 1.5	B+
Peas	-1.4	+ 1.5	-0.8	-4.0	+ 0.4	- 4.1	B-
Broccoli	+2.8	+ 4.4	-0.2	-2.5*	+ 5.0	+11.4	A
Spinach	-2.7	+ 1.4	-0.2	-2.5*	+ 0.9	- 5.4	B-
Cauliflower	+5.5	+ 6.6	-0.2	-1.5*	+ 7.7	+14.8	A
Corn (Sweet)	0.0	+ 2.4	-0.2	-1.0*	+ 2.4	+ 2.4	A
Potatoes	-3.7	+22.8	-0.2	-2.0*	+22.1	+15.4	A+

* These elasticities were based on fresh estimates, making a moderate upward allowance.

Canned Vegetables: Strength-of-Demand at the Farm Level, Trend of Prices, Trend of Per Capita Consumption, United States, 1957-1960

Item	1957-61 Average Per Cent Change in 1/		Suggested Range of Price Elasticity		Strength-of-Demand Range		
	Price	Per Capita Consumption	From	To	From	To	Rating
Asparagus	+6.5	- 1.3	-0.2	-2.5*	0.0	+15.0	A
Beans, Lima	-1.2	- 4.8	-0.8	-2.5*	- 5.8	- 7.8	C
Beans, Snap	-2.9	+ 1.9	-0.8	-2.5*	- 0.4	- 5.4	C
Beets	+0.3	- 2.1	-0.2	-2.5*	- 2.0	- 1.3	C
Carrots	-3.7	+ 6.0	-0.2	-2.5*	+ 5.3	- 3.2	B
Cabbage (Sauerkraut)	-0.5	+ 0.6	-0.2	-1.0*	+ 0.5	+ 0.1	A
Corn	-0.6	- 1.7	-0.2	-1.0*	- 1.8	- 2.3	C
Peas (Green)	-1.0	- 1.9	-0.8	-4.0	- 2.7	- 5.9	C
Potatoes	-2.2	+22.9	-0.2	-2.5*	+22.5	+17.4	A+
Spinach	-2.7	- 3.3	-0.2	-2.5*	- 3.8	-10.0	C
Tomatoes (Whole)	+3.7	+ 0.9	-1.1	-3.3	+ 5.0	+13.1	A
Tomato Products	+3.7	+ 4.2	-1.1	-3.3	+ 8.3	+16.4	A+
Sweet Potatoes	+2.3	+ 2.0	-0.2	-2.5*	+ 2.5	+ 7.8	A

* The estimates of elasticity marked with an asterisk are based largely on judgment.

1/ The least squares trend calculated as a percent of the five-year mean.

GENE A. MATHIA and RONALD A. SCHRIMPER. *Analysis of Shifts in Demand and Supply Affecting U.S. and N.C. Vegetable Production and Price Patterns.* North Carolina State University, Economics Information Report No. 35, January 1974.

Scope: U.S. demand for cabbage, cucumbers, peppers, potatoes, snap beans, sweet corn, sweet potatoes, and tomatoes.

Purpose: ". . . to examine some of the important changes in national production and prices of fresh and processed forms of selected vegetables and to identify relative demand and supply inducements that have been operating." p. 8.

Observational Interval: Annual.

Period of Analysis: 1949 through 1972.

Specification and Estimation Procedure: Linear OLS regressions were fitted for each of the eight vegetables in which the grower price was a function of quantity, income, U.S. population, time, and the price of a substitute. For most vegetables the substitute was the price of the processed product. The coefficient of the population variable was restricted in the estimation process to guarantee that the elasticity of demand with respect to population changes was unity.

Estimation Results:

Demand Relationships for Selected Fresh Vegetables[a/]

Product	Constant	Quantity[b/]	Population[c/]	Income[d/]	Time[e/]	Price of Substitute[f/]	R^2	Mean Values Price	Mean Values Quantity	Elasticities[g/] Price	Elasticities[g/] Income
Cabbage	1.67	-.00016*	.0174	.0028	-.094	.0691*	.64	2.84	19,945	- .89	.38
Cucumbers	6.50	-.00081*	.0192	-.0083	.139	.0271*	.39	6.27	4,295	-1.80	-1.15
Peppers	5.55	-.00140*	.0272	.0171*	-.220		.35	10.14	3,500	-2.07	1.50
Potatoes	- .34	-.00002*	.0222	.0047	-.068	.3146*	.62	2.33	232,062	- .50	.43
Snapbeans	- .51	-.00111*	.0269	.0285**	-.461**	.0409*	.79	70.89	4,368	-2.25	2.52
Sweet corn	5.18	-.00043**	.0290	-.0057	.078	.0375	.55	4.61	12,285	- .87	- .46
Sweet potatoes	4.64	-.00051**	.0311	.0042	-.204	.3674**	.90	4.79	11,065	- .85	.33
Tomatoes (domestic)	.90	.00008	-.0079	.0333**	-.411**	-.0212	.73	9.35	19,412	j/	j/
(total)[h/]	1.47	.00003	i/	.0307**	-.384*	-.0151	.72	9.35	21,527	j/	j/

a/ Price is the dependent variable and is expressed in dollars per cwt. deflated by Consumer Price Index (1967 = 100). The population coefficient was constrained at a level which yielded a population elasticity equal to one.

b/ Quantity is expressed in 1,000 cwt. and represents total domestic production for all products except sweet potatoes and white potatoes. Total quantity sold off farms was used for these two products.

c/ Population is coded in million people and the coefficients were not tested statistically.

d/ Income is expressed in billion dollars deflated by the Consumer Price Index (1967 = 100). Average real income was 429.2 million dollars.

e/ Time begins with 1949 = 1, 1950 = 2, etc.

f/ The price substitute variable is the deflated price of the processed form in dollars per ton for cabbage, cucumbers, snapbeans, sweet corn and tomatoes. A substitute product was not included for peppers. The deflated price of white potatoes in dollars per cwt. was used as the sweet potato substitute and deflated price of sweet potatoes in dollars per cwt. was used as the white potato substitute. The Consumer Price Index (1967 = 100) was used as the deflater in all cases.

g/ Computed at mean price and quantity levels.

h/ Includes domestic production and net imports.

i/ Absolute value was less than -.00005.

j/ Elasticity was not calculated because of the insignificant positive sign for quantity coefficient.

* Significant at the .10 level.

** Significant at the .01 level.

RONALD CARL MITTELHAMMER. *The Estimation of Domestic Demand for Salad Vegetables Using A Priori Information.* Unpublished Ph.D. dissertation, Washington State University, 1978.

Scope: U.S. demand for cabbage, carrots, celery, cucumbers, green peppers, lettuce, and tomatoes.

Purpose: ". . . the econometric estimation of annual aggregate domestic demand schedules for fresh vegetables both at the retail level and at the derived farm level. A secondary objective was to examine the empirical behavior and assess the usefulness of the technique of mixed statistical estimation which allows the incorporation of linear probabilistic constraints on the parameters . . ." p. v.

Observational Interval: Annual.

Period of Analysis: 1954 through 1975.

Specification and Estimation Procedure: A simultaneous system of seven retail-level demand equations for the seven vegetables, using linear probabilistic constraints[1/] and including all cross-price effects, was estimated by 3SLS, mixed estimation technique. A reasonable range was established for the direct and cross elasticities using previous studies, introspection, and subjective beliefs; and the estimates were constrained by the model to fall within these limits. The own-price elasticity for carrots, for example, was constrained to $-.5 \pm .3$. The direct elasticities and cross elasticities calculated at the mean from the structural equations are presented below.

1/ The constraints included 21 inexact symmetry constraints, seven mean-level direct price elasticity constraints, seven mean-level income elasticity constraints and six mean-level cross elasticity constraints.

In addition, seven margin equations were estimated by the TSLS mixed estimation technique. Elasticities were constrained to fall within a probable range. Margin estimation results are published in: Ron C. Mittelhammer and David W. Price, "Estimating the Effects of Volume, Prices, and Costs on Marketing Margins of Selected Fresh Vegetables through Mixed Estimation," *Agricultural Economics Research,* Vol. 30, No. 4, October 1978.

In the dissertation, the retail equations and the margin relationships were used to estimate demand at the farm level.

Estimation Results:

Retail price and income elasticities at the mean level of the data, 1954-1975

Elasticity of:	With respect to:							
	$\frac{P_{CAB}}{CPI}$	$\frac{P_{CAR}}{CPI}$	$\frac{P_{CEL}}{CPI}$	$\frac{P_{CUC}}{CPI}$	$\frac{P_{GP}}{CPI}$	$\frac{P_{LET}}{CPI}$	$\frac{P_{TOM}}{CPI}$	$\frac{Y}{CPI}$
Q_{CAB}	-.286	-.136	.162	-.034	.011	.018	---	.131
Q_{CAR}	-.118	-.448	.181	-.027	-.074	-.029	.032	.231
Q_{CEL}	.138	.176	-.254	-.124	.080	-.149	.128	.442
Q_{CUC}	-.050	-.045	-.215	-.501	.037	-.015	.237	.215
Q_{GP}	.012	-.096	.107	.029	-.228	-.144	-.187	.506
Q_{LET}	.006	-.012	-.064	-.004	-.046	-.106	.038	.629
Q_{TOM}	.236	.010	.040	.043	-.044	.028	-.515	.201

where $\frac{P}{CPI}$ and Q are price deflated by the consumers' price index and quantity, respectively, for each vegetable; and CAB, CAR, CEL, CUC, GP, LET, TOM stand for: cabbage, carrots, celery, cucumbers, green peppers, lettuce, and tomatoes.

Related Studies for Several Types of Vegetables Analyzed in One Study

Bohall, Robert W. *Pricing Performance of the Marketing System for Selected Fresh Winter Vegetables.* Unpublished Ph.D. dissertation, Department of Economics, North Carolina State University, 1971. A model evaluating pricing performance for carrots, lettuce, and tomatoes was developed. Three publications--one for each vegetable--based on the dissertation are reviewed in this report.

Foytik, Jerry. *Monthly Variations in Demand for Hawaii Vegetables.* Paper presented at the Western Agricultural Economics Association, Corvallis, Oregon, July 1969. Monthly data for 1961 through 1967 were used to derive both farm and wholesale level demand functions for nine vegetables in Hawaii: cucumbers, snap beans, head cabbage, Chinese cabbage, peppers, celery, daikon, lettuce, tomatoes, and green onions. Deflated price was fitted by OLS as a linear function of quantity and income. Dummy variables were used to allow variation in both the intercept and quantity-slope on a bimonthly basis.

Foytik, Jerry, César Velasco, and Lya Valenzuela. *An Examination of Vegetable Price Relationships in Chile.* A study conducted in cooperation with the Chile-California program, October 1967. Differences in various retail vegetable prices among cities were estimated as a function of distance from a base city. Monthly variations in the price-quantity relationship for cauliflower, squash, onions, carrots, and green peas were determined by the graphic method--that is: $P = f(Q) + g(M)$ where price is a function of quantity and also of month; $f(Q)$ was plotted first, then the predicted price for a particular month was read by adding or subtracting the deviation, $g(M)$, above or below the demand function, $f(Q)$.

Garoyan, Leon and A. N. Halter. *Termination of the Bracero Program: An Analysis of Economic Impact on Major Labor Intensive Horticultural Crops.* Prepared for the National Commission on Food Marketing, December 1965. The study of impact of the termination of the bracero program included price and production forecasting equations for asparagus, cantaloupes, lemons, oranges, lettuce, strawberries, and tomatoes grown in California.

George, P. S. and G. A. King. *Consumer Demand for Food Commodities in the United States with Projections for 1980.* California Agricultural Experiment Station, Giannini Foundation of Agricultural Economics, Monograph No. 26, March 1971. A matrix of retail demand interrelationships for 49 major food commodities (or commodity groups) in the U.S. was estimated. The 49 commodities were categorized into 15 groups and demand for each commodity was estimated as a function of own-price, prices within the group, price indexes of other groups and income. In most cases more than one equation was fitted so one coefficient based on statistical properties, had to be chosen for use in the matrix. A second matrix giving farm-level elasticities was derived from the retail-level elasticities and the elasticities of price transmission. Results of own-price elasticities for various vegetables were:

	Retail Level	Farm Level
Lettuce	-0.1414	-0.0956
Tomatoes	-0.3846	-0.3551
Beans	-0.2550	-0.2343
Onions	-0.2500	-0.1152
Carrots	-0.4971	-0.1884
Other fresh vegetables	-0.3200	-- a/
Canned peas	-0.1850	-0.1812
Canned corn	-0.2550	--
Canned tomatoes	-0.1760	-0.1760
Dry vegetables	-0.4800	-0.4532
Frozen vegetables	-1.0344	--
Potatoes	-0.3086	-0.1496

a/ Not computed

Hammig, Michael Dean. *Supply Response and Simulation of Supply and Demand for the U.S. Fresh Vegetable Industry.* Unpublished Ph.D. dissertation, Department of Agricultural Economics, Washington State University, 1978. Using demand and margin relationships estimated by Mittelhammer (reviewed in this report), the relevant supply response relations and necessary linkages between supply and demand were estimated, completing the fresh salad vegetable model. The vegetables included in the complete subsector model were cabbage, carrots, celery, cucumbers, green peppers, lettuce, and tomatoes.

Hassan, Zuhair A. "Urban Food Consumption Patterns in Canada". *Agriculture Canada,* Publication No. 77/1, January 1977. Demand parameters for 122 food items were estimated from data from the 1974 Urban Family Food Expenditure Survey conducted in 14 Canadian cities with 5,952 families and unattached individuals. Expenditures and quantity elasticities with respect to income and to family size were computed from singe equations in semi-log form for each commodity. Price elasticities for each commodity were derived from equations in which the quantity of the commodity purchased was fitted as a function of its price in the week the purchase was made, the purchasing family's income and family size. During the survey period there was enough variation in prices to obtain statistically significant results for most commodities. Direct price elasticities for various fresh, canned, and frozen vegetables were:

Potatoes	-0.8448
Tomatoes	-1.5190
Lettuce	-0.3731
Carrots	-0.5207
Celery	-0.2940
Onions	-0.9264
Cabbage	-0.5834
Cauliflower	-0.4834
Turnips	-0.6374
Beans, green & yellow	-0.8389
Corn	-1.0179
Cucumbers	-0.7820
Mushrooms	-1.0083
Canned peas	-0.8070
Canned corn	-0.7603
Canned baked beans	-0.8810
Frozen peas	-0.6392
Frozen green beans	-0.7296
Frozen potatoes	-0.3711
Frozen corn	-0.4256

Meissner, Frank. *Regional Supply-Demand Balances for Selected Fruits and Vegetables*. Stanford Research Institute, prepared for the Western Pacific Railroad Company, December 1959. Supply-demand--i.e. production-consumption relationships--for tomatoes, peaches, pears, grapes, asparagus, lettuce, dry onions, cantaloupes, and other melons were studied for each of the following geographical areas: Southern California, Northern California, the Northwest, the Mountain States, and the East. Forecasts of supply, demand, and supply-demand balances were prepared for 1965, 1970, and 1975.

Parker, Arthur F. and W. W. McPherson. *Changes in Seasonal FOB Price Patterns in Florida: Celery, Sweet Corn, Green Peppers, Irish Potatoes, and Tomatoes, 1950-51 through 1965-66*. Florida Agricultural Experiment Station, Economics Mimeo Report EC69-13, June 1969. Monthly indexes for each vegetable were constructed: each monthly price was divided by the yearly average price; a three year moving average of this ratio was then expressed as a percent which was regressed on time and tested for statistically significant changes in seasonal effects over time.

Pomareda, Carlos and Richard L. Simmons. "A Programming Model with Risk to Evaluate Mexican Rural Wage Policy." *Operational Research Quarterly*, Vol. 28, No. 4, ii, pp. 997-1011. For use in a linear programming model, linear demand functions for tomatoes, peppers, cucumbers, cantaloupes, and honeydews were estimated by OLS using dummy variables for monthly shifts. An earlier version--abstracted in this report on page 80--computed U.S. import demand from Mexico for tomatoes, peppers, and cucumbers, by subtracting estimated fixed U.S. supplies from the total demand functions. In this 1977 model, monthly stepwise linear supply functions were used instead of the estimated fixed supply to determine the net demand. Thus, the slopes are identical to the model reported on page 80, but the intercepts differ.

Price, David W., Dorothy Z. Price, and Donald A. West. *The Effects of Socio-Economic and Psychological Variables on Types of Fruits and Vegetables Consumed.* Paper presented at the American Association of Agricultural Economics, Blacksburg, Virginia, August 1978. From a sample of 497 Washington state households with an 8-12 year old child, factor analysis was performed, relating fruit and vegetables preferences to certain psychological variables such as need level and family management style. Liquid assets had a significant effect on consumption of certain fruits and vegetables.

Purcell, J. C. and K. E. Ford. "Consumption Requirements and Prospective Demand for Fruits and Vegetables in the South." In *The Fruit and Vegetable Industry of the South, Adjusting for the Future.* North Carolina State, Agricultural Policy Institute, in cooperation with the University of Florida, February 1965. No statistical analysis of demand was performed, but factors affecting demand for various fruits and vegetables were discussed. Elasticities from the Brandow study (see page 15) were presented, as well as quantity and expenditure income elasticities from an Atlanta consumer-household survey.

Raunikar, Robert, J. C. Purcell, and J. C. Elrod. *Consumption and Expenditure Analysis for Fruits and Vegetables in Atlanta, Georgia.* Georgia Agricultural Experiment Station, Technical Bulletin No. 53, June 1966. Data from a consumer panel in Atlanta, Georgia, in which households kept diaries of food quantities and expenditures for a period of six years (1957 through 1962), were used in the analyses. Four statistical models—linear, modified hyperbolic, semi-exponential, and logarithmic—were estimated by OLS, relating both quantities purchased of the various fruits and vegetables and expenditures to socio-economic variables.

Raunikar, Robert, J. C. Purcell, and J. C. Elrod. *Spatial and Temporal Aspects of the Demand for Food in the United States, XII. Potatoes, XIV. Sweet Potatoes, and XV. Dry Beans.* Georgia Agricultural Experiment Station, Research Bulletins 134, 138, and 139, respectively, June 1973. In addition to the three vegetable reports, similar bulletins were also published for beef, pork, poultry, fish and shellfish, eggs, table fats, frozen desserts, cheese, canned milk, citrus, apples, peanut butter, and salted peanuts. In each of the bulletins, demand for the commodity—meaning the quantity taken, assuming sufficient supply and 1965 prices—was estimated for 14 regional markets and 79 primary markets both on a per capita and aggregate basis. Socio-economic factors affecting consumption were analyzed using data from a panel of consumers in Atlanta. The relationships included the influence of household income, age composition, and race. An adjustment factor to account for regional differences was developed from the USDA national household survey for 1965-1966. Characteristics of the markets were compiled from 1950 and 1960 census data. Estimates were made for 1965; projections for 1985.

Rockwell, George R., Jr. *Income and Household Size: Their Effects on Food Consumption.* USDA, Agricultural Marketing Service, Marketing Research Report No. 340, June 1959. Using a 1955 food consumption survey of 6,060 U.S. households, the relationship between consumption (in terms of quantity and in terms of value), family income, and family size was analyzed. The sample was divided into farm and nonfarm and then each group was divided into high, medium, and low income groups--the income ranges being set to equalize the number in each group for each of the two sectors. Vegetables were grouped into: potatoes and sweet potatoes, dark green and deep yellow, other green, tomatoes, and other; and income elasticity estimates for fresh, frozen, canned, dried, strained or chopped, and juice were made.

DEMAND STUDIES FOR INDIVIDUAL VEGETABLE TYPES

Asparagus

Related Studies

French, Ben C. and Jim L. Matthews. "A Supply Response Model for Perennial Crops." *American Journal of Agricultural Economics*, Vol. 53, No. 3, August 1971, pp. 478-490. To test the general, theoretical supply response model for perennial crops, a supply equation for asparagus was estimated for each of three regions: California, Midwest-East, and Northwest.

Hoos, Sidney. *Statistical Analysis of the Annual Average FOB Prices of California Canned Asparagus, 1925-26 to 1950-51.* California Agricultural Experiment Station, Giannini Foundation of Agricultural Economics, Mimeographed Report No. 112, 1951. The report is one of an annual series issued by the Giannini Foundation of Agricultural Economics for use by the California canned asparagus industry. Other reports in the series include: G. M. Kuznets and H. R. Wellman, Report No. 80, 1942; Hoos, Report No. 95, 1949, Hoos, Report No. 106, 1950. Price forecasting equations were fitted by OLS under alternative specifications. Each report updates the previous one by adding more time series data.

Stover, H. J. *An Analysis of the Prices Received for Canned Asparagus by Canners in California--Seasons 1925-26 through 1934-35.* California Agricultural Experiment Station, Giannini Foundation of Agricultural Economics, Mimeographed Report No. 40, 1935. In the graphic analysis: (1) FOB prices were plotted against California shipments of canned asparagus 1925 through 1934, (2) the price deviations from the average relation in (1) were plotted against consumer income, and (3) deviations from (2) were plotted against time.

Beans

Abstracts

J. H. DROGE and R. H. REED. *Prediction Analysis of United States and Wisconsin Wholesale Prices of Canned Cut Green Beans, Sweet Corn, and Sweet Peas, 1948-1968.* College of Agricultural Life Sciences, University of Wisconsin, Agricultural Economics Project Report, January 1973.

Scope: National canner brand and Wisconsin private label f.o.b. price relationships for canned cut green beans, sweet corn, and peas.

Purpose: ". . . to formulate an appropriate set of six f.o.b. price prediction equations . . . to test the forecasting accuracy . . . and to update each equation to reflect the additional 1967-68 market year," p. 2.

Observational Interval: Annual.

Period of Analysis: 1948 through 1968.

Specification and Estimation Procedure: Since there was low correlation between national canners brand and Wisconsin private label prices (r = .22 for beans), separate price forecasting equations were estimated for each set of prices for each of the three vegetables. A step-wise regression procedure by OLS was used to determine which variables other than the *a priori* essential ones should be included in each equation. Each of the resulting six statistically best equations was validated by comparing the 1967-68 predicted price with the actual price. In each case the actual price was within the 95 percent confidence interval for forecast error. The equations were then rerun using the 1967-68 data. The updated equations appear below.

Estimation Results:

Canned Vegetable F.O.B. Price Prediction Equations-

Cut Green Beans:

National Canner Brands

$$Y_t = +80.7562 + \underset{(0.0721)}{0.3014Z_{2t}} + \underset{(0.1618)}{0.3168Z_{7t}} - \underset{(0.0307)}{0.1078Z_{9t}},$$

$R^2 = .757$ = 4.6870, D-W statistic = 2.4500 (inconclusive).

Wisconsin Private Label Brands

$$Y'_t = +235.4027 - \underset{(3.7031)}{12.5680Z'_{1t}} + \underset{(0.0956)}{0.3729Z'_{2t}} - \underset{(3.2354)}{10.5065Z'_{5t}} - \underset{(0.4939)}{1.0668Z_{6t}},$$

$R^2 = .877$ D-W statistic = 2.1445 (negative).

Sweet Corn:

National Canner Brands

$$Y_k = +256.6703 - \underset{(1.9249)}{17.7851Z_{1k}} + \underset{(2.0768)}{11.6396Z'_{3k}} - \underset{(0.5161)}{2.9418Z_{6k}} + \underset{(0.0965)}{0.4823Z_{7k}}$$

$$+ \underset{(0.1607)}{0.5619Z_{8k}},$$

$R^2 = .970$ D-W statistic = 2.0659 (negative).

Wisconsin Private Label Brands

$$Y'_k = +459.3961 - \underset{(2.0179)}{23.1948Z_{1k}} + \underset{(2.0319)}{17.1013Z'_{3k}} - \underset{(2.7212)}{13.4599Z_{5k}} - \underset{(0.9579)}{2.9188Z_{6k}}$$

$$- \underset{(4.7277)}{16.6752Z_{9k}},$$

$R^2 = .967$ D-W statistic = 2.4767 (inconclusive).

Sweet Peas:

National Canner Brands

$$Y_j = +1.2062 - \underset{(1.0978)}{4.1395Z'_{1j}} - \underset{(1.0382)}{6.1997Z_{9j}} + \underset{(0.0493)}{0.7851Z_{11j}} + \underset{(0.0611)}{0.1799Z_{13j}},$$

$R^2 = .983$ D-W statistic = 1.9203 (negative).

Wisconsin Private Label Brands

$$Y'_j = +93.2543 + \underset{(0.1941)}{0.7189Z_{8k}} - \underset{(0.4170)}{1.1278Z_{6j}} + \underset{(0.1277)}{0.5966Z_{7j}} - \underset{(1.9346)}{3.3912Z_{14j}}$$

$$- \underset{(0.0234)}{0.0614Z_{15j}},$$

$R^2 = .843$ D-W statistic = 1.9300 (negative).

where:

Description of Variables:

Y_t = Canned cut green beans; fancy grade market year FOB price per dozen No. 303 cans of U.S. national canner brands expressed in cents;

Y'_t = Canned cut green beans; market year fancy grade FOB price per dozen No. 303 cans of Wisconsin private label brands expressed in cents;

Y_k = Canned golden cream style sweet corn; fancy grade market year FOB price per dozen No. 303 cans of U.S. national canner brands expressed in cents;

Y'_k = Canned golden whole kernel sweet corn; fancy grade market year FOB price per dozen No. 303 cans of Wisconsin private label brands expressed in cents;

Y_j = Canned sweet peas; fancy grade market year FOB price per dozen No. 303 cans of U.S. national canner brands expressed in cents;

Y'_j = Canned sweet peas; fancy grade market year FOB price per dozen No. 303 cans of Wisconsin private label brands expressed in cents;

Z'_{1t} = U.S. per capita supply of shelf-size canned snap beans plus total per capita frozen supply of snap beans;

Z_{1k} = U.S. per capita total supply of shelf-size canned sweet corn in pounds net weight;

Z'_{1j} = U.S. per capita supply of canned plus frozen green peas in pounds;

Z_{2t} = Price variable for substitute canned vegetables in shelf-size cans; U.S. per capita supply weighted national canner brands f.o.b. price in cents per dozen No. 303 cans (included canned vegetables are sweet corn and green peas, and computations are based on price series included in this study);

Z'_{2t} = Same as variable Z_{2t} except based on Wisconsin private label f.o.b. prices;

Z'_{3k} = U.S. per capita personal disposable income expressed in thousand dollars squared $\$1{,}000^2$;

Z'_{5t} = U.S. per capita market year carry-in stocks of canned snap beans plus canned green peas in pounds net weight;

Z_{5k} = U.S. per capita market year carry-in stocks (August 1st) of shelf-size canned sweet corn in pounds net weight;

Z_{6t} = Z_{6k} = Z_{6j} = The time trend variable, market year 1948-49 = 48;

Z_{7t} = Y_{t-1};

Z_{7k} = Y_{k-1};

Z_{7j} = Y_{j-1};

Z_{8k} = BLS index of wholesale frozen pea prices (1957-59=100);

Z_{9t} = U.S. per capita market year carry-in stocks (July 1st) of shelf-size canned snap beans in pounds net weight multiplied by Z_{7t} (or Y_{t-1});

Z_{9k} = U.S. per capita supply of frozen snap beans and green peas in pounds;

Z_{9j} = U.S. per capita market year carry-in stocks of shelf-size canned snap beans, sweet corn and green peas in pounds net weight;

Z_{11j} = BLS reported retail price of national canner brands canned sweet peas expressed in cents per dozen No. 303 cans;

Z_{13j} = BLS wholesale price index for fresh and dried vegetables (1957-59=100);

Z_{14j} = U.S. per capita supply of shelf-size canned snap beans, sweet corn and green peas in pounds net weight;

Z_{15j} = U.S. per capita market year carry-in stocks (June 1st) of shelf-size canned green peas in pounds net weight multiplied by Y'_{j-1}.

(Standard errors are in parentheses.)

JERRY FOYTIK. *Demand Characteristics for Vine Vegetables in Honolulu, Hawaii, 1947-1961.* Hawaii Agricultural Experiment Station, Bulletin No. 23, July 1964.

Scope: Snap beans, cucumbers, and tomatoes at the Honolulu wholesale market.

Purpose: To analyze empirically how monthly price and quantity data indicate that changes in market supply are responsible for much of the variation in prices of vine vegetables.

Observational Interval: Monthly.

Period of Analysis: 1947 through 1961.

Specification and Estimation Procedure: For each vegetable, a price dependent equation was fitted as function, parabolic in both quantity and time. Then, monthly shift effects were determined graphically.

Estimation Results:

Snap beans

$$P = 37.00 - 17.5Q + 1.4Q^2 + 0.555T + 0.542T^2 + f(M)$$

Cucumbers

$$P = 26.57 - 7.90Q + 0.8Q^2 + 0.162T + 0.0448T^2 + f(M)$$

Tomatoes

$$P = 29.82 - 4.40Q + 0.3Q^2 + 0.153T + 0.0969T^2 + f(M)$$

where:

P = monthly wholesale price, cents per pound;

Q = monthly wholesale market supply in 100,000 pounds;

T = time measured from 1954;

f(M) = the monthly effect determined graphically.

The top panels of the following three figures show the parabolic price-quantity relationships when the trend and seasonal effects are set at their means (zeroes) for the period of study. The annual shifts in demand are shown in the middle panels, holding quantities constant at their means. Finally, the residuals from the equations were plotted (12 observations each year, each equation) and the monthly effects were graphed (bottom panels). The curves in the bottom panels show the shifts in the price-quantity relationships from month to month as the year progresses.

EDWARD H. KREBS, MARVIN L. HAYENGA, and JOHN N. LEHKER. *Various Price and Supply Control Programs for Navy Beans: A Simulation Analysis.* Michigan State University, Department of Agricultural Economics, Report No. 212, January 1972.

Scope: U.S. demand for navy beans (99 percent Michigan produced).

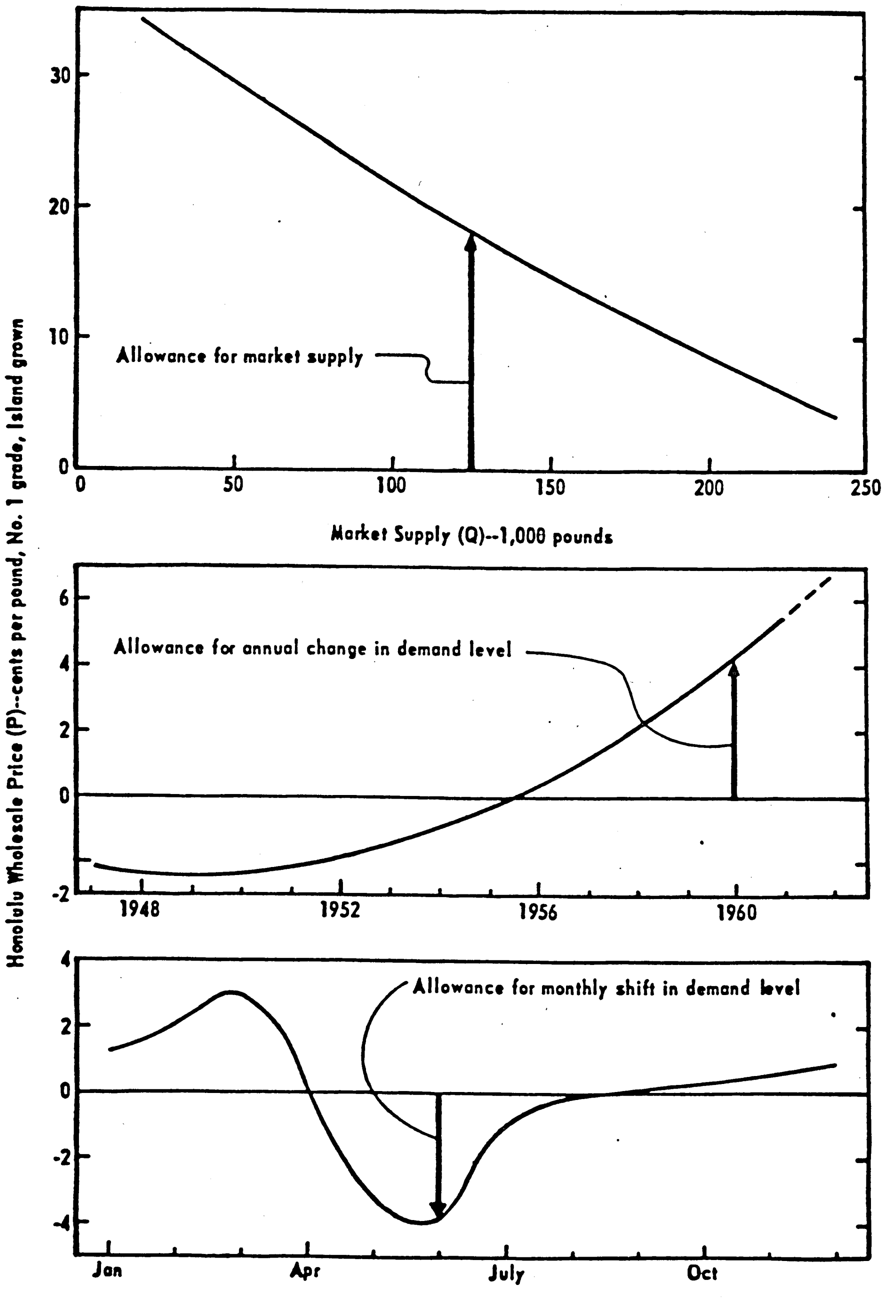
Purpose: "To explore the effects of variations in these (government commodity) programs, a computer simulation model of the navy bean's supply and demand behavior was developed and employed," p. 3.

Observational Interval: Annual.

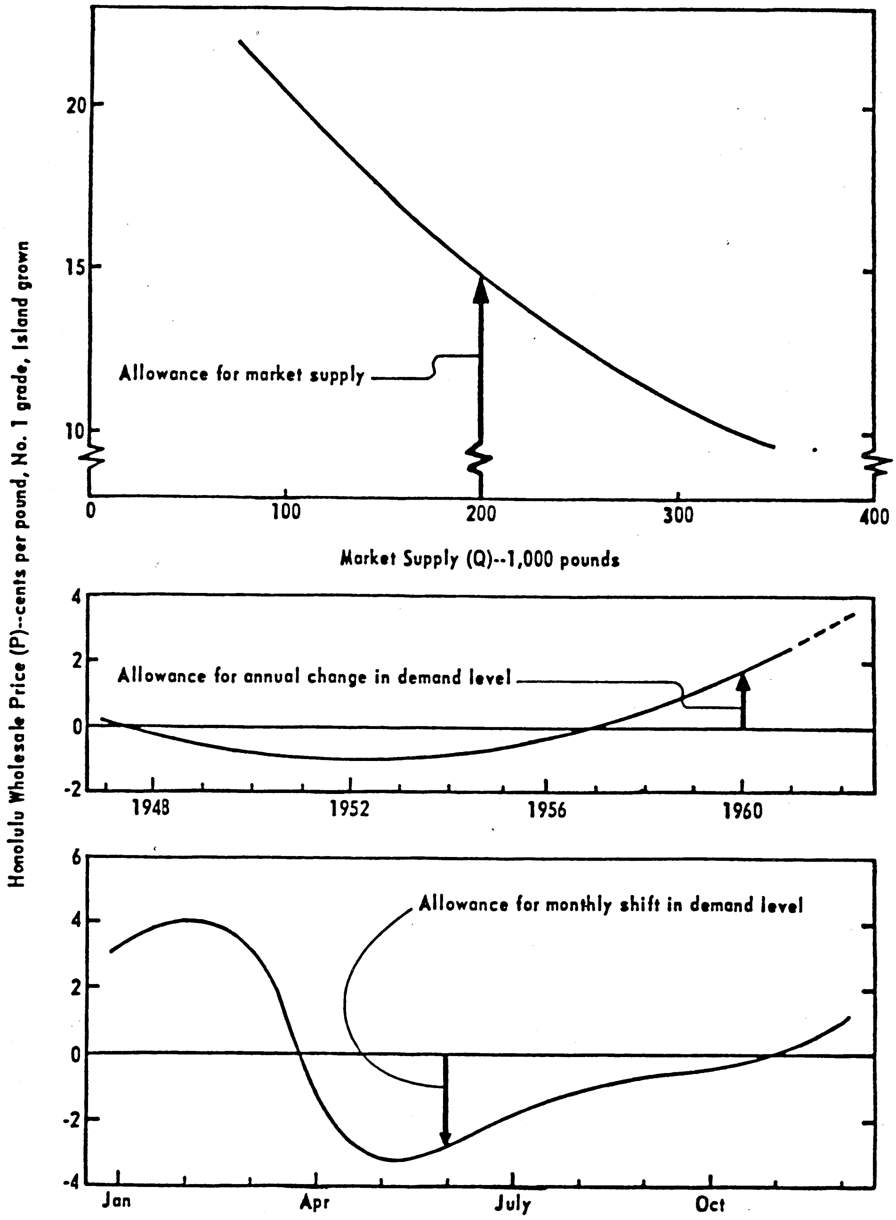
Period of Analysis: 1951 through 1967.

Specification and Estimation Procedure: For use in the simulation model a three equation demand model was estimated by 3SLS in which the four endogenous variables were: domestic use of navy beans, exports, price, and small white bean price. A fourth equation established an identity.

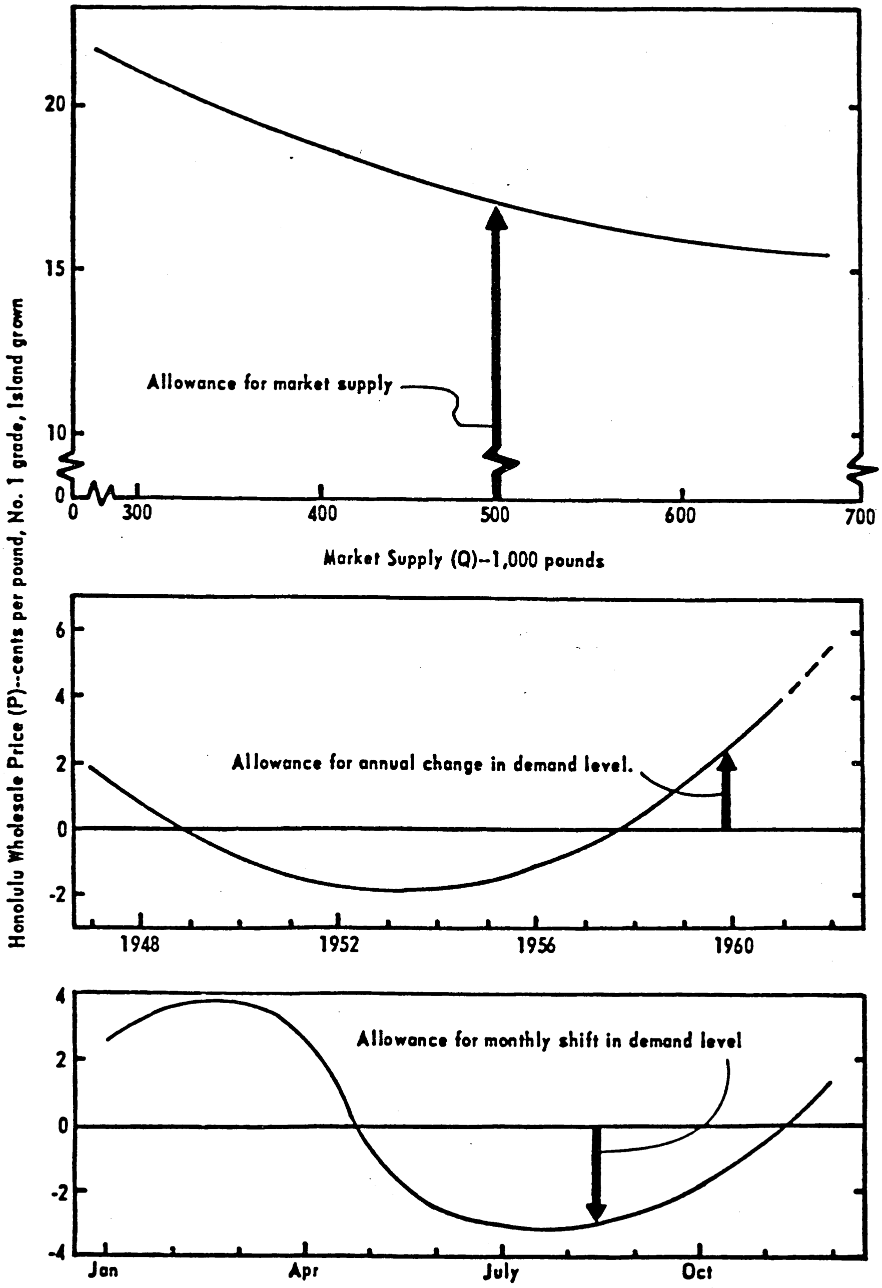
Beans, snap: Estimated wholesale price with variations in supply, year, and month, 1947–61.



Cucumbers: Estimated wholesale price with variations in supply, year, and month, 1947–61.



Tomatoes: Estimated wholesale price with variations in supply, year, and month, 1947–61.



Estimation Results:

$$DOMQ^* = -548.0 - \underset{(.097)}{80.2\ PNB^*} + \underset{(.026)}{13.6\ PSW^*} + \underset{(.877)}{.024\ USPOP} + \underset{(.513)}{696.3\ D_1}$$

$R^2 = .75$

$$EXQ^* = -15{,}332.2 - \underset{(.401)}{63.8\ PNB^*} + \underset{(4.186)}{.324\ UKPOP}$$

$R^2 = .55$

$$PSW^* = -2.3 + \underset{(3.359)}{.736\ PNB^*} - \underset{(3.090)}{.0034\ PRODSW} + \underset{(2.582)}{.0005\ USPOP}$$

$R^2 = .88$

$$PRODNB\text{-}CCCQ_t = DOMQ^*_t + EXQ^*_t - CANEX_t$$

where: * = endogenous variable;

$DOMQ^*_t$ = total U.S. commercial consumption of Michigan navy beans in year t (1,000 cwt.);

EXQ^*_t = total U.S. and Canadian export shipments of navy beans in year t (1,000 cwt.);

PNB^*_t = average quoted grower price for CHP navy beans--September through April in year t ($/cwt.);

PSW^*_t = average quoted grower price for small white beans--September through April in year t ($/cwt.);

$USPOP_t$ = U.S. population in year t (1,000 people);

D_1 = dummy variable (1 if 1958 or after, 0 if not) to account for an otherwise unexplained demand shift apparently occurring in 1958;

$UKPOP_t$ = United Kingdom population in year t (1,000 people);

$CANEX_t$ = total Canadian exports of navy beans in year t (1,000 cwt.);

$PRODSW_t$ = total small white bean production in year t (1,000 cwt.);

$PRODNB_t$ = Michigan annual production of navy beans in year t (1,000 cwt.);

$CCCQ_t$ = Commodity Credit Corporation acquisitions of navy beans in year t (1,000 cwt.).

(t-statistics are in parentheses.)

R. J. VANDENBORRE. *An Econometric Investigation of the Impact of Governmental Support Programs on the Production and Disappearance of Important Varieties of Dry Edible Beans.* California Agricultural Experiment Station, Giannini Foundation of Agricultural Economics, Research Report No. 294, December 1967.

Scope: White beans (navy, small white, and great northerns), blackeyes, and large and small limas in the U.S.

Purpose: ". . . to evaluate the impact of governmental support programs on the production and disappearance of some varieties of dry edible beans . . . Primarily, the study attempts to answer this question: What would have been the situation with respect to production and disappearance of these commodities had there been no price-support program for them?" p. 1.

Observational Interval: Annual.

Period of Analysis: 1948/49 through 1963/64.

Specification and Estimation Procedure: Both a supply-response model and a price-demand model were estimated. Since government takeover of a commodity is a function of the difference between the free-market price and the support price, and since the free-market price cannot be observed in years when takeover actually occurs, in the demand model, government acquisitions were estimated by: (1) the support price and (2) factors thought to determine the free-market price. A six-equation model was estimated for white beans by TSLS: disappearance and government acquisitions of navy beans, disappearance and acquisitions of small whites, ending stocks of small whites, and price of great northern beans. Since there was no government program for blackeyes, a two-equation model--supply and price--sufficed. For large and small limas, again a six-equation model was estimated by TSLS. The estimations were then used to simulate the behavior of the dry bean market under various assumptions about government interference.

Price-demand structure for white classes of dry edible beans

$$y_{7t} = 3.62477 - \underset{(.09190)}{.28322}\, y_{11t} + \underset{(.05373)}{.08269}\, (y_{10t} + y_{12t})^{1/}$$

$$- \underset{(.41081)}{.90644}\, x_{1t} + \underset{(.12587)}{.78091}\, x_{7t} + u_{7t}$$

$R^2 = .92$ $\qquad\qquad$ $d = 2.81$ (i)[2/]

$$y_{14t} = -1.58754 - \underset{(.05564)}{.01929}\, (y_{10t} + y_{12t}) + \underset{(.18235)}{.01105}\, y_{26t}$$

$$+ \underset{(.46998)}{.55279}\, x_{1t} + \underset{(.18010)}{.69240}\, x_{2t} + \underset{(.15200)}{.03092}\, x_{5t} - \underset{(.18236)}{.81436}\, x_{7t} + u_{8t}$$

$R^2 = .92$ $\qquad\qquad$ $d = 3.02$ (i)

$$y_{8t} = .32261 + \underset{(.01876)}{.08889}\, y_{11t} - \underset{(.01677)}{.08568}\, y_{12t} + \underset{(.09968)}{.30965}\, x_{1t} + u_{9t}$$

$R^2 = .74$ $\qquad\qquad$ $d = 2.02$ (n)

$$y_{13t} = -.62231 - \underset{(.01818)}{.05285}\, y_{11t} + \underset{(.01909)}{.03245}\, y_{27t} - \underset{(.06045)}{.11106}\, x_{1t}$$

$$+ \underset{(.18029)}{.55341}\, x_{4t} + \underset{(.02629)}{.11209}\, x_{6t} + u_{10t}$$

$R^2 = .86$ $\qquad\qquad$ $d = 2.27$ (i)

$$y_{9t} = .00880 - \underset{(.00834)}{.02011}\, y_{11t} + \underset{(.00979)}{.00892}\, y_{12t} - \underset{(.09299)}{.10254}\, y_{13t} + \underset{(.09663)}{.25011}\, x_{4t} + u_{11t}$$

$R^2 = .71$ $\qquad\qquad$ $d = 2.59$ (i)

$$y_{10t} = 3.09932 + \underset{(.22027)}{.48622}\, y_{11t} - \underset{(.58355)}{.07555}\, x_{3t} + \underset{(2.0561)}{1.73402}\, x_{1t} + u_{12t}$$

$R^2 = .39$ $\qquad\qquad$ $d = 2.48$ (i)

1/ Coefficients on y_{10t} and y_{12t} were nearly identical; to save on on degrees of freedom, y_{10t} and y_{12t} were added together and the equation run again.

2/ Where the symbol (i) follows the statistic d, the Durbin-Watson test for serial correlation of the error term was inconclusive; (n) indicates that the test showed no serial correlation.

where:

y_{7t} = commercial wholesale disappearance of navy beans in pounds per capita in t (production + beginning stocks + government domestic sales - government takeover - direct purchases by the government);

y_{8t} = commercial wholesale disappearance of small whites in pounds per capita in t (production + beginning stocks - government takeover - ending stocks);

y_{9t} = commercial ending stocks of small whites in pounds per capita in t;

y_{10t} = average wholesale price of great northerns in cents per pound;

y_{11t} = average wholesale price of navy beans in cents per pound;

y_{12t} = average wholesale price of small whites in cents per pound;

y_{13t} = government takeover of small whites in pounds per capita in t;

y_{14t} = government takeover of navy beans in pounds per capita in t;

y_{26t} = difference between actual market price of navy beans per pound and the support price in t

y_{27t} = difference between actual market price of small whites per pound and the support price in t;

x_{1t} = log of disposable income per capita (original series--thousand dollars per capita);

x_{2t} = production + beginning stocks + government domestic sales of navy beans - direct government purchases in pounds per capita in t;

x_{3t} = production + beginning stocks of great northerns in pounds per capita in t;

x_{4t} = production + beginning stocks of small whites in pounds per capita in t;

x_{5t} = support price of navy beans in cents per pound in t;

x_{6t} = support price of small whites in cents per pound in t;

and

x_{7t} = dummy variable in the navy bean model (x_{7t} = 1 for 1958/59 through 1963/64, = 0 for all other years).

(Standard errors are in parentheses.)

Price-demand structure for blackeyes

$$y_{15t} = .61857 + \underset{(.01169)}{.01659}\,\hat{y}_{11t} - \underset{(.00497)}{.021843}\,y_{16t} - \underset{(.07372)}{.15951}\,x_{1t} + u_{13t}$$

$R^2 = .74$ $d = 2.32$ (n)

$$y_{17t} = -.04649 - \underset{(.00481)}{.00224}\,\hat{y}_{11t} - \underset{(.00734)}{.00743}\,y_{16t} + \underset{(.11436)}{.36962}\,x_{9t} + u_{14t}$$

$R^2 = .76$ $d = 2.12$ (n)

where:

y_{15t} = production t + beginning stocks t - ending stocks t in pounds per capita;

y_{16t} = average price of blackeyes in cents per pound in t;

y_{17t} = ending stocks of blackeyes in pounds per capita in t;

$\hat{y}_{11t}$ = average price of navy beans in cents per pound in t (computed);

x_{9t} = production t blackeyes + beginning stocks t blackeyes in pounds per capita.

(Standard errors are in parentheses.)

Price-demand structure for limas:

$$y_{18t} = 1.23907 - \underset{(.00659)}{.03277}\,y_{22t} + \underset{(.01686)}{.02424}\,y_{23t} - \underset{(.06442)}{.77652}\,x_{1t} + u_{15t}$$

$R^2 = .96$ $d = 1.51$ (i)

$$y_{19t} = .12194 + \underset{(.00456)}{.00789}\,y_{22t} - \underset{(.01586)}{.02607}\,y_{23t} - \underset{(.32217)}{.73945}\,y_{24t} + \underset{(.06190)}{.08727}\,x_{10t} + u_{16t}$$

$R^2 = .48$ $d = 2.81$ (i)

$$y_{28t} = 34.82951 + \underset{(.74234)}{.82261}\,y_{23t} + \underset{(13.37828)}{14.46928}\,y_{24t} - 23.69600^{1/}\,x_{1t}$$

$$- \underset{(3.34720)}{26.87131}\,x_{10t} - \underset{(.76117)}{.79155}\,x_{12t} + u_{17t}$$

$R^2 = .96$ $d = 1.67$ (i)

$$y_{21t} = .16107 - \underset{(.00627)}{.01309}\, y_{23t} - \underset{(.07994)}{.09927}\, y_{18t} - \underset{(.25715)}{.09627}\, y_{25t} + \underset{(.12663)}{.08251}\, x_{11t} + u_{19t}$$

$R^2 = .37$ $\qquad\qquad$ d = 2.12 (n)

$$y_{25t} = 4.69705 - \underset{(.16208)}{4.20760}\, y_{18t} - \underset{(.09549)}{.13745}\, y_{22t} + \underset{(.01908)}{.10670}\, y_{29t} - 2.90368\, x_{1t}^{1/}$$

$$+ \underset{(.11857)}{.97589}\, x_{11t} + \underset{(.03583)}{.09871}\, x_{13t} + u_{20t}$$

$R^2 = .98$ $\qquad\qquad$ d = 2.50 (i)

$$y_{20t} = -4.85796 + \underset{(.01181)}{.14110}\, y_{22t} - \underset{(.01210)}{.09951}\, y_{23t} + \underset{(.34519)}{4.35855}\, y_{18t}$$

$$+ \underset{(.27002)}{2.90368}\, x_{1t} + u_{18t}$$

$R^2 = .98$ $\qquad\qquad$ d = 2.40 (i)

where:

y_{18t} = production t + beginning stocks t - ending stocks t - government takeover t of large limas in pounds per capita;

y_{19t} = ending stocks of large limas in pounds per capita in t;

y_{20t} = production t + beginning stocks t - ending stocks t - government takeover t of small limas in pounds per capita;

y_{21t} = ending stocks of small limas in pounds per capita in t;

y_{22t} = wholesale price of large limas in cents per pound in t;

y_{23t} = wholesale price of small limas in cents per pound in t;

y_{24t} = government takeover of large limas in pounds per capita in t;

y_{25t} = government takeover of small limas in pounds per capita in t;

y_{28t} = difference between actual market price of large limas in t and support price in t;

y_{29t} = difference between actual market price of small limas in t and support price in t;

x_{10t} = production t + beginning stocks t of large limas in pounds per capita;

x_{11t} = production t + beginning stocks t of small limas in pounds per capita;

x_{12t} = support price of large limas in cents per pount in t;

and

x_{13t} = support price of small limas in cents per pound in t.

(Standard errors are in parentheses.)

TABLE 2: Selected Econometric Analyses With Flexibility or Elasticity Estimates for Beans

Author and Date	Geographical Area	Time Period	Observational Interval	Form of Equation	Method of Estimation	Market Level	Product	Price Flexibility	Price Elasticity	Income Elasticity	Cross Elasticity
Droge and Reed, 1973	U.S. and Wisconsin	1948-1968	Annual	linear	OLS	FOB	National canner brand	-.1506			
							Wisconsin private label	-.4096			
Foytik	Hawaii	1957-1961	Monthly	linear	OLS	Wholesale	fresh snapbeans	I.-0.625[a/] II.-1.062 III.-0.696 IV.-0.621			
Krebs, Hayenga, and Lehker, 1972	U.S.	1951-1967	Annual	linear	3SLS	farm	navy beans		-0.14		
Vandenboore, 1967	U.S.	1948/49-1963/64	Annual	linear	TSLS	farm	navy		-0.81	-1.62	0.52[b/]
							small whites		-2.01	+0.55	1.73[c/]
							blackeyes		-0.44	-0.35	0.28[c/]
							small limas		-2.50	+5.19	5.78[d/]
							large limas		-0.68	-1.38	0.31[e/]

a/ Four quarters of the year

b/ wrt. small whites

c/ wrt. navy

d/ wrt. large limas

e/ wrt. small limas

Related Studies, Beans

Allen, M. B. and A. D. Seale, Jr. *An Evaluation of the Competitive Position of the Snap Bean Industry in Mississippi and Competing Areas*. Mississippi Agricultural Experiment Station, Agricultural Economics Technical Publication No. 3, December 1960. This report was not available, but it is presumed that the treatment was similar to the report on the green pepper industry--reviewed here on page 117 and the one on the cabbage industry--reviewed on page 56.

Cain, Jarvis L. and Ulrich C. Toensmeyer. *Interregional Competition in Maryland Produced Fresh Market Green Beans*. Maryland Agricultural Experiment Station, MP 731, October 1969. The transportation model was utilized to evaluate the least cost distribution pattern for fresh green beans grown in Maryland and in competing states. The optimum distribution pattern from 31 shipping points to 15 major cities was compared to the actual pattern and on the basis of discrepancies, possible alternatives were suggested to Maryland growers.

Hathaway, Dale E. *The Effects of the Price Support Program on the Dry Bean Industry in Michigan*. Michigan Agricultural Experiment Station, Technical Bulletin No. 250, April 1955. Three statistical models were developed for dry beans: acreage planted, yield, and price. In the two structural equations, (1) Michigan farm price was seen as a linear function of the amount delivered to the government under the price support program (endogenous), supply of U.S. pea and medium white beans, consumer income, and supply of great northern beans; (2) the amount delivered to the government, as a function of supply minus the right hand side of equation (1)--i.e., price. The reduced form was estimated by OLS, and the structural coefficients were recovered.

Nichols, T. Everett. *Interregional Competition in Marketing Snap Beans*. North Carolina State University, Agricultural Economics Information Series No. 113, April 1964. The transportation model was used to determine the optimum shipping pattern of snap beans to 22 major markets from 25 to 30 states for selected weeks of 1956.

Brussels Sprouts

Abstract

BEN C. FRENCH and MASAO MATSUMOTO. *An Analysis of Price and Supply Relationships in the U.S. Brussels Sprouts Industry*, California Agricultural Experiment Station, Giannini Foundation of Agricultural Economics, Research Report No. 308, March 1970.

Scope: U.S. demand for California-grown frozen and fresh Brussels sprouts.

Purpose: "to develop economic information which may aid the thinking of leaders in the Brussels sprouts marketing program and also be of value to individual firms, growers, and public agencies concerned with the industry," pp. 1-2.

Observational Interval: Annual.

Period of Analysis: 1947 through 1968.

Specification and Estimation Procedure: Brussels sprouts demand estimates were made at several levels as part of a complete system describing the total economic environment in which Brussels sprouts are produced and marketed. The report explains the theoretical relationships believed to hold, derives the equations to be estimated empirically, and then uses the results to generate expected values of the endogenous variables under alternative conditions that may hold in the future.

Farm-level demand involved four equations in this one component of the model. The first three--(1) freezer demand for the raw product, (2) frozen allocation, and (3) fresh allocation were estimated as a simultaneous system by TSLS. The fourth--fresh market demand--was estimated by OLS. Because of multicollinearity between per capita food expenditures and per capita disappearance of frozen Brussels sprouts, the equation was constrained by the assumption that the coefficient of the former was equal to one (for a one percent increase in expenditures on food, a one percent increase in the price of fresh Brussels sprouts was assumed).

Another component of the model involved estimating the U.S. demand facing freezers. This relationship was estimated both by OLS, and by TSLS with a sales allocation equation.

Estimation Results:

Farm-Level Equations

Freezer Raw Product Demand

$$\frac{Q_{pct}}{D_{pct-1}} = \underset{}{1.5352} + \underset{(0.0178)}{0.0576} (P_{pct-1} - C_{pct-1} - 1.172\, P_{gpct})$$

$$- \underset{(0.4169)}{1.8455} \frac{S_{ust}}{D_{pust-1}} - \underset{(0.0903)}{0.0350} L_t.$$

Frozen Allocation

$$\frac{Q_{pct}}{D_{pct-1}} = 0.2853 + \underset{(0.0484)}{0.2551} P_{gpct} - \underset{(0.0473)}{0.0754} \bar{P}_{gfct-1}$$

$$- \underset{(0.0696)}{0.0787} C_{gct} - \underset{(0.1540)}{0.4687} L_t$$

where

$$\bar{P}_{gfct} = \frac{1}{2} (P_{gfct-1} + P_{gfct-2}).$$

Fresh Allocation

$$Q_{fct} = B_{ct}A_{ct} - 1.172\ Q_{pct}.$$

Fresh Market Demand

$$\log P_{gfct} = 5.6766 - \underset{(0.1317)}{0.5830} \log X_{bpt} - \underset{(0.1954)}{0.6887} \log X_{bft}$$

$$- \underset{(1.8737)}{3.5835} \log X_{vt} + 1.0000 \log F_t$$

$R^2 = .56 \qquad DW = 1.62$

where:

Q_{pc} = quantity of Brussels sprouts frozen in California, million pounds;

D_{pc} = quantity of California frozen Brussels sprouts sold (disappearance), August 1 - July 31, million pounds;

P_{pc} = average f.o.b. California freezer price for Brussels sprouts, grade A, 10-ounce packages, cents per pound;

C_{pc} = cost of freezing Brussels sprouts in California excluding raw product cost, 10-ounce packages, cents per pound;

P_{gpc} = average price received by California growers for Brussels sprouts for freezing, cents per pound;

S_{us} = United States cold storage holding of Brussels sprouts on August 31, million pounds;

D_{pus} = United States quantity of frozen Brussels sprouts sold (disappearance), August 1 - July 31, million pounds;

L = A dummy shift variable to allow for possible changes in level of supply response or allocation with the establishment of the Brussels Sprouts Marketing Program. L = 0 prior to 1958; L = 1 from 1958;

P_{gfc} = average price received by California growers for fresh market Brussels sprouts, cents per pound;

C_{gc} = representative cost of growing Brussels sprouts in California, cents per pound;

O_{fc} = quantity of fresh market Brussels sprouts produced in California, million pounds;

B_c = yield per acre of Brussels sprouts in California, cents per acre;

A_c = acres of Brussels sprouts planted in California;

$X_{bp} = D_{pus} \div N$ = United States per capita disappearance of frozen Brussels sprouts, pounds;

$X_{bf} = O_{fus} \div N$ = United States per capita disappearance of fresh Brussels sprouts, pounds;

X_v = United States per capita total vegetable consumption, pounds retail weight, calendar year;

F = United States per capita total food expenditures expressed as an index, 1957-1959 = 100.

(Standard errors are in parentheses.)

Demand Facing Freezers

Ordinary least squares

$$\log P_{pct} = 5.8161 - \underset{(0.0780)}{0.6322} \log X_{bpt} - \underset{(0.1157)}{0.1528} \log X_{bft}$$

$$- \underset{(1.1095)}{3.2167} \log X_{vt} + 1.0000 \log Y_t$$

$$R^2 = .88 \qquad DW = 1.70.$$

Two-stage least squares

$$\log P_{pct} = 5.8975 - \underset{(0.0775)}{0.6747} \log X_{bpt} - \underset{(0.1130)}{0.2020} \log X_{bft}$$

$$- \underset{(1.0508)}{3.2898} \log X_{vt} + 1.0000 \log Y_t.$$

where:

Variables are as defined previously and

$Y = R \cdot F$

R = proportion of United States homes with refrigerators.

Cabbage

Abstracts

M. E. ALLEN and A. D. SEALE, JR. *An Evaluation of the Competitive Position of the Cabbage Industry in Mississippi and Competing Areas.* Mississippi Agricultural Experiment Station, Agricultural Economics Technical Publication No. 2, September 1960.

Scope: Cabbage unloads from Mississippi and competing early spring production areas (including California) at 35 consuming centers.

Purpose: To describe production trends, estimate demand in specified consuming centers, estimate transportation charges, and determine prices and revenues which would be associated with different situations.

Observational Interval: Weekly.

Period of Analysis: April 25 through July 19, 1959.

Specification and Estimation Procedure: Because of the incompleteness of the data in some of the consuming centers, an analysis of the price-quantity relationships was made for each center for the eight marketing weeks, but only those giving an inverse relationship were used in the price equation. Eight centers and data for eight weeks made a total of 64 observations for use in estimating the overall price equation by OLS in double log form. Statistical tests revealed significant differences in intercepts among the eight weeks; the adjustments were reported. Besides the quantity variable, the population variable had a statistically significant coefficient which was used to adjust the intercept according to the population of each of the 35 consuming centers.

Based on the estimated demand functions, the optimum distribution pattern--maximizing net revenues to producing areas--was computed.

<u>Estimation Results</u>:

For all eight periods:

$$\ln P = 4.40548 - \underset{(.07722)}{.43138} \ln X_1 + \underset{(.08667)}{.37923} \ln X_2$$

$$R^2 = .319$$

where:

P = average weekly wholesale price in dollars;

X_1 = quantity in carlot unloads;

X_2 = population in thousands.

(Standard errors are in parentheses.)

D. MILTON SHUFFETT. *The Demand and Price Structure for Selected Vegetables*. Abstracted under tomatoes on page 158.

TABLE 3: Selected Econometric Analyses With Flexibility or Elasticity Estimates for Cabbage

Author and Date	Geographical Area	Time Period	Observational Interval	Form of Equation	Method of Estimation	Market Level	Price Flexibility	Price Elasticity
Allen and Seale 1960	U.S.	April 25-July 19, 1959	Weekly	double log	OLS	Wholesale	-.431	
Shuffett, 1954	U.S.	1921-1941	Annual	first differences of the logarithms	OLS	farm		-2.398

Related Study, Cabbage

Mathia, Gene A. and Richard A. King. *An Analysis of Locational Advantage in the National Cabbage Market*. North Carolina University, Economics Research Report No. 8, January 1969. Using the transportation model, the actual and the optimum shipping patterns for spring and for fall cabbage from shipping points in four regions of the country to 22 receiving markets were compared.

Carrots

Abstracts

ROBERT W. BOHALL. *Pricing Performance in Marketing Fresh Winter Carrots.* USDA, ERS, Marketing Research Report No. 963, 1972.

Scope: Winter carrots marketed in 10 major consuming centers geographically dispersed across the United States.

Purpose: "To evaluate whether short-run changes in carrot prices were consistent with a competitive marketing system. . ." p. 2.

Observational Interval: Weekly.

Period of Analysis: First week of January through the last week in March for three years--1966, 1967, and 1968.

Specification and Estimation Procedure: As part of the analysis the relationship between FOB prices of Lower Rio Grande Valley carrots and the quantity of carrots available--both from Texas and from Southern California-Arizona--was estimated by OLS. Also included were rainfall and temperature variables to capture the effect of the weather on quality.

In addition, the difference between shipping-point and consuming-center prices was explored and found to be directly related to the costs of transporting, handling, and storing the carrots.

Estimation Results:

$$Y_{Cj} = 12.76 - \underset{(0.0027)}{0.0063} X_{CTj} = \underset{(0.0021)}{0.0107} X_{CCAj} = \underset{(0.018)}{0.172} R_j - \underset{(0.016)}{0.047} T_{j-1}$$

$$- \underset{(0.015)}{0.039} T_{j-2} \qquad DW = 0.95 \qquad R^2 = 0.88$$

where:

Y_{Cj} = the FOB price of Lower Rio Grande Valley carrots, 48-1's mesh, in week j;

X_{CTj} = total carlots of carrots shipped from Texas in week j;

X_{CCAj} = total carlots of carrots shipped from California and Arizona in week j;

R_j = deviation from normal Lower Rio Grande Valley rainfall for Division 10 the previous September = -0.34 inches in September 1965 for winter 1966; -3.18 inches in September 1966 for winter 1967; and 14.07 inches in September 1967 for winter 1968;

T_{j-1}, T_{j-2} = average high temperature at Weslaco, Tex., weather station 2E, j-1 = previous week, j-2 = week 2 weeks previous; and

j = weeks 1-39 with 1-13 = winter 1966; 14-26 = winter 1967; and 27-39 = winter 1968.

(Standard errors are in parentheses.)

CARL E. SHAFER. *A Statistical Analysis of Season's Average Prices for Texas Winter Carrots and Early Spring Onions, 1954-64.* Texas A & M University, Department of Agricultural Economics and Sociology, Technical Research Report No. 66-2, 1966.

Scope: Texas grower-level and FOB, and California FOB carrot prices; Texas grower-level onion prices.

Purpose: "(1) to develop price equations which would be useful in both explaining past price behavior and in forecasting the forthcoming season's average price and (2) to provide some evaluation regarding volume restriction policies for carrots and onions." p. 1.

Observational Interval: Annual.

Period of Analysis: 1954 through 1964.

Specification and Estimation Procedure: Alternative specifications for the grower-level carrot equations included: data on a per capita and on a total basis, in linear and double log form, in first differences and in first differences of the logs, using actual and deflated prices, using 1949-1964 and using 1954-1964 series. Eleven equations in all were given in the appendix; three in the text. These three were linear, price dependent: (1) Texas grower price, (2) Texas FOB price, and (3) California FOB price.

Similarly, various specifications were attempted for Texas grower-level price equations for early spring onions. The equation with the highest $\bar{R}^2$ is presented below.

Estimation Results:

Carrots

Texas "in field" prices:

$$X_1 = 8.837 - \underset{(4.64)}{1.0707}X_2 - \underset{(3.10)}{2.2224}X_3 - \underset{(2.17)}{0.00168}X_4$$

$\bar{R}^2 = .749$

Texas FOB prices:

$$X_1' = 17.203 - \underset{(4.36)}{1.6213}X_2 - \underset{(1.81)}{2.0853}X_3 - \underset{(2.80)}{0.0035}X_4$$

$\bar{R}^2 = .776$

California FOB prices:

$$X_1'' = 16.934 - \underset{(3.84)}{2.0518}X_2 - \underset{(3.06)}{5.0812}X_3 - \underset{(1.08)}{0.00195}X_4$$

$\bar{R}^2 = .615$

where:

X_1 = season's average price deflated,

X_2 = Texas' production per season divided by U.S. population,

X_3 = California's production per season divided by U.S. population,

X_4 = disposable personal income per capita deflated.

(t-statistics are in parentheses.)

Onions

$$X_1 = 12.2705 - \underset{(4.22)}{0.001118}X_2 - \underset{(4.47)}{0.001105}X_3$$

$$\bar{R}^2 = 0.72$$

where:

X_1 = deflated season's average price received by Texas growers in dollars per hundredweight,

X_2 = season's early spring onion production in Texas in 1,000 hundredweight units,

X_3 = stocks of onions on hand January 1 in 1,000 hundredweight units.

(t-statistics are in parentheses.)

CARL E. SHAFER and CHRISS H. CARLSON. *Intraseasonal Price Analysis for Texas and California Carrots*. Texas A & M University, Department of Agricultural Economics and Rural Sociology, Technical Report No. 71-5, 1975.

Scope: Texas carrots, December through May; California carrots, May through November.

Purpose: ". . .to examine weekly price and supply variables so that an optimum within season or intraseasonal rate of movement-to-market patterns may be developed.

Observational Interval: Annual, monthly, and weekly.

Period of Analysis: Annual, various time periods; monthly, 1966 through 1969; weekly, 1956 through 1968 and 1966 through 1969.

Specification and Estimation Procedure: First, several season average price (annual data) equations were fitted by OLS for various time periods. Texas FOB prices, Texas grower-level prices, and California prices were seen as functions of Texas production, California production, income, and a dummy variable for the 1961-1966 marketing order. Flexibilities for the Texas FOB level, 1954-1969 equation appear in Table 4.

Next a monthly analysis was performed using Texas FOB prices for December-May and California FOB prices for June-November. Price, lagged one month, was an important variable in four of the equations.

Using weekly data--Texas FOB prices for the first 20 odd weeks and California (Salinas) prices for the remainder of the year--several equations were fitted: one for each year, 1956-1968; one pooling all the data; and one using dummy variables to allow yearly intercept shifts. The latter equation is presented below.

Finally, several alternative specifications were run using weekly data for 1966-1968. Fifty-two week series used both Texas and California prices, and separate estimations used Texas prices only and California prices only. In some of the equations, price, lagged one week, was a statistically significant variable. In one Texas-California price equation, a dummy variable was used to separate the two price series and it revealed that Texas FOB prices were on the average about 21 cents per bag greater than California prices.

Estimation Results:

$$P = \underset{(6.89)}{-0.03200}\ TXSH \ \underset{(0.40)}{-0.00612}\ CFRR \ \underset{(2.05)}{-0.05601}\ CFTR$$

$$\underset{(6.43)}{-0.01988}\ OTKH \ \underset{(2.86)}{-0.73339}\ INPC + \begin{array}{ll} 18.392 & (1956) \\ 18.299 & (1957) \\ 19.085 & (1958) \\ 19.015 & (1959) \\ 18.575 & (1960) \end{array}$$

$R^2 = 0.67$	19.881	(1961)
	20.430	(1962)
	20.238	(1963)
	21.059	(1964)
	21.777	(1965)
	23.675	(1966)
	23.583	(1967)
	27.369	(1968)

where:

P = FOB weekly shipping point price; Texas prices for first 20 odd weeks and California prices (Salinas) for the remainder of the year.

TXSH = Texas shipments, carlot equivalents/10;

CFRR = California rail shipments, carlot equivalents/10;

CFTR = California truck shipments, carlot equivalents/10;

OTRH = on-track holdings of carrots at 16 terminal markets, carlot equivalents/10;

INPC = quarterly per capita income.

(t-statistics are in parentheses.)

TABLE 4: Selected Econometric Analyses With Flexibility Estimates for Carrots

Author and Date	Geographical Area	Time Period	Observational Interval	Form of Equation	Method of Estimation	Market Level	Product	Price Flexibility	Income Flexibility	Cross Effect
Bohall, 1972	Lower Rio Grande, Texas	1966-1968	Weekly	linear	OLS	FOB	fresh winter	-0.25		0.57[a/]
Shafer 1966	Texas, California	1954-1964	Annual	linear	OLS	farm	Texas carrots	-1.642	-2.319	-1.538[b/]
						FOB	Texas carrots	-0.789	-1.534	-0.458[b/]
						FOB	Calif. carrots	-1.134	-0.868	-1.015[c/]
Shafer and Carlson, 1975	Texas	1954-1969	Annual	linear	OLS	FOB	fresh	- .88		
						farm		-1.74		

a/ wrt. California-Arizona shipments

b/ wrt. California production

c/ wrt. Texas production

Related Studies, Carrots

Shafer, Carl E., *A Preliminary Analysis of Price and Demand Relationships for South Texas Winter Carrots*. Texas A & M University, Department of Agricultural Economics and Sociology, Department Information Report 65-1, 1965. Price-quantity relationships for South Texas winter carrots at the retail, FOB, wholesale, and grower levels were discussed and graphed.

Shafer, Carl E., "The Effect of a Marketing Order on Winter Carrot Prices." *American Journal of Agricultural Economics*, Vol. 50, No. 4, November 1968, pp. 879-887. In order to test the hypothesis that during the marketing order period (1961-1966), the demand curve for Texas carrots shifted outward, three linear regressions were run including a dummy variable for the marketing order years. The variable was statistically significant in the Texas grower-level price equation but not in the FOB-level nor in the California FOB price equation. The conclusion was that demand relations for carrots in Texas and in California did not appear to shift significantly during the marketing order period but that the in-field--FOB margin was narrowed.

Celery

Abstracts

THOMAS S. CLEVENGER. *Price Prediction Equations for Michigan Cooperative Celery.* Michigan State University, Agricultural Economics Report No. 122, April 1969.

Scope: Michigan Celery Promotion Cooperative prices.

Purpose: To develop equations computationally usable to the Cooperative Price Committee.

Observational Interval: Weekly.

Period of Analysis: 1963 through 1966 (also updated through 1967).

Specification and Estimation Procedure: The 15 week marketing season was divided into two periods of seven and eight weeks, respectively, because a better fit was obtained for the two equations than for a single one. Also the source of competing celery switched--Santa Maria, California, in the first period; Salinas, California, in the second. The linear equations were estimated by OLS. At the end of the report they were reestimated, including 1967 data.

Estimation Results:

First period (seven weeks)

$$P_{1m,\ t+1} = \underset{(30.4854)}{62.7915} - \underset{(0.0010)}{0.0019Q_{1m}} + \underset{(0.0551)}{0.9680P_{mf,\ t}}$$

$$R^2 = .95$$

where:

$P_{1m,\ t+1}$ = Michigan Celery Promotion Cooperative unweighted average FOB shipping point price in cents per crate of 2-1/2 size celery for any week t + 1 during the first seven weeks of the Cooperative's marketing season.

Q_{1m} = Sum of (1) number of Michigan Celery Promotion Cooperative 2-1/2 dozen crates on inventory Saturday evening for any week t, and (2) number of Michigan Celery Promotion Cooperative 2-1/2 dozen crates harvested for any week t + 1, both prior to the eighth week of the Cooperative's marketing season.

$P_{mf,\ t}$ = Midpoint of Santa Maria, California, FOB shipping point price range in cents per crate of 2-1/2 size celery on Friday of week t prior to the eighth week of the Cooperative's marketing season.

(Standard errors are in parentheses.)

<u>Second period (eight weeks)</u>

$$P_{2m,\ t+1} = \underset{(33.5785)}{97.1591} - \underset{(0.0009)}{0.0028}Q_{2m} + \underset{(0.0734)}{0.2351}P_{m7} + \underset{(0.1385)}{0.5216}P_{sf,\ t} + \underset{(0.0597)}{0.1234}P_{of,\ t}$$

$R^2 = .78$

where:

$P_{2m,\ t+1}$ = Michigan Celery Promotion Cooperative unweighted average FOB shipping point price in cents per crate of 2-1/2 size celery for any week t + 1 during the last eight weeks of the Cooperative's marketing season.

Q_{2m} = Sum of (1) number of Michigan Celery Promotion Cooperative 2-1/2 dozen crates on inventory Saturday evening for any week t from the seventh week on, and (2) number of Michigan Celery Promotion Cooperative 2-1/2 dozen crates harvested for any week t + 1 from the eighth to the season's completion.

P_{m7} = Michigan Celery Promotion Cooperative unweighted average FOB shipping point price in cents per crate of 2-1/2 size celery during the seventh week of the Cooperative's marketing season.

$P_{sf,\ t}$ = Midpoint of Salinas, California, FOB shipping point price range in cents per crate of 2-1/2 size celery on Friday of week t from the seventh week to the week prior to the season's completion.

$P_{of,\ t}$ = Midpoint of Orange County, New York, FOB shipping point price range in cents per crate of 2-1/2 size celery on Friday of week t from the seventh week to the week prior to the season's completion.

(Standard errors are in parentheses.)

MARSHALL R. GODWIN and BILLIE S. LLOYD. *Competition Between Florida and California Celery in the Chicago Market.* Florida Agricultural Experiment Station, Bulletin No. 636, November 1961.

Scope: Florida and California celery in nine large supermarkets in the Chicago metropolitan area.

Purpose: To determine the nature of the competitive relationship between California and Florida celery.

Observational Interval: Daily.

Period of Analysis: May and June 1958.

Specification and Estimation Procedure: Displays of Florida Pascal type celery were placed adjacent or near to the Utah type, California-grown celery in nine Chicago supermarkets. The stores were carefully selected so that three drew from high income clientele; three, from medium; and three, from lower income groups. An attempt was made to hold all factors other than price (e.g. size, grade, quality of the display) constant. On the assumption that the competitive advantage lay with California celery, in all test combinations, the Florida product was sold at prices lower than the price of the California product. Price differences ranged between two and 18 cents. From the data, double-log quantity-price relationships were estimated by OLS and cross elasticities examined. The effects on Florida price of various supply changes from either Florida or California celery were discussed and shown in several three dimensional graphs.

Estimation Results:

$$\ln Q_1 = 1.14475 - 1.01569 \ln P_1 + 0.58709 \ln P_2$$

$$\ln Q_2 = 3.20911 + 0.65947 \ln P_1 - 2.55301 \ln P_2$$

where:

Q_1 = quantity Florida celery purchased,

Q_2 = quantity California celery purchased,

P_1 = price of Florida celery,

P_2 = price of California celery.

Related Studies, Celery

Godwin, Marshall R., *Competitors in the Celery Market*. Florida Agricultural Experiment Station, Agricultural Economics Report No. 59-6, February 1959. A report based on the same study as the one reviewed here on page 70. The Agricultural Economics report was written in less technical language than was the Bulletin.

Godwin, Marshall R. and William T. Manley, *Customer Preference Aspects of Competition Between Florida and California Celery*. Florida Agricultural Experiment Station, Bulletin No. 648, June 1962. Consumer tests were done in four large retail stores in Dayton, Ohio. Comparisons were made between Florida Summer Pascal and the Utah type grown in California and between the Utah type grown in Florida and the same type grown in California. Results indicated that the Utah type from either state was preferred to the Pascal type and that there wasn't much difference between the two Utah types--unless the place of origin was identified. In this latter case, celery from California was clearly preferred. In all combinations, prices were the same for both.

Corn, Sweet

Abstracts

D. L. BROOKE and J. B. BELL. *Market Structure and the Economic Analysis of the Florida Sweet Corn Industry.* Florida Agricultural Experiment Station, Bulletin No. 696, October 1965.

Scope: Florida sweet corn FOB prices.

Purpose: "to develop basic economic information necessary to an understanding of the market structure of the Florida sweet corn industry." p. 6.

Observational Interval: Weekly--the winter season from the second week in February through the third week in February; the spring season from the last week in February through the last week in May.

Period of Analysis: 1960/61 through 1962/63.

Specification and Estimation Procedure: Ten independent variables were considered in the explanation of the variation in the weekly FOB price. Using a stepwise regression procedure, these were narrowed to three: Florida carlot shipments, the terminal market price of the previous week, and the market tone on Monday. The resulting equations--one for fall and winter, one for spring--were satisfactory for price prediction purposes (R^2 = .86; .92, respectively), but multicollinearity prevented the derivation of significant price elasticities. Consequently, a regression for each season was fitted in which the FOB price was a simple linear function of weekly carlot shipments. Prices were predicted at (1) the mean of the shipment variable, (2) at the mean plus one standard deviation, (3) at the mean minus one standard deviation, and (4) at the point of unitary elasticity. Elasticities were calculated for (1), (2), and (3) and are presented in Table 5.

Estimation Results:

Winter

$Y = 4.24 - .0174X$

$R^2 = .72$ $F = 114.9$ (significant at the 99% confidence level)

Spring

$Y = 3.68 - .00219X$

$R^2 = .84$ $F = 206.3$ (significant at the 99% confidence level)

where:

Y = FOB price for week w,

X = carlot shipments for week w.

J. H. DROGE and R. H. REED. *Prediction Analysis of United States and Wisconsin Wholesale Prices of Canned Cut Green Beans, Sweet Corn, and Sweet Peas.* Abstracted under beans on page 33.

TABLE 5: Selected Econometric Analyses With Flexibility or Elasticity Estimates for Sweet Corn

Author and Date	Geographical Area	Time Period	Observational Interval	Form of Equation	Method of Estimation	Market Level	Product	Price Flexibility	Price Elasticity
Brooke and Bell, 1965	Florida	1960/61 1962/63	Weekly	linear	OLS	FOB	winter		-1.37 $(\bar{X} + \sigma)$[a/] -2.72 $(\bar{X})$ -7.83 $(\bar{X} - \sigma)$
							spring		-1.34 $(\bar{X} + \sigma)$ -3.04 $(\bar{X})$ -13.15 $(\bar{X} - \sigma)$
Droge and Reed, 1973	U.S. and Wisconsin	1948-1968	Annual	linear	OLS	FOB	canned sweet corn:		
							National canner brand	-.7353	
							Wisconsin private label	-.9358	

a/ Price elasticities were computed at the mean of the shipment variable and at the mean plus and the mean minus one standard deviation.

Related Study, Sweet Corn

Cain, Jarvis L. and Ulrich C. Toensmeyer. *Interregional Competition in Maryland Produced, Fresh Market Sweet Corn.* Maryland Agricultural Experiment Station, MP 735, October 1969. Transportation rates from 23 shipping points for sweet corn to 13 major cities were estimated by regression analysis for use in the transportation model in order to test the hypothesis that "the present distribution pattern causes Maryland produced sweet corn to be allocated to major markets at least transportation cost to the fresh vegetable industry in Maryland and competing states." p. 3.

Cucumbers

Abstracts

ROBERT CASTRO and RICHARD L. SIMMONS. *The Demand for Green Peppers, Cucumbers, and Cantaloupes in the Winter Season.* North Carolina State University, Economics Research Report No. 27, April 1974.

Scope: U.S. demand relationships for green peppers, cucumbers, and cantaloupes at the wholesale level.

Purpose: ". . .to estimate demand functions for each of the five months of the winter season and to test statistically whether the slope and/or intercept of the demand functions differ among months." p. 5.

Observational Interval: Monthly for peppers and cucumbers; weekly for cantaloupes.

Period of Analysis: 1959/60 through 1970/71 for peppers and cucumbers; 1971 through 1972 for cantaloupes.

Specification and Estimation Procedure: An analysis of covariance model was used to test for seasonal differences using dummy variables to allow for possible month to month changes in intercepts and slopes. The hypothesis testing was done on a deflated (by the CPI), linear version of the model, but an undeflated, a double log, and a separate-monthly-equations version were also fitted by OLS.

Estimation Results:

In the green peppers model there seemed to be some difference among the months but it was not possible to determine whether the difference was to changes in intercepts or in slopes. In the cucumbers model the difference seemed to be due to changes in slopes; in the cantaloupe model, to changes in intercepts. Elasticity estimates appear in the respective tables in this report.

ROBERT S. FIRCH and ROBERT A. YOUNG. *An Economic Study of the Winter Vegetable Export Industry of Northwest Mexico.* Abstracted under tomatoes on page 148.

JERRY FOYTIK. *Demand Characteristics for Vine Vegetables in Honolulu, Hawaii, 1947-1961.* Abstracted under beans on page 37.

I. A. LINDSTROM and R. A. KING. *The Demand for North Carolina Slicing Cucumbers and Green Peppers.* North Carolina State College, Agricultural Economics Information Series No. 49, March 1956.

Scope: North Carolina grower-level prices for cucumbers and green peppers.

Purpose: To improve the decisions of vegetable producers regarding crop acreages based on expected prices and expected costs of production.

Observational Interval: Annual (also daily).

Period of Analysis: Cucumbers—1925 through 1941; post-war equations were also fitted. Green peppers—1925 through 1954, excluding 1942 through 1945.

Specification and Estimation Procedure: Several alternative specifications were fitted by OLS in which North Carolina grower-level cucumber prices were seen as a function of N.C. production and U.S. disposable income: linear with and without a trend variable, first differences of the logs, and logarithims of actual values. The equation in first differences of the logs was determined statistically best. An equation including the post-war years (1946-1954) was also fitted; the coefficient estimates obtained differed from those in the pre-war equation by less than four percent.

Daily cucumber prices from June 8 through July 3, 1953, on the Clinton, North Carolina, market were fitted by OLS as a function of New York wholesale market prices earlier the same morning and the supply that day on the Clinton market. Both linear and double log forms were used. Also, the daily price of cucumbers on the New York wholesale market was estimated in a linear equation as a function of the available supply that day, the available supply the preceding day, and the highest price paid the preceding day.

Similarly, for green peppers, equations using annual data were fitted, and daily Clinton prices and New York wholesale market prices were analyzed. Graphic analysis of the annual data revealed that a logarithmic specification would fit better than a linear one. Two double log equations were fitted by OLS--one for 1925 through 1941 and a second including also the post-war years through 1954.

<u>Estimation Results:</u>

Cucumbers (1925/26-1940/41):

$$\Delta \ln X_1 = -0.0369 - \underset{(.2287)}{0.7135} \Delta \ln X_2 + \underset{(.9725)}{1.7013} \Delta \ln X_3$$

$$R^2 = .5027$$

where:

X_1 = the annual average price received by North Carolina farmers, dollars per bushel;

X_2 = the production of cucumbers in North Carolina, thousand bushels;

X_3 = U.S. disposable income, billions of dollars.

(Standard errors are in parentheses.)

Green Peppers (1925-1954, excluding the war years):

$$\ln X_1 = 0.3784 - \underset{(.1582)}{0.5975} \ln X_2 + \underset{(.1926)}{1.466} \ln X_3$$

$$R^2 = .7593$$

where the variables are defined as above.

RICHARD L. SIMMONS and CARLOS POMAREDA. "Equilibrium Quantity and Timing of Mexican Vegetable Exports." *American Journal of Agricultural Economics*, Vol. 57, No. 3, August 1975, pp. 472-479.

Scope: Vegetables produced in two regions of the Mexican state of Sinaloa.

Purpose: ". . .to evaluate the impact of changes in economic factors on equilibrium timing and quantity of tomato, pepper, and cucumber exports." p. 472.

Observational Interval: Monthly.

Period of Analysis: December through May (tomato exports) and December through April (peppers and cucumbers), 1960 through 1972.

Specification and Estimation Procedure: For use in a linear programming model, U.S. and Canadian fresh market demand for Mexican-grown tomatoes, green peppers, and cucumbers was estimated. A single equation OLS linear model, for each vegetable was used with dummy variables to allow monthly changes in both the intercepts and slopes. Florida shipping-point prices were used for peppers and cucumbers; Nogales prices, for tomatoes. Fixed supplies from Florida and other U.S. production areas were substracted from the estimated demand functions to obtain import demand functions; marketing charges (sales commissions, U.S. tariff, and transportation charges) were substracted from the import demand functions to obtain Culiacan at-plant demand functions. The equations were converted to terms of pesos per kilogram and are presented below.

Mexican demand equations for eleven Mexican-produced crops were taken from Duloy and Norton,[1/] for use in the L.P. model. The L.P. results indicated that the expected increases in the minimum farm wage rates would reduce exports of the three vegetables substantially.

Estimation Results:

Estimated Demand Functions for Export Vegetables FOB Culiacan, Mexico

Product	Month	Demand Equation[a]
Tomatoes (U.S. and Canada)	Dec.	$P = 3.351 - 0.000043755\,Q$
	Jan.	$P = 3.184 - 0.000036722\,Q$
	Feb.	$P = 2.856 - 0.000020254\,Q$
	Mar.	$P = 4.309 - 0.000044305\,Q$
	Apr.	$P = 3.229 - 0.000019006\,Q$
	May	$P = 3.533 - 0.000039815\,Q$
Peppers	Dec.	$P = 1.905 - 0.00046591\,Q$
	Jan.	$P = 4.270 - 0.00040690\,Q$
	Feb.	$P = 5.092 - 0.00026592\,Q$
	Mar.	$P = 5.968 - 0.00035203\,Q$
	Apr.	$P = 5.896 - 0.00042629\,Q$
Cucumbers	Dec.	$P = 1.752 - 0.00016589\,Q$
	Jan.	$P = 2.419 - 0.00011539\,Q$
	Feb.	$P = 2.636 - 0.00009907\,Q$
	Mar.	$P = 3.121 - 0.00015937\,Q$
	Apr.	$P = 1.591 - 0.00008637\,Q$

[a] Price is measured in pesos per kilo and Q in metric tons.

1/ John Duloy and Roger D. Norton, "CHAC, A Programming Model of Mexican Agriculture", *Multi-Level Planning: Case Studies in Mexico*, eds. Louis M. Goreux and Alan S. Manne, Amsterdam: North-Holland Publishing Co., 1973, pp. 291-337.

TABLE 6: Selected Econometric Analyses With Flexibility or Elasticity Estimates for Cucumbers

Author and Date	Geographical Area	Time Period	Observational Interval	Form of Equation	Method of Estimation	Market Level	Price Flexibility	Income Flexibility	Price Elasticity
Castro and Simmons, 1974	U.S.	1959/60-1970/71	Monthly	linear	OLS	Wholesale			Dec. -.57 Jan. -.83 Feb. -.94 Mar. -.86 Apr. -.83
Firch and Young, 1968	U.S.	1961-1966	Weekly	linear	OLS	shipping point prices--Nogales, Arizona	from Mexico -.306 from elsewhere -.380 total quantity -.685		
Foytik, 1964	Hawaii	1957-1961	Monthly	linear	OLS	Wholesale	I.-0.479[a/] II.-0.905 III.-0.731 IV.-0.607		
Lindstrom and King, 1956	North Carolina	1925-1941	Annual	first differences of the logs	OLS	farm	-0.71	1.70	

a/ For the four quarters of the year

Related Studies, Cucumbers

Farris, Dennis E. and R. A. King. *Interregional Competition in Marketing Slicing Cucumbers*. North Carolina State College, Agricultural Economics Information Series No. 78, September 1960. In order to measure the locational advantage of producers of cucumbers in North Carolina relative to producers in other states, the transportation model was used. Distribution patterns from 28 shipping points (North Carolina, 9 other southern states, 7 northeastern states, 6 midwestern states, and 5 western states) to 32 major markets for the weeks between June 12 and July 20, 1956, were analyzed. Observed shipping point price differences were compared with expected price differences predicted by the model.

Hartman, Peter. *The Effects of Mexican Imports on Florida Cucumber Prices*. University of Florida, Food and Resource Economics Department. Paper presented in the student section of the American Agricultural Economics Association Annual Meeting, August 1978. In order to determine the effect from Mexican imports on prices received by Florida cucumber growers, a price forecasting equation was fitted by OLS. Price was predicted as a linear function of the quantity from Mexico, the quantity from Florida, the quantity from the rest of the U.S., last year's price, and U.S. personal income. The overall price flexibility with respect to the sum of three quantities was -.33.

Seale, Arthur D. Jr., Richard A. King, and Loyd C. Martin. *Vegetable Prices and Market Structure*. North Carolina Agricultural Experiment Station, Technical Bulletin No. 134, August 1958. Using annual data, for 1925/26 through 1940/41, two price forecasting equations were fitted--one for cucumbers, one for green peppers. The cucumber equation, in first differences of the logs, is the same as the one reported on page 79. The green pepper equation was in double-log form; the price flexibility estimate was -.604.

Lettuce

Abstracts

O. P. BLAICH. *Supply and Demand Relations for California Summer Head Lettuce.* Statement at a hearing to consider some of the economic effects of the California Marketing Order for summer head lettuce, Oct. 16, 1962.

Scope: New York wholesale prices.

Purpose: To address "a number of questions that might arise in regulating the shipments of summer head lettuce as is authorized under the marketing order which is now in effect in California." p. 1.

Observational Interval: Weekly.

Period of Analysis: May 1 through October 1, 1961.

Specification and Estimation Procedure: Weekly New York wholesale prices were fitted by OLS as a linear function of the quantity received in New York, the rail shipments from California in the previous week, and the weekly average temperature in New York.

Long-run U.S. consumption, long-run supply response, and short-run California harvest response to weekly price changes were also a part of the report.

Estimation Results:

$$P_{ny} = 492.5^{1/} - \underset{(4.23)}{2.61Q} + \underset{(2.21)}{.13C} + \underset{(1.02)}{2.30T}$$

$$R^2 = .55$$

1/ The constant was adjusted for the influence of the prices of substitutes computed at average levels.

where:

P_{ny} = the weekly average wholesale price of California lettuce in the New York market in cents per carton of 24,

Q = the weekly truck and rail receipts in the New York area in carlot equivalents,

C = rail shipments leaving California the previous week in carlot equivalents,

T = the weekly average 8 a.m. temperature in New York.

(t-statistics are in parentheses.)

ROBERT W. BOHALL. *Pricing Performance in Marketing Fresh Winter Lettuce.* USDA, ERS, Marketing Research Report No. 956, 1972.

Scope: Winter lettuce produced in Yuma County, Arizona and Imperial and Riverside Counties, California.

Purpose: ". . .to determine if the behavior of weekly lettuce prices at shipping points and wholesale terminal markets is generally consistent with a competitive marketing system." p. ii.

Observational Interval: Weekly.

Period of Analysis: The first week in January through the last week in March, 1966 through 1968.

Specification and Estimation Procedures: As part of the study an OLS multiple regression was used to estimate how FOB shipping point prices varied with changes in the quantity of lettuce available. Included were temperature and rainfall variables to capture effects of the weather on lettuce quality--and on its price.

In addition, other analyses included: the relationship between Arizona and California shipping-point prices (no statistically significant difference), the gross margin between shipping-point prices and wholesale terminal market prices at 12 consuming centers, the breakdown of the gross margin into transportation costs, precooling costs, and the residual, and tests of the correlation between shipping point prices and wholesale prices at the 12 centers.

<u>Estimation Results:</u>

$$Y_{CAj} = 14.61 - \underset{(0.00055)}{0.00398}\, X_{CAj} + \underset{(0.086)}{0.434}\, R_j - \underset{(0.018)}{0.040}\, T_{j-1} - \underset{(0.76)}{3.35}\, P_j$$

$$R^2 = 0.80$$

where:

Y_{CAj} = the blend FOB price of California-Arizona lettuce, cartons of 24's in week j;

X_{CAj} = total standardized carlot equivalents of 1,030 cartons shipped from California and Arizona in hundreds, rail and trucks, in week j;

R_j = total previous November-December rainfall at the Yuma, Ariz., International Airport = 2.25 inches in 1965 for winter season 1966; 0.02 inches in 1966 for winter 1967; and 2.10 inches in 1967 for winter 1968;

T_{j-1} = previous week's average high temperature at Yuma, Ariz., International Airport;

P_j = ratio of average total standardized carlot equivalents of 1,030 cartons of 24's shipped from California and Arizona the previous 2 weeks to the current week's shipments; and

j = weeks 1-39 with 1-13 = winter 1966, 14-26 = winter 1967, and 27-39 = winter 1968.

(Standard errors are in parentheses.)

THOMAS S. CLEVENGER and W. VERNON SHELLEY. "Intraseasonal Demand-Supply Relationships for Lettuce." *Proceedings,* Western Economics Association, 47th Annual Meeting, Moscow, Idaho, July 1974, pp. 18-21.

<u>Scope:</u> U.S. farm-level demand and supply for lettuce.

Purpose: ". . .to report the results of empirically estimating intra-seasonal farm level demand and supply parameters for United States lettuce using simultaneous equations. . ." p. 18.

Observational Interval: Annual

Period of Analysis: 1949 through 1970.

Specification and Estimation Procedure: Four seasonal demand and four supply equations (winter, spring, summer, and fall) were estimated by TSLS, where the quantity supplied each season and the farm-level price received were considered endogenous to the system. OLS estimates were presented for comparison. The structural demand equations for both estimation techniques are presented below. The quantity supplied for each of the four seasons was seen to be a linear function of the farm-level price, acres planted to lettuce in the current year, and the yield for the same season the previous year.

Estimation Results:

TSLS and OLS Demand Equations for the United States
Seasonal Lettuce Models, 1949-1970

Season	Model	Regression Coefficients[1/] Constant	Q_t	$DI_{t-1/4}$	M_{t-1}	R^2
Winter	TSLS	7.9283	-0.0023 (2.68)*	+0.0057 (2.62)*	+0.6165 (2.15)*	.36
	OLS	3.0520	+0.0002 (0.06)	+0.0004 (0.28)	+0.0253 (0.11)	.11
Spring	TSLS	26.3827	-0.0055 (3.44)*	+0.0045 (3.81)*	+0.7797 (2.19)*	.48
	OLS	6.0988	-0.0004 (0.75)	+0.0021 (1.80)*	-0.2242 (0.95)	.17
Summer	TSLS	4.0157	-0.0003 (1.03)	+0.0024 (2.33)*	-0.1260 (0.18)	.33
	OLS	3.3612	-0.00002 (0.09)	+0.0017 (1.88)*	-0.1830 (1.20)	.29
Fall	TSLS	11.6995	-0.0016 (2.27)*	+0.0039 (2.94)*	-0.887 (0.49)	.43
	OLS	7.2436	-0.0006 (1.50)	+0.0025 (2.29)*	-0.1541 (0.82)	.35

* Indicates significance at 0.10 level.

1/ Farm level price for lettuce (p^f_t) is the dependent variable.

where:

Q_t = quantity of U.S. lettuce supplied, 100,000 pounds;

$DI_{t-1/4}$ = U.S. per capita disposable personal income in the previous three-month period (dollars seasonally adjusted to annual rates);

M_{t-1} = average retail marketing margin for the same season the previous year, cents per head.

(t-statistics are in parentheses.)

R. S. McGLOTHLIN. *Price Relationships in the Western Lettuce Industry.* Arizona Agricultural Experiment Station, Bulletin No. 287, June 1957.

Scope: New York Wholesale Prices.

Purpose: To explain as much of the wide fluctuations in lettuce prices as possible "in terms of volume of shipments, income, and other factors, in order that producers and others connected with the industry may gain some understanding of the factors behind changes in lettuce prices." p. 3.

Observational Interval: Annual.

Period of Analysis: 1930 through 1955, excluding 1942 through 1946.

Specification and Estimation Procedure: Four price forecasting equations--one for each season--were estimated by OLS.

Estimation Results:

Winter: $P = 842.85 - .3738X_1 + .7206X_2 - 29.0472X_3$ $\quad R^2 = .82$
(2.6099) (4.2849) (2.3429)

Spring: $P = 510.73 - .1007X_1 + .2295X_2 + 7.0538X_3$ $\quad R^2 = .93$
(1.9476) (4.0516) (1.4532)

Summer: $P = 428.01 - .0832X_1 + .5233X_2 - 20.7382X_3$ $\quad R^2 = .78$
(1.5351) (3.7794) (1.6444)

Fall: $P = 720.41 - .3243X_1 + .6050X_2 - 11.7262X_3$ $\quad R^2 = .92$
(2.6025) (5.7762) (1.7214)

where:

P = New York wholesale price, dollars per crate;

X_1 = total carlot unloads of lettuce in New York during a particular season;

X_2 = per capita disposable income;

X_3 = time, 1930 = 1, 1931 = 2, . . ., 1955 = 20 (excluding the war years).

(t-statistics are in parentheses.)

D. MILTON SHUFFETT. *The Demand and Price Structure for Selected Vegetables.*

Abstracted under tomatoes on page 158.

TABLE 7: Selected Econometric Analyses With Flexibility or Elasticity Estimates for Lettuce

Author and Date	Geographical Area	Time Period	Observational Interval	Form of Equation	Method of Estimation	Market Level	Price Flexibility	Price Elasticity
Blaich, 1962	New York Market	May to October 1961	Weekly	linear	OLS	Wholesale		-0.544
Bohall, 1972	Calif.-Arizona	Jan.-March, 1966-1968	Weekly	linear	OLS	FOB	-1.81	
Clevenger and Shelley, 1974	U.S.	1949-1970	Annual	linear	TSLS	farm		-0.18 winter -0.10 spring -1.43 summer -0.33 fall
McGlothlin, 1957	New York Market	1930-1955, excluding 1942-1946	Annual	linear	OLS	Wholesale		-1.0162 winter -1.9942 spring -2.1455 summer -0.9532 fall

Related Studies, Lettuce

Firch, Robert S. and Daniel W. Mathews. *The Arizona Lettuce Industry*. Arizona Agricultural Experiment Station, Technical Bulletin No. 188, January 1971. The bulletin was based on a master's thesis entitled *Intraseasonal Demand for Arizona Lettuce*. The effects of changes in quantity and income on Arizona lettuce prices, for two periods 1948 through 1958 and 1959 through 1967, were summarized in a table. No statistical tests were reported.

Hoos, Sidney. *Statistical Analysis of the Annual Farm Prices for Seasonal Types of Commercial Head Lettuce, 1918-1947*. California Agricultural Experiment Station, Giannini Foundation of Agricultural Economics, Mimeographed Report No. 92, May 1948. Both price dependent and quantity dependent multiple regressions were fitted using annual observations for yearly averages and for each of four seasons; 1918 through 1947. Another set of equations was fitted in which the war years were excluded. The elasticities were not computed in the study, but using the data provided, Jerry Foytik calculated them at about -0.5 for all lettuce and about -0.3 for the seasonal types considered separately (*Competition in the Lettuce Industry* unpublished paper, Department of Agricultural Economics, University of California, Davis, October 1972).

Miklius, W. "Short-run Effects of the California Summer Head Lettuce Marketing Order." *Proceedings of the Western Farm Economics Association*, Los Angeles, 1966, pp. 179-185. Several statistical analyses were performed to test the effectiveness of the short-lived 1959-1960 marketing order for California summer head lettuce. The indications were that the marketing order had no significant effect on increasing lettuce prices, in reducing lettuce-price variances, or in reducing the frequency of low lettuce prices. Furthermore, apparently the marketing order contributed little to grower revenues. An attempt was also made to estimate what the price would have been during the 1959-1960 period without the marketing order.

Melons

Abstracts

ROBERT CASTRO and RICHARD L. SIMMONS. *The Demand for Green Peppers, Cucumbers, and Cantaloupes in the Winter Season.* Abstracted under cucumbers on page 77.

ADRIAN FAJARDO-CHRISTEN. *Demand for Honey Dew Melons in the New York City Wholesale Market, With Special Reference to the Potential Market for Supplies from Peru.* Florida Agricultural Experiment Station, Agricultural Economics Report No. 14, November 1970.

Scope: New York wholesale prices for honeydew melons.

Purpose: ". . .to estimate the wholesale demand, on a seasonal basis, for honeydew melons in the New York City wholesale market. There was a particular interest in estimating prices that might be expected for potential supplies from Peru during the winter months.

Observational Interval: Monthly.

Period of Analysis: 1951 through 1967.

Specification and Estimation Procedure: The year was divided into three marketing periods based on the geographical source of supply: (1) November through January, (2) February through April, and (3) May through October. Two approaches were used. First, in an analysis of covariance model four equations were fitted by OLS: (1) intercepts allowed to vary by using monthly dummy variables and slopes of the honeydew quantity variable allowed to vary using a dummy variable for each marketing period; (2) intercepts varied, but not slopes; (3) slopes varied, but not intercepts; and

(4) all dummy variables removed. Because it was decided that there was probably also significant variation in the other two coefficient estimates (quantity of Spanish melons and income) among periods, in the second approach separate equations for each of the three marketing periods were run. It was believed that the second approach produced more accurate estimates. Monthly dummy variables were used in each equation to allow intercept shifts.

Estimation Results:

Intercepts of honeydew price-quantity relationship

	Nov.-Jan.	Feb.-Apr.	May-Oct.
Base, last month of period	11.16	6.94	9.71
1st month[a/]	.23 (.73)	.23 (.34)	1.15 (.62)
2nd month[a/]	-.69 (.78)	-.33 (.37)	1.43 (.57)
3rd month[a/]	-	-	1.21 (.55)
4th month[a/]	-	-	1.71 (.61)
5th month[a/]	-	-	1.50 (.63)

Coefficients of independent variables

	Nov.-Jan.	Feb.-Apr.	May-Oct.
Quantity honeydew melons	-.000330 (.000079)	-.000019 (.000007)	-.000035 (.000008)
Quantity Spanish melons	-.000062 (.000019)	-.000031 (.000060)	-.000007 (.000028)
Income	.010276 (.002734)	.008894 (.002898)	.005458 (.001408)
R^2	.552	.305	.532

a/ Differences from base month.

(Standard errors are in parentheses.)

ROBERT S. FIRCH and ROBERT A YOUNG. *An Economic Study of the Winter Vegetable Export Industry of Northwest Mexico.* Abstracted under tomatoes on page 148.

GORHAM HUSSEY and JOHN T. PORTER. *Analysis of the Competitive Potential of the Indiana Watermelon Industry.* Indiana Agricultural Experiment Station, Research Progress Report No. 152, September 1964.

Scope: Late-summer-states' watermelons, with an emphasis on Indiana.

Purpose: ". . .the study was directed to two main questions: (1) what price levels are anticipated for Indiana during the decade 1960-1970?, and (2) what effects on price levels might be anticipated from: (a) differentiation of Indiana watermelons through a Seal of Quality program?, (b) improved marketing efficiency?, and (c) changes technology permitting the Indiana crop to mature earlier in the season?

Observational Interval: Annual and Weekly.

Period of Analysis: 1939 through 1959 for the annual analysis.

Specification and Estimation Procedure: Using the Theil-Basmann method, the season average, farm-level price relationship for Indiana and 19 competing states was estimated simultaneously with a harvest supply equation and an Indiana price equation. As the primary purpose was to explain the implications of the findings to Indiana growers, the methodology was not explained in detail. The equations were presented in an appendix table. In addition, an intraseasonal, wholesale-level price equation was estimated by OLS using weekly data.

Estimation Results:

Season average analysis

$$Y_1 = 228.6228 - \underset{(4.9362)}{5.8923}Y_2 + \underset{(.0538)}{.1566}Z_1 - \underset{(4.5476)}{23.3776}Z_3 - \underset{(.6543)}{1.4009}Z_4$$

where:

Y_1 = average season's farm price in 19 states, cents/cwt.;

Y_2 = per capita consumption of 19 states' supply, pounds/year;

Z_1 = per capita disposable income, dollars/year;

Z_3 = prior intraseasonal watermelon consumption, pounds/capita;

Z_4 = marketing margin index, annual.

(Standard errors are in parentheses.)

DANIEL B. SUITS. "An Econometric Model of the Watermelon Market." *Journal of Farm Economics*, Volume XXXVII, No. 2, May 1955, pp. 237-251.

Scope: The U.S. watermelon market.

Purpose: To present "a complete, empirically determined supply and demand structure for the watermelon market." To "apply the results to an analysis of some of the dynamic properties of the market." To "investigate its stability, the path of adjustment toward equilibrium, and the speed with which such adjustment would occur, other things being equal." Finally, "to forecast the watermelon market a year ahead." p. 237.

Observational Interval: Annual.

Period of Analysis: 1930 through 1951.

Specification and Estimation Procedure: The econometric model consisted of (1) a crop supply equation, (2) a harvested supply equation, and (3) a demand equation; all three in double-log form. Equation (1) was estimated by OLS; (2) and (3) as a simultaneous system using maximum likelihood, limited information. In an ingenious adaption of the cobweb model, equations (2) and (3) determine the equilibrium price if less than the entire crop is harvested; (1) and (3) if the entire crop is harvested. The model was then used to describe the dynamics of the watermelon market and to forecast production and price.

Estimation Results:

Crop Supply (1919-1951):

$$(1)\ Q = \underset{(.156)}{.587P_{-1}} - \underset{(.095)}{.320C_{-1}} + \underset{(27.40)}{34.41J} - \underset{(.238)}{.141T_{-1}} - \underset{(45.17)}{155.97K} + 768.735$$

Harvested Supply:

$$(2a)\ X = \underset{(.110)}{.237\ \frac{P}{W}} + \underset{(.114)}{1.205Q} - 118.041 \quad \text{or,}$$

(2b) X = Q whichever is smaller

Demand:

$$(3)\ P = \underset{(.088)}{1.530\ \frac{Y}{N}} - \underset{(.246)}{1.110\ \frac{X}{N}} - \underset{(.183)}{.682F} - 140.163$$

Dividing (3) by the coefficient of $\frac{X}{N}$ yields the more familiar form:

$$(3^*)\ \frac{X}{N} = 1.378\ \frac{Y}{N} - .901P - .614F - 126.273$$

where:

Q = the commercial crop of watermelons available for harvest, millions;

P_{-1}, C_{-1}, T_{-1} = prices of watermelons, cotton, and commercial truck, lagged one year, dollars per thousand;

J, K = dummy variables representing the government cotton policy and the war respectively;

W = index of southern farm wage rates;

X = the number of watermelons harvested, in millions;

N = population;

Y = disposable income;

F = freight cost.

H. O. A. WOLD. "A Case Study of Interdependent Versus Causal Chain Systems. *Review of the International Statistical Institute*, Vol. 26, No. 1/3, 1958, pp. 5-25.

Scope: The U.S. watermelon market.

Purpose: To compare the interdependent versus the causal chain systems, the Suits' econometric model for watermelons (interdependent) was reviewed and then respecified.

Observational Interval: Annual.

Period of Analysis: 1930 through 1951.

Specification and Estimation Procedure: Wold specified a "causal chain" model consisting of three independent equations in double-log form: (1) the supply relation (regulated by producers), (2) the demand equation (regulated by consumers), and (3) price mechanism (regulated by merchants). Equation (3) replaced Suits' harvested supply equation. (The Suits' paper is reviewed on page 95.) The three equations were assumed autonomously determined, so they could be estimated by OLS. The OLS elasticity estimates were substantially lower than the Suits' limited information estimates, leading to the conclusion that the latter were probably subject to "hybrid bias"--"a consequence of interdependent systems being constructed as a hybrid between static and dynamic approaches." p. 15.

Estimation Results:

Supply Relation (1919-1951):

$$(6)\ Q = 0.587P_{-1} - 0.320C_{-1} - 0.141T_{-1} + 0.034J - 0.156K + 0.769$$

Demand Relation (1931-1951):

$$(7)\ \frac{X^*}{N} = -\ 0.206\frac{P}{L} + 0.430\ \frac{Y}{NL} - 1.088$$

Price Mechanism (1931-1951):

$$(8)\ \frac{P}{L} = 0.261 \left[\left(\frac{X^*}{N}\right)_{-1} - \frac{Q}{N} \right] + 1.215\,\frac{Y}{NL} - 1.280$$

where:

Q = the number, in millions, of watermelons available for harvest;

P,C,T = average annual farm prices of watermelons (dollars per thousand), cotton (dollars per pound) and commercial truck (price index for vegetables);

J,K = dummy variables representing government cotton policy and the war, respectively. J is 1 for 1934-1951, K is 1 for 1943-1946; otherwise J and K are 0;

X = the number of watermelons harvested, in millions;

N = Unites States population, July 1st;

Y = disposable income of the United States;

X* = consumer demand, estimated as watermelon harvest X in the years when only part of the crop is harvested:

$X^* = X$ in years when X F Q,

X* is unknown in other years, that is, in 1941-45 and 1948.

L = a U.S. cost of living index. Thus P/L and Y/NL are (the logarithms of) real price and real per capita income.

Subscripts indicate lags so that P_{-1} means that P is lagged one year relative to Q.

TABLE 8: Selected Econometric Analyses With Flexibility or Elasticity Estimates for Melons

Author and Date	Geographical Area	Time Period	Observational Interval	Form of Equation	Method of Estimation	Market Level	Product	Price Flexibility	Income Flexibility	Cross Effect	Price Elasticity	Income Elasticity
Castro and Simmons, 1974	U.S.	1959/60 1970/71	Weekly	linear	OLS	wholesale	canta- loupes	-0.041 Feb. -0.146 Mar. -0.094 Apr.				
Fajardo-Christen, 1970	New York	1951- 1967	Monthly	linear	OLS	wholesale	honey dew melons Nov.-Jan. Feb.-Apr. May -Oct.	 -.148 -.094 -.198	 .302 .340 .180	 -.072 a/ -.007 a/ -.002 a/		
Firch and Young, 1968	U.S.	1961- 1966	Weekly	linear	OLS	shipping- point prices, Nogales, Arizona	canta- loupes: from Mex. total quantity Watermelons: from Mex. total quantity	 -0.087 -0.098 -0.113 -0.080				
Suits, 1955	U.S.	1930- 1951	Annual	double log	limited informa- tion, maximum likeli- hood	farm	water- melons				-0.901	1.378
Wold, 1958	U.S.	1930- 1951	Annual	double log	OLS	farm	water- melons				-0.206	0.430

a/ wrt. Spanish melons

Related Studies, Melons

Farrell, Kenneth R. *Sales of Cantaloupes in Selected Retail Stores in Minneapolis, Minnesota.* A report to the California Cantaloupe Advisory Board, 1961. Twelve retail stores in Minneapolis-St. Paul, of the same chain, were selected as test stores for promotion of California cantaloupes. Four display techniques were rotated among the stores every two weeks. Results were tested by discriminant analysis and by analysis of variance and covariance. In addition, a multiple regression was fitted in which the average weekly sales volume was seen as a function of cantaloupe prices, prices of substitutes, and temperature.

Fowler, Mark L. and George L. Klein. *Some Economic Factors Affecting the Oklahoma Watermelon Industry.* Oklahoma State University, Department of Agricultural Economics, Processed series P-312, March 1959. Two OLS price-dependent equations were estimated using annual data, 1921 through 1955, omitting 1942-1945. The first, in first differences of the logs, fitted U.S. farm price as a function of production, income, and temperature. The second attempted to capture a seasonal effect. With the data in actual values, early summer prices were fitted to late spring production and to early summer production, income, and a trend.

L'Esperance, Wilford L. "A Case Study in Prediction: The Market for Watermelons." *Econometrica,* Vol. 32, No. 1-2, January-April, 1964, pp. 163-173. Forecasts using the reduced form of an interdependent simultaneous equation system, limited information (Suits' model, see page 95), were compared with those of a single equation OLS model. The predictability of Suits' interdependent model was also compared with the causal chain system (Wold's model, see page 97). In both comparisons, the interdependent system gave generally better forecasts than the alternative models.

Rauchenstein, E. *Economic Aspects of the Cantaloupe Industry.* California Agricultural Experiment Station, Bulletin No. 419, February 1927. Five scatter diagrams (1922-1926) were made plotting daily shipments from Imperial Valley, California, against the FOB daily prices. The relationship was fitted mathematically in double log form; other factors affecting price were discussed but not fitted. A multiple regression in semi-log form was also estimated in which the logs of New York prices were predicted by quantity and a temperature variable.

Rauchenstein, Emil. *Factors Affecting the Price of Watermelons at Los Angeles.* California Agricultural Experiment Station, Hilgardia Vol. 3, No. 12, June 1928. Watermelon prices at Los Angeles were estimated in double-log form with a multiple regression using five factors: carlot arrivals, carlots on track, temperature, a seasonal index, and carlot arrivals of cantaloupes. This study is of historical interest in that the solution, steps from the five normal equations were spelled out.

Seale, A. D. Jr. and M. B. Allen. *Reactive Programming of Supply and Demand for Watermelons Produced in Mississippi and Competing Areas.* Mississippi Agricultural Experiment Station, Agricultural Economics Technical Publication No. 1, June 1959. For use in a reactive programming model, demand functions for 20 consuming centers for 13 marketing weeks in 1956 were estimated (ln Price = a + b ln quantity + c ln population). To determine whether or not the 260 observations could be pooled; statistical (F) tests were performed, with the result that the coefficient estimates could remain the same but the intercepts should be allowed to vary (by using dummy variables) over the 13 marketing weeks. The same model was used in a *Journal of Farm Economics* article (Vol. XLI, No. 5, December 1959, pp. 1012-1022) to illustrate the reactive programming technique.

Thompson, Stanley R. *A Simultaneous and Recursive Econometric Model of the U.S. Watermelon Market: A Comparison and Evaluation,* 1974. An unpublished student paper in which two watermelon models were updated to 1971 and compared: Suits' 1955 simultaneous, interdependent model and Wold's causal chain, recursive model. Both Suits' and Wold's papers are reviewed in this report on pages 95 and 97, respectively. On a goodness of fit basis, the explanatory power of the recursive model equations was somewhat superior to the simultaneous formulation. The simultaneous model emerged as a superior formulation when the evaluation criterion was derived from an analysis of turning point errors.

Onions

Abstracts

THOMAS S. CLEVENGER and FREDERICK F. GEITHMAN. *Market Prospects for New Mexico's Lettuce, Onions, Potatoes, and Sweet Potatoes.* New Mexico Agricultural Experiment Station, Bulletin No. 649, February 1977.

Scope: U.S. demand for onions, potatoes, and sweet potatoes. (The lettuce equations were not statistically satisfactory.)

Purpose: ". . .to (1) determine the optimal distribution for selected New Mexico fresh vegetables, and (2) establish whether production and marketing of these vegetables could be profitably increased." p. 6.

Observational Interval: Annual.

Period of Analysis: 1950 through 1972 for onions, 1957 through 1972 for potatoes and sweet potatoes.

Specification and Estimation Procedure: Farm-level, linear, price forecasting equations were estimated by OLS for onions, potatoes, and sweet potatoes, and elasticities were computed at the means of the variables. The price flexibility for lettuce (-.93) was taken from another study.[1/] From these estimates, wholesale demand equations were calculated for 37 markets (onions), 17 markets (potatoes), 21 markets (sweet potatoes), and 21 markets (lettuce) for use in a reactive programming model.

1/ William V. Shelley, *A Simultaneous-Equation Analysis of the United States Lettuce Demand and Supply, 1949-1970,* unpublished M.S. thesis, Department of Agricultural Economics and Agricultural Business, New Mexico State University, August 1971.

Estimation Results:

Onions

$$P = 31.03 - \underset{(5.98)}{.00012}\,Q + \underset{(4.49)}{.00649}\,DI + \underset{(3.79)}{33.97}\,DFI$$

$R^2 = .79 \quad DW = 2.66$

Potatoes

$$P = 2.91 - \underset{(2.09)}{.0006}\,Q - \underset{(3.88)}{.0604}\,CPFI + \underset{(2.11)}{.0004}\,POP$$

$R^2 = .56 \quad DW = 1.893$ inconclusive

Sweet Potatoes

$$P = 13.46 - \underset{(5.12)}{.00028}\,Q - \underset{(4.69)}{.04808}\,CPFI$$

$R^2 = .68 \quad DW = 1.645$ inconclusive

where:

P = seasonal average price per hundredweight in dollars received by farmers for the commodity, deflated by the consumer price index with 1967 = 100,

Q = total quantity produced of a commodity during the season in thousands of hundredweight,

DI = annual total personal disposable income in the United States in billions of dollars,

POP = annual total United States population in thousands,

CPFI = consumer food price index as a measure of the aggregate price level with 1967 = 100,

DFI = the deflated consumer food price index by the consumer price index with 1967 = 100.

(t-statistics are in parentheses.)

CONNOLLY, CHAN. *Feasibility of a Central Onion Sales Organization for South Texas.* Texas Agricultural Market Research and Development Center, Texas A&M University, Information Report MRC-71-1, August 1971.

Scope: South Texas dry onions.

Purpose: In order to examine the expected performance of a proposed central sales organizational structure, several aspects of the industry were analyzed. The FOB price analysis is reviewed here.

Observational Interval: Annual.

Period of Analysis: 1960 through 1970. Price analysis was also done for 1955 through 1970, but the better fit obtained for the shorter period was attributed in part to the initiation of a federal market order in 1961.

Specification and Estimation Procedure: In a preliminary analysis using a linear OLS price-dependent equation, it was found that increases in U.S. income had no statistically significant effect on the FOB price of South Texas onions. Two further specifications were run: in double-long form and in first differences of the actual data. In both versions the FOB price was fitted as a function of per capita supply of January 1 storage stocks and the per capita supply of South Texas onions produced.

Estimation Results:

$$\log Y = 1.78 - \underset{(7.46)}{2.22} \log X_1 - \underset{(10.24)}{1.51} \log X_2$$

$$\bar{R}^2 = .92$$

where:

Y = actual annual average FOB price per cwt,

X_1 = per capita supply of January 1 storage stocks,

X_2 = per capita supply of South Texas onions.

(t-statistics are in parentheses.)

EDWARD V. JESSE. *Structure of the Intraseasonal Pricing Mechanism for Late Summer Onions, 1930-68.* USDA, ERS, Marketing Research Report No. 1004, July 1973.

Scope: Michigan shipping point prices.

Purpose: To analyze how an initial price level is established at the beginning of the storage season, to identify factors causing price variability during the storage season, and to determine whether the structure of the pricing mechanism differed during the period of futures trading from the period preceding and from the period following trading.

Observational Interval: Annual and weekly.

Period of Analysis: 1930/31 through 1967/68.

Specification and Estimation Procedure: First, a "tone price" equation was estimated for the pre- and post-futures trading subperiods (1930/31-1942/43 and 1959/60-1967/68), the trading subperiod (1944/45-1958/59), and for the entire period (1930/31-1958/59). The tone price variable (the simple average of western Michigan FOB shipping point prices in the weeks preceding November 1st) was seen as a function of Michigan production, the total U.S. late summer onion production, and a trend. Then, three storage interval relations were estimated for the same subperiods and the total period: (1) November-December, (2) January-February, and (3) March-April. The dependent variable in each case was price in a particular week minus the "tone price" for that year. The explanatory variables were a weekly trend and the proportion of the total late crop shipped in the respective week.

Each of the equations discussed above was fitted by OLS, with all the variables, and a second time, using backwards stepwise regression retaining only those variables showing a statistically significant relationship with the dependent variable.

Since statistical tests on the subperiods did not show consistent differences, only the tone price equation using pooled data will be presented below.

Estimation Results:

$$P^0 = \underset{}{1.783} - \underset{(.058)}{.396}\ \text{Michprod} - \underset{(.014)}{.048}\ \text{Lateprod} + \underset{(.004)}{.021}\ \text{Year}$$

$$R^2 = .80$$

where:

P^0 = simple average of deflated western Michigan weekly prices for weeks prior to November 1, dollars per 50-pound bag;

Michprod = Michigan late summer onion production in million hundredweight;

Lateprod = total U.S. late summer onion production in million hundredweight;

Year = annual trend, 1930/31 season = 1, . . ., 1967/68 = 38.

(Standard errors are in parentheses.)

EDWARD V. JESSE. *Structure of Seasonal Supply and Demand in the Onion Market*. USDA, ERS, Marketing Research Report No. 985, February 1973.

Scope: U.S. seasonal supply and demand for onions.

Purpose: To develop and estimate a statistical model incorporating factors thought to influence seasonal average prices and production in order to represent the structure of supply and demand and "to assess possible differences in the basic structure of onion supply and demand between the futures trading and post-trading periods." p. 1.

Observational Interval: Annual.

Period of Analysis: 1946/47 through 1969/70.

Specification and Estimation Procedure: First, the supply and demand models for three seasons--late summer (August, September, and October), early spring (March, April, and May), and intermediate (May, June, July, August)--were estimated for two disjoint time periods: (1) the futures-trading period, 1946/47 through 1958/59 and (2) the post-trading period, 1959/60 through 1969/70. Statistical tests were performed testing the null hypothesis of no significant difference between the trading and post-trading periods. Since the hypothesis was not rejected for any of the three seasons, the data were pooled and the overall seasonal supply-demand structure was explored by OLS. Using a backwards stepwise regression procedure, only variables contributing significantly to the explanation of the variation in the dependent variable were retained.

Estimation Results:

Late Summer

$$\text{Price} = 10.54 - \underset{(0.12)}{0.77}\ \text{Prod.} \qquad R^2 = .66 \quad DW = 1.58$$

Early Spring

$$\text{Price} = 13.53 - \underset{(0.59)}{2.77}\ \text{Prod.} - \underset{(0.40)}{1.93}\ \text{Lagprod.} \qquad R^2 = .59 \quad DW = 2.41$$

Intermediate:

$$\text{Price} = 5.50 - \underset{(0.49)}{1.48}\ \text{Prod.} + \underset{(0.03)}{0.12}\ \text{Trend} \qquad R^2 = .40 \quad DW = 1.94$$

where:

Price = season average grower price for onions in dollars per cwt., deflated by index of prices received by farmers for all products, 1957-59 = 100;

Prod = seasonal onion production in pounds per capita;

Lagprod = per capita onion production in pounds for preceding seasonal crop (storage stocks January 1st);

Trend = crop year, 1946/47 = 1, . . . 1969/70 = 24.

(Standard errors are in parentheses.)

CARL E. SHAFER. *Intraseasonal Price Analysis for South Texas Early Spring Onions.* Texas A&M University, Department of Agricultural Economics and Rural Sociology, Technical Report No. 72-3, 1972.

Scope: South Texas FOB prices.

Purpose: ". . .to determine those factors and variables which influence South Texas FOB onion price per 50 pound bag (yellow granex medium) during the weeks of the early spring onion marketing season." p. 1.

Observational Interval: Annual and weekly.

Period of Analysis: 1955 through 1970 for one equation using annual data; 1966 through 1971 for all other equations.

Specification and Estimation Procedure: In order to analyze the factors affecting the price of Texas onions, several equations were fitted by OLS:

1. Season average price (annual data), deflated by the CPI, as a function of per capita Texas production and stocks, in both linear and double log forms.

2. Season average price as a function of total production and total stocks.

3. Storage onion stocks as a function of late-summer production in several functional forms (carry-over).

4. Simple linear regressions among planted acreage, harvested acreage, yield, and production for Texas early spring and late summer onions.

5. Weekly data to estimate prices as related to Texas shipments, other shipments, rain the previous week, and on-track holdings. The weekly data equations were fitted for each season (year) separately, then for all seasons (years), and finally using the pooled data, dummy variables were used to allow intercept changes each year. It is the latter equation that is reported below.

6. A buyer's expectations model into which the previous week's prices were incorporated, fitted both with and without seasonal dummies.

Estimation Results:

$$P = -\underset{(4.54)}{0.02088}\ OTSH - \underset{(5.03)}{0.01287}\ TXSH + \underset{(1.79)}{0.08631}\ RAIN\text{-}1$$

$$- \underset{(2.33)}{0.02928}\ OTKH + \begin{matrix} 4.44123 & (1966) \\ 3.92256 & (1967) \\ 5.56878 & (1968) \\ 3.18687 & (1969) \\ 4.73145 & (1970) \end{matrix}$$

$R^2 = 0.75$

where:

P = South Texas FOB price per 50 lb. bag, yellow granex medium onions;

OTSH = other than Texas shipments, carlots;

TXSH = Texas shipments, carlots;

RAIN-1 = rainfall in Lower Rio Grande Valley in previous week, inches;

OTKH = on-track holdings in 16 major terminal markets.

(t-statistics are in parentheses.)

CARL E. SHAFER. *A Statistical Analysis of Season's Average Prices for Texas Winter Carrots and Early Spring Onions*. Abstracted under carrots on page 61.

D. MILTON SHUFFETT. *The Demand and Price Structure for Selected Vegetables.* Abstracted under tomatoes on page 158.

DANIEL B. SUITS and SUSUNU KOIZUMI. "The Dynamics of the Onion Market." *Journal of Farm Economics*, Vol. XXXVIII, No. 2, May 1956, pp. 475-484.

Scope: The aggregated onion market for the U.S.

Purpose: The systematic oscillations of prices and outputs (almost a textbook example of an agricultural cobweb system) were modeled in a three-equation econometric system in order to analyze their dynamic properties.

Observational Interval: Annual.

Period of Analysis: 1929 through 1952.

Specification and Estimation Procedure: The three equations of the system (supply, demand, and an unharvested crop forecasting equation) were estimated independently by OLS. The demand equation was fitted in the first differences of the logs of the annual mean values of the variables.

Estimation Results:

$$\Delta \text{ Log } P^f = -\underset{(.4)}{2.27}\ \Delta \text{ Log } (D/N) + \underset{(.2)}{1.31}\ \Delta \text{ Log } (Y/N) + .681$$

$$\bar{R}^2 = .81$$

where:

P = farm price of onions,

D/N = crop-year demand per capita (crop less unharvested crop less net exports divided by U.S. population);

Y/N = U.S. per capita disposable income.

(Standard errors are in parentheses.)

The coefficient estimates are very comparable to those obtained by Shuffett reviewed on page 158.

TABLE 9: Selected Econometric Analyses With Flexibility or Elasticity Estimates for Onions

Author and Date	Geographical Area	Time Period	Observational Interval	Form of Equation	Method of Estimation	Market Level	Product	Price Flexibility	Cross Effect	Price Elasticity	Income Elasticity
Clevenger and Geithman, 1977	U.S.	1950-1972	Annual	linear	OLS	farm	fresh			-.98	
Connolly, 1971	U.S.	1960-1970	Annual	double log	OLS	FOB	South Texas dry onions	-1.51	-2.22[a/]		
Jesse, 1973	U.S.	1946/47 1969/70	Annual	linear	OLS	farm	fresh	-3.0 late summer -0.96 early spring -1.0 May-Aug.	-0.71[b/]		
Shafer, 1966	Texas	1954-1964	Annual	double log	OLS	farm	fresh	-0.974			
Shafer, 1972	Texas	1966-1971 1966-1970	Annual Weekly	linear	OLS	farm FOB	early spring onions yellow granex medium onions	-1.34 -0.32	-1.43[c/]		
Shuffett, 1954	U.S.	1921-1941	Annual	first differences of the logs	OLS	farm	late onions	-2.855			
Suits and Koizumi, 1956	U.S.	1929-1959	Annual	first differences of the logs	OLS	farm	fresh			-.4	.6

a/ wrt. per capita January 1 storage stocks

b/ wrt. late summer production

c/ wrt. stocks, January 1

Related Studies, Onions

Branson, Robert E. *A Summary Analysis of In-Store Onion Promotion Tests and Test Shipments of Pre-Packaged South Texas Onions.* Texas A&M University, Texas Agricultural Market Research and Development Center, Information Report MRC 69-2, September 1969. A promotion test was conducted in 1963 in 40 retail food stores operated by two national chains in four cities. Promotion bins were used in the stores in Denver and St. Louis; a special trading stamp promotion, in Cincinnati; and, as a control, no promotion, in Omaha. The 1964 promotion tests were conducted at 56 stores in Oklahoma City, Kansas City, St. Louis, and Nashville, but this time both promotion and control stores were located in each city. For both years the tests indicated that promotion can effectively increase demand for the mild flavored Texas onions.

Chen, Chao-chen. *An Analysis of the Supply-Demand-Price Structure of Onions in the United States.* Unpublished Ph.D. dissertation, Department of Agricultural Economics, Cornell University, 1965. Although the dissertation was not available, seasonal elasticity estimates were reported in the Western Extension Marketing Committee (*A Handbook on Elasticity of Demand for Agricultural Products in the United States,* WEMC Publication No. 4, July 1967). For the period 1947 through 1962, U.S. farm-level price elasticity estimates for onions were:

Early Spring	-1.74
Late Spring	-1.02
Early Summer	-0.68
Late Summer	-0.18

At the retail level, the "all seasons" elasticity was reported: -0.59.

Johnson, Aaron C., Jr. *Effects of Futures Trading on Price Performance in the Cash Onion Market, 1930-68.* USDA, ERS, Technical Bulletin No. 1470, February 1973. "Farm, shipping point, and wholesale onion prices on both a weekly and a monthly basis were used to assess the impact of trading in onion futures contracts on the performance of cash onion prices." The period 1930 through 1968 consists of three subperiods: no futures trading 1930-1940; active futures trading 1946-1957; and no futures trading 1959-1968. "Price variations over time, including year-to-year, within-season, seasonal, and within-month price changes, and price variations over space were considered. Evaluation of the results from all the analyses. . . support the general conclusion that there was no significant change in price performance over the entire period." From the abstract.

Lester, Bernard W. and Robert E. Branson. *An Analysis of Prices Received for Pre-Packaged and 50-Pound Sack South Texas Onions, 1965.* Texas A&M University, Progress Report No. 2384, December 1965. Correlation analysis between prices received for the 50-pound sack and for each of several

smaller pre-packaged test sizes was performed. Statistically significant (by the t-test) higher prices were received for two out of three smaller size packs when compared with the 50-pound sacks; lower prices, for the military 12-pound pack. Aggregating the smaller size packs for comparison with the 50-pound pack resulted in statistically significant results only when the military 12-pound pack was excluded.

Stone, Kenneth, Dale Young, Eldon Dixon, and Daniel Padberg. *Consumer Preferences for New York Onions.* Cornell University, Department of Agricultural Economics, A.E. Ext. 75-19, June 1975. A questionnaire soliciting responses about onion purchase and preferences was mailed to 7,395 New York households. On the useable responses (31.56 percent), chi square tests were used to evaluate comparisons. The sample had a high-income bias, but results indicated that consumers preferred smaller-than-25-pound packages, mesh bags (though acceptance of the plastic bag is growing), and a mild flavored onion.

Working, Holbrook. "Price Effects of Futures Trading." Stanford University, *Food Research Institute Studies*, Vol. 1, No. 1, February 1960, pp. 3-31. Statistical evidence was presented on the impact of hedging on onion cash prices. The evidence indicated that futures trading substantially reduced the amount of variation in spot prices of onions.

Peas

Abstracts

J. H. DROGE and R. H. REED. *Prediction Analysis of United States and Wisconsin Wholesale Prices of Canned Cut Green Beans, Sweet Corn, and Sweet Peas, 1948-1968.* Abstracted under beans on page 33.

H. M. HUTCHINGS and G. B. DAVIS. *An Economic Analysis of Interregional Competition in the Frozen Pea Industry.* Oregon Agricultural Experiment Station, Technical Bulletin No. 72, November 1963.

Scope: A six production regions-ten consuming regions model of the U.S. frozen pea industry.

Purpose: "To determine supply, demand, and price relationships for frozen peas. . .To determine the competitive position of the major pea-freezing areas of the United States. . .To project an efficient pattern of growth for this industry." p. 6. There were, in addition, some methodological objectives.

Observational Interval: Annual.

Period of Analysis: 1950/51 through 1959/60.

Specification and Estimation Procedure: In estimating the demand function for frozen peas, several models were specified but only one of these was presented in the bulletin. This OLS equation in linear form appears below. Regional adjustments in per capita consumption and prices were made using 1955 information in order to adapt the model to regional demand functions for use in the interregional competition model.

Estimation Results:

$$Q = .390610 - \underset{(.026883)}{.079385}\,P + \underset{(.000498)}{.002256}\,DI$$

$$R^2 = .914$$

where:

Q = the estimated U.S. per capita disappearance of frozen peas, pounds;

P = the average retail price, cents per 10-ounce package;

DI = the average U.S. per capita disposable income, 1947-49 dollars.

(Standard errors are in parentheses.)

D. MILTON SHUFFETT. *The Demand and Price Structure for Selected Vegetables.*

Abstracted under tomatoes on page 158.

TABLE 10: Selected Econometric Analyses with Flexibility or Elasticity Estimates for Peas

Author and Date	Geographical Area	Time Period	Observational Interval	Form of Equation	Method of Estimation	Market Level	Product	Price Flexibility	Price Elasticity
Droge and Reed, 1973	U.S. and Wisconsin	1948-1968	Annual	linear	OLS	FOB	canned:		
							National canners brand	-.2076	
							Wisconsin private label	-.2090	
Hutchings and Davis, 1961	U.S.	1950/51 1959/60	Annual	linear	OLS	retail	frozen		-.6760
Shuffett, 1974	U.S.	1921-1941	Annual	first differences of the logs	OLS	farm	fresh	-0.353	
						FOB	canned	-0.624	

Peppers

Abstracts

M. B. ALLEN and A. D. SEALE, JR. *An Evaluation of the Competitive Position of the Green Pepper Industry in Mississippi and Competing Areas.* Mississippi Agricultural Experiment Station, Agricultural Economics Technical Publication No. 4, March 1961.

Scope: Mississippi and other early summer producing areas of green peppers.

Purpose: To describe production trends, to estimate demand in specified consuming centers, to estimate transportation charges from producing to consuming areas, and to determine prices and revenues which would be associated with alternative production and distribution patterns.

Observational Interval: Annual.

Period of Analysis: 1929 through 1958.

Specification and Estimation Procedure: Since several alternative analyses of weekly price-quantity relationships for 23 consuming centers did not yield logical demand functions, a demand function was developed using annual data. First differences of the logs of the variables were specified and fitted by OLS. Using the price flexibility from the resulting equation, the average demand level (A) for each of seven weekly periods was computed using the average weekly price, the average weekly carlot receipts, and the average population for the 23 cities. There was a downward but not consistent trend in the A values, so they were adjusted to an average trend. Then, demand functions for each city for each period were developed by further adjusting the intercept by the population of the city times the positive flexibility estimate from the original equation.

Based on the demand functions and transportation charge estimates, alternative distribution patterns were evaluated.

<u>Estimation Results</u>:

The U.S. time series equation.

$$\Delta \ln P = -.05126 - .78335 \Delta \ln Q + .91320 \Delta \ln I$$

$$R^2 = .53$$

where:

P = farm price per cwt.,

Q = quantity in thousand cwt.,

I = U.S. total disposable income in billions of dollars.

(All coefficients were significant at the 99 percent confidence level.)

ROBERT CASTRO and RICHARD L. SIMMONS. *The Demand for Green Peppers, Cucumbers, and Cantaloupes in the Winter Season.* Abstracted under cucumbers on page 77.

ROBERT S. FIRCH and ROBERT A. YOUNG. *An Economic Study of the Winter Vegetable Export Industry of Northwest Mexico.* Abstracted under tomatoes on page 148.

I. A. LINDSTROM and R. A. KING. *The Demand for North Carolina Slicing Cucumbers and Green Peppers.* Abstracted under cucumbers on page 77.

RICHARD L. SIMMONS and CARLOS POMAREDA. "Equilibrium Quantity and Timing of Mexican Vegetable Exports." *AJAE.* Abstracted under cucumbers on page 80.

TABLE 11: Selected Econometric Analyses With Flexibility or Elasticity Estimates for Peppers

Author and Date	Geographical Area	Time Period	Observational Interval	Form of Equation	Method of Estimation	Market Level	Product	Price Flexibility	Income Flexibility	Price Elasticity
Allen and Seale, 1961	U.S.	1929-1958	Annual	first differences of the logs	OLS	farm	fresh green peppers	-.78335	.91320	
Castro and Simmons, 1974	U.S.	1959/60-1970/71	Monthly	linear	OLS	wholesale	fresh green peppers			-.52 Dec. -.50 Jan. -.92 Feb. -.71 Mar. -.67 Apr.
Firch and Young, 1968	U.S.	1961-1966	Weekly	linear	OLS	shipping-point prices, Nogales, Arizona	quantity from other-than-Mexican sources	-0.653		
							total quantity	-0.820		
Lindstrom and King, 1956	North Carolina	1925-1954, excluding 1942-1945	Annual	double log	OLS	farm	fresh green peppers	-0.5975	1.4666	

Related Studies, Peppers

Castro S., Roberto and J. A. Seagraves. *The Supply of Winter Green Peppers in Florida.* North Carolina State University, Economics Research Report No. 31, December 1974. A supply response model was estimated. The analysis indicated that "the expected total revenue from green peppers, the total revenue from tomatoes lagged two periods, the cost of producing green peppers, and the lagged dependent variable were the most important variables affecting the acreage used for winter green peppers in Florida." From the abstract.

Farris, Donald F. and Richard A. King. *Interregional Competition in Marketing Green Peppers.* North Carolina State College, Agricultural Economics Information Series No. 87, December 1961. The weekly shipments of green peppers during the 1956 season (May 28th through July 27th) from North Carolina and six other states to 21 shipping points were analyzed using the transportation model.

Potatoes

Abstracts

A. A. ARAJI and W. C. SPARKS. *Economic Value of Agricultural Research, A Case Study--Potato Storage Research.* Idaho Agricultural Experiment Station, Research Bulletin No. 101, March 1977.

Scope: U.S. potatoes.

Purpose: ". . .to analyze the contribution of the new potato storage technique developed at Aberdeen (Idaho) to various sectors of the economy and to estimate the rate of return to investment in the project." p. 5.

Observational Interval: Annual.

Period of Analysis: 1955 through 1973.

Specification and Estimation Procedure: As part of the analysis a linear price response equation was estimated by OLS.

Estimation Results:

$$P_p = -4.1756 + \underset{(2.19)}{.04705}U_p - \underset{(2.52)}{.00001}\,Q_p + \underset{(1.95)}{.0078}C$$

$$R^2 = .501$$

where:

P_p = price per cwt. received by farmers for potatoes,

U_p = United States population,

Q_p = quantity of potatoes produced in the United States,

C = per capita potato consumption in the United States.

(t-statistics are in parentheses.)

THOMAS S. CLEVENGER and FREDERICK F. GEITHMAN. *Market Prospects for New Mexico's Lettuce, Onions, Potatoes, and Sweet Potatoes.* Abstracted under onions on page 102.

ROGER W. GRAY, VERNON L. SORENSON, and WILLARD W. COCHRANE. *An Economic Analysis of the Impact of Government Programs on the Potato Industry of the United States*. Minnesota Agricultural Experiment Station, North Central Regional Publication No. 42, June 1954.

Scope: The U.S. potato market.

Purpose: In order to assess the impact of government programs on the industry, a lengthy, thorough analysis was done.

Observational Interval: Annual.

Period of Analysis: 1870 through 1909 and 1910 through 1942.

Specification and Estimation Procedure: Estimation of demand functions was only a part of the study but is of interest because of the change of sign for the trend variable for the two time periods estimated. Demand was rising during the earlier period (partly due to immigration from European potato-consuming countries) and falling over time after 1910. The per capita equations were both linear and in logarithms of the variables; the total market equations were linear. The time effect for the total market demand was graphed along with price and production in a three dimensional figure presented below.

Estimation Results:

Market Demand for Potatoes

Period 1 (1870-1909):

$$Y^* = 90.5625 - .3967 X + 2.6494 T \qquad R^2 = .89$$

Period 2 (1910-1942):

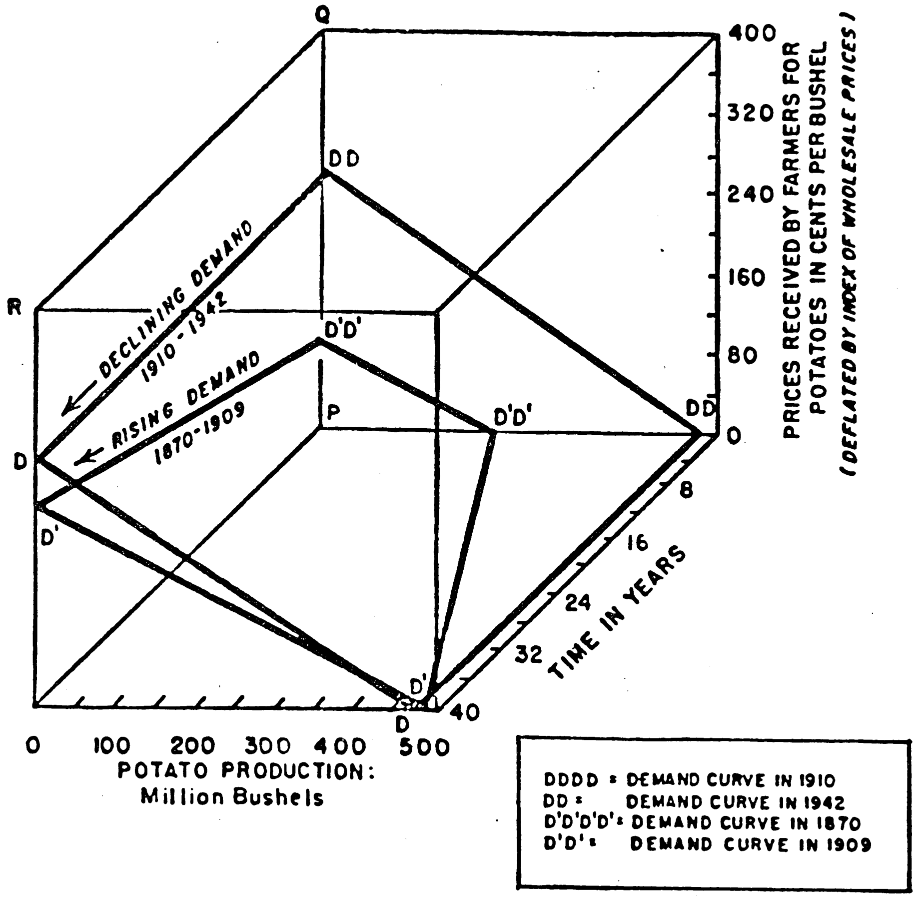
$$Y = 250.7345 - .5108 X - .0788 T \qquad R^2 = .84$$

where:

Y^* = deflated farm price per bushel,

X = U.S. production in millions of bushels,

T = time in years.



The rise and decline in the market demand for potatoes, United States, 1870-1942.

OLMAN HEE, *Demand and Price Analysis for Potatoes.* USDA, ERS, Technical Bulletin No. 1380, July 1967.

Scope: U.S. market for winter and early spring, late spring, early summer, and late summer and fall potatoes.

Purpose: ". . .to provide measurements of elasticity, competitive behavior, and substitutability for different crops of potatoes." p. i.

Observational Interval: Annual.

Period of Analysis: 1947 through 1960.

Specification and Estimation Procedure: Four national-level econometric models were estimated using several estimation procedures: (1) The late

summer and fall crop model was primarily a utilization model, rather than testing for substitutability. The four equations--consumption for food (retail-level prices), consumption for feed and for starch (farm-level prices), and the farm-to-retail spread--were estimated by OLS, TSLS, and limited information, maximum likelihood. (2) The winter and early spring and (3) the late spring models included demand equations for storage potatoes for food and demand for potatoes to go to storage as well as the demand for the seasonal crop. Model (2) was estimated by the same three techniques, but model (3) had only one endogenous variable per equation, so OLS was used. (4) The early summer model (July-August) tested for substitutability between the early summer crop and late spring potatoes in early summer and also late summer potatoes on the market in early summer. OLS, TSLS, and limited information estimation techniques were used on (4).
Estimation Results: Rather than duplicating the many equations here, the limited information, maximum likelihood elasticity estimates for (1), (2), and (4) and the OLS elasticities for (3) are presented in Table 12.

RONALD A. SCHRIMPER and GENE A. MATHIA. "Reservation and Market Demands for Sweet Potatoes at the Farm Level." *American Journal of Agricultural Economics*, Vol. 57, No. 1, February 1975, pp. 119-121.
Scope: U.S. commercial demand for sweet potatoes and demand for on-farm use in the 13 sweet potato producing states.
Purpose: To explain trends that had been observed in the sweet potato industry: a stable quantity in commercial channels, declines in on-farm use, in real farm price, and in acreage.

Observational Interval: Annual.

Period of Analysis: 1949 through 1972.

Specification and Estimation Procedure: The quantity of sweet potatoes entering commercial channels, the quantity reserved for on-farm use, and the farm price received were considered as simultaneously determined. A 3SLS procedure was used. Prices were deflated by the Consumer Price Index (1967 = 100). The final structural equations appear below.

In addition, the reduced-form equations were used to predict the farm price and the commercial quantity to 1980 under alternative assumptions about total production and projected values for income, population, and the price of white potatoes.

Estimation Results:

$$Q_s = 7{,}609 - \underset{(196)}{1{,}606}P_s + 59N + \underset{(1326)}{947}Y + \underset{(234)}{479}P_w - \underset{(78)}{271}T$$

$$Q_r = 10{,}180 - \underset{(205)}{1{,}371}P_s + \underset{(331)}{829}F + \underset{(1023)}{1{,}076}Z - \underset{(254)}{375}P_w - \underset{(602)}{2{,}401}\ln T$$

where:

Q_s = total sweet potato production sold off farms in 1000 cwt.,

P_s = real farm price ($/cwt.) received for sweet potatoes,

N = two year moving average of total U.S. population in millions as of July 1,

Y = real per capita personal disposable income in thousand dollars,

P_w = real farm price ($/cwt.) received for white potatoes,

T = time trend (1949 = 1, 1950 = 2, etc.),

Q_r = total on-farm use of sweet potatoes in 1000 cwt.,

F = total farm population in 13 major sweet potato producing states in millions as of April 1,

Z = real per capita net farm income in thousand dollars for the same 13 states.

(Standard errors are in parentheses.)

D. MILTON SHUFFETT. *The Demand and Price Structure for Selected Vegetables.*
Abstracted under tomatoes on page 158.

JEROME B. SIEBERT. *An Analysis of the California Potato Industry's Market Alternatives.* California Agricultural Experiment Station, Giannini Foundation of Agricultural Economics, Information Series No. 67-2, December 1967.

Scope: California late spring potatoes.

Purpose: To provide some insight into the consequences of diverting production into processing channels in order to increase the price of potatoes sold in fresh channels.

Observational Interval: Annual.

Period of Analysis: 1956 through 1966.

Specification and Estimation Procedure: Three price forecasting equations in double-log form were estimated by OLS. The equation considered both simplest and statistically best is presented below.

Estimation Results:

$$\ln X_1 = 10.5097 - \underset{(-1.9644)}{.83531} \ln X_2 - \underset{(-7.3247)}{2.78971} \ln X_3$$

$$R^2 = .8776$$

where:

X_1 = California late spring seasonal potato price adjusted by the Consumer Price Index, dollars per cwt;

X_2 = California late spring potato production, pounds per capita;

X_3 = May 1 stocks of U.S. raw potatoes other than California late spring production, pounds per capita.

(t-statistics are in parentheses.)

WILL M. SIMMONS. *An Economic Study of the U.S. Potato Industry.* USDA, ERS, Agricultural Economic Report No. 6, March 1962.

Scope: U.S. potatoes including seasonal and regional analysis.

Purpose: "This potato study is part of a continuing program of economic research designed to provide information on factors influencing supply, demand, and price of important agricultural commodities. Such a study has special interest at this time because of recurring overproduction and consequent low prices to potato growers in recent years." From the Preface.

Observational Interval: Annual.

Period of Analysis: 1951 through 1960 and one equation for the 1930 through 1941 period.

Specification and Estimation Procedure: Thirteen price-dependent, linear, OLS equations were fitted: total U.S. production 1930-1941, total U.S. production 1951-1960, winter and early spring production, late spring production, early summer production, late summer and fall production, late summer and fall in the eastern region, late summer and fall in the central region, late summer and fall in the western region, late summer and fall in Maine, late summer and fall in the Red River Valley of North Dakota and Minnesota, late summer and fall in Idaho, and late summer and fall in Maine. All variables were expressed in first differences. A representative equation appears below, and selected flexibilities computed at the means of the variables appear in Table 12.

Estimation Results:

Late summer and fall production in the western region, 1951-1960:

$$P = -0.038 + \underset{(.042)}{0.036}\, Q_W (LS+F) - \underset{(.004)}{0.006}\, D - \underset{(.044)}{0.142}\, G_W + \underset{(.062)}{0.386}\, Q_W (W+ES+LS)$$

$$- 0.161\, Q\, (LS+F)-W \qquad R^2 = .94$$

where:

P = season average price received by farmers, late summer and fall potatoes in the western region, deflated by index of prices received by farmers for all farm products;

$Q_W(LS+F)$ = per capita production of late summer and fall potatoes in the western region;

D = per capita disposable income;

G_W = quantity of late summer and fall potatoes diverted under the government programs in the western region;

$Q_W(W+ES+LS)$ = per capita production of winter, early spring, and late spring potatoes in the western region;

$Q(LS+F)-W$ = per capita production of late summer and fall potatoes outside of the western region.

(Standard errors are in parentheses.)

X FREDERICK V. WAUGH. *Demand and Price Analysis: Some Examples from Agriculture.* USDA, ERS, Technical Bulletin No 1316, November 1964.

Scope: A general work on the methodology of estimating demand curves. Among the examples were three vegetable estimations: U.S. retail price for potatoes, sweet potatoes, and tomatoes.

Purpose: To present a base book in the area of demand and price analysis. "To make real progress, the statistician, the economic theorist, and the mathematician must cooperate closely with one another. Pure economic theory is merely idle amusement unless it is tested and applied. On the other hand, the compilation of statistical data is of no value unless the data are used to test and to quantify theory." p. 9.

Observational Interval: Annual.

Period of Analysis: 1948 through 1962 for potatoes and sweet potatoes, 1950 through 1962 for tomatoes.

Specification and Estimation Procedure: Price forecasting equations for each vegetable were fitted by OLS where the retail price was a linear function of per capita consumption and per capita disposable income. The farm-retail spread was also estimated as a function of the same two explanatory variables, and then the farm-level equations were derived by subtracting the spread from the retail equations. The equation sets for potatoes and tomatoes are presented below.

Estimation Results:

Potatoes

$$\hat{R} = 197.918 - \underset{(.469)}{1.448}\,Q + \underset{(.00698)}{.00751}\,Y \qquad R^2 = .6424$$

$$\hat{S} = 32.354 - \underset{(.132)}{.365}\,Q + \underset{(.00197)}{.02065}\,Y \qquad R^2 = .9654$$

$$\hat{F} = 165.564 - 1.083\,Q - .01854\,Y$$

Tomatoes

$$\hat{R} = 42.582 - \underset{(1.020)}{1.907}\,Q + \underset{(.00197)}{.00595}\,Y \qquad R^2 = .7291$$

$$\hat{S} = 21.574 - \underset{(.734)}{1.070}\,Q + \underset{(.00142)}{.00593}\,Y \qquad R^2 = .7901$$

$$\hat{F} = 21.008 - .837\,Q + .00002$$

where:

R = retail price per pound,

S = farm-retail spread per pound,

Q = per capita consumption, pounds,

Y = disposable income per capita.

(Standard errors are in parentheses.)

HOLBROOK WORKING. *Factors Affecting the Price of Minnesota Potatoes.* Minnesota Agricultural Experiment Station, Technical Bulletin No. 25, October 1925 (of historical interest).

Scope: Price of Minnesota potatoes in St. Paul and Minneapolis.

Purpose: To bring together information which helps in answering questions such as: Why does the price of potatoes change so much from year to year? How much are prices affected by a ten percent increase in production?

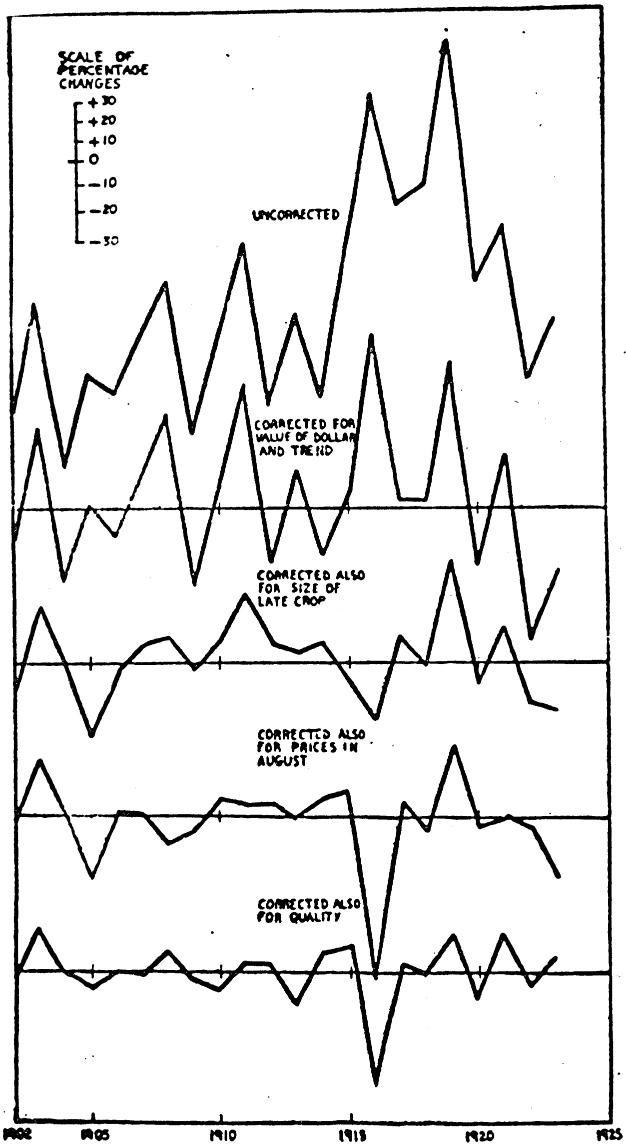
Observational Interval: Annual.

Period of Analysis: 1902 through 1924.

Specification and Estimation Procedure: Five factors were considered to affect the variation in potato prices. These were discussed one by one and then the effect of that factor was removed graphically leaving the residual to be explained by the next factor. First, changes in the value of the dollar were removed from the original potato price-against-time graph. Second, the general increase in the value of potatoes (an upward trend) was removed. Next, the fluctuation in potato production in percent above or below "normal" was taken away. Fourth, an adjustment was made for the price of potatoes in August. Finally, a proxy to measure the variation in quality of Minnesota potatoes was created (the difference is price between

Minnesota potatoes and "Maine" and "State and Western" potatoes in New York City), and its effect removed. The figures below show how close this procedure came to explaining the variation in potato prices. One final factor was considered, but the data were not available to use--the loss in storage from rot which was expected to have an inverse effect on price just as any other change in quantity would. The years in which field blight (causing rot in storage) was heavy or light corresponded closely with the remaining peaks and troughs, respectively.

Estimation Results:



Changes Remaining To Be Explained at Successive Stages in the Study

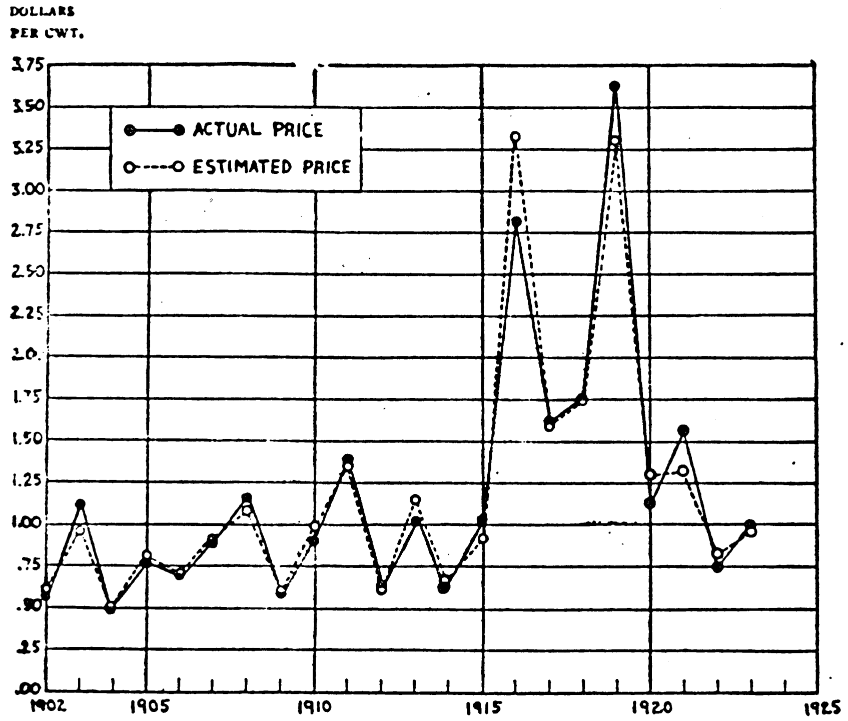


Fig. II. Actual and Estimated Prices of Potatoes, 1902-23

The hollow circles connected by the dotted lines show what the price would have been each year since 1902 if it had been affected by these five factors only. The solid circles show what the price actually was. The five factors explain most of the changes in the price of potatoes.

PINHAS ZUSMAN, "Econometric Analysis of the Market for California Early Potatoes," *Hilgardia*, V. 33, No. 11, December 1962, pp. 539-668.

Scope: The California early potato market relative to the U.S. market.

Purpose: "To analyze quantitatively the static and dynamic properties of the market for California early potatoes." p. 539.

Observational Interval: Annual.

Period of Analysis: 1930 through 1958. The 1942 through 1950 period was excluded since the heavy support program during this period was expected to alter the structure substantially.

Specification and Estimation Procedure: An econometric model of 14 linear equations consisting of 14 endogenous, 15 exogenous, 8 lagged endogenous, and several lagged exogenous variables was constructed. Six of the equations were treated as a simultaneous subsystem and estimated by TSLS: (1) transfer farm-retail, late crop, (2) demand for late potatoes for food, September-February, (3) demand for late potatoes for nonhuman use, (4) supply of late potatoes in September-February, (5) late crop supply (identity I), and (6) late crop supply (identity II). The remaining eight equations were estimated by OLS: (1) production--late crop, (2) demand for potatoes in the spring, (3) California supply identity, (4) other spring potatoes supply identity, (5) California production response, (6) other spring production response, (7) transfer farm-retail, California, (8) transfer farm-retail, other spring potatoes. The three demand relationships are presented below.

Estimation Results: Demand for late potatoes for food, September-February (TSLS)

$$Y_{6t} = - .951326 - \underset{(.0379)}{.061216}\, Y_{3t} + \underset{(.00420)}{.008383}\, Z_{2,t-1} - \underset{(.000197)}{.000137}\, Z_{6t}$$

$$- \underset{(.00411)}{.004209}\, Z_{7t}$$

Demand for late potatoes for nonhuman use (TSLS):

$$Y_{4t} = - .149629 + \underset{(.0498)}{.136288}\, Y_{1t} - \underset{(.0432)}{.073369}\, Y_{2t} + \underset{(.00168)}{.004926}\, Z_{2,t-1}$$

Demand for potatoes in the spring (OLS):

$$Y_{8t} = - 8.552166 - \underset{(2.152)}{8.152740}\, Y_{7t} - \underset{(8.497)}{19.568923}\, Y_{9}$$

$$- \underset{(3.435)}{10.252981}\, Y_{10} + \underset{(.0641)}{.004885}\, Z_{2t} - \underset{(.00136)}{.002842}\, Z_{6t} + \underset{(.0258)}{.006765}\, Z_{7t}$$

$R^2 = .6867$

where:

Y_6 = quantity per capita of late potatoes consumed as food September-February, bushels per capita;

Y_3 = real retail price of potatoes in September-February, dollars per bushel;

Z_2 = time (calendar year 1925 = 1);

Z_6 = real United States per capita disposable income, dollars per capita;

Z_7 = real index of retail prices of cereals and bakery products;

Y_4 = quantity per capita of late potatoes fed to livestock, lost, etc., bushels per capita;

Y_1 = per capita production of late potatoes, bushels per capita;

Y_2 = real average price received by growers of late crop in September-February, dollars per bushel;

Y_8 = real retail price of potatoes in the spring, dollars per bushel;

Y_7 = quantity per capita of late potatoes carried over to the spring bushels per capita;

Y_9 = per capita consumption of California spring potatoes, bushels per capita;

Y_{10} = per capita consumption of other states spring potatoes, bushels per capita.

(Standard errors are in parentheses.)

TABLE 12: Selected Econometric Analyses With Flexibility or Elasticity Estimates for Potatoes

Author and Date	Geographical Area	Time Period	Observational Interval	Form of Equation	Method of Estimation	Market Level	Product	Price Flexibility	Income Flexibility	Cross Effect	Price Elasticity	Income Elasticity	Cross Elasticity
Clevenger and Geithman, 1977	U.S.	1957-1972	Annual	linear	OLS	farm	potatoes				-0.83		
							sweet potatoes				-1.05		
Hee, 1967	U.S.	1947-1960	Annual	linear	limited information		late summer and fall					0.07 n.s.[a]	
						retail	for food				-0.21		
						farm	for feed				-0.51		
						farm	for starch				-1.01		
					limited information		winter and early spring for food				-2.63	0.32 n.s.	2.07
						farm	fall (from storage)				-0.21	-0.34 n.s.	0.17
					OLS		late spring for food				-0.59	0.38 n.s.	0.38
						farm	fall (from storage)				-1.88	0.48 n.s.	1.32
					limited information		early summer (July-August)						
							early summer potatoes				-0.67	0.52 n.s.	0.44[b] 0.28[c]
						farm	late spring potatoes				-0.52	-0.18	0.89[d]
							late summer potatoes (early maturing)				-0.48	0.24 n.s.	0.29 n.s.[d]
Schrimper and Mathia, 1975	U.S.	1949-1972	Annual	linear	3SLS		sweet potatoes						
						farm	commercial use				-0.65	0.21	> 0[e]
							on-farm use				-1.25	0.21	> 0[e]
Shuffett, 1954	U.S.	1921-1941	Annual	first differences of the logs	OLS	farm	early and intermediate crop	-2.114					
							late crop	-4.028					
							total crop	-3.517					
Siebert, 1967	California	1956-1966	Annual	double log	OLS	farm	late spring crop				-1.20		-0.36[f]
Simmons, 1962	U.S.	1951-1960	Annual	first differences of the variables	OLS	farm	U.S. winter and early spring crop	n.s.		-2.44[g]			
							U.S. late spring	-4.00		-1.41[g]			
							U.S. late summer and fall	-5.00					
Waugh, 1964	U.S.	1948-1962	Annual	linear	OLS		potatoes						
						retail		-2.567	.212				
						farm		-5.277	-1.439				
							sweet potatoes						
						retail		- .764	- .627				
						farm		-1.148	-1.662				
Zusman, 1962	U.S.	1938-1958, excluding 1942-1950	Annual	linear	TSLS	farm	late potato crop	-7.225	.909	2.717[h]			
					OLS	farm	spring potatoes	-3.397[i] -1.780[k]	.989	-1.415[j]			

a/ n.s. = not statistically significant by the t-test, 90 percent, one-tailed confidence level.
b/ wrt. late spring potatoes
c/ wrt. late summer potatoes
d/ wrt. early summer potatoes
e/ the positive coefficient indicates a substitution effect with white potatoes
f/ wrt. other U.S. raw potato supplies
g/ wrt. stocks of storage potatoes
h/ wrt. cereals and bakery products
i/ wrt. per capita consumption of California spring potatoes
j/ wrt. per capita quantity of carry over potatoes
k/ wrt. per capita consumption of states other-than-California spring potatoes

Related Studies, Potatoes

Brandow, G. E. *Causes of Changes in the Prices of Potatoes.* Pennsylvania Agricultural Experiment Station, Journal Series Paper No. 1331, June 1946. The variations in the U.S. farm, Pennsylvania farm, N. Y. wholesale, and U.S. retail prices for the 20 years between World Wars I and II were analyzed by graphics and by correlation with changes in U.S. production.

Foytik, Jerry and Ann Hertzendorf. *Consumption Patterns for Potatoes, Rice, and Macaroni in Northern California, 1968.* California Agricultural Experiment Station, Bulletin No. 848, January 1971. The report describes the findings about the prevailing purchase and use of patterns in Northern California from interviews made at 1192 households.

Grieg, W. Smith, Forrest O. Strand, and Henry Larzelere. *Relative Retail Sales and Elasticity of Demand for Dehydrated Mashed Potato Products.* Cooperative Extension, Michigan State University, Agricultural Economics Report No. 732, July 1958. Market tests at seven retail stores in the Detroit area were performed on a new potato flake product and sales were compared with two other dehydrated products already on the market.

Grieg, W. Smith and Leroy Blakeslee. *Potatoes: Optimum Use and Distribution with Comparative Costs by Major Regions of the U.S.* College of Agriculture Research Center, Washington State University, Bulletin No. 865, August 1978. A linear programming model was used to minimize the total cost of production, processing, and distribution of major product forms (fresh, potatoes for chips, frozen french fries, and dehydration) from nine major U.S. potato producing areas.

Hee, Olman. *A Seasonal Potato Market: Area of Competitive Behavior.* USDA, ERS. Paper presented at the American Farm Economics Association Annual Meeting, August 1964. From two reduced form, price dependent, linear equations estimated by OLS, direct price and cross elasticities were computed for late spring potatoes and for fall (storage) potatoes. A more complete analysis is found in the study by Hee, reviewed in this report on page 123.

Mathia, Gene A. and Richard A. King. *Planning Data for the Sweet Potato Industry.* North Carolina State College, Agricultural Economics Information Series No. 97, December 1962. A study of the optimum number, size, and location of sweet potato processing plants in Eastern North Carolina counties. An economic-engineering approach was used to estimate assembly and processing costs.

McCorkle, Chester O. and Yair Mundlak. "Statistical Analysis of Supply Response in Late Spring Potatoes." California Agricultural Experiment Station, *Hilgardia*, Vol. 24, No. 16, April 1956. An acreage response function was specified for late spring potatoes in California. From alternative expressions of this function, estimated by OLS, it was determined that a large part of the variation in acreage could be explained by gross income from competing crops, potato prices from previous season(s), and acreage available to be planted in potatoes.

Meinken, Kenneth W. *Factors That Affect Price and Distribution of New Jersey Potatoes*. New Jersey Agricultural Experiment Station, Bulletin No. 786, June 1957. Several price forecasting equations were fitted in double log form by OLS: (1) New Jersey farm-level price as a function of New Jersey production and Long Island production; (2) Maine farm-level price as a function of Maine production, production in eight eastern late-potato states, and production in nine central late-potato states; (3) Long Island farm-level price as a function of Long Island production, New Jersey production, and production in eight eastern late-potato states and western New York.

Mundlak, Yair and Chester O. McCorkle, Jr. "Statistical Analysis of Supply Response in Late Spring Potatoes in California." *Journal of Farm Economics*, Vol. XXXVIII, No. 2, May 1956, pp. 553-569. Several formulations of acreage response equations were estimated by OLS for the period 1929 through 1953.

Summers, Larry V. and Carole Drury. *Marketing Northwest Potatoes*. Idaho Agricultural Experiment Station, Bulletin No. 529, December 1971. A description was given of the recent changes and the present importance of potato production and marketing in four regions of the Northwest: Washington; ten southwest counties of Idaho and Malheur County, Oregon; other counties in Idaho; other counties in Oregon. Growth rates, marketing patterns, and price changes were compared among the regions and with the total U.S. potato production.

Young, Ralph and William G. Tomek. *A Comparison of Marketing Strategies for Potatoes in Upstate New York*. Department of Agricultural Economics, Cornell University, Staff Paper No. 78-15, June 1978. A price forecasting equation was used in two of six marketing strategies evaluating the effect of hedging on a farmer's returns. From March 31, 1968 to March 31, 1977, the midpoint of the N. Y. price range for the last full week in March was fitted by OLS as a linear function of price the last full week of the previous October and total U.S. production of fall potatoes the previous year.

Zusman, P. "An Investigation of the Dynamic Stability and Stationary Status of the United States Potato Market." *Econometrica*, Vol. 30, No. 3, July 1962. The paper is based on the same model as the larger work reviewed in this report on page 132.

Strawberries and Other Berries

Abstracts

WILLIAM E. GOBLE. *Tennessee's Competitive Position in Producing and Marketing Strawberries.* Tennessee Agricultural Experiment Station, Bulletin No. 332, September 1961.

Scope: U.S. strawberry farm prices and acreage response.

Purpose: To present information of help in determining Tennessee's competitive status in the strawberry industry.

Observational Interval: Annual.

Period of Analysis: 1929 through 1958, excluding 1942 through 1947.

Specification and Estimation Procedure: As part of the study a price forecasting equation was fitted by OLS in first differences of the logs. Graphic analysis revealed a cobweb-like behavior in production and prices. Accordingly, acreage response was seen as a function of deflated prices, lagged two years, as well as per capita income and strawberry consumption.

Estimation Results:

$$\Delta \ln X_1 = -0.0170 - \underset{(0.3003)}{0.0595}\,\Delta \ln X_2 + \underset{(0.2077)}{0.8175}\,\Delta \ln X_3 - \underset{(0.3626)}{0.6959}\,\Delta \ln X_4$$

$$R^2 = .66$$

where:

X_1 = average farm price of strawberries, cents per pound;

X_2 = production of strawberries in pounds;

X_3 = disposable personal income per capita;

X_4 = consumption of strawberries per capita.

(Standard errors are in parentheses.)

G. L. MEHREN and H. E. ERDMAN. "An Approach to the Determination of Intraseasonal Shifting of Demand." *Journal of Farm Economics*, Vol. 27, No. 2, May 1946, pp. 587-596.

Scope: Louisiana auction prices in response to total U.S. strawberry shipments and in response to Louisiana and other-than-Louisiana shipments.

Purpose: To determine ". . .whether changes in price of a perishable product during its marketing season represent intraseasonal movements along a single seasonal demand function or a systematic pattern of intraseasonal shifts of the demand function itself." p. 587.

Observational Interval: Annual--using the weekly average of daily observations for the same week of each marketing season, not corresponding to calendar classification.

Period of Analysis: 1924 through 1940.

Specification and Estimation Procedure: Separate linear multiple regressions were fitted by OLS for each week of seven weeks of the Louisiana marketing season. The equations were of the form:

$$P = a_1 + b_1 Q_{U.S.} + c_1 I + d_1 T \text{ and}$$

$$P = a_2 + b_2 Q_L + c_2 Q_O + d_2 I + e_2 T$$

where:

P = the weekly weighted average of daily auction prices of Louisiana strawberries,

$Q_{U.S.}$ = U.S. shipments of strawberries in cars,

Q_L = shipments of Louisiana strawberries in cars,

Q_O = shipments of other-than-Louisiana strawberries in cars,

I = index of nonagricultural income for April of each year (1924-29 = 100),

T = time in years (origin = 1933).

Estimation Results: In the 14 equations, all coefficient estimates were statistically significant (by the t-test) except for the one associated with Louisiana shipments in week seven. The explanatory power of all equations was good.

The net regressions of price on U.S. shipments (holding all other variables constant at their mean values) revealed an interesting pattern:

Week of Season	Constant	Slope Coefficient, U.S. Quantity
1.	4.1013	-0.0042
2.	3.9692	-0.0029
3.	4.1703	-0.0027
4.	3.9147	-0.0018
5.	3.8474	-0.0016
6.	4.0330	-0.0016
7.	2.6818	-0.0006

"The striking fact is the systematic decrease in slope from week to week as the season progresses. The probability of the purely fortuitous occurrence of this stable pattern seems indeed small. It is evident. . . that either for constant shipments or for constant price, elasticity of demand increases as the season advances." p. 594-5

Related Studies, Strawberries and Other Berries

Bain, Beatrice M. and Sidney Hoos. *The California Strawberry Industry--Changing Economic and Marketing Relationships*. California Agricultural Experiment Station, Giannini Foundation of Agricultural Economics, Research Report No. 267, January 1963. The informational report was made in view of two dramatic changes that took place in the strawberry industry after World War II: "(1) the growth in importance of the Pacific Coast in the production of strawberries, with the greatest increase found in California, and (2) the shift in utilization of the strawberry crop--with a larger percentage of the national production going into processing. . ." p. 1. As part of the report, several OLS grower-level price analyses were performed considering fresh and processing berries, both aggregated and disaggregated. Annual data for the years 1947 through 1961 were used.

Cravens, M. E. and L. U. Cockroft. *Trends in the Ohio Strawberry Industry*. Ohio Agricultural Experiment Station, Research Bulletin No. 787, January 1957. As part of the report on the Ohio and U.S. strawberry industry, an OLS price forecasting equation for Ohio strawberries was fitted using annual data, 1919 through 1954.

Dennis, Carleton C. "Strawberry Prices and Marketing Margins." *Quarterly Bulletin*, Michigan Agricultural Experiment Station, Vol. 43, No. 3, February 1961, pp. 648-659. In investigating the marketing situation for Michigan strawberries, several simple, linear, price dependent regressions were fitted by OLS: Michigan fresh, California fresh, U.S. fresh, and U.S. processing.

Dennis, C. C. and L. L. Sammet. "Interregional Competition in the Frozen Strawberry Industry." California Agricultural Experiment Station, *Hilgardia*, Vol. 31, No. 15, December 1961, pp. 499-611. Using an adaption of the linear programming transportation problem, optimal locations of processing plants for frozen strawberries was determined under the assumptions of several different models. Projections of frozen strawberry consumption by region were made to 1970, for use in the models.

Dennis, C. C. and L. L. Sammet. *Regional Location of Production and Distribution of Frozen Strawberries*. California Agricultural Experiment Station, Giannini Foundation of Agricultural Economics, Mimeographed Report No. 231, June 1960. A study was made of the comparative advantage of different U.S. producing regions in supplying frozen strawberries to the national market. The report is one of a series on the supply and distribution of frozen fruits and vegetables.

French, B. C. "Trends in Blueberry Consumption." *Quarterly Bulletin of the Michigan Agricultural Experiment Station*, Vol. 40, No. 1, August 1957, pp. 34-43. From food consumption records of the Michigan State University Consumer Panel (about 250 urban families), trends in blueberry consumption were compared with some national-level statistics, 1929-1954.

Mathia, Gene A. and Ronald A. Schrimper. *The Fresh Market Demand for Blueberries*. Department of Economics, North Carolina State University at Raleigh, Economics Research Report No. 22, July 1972. Wholesale market daily demand relationships (1965-1971) were estimated by OLS from three supply areas--North Carolina, New Jersey, and Michigan--to ten major metropolitan areas. Demand for fresh blueberries was found to be highly elastic when elasticities were computed at the means of the variables for several of the equations.

Tomatoes

Abstracts

ROBERT W. BOHALL. *Pricing Performance in Marketing Fresh Winter Tomatoes.* USDA, ERS, Marketing Research Report No. 977, 1972.

Scope: FOB prices of southern Florida large and extra-large vine-ripe tomatoes; also Mexican winter tomatoes marketed from Arizona.

Purpose: ". . .to determine if the behavior of weekly tomato prices at shipping points and wholesale terminal markets is generally consistent with a competitive marketing system." p. ii.

Observational Interval: Weekly.

Period of Analysis: First week of January through the last week in March for three years--1966, 1967, and 1968.

Specification and Estimation Procedure: As part of the analysis, a price forecasting equation for Florida large and extra-large vine-ripe tomatoes was estimated by OLS. Two weather variables--the previous week's average low temperature at Pompano Beach and the total previous October rainfall--were included as proxies for quality differences. To allow for a build-up of supplies in marketing channels, the ratio of average Florida shipments over the previous two weeks to the current week's shipment was added as a variable.

Another equation was fitted which estimated the relationship between weekly, Nogales, Arizona, shipping-point prices of Mexican tomatoes and the quantity of tomatoes available. The Arizona equation included two dummy variables to separate the three years so that the discontinuity in the data series was accounted for.

Estimation Results:

The Florida Equation:

$$Y_{TFj} = 15.62 - \underset{(0.0014)}{0.0094}\, X_{TFj} - \underset{(0.0007)}{0.0012}\, X_{TMj} - \underset{(0.0167)}{0.0446}\, T_{j-1} - \underset{(0.0096)}{0.0191}\, R_j$$

$$- \underset{(0.6488)}{2.9957}\, P_j \qquad R^2 = 0.73$$

where:

Y_{TFj} = the FOB price of southern Florida large and extra-large vine-ripe tomatoes in 20-pound cartons, week j;

X_{TFj} = total carlots of tomatoes shipped from Florida in week j;

X_{TMj} = total carlots of tomatoes shipped from Mexico, week j;

T_{j-1} = previous week's average low temperature at Pompano Beach, Fla.;

R_j = total previous October rainfall at Pompano Beach, Fla., = 34.40 inches in 1965 for winter of 1966; 12.72 inches in 1966 for winter of 1967; and 13.77 inches in 1967 for winter of 1968;

P_j = ratio of average shipments from Florida the previous 2 weeks to the current week's shipments; and

j = weeks 1-39 with 1-13 = winter 1966, 14-26 = winter 1967, and 27-39 = winter 1968.

(Standard errors are in parentheses.)

The Arizona Equation:

$$Y_{TMj} = 1.79 - \underset{(0.0008)}{0.0017}\, X_{TMj} + \underset{(0.0281)}{0.0495}\, T_{Cj-2} - \underset{(0.4342)}{0.7729}\, P_j - \underset{(0.25)}{1.55}\, D_{66}$$

$$- \underset{(0.26)}{1.79}\, D_{67} \qquad R^2 = 0.68$$

where:

Y_{TMj} = the Nogales, Ariz., FOB price of Mexican 6 x 6 tomatoes in 3-layer lugs, week j;

X_{TMj} = total carlots of tomatoes shipped from Mexico, week j;

T_{Cj-2} = average high temperature, Culiacan, Mexico, 2 weeks previous;

P_j = ratio of average shipments from Florida the previous 2 weeks to the current week's Florida shipments;

D_{66} = dummy or indicator variable for 1966 winter season = 1.0 for 1966 and 0 for 1967 and 1968;

D_{67} = indicator variable for 1967 winter season = 1.0 for 1967 and 0 for 1966 and 1968; and

j = weeks 1-39 with 1-13 = winter 1966, 14-26 = winter 1967, and 27-39 = winter 1968.

(Standard errors are in parentheses.)

WEN S. CHERN and RICHARD E. JUST. *Econometric Analysis of Supply Response and Demand for Processing Tomatoes in California.* California Agricultural Experiment Station, Giannini Foundation of Agricultural Economics, Monograph No. 37, September 1978.

Scope: Processing tomatoes in ten major producing counties in California.

Purpose: ". . .to assess the effect of contracting on acreage and price determination in the raw tomato market and to estimate the impact of the tomato harvester on structural parameters of acreage response and demand for processing tomatoes in California." From the Abstract.

Observational Interval: Annual.

Period of Analysis: 1951 through 1975.

Specification and Estimation Procedure: First, using ten-county aggregate data, an earlier model[1/] was updated by adding three more years of data (1973 through 1975). The model included: (1) an acreage response equation;

1/ Wen S. Chern, *Supply Response and Price-Demand Relationship for California Processing Tomatoes*, Unpublished Ph.D. dissertation, Department of Agricultural Economics, University of California, Berkeley, 1975.

(2) the demand for processing tomatoes as a function of grower price, inventory of tomato products, weighted FOB price of tomato products, and disposable income; and (3) acreage related to quantity demanded and yield. The estimates of the updated (2) and (3) were quite similar to the earlier version, but notable changes occurred in the acreage response equation (1). The 3SLS estimate of the price elasticity of acreage response, for example, increased to 2.70 for 1951-1975, up from 1.66 for 1951-1972. It was noted that the previous model included only six years of the post-harvester period and so actually reflected mainly the pre-harvester situation.

In order to increase the sample size so that pre- and post-harvester time periods could be investigated, pooled time series and cross-section (nine county[2/]) analysis was performed. When the number of time series observations is small compared with the number of cross-section units, however, the 3SLS estimator does not exist. Three different techniques were therefore used at the second of the three stages resulting in models: III. Covariances between counties constrained to be zero, IV. Covariances between equations constrained to be zero, and V. Ridge regression (a scalar times an Identity matrix). It was thought that all three versions improved upon the efficiency of TSLS estimates (II). The system was also estimated by OLS (I).

Since Fresno County was an important tomato producer only after the adoption of the harvester, pre-harvester estimates (1951-1963) exclude Fresno. Two sets of post-harvester estimates were done--with and without Fresno County.

2/ Merced County was excluded since noncontract acreage predominated there.

Estimation Results:

Aggregate ten county demand results by three estimation methods, 1951-1975:

Normalized variable	Estimation method	Constant	ln P	ln R	ln I	R^2
	3SLS	4.28 (.81)	-.703 (.45)	1.247 (.42)	.629 (.10)	.82
$\ln Q_c$	2SLS	4.19 (.81)	-.659 (.45)	1.195 (.42)	.633 (.10)	.91
	OLS	3.61 (.52)	-.284 (.23)	.875 (.25)	.608 (.09)	.92

where:

Q_c = purchased quantity (production), thousand tons;

P = grower price, dollars per ton;

R = January-March, weighted average of product prices, dollars;

I = U.S. disposable personal incomes, billion dollars.

(Standard errors are in parentheses.)

Pooled time series and cross-section demand results by five estimation methods, 1951-1963 and 1967-1975:

Elasticity	Estimation method	Preharvester (1951-1963)	Postharvester (1967-1975)	
			Without Fresno County	Including Fresno County
Grower price	I (OLS)	- .82	- .37	- .44
	II (2SLS)	-1.91	- .61	- .73
	III (3SLS)	-1.65	- .19	- .16
	IV (3SLS)	- .75	- .18	a
	V (3SLS)	-1.60	-5.53	- .39
Inventory	I (OLS)	- .14	- .13	- .10
	II (2SLS)	- .19	- .15	- .13
	III (3SLS)	- .16	- .24	- .27
	IV (3SLS)	- .16	- .01	
	V (3SLS)	- .07	.39	- .33
Consumer income	I (OLS)	1.64	.29	.40
	II (2SLS)	1.86	.23	.33
	III (3SLS)	1.64	.76	.97
	IV (3SLS)	1.67	.27	
	V (3SLS)	1.57	.85	1.15
Produce price	I (OLS)	1.80	.77	.94
	II (2SLS)	2.65	1.03	1.27
	III (3SLS)	2.10	.30	.26
	IV (3SLS)	1.49	.67	
	V (3SLS)	2.49	.64	.64

Note that, except for V (3SLS), demand for processing tomatoes at the grower-level became more inelastic after the adoption of the harvester, as did the income elasticity. The aggregate estimates in the previous table appear in most cases to fall in between the pooled pre-and post-harvester elasticities. Also, note that in all cases the elasticity with respect to the price of tomato products is greater in absolute value than that with respect to the grower price.

ROBERT S. FIRCH and ROBERT A. YOUNG. *An Economic Study of the Winter Vegetable Export Industry of Northwest Mexico.* Arizona Agricultural Experiment Station, Technical Bulletin No. 179, October 1968.

Scope: U.S. demand for Mexican-grown tomatoes, cantaloupes, peppers, watermelons, cucumbers, eggplant, summer squash, and green beans.

Purpose: ". . .to present information which will assist. . .individuals and organizations in both nations to understand the effects" of important economic relationships in the production, packing, exportation, and distribution of fresh winter vegetables from the Northwest Coast of Mexico. p. 9.

Observational Interval: Weekly.

Period of Analysis: 1961 through 1966.

Specification and Estimation Procedure: By far the most important exported vegetable is fresh tomatoes, so a more complete specification of the demand for tomatoes was done. First, six separate equations for each year were fitted by OLS with the weekly price in Nogales, Arizona, as a linear function of the U.S. per capita shipments from West Mexico and shipments from all other sources. Only the 1963 equation, however, produced significant statistical results. The six-year average of the residuals (R) from the equations was then added as a variable to capture any systematic seasonal variation. The six years of data were combined and another equation was fitted including R and also U.S. per capita disposable income. In another version, five 0-1 dummies for five of the six years replaced the income variable. Finally, to get a measure of the total elasticity of demand, the quantities from Mexico and from all other sources were summed and the equation was rerun with R and the five dummies.

Demand for the other six vegetables was estimated in two ways: (1) price as a function of the quantity from West Mexico and from all other sources and (2) price as a function of the total supply.

Estimation Results:

Tomatoes

$$(1)\quad P = 5.2547 - \underset{(0.1028)}{0.2818}\, Q_1 - \underset{(0.0503)}{0.1438}\, Q_2 + \underset{(0.2124)}{1.1126}\, R - \underset{(0.2482)}{1.3259}\, T_1$$

$$- \underset{(0.2371)}{0.4428}\, T_2 - \underset{(0.2366)}{0.2908}\, T_3 - \underset{(0.2333)}{0.0836}\, T_4 - \underset{(0.2330)}{0.4168}\, T_5$$

$$\bar{R}^2 = .31$$

where:

P = price in Nogales, Arizona;

Q_1 = shipments per capita (U.S.) of tomatoes from West Mexico;

Q_2 = shipments per capita (U.S.) of tomatoes from all other sources;

R = the average of the residuals from the six yearly equations;

$T_1, \ldots, T_5$ = 0-1 dummy variables for five of the six years.

(Standard errors are in parentheses.)

$$(2)\quad P = \underset{}{5.0394} - \underset{(0.0499)}{0.1606}\, Q_3 + \underset{(0.2043)}{1.0439}\, R = \underset{(0.2444)}{1.2655}\, T_1 - \underset{(0.2365)}{0.4716}\, T_2$$

$$- \underset{(0.2369)}{0.2958}\, T_3 - \underset{(0.2336)}{0.0987}\, T_4 - \underset{(0.2335)}{0.4733}\, T_5$$

$$\bar{R}^2 = .30$$

where:

Q_3 = total shipments of tomatoes to United States markets.

Other variables are as defined above.

Regression Estimates from Single Equation Model

Vegetable	b_0	b_1	b_2	Adjusted R^2
Cantaloups	16.5806	— 0.9082† (0.3446)	—0.2170 (0.2563)	0.2960
Peppers	37.6223	— 0.4907 (0.4742)	—5.2202‡ (1.5063)	0.1671
Watermelons	145.3294	—10.5740‡ (2.9204)	—0.7223 (1.8015)	0.4553
Cucumbers	30.8032	— 2.3464‡ (0.3302)	—2.9089‡ (0.6255)	0.6382
Eggplant	6.2107	— 0.3620† (0.1406)	—0.8025‡ (0.2639)	0.1805
Squash	13.4445	— 0.9605† (0.3610)	—1.5400 (0.9574)	0.1512

*$P = b_0 + b_1 \log Q_1 + b_2 \log Q_2 + e$
where P = Price in Nogales, Arizona
Q_1 = Shipments of vegetables from West Mexico
Q_2 = Shipments of vegetables from all other sources.
†T test significant at 5 percent level
‡T test significant at 1 percent level

Demand in the Total Market

Vegetable	b_0	b_3	R^2
Cantaloups	16.7430	—1.0187‡ (0.3382)	0.2777
Peppers	44.2183	—6.5533‡ (1.7009)	0.2325
Watermelons	140.2008	—7.0590‡ (1.8369)	0.3309
Cucumbers	35.2157	—5.2546‡ (1.0344)	0.3888
Eggplant	6.8600	—1.1238† (0.3221)	0.1615
Squash	12.9151	—1.8200 (1.1325)	0.0445

*$p = b_0 + b_3 Q_3 + e$
where P = Price in Nogales, Arizona
Q_3 = Shipments of vegetables from all sources.
†T test significant at 5 percent level
‡T test significant at 1 percent level

JERRY FOYTIK. *Demand Characteristics for Vine Vegetables in Honolulu, Hawaii, 1947-1961.* Abstracted under beans on page 37.

MARSHALL R. GODWIN and WILLIAM T. MANLEY. *Demand and Competitive Relationships for Florida and Greenhouse-Grown Tomatoes.* Florida Agricultural Experiment Station and the Institute of Food and Agricultural Sciences in Cooperation with the USDA, Bulletin No. 703, December 1965.

Scope: Florida vine-ripened and mature green tomatoes and greenhouse-grown tomatoes from the Great Lakes region.

Purpose: To examine the characteristics of demand for the three types of tomatoes--the relationship between the price of each of these products and the quantities that consumers will purchase and the economic interrelationships among the three kinds of tomatoes.

Observational Interval: Daily.

Period of Analysis: April 22 through June 1, 1963.

Specification and Estimation Procedure: Market experiments were conducted at six retail food centers in northwestern Ohio. The stores selected were representative of population variation with respect to race, income, and ethnic background. All three types of tomatoes were of U.S. No. 1 quality. Prices were varied in four cent intervals above and below a base price for each type. Thirty-one different price combinations generated the test data. Price elasticities and substitution relationships are summarized below.

Estimation Results:

Effect of Price on Purchase of Tomatoes

Product Type:	Sales Response to a 1 Percent Price Change:
Greenhouse-grown	-1.8
Vine-ripened	-1.8
Repacked (mature green)	-1.7

Substitution relationships between greenhouse-grown, vine-ripened, and mature green tomatoes.

A One Percent Price Change for:	Percentage Effect on Sales of:		
	Greenhouse-Grown Tomatoes	Vine-Ripened Tomatoes	Mature Green Tomatoes
Greenhouse-grown tomatoes	——	.31	None
Vine-ripened tomatoes	.47	——	.25
Mature green tomatoes	.39	1.01	——

E. V. JESSE and M. J. MACHADO. *Trends in Production and Marketing of California Fresh Market Tomatoes.* University of California Agricultural Extension Service, Division of Agricultural Sciences, 75-BL/1871, April 1974.

Scope: In a technical appendix to the general report, an econometric model of the pricing system for California fresh tomatoes, including seasonal variations, was estimated.

Purpose: Information from interrelationships analyzed in the model may be helpful in understanding "how prices evolve" and can be used "to protect production and price levels under alternative market conditions." pp. 16-17.

Observational Interval: Annual. The three seasons--spring, summer, and fall--were treated separately.

Period of Analysis: 1948 through 1972.

Specification and Estimation Procedure: A three equation, econometric model was estimated. First, three acreage response equations for the three seasonal crops were fitted by OLS since the independent variables were considered predetermined. Planted acreage was expressed as a function of a declining weighted average price for the preceding three years, the wage rate for farm labor, the standard deviation of grower returns over the past five years (a measure of risk), a trend variable, and the California average contract price for cannery tomatoes (a competing crop).

The two linear equations for harvest tonnage supply and demand for each of the three seasons were over-identified and were estimated by TSLS. The endogenous variables were price and production; the exogenous, an other-states competing production variable, the date of first reported seasonal shipment, a trend variable, the California average contract price for cannery tomatoes, and acreage planted.

Estimation Results:

1. Spring

Demand: $$P_F = 14.685 + \underset{(2.883)}{3.002}\,\hat{Q}_F - \underset{(1.140)}{2.470}\,C + \underset{(.043)}{.066}\,F + \underset{(.054)}{.243}\,T$$

$$R^2 = .70$$

Supply: $$Q_F = -.104 + \underset{(.014)}{.011}\,\hat{P}_F + \underset{(.029)}{.153}\,A$$

$$R^2 = .63$$

2. Summer

Demand: $P_F = 10.72 - \underset{(1.490)}{4.513}\ \hat{Q}_F - \underset{(1.289)}{.591}\ C - \underset{(.037)}{.043}\ F + \underset{(.137)}{.668}\ T$

$R^2 = .77$

Supply: $Q_F = -.948 + \underset{(.032)}{.119}\ \hat{P}_F + \underset{(.026)}{.181}\ A - \underset{(.014)}{.007}\ P_C$

$R^2 = .85$

3. Fall

Demand: $P_F = 13.666 - \underset{(1.306)}{2.620}\ \hat{Q}_F - \underset{(1.052)}{.301}\ C - \underset{(.017)}{.035}\ F + \underset{(.117)}{.335}\ T$

$R^2 = .83$

Supply: $Q_F = -1.605 + \underset{(.032)}{.177}\ \hat{P}_F + \underset{(.033)}{.175}\ A$

$R^2 = .61$

where:

P_F = California season-average grower returns for fresh tomatoes, dollars per cwt.;

$\hat{P}_F$ = returns as estimated from the reduced form equation;

Q_F = California seasonal production, million cwt.;

$\hat{Q}_F$ = production as estimated from the reduced form equation;

C = competitive production--seasonal production in states other than California, million cwt.;

F = date of first reported seasonal shipments, expressed as the deviation in number of days from the mean first-shipment-date, 1948-1972;

T = time, 1948 = 1, 1949 = 2,..., 1972 = 25;

A = planted acreage, 1000 acres;

P_C = California average contract price for cannery tomatoes, dollars per ton.

(Standard errors are in parentheses.)

GORDON A. KING, EDWARD V. JESSE, and BEN C. FRENCH. *Economic Trends in the Processing Tomato Industry.* California Agricultural Experiment Station, Giannini Foundation of Agricultural Economics, Information Series No. 73-4, November 1973.

Scope: In the appendix of the report on the U.S. tomato processing industry, estimates of U.S. demand for canned tomatoes, tomato juice, catsup and chili sauce, puree, and paste at the FOB price level were presented.

Purpose: The demand analysis provided statistical background for the overall, general report which included structural characteristics of the processed tomato industry (at the grower and processor levels), trends in per capita consumption, trends in the supply and disposition of tomato products, factors influencing the utilization of tomatoes by region, trends in production and cost, and a verbal description of demand for processed tomato products.

Observational Interval: Annual.

Period of Analysis: 1948 through 1971 for canned tomatoes and juice; 1948 through 1967 for catsup and chili sauce; 1953 through 1971 for paste.

Specification and Estimation Procedure:

1. Canned whole tomatoes. Two equations of a theoretical five-equation system were estimated by TSLS: domestic consumption and change in canners' stocks. Export and import equations were not estimated due to difficulty in obtaining data. It was noted that exports amounted to only one percent of the total U.S. supply of canned tomatoes. The quantity imported, which amounted to approximately ten percent of U.S. supply, was treated as a predetermined variable in the system. The fifth equation established the identity: the total quantity equals the quantity packed plus imports (minus exports) minus the change in stocks.

Estimation Results:

$$Q_{tc} = -22.49 - \underset{(4.08)}{12.07}\, P_{tc} + \underset{(3.37)}{36.17}\, \ln Y$$

$$\Delta_{ts} = 13.01 - \underset{(3.727)}{7.340}\, P_{tc} + \underset{(.0611)}{.3251}\, Q_{tp} - \underset{(.1180)}{.7392}\, Q_{tbs}$$

where:

Q_{tc} = total U.S. consumption, million cases;

P_{tc} = season average price, 303 cans, deflated by the CPI (1958 = 100), dollars per case;

Y = total U.S. disposable personal income, deflated by the CPI, dollars;

Δ_{ts} = change in stocks, million cases;

Q_{tp} = quantity packed, million cases;

Q_{tbs} = stocks on hand, July 1, million cases.

(Standard errors are in parentheses.)

2. Tomato juice. A similar model was estimated for tomato juice consumption on a per capita basis. The price of orange juice was included as a substitute. The coefficient estimates except for the one associated with income were not statistically significant and a wrong sign was obtained for the coefficient of own-price. Using the OLS version of the demand equation, an elasticity estimate of -.15 was computed at the means of the variables suggesting that per capita consumption shows little reaction to price.

3. Catsup and Chili Sauce. A two equation model: (1) domestic consumption per capita related to price and income, and (2) change in canners' stocks, was estimated by TSLS. Neither imports nor exports were considered important enough to be included. The structural equation reflecting demand is presented below.

Estimation Results:

$$Q_{cc/c} = -.5275 - \underset{(.0079)}{.0260}\, P_c + \underset{(.0260)}{.2318} \ln Y/c$$

where:

$Q_{cc/c}$ = per capita consumption of catsup and chili sauce, cases;

P_c = season average price, 14 oz. fancy, deflated by the CPI, dollars per case;

Y/c = per capita disposable personal income, deflated by the CPI, dollars.

(Standard errors are in parentheses.)

4. Puree. A similar model was estimated, but the incomplete data series produced statistically unsatsifactory results.

5. Paste. The severe deficiency of tomato paste data on pack and stock, meant that only a "particularly naive" model could be fitted, defining supply as the sum of California institutional pack, California beginning stocks, and U.S. imports. The need for a separate import demand equation was emphasized, due to the importance of imports to U.S. total supply. The reduced form equation (1st stage, OLS) was considered satisfactory in that the coefficients associated with pack, stock, and income were of expected sign and statistically significant. A positive (incorrect) sign, however, was obtained for the coefficient associated with imports; but as is suggested above, import demand should not have been considered a predetermined variable in the system. The second stage, structural demand equation was not estimated due to data-insufficiency.

Estimation Results:

$$P_s = -7.497 - \underset{(.0918)}{.2015}\, Q_{sp} - \underset{(.1807)}{.7864}\, Q_{sbs} + \underset{(.1764)}{.2371}\, Q_{sm} + \underset{(4.582)}{6.320} \ln Y$$

$R^2 = .69$ DW = 1.25, inconclusive at the 5% level

where:

P_s = season average price, 10 oz. can, deflated by the CPI, dollars per case;

Q_{sp} = California institutional pack, million cases;

Q_{sbs} = California beginning stocks, million cases;

Q_{sm} = quantity imported, million cases;

Y = total U.S. personal disposable income, deflated by the CPI, dollars.

(Standard errors are in parentheses.)

D. MILTON SHUFFETT. *The Demand and Price Structure for Selected Vegetables*. USDA, Agricultural Marketing Service, Technical Bulletin No. 1105, December 1954.

Scope: Demand for lettuce, onions, potatoes, cabbage, peas, and tomatoes.

Purpose: To discuss the principal economic forces that influence the price and consumption of six important vegetable crops.

Observational Interval: Annual. (Seasonal analysis was also done for lettuce, cabbage, peas, and tomatoes.)

Period of Analysis: 1921 through 1941, then computed values of the dependent variables were reported through 1952.

Specification and Estimation Procedure: One question that was considered for each vegetable was whether the traditional single-equation analysis could be used to measure the elasticity of demand with respect to price. Single equations in first differences of the logarithms of the variables estimated by OLS gave satisfactory results for late onions, potatoes, summer and fall cabbage, fresh and canned peas. Simultaneous equation estimation methods were apparently needed for "lettuce and for the winter and spring seasons for certain other crops because of the importance of non-harvesting for economic reasons and for tomatoes because of dual outlets for the crop." p. 2. The simultaneous system estimated for tomatoes will be reviewed here, but the single equations for lettuce (not statistically significant), onions, potatoes, cabbage, peas, and tomatoes (not statistically significant) were reported in Buchholz, Judge, and West[1/] and will not be repeated here. Elasticity estimates will appear in the relevant summary tables of this report.

For tomatoes: the original structural relationship of (1) retail price as a function of domestic (Q_d) plus imported quantity (Q_i), and income (Y); and (2) imported quantity as a function of retail price minus duty (T), and income was converted to a just-identified system and farm price (P_f) was substituted for retail price:

$$P_f = a_1 + b_1 Q_d + c_1 Q_i + d_1 Y$$

$$Q_i = a_2 + b_2 P_f + c_2 T + d_2 Y$$

Domestic quantity was considered predetermined; the reduced form, therefore, fitted P_f and Q_i as functions of Q_d, T, and Y. The data were expressed in first differences of the logarithms. The recovered structural equations are presented below.

Estimation Results:

$$P_f = -0.007 - \underset{(.15)}{0.45Q_d} - \underset{(.76)}{0.18Q_i} + \underset{(.90)}{0.11Y} \qquad R^2 \cong .35$$

$$Q_i = 0.043 + \underset{(.35)}{0.27P_f} - \underset{(.26)}{0.22T} + \underset{(.79)}{0.69Y} \qquad R^2 \cong .05$$

1/ H.E. Buchholz, G.G. Judge, and V.I. West. *A Summary of Selected Estimated Behavior Relationships for Agricultural Products.* Illinois Agricultural Experiment Station, Research Report AERR-57, October 1962, pp. 104-108. Short summaries of the empirical findings from many sources of both demand and supply relationships for food, meat, livestock, products, feed grains, fruits and vegetables, cotton, tobacco, and coffee were given in the Buchholtz, et al. report.

where:

P_f = price of tomatoes received by farmers,

Q_d = per capita domestic production,

Q_i = per capita imports,

Y = per capita disposable income,

T = duty on imports.

(Standard errors are in parentheses.)

RICHARD L. SIMMONS and CARLOS POMAREDA. "Equilibrium Quantity and Timing of Mexican Vegetable Exports." Abstracted under cucumbers on page 80.

FREDERICK V. WAUGH. *Demand and Price Analysis: Some Examples from Agriculture.* Abstracted under potatoes on page 128.

TABLE 13: Selected Econometric Analyses With Flexibility or Elasticity Estimates for Tomatoes

Author and Date	Geographical Area	Time Period	Observational Interval	Form of Equation	Method of Estimation	Market Level	Product	Price Flexibility	Income Flexibility	Cross Effect	Price Elasticity	Income Elasticity
Bohall, 1972	Florida	1966-1968	Weekly	linear	OLS	FOB	large and extra-large vine ripe	-1.19		-0.15[a]		
Chern and Just[b], 1978	California	1951-1963[c]	Annual	double log	3SLS; pooled cross section, time series; covariances between counties constrained to be zero	grower	processing tomatoes				-1.65	1.64
		1967-1975[d]									- .16	.97
Firch and Young, 1968	U.S.	1961-1966	Weekly	linear	OLS	shipping point prices--Nogales, Arizona	fresh: from W. Mexico	-0.181				
							from elsewhere	-0.157				
							total shipments	-0.278				
Foytik, 1964	Hawaii	1947-1961	Monthly	linear	OLS	wholesale	fresh	I.-0.343[e] II.-0.399 III.-0.414 IV.-0.399				
Jesse and Machado, 1974	California	1948-1972	Annual	linear	TSLS	farm	fresh summer	-1.0				
							fall	-1.0				
King, Jesse, and French, 1973	U.S.	1948-1971	Annual	semilog	TSLS	FOB, processors	canned whole tomatoes				- .87	
		1948-1971			OLS		tomato juice				- .15	
		1948-1967			TSLS		catsup & chili sauce				- .65	
		1953-1971			OLS		paste	- .28[f]				
Waugh, 1964	U.S.	1950-1962	Annual	linear	OLS	retail	fresh	- .853	.360			
						farm	fresh	-1.030	.003			

a/ wrt. Mexican shipments

b/ for other elasticity estimates by various methods see the review in

c/ pre-harvester

d/ post-harvester

f/ wrt. California institutional pack

Related Studies, Tomatoes

Brandt, Jon A., Ben C. French, and Edward V. Jesse. *Economic Performance of the Processing Tomato Industry.* California Agricultural Experiment Station, Giannini Foundation Information Series No. 78-1, Division of Agricultural Sciences Bulletin No. 1888, Davis, April 1978. ". . .the first of two reports dealing with the economics of the U.S. processing tomato industry." (p. ii). This report is primarily descriptive in nature and discusses: (1) structural characteristics and adjustments of the industry at both the grower and processor levels, (2) measurement of economic performance including technological progress, employment and productivity, tomato plant capacity utilization, product quality, price performance and variability, profits, and processor-grower price spreads.

Brown, J. D. and M. E. Cravens. *Retail Margins on Tomatoes.* Ohio Agricultural Research and Development Center, Wooster, Ohio, Research Bulletin 984, February 1966. Wholesale-retail margins for three types of fresh tomatoes--tube, vine-ripe, and greenhouse--were calculated from wholesale and retail prices measured weekly at 214 Ohio retail food stores from March 27 through June 17, 1961.

Brooker, John R. and James L. Peterson. *The Winter Fresh Tomato Industry, A Systems Analysis.* USDA, ERS in cooperation with the University of Florida's Agricultural Experiment Station and Food and Resource Economics Department, Agricultural Economics Report No. 330, April 1976. A computer model was constructed with an interseasonal and an intraseasonal phase to simulate the long-run effects of alternative supply controls and marketing policies on handlers of fresh winter tomatoes at the U.S.-Mexican border, on Florida producers and handlers, and on U.S. consumers.

Cain, Jarvis L. and Ulrich C. Toensmeyer. *Interregional Competition in Maryland Produced Fresh Market Tomatoes.* Maryland Agricultural Experiment Station, Bulletin No. 741, October 1969. A linear programming transportation model was used to evaluate the competitive position of Maryland fresh tomatoes in 13 major eastern and midwestern markets. The solution provided the minimum cost distribution pattern from major producing areas to the 13 markets. The optimum was then compared with actual weekly shipment data.

Chern, Wen S. "Acreage Response and Demand for Processing Tomatoes in California." *American Journal of Agricultural Economics,* Vol. 58, No. 2, May 1976, pp. 209-216. Demand for processing tomatoes produced in ten California counties was estimated for 1951 through 1972 by OLS and by 3SLS as a part of a three equation system. This model was updated in 1978 and the later version is reviewed in this report on page 145.

Dillman, Buddy L. and Donald E. Farris. *Arkansas' Competitive Position in Marketing Fresh Tomatoes.* University of Arkansas, Agricultural Experiment Station, Bulletin 663, February 1963. The possibility of expanding production of Arkansas fresh tomatoes was investigated by exploring locational advantages using an interregional competitive model.

Feick, Lawrence F. and Ulrich C. Toensmeyer. *Delaware Household Consumption of Fresh Tomatoes.* Delaware Agricultural Experiment Station, Bulletin No. 424, February 1978. In a mail survey of 500 Delaware consumers--response rate 23.6 percent--it was found that taste was a more important determinant of purchase than was price or other considerations. This is of interest in that taste is of lower priority to growers than are other features such as: suitability for mechanical harvesting, high yield, disease resistance, and capability of ripening at the same time.

Goble, W. E. and Erven J. Long. *Marketing Tennessee Tomatoes.* University of Tennessee Agricultural Experiment Station, Bulletin No. 226, June 1953. The report gives the findings from a four-year, three-phase project: phase 1, a study of production and marketing practices in West Tennessee; phase 2, interviews to determine consumers preferences regarding quality and characteristics of tomatoes; phase 3, controlled market experiments in Knoxville retail grocery stores.

Lee, Woo Bong. "The Competitive Nonlinear Spatial Equilibrium Analysis--An Empirical Study." *The Southern Economic Journal,* Vol. 41, No. 1, July 1974. For use in a nonlinear (quadratic) spatial equilibrium model, reduced form demand and supply functions for fresh and processing tomatoes were estimated for nine regions of the U.S.

Hoos, Sidney. *Tomatoes and Tomato Products--Economic Trends and F.O.B. Price Relationships.* California Agricultural Experiment Station, Giannini Foundation of Agricultural Economics, Mimeographed Report No. 185, March 1956. The report summarized economic trends in the tomato industry in California: production, acreage, yield, farm prices, the various processed products, canners' pack and shipments, and consumption. In addition, FOB canners' price relationships for canned tomatoes were estimated. In the equation selected as best for statistical and economic reasons, the average annual FOB price of California canned tomatoes was expressed as a linear function of California canners' pack and movement, the log of the index of U.S. disposable personal income, and an adjusted index of competing canned vegetable prices.

Hoos, Sidney and R. D. Aplin. *California Canned Tomatoes: Analysis of F.O.B. Price Relationships.* California Agricultural Experiment Station, Giannini Foundation of Agricultural Economics, Mimeographed Report No. 156, June 1953. As part of the report, price forecasting equations for FOB prices of California canned tomatoes were fitted by OLS with alternative combinations of independent variables. In the equation selected as statistically best, the FOB price was expressed in log-linear form as a function of California canners' pack, an index of U.S. disposable personal income, an index of prices for competing canned vegetables, and a trend variable.

Jesse, Edward V. "Marketing California Fresh Market Tomatoes: Trends and Outlook." *The Vegetable Situation,* No. 193, USDA-ERS, August 1974. Abstract, p. 31: "California provides about a third of the fresh tomatoes marketed commercially in the United States, and is the only domestic source of supplies during the late fall marketing season. This report traces trends in production and marketing of the state's crop in 1948-72."

Mathia, Gene A. and John R. Brooker. *Vine-Ripe Tomato Production and Marketing in North Carolina and Tennessee.* Southern Cooperative Series Bulletin No. 230, June 1978. In order to investigate the economic potential for expansion of vine-ripe tomato production in North Carolina and Tennessee, a linear programming model was used. Demand elasticities for the model were obtained from secondary sources.

Sullivan, G. H., A. J. Minden, and L. F. Schrader. "Interregional Competition in Processed Tomato Products." *Florida State Horticultural Society Proceedings,* Vol. 86, November 1973. "A quantitative evaluation of interregional competition and projected advantage was completed for the processed tomato industry using linear programming techniques. Results of this analysis indicated that under current regional cost structures, the Western Region will likely continue to expand tomato production at the expense of production areas in the Midwestern and Eastern Regions. However, it was found that the interregional dominance of the Western Region was tenuously held for the production of selected tomato products and subject to substantive dilution if lower production cost structures, attainable through the implementation of available cost reducing technologies, were realized in competing supply regions." p. 289.

Uhl, Joseph N. *The Demand and Price Structure for Processed Tomato Products: Preliminary Findings and Implications for Interregional Research.* Department of Agricultural Economics, Purdue University, paper presented at the NCM-44 meeting, Chicago, September 1969. Three separate wholesale-level demand equations--fall, winter, and spring--were fitted by OLS for each of three tomato products--whole pack, catsup, and juice.

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