AN ANALYSIS OF INTRASEASONAL APPLE PRICE MOVEMENTS

Thesis for the Degree of Ph. D.

MICHIGAN STATE UNIVERSITY

Ernest C. Pasour, Jr.

1963

This is to certify that the

thesis entitled

AN ANALYSIS OF INTRASEASONAL APPLE
PRICE MOVEMENTS

presented by

Ernest C. Pasour, Jr.

has been accepted towards fulfillment
of the requirements for

Ph. D. degree in Agricultural Economics

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Date August 28, 1963

O-169

AN ANALYSIS OF INTRASEASONAL APPLE PRICE MOVEMENTS

By

Ernest C. Pasour, Jr.

AN ABSTRACT OF A THESIS

Submitted to
Michigan State University
in partial fulfillment of the requirements
for the degree of

DOCTOR OF PHILOSOPHY

Department of Agricultural Economics

1963

ABSTRACT

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PRICE MOVEMENTS

by Ernest C. Pasour, Jr.

Fresh apple prices at the farm level varied widely both between years and within a given marketing year during the postwar period. During this period, apple storage was profitable only in certain years. In addition to the variation in fresh apple prices, processing apple prices varied widely from year to year.

The purpose of this study was to isolate and measure the effects of factors associated with within-year movements of United States apple prices at the farm level. An economic model was formulated after studying the economic behavior of the apple industry. This model consisted of fresh and processing apple demand functions, allocation and storage functions, and an identity. Total apple production in any year was assumed to be predetermined.

The apple marketing year was divided into three periods to facilitate economic analysis. Period I coincides with

the harvest period, July - November. Periods II and III included the months December - March and April - June, respectively. All relationships of the model did not hold in each period, but there were as many equations as current endogenous variables in each period.

Major data sources were publications of: (1) the U.S. Department of Agriculture, (2) International Apple Association, and (3) National Canners Association.

All production and quantity variables were put on a per capita basis to adjust for changes in population. Farm prices were deflated by the Wholesale Price Index.

After formulating the model and collecting the necessary data, the various relationships were estimated by single equation and two-stage least squares procedures. In general, relationships estimated by the two methods were quite similar.

A satisfactory estimated demand function for processing apples could not be obtained. The model was reformulated by replacing the processing demand function with a demand relationship for all apples sold during the harvest period. In this relationship, a blend fresh and processing price was considered dependent and combined sales of fresh and processing apples and carryover stocks of processed apples were explanatory variables.

The demand for all apples sold in period I was inelastic. Demand for fresh apples during this period appeared slightly more inelastic than the demand for all apples sold. The findings mildly suggest that demand for fresh apples is slightly more inelastic than the demand for processing apples during the harvest period.

Fresh apple sales, lagged fresh price, sales of competing fruits, and income accounted for 92 and 84 percent of the fresh price variation in periods II and III, respectively. Demand was slightly inelastic in period II but elastic in period III.

In the allocation function of period I, the ratio of processing to period I fresh price, Eastern apple production, and other apple production explained more than 90 percent of the variation in sales to apple processors during the postwar period. The same factors explained about 80 percent of the variation in December 1 storage holdings. Beginning stocks explained more than 90 percent of the variation in storage movement during period II.

The results of this and other studies were used to evaluate the feasibility of several apple supply control programs. The conclusion was that there are formidable theoretical and practical problems in instituting a diversion or quantity control program. The large number of apple grades and varieties and the large geographical area of production intensify these problems.

A predictive equation for canning and freezing processing apple prices was estimated which explained about 90 percent of the year-to-year variation in season average farm prices of canning and freezing apples. Predictive equations were also estimated for fresh apple prices in each period. Storage "rules" were then developed for periods I and II to illustrate the possibility of improving storage decisions through application of the price prediction equations.

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ACKNOWLEDGMENTS

The author is grateful to the large number of individuals who contributed toward the completion of this thesis.

At Michigan State University, thanks are due the author's guidance committee: Robert L. Gustafson (Chairman), John R. Brake, Abba P. Lerner, Lester V. Manderscheid, and James H. Stapleton. Dr. Gustafson provided direction and assistance during all phases of the study. With the exception of Lerner (who is currently on leave), all committee members contributed toward the final draft. The author also benefitted from discussions with Dennis L. Oldenstadt, a fellow graduate student.

Thanks are also expressed to Mrs. Laura Flanders and Mrs. Karma Beal for their care in supervising the computing work and to Mrs. Kathy West who typed a preliminary draft of the manuscript.

A number of individuals outside the university also provided assistance. Anthony S. Rojko, of the U.S. Department of Agriculture, analyzed the preliminary results and suggested a number of improvements. Dana G. Dalrymple, a former student at Michigan State University now with the

U.S. Department of Agriculture, provided much of the basic data used in the analysis.

Finally, the author appreciates the joint efforts of L. L. Boger and Loyd C. Martin who were instrumental in developing the research project, of which this thesis is a part, as a co-operative arrangement between Michigan State University and the U.S. Department of Agriculture.

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CHAPTER I

INTRODUCTION

Price analysis, in general, is concerned with isolating and measuring the effects of the most important factors associated with price movements. Such analyses serve the goal of providing more accurate information to producers, marketing firms, and consumers. More accurate information should decrease uncertainty to all participants in the marketing process and thereby increase production and marketing efficiency.

Price changes are associated with changes in supply and/or demand. Thus, in analyzing price variations, we must study the conditions affecting supply and demand. There are, however, innumerable forces affecting the level of demand and supply (and hence price) for any product. As a result, we must select and try to measure the influence of the most important factors associated with price movements.

There are two categories of factors which need not be studied explicitly in short run price analysis. One category includes factors which have a negligible influence on price. In this category are prices and quantities of products which have a negligible effect on the price being studied. Another category contains factors which are important but which change slowly over time. The institutional framework, legal system, and consumer tastes often fall into this category.

Information concerning the factors associated with price can be especially helpful to all segments of an industry which experiences wide price movements either between or within seasons. Apple prices at the farm level vary widely both between seasons and within a given season.

Information pertaining to demand elasticities of fresh and processing apples is useful to producers or producer groups who wish to develop a marketing pattern that will maximize producer returns. Commodity groups are becoming more interested in the results of price analysis to answer practical problems.[1]

In apple marketing, information is needed during various parts of the marketing season. The elasticity of demand is likely to vary during the year since the availability of substitutes varies. Also, weather or apple

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[1] Shepherd points out that empirical work showing the demand for turkeys to be elastic (-1.4) was recently used as a basis for recommending to turkey producers that they not seek to reduce turkey production. G. S. Shepherd, Agricultural Price Analysis (Ames, Iowa: Iowa State University Press; fifth edition, 1963), p. 4.

quality may cause a change in consumer tastes and affect the demand for apples.

This study was addressed to an analysis of U.S. apple prices at the farm level. The primary emphasis was placed upon determining and measuring the effects of factors associated with changes in apple prices during various periods of the apple marketing season. Previous work in this area has been quite limited. Most past analyses of apple prices have dealt with changes in the season average farm price instead of focusing on within-year or intraseasonal price changes.[1] The need for an analysis which considers changes during the marketing year is presented in the following section.

The Problem

Income from any agricultural commodity is determined by price as well as volume. The rate of marketing for commodities with wide within-year price changes is likely to significantly affect producer returns.[2] For apples, a major U.S. fruit crop, the potential effect of the rate of

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[1] Season average farm price, as used in this study, refers to the average price during the marketing season. The apple marketing season (or marketing year) begins in July and ends the following June.

[2] It should be recognized that maximizing net returns may not stabilize prices.

marketing on producer returns is quite large.

In determining the most profitable marketing pattern for a commodity, we are not only interested in the average yearly price of the commodity over a period of years; we also need to know the price pattern which is likely to occur within a particular year. That is, an important problem in this area centers around seasonal fluctuations in demand and supply.

Apples at the time of harvest may be sold for fresh use, for processing, or they may be stored and marketed later in the marketing year. Different prices are obtained for apples going into various end uses. The demand for processing apples relative to the demand for fresh apples at harvest varies from year to year for many reasons including changes in carryover stock of processed apple products, changes in government purchases, and changes in consumer tastes and preferences.

Similarly, the pattern of within-year changes in demand for fresh apples may vary from year to year. Under similar supply conditions, the price change during one marketing season may differ from the price change in another marketing season. Production and prices of competing fruits during various stages of the marketing season and changes in consumer income are among the factors which might be expected to result in larger seasonal increases in apple prices in some years than in other years.

The quantity of apples to store and the rate of sale from storage present major problems to the apple producer in each marketing year. Storage since World War II has been generally profitable only in certain years. Apple prices were lower at the end of the marketing year than at the time of storage during four of the fifteen postwar years (Table 1).[1] In at least two of the remaining 11 years, the increase in price during the marketing year was not sufficient to cover storage costs.

The decision as to whether to store apples must be made at harvest. The apple producer is likely to secure a greater return by varying his initial storage holdings from year to year. The rate of sale from storage presents other problems. After the initial storage decision has been made the producer is likely to increase the profitability of his

---

[1]Many varieties and grades of apples are sold in the fresh market. The fresh price (reported monthly by the U.S. Department of Agriculture) is a blend price covering all varieties and grades.

There is an additional problem in comparing apple prices at the beginning and end of the marketing season since the percentage of various grades and varieties marketed varies during the season. In general, however, the higher priced apples are placed in storage, so that the change in reported blend price may understate the actual per bushel gross return to storage.

Table 1. U.S. fresh apple prices at farm level, beginning and end of marketing year, 1947-1961.

Crop year	Fresh apple price: At harvest[a]	Fresh apple price: At end of marketing year[b]	Change in price during marketing year[c]
	-- Dollars per bu. --		
1947	2.00	1.42	-0.58
1948	2.06	2.08	+0.02
1949	1.27	1.99	+0.72
1950	1.77	1.23	-0.54
1951	1.79	2.70	+0.91
1952	2.46	2.93	+0.47
1953	2.61	2.63	+0.02
1954	2.38	2.61	+0.23
1955	2.09	2.01	-0.08
1956	2.47	3.03	+0.56
1957	1.93	2.16	+0.23
1958	1.81	1.65	-0.16
1959	2.11	2.68	+0.57
1960	2.58	3.38	+0.80
1961	2.30	2.99	+0.69

[a]Average fresh apple price during September, October and November.

[b]Average fresh apple price during April, May, and June.

[c]There has been a large increase in the quantity of apples placed in Controlled Atmosphere storage since 1955. We should expect this trend to be associated with an increase in the average within-year price movement.

Source: Computed from U.S. Department of Agriculture Crop Reporting Board statistics.

storage operation from year-to-year by varying his monthly sales from storage. In determining the most profitable pattern of storage holdings, information is needed concerning the factors which influence apple prices during various stages of the marketing season.

At the same time the apple producer is making the storage decision, supplies are also being allocated to the fresh and processing markets.[1] These decisions are interrelated and will be determined by existing and expected prices in the various markets. There are substitution possibilities both on the supply and demand side.

On the supply side, approximately one-third of U.S. apples are classified as "dual purpose" varieties.[2] These apples are about equally suitable for use in either a fresh or processed form. In addition, some varieties classified as "fresh" are also often used in processing outlets. Producers wish to allocate their crops between fresh and processing forms of utilization in such a way that net

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[1] Apple processors are concentrated in the Eastern and Central states. Growers in some areas do not have an attractive alternative to selling in the fresh market.

[2] Dana G. Dalrymple, "Economic Aspects of Apple Marketing in the United States," (unpublished Ph.D. dissertation, Michigan State University, Department of Agricultural Economics, 1962), p. 16.

returns are maximized. A large part of all apples produced are storable--at least for some period of time. In addition to allocating his crop between fresh and processing outlets, the producer desires to move his crop during the apple marketing season at the most profitable rate.

On the demand side, empirical evidence suggests that consumers consider fresh and processed apple products to be substitutes.[1] That is, a high price for processed apple products relative to fresh apples tends to increase fresh apple purchases. Substitution possibilities on both the supply and demand sides result in a high degree of interdependence among apple markets at the farm level.

Objectives

The major problem of this study was to develop and fit an economic model which included the major behavioral relationships of the U.S. apple market. These estimated relationships should provide needed information about the factors associated with apple prices during various parts of the apple marketing season to apple producers, processors, and other apple buyers. From this model, equations were derived where feasible to predict apple prices in various periods of the apple marketing season.

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[1]This subject is discussed more fully in Chapter III.

Providing accurate information of this nature to apple producers and buyers should increase the efficiency of the price mechanism in the allocation of resources and products within both the production and marketing sectors. Specifically, an attempt was made to provide information concerning the most profitable allocation of the apple crop for different sizes of crops and under alternative economic conditions. This information should assist apple producers in determining the quantity to store and the rate of sale from storage.

In summary, the objectives of the study were:

1. To construct an economic model relating appropriate variables to fresh and processing apple prices during various periods of the marketing season.
2. To estimate the parameters of the model.
3. To relate findings of the study to apple marketing policy.

Procedure

A major objective of this study was to formulate an economic model of the U.S. apple industry that will explain short term fluctuations in apple prices at the farm level during the postwar period. The construction of such a model necessitated a study of the behavior of the apple industry.

The Cromarty-Boger model was reformulated in view of structural changes in the U.S. apple industry since World War II.[1] Consumption of processed apple products has been increasing relative to fresh consumption (Table 2). In addition, there have been important changes in the product mix of processed apples. In view of the increasing importance of canned and frozen apple slices and sauce, this portion of the processing apple industry was given special attention in the processing sector of the model employed in this study.

U.S. apple exports and imports have been low since World War II. After studying the apple export situation, a decision was made to adjust U.S. production data for exports and imports rather than formulate an export function (to explain changes in apple exports) as part of the over-all model. The rationale for assuming that U.S. apple exports will continue to be negligible is presented in Chapter II.

For reasons of practicality, since research resources are not unlimited, the analysis presented here is based on

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[1]W. A. Cromarty, "An Experiment in Designing an Econometric Model to Explain Short-Term Demand Fluctuations for Apples," (unpublished M.S. thesis, Michigan State University, Department of Agricultural Economics, July, 1953), and L. L. Boger and W. A. Cromarty, "A Model to Explain the Short-Term Demand for Apples," paper presented at Econometric Society Meeting, Washington, D.C., December 28, 1953.

Table 2. Per capita consumption of fresh, canned and frozen, and dried apple products, fresh equivalent basis, 1947-1961.

		Per Capita Consumption Processed (Fresh Equivalent Basis)				
Calendar Year	Fresh (lbs.)	Canned and Frozen[a] (lbs.)	Canned Juice (lbs.)	Dried (lbs.)	Total Processed[b] (lbs.)	Total Fresh and Processed (lbs.)
1947	25.4	3.0	.4	1.3	4.7	30.1
1948	26.3	3.4	0.3	1.3	5.0	31.3
1949	24.7	3.4	.7	1.1	5.2	29.9
1950	22.7	4.0	.9	1.3	6.2	28.9
1951	25.7	3.8	.8	1.2	5.8	31.5
1952	21.6	4.5	.8	1.0	6.3	27.9
1953	20.9	3.9	.8	.9	5.6	26.5
1954	20.0	4.1	1.1	.9	6.1	26.1
1955	19.6	4.8	.8	.9	6.5	26.1
1956	18.9	5.3	1.0	.8	7.1	26.0
1957	19.3	5.0	1.0	.7	6.7	26.0
1958	22.6	5.4	1.2	.7	7.3	29.9
1959	23.0	5.2	1.5	.8	7.5	30.5
1960	20.1	5.6	1.4	.7	7.7	27.8
1961	18.6	5.7	1.4	.7	7.8	26.4

[a]Excludes quantities consumed as baby food.

[b]These data include only canned, frozen, and dried apples. There are more than a dozen apple products on the market. Minor quantities of apples are used for jam, butter, jelly, wine, vinegar, brandy, etc.

[c]Preliminary

Source: U.S. Department of Agriculture, The Fruit Situation, No. 144, August, 1962, p. 28.

aggregation of the data into three within-year time periods or "seasons."[1] Thus, the study deals with the broad overall pattern of within-year price movements, rather than day-to-day or even month-to-month movements. Selection of the specific periods used was based primarily on the economic and technical or physical characteristics of the apple industry, but was partly influenced by practical data limitations.

The quantities of apples channeled into the various outlets (fresh, processing, or storage) were considered as current endogenous variables during periods of the year when farmers have a choice of apple outlets. Fresh and processing apple prices were also considered endogenous variables.

Models Estimated.--The initial model formulated in this study had one function relating fresh apple prices at the farm level, consumer income, production of competing fruits, and other variables to changes in movements of fresh apples during various periods of the apple marketing year. In another relationship, the quantity of apples processed was a function of processing apple price, processing costs, carryover stocks, and other relevant variables. In

[1] Some preliminary experimentation was also conducted with a four period model.

addition to the demand relationship for fresh and processing apples, the model contained a fresh apple storage function, a processing allocation equation and a production-stocks identity.

One formulation of the initial model included a processing demand relationship for all processing apples. The price indicator for this relationship was a blend price for all processing apples. A second formulation of the initial model excluded all apples utilized for processing purposes except canning and freezing apples. Most other apples processed may be considered as residual forms of utilization. In this way, attention was focused on the most important economic relationship. In each case, single-equation least squares estimates of the parameters were made prior to making two-stage least-squares estimates.[1]

Satisfactory results could not be obtained for either of the processing demand relationships. Consequently, a revised model was adopted which contained a demand function for all apples sold (fresh and processing) during the harvest period.[2]

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[1]For a discussion of two-stage least-squares regression procedures, see J. Johnston, Econometric Methods (New York: McGraw-Hill Book Company, Inc., 1963), pp. 258-260.

[2]This model is explained in detail in a later chapter.

After the relationships of the model were estimated by period, a different model was constructed for fresh apples. This model assumed no change in demand for apples between periods--allowing no shift in either the level or slope of the demand function. Then the model was adjusted to allow for shifts in the level of demand for fresh apples between periods while holding the slope of the demand function constant.

In using time series data to explain the closely related processes in the apple market, more accurate estimates should be obtained by considering the dependent variables jointly. As indicated above, a number of structural equations are necessary in a model to describe the behavior of the U.S. apple economy. Any single equation selected from all the relationships comprising the economic model is just a part of the economic interaction in the apple market. The estimation of such relationships individually, ignoring closely related processes, may result in parameter estimates which are seriously biased. Thus, single-equation least-squares estimating procedures under such conditions are likely to give biased estimates since each equation is considered singly and potential simultaneity is ignored.[1]

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[1]Shepherd, op. cit., pp. 153-173.

In this study, an attempt was made to develop a behavioral model for the U.S. apple market. Each structural equation of the model contained variables having immediate logical connections with the behavior of the marketing sector which that equation purports to represent. In such a model, we are interested in estimating structural coefficients. A knowledge of structural coefficients is helpful even though our major purpose may be prediction. If a change in structure is expected, one needs to take into account experience collected under the old structure. Any attempt to predict the outcome of alternative decisions under the new structure without consideration of past experience under the old structure is "either so lacking in precision or so wasteful of time as to be useless."[1] Marschak indicates that a more promising

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[1]J. Marschak, "Economic Measurement for Policy and Prediction," W. C. Hood and T. C. Koopmans (eds.), Studies in Econometric Method (New York: Wiley, 1953), p. 17. A. S. Rojko of the U.S. Department of Agriculture has pointed out to this writer that Marschak's statement concerning the unique power of the simultaneous equations approach is misleading. His argument follows. The example Marschak used was a tax problem in which one *knows* the change in structure. In practically all other situations, however, we cannot predict change in structure. In such situations, the unique power or advantage of the simultaneous equations approach is lost. A similar view apparently is shared by F. V. Waugh. See F. V. Waugh, "The Place of Least Squares in Econometrics," Econometrica, Vol. 29, No. 3, (July, 1961), pp. 386-396. R. J. Foote has accumulated a considerable amount of empirical evidence indicating that simultaneous equations methods lead to better predictions, even when there is no change in structure. See R. J. Foote,

approach is to base the decision upon an estimate of the old structure and on the knowledge of its expected change.[1]

In the behavioral model of the apple market, quantities of apples stored, processed, and sold on the fresh market are determined simultaneously and vary according to conditions of supply and demand in the various markets. As a result, a simultaneous equations method of estimating the relationships comprising the economic model becomes logically appropriate during certain periods of the apple marketing year.

During the final period of the marketing year, all remaining apples move into consumption as fresh, and the total quantity is predetermined. During this period, price is the only current endogenous variable, and the least-squares single-equation method of estimation becomes a valid application of the simultaneous equations theory.[2]

After formulating the economic relationships, collecting

W. A. Cromarty, and W. R. Sparks, "Empirical Results from Alternative Methods of Fitting Systems of Simultaneous Equations," (unpublished paper presented by Foote at Midwest Quantitative Economic Symposium held at Michigan State University, February 4-6, 1963).

[1] Ibid.

[2] M. Ezekiel and K. A. Fox, Methods of Correlation and Regression Analysis (New York: John Wiley and Sons, Inc.; third edition, 1959), p. 432.

the necessary data, and fitting the final revision to the model, the findings of this study and other studies were related to apple marketing policy. Storage "rules" were developed to illustrate the possibility of improving storage decisions through the application of price prediction equations.

Major Data Sources

A large part of the basic data was obtained from a previous study.[1] In view of major differences in the U.S. apple industry before and after World War II, only postwar data, 1947-1961, were used in the study. Some of the more important variables and data sources are presented at this point.

Prices.--Fresh apple prices at the farm level are reported monthly by the U.S. Department of Agriculture.[2] A simple average of U.S. monthly farm prices in each of the three periods was used in the analysis.[3]

Processing apple prices at the farm level are reported on a season average basis by the Department. Prices are

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[1]Dalrymple, op. cit.

[2]U.S. Department of Agriculture, Agricultural Prices.

[3]A weighted average would presumably have been better than a simple average since movement varies by month within each period. However, movement data were not available for the fall months.

reported for apples to be (a) processed into canned and frozen slices and sauce, (b) dried, and (c) processed into other forms. In addition, a blend price is reported for all apples processed. This blend price was used in the processing demand relationship in one model fitted. Another model considered only canning and freezing apples in the processing demand relationship. In this model, the price of canning and freezing apples was used as the price variable.

Production.--U.S. apple production is estimated by the U.S. Department of Agriculture.[1] A small portion of apples produced is not sold. These apples are used in producer's homes or are not sold due to economic conditions. Economic abandonment includes apples not harvested and excess cullage of harvested apples. A function to explain that part of the crop not sold was not included in the model. As apple production has become more highly commercialized, the extent of economic abandonment has become negligible. For the purposes of this study, production refers to total apple sales.

Apple Storage Holdings.--Data from the International

[1] Estimates are made monthly during apple harvest from July-December and appear in *Crop Production*.

Apple Association were used in determining apple storage holdings by periods. Total apple holdings in each period were adjusted to eliminate processor holdings. This was done to get a more accurate record of the volume available for fresh use.

Adjusting for Exports.--Fresh apple exports and imports on a monthly basis were obtained from U.S. Departments of Agriculture and Commerce publications.[1] Apple exports and imports were aggregated by time period. Net apple exports were determined for each of the three within-year periods, and apple sales were adjusted in each period. Exports and imports of processed apple products were of minor importance during the postwar period and no data adjustments were made for them.

Processed Apple Stocks.--Large carryover stocks of processed apple products were assumed to affect the demand for processing apples adversely. August 1 packer stocks of canned and frozen apple slices and sauce were used as an indicator of total carryover stocks in the demand relationship for processing apples. These data were obtained from the National Canners Association and the U.S. Department of

[1] U.S. Department of Commerce, Foreign Trade Reports and U.S. Department of Agriculture, Monthly Foreign Agricultural Trade of the United States.

Agriculture.[1] Canned stocks are reported in cases of various size cans. Frozen apple products are reported in pounds. Canned and frozen stocks were converted to a raw product basis in order to combine these stocks into a single indicator variable. The conversion factors used are presented in Appendix B, Table 3.

Other variables and data sources of the analysis are presented at the time the model is presented (Chapter IV).

Data Adjustments

Fresh and processing apple prices were deflated by the Wholesale Price Index to remove changes over time in apple prices caused by changes in dollar purchasing power. Deflation in this manner assumes that a change in price level has no effect on consumption. "This seems a reasonable assumption with respect to most perishable items . . ."[2] The Wholesale Price Index was chosen as the deflator since this study deals with apple prices at the farm or wholesale level.

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[1] Canned stocks appear in NCA monthly reports and frozen stocks appear in U.S. Department of Agriculture, Cold Storage Reports.

[2] U.S. Department of Agriculture, Analytical Tools for Studying Demand and Price Structures, Agriculture Handbook No. 146, 1958, p. 27.

Population in the U.S. increased from about 143 million in 1947 to approximately 185 million in 1962. Increases in population shift the demand function, assuming other factors remain unchanged. In order to adjust for these changes, all production, consumption, and stocks data were placed on a per capita basis.[1]

Data Limitations

Data problems exist in all empirical work. In apple price analysis, however, data problems are especially pronounced and this fact has been recognized by previous workers. Drew, in a recent study concerned with analyzing demand and spatial equilibrium models for U.S. fresh apples, made the following observation, "By far the most important problem encountered concerns the basic data."[2]

In addition to the usual limitations and shortcomings with respect to the accuracy and representativeness of available data, there is a dearth of price data by grade, variety, and origin of production in the apple industry.

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[1]Population estimates and the Wholesale Price Index were obtained from U.S. Department of Commerce, Survey of Current Business, and Economic Statistics Bureau of Washington, D.C., The Handbook of Basic Economic Statistics.

[2]W. H. Drew, "Demand and Spatial Equilibrium Models for Fresh Apples in the United States" (unpublished Ph.D. dissertation, Vanderbilt University, Department of Economics, January, 1961), p. 140.

A blend price was used in this study for both fresh and processing apples. Changes in this blend price over time may or may not be highly correlated with price changes for a specific variety or grade. The individual apple producer needs information on demand and supply conditions for his particular varieties and grades of apples. At present, data limitations preclude apple price analyses for particular grades and/or varieties on either a regional or a national basis.

Changes in apple prices resulting from a changing varietal composition is difficult to distinguish from changes in demand when only a blend price is available. In recent years, there has been a shift in apple plantings to varieties best suited for the fresh market. At the same time, consumption of processed apple products has been increasing relative to consumption of fresh apples. Apple price information on a grade and variety basis would be helpful in adjusting production to changes in consumer tastes and preferences.

CHAPTER II

THE U.S. APPLE EXPORT SITUATION

In this chapter, both the postwar export situation and potential increases in movement of U.S. apples in world markets are considered.

U.S. Exports

Prior to World War II, the export market (largely European) provided a significant outlet for U.S. apples. From 1934-1938, U.S. fresh apple exports averaged ten million bushels per year. During this period, the U.S. was the world's leading apple exporter, and exports averaged 10-15 percent of total production.[1] Today, the U.S. ranks fifth in apple exports after Italy, Argentina, the Netherlands, and Australia.

During World War II, apple exports of the U.S. shrank to one-tenth of the level prevailing before the war.[2] Following the war, most European countries prohibited or

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[1] U.S. Department of Agriculture, Foreign Agricultural Service, Information Relating to World Production and Trade in Deciduous Fruits, November, 1961.

[2] The Produce News, February 9, 1963, p. 18.

severely restricted imports of United States apples and other fruit. This was done in order to preserve their limited dollar exchange for more essential goods. Such actions tended to increase the price of fruit and encourage the expansion of European orchards. A vested interest was established which has firmly resisted the reduction or removal of these restrictions.

Since World War II, United States apple exports have been primarily to Canada, the United Kingdom, and countries of the European Economic Community (hereafter called EEC).[1] Exports during this period have varied between one and six percent of total United States' production with an annual average of about 3 percent. About 75 percent of all United States' apple exports were in the fresh form.[2] Today, import restrictions on United States' apples are much less onerous in Canada and the United Kingdom relative to countries of the EEC. Although not barring U.S. exports, most of the EEC members (except Italy and the Netherlands) admit U.S. apples only when local stocks have been completely used.

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[1]The six member nations of the European Economic Community (EEC), often called the European Common Market, are France, Germany, Italy, Belgium, Holland, and Luxembourg.

[2]Exports and import data were computed from U.S. Department of Commerce, <u>Foreign Trade Reports</u> and from data supplied by the Foreign Agricultural Service of the U.S. Department of Agriculture.

U.S. Imports

Imports of apples into the United States historically have been quite small even though United States' import duties are low compared to those of most other countries. Since World War II, imports of apples into the United States have averaged about 1.5 million bushels per year, representing slightly less than 1.5 percent of total United States' apple production. More than 80 percent of all United States' apple imports during this period came from Canada. Approximately 80 percent of all apple imports were in the form of fresh apples.

Summarizing the trade situation since World War II, U.S. exports and imports of apples and apple products have been quite low. In evaluating potential changes in U.S. apple exports and imports, attention is focused on countries likely to be most important as outlets for U.S. apples. Trade policies of Canada, the United Kingdom, and the EEC are likely to be crucial in determining whether U.S. apple exports and imports will continue to be of minor importance as they have been since World War II. A discussion follows of the effect of alternative trade policies by these countries.

Trade Policies of the EEC

Recent actions by the EEC indicate that a protectionist policy for many agricultural products will be continued. The EEC official fruit policy, released early in 1962, in addition to continuing the existing high tariff rates, imposes a variety of import restrictions on nonmember countries in the form of quantitative controls, suspension of exports, and a compensatory tax. In addition, at the end of a transition period, nonmember countries will face a common external tariff (CXT) while tariffs between member countries will be eliminated.[1]

External and Internal Tariffs.--The establishment of "internal" and "external" tariff rates by Member States in 1962 was one step in the transition toward a common agricultural policy within the EEC. "Internal" rates are the rates applied by Member Countries to other Member States of

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[1] The CXT to be applied after the transitional period on imports from nonmember countries is determined by taking the arithmetic mean of the tariff rates applied by member nations on January 1, 1957. However, the CXT determined in this way cannot be applied in all cases since some Member Countries are bound by treaty to respect tariff rates with nonmember countries, including countries operating under the General Agreement on Tariffs and Trade (GATT). These treaties will often contain a "most favored nation" clause. In such cases, GATT provides that the violation of the guarantee shall be compensated by the downward adjustment of another rate of comparable trade value.

the EEC during a transition period, while "external" rates apply to nonmember countries such as the United States. The "internal" rates represent the first of the gradual steps in the move toward ultimate elimination of duties between the Member States, while the "external" rates represent a move toward the Common External Tariff of the EEC. The CXT is to be in effect by the end of a transition period for agriculture. At the end of this transition period, tariffs and quotas between member nations are scheduled to be abolished. The original time-table has been accelerated. Starting in July, 1962, 7-1/2 years were allowed for the move to a common agricultural policy.

The common external tariff at the end of the transition period will likely be a greater obstacle to U.S. exporters than the previous duties even though it will approximate the average of the prior separate tariffs. The imposition of a CXT accompanied by the elimination of tariff barriers between Member Countries, when contrasted with the present situation, will give producers within the Community an advantage relative to nonmember countries.

In addition, if internal trade barriers are eliminated, apple production will tend to shift to those areas of the EEC in which apples have the best comparative advantage. This factor in the long run will also tend to decrease the competitiveness of U.S. apples with those produced within the EEC.

Apple Production.--Although the EEC is currently a deficit area in apple production, apple plantings have been taking place within the area at an "alarming rate."[1] The relatively high proposed common external tariff along with other barriers of the official EEC fruit policy such as a compensatory tax, quantitative controls, and suspension of imports leave little doubt that EEC apple producers will receive preferred treatment. This is especially likely since farm producers in Western Europe have a strong political voice. Under such conditions, traditionally important factors in trade such as cost of production or transportation differentials will have little effect on the allocation of EEC apple markets.

In recent years, import barriers by individual countries of the EEC have effectively restricted United States' apple exports into the area to a low level. In view of this fact, the Common Fruit Policy of the EEC is significant

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[1] International Fruit World, Autumn, 1959, p. 15. In May, 1962, a horticultural team of the National Farmers' Union visited several countries of the EEC. Their conclusion was that the EEC faces the prospect of a possible chronic surplus of apples. Source: IAA Special Letter, July 20, 1962.

to the United States apple producer more as an instrument of <u>continuing</u> the past policy of restricting United States' apples into markets of the EEC rather than as a means of decreasing United States' exports to this area. The point is that though there will likely be reductions in United States' apple exports to the EEC, exports to this area have been low since World War II due, in part at least, to arbitrary restrictions on imports from the United States by volume quotas, time restrictions, etc.

<u>Canada and the United Kingdom</u>

Let us now consider the potential for U.S. apple exports in markets of the U.K. and Canada, both important importers of U.S. apples in the postwar period. Export policies of these countries toward U.S. apples is highly dependent upon future actions of the Common Market countries. The potential effects of the interdependence of Canada and the U.K. with the EEC will now be explored.

A potentially important problem of the United States' apple industry is the admission of the United Kingdom into the EEC. At the time this is being written, entry of the United Kingdom into the EEC as a full member seems unlikely in the near future. So far, the U.K. has taken an all or nothing approach toward entry into the EEC. Even if the U.K.

does not join the EEC, she may enter an economic arrangement whereby special trade preferences are obtained.[1] There are at least two facets to this problem (the entry of the U.K. into the EEC) which are important in considering the impact of the EEC on the United States' apple industry.

At the present time, the United States competes for markets of the United Kingdom on the same basis as countries outside the Commonwealth. The tariff levels and other import barriers of the United Kingdom are much less stringent relative to present or proposed barriers of the EEC. During the past few years, exports of United States' apples to the United Kingdom have been larger than those to the entire EEC. Entry of the United Kingdom into the EEC would mean a sharp increase in her import duties, which could have a severe impact on United States' apple exports to the area.

Commonwealth Preferential Trading Arrangements.--The effect on U.S. exports of the entry of the United Kingdom

[1]During the past three years, ten nations have applied for membership into the EEC. The U.K., Norway, Denmark, and Ireland have applied for full membership. Greece became an Associate Member on November 1, 1962. Turkey and Spain have applied to become Associate Members prior to becoming full members. Austria, Sweden, and Switzerland have applied for Associate membership with a stipulation that they maintain their neutral status. In addition, Portugal, Israel, Iran, and Yugoslavia have indicated interest in some form of economic arrangement with the EEC such as a general Trade and Tariff agreement. U.S. Department of Agriculture, Foreign Agricultural Trade of the United States, October, 1962, and Time Magazine, October 5, 1962, p. 23.

into the EEC is further complicated by the preferential trading arrangements which now exist between the United Kingdom and members of the British Commonwealth. If the United Kingdom is successful in securing preferential terms for Commonwealth exports in the United Kingdom market, United States' apple exporters will face both increased duties and increased preferences in this market. However, if the United Kingdom should secure preferential arrangements for Commonwealth exports in the entire EEC area, United States' apple exporters will face even greater disadvantages.

In the eventuality that the United Kingdom is not successful in negotiating the continuation of Commonwealth preferential trade arrangements, the United States would likely face increased competition from the Commonwealth countries in her home markets. With respect to apples, the United States would face increased competition from Canada and Australia. Canada, in recent years, has been exporting between two and three million bushels of apples per year. Less than one-half of these have been exported to the United States, with a majority going to the United Kingdom. Australia has been exporting annually between four and five million bushels of apples to Europe. In addition, Argentina has been a heavy exporter of apples to Europe. The attainment of the predicted chronic apple surplus within the EEC, or even a move toward self-sufficiency, along with the United Kingdom's entry into the EEC would likely serve to increase United States' imports from these countries. In summary, the entry of the United Kingdom into the EEC, with or without preferential trade arrangements for the Commonwealth countries, is likely to have an adverse effect on United States' apple exports and may have an effect on United States' apple imports.

Though the future relationship of the U.K. to the EEC is not clear at this time, the probability seems quite high that the United Kingdom will be successful in negotiating some form of trade agreement involving closer economic ties with the EEC. Under these circumstances, the U.S. would no longer be competing for markets of the U.K. on the same basis as countries of the EEC.

Summary

In view of increasing apple production in Western Europe and present and proposed trade policies of the EEC, increases in exports of U.S. apples to Canada, the U.K., or the EEC seem unlikely. Furthermore, exports of a significant nature to countries that have been unimportant as importers of U.S. apples seem unlikely in the foreseeable future.

In summary, apple exports were found to have a negligible influence in the U.S. apple economy since World War II. A study of the proposed trade policies in countries that have historically been important importers of U.S. apples reveals that future increases in U.S. apple exports are unlikely. Consequently, the export demand for U.S. apples was not considered explicitly in this study.

CHAPTER III

ECONOMIC BEHAVIOR OF THE APPLE INDUSTRY

Apple Production

Apples are produced commercially in 34 states of the U.S.[1] Currently, the leading states in apple production are Washington, New York, Michigan, Virginia, and California in that order. Considered together, these 5 states account for about 60 percent of U.S. apple production.

During the postwar period, annual U.S. apple production varied from 86.9 to 134.3 million bushels (Table 3). Small, and progressively smaller, quantities of apples were used in farm households. Production having value during the period was about 97.7 percent of total production.[2] Thus, an average of 2.3 percent of the commercial crop was not

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[1]Commercial apple production, as used in this study, refers to the total apple crop in the commercial areas of these 34 states.

[2]"Production having value" includes quantities sold and quantities used on the farm but excludes "economic abandonment." Economic abandonment includes fruit not harvested and excess cullage of harvested fruit. Cullage represents sorts and culls (from marketable apples) which are not moved in a lower value outlet. Excess cullage is a subjective measure and includes cullage in excess of some "normal" level. U.S. Department of Agriculture, Crop Reporting Board, Statistical Bulletin No. 292, August, 1961, p. 3.

Table 3. Production and utilization of U.S. apples, 1947-1961, thousands of bushels.

Crop Year	Total Production	Total Fresh Sales	Sales of Processing Apples					Not Marketed		
			Total	Canned	Dried	Frozen	Other	Total	Farm Use	Economic Abandonment[a]
1947	112,892	77,207	26,369	9,003	4,926	762	11,678	9,316	4,846	4,470
1948	89,330	64,887	19,455	7,796	2,564	913	8,182	4,988	4,155	833
1949	134,309	80,082	37,218	14,140	4,667	1,731	16,680	17,009	4,777	12,232
1950	123,769	75,184	40,353	17,052	6,331	1,730	15,240	8,232	4,437	3,795
1951	111,799	69,153	28,196	11,925	3,495	1,229	11,547	14,450	4,374	10,076
1952	94,085	65,587	24,918	11,364	3,529	1,496	8,529	3,580	3,580	0
1953	95,778	65,023	27,612	13,341	3,272	1,441	9,558	3,143	3,143	0
1954	111,878	69,277	39,112	19,260	3,693	2,342	13,817	3,489	3,189	300
1955	106,263	67,836	32,930	15,884	3,890	2,041	11,115	5,497	2,628	2,869
1956	101,315	63,408	35,161	18,220	3,589	3,014	10,338	2,746	2,726	20
1957	119,258	78,553	36,274	17,423	4,509	2,528	11,814	4,431	2,665	1,766
1958	127,485	82,297	40,342	19,553	4,110	3,219	13,460	4,846	2,540	2,306
1959	126,847	79,872	43,003	19,131	3,807	4,268	15,797	3,972	2,365	1,607
1960	108,515	70,164	36,091	18,477	2,859	3,873	10,882	2,260	2,160	100
1961	126,710	77,705	45,502	22,732	3,903	3,876	14,991	3,503	2,202	1,301

[a]Apples not harvested or lost through excess cullage.

Source: Data for 1947-1948 from U.S. Department of Agriculture, SRS, Statistical Bulletin No. 192, September, 1956. Data for 1949-1959 from SRS, Statistical Bulletin No. 292, August, 1961. Data for 1960-1961 from Annual Supplements published by the Crop Reporting Board.

harvested or was lost through heavy cullage.

Harvest Period.--Apple production is seasonal in nature. The harvest date depends upon the variety, geographical area, and weather conditions. Varieties are classified into three groups on the basis of harvest date and storage quality - "summer," "fall," and "winter." The harvesting of summer varieties, which comprise roughly five percent of total production, begins in July and ends in September.[1] The major portion of these apples are stored for a very short period to permit cooling and distribution to truckers and then move directly from packing sheds into the fresh apple market. A minor portion of the summer apples are sold to processors.

The harvest period for fall and winter varieties begins in August and ends in November.[2] These apples may move from packing sheds directly into fresh or processing apple markets or they may be stored and sold later in the apple marketing season. Thus, producers must make the economic decisions concerning most profitable rates of sales from storage as the marketing season advances. Most apples are

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[1] U.S. Department of Agriculture, Fruits and Tree Nuts, Bloom, Harvesting, and Marketing Dates, and Principal Producing Counties, Agriculture Handbook No. 186, July, 1960, pp. 16-19.

[2] Ibid., pp. 20-58.

stored in farmer owned facilities.[1]

Apple Storage

Storage holdings tend to vary according to crop size with a larger quantity placed in storage when the crop is large. Since World War II, the percent of annual production of fall and winter varieties which was in storage on December 1 has varied between 34 and 45.[2]

Types of Storage.--There are three types of apple storage facilities. Common storage facilities are unrefrigerated. Such storage is for short duration and is frequently used by apple processors. The proportion of total apple holdings in common storage is not known, so these apples were considered as part of regular refrigerated storage.

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[1]Since World War II, apple producers have been shifting from public to private storage facilities. This change has been due to both physical and economic factors. Some of these factors are:

1) apples are very sensitive to temperature and humidity conditions. Proper storage conditions for apples are not easily obtained in public warehouses which store other commodities.
2) Controlled Atmosphere storage is not available in public warehouses.
3) construction of storage facilities provides off-season employment for farm workers.
4) on farm storage facilities decrease marketing costs in terms of hauling costs and quality loss.

Drew, op. cit., p. 38.

[2]International Apple Association, "Special Letters," various issues.

The bulk of all stored apples is placed in regular refrigerated storage. A much smaller but rapidly increasing portion of apples is being held in Controlled Atmosphere (referred to as CA) storage. With this method of storage, a special atmosphere is maintained in a sealed storage room. The percentage of stored apples held in CA storage on December 1 increased from 0.2 percent in 1947 to 13.3 percent in 1961.[1] Most of this increase has occurred since 1956. The proportion of stored apples in CA storage becomes progressively greater as the marketing year advances. In April, 1962, CA holdings represented 39 percent of all apple holdings.[2]

The increase in CA storage has had a strong effect on marketing patterns. Such storage has enabled apple varieties which do not store well for long periods, such as the McIntosh and Jonathan, to be held in good condition for several additional months.

There are at least two factors, however, which have tended to hold down storage in CA facilities. Average total storage costs under this system are approximately one and one-half times as high as for regular refrigerated

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[1] _Ibid_.

[2] _Ibid_.

storage.[1] The special facilities required in CA storage increase average fixed costs relative to regular refrigerated storage costs. Average variable costs are also higher since refrigeration materials cost more in CA storage.

The producer's flexibility in marketing is also decreased when apples are stored in CA facilities. Apples placed in CA storage must be held in storage for a minimum of 90 days (to be sold as CA apples).[2] Once the room is opened, the apples must be marketed within a relatively short time period to maintain quality.

Apples not stored during the harvest season go directly into either the fresh or processing market.

The Apple Processing Industry

Location.--The apple processing industry varies according to geographical location. In general, processors are concentrated in the Appalachian Area, (Pennsylvania, Maryland, West Virginia and Virginia), New York and, to a lesser extent, Michigan and California.

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[1] J. C. Thompson, Jr., Apple Storage Costs in New York State, A.E. Res. 87, Cornell University, Department of Agricultural Economics, Ithaca, New York, March, 1962, p. 56.

[2] This legal requirement is based on the fact that apples must be in storage for a considerable period of time to get the "CA effect," i.e., to be able to differentiate CA apples from other stored apples.

During the 10 years, 1951 to 1960, 85 percent of the canned apple slices and 78 percent of all canned sauce were packed in New York and the Appalachian Area.[1] The pack of frozen apples, though small relative to canned apples, was more evenly distributed among areas. The pack of frozen apples by area during the same period was as follows: 36 percent in the Northeast, 33 percent in the Midwest, and 26 percent in the West.[2] Dried apples were processed almost exclusively in California and Washington.

Processing facilities are located in areas where sufficient quantities of apples suitable for processing are produced since it is not economically feasible to ship such apples over long distances. Consequently, the processing outlet is limited for producers in many areas of the U.S.[3] However, fresh and processing markets are interrelated to a major extent in areas where canning and freezing outlets take substantial portions of the crop. Even in areas where processing utilizes low grade fruit deemed unmarketable as

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[1]National Canners Association, "Supply, Stocks and Shipments Canned Apples," and "Supply, Stocks and Shipments Canned Apple Sauce," monthly.

[2]Dalrymple, <u>op. cit</u>., p. 132.

[3]Juice mills are found in every area, but apples pressed into juice are mainly sorts and culls from apples going into higher value outlets.

fresh fruit, price can influence to some extent the portion of the crop marketed in the fresh outlet.

Processing-Apple Utilization.--From 1947-1961, processing utilization averaged about 30 percent of total apple production.[1] Approximately 20 percent of all apples produced were canned, frozen, or dried. Other apples processed were used for lower value products such as vinegar, juice, and cider.

In recent years, the proportion of apples processed as slices or sauce has been increasing while the proportion going into the fresh market has been decreasing. The increase in pack of apple sauce has been especially pronounced.

These trends in apple utilization are reflected in the consumption data of Table 2. During the 15 year period from 1947-1961 per capita consumption both of canned and frozen apples and of apple juice increased quite sharply. Although dried apple consumption decreased, there was a net increase of consumption of processed apple products. During the same period, per capita fresh apple consumption trended downward. On balance, considering both fresh and processed

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[1]U.S. Department of Agriculture, Fruits Noncitrus by States, 1949-1959, Production, Use, Value, Statistical Bulletin No. 292, August, 1961, and annual issues with similar title dated July, 1962.

apple products, per capita apple consumption changed little in the postwar era.

Substitution Between Fresh and Processed Apple Products

Empirical evidence indicates that consumers, especially institutional users, consider fresh and processed apple products as substitutes.[1] There is also a high degree of substitution on the supply side. Many apples are suitable for use in either a fresh or processed form, and the quantity of apples supplied by producers to processors is strongly influenced by the relative prices of processing and fresh apples.[2] Although apple processing takes various forms, the total quantity of apples purchased for each end use is influenced by the prices at which apples are available. Thus, crop utilization and apple prices are jointly determined in the market.

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[1]Drew, *op. cit.*, pp. 213-214. At the retail level, Drew obtained a positive cross elasticity coefficient of .32 between fresh apple purchases and price of canned apples (the price elasticity of demand for fresh apples was -1.10). A positive cross elasticity coefficient of .67 was obtained between canned apple purchases and prices of fresh apples (the price elasticity of demand for processed apples was -0.73). See also Homer C. Evans, *The Nature of Competition Among Apple Processors in the Appalachian Area*, West Virginia University, Agricultural Experiment Station, Bul. No. 405, June, 1957, p. 56.

[2]Evans found that apple growers in the Appalachian Area consider fresh and processor buyers as highly substitutable. Evans, *op. cit.*, p. 88.

Time Periods

In studying demand or price fluctuations, aggregation of data according to definite time periods facilitates economic analysis. In this study, the apple marketing year, July through June, was divided into three within-year periods or "seasons."

Period I.--The first period is the beginning of the apple marketing season and includes the months of July-November. Almost all apples are harvested during this period. Production during period I was assumed equal to total annual sales of summer, fall, and winter apple varieties.

Fresh Sales.--During period I, large quantities of apples are moved in the fresh market. In addition, both apple processing and storage are important during this period. The following characteristics relating to apple storage and processing activities provide a major part of the rationale for including the months July-November in period I.

Storage.--The International Apple Association (hereafter referred to as the IAA) estimates apples in storage on a monthly basis. These estimates in each marketing year begin with a November 1 estimate and end with the June 1 estimate of storage holdings. The December 1 estimate seems to be considered the most significant of all the storage estimates.[1] By this time in the marketing year, such factors as apple size, grade, and condition along with the general reactions of buyers are pretty well sized up. In this study, December 1 holdings were assumed equal to the quantity of apples stored during period I.

Processing.--Apple processing is limited during July and August and is heavily concentrated during September, October, and November. In the period 1951-1960, 74 percent of the canned apple pack and 82 percent of the canned sauce pack was processed prior to December.[2]

Apples processed as canned apple slices and sauce are mainly tree-run and are sold to the processor at harvest. Consequently, most apples to be processed in these forms would be owned by processors or in their hands by the end of November (end of period I). Small quantities of apples are pressed into juice after period I. However, these are mainly apples graded out of fresh operations. In this study, all apples to be processed were assumed to be sold to processors in period I.

Period II.--The second period includes the months of December, January, February, and March. During this

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[1] Dalrymple, op. cit., p. 85.

[2] National Canners Association, op. cit.

period, apples move out of storage to meet the demand in the fresh apple market. A small quantity of apples are processed in period II; most of these are sorts and culls from stored fresh apples or are fresh apple stocks held by processors. Apple processing which occurs after period I was ignored in this study because it is minor and these apples are mainly utilized in lower value outlets such as juice and cider.

Period III.--The third period includes the months of April, May, and June. The economic relationships of period II and III are similar. When contrasted with period II, however, a much larger proportion of the apples sold in period III are CA apples. Apples continue to move from storage and storage stocks reach a minimum before the next crop harvest begins in July. In this study, all apples stored in any marketing year were assumed to be sold prior to July 1 since quantities sold after this date are very minor. Thus, in each year at the end of period III (or, at the beginning of period I) there were assumed to be no storage stocks of fresh apples.

Production-Stocks Identity

The physical supply available during each of the four periods is equal to the quantity of apples in storage at the beginning of the period plus the quantity harvested during that period. Apples may remain in storage or be sold in the fresh and/or processing markets. Storage and processing activities are, however, restricted to certain periods. A production stocks identity may be written

$$(1) \quad S_{(m-1)t} + q_{mt} = S_{mt} + f_{mt} + a_{mt}$$

$$m = 1, 2, 3; \; t = 1947, 1948, \ldots, 1961.$$

In this identity, small letters represent flows and capital letters represent stocks. The subscripts m and t indicate, respectively, the period and year being considered. The identity states that for any period of any year, the supply of apples at the beginning of the period, $S_{(m-1)t}$, plus the quantity harvested during the period, q_{mt}, constitute the total supply. This supply is equal to the quantity of apples stored at the end of the period, S_{mt}, plus the quantities used during the period in the fresh form, f_{mt}, and in the processed form, a_{mt}.

The identity holds for all periods, but in some periods storage and processing activities are at the zero level. For example, production takes place only in period I. Therefore, $q_{2t} = 0$ and $q_{3t} = 0$. There are no storage stocks at the beginning of period I. Hence, $S_{3(t-1)} = 0$. Apples were assumed processed only in period I. So, $a_{2t} = 0$ and $a_{3t} = 0$. The quantity of apples moved in the fresh form, f_{mt}, however, is positive during each of the three periods.

In the storage function which is developed in the next chapter,

(2) $s_{mt} = S_{mt} - S_{(m-1)t}$

In this relationship, s_{mt} represents a flow during the m^{th} period. In determining s_{1t}, $S_{3(t-1)} = 0$. Therefore, $s_{1t} = S_{1t}$.[1] In period I, s_{1t} is positive representing movement into storage. In periods II and III, s_{mt} is negative indicating the rate of movement out of storage during the two periods.

Total Apple Supply Predetermined

Apple supply is largely predetermined in any given year. Small quantities of apples, as previously indicated, may be left unharvested or culled during the marketing year because of price or price expectations. However, only to this very small extent can the season's supply of apples be considered endogneous.[2] Orchards are becoming larger

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[1] S_{1t} represents stocks at the end of period I for any year t. $S_{(m-1)t}$ for period I and year t represents the stocks at the beginning of this period which is equivalent to the stocks at the end of period III of the previous crop year (t-1).

[2] A. H. Harrington, "Demand for Fresh Market Apples" (unpublished Ph.D. dissertation, University of Illinois, Department of Agricultural Economics, May, 1962), p. 84.

and apple production is increasingly a more specialized operation. The trend toward a fewer number of larger producing units has permitted economies of scale in apple production. The typical apple producer has mechanical sprayers, pruners, and harvesting equipment which has decreased the proportion of apples not suitable for market and reduced average total harvesting costs. The result has been a sharp decline in apples not sold for economic reasons.[1] In this study, the quantity of apples sold was assumed to equal production and, consequently, was considered predetermined in any crop year.

[1]Drew, op. cit., p. 12.

CHAPTER IV

THE ECONOMIC MODEL

A complete economic model for apples at the farm level was formulated for each of the three periods of the marketing season.[1] In period I, there is a demand for fresh apples and for processing apples at the farm level.[2] In addition, apples may be stored during this period by the grower and moved into the fresh market later in the marketing year. Two demand relationships, a storage function, an allocation function, and an identity comprise the economic model. The rationale for including a processing apple

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[1] The model was complete in the sense that there were as many equations as current endogenous variables in each period. The model initially formulated is presented in this chapter. The revised model for period I is presented in the next chapter.

[2] In this study, the quantity of apples sold was related to farm or wholesale prices along with a group of consumer "demand shifters" such as income and sales of competing fruits. Hence, the demand relationships of this study are not behavior relations in the strict sense but are "partially reduced form" equations. Hildreth and Jarrett make the following observation concerning partially reduced form equations: "In a certain fundamental sense, all equations we are likely to deal with may be regarded as partially reduced form relations. It is always possible to imagine a more fundamental explanation of the phenomena that we observe, involving more equations and more endogenous variables." C. Hildreth and F. G. Jarrett, A Statistical Study of Livestock Production and Marketing, Cowles Commission Monograph No. 15, 1955, p. 108.

allocation function in the model in period I is presented later in this chapter.

No processing occurs in period II. Hence, the fresh apple demand function, the storage function, and the identity comprise the economic model. In period III, storage movement is predetermined (movement equals stocks at beginning of period) and there is no processing. Thus, the fresh apple demand relationship and the identity comprise the economic model in this period.

The existence of different prices at the farm level implies that fresh and processing apples are different commodities to producers and buyers. From the producer's standpoint, production costs are lower in producing apples for processing outlets.[1] Pruning and thinning may be done more lightly with a consequent increase in yield per tree. In addition, color, size, and shape need not be as uniform as for apples going into the fresh market. Minor skin blemishes can be peeled off and less care is needed in assembling fruit to be processed. The result is lower harvesting and hauling costs.

Growers selling on the fresh market must also supply

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[1] D. R. Papera, "The Rise and Decline of the California Apple Industry" (unpublished Ph.D. thesis, Stanford University, Food Research Institute, 1958), p. 114.

the containers whereas growers selling to processors usually get their containers back. Fresh growers, as an additional marketing cost, generally must pay a sales fee which is not required by growers selling apples to processors.[1] Evans found that grower costs in the Appalachian Area were from $0.96 to $1.28 more per bushel in selling on the fresh market.[2]

The demand at the farm for fresh or processing apples is a derived demand based on consumer demand for fresh and processed apple products. A shift in the demand for fresh relative to the demand for processing apples may be brought about by changes in tastes, prices of competing fruits, income level, etc.

The various relationships of the model and the sources of data used in estimating the parameters of the model follow.

Demand for Fresh Apples

The demand relationship for fresh apples is applicable during each of the three periods of the marketing year. This structural equation adapted from the Cromarty-Boger model

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[1]Dalrymple, op. cit., p. 59. The sales fee may be brokerage or commission. This fee is not required for the grower selling directly to the processor.

[2]Evans, op. cit., p. 47.

took the form:[1]

$$(1)\ f_{mt} = f(p^{f}_{mt},\ p^{f}_{(m-1)t},\ y_{mt},\ c_{mt},\ p^{a'}_{1t},\ u_{mt})$$

where

f_{mt} = per capita sales (in pounds) of fresh apples in period m and year t on a monthly basis.

p^{f}_{mt} = deflated farm price in cents per pound of fresh apples in period m and year t.

$p^{f}_{(m-1)t}$ = deflated farm price in cents per pound of fresh apples in the previous period.

y_{mt} = deflated per capita consumer disposable income in period m and year t in hundred dollar units, on an annual basis.

c_{mt} = per capita marketings (in pounds) of competing fruits in period m and year t on a monthly basis.

$p^{a'}_{1t}$ = deflated season average farm price in cents per pound of canning and freezing processing apples. This variable was included only in period I.

u_{mt} = an error term.

In period III, f_{mt} can be considered as predetermined since there is no processing or storage (the movement out of

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[1]Cromarty, op. cit., p. 27. To simplify notation in this chapter, the dependent variable (Y) in each relationship discussed is expressed as a function of a group of explanatory variables ($X_1, X_2, \ldots, X_k, u$) as $Y = f(X_1, X_2, \ldots, X_k, u)$. In some cases, a parameter will refer to a coefficient of a variable in a linear expansion of the function. In other cases, a parameter is the coefficient of the log of a variable when the relationship is linear in logs. Assumptions made concerning the disturbance term u in the estimation procedures of this study are presented in a later section of this chapter.

storage in period III is always equal to beginning stocks). Consequently, p^f_{mt} is the only endogenous variable in the relationship. Thus, in estimating the parameters of the fresh apple demand relationship during the final period of the apple marketing year, least-squares single-equation methods can yield unbiased parameter estimates. In periods I and II, however, the quantity of fresh apples sold is jointly determined with the quantities stored or sold to processors and prices. The structural equations in these periods must be estimated by a simultaneous equations method to obtain (asymptotically) unbiased estimates of the parameters.

<u>Fresh Sales</u>.--Data on sales of fresh apples in period m and year t, f_{mt}, were obtained using the production storage-stocks identity:

$$q_{mt} + S_{(m-1)t} = S_{mt} + f_{mt} + a_{mt}$$

Storage stocks information from the International Apple Association provided the necessary data to compute S_{mt} and $S_{(m-1)t}$.[1] Quantities produced and processed, q_{mt} and a_{mt}, are estimated by the Crop Reporting Board.[2] Hence,

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[1]IAA, <u>op. cit</u>.

[2]U.S. Department of Agriculture, <u>Fruits Noncitrus by States 1949-1959</u>, Statistical Bulletin No. 292, August, 1961, and annual supplements.

fresh sales were found by solving the relationship for f_{mt}.

$$f_{mt} = S_{(m-1)t} + q_{mt} - S_{mt} - a_{mt}$$

Fresh Price.--The U.S. average farm price of fresh apples (in any period), p^f_{mt}, was used as the price indicator. Monthly prices were averaged to get the price indicator in each of the three periods. Fresh apple price is an endogenous variable in relationship (1) during each period. In accordance with traditional demand theory, the coefficient of price was expected to have a negative sign.

Lagged Fresh Price.--The rationale for including fresh price during the preceding period, $p^f_{(m-1)t}$, as a predetermined variable was as follows. It was hypothesized that consumption now and consumption next period are substitutes. Thus, a high price in the present period is expected to be associated with smaller purchases in the current period and larger purchases in the next period. That is, an increase in $p^f_{(m-1)t}$ is expected to be associated with an increase in f_{mt}. Or, viewed differently, large purchases in the previous period due to an abnormally low price are expected to be associated with a decrease in sales of the present period, f_{mt}. This result might be caused by either the partial satisfaction of consumer desires or the partial filling of storage facilities within retail outlets or households.

Income.--Consumer disposable income was used as the income indicator variable in the analysis. Income was assumed to be predetermined although changes in apple prices have a small influence on disposable income. Income data are reported on a quarterly basis and do not coincide with the three time periods used in this analysis. Income during period I, y_{1t}, was a weighted average of consumer disposable income during the third and fourth quarters. A weighted average of consumer disposable income during the fourth quarter of year t and the first quarter of year (t+1) was constructed to get y_{2t}. In period III, y_{3t} equals consumer disposable income in the second quarter.

Fruits are generally considered to be "normal" goods. That is, an increase in income is expected to be associated with an increase in sales. Brandow estimated the retail income elasticity of fruits to be +.40 during the period 1955-57.[1] For apples, the empirical evidence presents a mixed picture. Drew estimated an income elasticity coefficient of +.35 for fresh apples at the retail level based on data for the period 1934-1956.[2] Harrington analyzed annual retail

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[1] G. E. Brandow, Interrelations among Demands for Farm Products and Implications for Control of Market Supply, Penn. State Univ., AES Bul. No. 680, Aug., 1961, p. 17.

[2] Drew, op. cit., p. 213.

fresh apple prices for the period 1934-1959 and concluded that the income effect was positive through 1954 but has not exerted a measurable influence since that time.[1]

<u>Permanent Income</u>.--Brandow, Drew, and Harrington in apple price analyses used consumer disposable income as the income indicator. Other measures of consumer income were tried in preliminary stages of the present analysis. One of these was a measure of "permanent income."[2]

The permanent income hypothesis suggests that consumer demand depends on the expected normal level of income. The following formulation permits an application of this hypothesis without constructing a permanent income series.

A slightly simplified form of the fresh apple demand function was assumed.

$$(2) \quad f_{mt} = b_o + b_1 p^f_{mt} + b_2 c_{mt} + b_3 y^*_{mt} + v_{mt}$$

where

f_{mt}, p^f_{mt}, and c_{mt} are as defined previously, and

y^*_{mt} = expected or normal income in period m of year t.

v_{mt} = an error term

An expectational equation of the following form was

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[1]Harrington, <u>op. cit</u>., p. 171.

[2]M. Friedman, <u>A Theory of the Consumption Function</u> (Princeton, New Jersey: National Bureau of Economic Research, 1957).

assumed.

$$(3) \quad y^*_{mt} - y^*_{(m-1)t} = \alpha(y_{m-1)t} - y^*_{(m-1)t})$$

where

y^*_{mt} is as defined above, and

y_{mt} = consumer disposable income in period m of year t.

This function assumes that the change in expected income between the previous and the present period is a constant proportion of the difference between expected and realized income in the previous period.[1]

After making the necessary substitutions to express (2) in terms of y_{mt} rather than y^*_{mt}, we have:

$$(4) \quad p^f_{mt} = - \alpha \frac{b_o}{b_1} + \frac{1}{b_1} f_{mt} + (1-\alpha) p^f_{(m-1)t} - \frac{b_2}{b_1} c_{mt}$$

$$+ \frac{b_2}{b_1}(1-\alpha) c_{(m-1)t} - \frac{1-\alpha}{b_1} f_{(m-1)t} - \alpha \frac{b_3}{b_1} y_{(m-1)t}$$

$$+ u_{mt}$$

where

$$u_{mt} = - \frac{1}{b_1} v_{mt} + \frac{(1 - \alpha)}{b_1} v_{(m-1)t}$$

In this formulation, all variables other than income

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[1] M. Nerlove, Distributed Lags and Demand Analysis for Agricultural and Other Commodities, Agriculture Handbook No. 141, AMS, U.S. Department of Agriculture, June, 1958, p. 111.

enter as current and lagged variables. Income enters only as a lagged variable. In view of the large number of variables arising out of this approach and the limited number of observations available, this method was not pursued. This approach does provide another basis, however, for including $p^{f}_{(m-1)t}$ as an explanatory variable in the fresh apple demand relationship and for expecting its coefficient to be positive.

<u>Personal Consumption Expenditures</u>.--Consumer disposable income less personal savings equals personal consumption expenditures. Measured consumer income is viewed as consisting of "permanent" and "transitory" components in the permanent income hypothesis. The transitory components show up mainly in measured consumer savings. These components do not affect consumption except as they are translated into effects lasting beyond the consumer's "horizon."[1] Hence, under Friedman's hypothesis, we might expect the correlation between personal consumption expenditures and permanent income to be higher than the correlation between disposable and permanent income.

Exploratory results revealed that consumer disposable income and personal consumption expenditures were highly

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[1]M. Friedman, <u>op. cit.</u>, p. 221.

correlated during the period of analysis. Preliminary results obtained were virtually the same when consumption expenditures were substituted for disposable income as the income indicator in the fresh apple demand relationship.[1] Consequently, the consumption expenditures variable was not given further consideration, and consumer disposable income was included as an income variable in the fresh and processing demand relationships. This variable was deflated by the consumer price index.[2]

Competing Fruits.--Sales of competing fruits, c_{mt}, was included as an exogenous variable. Sales rather than prices were used because it was felt that sales are more nearly predetermined.

Oranges are often considered to be competitive with apples in consumption. Work by Harrington and Dalrymple, however, indicates that the relationship of oranges and fresh apples during the postwar period is one of independence rather than substitution.[3] In the present study, sales of peaches, pears, and California table grapes by period were included in the index of competing fruits. The method of estimating

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[1]These results are presented in Appendix A, Table 6.

[2]U.S. Department of Commerce, Survey of Current Business.

[3]Dalrymple, op. cit., p. 176 and Harrington, op. cit., p. 170.

sales of each of these fruits by period is presented in Appendix B, Table 6.

Processing Apple Price.--Empirical evidence shows that fresh and processed apple products are substitutes at the retail level.[1] Hence, if increases in the farm price of processing apples cause increases in the retail price of processed apples, they should, other things equal, be associated with increases in fresh apple purchases. The price of canning and freezing apples, $p^{a'}_{1t}$, was included as the processing price variable since processing apples other than canning and freezing are of lower quality and are not as competitive with fresh apples. This variable was included as an explanatory variable in the fresh apple demand relationship only in period I. p^{f}_{1t} and $p^{a'}_{1t}$ are highly intercorrelated ($r = +.84$), and satisfactory results could not be obtained in the fresh apple demand function by including $p^{a'}_{1t}$.[2] Consequently, this variable was dropped from further consideration in the fresh apple demand function.

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[1] Drew, op. cit., pp. 213-214.

[2] When $p^{a'}_{1t}$ was included as an explanatory variable in the fresh apple demand relationship with price dependent, the coefficient of fresh sales was positive.

Demand for Processing Apples

Apple sales to processors were assumed to be made only in period I. Both price and quantity in the processing demand relationship were considered current endogneous variables. The quantity, a_{1t}, and price, p^a_{1t}, of apples processed are determined jointly with fresh price, fresh sales, and apple storage in period I.

The processing demand function was of the form:

$$(5) \quad a_{1t} = f(p^a_{1t}, A_{1t}, d_{1t}, y_{1t}, p^f_{1t}, e_{1t}, c'_{1t}, p^a_{1(t-1)}, u_{mt})$$

where

y_{1t}, p^f_{1t}, and u_{mt} are as previously defined and

a_{1t} = quantity of apples (in pounds) utilized by all apple processors on a per capita basis.

p^a_{1t} = deflated season U.S. average farm price in cents per pound of all processing apples.

A_{1t} = per capita carryover stocks (in pounds) of processed apple products in canners hands at the beginning of period I.

d_{1t} = an index of processing costs.

e_{1t} = August apple crop estimate in pounds per capita.

c'_{1t} = production of competing fruits in pounds per capita.

$p^a_{1(t-1)}$ = deflated season U.S. average farm price in cents per pound of all processing apples in the previous year.

<u>Processing Price</u>.--Lower processing apple price (p^a_{1t}), other factors equal, was expected to result in a larger quantity of apples processed.

<u>Carryover Stocks</u>.--An increase in carryover stocks of processed apple products, A_{1t}, was expected to decrease the demand by processors for apples in the current marketing year. Processed stocks data on a monthly basis are available only for canned and frozen apple slices and sauce. These stocks constitute a large part of carryover and were assumed to be representative of carryover stocks of all processed apple products during the period of analysis.

Apple processing begins in July but few apples are processed before August. Opening dates for apple processing vary from year to year depending upon crop conditions. End of July stocks data were used as the carryover indicator variable since stocks on hand at this time would include almost entirely products carried over from the previous apple marketing year.

<u>Processing Costs</u>.--An increase in processing costs, d_{1t}, would decrease the processor demand for apples if other factors remain unchanged. Processing costs for the postwar period are not available. Consequently, an index was constructed to estimate changes in processing costs during the period of analysis.

Labor and cans were selected as items to represent all processing costs. These items represent approximately 75 percent of total processing costs - a figure which has been quite constant in the postwar years.[1]

In constructing d_{1t}, the labor component was represented by average hourly earnings in the canning and freezing industries.[2] Can prices were obtained from The Almanac of the Canning, Freezing, and Preserving Industries.[3] Can costs were weighted twice as heavily as labor costs. The index was then deflated by the Wholesale Price Index.

In 1962, an index of the prices of intermediate goods and services used in marketing farm products was constructed for the postwar period by the U.S. Department of Agriculture.[4] This index and the constructed index were highly correlated (these indices are presented in Appendix B, Table 14).

Income.--Drew estimated an income elasticity of

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[1] V. F. Kaufman, "Costs and Methods for Pie-Stock Apples," Food Engineering, December, 1951. Other data used were supplied through correspondence with an accounting firm.

[2] U.S. Department of Labor, Bureau of Labor Statistics, Monthly Labor Review, various issues. A simple average for September, October, November and December was used.

[3] E. E. Judge, The Almanac of the Canning, Freezing, and Preserving Industries, No. 9, Court Street, Westminister, Maryland, 1962, p. 308.

[4] U.S. Department of Agriculture, The Marketing and Transportation Situation, May, 1962.

+.53 for processed apple products at the retail level.[1] If this estimate is approximately accurate, an increase in income would likely be associated with an increase in demand at the farm level, other things equal.

Preliminary investigation revealed that y_{1t} and d_{1t} were highly intercorrelated (r = .94) and d_{1t} explained very little of the price variation in initial analyses of the processing demand relationship. Consequently, the processing cost index, d_{1t}, was dropped from the analysis.

If there is a negative relationship between a_{1t} and d_{1t}, omitting d_{1t} would likely cause a downward bias in the estimated coefficient of y_{1t}. As the estimates turned out, however, the coefficient of y_{1t} was significantly positive, and indicated an unreasonably high (rather than unreasonably low) income elasticity (about 4).

<u>Fresh Price in Period I</u>.--Fresh apples appear to be substitutes in consumption for processed apple products.[2] That is, an increase in fresh price increases consumer demand for processed products. Fresh apple prices in period I are positively correlated with fresh prices during the remainder of the apple marketing season. For these reasons,

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[1] Drew, <u>op.cit</u>., pp. 213-214.

[2] <u>Ibid</u>.

a high fresh price during period I might indicate to the processor that the demand for processed apples will be high. Under these conditions, the coefficient of fresh price was expected to have a positive sign. Fresh and processing apple prices are highly correlated as indicated previously. Satisfactory results could not be obtained by including fresh price in the processing apple demand relationships.[1] Consequently, this variable was dropped from further consideration in the processing demand function.

Crop Estimate.--The September crop estimate, e_{1t}, made by the U.S. Department of Agriculture, is available to all segments of the apple industry. A large crop estimate is associated with lower fresh apple prices both at harvest and later in the marketing season. Under such conditions, processors may expect the demand for processed products to be adversely affected during the ensuing marketing year due to the competitive relationship between fresh and processed apple products. If this is the case, a large crop estimate will adversely affect processor demand for apples.

Competing Fruits.--Another variable included in the

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[1]When p^f_{1t} was included as an explanatory variable in the processing demand relationship with price dependent, the coefficient of processing sales was positive.

processing demand relationship was an index of production of fruits that are competitive with processing apples, c'_{1t}. c'_{1t} differs from c_{1t} since different fruits are competitive with fresh apples than with processing apples (or processed apple products).

A change in price of competing fruits might affect processor demand for apples in two ways. Many apple processors also process other fruits. Under given demand conditions for processed products, relatively lower prices of competing fruits would tend to make apple processing a less profitable operation at any given cost for apples.

There is also substitution in consumption for processed apple products and canned peaches, pears, cherries, etc. An increase in production of competing fruits would tend to result in lower prices and hence result in a decrease in demand for processed apple products.

Fruits included in c'_{1t} were felt to be closely competitive with sliced apples (used mainly for pie stock) or apple sauce. Production of sour cherries, Washington, California, and Oregon Bartlett pears, California peaches, and California, Washington, and Utah apricots were included in c'_{1t}. These fruits are primarily used for processing purposes. Preliminary results indicated that changes in this variable were not associated with changes in a_{1t}

and c'_{1t} was dropped from the analysis.

Lagged Processing Price.--Because processed apples can be stored for long periods, one might expect processors to buy larger quantities of apples in years when prices are low. That is, there is likely to be substitution in apple purchases between years on the part of apple processors. If this hypothesis is true, an increase in $p^a_{1(t-1)}$, other factors equal, would be associated with an increase in a_{1t}.

The Processing Apple Allocation Function

The total quantity of apples produced in any year was considered predetermined in this study. In period I, producers sell apples for fresh use, f_{1t}, and for processing, a_{1t}. Apples produced and not moved in fresh or processing outlets at harvest are stored and sold at a later time in the fresh market.

Although the total quantity of apples produced was considered predetermined, the quantity sold in the fresh or processing markets or the quantity stored cannot be considered as predetermined. Two prices, p^f_{1t} and p^a_{1t}, are determined simultaneously with the allocation by producers of apples into fresh or processing markets or into storage.

In this study, functions were estimated to explain changes in quantities of apples which producers wish

(1) to store (s_{1t}) and (2) to sell to processors (a_{1t}). The quantity producers sell fresh was treated as a residual. This choice of treating the quantity of fresh apples sold as a residual was arbitrary. With production predetermined, functions explaining changes in any two of the three quantities (f_{1t}, a_{1t}, s_{1t}) may be estimated and the third treated as a residual.

The allocation equation formulated in this study to explain the quantity of apples sold for processing in period I was:

$$(6)\quad a_{1t} = f\left(\frac{p^a_{1t}}{p^f_{1t}}, m_t, n_t, u_{mt}\right)$$

where

a_{1t}, p^a_{1t}, p^f_{1t} and u_{mt} have the same meaning as in the processing demand relationship.

m_t = per capita Eastern apple sales (in pounds) in year t.

n_t = per capita apple sales (in pounds) in other parts of the U.S. in year t.

<u>Processing-Fresh Apple Price Ratio</u>.--An increase in the processing-fresh price ratio would tend to result in more apples being allocated to the processing sector. The equilibrium price ratio in any season is determined simultaneously with the allocation of apples to fresh and

processing markets.

Regional Apple Production.--The processing apple industry is concentrated in the East. Therefore, the location of production may have an important effect upon the fresh and processing apple supply functions. A large crop in the East, m_t, relative to production in other parts of the U.S., n_t, would likely mean that a larger portion of all apples produced would be processed.[1] For these reasons, production was divided into "Eastern production" and "other production."[2]

The Storage Functions

Each producer makes his allocation among processing, fresh, and storage outlets more or less simultaneously. These decisions concerning the quantities to sell in each market and the quantity to store must be made at harvest. Since these decisions are interdependent, we might expect the same explanatory variables to be appropriate in

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[1] G. E. Brandow, A Statistical Analysis of Apple Supply and Demand, A.E. & R.S. No. 2, Pennsylvania State University, Dept. of Ag. Econ. and Rural Sociology, University Park, Pennsylvania, January, 1956, p. 10.

[2] Eastern production is labeled as such by the Crop Reporting Service. Production of 14 Eastern states from Maine to N. Carolina is included. "Other production" equals total production less Eastern production.

the storage function (of period I) and in the processing allocation function. A storage function including these explanatory variables was adopted for period I after experimenting with a storage function of the type described below for period II.

Storage occurs in period I and apples move from storage in periods II and III.[1] The storage function is positive in period I and negative in periods II and III. In period III, movement from storage always equals beginning stocks so that s_{3t} is predetermined.

Period I.--The storage function of period I was:

$$(7)\quad s_{1t} = f\left(\frac{p^a_{1t}}{p^f_{1t}},\ m_t,\ n_t,\ u_{mt}\right)$$

where

p^a_{1t}, p^f_{1t}, m_t, n_t, and u_{mt} have the same meaning as in the processing allocation function.

$s_{1t} = S_{1t} - S_{3(t-1)}$

Processing-Fresh Apple Price Ratio.--An increase in the price ratio is a reflection of an increase in processor demand relative to fresh demand. A relative increase in

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[1] A small quantity of apples moves in and out of storage in period I, but the extent of this movement is not known.

processing price will be reflected in a larger percent of the apples being allocated to the processing sector. It seems likely that part of the decrease in fresh sales would be in sales of periods II and III and, hence, would be reflected by a decrease in initial storage. The decrease in fresh sales, however, could be entirely at the expense of period I fresh sales.

Regional Apple Production.--As indicated previously, the apple processing industry is concentrated in the Eastern states although large quantities of apples are stored in these states. Apple production in other states is mainly for fresh use. An increase in m_t or n_t is likely to be associated with an increase in storage, but a given increase in n_t is likely to have a larger effect on s_{1t} than the same increase in m_t.

Period II.--The storage function of period II, as initially formulated, was:

$$(8) \quad s_{2t} = f(p^f_{2t}, k_{2t}, g_{(t-1)}, S_{1t}, c_{2t}, S^*_{2t}, u_{mt})$$

where

p^f_{2t}, c_{2t}, and u_{mt} have the same meaning as in the fresh apple demand relationship, and

$s_{2t} = S_{2t} - S_{1t}$

k_{1t} = the percent of stored apples in CA storage on December 1.

$g_{(t-1)}$ = the price increase in dollars per bushel in the previous year from period I to period III.

S_{1t} = the per capita quantity (in pounds) of apples on hand at the beginning of period II.

S^{*}_{2t} = the average quantity (pounds per capita) of apples on hand at the end of period II during the three preceding years.

<u>Fresh Price</u>.--The effect of current price, P^{f}_{2t}, upon movement from storage is not clear. Pubols found that current stocks and prices tend to move in the same direction.[1] Lower prices, however, might be associated with decreases in movement from storage due to expectations of higher future prices.

Expected future price less current price is the relevant consideration, in any period, in determining the quantity to store and the rate of sale from storage. The difference between the expected price of period III and P^{f}_{2t}, $(EP^{f}_{3t} - P^{f}_{2t})$, could not be included as a variable in the storage function of period II since the expected price of

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[1] B. H. Pubols, "Factors Affecting Prices of Apples," <u>Agricultural Economics Research</u>, Vol. VI, No. 3 (July, 1954), pp. 77-84.

period III was not known. However, three variables (k_{1t}, $g_{(t-1)}$, and c_{2t}) in the equation were included because of their possible relevance to the formulation of price expectations, and given Ep^f_{3t}, an increase in p^f_{2t} should cause a decrease in quantity stored.

<u>Storage Cost Considerations</u>.--Storage costs influence storage decisions by influencing expected profits. Apples will, in general, be stored and remain in storage as long as the expected price at a later date exceeds the current price plus storage costs (allowing for risk, spoilage, etc.). A large portion of apples are stored in producer owned facilities, and a large part of total storage cost consists of fixed cost. In the short run, apples will be stored as long as the expected price increase is greater than variable storage costs.

Available data for years prior to 1951 and for years since 1957 indicate that regular storage rates varied little during the postwar period.[1] This was made possible by economies resulting from increased storage capacity and increased efficiency and technology in storing apples. Average storage costs in recent years, however, have been

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[1]Cromarty, <u>op. cit</u>., p. 42 and personal correspondence with J. C. Thompson, Jr., Research Associate, Department of Physical Biology, Cornell University, Oct. 30, 1962.

increasing due to the increase in CA storage. Controlled Atmosphere storage costs are approximately one and one-half times as high as costs of regular refrigerated storage. This increase in costs, however, is more than compensated for by the price premium realized for CA apples.[1] Under these conditions, we might expect an increase in CA storage to be associated with an increase in period III price and a decrease in movement from storage in period II.

Price Increase in Previous Year.--The variable $g_{(t-1)}$ was included on the grounds that an increase in the within year movement of apple prices during the preceding year would adversely affect the movement of apples out of storage in the current year. In the storage relationship of period II, $g_{(t-1)}$ represented the price increase from period II to period III of the previous apple marketing season.

Storage Holdings at the Beginning of Period II.--Storage holdings are published monthly by the IAA and are expected to influence decisions of apple producers concerning rates of sale from storage. An increase in storage holdings

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[1] Thompson, op. cit., p. 56. Thompson found total annual storage costs in New York were $0.23 per box for regular and $0.37 per box for CA storage. The average price premium for CA apples was $0.86 per box.

is likely to adversely affect the producer's expectations concerning future prices.

Competing Fruits.--Sales of competing fruits, c_{2t}, will influence the movement of apples from storage. The expectation of sharp decreases in supplies of competing fruits would lead apple producers to expect more favorable prices. Information pertaining to current and expected production and prices of competing fruits is published in the widely distributed Newsletter published by the IAA.

Stocks During Same Period for Preceding Years.--Apples in storage at the end of period II during the three preceding years, S^*_{2t}, may influence storage decisions due to past habits or experience. This variable may reflect either commitments or past experience by producers with apple buyers.[1] A three year moving average was used to give

$$S^*_{2t} = \frac{S_{2(t-1)} + S_{2(t-2)} + S_{2(t-3)}}{3}$$

Simplified Storage Function

Preliminary results showed that the storage function

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[1]Evans, op. cit., pp. 63-64. Evans found that apple processors take a long-range view toward maximizing returns and place a great deal of emphasis upon maintaining good relations with growers. The same situation may well prevail in the fresh apple market.

in period II could be greatly simplified.[1] Beginning stocks, S_{1t}, and the percent of stored apples in CA storage at the beginning of period II, k_{1t}, explained about 90 percent of the variation in the storage movement during the period. Hence, the simplified function

(9) $s_{2t} = f(S_{1t}, k_{1t}, u_{mt})$

was substituted for the more involved storage function (8).

Gustafson has shown that under certain conditions ". . . the behavior of private inventory holders in aggregate operating in a competitive market, can be represented by a fairly simple functional relationship between the aggregate quantity of the commodity which is stored (carried over) at the end of a period and the total supply of the commodity which is available during the period (quantity carried in from the preceding period plus quantity produced during the period)."[2]

In the case of a three period model, with all production occurring in period I (and predetermined) and storage stocks at the end of period III equal to zero, the

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[1]Results of the preliminary storage functions are presented in Appendix A, Table 7.

[2]R. L. Gustafson, "Storage of Pork" (unpublished manuscript, Dept. of Ag. Economics, Michigan State University, February, 1959), p. 41.

essential conditions, in their simplest form can be stated as follows. First consider period II, and postulate that

a) price in period II is a decreasing function of quantity sold in period II, i.e.,

$$P_2 = \rho_2(S_1 - S_2), \; \rho_2' < 0;$$

b) price in period III is a decreasing function of quantity sold in period III, i.e.,

$$P_3 = \rho_3(S_2), \; \rho_3' < 0;$$

c) the marginal cost of storage is the same for all storers and is equal to

$$\gamma_2(S_2), \text{ with } \gamma_2' \overline{>} 0.$$

Then in competitive equilibrium,

$$(1) \quad \gamma_2(S_2) = \rho_3(S_2) - \rho_2(S_1 - S_2)$$

which if solved for S_2 as a function of S_1 gives, say, $S_2 = \theta_2(S_1)$.

Differentiating (1) with respect to S_1, we obtain

$$\frac{dS_2}{dS_1} = \frac{\rho_2'(S_1 - S_2)}{\rho_2'(S_1 - S_2) + \rho_3'(S_2) - \gamma_2'(S_2)}$$

Hence, $0 < \theta_2' < 1$

Next consider period I and postulate additionally that

d) price in period I is a decreasing function of quantity sold in period I,

$$P_1 = \rho_1(Q - S_1),\ \rho_1' < 0,$$

where Q is production;

e) the marginal cost of storage is the same for all storers and is equal to $\gamma_1(S_1)$, with $\gamma_1' \geq 0$. Then in competitive equilibrium

$$\gamma_1(S_1) = \rho_2(S_1 - S_2) - \rho_1(Q - S_1)$$

or

$$(2)\quad \gamma_1(S_1) = \rho_2[S_1 - \theta_2(S_1)] - \rho_1(Q - S_1)$$

which if solved for S_1 as a function of Q gives, say, $S_1 = \theta_1(Q)$.

Differentiating (2) with respect to Q, we obtain

$$\frac{dS_1}{dQ} = \frac{\rho_1'(Q - S_1)}{\rho_1'(Q - S_1) + \rho_2'[S_1 - \theta_2(S_1)][1 - \theta_2'(S_1)] - \gamma_1'(S_1)}$$

Hence, $0 < \theta_1' < 1$.

The conditions can be generalized without changing the essential nature of the results by, for example, introducing random components to represent other factors influencing demand, and then setting marginal cost equal to expected change in price.[1] This type of argument can be used to rationalize simplified storage functions such as (7) or (9).

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[1]See, for example, R. L. Gustafson, Carryover Levels for Grains, U.S. Department of Agriculture Technical Bulletin 1178, 1958.

In period I, m_t and n_t represent the total supply available during the period since $S_{3(t-1)} = 0$. In period II, there is no production and initial storage holdings, S_{1t}, constitute the total available supply during the period.

Summary of Relationships in Model

The economic model of the apple industry constructed in this study consists of fresh and processing demand relationships, an allocation function, a storage function, and an identity.[1] In the formulation which follows, the jointly dependent or current endogenous variables appear first in each relationship and are separated from predetermined variables by a semicolon. The period(s) in which each equation of the model holds is indicated by an X to the right of the equation. Variables excluded from the analysis after the preliminary stages (for reasons explained previously) are not included.

	Period		
	I	II	III
(1) $f_{mt}, p^f_{mt} ; p^f_{(m-1)t}, y_{mt}, c_{mt}$	X	X	X
(2) $a_{1t}, p^a_{1t} ; A_{1t}, e_{1t}, p^a_{1(t-1)}$	X		
(3) $a_{1t}, \frac{p^a_{1t}}{p^f_{1t}} ; m_t, n_t$	X		

[1]The assumed functional form of the model and the assumed distribution of the error term are presented in sections following this summary of the relationships comprising the model.

	Period I	Period II	Period III
(4) a. $s_{1t}, \dfrac{p^a_{1t}}{p^f_{1t}}\ ;\ m_t, n_t$	X		
b. $s_{2t}\ ;\ k_{1t}, S_{1t}$		X	
(5) $S_{(m-1)t} + q_{mt} \equiv f_{mt} + a_{mt} + S_{mt}$	X	X	X

A review of the economic activities during each period reveals that the model is complete, i.e., the number of current endogenous variables in any period is equal to the number of equations in that period. In period I, the model has both fresh and processing demands and an allocation equation for apples at the farm level. In addition, a storage function is included to explain changes in quantity of apples stored for later sale in the fresh market. Current endogenous variables in period I are f_{1t}, a_{1t}, s_{1t}, p^f_{1t}, and p^a_{1t}. Each of the four relationships (1), (2), (3), and (4a) and the identity hold in period I.

After period I, apples move from storage into the fresh market. This movement is at a variable rate depending upon present and expected future prices. In period II, f_{2t}, p^f_{2t}, and s_{2t} are current endogenous variables and (1), (4b), and (5) are the relevant relationships.

It was assumed that no fresh apples are carried over to the next marketing year ($S_{3t} = 0$). Consequently, $s_{3t} = S_{2t}$.

That is, the movement from storage in period III is always equal to the quantity of apples stored at the beginning of the period, so a storage function is not needed during the final period of the apple marketing year. There is one current endogenous variable, p^f_{3t}, and the relevant relationships are (1) and (5).[1]

Estimation Procedures and Assumptions

The assumptions of the ordinary least squares (OLS) and two-stage least-squares (TSLS) estimation procedures (and statistical tests) used in this study are listed at this point. The data are then examined in an attempt to determine if there were serious deviations from the basic assumptions upon which the analysis was based.

In matrix notation, the standard model employed in the OLS procedure is of the form:

$$(6) \quad \underset{Tx1}{Y} = \underset{TxK}{X} \underset{Kx1}{\gamma} + \underset{Tx1}{U}$$

where:

(a) U is a vector of unobserved random disturbances with $N(0,\sigma^2 I)$ distribution

(b) X is a set of fixed numbers (measured without error)

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[1] There is really just one equation since the identity in period III reduces to $S_{2t} \equiv f_{3t}$ and f_{3t} is a predetermined variable in (1).

(c) X has rank $K < T$.

The standard simultaneous equations model is of the form:

$$(7) \quad \underset{T\times G}{Y} \; \underset{G\times G}{\beta} = \underset{T\times K}{X} \; \underset{K\times G}{\Gamma} + \underset{T\times G}{U}$$

where:

(a) Y is a matrix of T observations on G jointly dependent variables

(b) X is a matrix of T observations on K predetermined variables

(c) All variables (Y's and X's) are measured without error

(d) β is nonsingular ($|\beta| \neq 0$)

(e) $\underset{1\times G}{U_t}$ $(t = 1, 2, . . . , T)$ has $N(0, \underset{G\times G}{\Sigma})$ with U_t independent of U_s. Elements of a given row of U may be correlated.

(f) Some elements of β and of Γ are assumed identically equal to zero; in the TSLS procedure one element in each column of β is assumed identically equal to one.

Under the assumptions of (6), the OLS estimate of γ is consistent and best linear unbiased. In addition, the standard significance tests of the regression coefficients are valid. In time-series analyses, however, the data often do not conform to these specifications. If the predetermined variables are not independent of the error term, if the disturbances are serially correlated, or if lagged endogenous variables are among the predetermined variables, the estimators no longer have all the characteristics noted above.

The two-stage least-squares (TSLS) procedure used in this study is one procedure for estimating the parameters of a simultaneous equations model and under the assumptions listed under (7), yields estimates which are consistent and asymptotically as efficient as any obtainable using the same amount of information. Where the number of observations is small, as in this study, however, a simultaneous equations estimation approach may not estimate the parameters more accurately than the OLS single equation procedure.

The model used for period II in this study was a linear simultaneous equations model in standard form, with $G = 3$. The model used for period I was not quite standard, since the ratio of two of the current endogenous variables appears in two of the six equations. No attempt was made to investigate the asymptotic properties of the TSLS estimates when a ratio is included in the model; intuitively it seems that they should still be at least consistent.

The relationships of this study estimated by TSLS, in general, seemed somewhat closer to <u>a priori</u> expectations than did the OLS estimates (although differences were negligible in several cases). Other investigators have also found this to be true for small samples. Foote found that TSLS procedures for small samples fairly regularly gave more accurate predicted values outside the period of fit than OLS methods.[1]

The problem of serial correlation in the disturbances in some cases has also been found to be serious in practice.[2] This problem is especially likely to occur in time series analysis. Two or more successive disturbances may be influenced by the same factor rather than by the independent or random influences. In such cases, the result may be serious errors in the analysis. An attempt was made to test for serial correlation of the disturbances in this study.

The Durbin-Watson test, the published tabulations for which extend to only five independent variables, was extrapolated linearly, where necessary, to include six variables. In this test, the following statistic was computed:[3]

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[1] R. J. Foote, W. A. Cromarty, and W. R. Sparks, "Empirical Results from Alternative Methods of Fitting Systems of Simultaneous Equations."

[2] Clifford Hildreth and J. Y. Lu, Demand Relations with Autocorrelated Disturbances, Tech. Bul. No. 276, Dept. of Ag. Econ., MSU, November, 1960.

[3] Joan Friedman, and R. J. Foote, Computational Methods for Handling Systems of Simultaneous Equations, AMS, U.S. Department of Agriculture Handbook No. 94, Revised May, 1957, pp. 77-78.

$$d' = \frac{\sum_{t=2}^{T} (d_t - d_{t-1})^2}{\sum_{t=1}^{T} d_t^2}$$

where

d_t = the unexplained residual for observation t.

The values d' and 4-d' were computed for the estimated relationships of the study and compared with the upper and lower limits of the test statistics. The three possible outcomes of the test are rejection of the null hypothesis (that is, no serial correlation exists among the residuals), non-rejection of the null hypothesis and indeterminancy. The indeterminate result is very common (this is especially true when the number of observations is small) which is a serious drawback in applying the Durbin-Watson test. At the 5 percent level of significance, the test was inconclusive for each of the relationships estimated in this study.

The presence of lagged endogenous variables also affects the properties of the estimators. Each of the fresh and processing demand relationships contained a lagged endogenous variable. If the disturbances in these relationships are normal and independent with zero means and a common variance, the estimators would be consistent but would not be unbiased.[1]

Other Estimation Problems

Single Equation.--The demand, storage, and allocation functions, except in period III, have at least two jointly dependent variables. When estimating structural equations with single-equation least-squares regression procedures, the choice of which of the current endogenous variables to consider dependent is open to question. Hildreth and Jarrett suggest that "least-squares bias might be minimized by treating as independent those current endogenous variables that are most strongly influenced by predetermined variables not appearing in the equation being estimated."[2] Though this criterion does provide a guide, the grounds for making a choice remain quite uncertain. Consequently, alternative estimates were obtained taking price and quantity as dependent in the demand relationships. The estimated relationships not presented and discussed in the following chapter are presented in Appendix A.

Two-Stage Least Squares.--In two-stage least-squares procedures, the jointly dependent variable to consider

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[1] Clifford Hildreth, class notes taken in AEC 876, Statistical Inference in Economics, July, 1961.

[2] C. Hildreth and F. G. Jarrett, op. cit., p. 71.

dependent in the second stage may be influenced by economic considerations but is still, at least to some extent, partly arbitrary. Thus, in estimating a demand relationship, quantity may be more appropriate than price as the dependent variable. In this study, alternative estimates were obtained with price and quantity taken as dependent in the second stage in the fresh and processing demand relationships. Quantity was selected as dependent (in the second stage) in both the allocation and the storage functions.

Identification.--Each equation in Periods I and II satisfies the necessary condition for over-identification in the standard linear simultaneous equations model, namely the number of predetermined variables in the system less the number of predetermined variables in each equation is greater than the number of current endogenous variables in that equation minus one. No attempt was made to investigate the effect on identifiability of including, in two of the equations in period I, the ratio of two of the current endogenous variables. Intuitively it seems that using the variables in ratio form should, if anything, increase, rather than decrease, identifiability. Also, when the TSLS procedure is used, if an equation is under-identified, that fact will tend to be revealed in the computations (at least when using the standard linear model), as one of the matrices which has to be inverted turns out to be singular (except for rounding error).

Standard Errors of Regression Coefficients.--The procedure for computing standard errors of regression coefficients in two-stage least squares is not a settled matter.[1] In this study, standard errors of the b's from the second stage were derived by use of the formula:[2]

$$S^*_{b_i} = c_{ii}\left[\frac{\Sigma_k(Y_k - \hat{Y}_k)^2}{df_2}\right]^{1/2}$$

where

$S^*_{b_i}$ ≙ the "correct" standard errors of the coefficients at the second stage.

c_{ii} = elements of the inverse matrix at the second stage.

$\Sigma_k(Y_k - \hat{Y}_k)^2$ = the sum of squared residuals using the observed Y's.

df_2 = the degrees of freedom in the second stage, i.e., the number of observations minus the number of predetermined variables in the second stage (including the vector of 1's since a constant term was included).

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[1]All TSLS standard error formulas are asymptotic. Consequently, tests are valid, strictly speaking, only asymptotically.

[2]L. V. Manderscheid and W. Ruble, Estimation of Two-Stage Least Squares with Special Reference to Mistic Facilities, M.S.U., A.E. 868, May, 1962, p. 5 (revised).

Some statistical investigators define $S^{*}_{b_i}$ using different degrees of freedom. Among the other degrees of freedom measures used are (1) the number of observations and (2) degrees of freedom in the first stage.[1] The former would give a smaller standard error while the latter would give a larger standard error than the procedure followed in this study.

Choice of Functional Form.--Inspection of the data did not point strongly toward any particular functional form. Estimates were first obtained by ordinary least squares assuming the underlying structure was linear. The relationships were then re-estimated with the data in log form.

If the relationships among the variables are proportional rather than absolute, transforming all data to logs should give a relationship which better fits the data. That is, if the underlying structure, which we are trying to approximate, is more nearly represented by constant percentage changes than by constant absolute changes, a log form would be appropriate.

The estimated relationships were quite similar in log and non-log form. However, the fits, based on $\bar{R}^2$, tended to be somewhat better when the data were not transformed

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[1] *Ibid.*, p. 6.

to logs. Consequently, in most cases the results of the model in log form are not discussed (but are summarized in Appendix A).

CHAPTER V

THE ESTIMATED RELATIONSHIPS

In this chapter, the estimated relationships are presented. The first section is a brief discussion of the various statistics which accompany each of the estimated relationships.

General Procedure

Testing the Regression Coefficients.--In the analysis, t values appear just below the regression coefficients in the relationships estimated by ordinary least squares and by two-stage least squares. A one-tailed t test was used in testing whether each partial regression coefficient was significantly different from zero since *a priori* information indicates the direction of the effect of each predetermined variable upon the dependent variable. In testing $H_o:\beta_1 \leq 0$ in a one-tailed t test, we do not reject if b_i happens to be negative. Consequently, X_i can have a significant effect in this case only if $b_i > 0$.

In testing whether a partial regression coefficient is significantly different from zero, it is useful to consider the consequence of making a type I or type II error. Since we cannot simultaneously minimize both types of errors (except by increasing the number of observations) we must consider in any test which error would have the more serious consequences. Very often in empirical work the α level is chosen at .01 or .05 without any real consideration of just how serious rejection of a true null hypothesis would be when contrasted with the error involved in accepting the null hypothesis when the alternative hypothesis is true.

In this study, as in much econometric work, fairly strong a priori beliefs are held about the directions of the effects of the various explanatory variables upon the dependent variable. Thus, for example, it is felt with a high degree of confidence that $\beta_i < 0$ where β_i is the parameter for carryover stocks in the processing demand relationship. The strength of this belief is such that it probably should not be questioned unless an estimate of β_i is obtained for which the probability of occurrence, given $H_0 : \beta_i > 0$ is true, is quite high. A similar situation holds for most of the other explanatory variables. Consequently, in the results presented below, the .05, .10, and .20 levels of significance are all considered relevant, and are designated by ***, **, and *, respectively.

Partial Correlation Coefficients.--The coefficient of partial correlation (partial r/y) measures the importance of each of the independent variables taken separately while allowing at the same time for the variation associated with the other independent variables. Or, stated differently, the coefficient of partial correlation is a measure of the extent to which that part of the variation in the dependent variable not explained by the other predetermined variables can be explained by the addition of a specific predetermined variable.[1] The partial correlation coefficients appear just below the t values of the regression coefficients.

Coefficient of Multiple Determination.--R^2 measures the percentage of the variation in the dependent variable which is explained by or associated with changes in the predetermined variables. $\bar{R}^2$ denotes an R^2 which has been adjusted for degrees of freedom.[2] In this study, $\bar{R}^2$ is presented instead of R^2 due to the small number of observations.

Standard deviation of the residuals.--This statistic, often called the standard error of estimate, is denoted by

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[1]Ezekiel and Fox, op. cit., pp. 192-196.

[2]$\bar{R}^2 = 1-(1-R^2)\ (\frac{T-1}{T-K})$ where T is the number of observations and K is the number of predetermined variables including a vector of 1's.

$S_{y \cdot x}$. It is a measure of how well the regression hyperplane fits the data, i.e., how closely the estimated values of the dependent variable approximate the observed values.[1]

Demand For Fresh and Processing Apples

The estimation of fresh and processing demand relationships presented special problems in period I. Consequently, the model as summarized at the end of Chapter IV was substantially revised. Results from the model as formulated in Chapter IV will first be presented and briefly analyzed. The revised model for period I will then be presented.

In period I, the demand relationships for fresh and processing apples were estimated using both single-equation least-squares (OLS) and two-stage least-squares (TSLS) procedures. During this period, neither fresh sales (f_{1t}) nor processing sales (a_{1t}) can be considered predetermined. In period I, the producer may either, (1) sell in the fresh market, (2) sell in the processing market, or (3) store and sell on the fresh market later in the marketing season.

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[1]In two-stage least-squares regression procedures, all current endogenous variables in the equation (to be estimated) except the variable considered dependent in the second stage are replaced by a linear combination of all the predetermined variables in the system. $S_{y \cdot x}$ and $\bar{R}^2$ values presented in conjunction with relationships estimated by two-stage least-squares were based on estimated instead of observed values of all endogenous variables except the variable which is dependent in the second stage.

Both the fresh and processing demand relationships were based on 15 observations. Since the periods of the analysis were of unequal length, quantity variables were put on a monthly or yearly basis to facilitate the comparison of coefficients for any given variable in different periods. The variables included in the fresh and processing apple demand relationshipsare presented and defined again at this point for ease of reference.

f_{mt} = per capita sales (in pounds) of fresh apples in period m and year t on a monthly basis.

p^{f}_{mt} = deflated farm price in cents per pound of fresh apples in period m and year t.

y_{mt} = deflated per capita consumer disposable income in period m and year t (on an annual basis) in hundred dollar units.

c_{mt} = per capita sales (in pounds) of competing fruits in period m and year t on a monthly basis.

$p^{a'}_{1t}$ = deflated season average farm price in cents per pound of canning and freezing apples in year t.

a'_{1t} = per capita farm sales of canning and freezing apples (in pounds) in period I and year t on a monthly basis.

e_{1t} = September apple crop estimate of year t in pounds per capita.

A_{1t} = August 1 per capita carryover canner stock (in pounds) of processed apple products in year t.

The following fresh and processing demand relationships with quantity dependent were estimated by TSLS.[1]

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[1]OLS estimates of these relationships were quite similar to TSLS estimates and are presented in Apprndix A.

Demand for fresh apples:

$$(1)\ \hat{f}_{1t} = 2.40 - .04p^{f}_{1t} - .08p^{f}_{3(t-1)} + .34c_{1t} - .06y_{1t}$$

t_b	.39	1.60	2.25	1.12
Partial r/y	-12	-.44	+.57	-.33

$$S_{y \cdot x} = .16,\ \bar{R}^2 = .63$$

Demand for canning and freezing apples:

$$(2)\ \hat{a}'_{1t} = 5.93 + .26p^{a'}_{1t} - .05p^{a'}_{1(t-1)} + .32y_{1t} - .10A_{1t} + .06e_{1t}$$

t_b	1.15	.85	4.24***	.63	2.07
Partial r/y	+.39	-.30	+.84	-23	+.61

$$S_{y \cdot x} = .13,\ \bar{R}^2 = .72$$

Coefficients of income (y_{1t}), competing fruits (c_{1t}), and lagged fresh price ($p^{f}_{3(t-1)}$) have "wrong" signs in (1). Downward trends in f_{1t} and c_{1t} and an upward trend in y_{1t} during the period of analysis may provide an explanation of the perverse signs of c_{1t} and y_{1t}.

The regression coefficient of fresh price, p^{f}_{1t}, has the right sign in (1), but the effect of fresh price on sales is not significantly different from zero. When c_{1t} and y_{1t} were replaced by a trend variable and lagged price was eliminated, the estimated fresh apple demand relationship became more consistent with conventional demand theory, and this function was retained in the revised model of period I (presented later in this chapter).

In the demand relationship for canning and freezing apples, price ($p^{a'}_{1t}$), lagged price ($p^{a'}_{1(t-1)}$), and crop estimate (e_{1t}) have "wrong" signs. The effect of income on canning and freezing apple sales was highly significant. However, there has been a sharp upward trend both in income and utilization of apples for canning and freezing purposes. Thus, income is likely acting as a proxy variable for a large number of factors which have caused the upward trend in processing utilization.

The sign of the coefficient of processing price in (2) is especially disturbing. Similar results were obtained when this relationship was estimated with price as the dependent variable. In this case too, a change in sales appeared to have no effect on price.[1] The results from this model are not consistent with conventional demand theory which holds that a change in sales, other factors equal, is associated with a change in price in the opposite direction.

The model for period I was then reformulated to incorporate a demand function for total apple sales (fresh plus processing) of period I. The inclusion of this relationship means that only a fresh or processing demand

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[1]Similar results were obtained when a processing demand relationship was estimated for all processing apples. These estimated relationships (mentioned but not presented in the text) are presented in Appendix A.

relationship (but not both) is needed to complete the model in period I. Various possible processing demand relationships were investigated, but an acceptable demand function for processing apples could not be formulated. A simplified demand function for fresh apples based on (1) (previously mentioned) was chosen to complete the model, although it appears to be less satisfactory than the other relationships of the model. The revised model of period I was:

(3) $p_{\overline{1t}} = \gamma_1 p^f_{1t} + \gamma_2 p^a_{1t}$

(4) $a_{1t} + f_{1t} = f(p_{\overline{1t}}, A_{1t}, u_{1t})$

(5) $f_{1t} = f(p^f_{1t}, T, u_{1t})$ T is a trend variable

(6) $a_{1t} = f(\frac{p^a_{1t}}{p^f_{1t}}, m_t, n_t, u_{1t})$

(7) $s_{1t} = f(\frac{p^a_{1t}}{p^f_{1t}}, m_t, n_t, u_{1t})$

(8) $q_{1t} = s_{1t} + a_{1t} + f_{1t}$

In this revised model of period I, there are six equations and six currently endogenous variables. The jointly dependent variables are p^a_{1t}, p^f_{1t}, $p_{\overline{1t}}$, a_{1t}, f_{1t}, and s_{1t}.

The first relationship in the revised model, (3), simply defines $p_{\overline{1t}}$ as a weighted average of p^f_{1t} and p^a_{1t}, where the weights, γ_1 and γ_2 (with $\gamma_1 + \gamma_2 = 1$), were based on sales of fresh and processing apples during period I.[1] The second relationship (4) is the demand function for all apples sold in period I. Period I fresh demand is represented by equation (5). Allocation and storage functions and the identity are as in the initial model of period I and comprise the last three equations of the revised model.

Demand for All Apples Sold in Period I

The following demand function for total apple sales in period I (based on 15 observations) was estimated by TSLS:

$$(4)\quad \hat{\bar{p}}_{1t} = 8.33 - 1.22(a_{1t} + f_{1t}) - .70A_{1t}$$

t_b	5.57***	4.29***
Partial r/y	-.83	-.76

$$S_{y \cdot x} = .29, \bar{R}^2 = .69$$

where

a_{1t}, f_{1t}, A_{1t}, and $p^f_{3(t-1)}$ are as defined previously, and

$\bar{p}_{1t}$ = the average price of total apple sales of period I (cents per pound) weighted by sales of fresh (f_{1t}) and processing (a_{1t}) apples in period I.

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[1]The weights were changed each year in accordance with changes in relative sales of fresh and processing apples. It may have been better to use constant weights based on average sales for the whole period.

All variables had the hypothesized effect in (4). Increases in sales ($a_{1t} + f_{1t}$) and in carryover canner stocks (A_{1t}) were associated with decreases in the average price of period I. The regression coefficients of sales and stocks will now be analyzed in more detail.

Fresh and Processing Sales.--An increase in sales of one pound per capita per month (3.8 million bushels at 1961 population level) in period I was associated with a decrease in price of 1.22 cents per pound ($0.59 per bushel). Based on average price and sales figures during the period of analysis, the elasticity of demand computed from (4) was -0.60.[1] Results were almost the same when all data were transformed to logs and the relationships were estimated by OLS.[2] In log form, the elasticity of demand was -0.42 with quantity dependent and -0.61 with price dependent. The effect of changes in total sales of period I upon changes in average price was highly significant in each of the relationships estimated.

[1]When a demand equation is fitted with price dependent, a price flexibility is obtained. The reciprocal of price flexibility was taken to be the price elasticity of demand. When quantity was taken to be the dependent variable, the elasticity of demand was -0.58.

[2]One might expect $a_{1t} + f_{1t}$ to be largely predetermined for the following reasons. Production is, for the most part, predetermined and storage, s_{1t}, is largely determined by production. If $a_{1t} + f_{1t}$ is largely predetermined, the OLS estimate should be quite good when the relationship is estimated with price taken to be dependent.

A 90 percent confidence interval was constructed for the coefficient of quantity in the demand relationships estimated by TSLS and OLS with price dependent.[1] Demand was found to be inelastic (at the mean levels of price and quantity in the linear function) throughout the range of the confidence interval. Similarly, when quantity was taken to be dependent, demand was inelastic throughout the range of the 99 percent confidence interval constructed for the coefficient of price. Hence, the evidence fairly strongly suggests that demand is inelastic for aggregate fresh and processing apple sales during the harvest period.

Canned Carryover Stocks.--Carryover of canned apples and apple sauce on August 1 ranged from 0.2 to 1.8 pounds per capita during the postwar period. In (4), an increase in carryover stocks of one pound per person (fresh equivalent basis) was associated with a decrease in price of $0.34 per bushel.

Although a satisfactory demand relationship for processing apples could not be formulated, a predictive equation was estimated which explained a high percent of the year-to-year variation in canning and freezing apple prices.

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[1]Confidence intervals of coefficients in the relationships estimated by TSLS were based on asymptotic standard error formulas.

This relationship is presented in the following chapter.

Whether fresh or processing apples have the more inelastic demand at the farm level is a moot question. If demand is, in fact, less elastic for fresh apples than for processing apples in period I, demand should be less elastic for fresh apples than for fresh and processing apples combined. Demand relationships are now presented for fresh apples.

Demand for Fresh Apples

Period I.--In the estimated demand relationship of period I for fresh apples previously presented (see [1]), income, competing fruits, and lagged fresh price had "incorrect" signs. As noted previously, trends were possibly masking the true effect of the explanatory variables in this relationship. A trend variable was added and y_{1t}, c_{1t}, and $p^f_{3(t-1)}$ were dropped from the analysis.

A much higher proportion of variation in the dependent variable was explained when quantity was considered dependent in the fresh apple demand relationship of period I. The estimated demand function for fresh apples in period I when all data were transformed to logs was:

$$(5.1)\quad \hat{f}_{1t} = 0.57 - .35p^{f}_{1t} - .10T$$

$$\begin{array}{llll} t_b & 1.70^{**} & 2.97^{***} & \\ \text{Partial } r/y & -.44 & -.65 & S_{y\cdot x} = .04,\ \bar{R}^2 = .46 \end{array}$$

where

f_{1t} and p^{f}_{1t} are as defined previously in logs, and

T = trend (1947 = 1, 1948 = 2, . . . , 1961 = 15) in logs.

Price.--An increase of one percent in fresh price was associated with a decrease of .35 percent in period I per capita fresh sales. Thus, the elasticity of demand for fresh apples in period I was -0.35. When this relationship was fitted in non-log form, the elasticity of demand at the mean values of price and quantity was -0.38 and $\bar{R}^2$ = .41. These results suggest that demand is more inelastic for fresh apple sales than for combined fresh and processing apple sales in period I. If this, in fact, is true, it implies that demand is more inelastic for fresh than for processing apples in period I. A comparison of standard errors suggests, however, that the relationship between sales and price was measured much more accurately in (4) than in (5.1). Also, the fit of (4) was considerably better than that of (5.1). The reason that results were more satisfactory when fresh and processing sales were combined and a blend price used than when demand functions for fresh or processing apples were estimated individually is not clear.

Trend.--Fresh sales in period I (on a per capita basis) trended downward during the postwar period. (The trend variable in (5.1) was significant at the .01 level.) Thus, the net effect of the many factors not included in the analysis was to decrease fresh sales.

A predictive equation was estimated for period I fresh price.[1] In this relationship, the effect of changes in the July U.S. Department of Agriculture crop estimate upon p^f_{1t} was highly significant. Fresh price appears to be influenced more by total production than by fresh sales during period I.

Periods II and III.--In period II, the producer has the alternative of selling on the fresh market or of leaving his apples in storage for sale in period III. All apples in storage at the beginning of period III are sold (in the fresh market) during the period. Consequently, p^f_{3t} is the only endogenous variable in this period. In this case, the OLS method of estimation (with price dependent) becomes a valid application of the simultaneous equation theory.

The estimated fresh apple demand relationships for

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[1]This equation is presented in the next chapter.

periods II and III appear in Table 4. In general, the results are consistent with a priori reasoning. The OLS and TSLS estimates differed little in period II.[1] In each case, the coefficient of income had the "wrong" sign. In period III, sales of competing fruits had the "wrong" sign. The individual regression coefficients in (5.2a) and (5.3) will now be discissed.

Lagged Fresh Price.--This variable was included on the grounds that anything which decreases current consumption will increase demand in the immediate future. Under this hypothesis, an increase in $p^f_{(m-1)t}$, other factors constant, would result in decreased apple sales, $f_{(m-1)t}$, and increase the demand for apples in the following period, f_{mt}.

In periods II and III, an increase in fresh price in the previous period was associated with a price increase in the current period. These results alone do not support the hypothesis that consumption is substitutable between periods since prices in successive periods are highly positively

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[1]It is not surprising that the OLS and TSLS estimates are very similar in period II since S_{2t} (and hence f_{2t}) in a later section is shown to be largely determined by S_{1t} and k_{1t} which are predetermined. If f_{2t} is largely perdetermined, the OLS estimate of the fresh apple demand relationship in period II should be quite good when price is considered dependent.

Table 4. Estimated fresh apple demand relationships, periods II and III.

Dependent Variable and Estimation Procedure	Constant Term	Regression Coefficients, t values, & Partial Correlation Coefficients[a]				$S_{y \cdot x}$	$\bar{R}^2$
		f_{mt}	$p^f_{(m-1)t}$	c_{mt}	y_{mt}		
Period II:							
OLS							
(5.2)p^f_{2t}	9.54	-2.34	+ .42	-1.16	- .13	.24	.93
		8.36***	2.88***	2.56***	2.10		
		- .94	+ .67	- .63	- .55		
TSLS							
(5.2a)p^f_{2t}	9.66	-2.37	+ .41	-1.15	- .13	.25[b]	.92[b]
		8.29***	2.83***	2.53***	2.12		
		- .92	+ .64	- .60	- .53		
Period III:							
OLS							
(5.3)p^f_{3t}	3.03	-2.63	+ .49	+1.21	+ .09	.44	.84
		3.89***	2.79***	1.41	.81		
		- .78	+ .66	+ .41	+ .25		

[a]t values of the regression coefficients appear just below the coefficient to which they apply. Partial correlation coefficients are below the t values.

[b]In two-stage least-squares regression procedures, all current endogenous variables in the equation (to be estimated) except the variable considered dependent in the second stage are replaced by a linear combination of all the predetermined variables in the system. $S_{y \cdot x}$ and $\bar{R}^2$ values presented are based on estimated instead of observed values for all current endogenous variables except the variable which is dependent in the second stage.

correlated. However, similar results were obtained when quantity was considered dependent (Appendix A, Table 1). Thus, consumption appears to be substitutable between periods, at least to some extent.

Competing Fruits.--The sign of the coefficient for competing fruits, c_{mt}, agrees with *a priori* reasoning in period II but is not consistent in period III. In period II, an increase of one pound per capita in sales of competing fruits resulted in a decrease in fresh price of $0.55 per bushel (1.15 cents per pound). The reason for the positive sign of c_{3t} is not clear. While it is possible that apples and the fruits included in c_{3t} are complementary in period III, c_{3t} is more likely acting as a proxy variable for factors not included in the analysis.

Income.--The income coefficient had the "wrong" sign in period II. In period III, the income coefficient had a positive sign as expected indicating that apples are a normal good. The coefficient, however, was less than its standard error and the effect of y_{3t} was not significant at an acceptable level.

It is likely that the effect of income is being masked by the effect of other variables. Measuring the effect of income upon apple demand during the postwar period presents difficult problems arising out of trend considerations.

There has been a strong downward trend in per capita fresh apple sales accompanied by a strong upward trend in per capita income.

The fresh apple demand relationships for periods II and III were re-estimated substituting a trend variable for c_{mt} and y_{mt}. In period II, the trend coefficient was negative (significant at the .05 level) and $\bar{R}^2 = .90$. The trend coefficient was positive in period III (significant at the .20 level) and $\bar{R}^2 = .83$. Thus, the fits were about the same in both cases when a trend variable was substituted for c_{mt} and y_{mt} (Appendix A, Table 1).

Apple sales (on a per capita basis) have been decreasing during all portions of the marketing season but have decreased less in period III. This trend toward moving a higher percent of apples late in the marketing season and the upward trend in price in period III, probably are related to improvements in storage facilities and techniques which permit late marketings of higher quality products. CA storage is an important example of an improvement in storage technology which enables apples formerly of limited storage life to be stored for a considerable period of time.

Fresh Sales.--Changes in sales explained a large part of the price variation in periods II and III. In period II, an increase of one pound per capita (3.9 million bushels at the 1961 population level) in fresh sales (monthly) in period II was associated with a price decrease of $1.14 per bushel (see [5.2a]). At the mean value of sales and price, demand was inelastic for fresh apples in period II (-0.78).[1] Thus, demand for fresh apples appeared to be more elastic in period II than in period I.

In period III, at the mean values of fresh sales and price, the elasticity of demand is -1.85--apparently higher than the elasticities of periods I and II. However, the average quantity of sales was much less in period III. Consequently, the increased elasticity could represent a move along a stable demand function rather than a shift in the function between periods. If the relationships among the variables are proportional, it is appropriate to estimate a relationship in log form. In this case, the elasticity of demand would be constant. When the data were transformed to logs, the elasticity of demand was -1.33 and $\bar{R}^2 = .86$ which was a slightly better fit than was obtained in the linear relationship ([5.3] Table 4). Thus, it appears that demand is, in fact, more elastic late in the marketing season.

The reason for a more elastic demand late in the

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[1]When the fresh apple demand relationship was re-estimated with the data in logs, elasticity of demand = -0.75 and $\bar{R}^2 = .92$.

marketing season is not clear. However, it is likely to be connected with apple quality. Elasticity of demand provides a measure of the degree of substitutability between the product in question and competing products.

A product with a highly elastic demand has close substitutes. The problem of poor apple quality (especially at the retail level) late in the marketing season has not been solved. Consumers are likely to substitute other fresh or processed foods more readily as apple quality deteriorates late in the marketing year.

The weather is another factor which may be involved. Many people probably think of fresh apples as a cold weather food. The increase in ice cream and cold beverage consumption in warm weather is likely to be, at least to some extent, at the expense of apples.

The difficulties in optimizing the marketing pattern for fresh apples posed by the apparent change in elasticity during the marketing season will be discussed in the following chapter. At this point, general problems in measuring elasticity of demand are discussed, and the results of an attempt to determine whether the level of demand for fresh apples shifts during the marketing season are presented.

<u>Seasonal Changes in Elasticity of Demand</u>.--Elasticity of demand for most commodities is likely to vary depending upon the length of time involved. There are two opposing forces affecting the elasticity of demand. Short-time elasticities (e.g., week or month) are likely to be greater than longer time elasticities (e.g., year) since a large part of the short-term fluctuations in supplies can be absorbed by storage operations.[1] Annual fluctuations in supplies of a semi-perishable commodity, such as fresh apples, cannot be absorbed in this manner.

The ease of substitution is another force affecting elasticity of demand. The more time allowed for adjustment to a price change, the greater the adjustment is likely to be. Thus, in the long run, we expect elasticities to be greater than on an annual basis. Within short periods of time, the substitution effect on elasticity is likely to be more than offset by the opposite effect of storage. The lowest elasticity of demand is thus likely to be that based on data for a period just a little longer than the storage life of the good.[2] Most elasticity estimates for farm products are based on annual data. For semi-perishable commodities, such

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[1] Shepherd, <u>op. cit</u>., p. 64.

[2] <u>Ibid</u>., p. 65.

as apples, elasticities based on annual data are likely to represent minimum elasticities. Recent studies indicate that demand for fresh apples is inelastic when based on annual data.[1] On the basis of the above argument, we would expect demand to be less inelastic when using data for shorter periods.

In addition to problems with respect to the time period involved, the demand function may shift during the season. A limited amount of empirical work has been concerned with intraseasonal shifting of demand for fruits and vegetables. In demonstrating that intra-seasonal shifts in demand occur, it must be shown that intra-seasonal price changes cannot be explained by changes in quantity placed on the market. Mehren and Erdman found that the elasticity of demand for strawberries, computed from weekly data, increased as the season advanced.[2] Foytik found that the demand function for plums shifted upward during the first few weeks of the marketing season and then began to drift downward.[3]

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[1]Brandow, op. cit., p. 20 and Bartter, L. M. Effects of Apple Supply Management Programs in New York State, A.E. Res. 62, Cornell University, Dept. of Agricultural Economics, N.Y., April, 1961, p. 3.

[2]G. L. Mehren, and H. E. Erdman, "An Approach to the Determination of Intraseasonal Shifting of Demand," Journal of Farm Economics, May, 1946, p. 595.

[3]J. Foytik, Characteristics of Demand for California Plums, Hilgardia, University of California, April, 1951, p. 487.

The estimated fresh apple demand relationships of this study indicate that apple prices at the farm level are more responsive to changes in sales in period I than in periods II or III. If these coefficients are correct, demand is least elastic in period I and most elastic in period III.

If the elasticity of demand for apples varies between periods, it could be the result of a change in slope or level (or, some combination of the two) or a move along the demand curve. The less steep the slope at a given level, the more elastic is demand. Similarly, the higher the level with a given slope, the more elastic is demand. Hence, in comparing elasticities between markets, an increase in slope may be offset by an increase in level, so that the elasticity of demand remains unchanged, or even increases.

In computing elasticities in periods II and III, average prices and quantities were used. At these values, the ratio $\overline{p^{f}_{mt}}/\overline{f}_{mt}$ was equal to 1.87 and 4.86 in periods II and III, respectively. Thus, even though the slope (regression coefficient of f_{mt}) was greater in period III than in period II (Table 4), the increase in the ratio of average price to average quantity between periods II and III was enough to offset the change in slope so that demand was more elastic in period III.

In an effort to gain additional knowledge about intraseasonal shifts in demand, a more restricted fresh apple demand relationship was formulated and estimated. This model assumed no change in demand for fresh apples between periods, allowing no shift either in the slope or level of the demand function between periods.

The estimated relationship (by OLS) below for the period studied (1947-1961) had 45 observations and 40 degrees of freedom.[1]

$$(9)\quad \hat{p}^{f}_{mt} = 1.08 - .29f_{mt} + .53p^{f}_{(m-1)t} - .03\,c_{mt} + .02y_{mt}$$

t_b	3.46***	4.84***	.61	.58
Partial r w/y	- .48	+ .61	- .10	+.09

$$S_{y.x} = .30,\ \bar{R}^2 = .50$$

All signs were "correct" in (9), but the effects of c_{mt} and y_{mt} on price were not significant. Only half the variation in the dependent variable was explained by the four explanatory variables.

This model was then adjusted to allow shifts by period in the intercept of the demand relationship. Three 0, 1 (dummy) variables (Q_{1t}, Q_{2t}, and Q_{3t}) were used. In any period m of year t, Q_{mt} has a value of 1 while the other

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[1]In relationship (9), all variables are as defined previously except that price is in dollars per bushel.

two shift variables assume a zero value during this period. These shift variables allow changes in the level of demand by period while holding the slopes (regression coefficients) constant.

The function to be estimated is of the form:

$$(10)\quad p^f_{mt} = \alpha_1 Q_{1t} + \alpha_2 Q_{2t} + \alpha_3 Q_{3t} + \beta_1 f_{mt} + \beta_2 p^f_{(m-1)t} + \beta_3 c_{mt} + \beta_4 y_{mt}$$

In estimating this relationship, an overall constant term was included in the regression and Q_{1t} was omitted.[1] The equation to be estimated was then of the form

$$(10a)\quad p^f_{mt} = \alpha_1 + (\alpha_2 - \alpha_1)Q_{2t} + (\alpha_3 - \alpha_1)Q_{3t} + \beta_1 f_{mt} + \beta_2 p^f_{(m-1)t} + \beta_3 c_{mt} + \beta_4 y_{mt}$$

In this formulation, α_1 is the coefficient of Q_{1t} and is the intercept in period I. In (10a), the regression coefficients obtained for Q_{2t} and Q_{3t} are estimates of the difference between the intercept of the first and the second and third periods, respectively.[2] The estimated demand function in this case had 45 observations and 38 degrees of

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[1]If one of the dummy variables were not omitted, these variables and the vector of 1's for the constant term would be linearly dependent and a solution could not be obtained.

[2]R. L. Gustafson, "The Use and Interpretation of 'Dummy Variables' in Regressions," Michigan State University, Department of Agricultural Economics mimeo, January 30, 1962.

freedom. The OLS estimate of (10a) was:

$$\text{(10b)}\quad \hat{p}^{f}_{mt} = 3.08 + 1.05Q_{2t} - .29Q_{3t} - 1.23f_{mt} + .26p^{f}_{(m-1)t} + .32c_{mt} - .02y_{mt}$$

	Intercept	Q_{2t}	Q_{3t}	f_{mt}	$p^{f}_{(m-1)t}$	c_{mt}	y_{mt}
t_b	3.66***	2.72***	.84	6.67***	2.69***	2.03	.44
Partial r w/y		+.40	-.14	-.73	+.40	+.31	-.07

$$S_{y \cdot x} = .23, \quad \bar{R}^2 = .70$$

In (10b), coefficients of both income and competing fruits had incorrect signs. The results in (10b) indicate that the intercept in period II was significantly higher than the intercept in period I. That is, the coefficient of $Q_{2t}(\alpha_2 - \alpha_1)$ was positive and significantly different from zero. This was the expected result since demand from (5.1) and (5.2a) appeared to be more elastic in period II. With equal slopes, the more elastic demand would have a higher intercept. When slopes are, in fact, unequal, however, a model such as (10b) is not reliable in indicating the direction of change in the elasticity of demand between periods. As previously indicated, a change in level may more than be offset by a change in slope. Thus, results from (10b) cannot be used to make inferences about the relative elasticities of demand for fresh apples in periods I, II, and III.

One might view (9) as the most restricted demand relationship for fresh apples estimated in this study since it allows no change in either slope or level of demand between periods. Similarly, (10b) is less restrictive than (9) because it allows a change in level between periods but not in slope. Relationships (5.1), (5.2), and (5.3) are least restrictive, allowing changes between periods both in level and slope.

In summarizing the results of the estimated relationships for fresh and processing apples, demand appears to be inelastic for total sales of apples in period I. The evidence mildly suggests that the demand for fresh apples is more inelastic than the demand for processing apples during the harvest period (period I). Demand for fresh apples appears to become less inelastic as the marketing season advances and becomes elastic near the end of the marketing season. The implications of the apparent difference in demand of fresh and processing apples and the change in demand for fresh apples during the apple marketing season will be discussed in the next chapter. Estimated allocation and storage functions are now presented.

Allocation Functions

Although total production was assumed predetermined in any given year, the quantities channeled into the various outlets (f_{1t}, a_{1t}, and s_{1t}) are jointly dependent in period I. In this study, relationships were estimated to explain changes in the quantity of apples allocated to processors and in the quantity stored. The reasons that fresh and processing apples are really different commodities from the producer's standpoint were presented in Chapter IV.

Allocation or supply functions to explain the quantity of (1) all apples sold to processors, and (2) canning and freezing apples sold to processors are presented below. These functions include variables expected to influence the allocation of apples to processors within any given year.

The definition of the variables included in the allocation function for all processing apples follow:

a_{1t}, p^a_{1t}, p^f_{1t} were defined previously.

m_t = per capita sales (in pounds) of Eastern apples in year t.

n_t = per capita sales (in pounds) of apples produced in other parts of the U.S. in year t.

<u>All Processing Apples</u>.--Single and simultaneous equation parameter estimates were quite similar in the allocation function for all processing apples (Table 5).

Table 5. Estimated allocation functions for canning and freezing and for all processing apples.

Dependent variable and Estimation	Constant Term	Regression Coefficients t values, & Partial Correlation Coefficients[a]: p^a_{1t}/p^f_{1t}[b]	m_t	n_t	$S_{y.x}$	$\bar{R}^2$
All Processing Apples						
OLS						
(11) a_{1t}	-7.57	+5.56	+ .84	+ .19	.49	.93
		2.83***	12.40***	3.03***		
		+ .65	+ .97	+ .67		
TSLS						
(11a) a_{1t}	-7.80	+5.92	+ .84	+ .19	.63[c]	.92[c]
		2.77***	12.38***	3.05***		
		+ .64	+ .97	+ .67		
Canning and Freezing Apples						
OLS						
(12) a'_{1t}	-0.56	+1.94	+ .57	- .21	.63	.74
		1.06*	6.29***	2.76		
		+ .30	+ .88	- .64		
TSLS						
(12a) a'_{1t}	-0.53	+1.89	+ .58	- .21	.64[c]	.73[c]
		.89*	6.09***	2.69		
		+ .26	+ .88	- .63		

[a]t values of the regression coefficients appear just below the coefficient to which they apply. Partial correlation coefficients are below the t values.

[b]In (12) and (12a), $p^{a'}_{1t}/p^f_{1t}$ was used instead of p^a_{1t}/p^f_{1t}.

[c]In two-stage least-squares regression procedures, all current endogenous variables in the equation (to be estimated) except the variable considered dependent in the second stage are replaced by a linear combination of all the predetermined variables in the system. $S_{y.x}$ and $\bar{R}^2$ values presented are based on estimated instead of observed values for all current endogenous variables except the variable which is dependent in the second stage.

In each case, (11) and (11a), the three explanatory variables explained more than 90 percent of the year-to-year variation in sales of processing apples from 1947-1961. The discussion which follows pertains to (11a).

Price Ratio.--A large part of total apple production consists of dual purpose varieties. These apples are suitable for use in either fresh or processing outlets. Under these circumstances, we expect the allocation of apples among alternative uses to be influenced by prices in fresh and processing apple markets.

The ratio of processing to fresh price ranged from 0.32 to 0.57 during the period of analysis. In (11a), an increase in the price ratio of .1 is associated with an increase in processing sales of .59 pounds per capita. This result is consistent with economic logic. We expect that for a given level of m_t and n_t, producers will sell more to processors if p_{1t}^{a}/p_{1t}^{f} is high than if this ratio is low.

Eastern Production.--A much higher part of the Eastern states' crop goes into processing uses than is true for production in other parts of the United States. Thus, it is not surprising that Eastern production was a more important explanatory variable (in the allocation function) than other production as evidenced by the higher partial correlation coefficient. An increase in Eastern production of 3.8 million bushels (one pound per capita at 1961 population level) was associated with an increase in total apples processed of 3.2 million bushels.

Other Production.--Apple production in non-Eastern states is channeled primarily into the fresh market, but apple processing has some importance in all areas. As production increases more of the apples in the non-Eastern states are processed. Under these circumstances, we expect an increase in production to be associated with an increase in apples processed. In the estimated relationship, an increase of one pound per capita in non-Eastern apple production was associated with an increase in all apples processed of 0.19 pounds per capita.

An alternative allocation function for all processing apples was also estimated. This relationship was:

$$(11b)\quad \frac{a_{1t}}{q_{1t}} = -.06 + .10\frac{p^a_{1t}}{p^f_{1t}} + .74\frac{m_t}{m_t + n_t}$$

$$t_b \qquad 1.07^{*} \qquad 4.49^{***}$$

$$\text{Partial } r/y \qquad +.29 \qquad +.79 \qquad S_{y.x} = .03,\ \bar{R}^2 = .61$$

where

All variables are as defined previously.

The proportion of production processed (a_{1t}/q_{1t}) varied from 0.23 to 0.37 during the period of analysis.

An increase in the ratio of processing to fresh apple prices, as expected, was associated with an increase in the proportion of the total crop processed. An increase in the proportion of the crop produced in the East, where apple processing is concentrated, was also associated with an increase in the proportion of the total crop processed. Although changes in both explanatory variables had the "correct" effect upon changes in the dependent variable, the coefficient of multiple determination (adjusted), $\bar{R}^2$, was much lower than in the previously estimated allocation function (see [11a] in Table 5).

Canning and Freezing Apples.--The allocation functions presented above were for all apples processed. An allocation function was also estimated for canning and freezing processing apples. This portion of apples processed is by far the most important part of all apples processed. Canning and freezing apple sales, a'_{1t}, include virtually all of the apples processed which have the fresh market as an alternative outlet.

Variables included in this allocation function have been defined previously in the analysis. The OLS and TSLS estimates of the allocation function for canning and freezing apples differed very little (Table 5).

Price Ratio.--During the postwar period, the ratio $p^{a'}_{1t}/p^{f}_{1t}$ varied between 0.42 and 0.73. The effect of a change in price ratio on quantity (of apples canned and frozen) was less than in the allocation equation for all processing apples. The canning and freezing processing industry is concentrated in the Eastern states to a greater extent than is true of the total processing industry. In addition, higher quality apples are required for canning and freezing purposes than in other processing outlets. Under these conditions, it is not surprising that the allocation response to a change in price ratio should be less pronounced for canning and freezing apples than for all processing apples.

<u>Eastern production</u>.--An increase of one pound per person in Eastern apple production was associated with an increase in sales of canning and freezing apples of 0.58 pounds per capita ([12a] Table 5). Apples in addition to those used in canning and freezing outlets are processed in the Eastern states. Since a'_{1t} is included in a_{1t}, it follows that any given increase in Eastern production is likely to be associated with a larger change of a_{1t} than of a'_{1t}.

<u>Other Production</u>.--An increase in non-Eastern production was associated with a decrease in sales of canning

and freezing apples. The reason is not clear why the coefficient of "other production" is negative. Some apples are sold into canning and freezing outlets outside the Eastern states. Other factors equal, a portion of any increase in apple production in these areas would likely be sold to processors for canning and freezing.

In general, the estimated allocation functions appear satisfactory. The three explanatory variables explain a large proportion of the annual variation in sales of processing apples. This is especially true of the allocation function for all processing apples.

Storage Functions

Apples not allocated by producers into fresh or processing outlets in period I are stored and sold later in the fresh market. Hence, the quantity of apples stored in period I is jointly determined with quantities moved into fresh and processing outlets. s_{1t} represents the quantity of apples stored in period I and is positive.

In period II, the quantity of apples remaining in storage and fresh sales from storage, f_{2t}, are jointly determined. In the storage function of period II, s_{2t} is negative. This is true since $s_{2t} = S_{2t} - S_{1t}$ and $S_{1t} > S_{2t}$ (some apples always move out of storage in period II).

Since s_{2t} is negative, an increase of a predetermined variable with a positive sign is associated with a decrease in apples moving from storage.

All apples in storage at the beginning of period III are sold during the period. Consequently, storage movement in period III, s_{3t}, is predetermined.

Period I.--The variables included in the storage function of period I follow:

p^f_{1t}, $p^{a'}_{1t}$, m_t, and n_t are as defined previously.

$s_{1t} = S_{1t} - S_{3(t-1)}$

S_{1t} = the per capita quantity of apples in storage (in pounds) at the end of period I of year t.

$S_{3(t-1)}$ = the per capita quantity of apples in storage (in pounds) at the beginning of period I of year t ($S_{3(t-1)} \equiv 0$).

The estimated (OLS) storage function for period I was:[1]

$$(13) \quad \hat{s}_{1t} = -3.71 + .18\frac{p^f_{1t}}{p^{a'}_{1t}} + .25m_t + .67n_t$$

t_b	.24	2.05***	6.52***	
Partial r/y	+.07	+.53	+.89	$S_{y.x} = .85$, $\bar{R}^2 = .80$

[1]The results were virtually the same when the function was estimated using TSLS regression procedures. In neither case did a change in the price ratio have a significant effect upon s_{1t}.

Price Ratio.--A change in the ratio of fresh to processing apple prices had no significant effect on the quantity stored in period I. This is not surprising in view of Gustafson's findings.[1]

Production.--Increases in Eastern production, m_t, and in other production, n_t, were associated with increases in the quantity stored in period I. These two variables explained more than 80 percent of the annual variation in December 1 storage holdings from 1947-1961.[2] An increase in Eastern production, however, had a smaller effect on initial storage than an increase in production in other areas. This seems reasonable since a larger proportion of "other" production is moved in the fresh market.

Period II.--The storage function of period II contained only one dependent variable and was estimated by single equation regression procedures. The estimated relationship was:

$$(14) \quad \hat{s}_{2t} = -1.90 - .58S_{1t} + .04k_{1t}$$

$$t_b \qquad 14.67^{***} \quad 1.70^{**}$$

$$\text{Partial } r/y \qquad -.97 \qquad +.46 \qquad S_{y \cdot x} = .27, \ \bar{R}^2 = .95$$

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[1]This point is discussed more fully following the estimated storage function of period II.

[2]When the price ratio was eliminated from the analysis, $\bar{R}^2 = .81$.

where

S_{1t} is as defined previously.

$s_{2t} = S_{2t} - S_{1t}$

S_{2t} = the per capita quantity of apples in storage (in pounds) at the end of period II of year t.

k_{1t} = the percent of all stored apples in CA storage at the beginning of period II.

Storage Holdings at the Beginning of the Period.--An increase of 3.8 million bushels (one pound per capita at 1961 population level) in initial storage stocks was associated with an increase of 2.2 million bushels in the rate of movement from storage. This variable alone explained about 93 percent of year-to-year changes in storage stocks during period II from 1947-1961. Thus, a knowledge of storage in period I provides a good indication of the rate of movement from storage and, hence, price since changes in sales were found to explain a large part of the price variation of periods II and III. Predictive equations for fresh price in periods II and III using S_{1t} as an explanatory variable are presented in the following chapter.

CA Storage.--The CA storage technology enables a higher quality product to be stored for a longer period of time. Some varieties of apples may be held in CA storage facilities until period III with little deterioration in quality. In recent years, an increasing percent of all apples stored have been placed in CA storage and held until period III.

In (14), an increase of one percent in CA holdings as a percent of all storage holdings was associated with a decrease of .04 pounds per capita in the rate of movement from storage in period II. At the 1961 population level, this is equivalent to 154,000 bushels.

The preceding results indicate that the aggregate behavior of apple storage operators in periods I and II can be represented quite accurately by simple functional relationships of the type suggested by Gustafson.[1] Under the conditions specified by Gustafson, changes in aggregate quantity of the commodity stored or carried over during any period can be explained by changes in the total supply during the period. The total supply consists of the quantity carried in from the previous period plus the quantity produced during the period.

There are no apple stocks at the beginning of period I. Thus, production, $m_t + n_t$, constitutes the total supply. These two variables were found to explain more than 80 percent of the variation in initial storage stocks.

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[1]R. L. Gustafson, "Storage of Pork," pp. 41-44.

In period II, there is no production. Consequently, initial storage holdings, S_{1t}, constitute the total supply during period II. Changes in S_{1t} were found to explain more than 90 percent of the variation in storage movement during period II.

CHAPTER VI

IMPLICATIONS OF RESULTS

There is current interest in exploring alternative marketing policies for the apple industry. In this section, the economic implications of several methods of controlling supply are evaluated. In addition, predictive equations for fresh and processing apple prices are presented and illustrative apple "storage rules" are developed based on these price predictive equations. Before discussing apple programs as such, general methods and problems in controlling distribution are discussed.[1]

Theoretically, there are two major approaches which may be used by a monopolist in controlling the distribution of a commodity being sold in two or more markets.[2] A diversion program may be instituted in which a portion of the

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[1]Production controls have not been proposed in the apple industry and will not be discussed.

[2]For a monopolist to profitably practice price discrimination, three conditions are necessary: (1) the seller must be able to separate the market, (2) demands in the various separable parts of the market must be "considerably different," and (3) the cost of separating the markets must not be too large. G. J. Stigler, The Theory of Price (Revised edition; New York: The Macmillan Co., 1952), pp. 215-216.

product is diverted from markets having lower elasticities into markets with higher elasticities until the marginal net revenues are equal in each market. In the diversion programs which have been adopted in agriculture, demand in the market yielding the highest price is more inelastic than in lower value uses. Hence, sales of the product are restricted in the high price market and channeled into lower value uses. The California lemon program is an example. Lemons are diverted from the inelastic fresh market into the more elastic juice market.

Another approach in controlling distribution of a commodity is to restrict the total quantity marketed. Such a program may or may not be applied in conjunction with a diversion program. Demand conditions are also crucial in the operation of a program limiting the total quantity marketed. For simplicity, assume there is only one market for the product. The quantity marketed under such a program would be restricted to some specified level. Unless demand were inelastic, however, this program would not increase total returns.

General Problems

A number of theoretical and practical problems restrict the usefulness of supply control programs of the types described above. Some of the major problems are described at this point.

Determining Appropriate Elasticities.--Elasticities vary according to the period of time involved. Due to data limitations, the elasticity of demand for agricultural commodities is most readily computed from annual data. However, demand for a semi-perishable product computed in this manner is likely to give its minimum elasticity. For a commodity with alternative outlets, the appropriate elasticities in controlling distribution are those which prevail at the time the allocation decision must be made. Demand conditions at this time may differ greatly from the average demand based on annual data. For most agricultural commodities, which may or may not have a large number of grades, varieties, etc., the necessary data are not available to compute within season elasticities. Under these conditions, a commodity which appears to have an inelastic demand based on annual data may have an elastic demand during that portion of the marketing season when the quantity marketed is to be restricted.

A closely related problem centers around the question of whether farm or retail elasticities are to be chosen as the basis of action. Consider a commodity selling in two retail markets, say in fresh and in processed form. The demand in the fresh market is likely to be less elastic than in the processed market due to the relative availability of substitutes for the two products. Assume this to be true. It is quite possible that the derived demand at the farm level would be less elastic for the product channeled into the processing market.

In general, we expect marketing margins to be greater for products which are more highly processed. Hence, the derived demand for the processed product (relative to the fresh product) would be more inelastic at the farm if the difference in marketing margins was enough to offset the difference in elasticities at the retail level. Thus, a knowledge that elasticities differ at the retail level for a commodity being sold in different markets does not imply that the derived elasticities at the farm level would have the same ordering.

<u>Changes in Elasticity</u>.--The fact that elasticities may change over time is another important consideration relating to supply control programs. A marketing policy relying on either diversion or restricting the quantity of sales may itself bring about a change in the elasticity of demand.

The California lemon industry provides a classic example of the problems arising out of an attempt to increase producer income through a diversion program. In this "prorate" program, growers have attempted to increase average returns by exploiting an assumed inelasticity of demand for fresh lemons. Both the effect on long-run market demand and on long-run production apparently have been disregarded. The program is steadily forcing fresh lemons out of the market by subsidizing processed lemon products. The result is that grower returns per carton in the long run have not been increased.[1]

Foreign Competition.--The world-trade situation is another important factor to consider in restricting supply. The maintenance of domestic price above world market prices for a semi-perishable or storable commodity requires permissive legislation in the form of import tariffs, quotas, etc. Such barriers must be implemented to prohibit the substitution of the cheaper import for the more expensive domestic good. In the absence of import controls, imports, to a great extent (for many products), could negate the effect of any policy of restricting supply.

Production Response.--If returns increase above a normal level of profits, production will tend to increase.

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[1] R. J. Smith, "The Lemon Prorate in the Long Run," The Journal of Political Economy, December, 1961, p. 586.

Hence, if an industry is in equilibrium and the method employed in controlling distribution is effective in raising average price, there will be an appropriate adjustment in production. This problem has been evident in the acreage control and price support programs for agricultural products.

Apple Marketing

The previous discussion is relevant in considering marketing policy for any commodity. The following analysis is related specifically to apple marketing.

In analyzing present and proposed apple marketing policies, we must recognize (1) differences in demand elasticities between fresh and processing apples at harvest and (2) changes in the elasticity of demand of fresh apples during the apple marketing season. The economic implications of proposed diversion or quantity control programs for apples will now be discussed.

Diversion.--A diversion program for apples was recently discussed.[1] This program consists of a utilization model which would control sales of fresh apples at the farm level and allocate the surplus to various processing

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[1] W. S. Greig, Maximizing Total Dollar Sales of Apples and Apple Products by a Utilization Model, MSU, Ag. Econ. 889 August, 1962, p. 22.

outlets. The underlying premise of such a program is that the demand for fresh apples is more inelastic (at the farm level) than the demand for apples going to processors. Empirical evidence concerning the relative elasticities of demand for fresh and processing apples at the farm level is mixed.

Tomek in a recent study covering the period 1947-1961 (using annual data) found fresh apples to have a slightly more inelastic demand than processing apples at the farm level.[1] The quantity of apples sold in the fresh market, when contrasted with the quantity sold to processors, is more stable from year to year. That is, a larger percent of apples are sold in the fresh market in small crop years and a smaller percent in large crop years. This fact supports the findings of Tomek that the demand for fresh apples is, in fact, more inelastic than the demand for processing apples. Assuming Tomek's results are true, let us consider the effect of diverting a bushel of apples from the fresh market to the processing market.

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[1]Using a simultaneous equations approach, Tomek estimated elasticities of demand at -0.4 and -0.6 for fresh and processing apples, respectively. W. G. Tomek, "An Analysis of the Utilization of Apples at the Farm Level in the United States" (unpublished manuscript, February, 1963).

Harvest prices for fresh and processing apples averaged \$1.93 and \$0.82 per bushel, respectively, during the postwar period. At these prices and using Tomek's elasticity estimates, a bushel of apples diverted from fresh to processing would increase total revenue by about \$2.35.[1] Marginal costs are also higher for harvesting and selling fresh apples. Evans found that grower costs in the Appalachian Area were from \$0.96 to \$1.28 more per bushel when selling on the fresh market.[2] Hence, diverting a bushel of apples from fresh to processing outlets would likely decrease total costs, although a diversion program would require increased costs of grading and sorting. Thus, a diversion program for apples theoretically might have a large effect on net revenue even when the elasticity coefficients are not much different for fresh and processing apples.

Using MSU consumer panel data, Greig found that processed apple products relative to fresh apples were more

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[1]Marginal revenue fresh = 1.93 (1 + 1/-.4) = -2.89. Marginal revenue processing = 0.82 (1 + 1/-.6) = -0.55.

[2]Evans, op. cit., p. 47.

elastic at retail.[1] This finding seems reasonable since we usually expect the processed form of an agricultural product to have a more elastic demand. Greig then assumed that the derived elasticities of demand at the farm level had the same ordering as at retail.

If marketing margins (as a percent of retail price) were the same in each market, the elasticities of demand at wholesale would have the same ordering as at the retail level. However, dollar marketing margins tend to be inflexible as the quantity marketed changes. Also, processing and distribution costs are likely to constitute a larger proportion of retail price for processed apples than for fresh apples.[2] Under these circumstances, the elasticity of demand for processing apples could be lower at the farm level.

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[1]Using annual data cited by Greig for the years 1953-1957, this writer estimated retail demand elasticities for fresh apples and apple sauce of -.34 and -3.4, respectively (these results agree with findings reported by Greig). The estimated relationship for fresh apples, was of the form $Q = a + bP$. The standard error of b was almost as large as b indicating that the effect of P was not significant. In this situation, changes in quantity were not closely associated with changes in price and $\bar{R}^2 = .09$. Hence, the estimated elasticity of demand for fresh apples is not reliable.

[2]Dalrymple quotes estimates of marketing margins for fresh and processed apples of 66 and 79 percent (of retail price), respectively. Dalrymple, op. cit., p. 244.

Brandow and Bartter estimated the demand for fresh and processing apples at the farm level. The demand was inelastic for each, but processing apples had the more inelastic demand.[1] However, these estimates were based on annual data and results from the previous chapter indicate that the elasticity of demand for fresh apples varies widely during the marketing season. If demand at harvest (when virtually all processing apples are moved) is more inelastic for processing apples than for fresh apples, the utilization control program discussed by Greig would decrease instead of increasing total returns to producers.

In the present study, total apple sales (fresh plus processing) in period I were found to have an inelastic demand. A satisfactory demand function for processing apples was not obtained in this study. The evidence mildly indicated that fresh apples in period I had a more inelastic demand than the demand for total sales, implying that the demand was more elastic for processing apples. The analysis was not adequate, however, to conclude that there was, in fact, a difference in the elasticity of demand in processing and fresh apple markets. In view of the uncertainty and

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[1]Brandow, op. cit., p. 20 and Bartter, op. cit., p. 3.

conflicting empirical findings with respect to the relative elasticities of fresh and processing apples at the farm level, a diversion program for apples does not appear feasible to this writer.

In addition to the theoretical problems, there are a large number of practical problems in setting up a diversion program for the apple industry. In the first place, data are not available for various apple grades, varieties, etc. In addition to data problems, there are a host of administrative problems. Any program of this type, if effective, would increase returns to producers of fresh apples at the expense of processing producers. Such a program would not likely be favored by producers of processing apples.

The type of apples produced varies by region but there is a high degree of market interdependence between regions. Hence, any diversion program on a state or regional basis would be strongly tempered by imports from other areas. A diversion program which changed the relative prices between uses would also require policing to keep the markets separated.

Quantity Limitation.--A volume control program has also been discussed for the apple industry.[1] Under this

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[1] Bartter, op. cit., p. 1.

program, apples less than a given size would be prevented from entering the market. The restriction might be placed only on the sale of processing apples or on sales of both fresh and processing apples. Such a program is based on the assumption that apples have an inelastic demand (in the market[s] to be restricted) at the farm level. Even if this requirement is met, the problems described earlier would persist. These are: (1) demand becomes more elastic in the long run accentuated by the price increase; (2) foreign competition is increased; and (3) in the long run, production would tend to increase in response to higher prices.

Even if the theoretical problems were resolved, a host of practical and administrative problems would remain as under a diversion program. The operation of this program requires a knowledge of demand conditions for apples of various sizes. This information is not available. The quantity to hold off the market and the method of doing so present formidable administrative problems. Some regions and some producers have a higher proportion of smaller apples. In a quantity limitation program based on size, these producers would, in effect, be subsidizing producers having fewer small apples.

On the basis of the preceding discussion, it is far from certain that either a general diversion or a quantity limitation program would be an effective means of increasing returns to the apple industry. At this point, a number of potential measures for increasing returns (in some cases involving qualitative controls) are mentioned. These measures may be subsumed under a general heading called product promotion. These measures are beyond the purview of this study and will not be evaluated.

<u>Product Promotion</u>.--A wide range of activities may be included in policies of product promotion. Advertising is one method widely used in promoting the sellers' wares. A specific commodity may also be enhanced in the eyes of the buyer through various merchandising practices which recognize market preferences with respect to size, quality, packaging, etc. In general, the costs and returns from programs of product promotion are difficult to assess.

In the apple market, a strong consumer preference for high color fruit has been recognized. The preferred type of retail pack for apples appears to vary by region. Observing and following market preferences such as these could increase grower returns if the cost of complying with market preferences does not more than offset the increase in returns. Such programs might entail a degree of supply control and require more care in holding lower quality apples off the fresh market.

Bargaining.--Currently, there is interest on the part of apple producers in bargaining activities with apple processors. Available evidence indicates that competitive pressure is strong among processors and that net returns are equal from processing and fresh apple sales.[1] In the event that processors are not making excess profits, bargaining efforts could be expected to have little effect on price in the absence of supply restrictions.

If apple processors are not realizing monopoly gain as a result of their oligopolistic position, bargaining in conjunction with a program of controlled distribution on the part of producers would be subject to the same theoretical and practical limitations discussed previously. As in the previous case, theoretical and practical obstacles would be formidable in developing and administering such a program.

Predicting Processing Apple Prices

A high proportion of apple production consists of dual purpose varieties. Growers of these varieties have the choice at harvest of immediately selling their apples in the fresh or processing market or of storing part, or all of them, in anticipation of later fresh price advances.

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[1] Evans, op. cit., p. 90 and Bartter, op. cit., p. 6.

This decision requires that judgments be made about seasonal price movements for fresh apples and about the price of processing apples.

Farm prices of canning and freezing apples have varied widely from year to year during the postwar period. Widely varying prices mean more attention must be given to questions of when and where to market the apples produced.

Producers and processors need information prior to harvest in making plans for the ensuing apple marketing season. A knowledge of the market clearing price for canning and freezing apples should be of value to producers in determining quantities to sell (in various outlets) and store at harvest. This information would also assist processors and food manufacturers in planning their operations.

Results from a recent study indicate that the U.S. season average farm price of canning and freezing apples can be estimated quite accurately by using data that are available early in the marketing season.[1] Information

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[1]E. C. Pasour and D. L. Oldenstadt, Farm Prices of Apples for Canning and Freezing, United States 1951-61, Agricultural Economics Report No. 35, Marketing Economics Division, ERS, U.S. Department of Agriculture in cooperation with Michigan AES, MSU, June, 1963, p. 14.

on the economic factors, July crop estimate, July processed canner stocks, and July farm price of fresh apples explained almost 90 percent of the year-to-year variation in deflated farm prices of processing apples from 1951 to 1961. Data concerning these three economic factors are available early in the marketing season. The estimated predictive equation for farm price of canning and freezing apples follows.[1]

$$(1)\quad \hat{p}^{a'}_{1t} = 130.68 - 112.04e_{jt} - 21.33A_{1t} + 6.49p^{f}_{jt}$$

t_b	2.88***	3.69***	1.11*
Partial r/y	-.79	-.86	+.44

$\bar{R}^2 = .87,\ S_{y.x} = 5.53$

where

$p^{a'}_{1t}$ = deflated U.S. season average farm price of canning and freezing apples in dollars per ton in year t.

e_{jt} = U.S. Department of Agriculture July apple crop estimate (for the U.S.) in bushels per capita in year t.

A_{1t} = July canner stocks of canned and frozen apple slices and sauce on a pound per capita fresh equivalent basis in year t.

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[1]The relationship which appears in the publication cited contained a trend variable which did not have a significant effect. This variable was eliminated and the other coefficients re-estimated to obtain the relationship presented.

p^{f}_{jt} = deflated U.S. average July farm price of fresh apples in dollars per bushel in year t.

All signs in (1) are as hypothesized. Increases in both July apple crop estimate and in carryover canner stocks were associated with decreases in the season average farm price of canning and freezing apples. An increase in July fresh price, however, was associated with an increase in $p^{a'}_{1t}$. The interpretation of the three regression coefficients in (1) follows.

July Crop Estimate.--An increase of 0.1 bushel per capita (18.4 million bushels at the 1961 production level) was associated with a decrease of $11.20 per ton in the deflated season average farm price of canning and freezing apples. The July crop estimate was between 89 and 124 million bushels during the period of the estimated relationship.

July Stocks.--July canner stocks of canned and frozen apples and apple sauce ranged from 0.345 to 1.622 pounds per capita, on a fresh equivalent basis, during the period 1951-1961. An increase of 0.1 pound per capita was associated with a decrease of $2.13 per ton in $p^{a'}_{1t}$.

July Price of Fresh Apples.--During the period 1951-1961, July fresh apple price (deflated) was between $1.11 and $2.48 per bushel. An increase of $0.10 per bushel in

July fresh price was associated with an increase in $p_{1t}^{a'}$ of \$0.65 per ton.

The results presented above indicate that canning and freezing apple prices can be estimated quite accurately early in the season so long as the factors in (1) associated with processing apple prices continue to have the relationship of the estimated period.

Predicting Fresh Apple Prices

Period I.--Fresh apple price, relative to processing price, is more difficult to predict early in the marketing season. A predictive relationship for fresh price in period I (July-November) was estimated in this study. In this relationship, the explanatory variables were July fresh price and the July U.S. Department of Agriculture apple crop estimate.[1] Information concerning these variables is available at the beginning of the marketing season.

This estimated relationship based on data for the period 1947-1961 was:

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[1]Lagged fresh price, $p_{3(t-1)}^{f}$, was initially included as an explanatory variable in this relationship. The effect of lagged fresh price, however, was not significant at the .10 level and it was dropped from the equation.

$$(2)\quad \hat{p}^f_{1t} = 2.33 + .39p^f_{jt} - 1.76e_{jt}$$

t_b	1.73**	3.49***	
Partial r/y	+.46	-.72	$S_{y.x} = .14,\ \bar{R}^2 = .67$

where

p^f_{jt} and e_{jt} are as defined in the predictive equation for canning and freezing apple prices and

p^f_{1t} = deflated U.S. average farm price per bushel (in dollars) of fresh apples in period I of year t.

Changes in period I fresh price were highly associated with changes in total production or forecast.[1] Taken together, July fresh price and apple crop estimate explained almost 70 percent of the variation in period I fresh prices from 1947-61.

Periods II and III.--After period I, fresh prices vary inversely with the quantity of apples in storage at the end of period I. During the postwar period, changes in the quantity of apples in storage at the beginning of period II, S_{1t}, explained about 85 and 75 percent of the annual variation in fresh price in periods II and III, respectively. These relationships estimated by OLS are:

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[1]The July apple crop estimate during the postwar period has been quite accurate as an indicator of total production.

(3) $\hat{p}^f_{2t} = 4.36 - .21S_{1t}$

t_b 8.25 $S_{y.x} = .18$, $\bar{R}^2 = .83$

(4) $\hat{p}^f_{3t} = 4.93 - .24S_{1t}$

t_b 6.31 $S_{y.x} = .27$, $\bar{R}^2 = .75$

where

p^f_{mt} = deflated U.S. average farm price per bushel (in dollars) of fresh apples in period m and year t.

S_{1t} = the per capita quantity (in pounds) of apples in storage at the end of period I in year t.

After period I, there is no production, and storage stocks constitute the total supply of apples. All of the apples in storage at the end of period I are moved by the end of period III. Under these conditions, it is not surprising that the quantity initially stored has a highly significant effect upon price in both period II and period III.

In the following section, apple storage problems are discussed and storage rules are formulated which appear to reduce the year-to-year variability in seasonal price movements.

Storage

In earlier sections of this chapter, marketing policies arising out of possible differences in elasticities in fresh and processing apple markets were evaluated. Another problem revolves around the question of how to optimally allocate fresh apples during the marketing season. That is, in view of the apparent shifts in demand during the marketing season and the uncertain seasonal price movements, what is the marketing pattern for fresh apples that would maximize net returns to the apple industry.

Optimum Allocation Over Time.--Theoretically, returns can be maximized by allocating a commodity over time in the same way as between different markets in any given point in time. Net returns would be maximized when the marginal revenues were equal in each time period assuming marginal costs were equal. In this situation, sales would be increased in periods of more elastic demand at the expense of periods of less elastic or inelastic demands.

When a difference in time is involved, there is usually a difference in total costs due to storage costs and, hence, in marginal costs. The allocation principle remains the same, however, when marginal costs differ in different time periods. In such cases, net returns would be maximized by equating marginal net revenue in each time period, where marginal net revenue is defined as the difference between marginal revenue and marginal cost in any market.

In the case of apples, net returns would be maximized over time by equating properly discounted marginal net revenues in fresh and processing markets for periods I, II, and III. Information relating to storage costs and demand conditions in various periods of the apple marketing season is necessary to determine the most profitable marketing pattern. The attempt to determine separate demand functions for fresh and processing apples during the harvest period in this study was not successful enough, it was felt, to warrant using the estimated functions as the basis for constructing marginal revenue functions. Estimated price <u>prediction</u> equations, on the other hand, seem relatively satisfactory. In the following section, to illustrate the possibility of storage decisions being improved by use of the price prediction equations, storage "rules" are developed such that (a) the quantity in storage at the end of period m (for m = 1,2) is a specified function of variables observable in or before period m, and (b) the parameters of the function are determined so as to equalize the marginal cost of storage and the expected change in price. Equating marginal cost of storage and expected change in price does not maximize producers' or storers' expected revenue, but it does maximize the expected "social value" of storing activity, provided one accepts market price

as the measure of the "marginal social value" of the commodity in utilization.[1]

Storage Rules[2]

The average seasonal price increase during the period 1947-1961 was $0.26 per bushel. Storage costs are about $0.23 per bushel for regular storage and $0.37 per bushel for CA storage and most apples are stored in regular storage facilities.[3] Hence, on an average, the seasonal price increase appears to have approximated the cost of storage. However, there has been wide variation from year to year in within-year price movement (Table 1, page 6), and *ipso facto* large deviations in particular years from equality of price change with cost of storage.

Storage costs used in the following analysis were taken from Thompson's study of apple storage costs in New York State.[4] As indicated in Chapter IV, however, storage costs appear to be fairly constant over the U.S. Marginal

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[1] See Gustafson, *Carryover Levels for Grains*.

[2] The procedure followed in this section is similar to the method used in Gustafson, "*Storage of Pork*."

[3] Thompson, *op. cit.*, p. 56.

[4] *Ibid*.

costs of storage were assumed constant. After apples are stored, variable storage costs are quite low. Storage costs between periods I and II and between periods II and III were taken to be \$0.22 and \$0.04 per bushel, respectively.[1]

Estimated price predictive relationships used in developing storage rules were adapted from relationships previously analyzed.[2] These relationships for periods I, II, and III are:

(2) $\hat{p}^f_{1t} = 2.33 + .39p^f_{jt} - 1.76e_{jt}$ $\qquad \bar{R}^2 = .67$

(5) $\hat{p}^f_{2t} = 5.21 - 1.47f_{2t} - .02T_1$ $\qquad \bar{R}^2 = .84$

(6) $\hat{p}^f_{3t} = 3.63 - 2.44f_{3t} + .01T_1$ $\qquad \bar{R}^2 = .73$

where

p^f_{mt} = deflated U.S. average farm price per bushel (in dollars) of fresh apples in period m of year t.

p^f_{jt} = deflated July U.S. average farm price per bushel (in dollars) of fresh apples in year t.

e_{jt} = July U.S. apple crop estimate of year t in pounds per capita.

f_{mt} = per capita sales (in pounds) of fresh apples in period m and year t on a monthly basis.

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[1] The cost of storage in each period was weighted by the average percent of apples in regular and CA storage facilities in that period.

[2] Lagged price was eliminated as a variable from (5.2) and (5.3) in Chapter V and the relationships were re-estimated replacing c_{mt} and y_{mt} with a trend variable. When lagged price is left in, the quantity to store in the storage rule for period I or II becomes a function of current price.

T_1 = trend (1947 = 1, 1948 = 2, . . . , 1961 = 15).

Relationship (2) was used instead of the fresh apple demand relationship of period I estimated in the previous chapter. As a fresh price predictive relationship, (2) explained a higher percent of the period I price variation and contains explanatory variables estimated by the U.S. Department of Agriculture early in the apple marketing season.

Storage Rule for Period II.--In determining how many apples should be in storage at the end of period II, S_{2t}, the expected price change between periods II and III is equated with marginal cost of storage between these periods. That is, the equation to be satisfied is

(7) $5.21 - 1.47f_{2t} - .02T_1 = 3.63 - 2.44f_{3t} + .01T_1 - .04$

where the left side is price in period II, the first three terms on the right are expected price in period III and the fourth term on the right is the (constant) marginal cost of storage between periods II and III.

The quantity of sales during period II, f_{2t}, is equivalent to the quantity in storage at the beginning of period II, S_{1t}, less the quantity in storage at the end of the period, S_{2t}. All apples in storage at the end of period II are moved during period III. Consequently, $f_{3t} = S_{2t}$.

Substituting $(S_{1t} - S_{2t})$ for f_{2t} and S_{2t} for f_{3t} in (7) and solving for S_{2t}, we obtain S_{2t} as a function of S_{1t} and T_1. When these substitutions are made, the storage rule of period II is:

$$(8)\quad \hat{S}_{2t} = .41 + .38S_{1t} + .01T_1$$

where

S_{mt} = the quantity of apples stored at the end of period m in year t in pounds per capita.

Thus, the quantity of apples in storage at the end of period II under rule (8) is a positive function of the quantity on hand at the beginning of period II and the trend variable.[1]

Storage Rule for Period I.--In period I, the equation to be satisfied is:

$$(9)\quad 2.33 + 39p^f_{jt} - 1.76e_{jt} = 5.21 - 1.47f_{2t} - .02T_1 - .22$$

where the left side is price in period I, the first three terms on the right are expected price in period II, and the last term on the right is the (constant) marginal cost of

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[1]The storage rule for period II when net marginal revenues are equated in periods II and III (instead of equating the expected price change) follows.

From (5) and (6) and the cost assumption, it follows that

$$TR_{III} = p^f_{3t}f_{3t} = 3.63f_{3t} - 2.44f^2_{3t} + .01T_1f_{3t}$$

storage between periods I and II. Substituting $(S_{1t} - S_{2t})$ for f_{2t} and equation (8) for S_{2t} gives the following storage rule for period I:

$$(10)\quad \hat{S}_{1t} = 2.26 - .43p^f_{jt} + 1.93e_{jt} - .01T_1$$

In this case, the quantity stored in period I is a function of July fresh price, July crop estimate and the trend variable.

$$TR_{II} = p^f_{2t}f_{2t} = 5.21f_{2t} - 1.47f^2_{2t} - .02T_1f_{2t}$$

$$TC = .04S_{2t}$$

Then

$$MR_{III} = 3.63 - 4.88f_{3t} + .01T_1$$

$$MR_{II} = 5.21 - 2.94f_{2t} - .02T_1$$

$$MC = .04$$

Substituting $S_{1t} - S_{2t}$ for f_{2t} and S_{2t} for f_{3t}, setting $MR_{II} = MR_{III} - MC$, and solving for S_{2t}, we obtain the storage rule

$$\hat{S}_{2t} = - .21 + .38S_{1t} + .004T_1$$

which maximizes net returns in periods II and III. This rule is quite similar to (8). The coefficient of S_{1t} (the slope) is the same in each case, while the level of S_{2t} for a given quantity of S_{1t} is lower in the case where net returns are maximized.

Both the "derived" storage rules for period II are very similar to the empirically estimated "observed" storage equation for that period which was

$$\hat{S}_{2t} = - 1.90 - .58S_{1t} + .04k_{1t}$$

or (since $S_{2t} = S_{1t} + s_{2t}$)

$$\hat{S}_{2t} = - 1.90 + .42S_{1t} + .04k_{1t}$$

Application of Storage Rules

After computing the storage rules ([8] and [10]), they were applied to the years 1947-1961 to see what difference their application would have made in the variability of seasonal price changes. For each year 1947-1961, using equation (10), the quantity was computed that would have been stored in period I applying the storage rule, $\hat{S}_{1t}$. Then substituting the quantities that would have been stored under the storage rule of period I, $\hat{S}_{1t}$, into (8), $\hat{S}_{2t}$ was computed for each year of the analysis.

After computing $\hat{S}_{1t}$ and $\hat{S}_{2t}$ from the storage rules, sales for period II and III under the storage rules were computed. In these computations, $\hat{f}_{2t} = \hat{S}_{1t} - \hat{S}_{2t}$ and $\hat{f}_{3t} = \hat{S}_{2t}$. Then the demand functions estimated in this study were used to determine the price that would have occurred in periods I, II, and III had the storage rule been in effect. The observed price of each period was adjusted as follows:[1]

$$(11) \quad \hat{p}_{mt} = p^{o}_{mt} - b_m(\hat{f}_{mt} - f^{o}_{mt})$$

where

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[1]The following procedure assumes that other factors affecting demand, e.g., competing fruits, income, etc. would not have been affected by the storage rule.

$\hat{p}_{mt}$ = the price which would have occurred in period m of year t had the storage rule been in effect.

p^o_{mt} = the observed price in period m of year t.

b_m = the regression coefficient of sales in the fresh apple demand function of period m.

$\hat{f}_{mt}$ = quantity of sales in period m of year t under the storage rule.

f^o_{mt} = the actual quantity of sales in period m of year t.

In period I, the difference in total apple sales due to the storage rule during the period 1947-1961 would be $(\hat{S}_{1t} - S^o_{1t})$, where S^o_{1t} is the quantity actually stored in period I and $\hat{S}_{1t}$ is the quantity that would have been stored under the rule (10). In computing $\hat{p}_{1t}$, b_1 was the regression coefficient of sales in the estimated demand relationship (of period I) for fresh and processing apples presented in the previous chapter.[1]

The change in fresh sales in period II that would have occurred had the storage rules been applied was determined as follows. Since, in general, $f_{mt} = S_{(m-1)t} - S_{mt}$, we have:

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[1]A weighted price (weighted by f_{1t} and a_{1t}) was used as the price indicator in the demand relationship for combined fresh and processing sales. When this function was re-estimated with p^f_{1t} as the dependent variable, the coefficient of $(a_{1t} + f_{1t})$ changed very little (from -1.17 to -1.15).

(12) $\hat{f}_{2t} - f^{o}_{2t} = \hat{s}_{1t} - s^{o}_{1t} + s^{o}_{2t} - \hat{s}_{2t}$

where all quantities are as previously defined. In period III, $f_{3t} = s_{2t}$.

Therefore, $\hat{f}_{3t} - f^{o}_{3t} = \hat{s}_{2t} - s^{o}_{2t}$.

After computing the prices which would have occurred in period m and year t under the storage rules, $\hat{p}_{mt}$, seasonal price changes in $\hat{p}_{mt}$ were compared with seasonal price changes in observed price, p^{o}_{mt}. This comparison follows.

Let $D^{o}_{12} = p^{o}_{2t} - p^{o}_{1t}$, $D^{o}_{23} = p^{o}_{3t} - p^{o}_{2t}$, $D^{o}_{13} = p^{o}_{3t} - p^{o}_{1t}$

and $\hat{D}_{12} = \hat{p}_{2t} - \hat{p}_{1t}$, $\hat{D}_{23} = \hat{p}_{3t} - \hat{p}_{2t}$, $\hat{D}_{13} = \hat{p}_{3t} - \hat{p}_{1t}$

D^{o}_{ij} is the observed price change between period i and j, and $\hat{D}_{ij}$ is the price change between periods i and j which would have occurred under the application of the derived storage rules, (8) and (10). The variance of D^{o}_{ij} and $\hat{D}_{ij}$ were computed for the period 1947-1961. These results are summarized below.

	Periods of the Analysis		
	I - II	II - III	I - III
Variance of D^{o}_{ij}	0.095	0.089	0.212
Variance of $\hat{D}_{ij}$	0.089	0.064	0.053
Ratio of variances $(\frac{\text{estimated}}{\text{observed}})$	0.937	0.719	0.250
Percent decrease in variance under the derived storage rule	6%	28%	75%

There was a large reduction in variability (under the storage rules) of the price change from period I to period

III, but the other two reductions were quite modest. The explanation for this outcome is not clear, but the computations at least suggest the possibility of improving storage decisions through the use of price prediction equations.

The decrease in variability in the seasonal price change under the storage rules would in this case have been accompanied by an increase in total revenue. In a comparison of sales and prices computed from the storage rules with actual prices and sales, total revenue was higher under the rules in 13 of the 15 years included in the analysis. The average annual increase in total revenue under the rules was about two percent. The application of the rules would have affected total costs very little since the average quantity stored under the rule was about the same as the actual average quantity stored. Hence, the percentage increase in net revenue would have been greater than the percentage increase in total revenue.

The above computations are indicative of the possible magnitude of the effect of improved storage decisions. The rules, however, were only applied to the same data from which the rules were developed, so that the substantial reduction in variability of the price change from period I to III which was obtained is undoubtedly an "upper limit" estimate of the improvement which might be possible using price prediction equations of the fairly simple type presented here.

The computed storage rules are aggregate inventory functions. Such rules, however, could be of value to individual apple producers. Apple production occurs only in period I. Prices during the remainder of the season are greatly influenced by the quantity of apples initially stored and the rate of sale from storage. Apple storage is profitable if the increase in price is more than enough to cover the costs of storage. Hence, if it appears that aggregate apple holdings will be less than that called for by (10) for period I or (8) for period II, the individual producer might profitably increase the quantity stored in period I or defer sales from period II to period III.

During the postwar period, changes in initial storage holdings in period I were explained quite well by the simple storage function of Chapter V. After harvest, more than 90 percent of the change in storage movement between periods II and III was explained by changes in initial storage holdings. The IAA also publishes monthly storage reports which indicate the level of aggregate storage holdings. The individual firm might use such data in conjunction with the storage rules to determine whether or not to change its own storage holdings. Such information could provide a basis for more orderly marketing.

One complicating factor in developing a storage policy for the apple industry is that all producers do not have the same costs and the same expected returns. For example, both costs and returns are higher under CA storage conditions. Also, there are numerous grades and varieties of apples. The individual producer needs information pertaining to his specific apples. However, a knowledge of total storage holdings and the probable price increase for all apples is useful since there is generally a high degree of substitution among varieties and grades of apples.

CHAPTER VII

SUMMARY

Fresh apple prices at the farm level have varied widely both between seasons and within a given marketing season during the postwar period. During this period, apple storage has been profitable only in certain years. In addition to the within-year variation in fresh apple prices, processing apple prices have also varied widely from year to year during this period.

In general, price analysis is more difficult both theoretically and practically when the commodity is being channeled into more than one end use. This is the situation with apples during certain periods of the apple marketing season in areas where processing outlets provide an attractive alternative to the fresh market. Apples are harvested from July-November, and the marketing season extends through the following June. At harvest, some apples are sold on the fresh market, some are sold to processors, and the remainder are stored for later sale in the fresh market. A large portion of the apple crop consists of dual purpose varieties which are suitable for fresh or processing uses.

Demand for apples is likely to change as the marketing season advances. Thus, in determining the most profitable marketing pattern for apples, information is needed concerning demand conditions for fresh and processing apples at harvest and for fresh apples throughout the marketing season. The primary objective of this study was to formulate and estimate an economic model of the U.S. apple industry for the postwar period relating relevant variables to fresh and processing apple prices at the farm level during various periods of the marketing season. The economic behavior of the U.S. apple industry (including the U.S. apple export situation) was studied prior to formulating an economic model.

Total per capita apple consumption has changed little in the postwar period. However, there have been important changes in the forms of consumption. Consumption of processed apple products has been increasing at the expense of fresh apples. The increase in processed apple products has been especially pronounced for canned and frozen apple sauce and apple slices.

Structural equations were initially formulated for the following relationships: (1) demand for fresh apples at the farm, (2) demand for processing apples at the farm, (3) storage function, and (4) allocation function.

A production-stocks identity completed the model. An export function was not included to explain changes in U.S. apple exports since preliminary investigation revealed that exports have been of minor importance since World War II. Total supply was assumed to be predetermined in any year. Hence, a function was not included to explain the quantity of apples not harvested (which has been minor in recent years).

The apple marketing season was divided into three periods to facilitate economic analysis. There were as many equations as currently endogenous variables in each period of the analysis. Thus, the model was complete.

Period I included the months July-November. All apples are harvested during this period. It was assumed that all apple sales to processors take place in period I since it is not economically feasible to store processing apples. Small quantities are sold to processors after period I, but these are mainly sorts and culls from stored fresh apples. Apples not sold to processors are sold in the fresh market. Some of these are sold in period I, while the remainder are stored for sale later in the marketing season.

The fresh and processing demand relationships, storage function, allocation function and identity comprised the model as initially formulated in period I. Fresh sales, processing sales, the quantity stored, fresh price, and processing price were jointly dependent variables in this period. A satisfactory demand relationship for processing apples could not be formulated in this study. The model of period I was then revised to incorporate a demand function for combined fresh and processing apple sales. In this relationship, the price indicator was weighted by fresh and processing apple sales in period I.

An allocation function is necessary to complete the model in the harvest period because apples move into fresh and processing outlets with a different price existing in each outlet. Processing and fresh apples are different commodities from the producer's standpoint since production costs are lower in producing apples for processing outlets.

Period II included the months December-March. There is no production during this period, and apples move from storage into fresh market outlets. Under these conditions, the quantity moving out of storage, the quantity sold fresh, and fresh price are current endogenous variables. Hence, the storage function, the fresh apple demand relationship and the identity comprised the economic model in period II.

The final period of the marketing season included the months April-June. All apples in storage from the previous year's harvest move into fresh market outlets during this period. Thus, at the end of June, stocks are depleted and the new harvest begins. There is no processing and both storage movement and fresh sales are predetermined in the final period of the marketing season. Consequently, fresh price is the only current endogenous variable in period III. The demand function for fresh apples and the identity comprised the economic model in this period.

Secondary data were used in the analysis. The major data sources were publications of (1) the U.S. Department of Agriculture, (2) the International Apple Association, and (3) the National Canners Association.

All production and quantity data were put on a per capita basis to adjust for changes in population during the period of analysis. Since the periods of the analysis were of unequal length, quantity variables were put on a monthly or yearly basis to facilitate the comparison of coefficients for any given variable in different periods. Farm prices of apples were deflated by the Wholesale Price Index to adjust for changes in the purchasing power of the dollar.

As implied above, there is simultaneity among the structural relations in period I. The same situation to a lesser extent is true in period II. A simultaneous equations system of estimation might be expected to yield more accurate estimates of parameters for the structural equations even though the number of observations is small. Thus, the structural equations in periods I and II were estimated by two-stage least-squares procedures as well as by ordinary least squares. In period III, there was only one current endogenous variable, and the ordinary least-squares procedure is a valid application of the simultaneous equations theory.

In general, the estimated relationships were more satisfactory for periods II and III than for period I. Fresh apple sales, lagged fresh price, sales of competing fruits, and income explained a high percent of the variation in fresh price in periods II and III. Demand was slightly inelastic in period II but elastic in period III. Fresh apple sales, sales of competing fruits, and income were intercorrelated due to a downward trend in the first two of these variables and an upward trend in income during the period of analysis. Possibly because of these conditions, income had the "wrong" sign in period II and competing fruits had the "wrong" sign in period III. In both these periods, fresh sales and lagged fresh price were the most important explanatory variables.

In period I, the demand for all apples sold (fresh plus processing) was inelastic. The elasticity of demand (average prices and quantities were used in computing elasticities) varied from -0.46 with quantity dependent to -0.62 with price dependent. These values were almost the same when the relationships were re-estimated with the data in log form.

Fresh apple price in period I appeared to be determined more by total production or crop forecast than by fresh sales during the harvest period. A demand function with quantity dependent was estimated for fresh apples in period I, although it was not as satisfactory as the estimated relationship for combined fresh and processing sales during this period. The coefficients of competing fruits and income had "wrong" signs in the demand function of fresh apples in period I. These variables were dropped and replaced by a trend variable. On the basis of results from this estimated relationship, demand for fresh apples in period I was slightly more inelastic than the demand for total apple sales. This, if true, implies that the demand for fresh apples is more inelastic at harvest than the demand for processing apples. Thus, on the basis of the estimated demand functions in this study, the evidence mildly suggests that the demand for fresh apples is slightly more inelastic than the demand for processing apples.

In this study, the total quantity of apples produced in any year was considered predetermined. However, the quantity moved in the fresh or processing markets or the quantity stored in period I cannot be considered predetermined. Fresh and processing apple prices are determined simultaneously with the allocation of apples into fresh or processing markets or into storage. In this study, functions were estimated to explain changes in quantities stored or allocated to processors, while the quantity allocated to the fresh market in period I was treated as a residual.

In the estimated allocation function for all processing apples, the ratio of processing to period I fresh apple price, Eastern apple production, and other apple production explained more than 90 percent of the variation in total sales to apple processors during the post-war period. The most important explanatory variable was Eastern apple production. This is understandable since a large part of Eastern apples are sold to processors.

An allocation function was also estimated for canning and freezing apples using explanatory variables similar to those in the allocation function for all processing apples. The ratio of canning and freezing to period I fresh apple price, Eastern apple production, and other apple production explained about 75 percent of the year-to-year variation in canning and freezing apple sales during the postwar period.

Each producer allocates apples among processing, fresh, and storage outlets more or less simultaneously. Thus, we might expect the same factors to be significant in the allocation and storage function. The same explanatory variables used in the allocation function were included in the storage function of period I. This function explained year-to-year changes in the quantity of apples stored at harvest.

The two factors, Eastern apple production and production in other areas of the U.S. explained more than 80 percent of the variation in December 1 storage holdings during the postwar period. The price ratio did not have a significant effect in this relationship.

The storage function of period II explained changes in the rate of sale from storage. Beginning stocks and the percent of all stored apples in CA facilities explained about 95 percent of the variation in storage movement during period II. Changes in the quantity of apples stored at the beginning of period II was by far the most important explanatory variable in this relationship--explaining more than 90 percent of the variation in storage movement.

The estimated storage functions of this study indicated that the aggregate behavior of apple storage operators in periods I and II could be explained quite well by simple functional relationships of the type suggested by Gustafson. Under conditions specified by Gustafson, changes in the aggregate quantity of the commodity stored or carried over during any period can be explained by changes in the total supply during the period.

After presenting and analyzing the relationships estimated in this study, the results of this study and other studies were used to evaluate the feasibility of proposed producer supply control programs for apples. Two major types of programs were evaluated. In a program of the first type, processing apple sales are increased at the expense of fresh apples. This program assumes that fresh apples have a more inelastic demand at the farm level relative to processing apples. A large number of theoretical and practical problems must be considered in evaluating a diversion program of this type.

There are few empirical results available pertaining to elasticities of demand for fresh and processing apples. The data that are available relate to blend prices without considering various grades, sizes, varieties, etc. Price and quantity time series are available only on an aggregative basis. Hence, data limitations prevent the estimation of demand at the farm level for apples of particular grades, varieties, etc.

The total quantity of apples moved in the fresh market relative to the quantity processed is more stable from year to year. This suggests that the demand for fresh apples in general is more inelastic than the demand for processing apples at the farm level. Tomek found this to be the case. As indicated previously, results of the present study also mildly support this thesis.

Fresh apples quite likely have a less elastic demand (relative to processed apple products) at the retail level due to the relative availability of substitutes for fresh and processed apple products. Elasticities computed from M.S.U. Consumer Panel data support this thesis. However, marketing margins appear to be greater for processed than for fresh apples. Hence, the ordering of elasticities may be reversed at the farm level. In at least two studies, researchers found the derived demand for processing apples to be more inelastic than the demand for fresh apples at the farm. Under these conditions, the policy of diverting apples from fresh to processing outlets would decrease net returns.

There is also a problem of the length of time involved in computing elasticities. The elasticity of demand for semi-perishable commodities, such as apples, when computed from annual data probably gives a lower limit elasticity. A policy of supply control might appear profitable based on an elasticity computed from annual data and unprofitable when elasticity is computed from data for shorter periods of time.

In addition to the above problems there are a number of formidable administrative problems which must be faced in considering a supply control program for apples. Producers in different areas produce different varieties. In some areas mainly fresh apples are produced while a large proportion of total production consists of dual purpose and processing varieties in other areas. Any program of increasing processing sales at the expense of fresh sales (if both have inelastic demands) would subsidize fresh producers at the expense of other producers.

A quantity control program has also been considered for the apple industry. In this program, apples under a certain size would not be marketed. This program would face most of the same theoretical and practical problems enumerated above for the diversion program.

Producer and processor bargaining has also been discussed as a policy for the apple industry. Though the number of apples processors is limited, the price paid for processing apples appears to approach the competitive price. If apple processors are not realizing monopoly gain as a result of their oligopolistic position, bargaining on the part of producers with apple processors would likely have little effect on processing apple prices in the absence of supply controls.

A predictive equation for canning and freezing apple prices was developed in this study using July fresh price, July canner stocks, and the U.S. Department of Agriculture July apple crop estimate. During the period 1951-1961, these three explanatory variables explained almost 90 percent of the year-to-year variation in season average prices of canning and freezing apples. If similar conditions prevail in the future, the price of canning and freezing processing apples can be estimated quite accurately early in the marketing season.

Information available early in the marketing season concerning the probable price of processing apples can be used by producers in developing an apple marketing pattern. Such information would also be useful to processors and food manufacturers in making plans for the ensuing apple marketing season.

Predictive equations were also estimated for fresh apple prices in each of the three periods of the analysis. In the period I relationship, July fresh price and July apple crop estimate explained about 70 percent of the year-to-year variation in fresh prices at harvest.

After period I, fresh price is highly correlated with movement from storage. Storage movement in periods I and II was explained quite accurately by changes in total supply. Total supply after period I consists of the quantity stored since production occurs only in period I. Changes in the quantity stored in period I explained about 85 and 75 percent, respectively, of the year-to-year price changes in periods II and III.

After estimating and presenting predictive equations for fresh and processing apple prices, apple storage rules were developed for periods I and II to illustrate the possibility of improving storage decisions through application of the price prediction equations. In developing a storage rule for a given period, the expected price change between that period and the following period was equated with the marginal cost of storage between the two periods. The quantity to store under the rule developed for period I was a function of July crop estimate, July fresh price and a trend variable. Under the storage rule of period II, the quantity stored at the end of the period was a function of the quantity stored in period I and a trend variable.

After the rules were developed, they were applied to the years 1947-1961 to see what difference their application would have made in the variability of seasonal price changes and in total revenue. There was a large reduction in variability (under the storage rules) of the price change from period I to period III, and total revenue was higher in 13 of the 15 years included in the analysis. Thus, it appears at least possible that storage decisions based on the price prediction equations could decrease the year-to-year variability in seasonal price movements.

The U. S. Department of Agriculture July estimates of apple production and fresh price provide the data needed to apply the storage rule of period I. Storage estimates of the IAA provide the necessary information to apply the storage rule of period II.

This study has not considered the demand for specific grades, varieties, etc. of apples for different geographical locations (these data are not available). The individual producer is most interested in the demand for his specific varieties and sizes of apples rather than in some general average. However, as has been indicated previously, there is a great deal of interdependence both among regions and among various varieties and grades of apples. Regional prices are highly correlated with U. S. prices. A knowledge of the factors associated with changes in U. S. farm prices will enable producers and apple buyers to more accurately estimate the market clearing price for apples of various varieties, grades, etc. in different regions.

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APPENDIX A

STATISTICAL RESULTS

DEFINITION OF VARIABLES

f_{mt} = per capita sales (in pounds) of fresh apples in period m and year t on a monthly basis.

p^f_{mt} = deflated farm price in cents per pound of fresh apples in period m and year t.

y_{mt} = deflated per capita consumer disposable income in period m and year t (on an annual basis) in hundred dollar units.

y'_{mt} = deflated personal consumption expenditures in period m and year t (on an annual basis) in hundred dollar units.

c_{mt} = per capita sales (in pounds) of competing fruits in period m and year t on a monthly basis.

$p^{a'}_{1t}$ = deflated season average farm price in cents (per pound) of canning and freezing apples in year t.

a'_{1t} = per capita farm sales of canning and freezing apples (in pounds) in period I and year t on a monthly basis.

p^a_{1t} = deflated season average farm price in cents per pound of all processing apples in year t.

a_{1t} = per capita farm sales of all processing apples (in pounds) in period I and year t on a monthly basis.

e_{1t} = September apple crop estimate of year t in pounds per capita.

A_{1t} = August 1 per capita carryover canner stocks (in pounds) of processed apple products.

m_t = per capita sales (in pounds) of Eastern apples in year t.

n_t = per capita sales (in pounds) of apples produced in other parts of the U.S. in year t.

$\bar{p}_{1t}$ = the average price in cents per pound of total apple sales of period I weighted by sales of fresh (f_{1t}) and processing (a_{1t}) apples.

s^*_{mt} = the average quantity of apples on hand at the end of similar periods during the three preceding years in pounds per capita.

k_{mt} = the percent of all stored apples in CA storage at the end of period m.

T = trend (1947 = 1, 1948 = 2, . . . , 1961 = 15).

Table 1. Estimated fresh apple demand relationships by period.

Period, Estimation Procedure and Dependent Variable	Constant Term	Regression Coefficients, t Values and Partial Correlation Coefficients[1]					$S_{y.x}$	$\bar{R}^2$
		f_{mt}	p^f_{mt}	$p^f_{(m-1)t}$	c_{mt}	y_{mt}		
Period I:								
OLS								
(1) p^f_{1t}	5.60	- .93	--	+ .19	+ .13	- .07	.48	.16
		1.00*		1.31*	.23	.38		
		- .30		+ .38	+ .07	- .12		
TSLS								
(2) p^f_{1t}	5.21	- .76	--	+ .21	+ .07	- .06	.50	.10
		.55		1.20*	.10	.30		
		- .17		+ .35	+ .03	- .09		
OLS								
(3) f_{1t}	2.59	--	- .10	- .06	+ .33	- .06	.16	.66
			1.00*	1.33	2.22	1.14		
			- .30	- .39	+ .57	- .34		
Period II:								
OLS								
(4) f_{2t}	4.05	--	- .37	+ .13	- .38	- .06	.10	.89
			8.36***	1.96***	1.89***	2.46		
			- .94	+ .53	- .51	- .61		

[1] t values of the regression coefficients appear just below the coefficients to which they apply. Partial correlation coefficients are below the t values.

When the demand relationships for periods II and III were re-estimated substituting a trend variable (T) for c_{mt} and y_{mt}, the OLS estimated relationships were:

(5) $\hat{p}^f_{2t} = 7.82$	$- 2.59\, f_{2t}$	$+ .49\, p^f_{1t}$	$- .04\, T$		
t_b	8.03***	2.98***	2.15***		
Partial r/y	- .92	+ .67	- .54	$S_{y.x} = .28$,	$\bar{R}^2 = .90$
(6) $\hat{p}^f_{3t} = 4.21$	$- 2.46\, f_{3t}$	$+ .52\, p^f_{2t}$	$+ .03\, T$		
t_b	3.44***	2.86***	1.22*		
Partial r/y	- .72	+ .65	+ .34	$S_{y.x} = .46$,	$\bar{R}^2 = .83$

Table 2. Estimated processing apple demand relationships.

Dependent Variable and Estimation Procedure	Constant Term	a'_{1t}[2]	p^a_{1t}	e_{1t}	y_{1t}	$p^{a'}_{1(t-1)}$[2]	A_{1t}	$S_{y.x}$	$\bar{R}^2$
		Regression Coefficients, t values, and Partial Correlation Coefficients[1]							
Canning and Freezing Apples									
OLS									
(1) $p^{a'}_{1t}$	12.74	+ .81	--	- .14	- .46	+ .12	- .42	.39	.61
		.88		3.22***	1.66	.86	1.40**		
		+ .28		- .73	- .48	+ .28	- .42		
TSLS									
(2) $p^{a'}_{1t}$	12.41	+ .71	--	- .14	- .44	+ .13	- .36	.39	.61
		.73		3.15***	1.05	.96*	1.05*		
		+ .23		- .71	- .45	+ .30	- .32		
All Processing Apples									
OLS									
(3) p^a_{1t}	8.47	+ .34	--	- .13	- .21	+ .03	- .33	.29	.66
		.91		3.18***	1.24	.20	1.44**		
		+ .29		- .73	- .38	+ .07	- .43		
(4) a_{1t}	- 7.11		+ .25	+ .11	+ .38	.00	- .23	.25	.55
			.91*	3.19	4.36***	.01	1.17*		
			+ .29	+ .73	+ .82	+ .00	- .36		

[1]t values of the regression coefficients appear just below the coefficients to which they apply. Partial correlation coefficients are below the t values.

[2]Primes denote that portion of all processing apples sold to be manufactured into canned or frozen apple slices or sauce. Prices and quantities of all apples sold to processors were used in estimating relationships (3) and (4).

Table 3. Estimated demand relationships for all apples sold in period I, $a_{1t} + f_{1t}$.

Form of Function & Dependent Variable	Constant Term	Regression Coefficients, t Values, & Partial Correlation Coefficients[1] $\bar{p}_{1t}$	$a_{1t} + f_{1t}$	A_{1t}	$S_{y.x}$	$\bar{R}^2$
Linear:						
OLS						
(1) $a_{1t} + f_{1t}$	6.20	- .63	-- --	- .48	.20	.71
		5.80***		3.84***		
		- .86		- .74		
(2) $\bar{p}_{1t}$	8.09	--	-1.17	- .69	.27	.74
			5.80***	4.26***		
			- .86	- .78		
TSLS						
(3) $a_{1t} + f_{1t}$	6.74	- .80	-- --	- .56	.16	.80
		5.62***		3.95***		
		- .91		- .83		
Logs:						
OLS						
(4) $\bar{p}_{1t}$	1.42	--	-1.65	- .13	.05	.67
			5.19***	3.16***		
			- .83	- .67		
(5) $a_{1t} + f_{1t}$	0.77	- .42	-- --	- .06	.02	.67
		5.19***		3.13***		
		- .83		- .67		

[1] t values of the regression coefficients appear just below the coefficients to which they apply. Partial correlation coefficients are below the t values.

Table 4. Estimated fresh apple demand relationships (OLS) by period, data transformed to logs.

Period and Dependent Variable	Constant Term	Regression Coefficients, t values & Partial Correlation Coefficients[1]					$S_{y.x}$	$\bar{R}^2$
		f_{mt}	p^f_{mt}	$p^f_{(m-1)t}$	c_{mt}	y'_{mt}		
Period I:								
(1) p^f_{1t}	1.15	- .57	--	+ .19	+ .12	- .51	.05	.21
		1.23*		1.33*	.28	.74		
		- .36		+ .39	+ .09	- .23		
(2) f_{1t}	0.66	--	- .23	- .10	+ .55	- .37	.03	.69
			1.23*	1.11	2.68	.88		
			- .36	- .33	+ .65	- .27		
Period II:								
(3) p^f_{2t}	1.28	-1.33	--	+ .35	- .16	- .48	.03	.92
		7.89***		2.20***	2.71***	1.89		
		- .93		+ .57	- .65	- .51		
(4) f_{2t}	.95	--	- .65	+ .17	- .09	- .35	.02	.88
			7.89***	1.44**	1.87***	2.01		
			- .93	+ .41	- .51	- .54		
Period III:								
(5) p^f_{3t}	- .11	- .75	--	+ .41	+ .09	+ .43	.05	.86
		4.42***		2.40***	1.31	1.09*		
		- .81		+ .60	+ .38	+ .32		

[1] t values for the regression coefficients appear just below the coefficients to which they apply. Partial correlation coefficients are below the t values.

Table 5. Estimated allocation and storage function (OLS), data transformed to logs.

Type Function and Dependent Variable	Constant Term	Regression Coefficients, t values, & Partial Correlation Coefficients[1]			$S_{y.x}$	$\bar{R}^2$
		$p^{a'}_{1t}/p^{f}_{1t}$[2]	m_t	n_t		
Allocation						
(1) a_{1t}	-0.76	+ .28	+1.25	+ .35	.02	.91
		2.86***	11.44***	2.70***		
		+ .65	+ .96	+ .63		
(2) a'_{1t}	-0.29	+ .26	+1.78	- .79	.06	.73
		1.18*	6.24***	2.64		
		+ .34	+ .88	- .62		
Storage						
(3) s_{1t}	-0.55	- .03	+ .32	+1.01	.03	.82
		.28	2.32***	6.91***		
		- .08	+ .57	+ .90		

[1] t values for the regression coefficients appear just below the coefficients to which they apply. Partial correlation coefficients are below the t values.

[2] In (1), p^{a}_{1t}/p^{f}_{1t} was used instead of $p^{a'}_{1t}/p^{f}_{1t}$.

Table 6. Estimated fresh apple demand relationships (OLS) by period, consumer disposable income variable replaced by personal consumption expenditures.

Period and Dependent Variable	Constant Term	Regression Coefficients, t values, & Partial Correlation Coefficients[1] f_{mt}	p^f_{mt}	$p^f_{(m-1)t}$	c_{mt}	y'_{mt}	$S_{y.x}$	$\bar{R}^2$
Period I:								
(1)p^f_{1t}	7.44	-1.06	--	+0.21	+ .04	- .18	.47	.22
		1.18*		1.47**	.07	.91		
		- .35		+ .42	+ .02	- .28		
(2)f_{1t}	2.76	--	- .12	- .05	+ .33	- .08	.16	.66
			1.18*	1.01	2.28	1.22		
			- .35	- .30	+ .59	- .36		
Period II:								
(3)p^f_{2t}	9.65	-2.30	--	+ .42	-1.21	- .15	.24	.93
		8.53***		2.95***	2.72***	2.19		
		- .94		+ .68	- .65	- .57		
(4)f_{2t}	4.13	--	- .38	+ .13	- .41	- .07	.10	.89
			8.53***	2.02***	2.03***	2.45		
			- .94	+ .54	- .54	- .61		
Period III:								
(5)p^f_{3t}	3.23	-2.64	--	+ .49	+1.20	+ .08	.45	.84
		3.79***		2.74***	1.35	.62		
		- .77		+ .66	+ .39	+ .19		

[1]t values for the regression coefficients appear just below the coefficients to which they apply. Partial correlation coefficients are below the t values.

Table 7. Estimated preliminary storage functions for periods I and II.

Dependent Variable & Estimation Procedure	Constant Term	Regression Coefficients t values and Partial Correlation Coefficients[a]						$S_{y.x}$	$\bar{R}^2$
		p^f_{mt}	$s_{(m-1)t}$[b]	s^*_{mt}	$g_{(t-1)}$[c]	c_{mt}	k_{2t}[d]		
Period I:									
OLS									
(1) s_{1t}	10.61	- .56	+ .33	- .68	-1.91	+ .00	--	.95	.77
		.34	2.82***	2.32***	3.17***	.00	--		
		- .11	+ .68	- .61	- .73	.00	--		
TSLS									
(2) s_{1t}	7.59	+ .35	+ .38	- .70	-1.80	- .02	--	.95	.75
		.14	2.22***	1.79**	2.21***	.10	--		
		+ .06	+ .70	- .62	- .70	- .04	--		
Period II:									
OLS									
(3) s_{2t}	- 2.76	+ .27	- .55	- .04	- .43	+ .08	+ .02	.26	.95
		.50	4.80***	.16	1.67**	.37	2.43***		
		+ .17	- .86	- .06	- .51	+ .13	+ .65		
TSLS									
(4) s_{2t}	- 3.58	+ .45	- .51	- .05	- .40	+ .12	+ .02	.26	.95
		.69	3.73***	.17	1.41**	.47	2.31***		
		+ .26	- .82	- .07	- .48	+ .18	+ .67		

[a] t values appear just below the regression coefficients. Partial correlation coefficients are below the t values.

[b] There are no stocks at the beginning of period I. In period I, September crop estimate, e_{1t}, replaced $S_{(m-1)t}$.

[c] In period I, $g_{(t-1)}$ was the price increase in dollars per bushel in the previous year from period I to period III. In the storage function for period II, $g_{(t-1)}$ was the price increase in the previous year from period II to period III.

[d] The k_{mt} variable was not included in the storage function of period I.

APPENDIX B

DATA USED IN ANALYSIS

Table 1. U.S. production and sale of apples by period, 1947-1961, thousands of bushels.

		Sales of Fresh Apples[2]			Sales of Processing Apples (period I)	
Crop Year	Production[1] Period I	Period I	Period II	Period III	Canning & Freezing	All
1947	103,576	33,280	30,202	12,100	9,765	26,369
1948	84,342	36,358	22,452	6,580	8,709	19,455
1949	117,300	37,506	32,518	8,928	15,871	37,218
1950	115,537	26,151	34,214	13,771	18,782	40,353
1951	97,349	34,212	25,633	6,774	13,154	28,196
1952	90,505	33,731	24,790	7,601	12,860	24,918
1953	92,635	30,752	26,369	7,963	14,782	27,612
1954	108,389	31,118	27,972	9,226	21,602	39,112
1955	100,766	26,449	31,321	9,417	17,925	32,930
1956	98,569	29,141	26,405	6,913	21,234	35,161
1957	114,827	31,209	34,297	8,614	19,951	36,274
1958	122,639	35,542	31,829	13,687	22,772	40,342
1959	122,875	36,908	31,120	8,724	23,399	43,003
1960	106,255	33,597	26,261	8,525	22,350	36,091
1961	123,207	32,832	31,081	9,766	26,608	45,502

[1] Only apples sold were included in "production" as used in this study. Consequently, production in this study represents total production less apples for home use and apples not sold for economic reasons (i.e., apples not harvested and excess cullage).

[2] Sales were adjusted for exports and imports. Consequently, total fresh sales plus all processing sales does not equal production (total sales).

Sources: Production statistics and sales of processing apples are published by the Crop Reporting Board, SRS, U.S. Department of Agriculture. Sales of fresh apples by period were determined from the production stocks identity.

Table 2. Per capita U S. farm sales of fresh and processing apples by period, 1947-1961, in pounds.[1]

Crop Year	Fresh Apple Sales			Processing Apple Sales	
	Period I	Period II	Period III	All	Canning & Freezing
	f_{1t}	f_{2t}	f_{3t}	a_{1t}	a'_{1t}
1947	11.05	9.96	3.97	8.76	3.24
1948	11.86	7.28	2.12	6.35	2.84
1949	12.03	10.36	2.83	11.93	5.09
1950	8.25	10.72	4.30	12.73	5.92
1951	10.60	7.89	2.08	8.74	4.08
1952	10.28	7.51	2.29	7.59	3.92
1953	9.21	7.85	2.36	8.27	4.43
1954	9.16	8.18	2.69	11.52	6.36
1955	7.66	9.01	2.70	9.53	5.19
1956	8.29	7.46	1.94	10.00	6.04
1957	8.72	9.53	2.38	10.14	5.58
1958	9.77	8.69	3.72	11.09	6.26
1959	9.94	8.32	2.32	11.58	6.30
1960	8.90	6.91	2.23	9.56	5.92
1961	8.56	8.05	2.52	11.86	6.93

[1]In estimating the demand relationships, the quantities presented below were converted to a monthly basis to facilitate the comparison of regression coefficients of f_{mt} in different periods.

Source: Computed from Tables 1 and 10.

Table 3. U.S. fresh apple storage stocks at end of period, 1947 to 1961, thousands of bushels and end of July canner stocks of canned and frozen apple slices and apple sauce in fresh apple equivalents.

Crop Year	Fresh Apples-Storage Stocks		Canned and Frozen Slices and Sauce[1]
	Period I	Period II	
	(1000 bu.)		(1000 lbs.)
1947	42,645	12,100	136,583
1948	29,124	6,580	144,616
1949	41,436	8,928	29,121
1950	48,100	13,771	188,756
1951	32,631	6,774	278,242
1952	32,578	7,601	152,329
1953	34,557	7,963	33,682
1954	37,462	9,226	43,047
1955	41,077	9,417	177,111
1956	33,255	6,913	155,918
1957	43,370	8,614	235,279
1958	45,705	13,687	211,993
1959	40,180	8,724	152,228
1960	34,948	8,525	233,182
1961	41,097	9,766	243,846

[1]Conversion factors used were:

Apple Slices (cans per case/can size)		Fresh Apple Equivalent/Case
		(lbs.)
24/2 1/2's	=	67.200
24/2's	=	46.345
6/10's	=	61.639
Apple Sauce (cans per case/can size)		
24/2's	=	39.724
24/303's	=	29.396
48/8 oz.	=	33.368
6/10's	=	52.833
Misc. sizes	=	55.000

Frozen apples were converted to a fresh apple basis using a conversion ratio of 1.25, i.e., one pound of frozen apples equals 1.25 pounds of fresh apples.

Table 3. Continued.

Sources: Conversion factors for canned apples were taken from U.S. Department of Agriculture, Agricultural Statistics, 1961, and National Canners Association, Canned Food Pack Statistics 1961, June, 1962.

The conversion factor for frozen apples was taken from Kaufman, V. F., "Costs and Methods for Pie-stock Apples." Food Engineering, December, 1951.

(a) Information concerning fresh apple storage stocks were obtained from the International Apple Association.

(b) Carryover stocks of canned apple slices and sauce were obtained from the National Canners Association, and M. B. Bain, and S. Hoos, Apples - Fresh and Processed - Economic and Marketing Statistics, Cal. AES, May, 1959. For the period 1947-1950 June Stocks were available but July stocks were not. June stocks were converted to a July basis by determining the average relationship between June and July stocks during the period 1951-1955. Stocks of frozen apple slices were obtained from Cold Storage Reports of the USDA.

Table 4. U.S. per capita storage movement of fresh apples by period, 1947-1961, and U.S. per capita canner stocks of canned and frozen apple slices and sauce in fresh apple equivalents.

Year	Storage Movement of Apples[1]			August 1 Processed Stocks
	s_{1t}	s_{2t}	s_{3t}	A_{1t}
	--- pounds per capita ---			
1947	14.53	- 9.96	-3.97	0.947
1948	9.41	- 7.28	-2.12	0.986
1949	13.60	-10.36	-2.83	0.195
1950	15.44	-10.72	-4.30	1.244
1951	10.57	- 7.89	-2.08	1.801
1952	9.79	- 7.51	-2.29	0.970
1953	10.32	- 7.85	-2.36	0.211
1954	11.19	- 8.18	-2.69	0.265
1955	11.94	- 9.01	-2.70	1.071
1956	9.64	- 7.46	-1.94	0.926
1957	12.94	- 9.53	-2.38	1.373
1958	12.73	- 8.69	-3.72	1.217
1959	11.36	- 8.32	-2.32	0.858
1960	9.53	- 6.91	-2.23	1.290
1961	11.35	- 8.05	-2.52	1.327

[1] $s_{mt} = S_{mt} - S_{(m-1)t}$.

Source: Computed from Tables 3 and 10.

Table 5. Average deflated farm price by period of fresh apples and season average U.S. farm price (deflated) of processing apples, 1947-1961.[1]

Crop Year	Fresh Apples			Processing Apples	
	Period I p^f_{1t}	Period II p^f_{2t}	Period III p^f_{3t}	All p^a_{1t}	Canning & Freezing $p^{a'}_{1t}$
	--- dollars/bushel ---				
1947	1.94	1.43	1.35	0.72	1.29
1948	1.91	2.39	2.09	0.71	1.04
1949	1.51	1.42	2.01	0.55	0.86
1950	1.82	1.29	1.06	0.76	1.12
1951	1.61	1.86	2.42	0.51	0.68
1952	2.19	2.51	2.67	0.94	1.24
1953	2.40	2.38	2.38	1.36	1.75
1954	2.17	2.24	2.37	1.13	1.50
1955	1.99	1.75	1.76	0.74	0.95
1956	2.12	2.29	2.59	1.12	1.39
1957	1.83	1.29	1.81	0.70	0.90
1958	1.68	1.57	1.38	0.59	0.72
1959	1.62	1.89	2.24	0.69	0.86
1960	2.13	2.32	2.84	0.98	1.15
1961	2.05	2.04	2.51	0.78	0.89

[1]All prices were deflated by the Wholesale Price Index. In estimating the demand relationships, all prices were in cents per pound.

Source: Apple prices by period are simple monthly averages and were computed from Crop Reporting Board statistics.

Table 6. U.S. per capita sales of competing fruits by period, 1947-1961, in pounds.[1]

Crop Year	Period I		Period II	Period III
	c_{1t}	c'_{1t}	c_{2t}	c_{3t}
1947	19.46	21.80	2.03	1.53
1948	14.20	19.88	1.40	1.14
1949	15.53	21.82	1.53	1.26
1950	11.78	19.66	1.50	0.83
1951	13.26	21.09	1.57	1.00
1952	14.81	18.81	1.46	1.15
1953	13.25	19.56	1.20	1.23
1954	13.71	18.34	1.18	0.82
1955	10.73	20.86	1.41	0.31
1956	12.95	20.59	1.08	0.94
1957	12.15	19.47	2.70	1.03
1958	13.30	16.47	1.18	1.45
1959	12.36	20.09	0.99	1.77
1960	11.87	18.65	1.06	1.57
1961	11.03	19.21	0.96	2.05

[1] The three fresh fruits included in c_{mt} were California table grapes, U.S. peaches and U.S. pears. Four fruits were included in c'_{1t}. These were Utah, Washington, and California apricots, Washington, California, and Oregon Bartlett pears, California peaches and U.S. sour cherries. In estimating the demand relationships, the quantities below were converted to a monthly basis to facilitate the comparison of regression coefficients of c_{mt} in different periods.

Source: Annual sales are reported in U.S. Department of Agriculture, Crop Reporting Board statistics. Unpublished data giving monthly sales as a percent of total sales for peaches and pears were furnished by the U.S.D.A. Sales of grapes by period were estimated on the basis of interstate truck and rail movement of California table grapes. Data pertaining to movement of California table grapes were obtained from various issues of, U.S. Department of Agriculture, Marketing California Grapes.

Table 7. September apple crop estimate, eastern apple sales, other apple sales, 1947-61, pounds per capita.

Crop Year	Crop Estimate e_{1t}	Eastern Sales m_t	Other Sales n_t
		--- pounds per capita ---	
1947	37.56	12.17	21.42
1948	32.79	11.11	15.51
1949	41.50	15.76	21.85
1950	37.55	16.64	19.80
1951	37.15	14.17	16.00
1952	29.88	11.90	15.68
1953	29.85	11.95	15.81
1954	30.13	16.30	15.62
1955	31.32	13.35	15.82
1956	26.58	13.01	15.04
1957	31.13	14.02	18.08
1958	34.86	16.23	17.49
1959	31.86	16.61	16.49
1960	28.93	13.77	14.38
1961	32.61	16.69	15.42

Sources: (a) Crop estimates were taken from Crop Production, published monthly by the Crop Reporting Board of the U.S. Department of Agriculture.

(b) Apple sales by region are published by the Crop Reporting Board, Statistical Reporting Service, U.S. Department of Agriculture.

Table 8. Percent of total apple holdings held in CA storage on December 1 and April 1, 1947-1961, United States.

Crop Year	December 1 k_{1t}	April 1 k_{2t}
	--- percent ---	
1947	0.19	0.57
1948	0.29	0.87
1949	0.22	0.66
1950	0.21	0.63
1951	0.57	1.71
1952	0.90	2.70
1953	1.06	2.89
1954	1.23	4.40
1955	1.81	6.32
1956	2.44	8.84
1957	3.43	13.30
1958	6.31	18.70
1959	8.45	22.80
1960	11.40	26.20
1961	13.30	39.00

Source: International Apple Association.

Table 9. U.S. storage holdings at end of similar periods in previous years[1] and within-year price increase of apples in storage, 1947-1961.

Crop Year	Storage Holdings: December 1 S^*_{1t}	Storage Holdings: April 1 S^*_{2t}	Price Increase in Previous Year: Period I-Period III[2] $g_{(t-1)}$	Price Increase in Previous Year: Period II-Period III $g^*_{(t-1)}$
	pounds per capita		dollars per bushel	
1947	12.99	2.86	-0.58	-0.07
1948	13.76	3.48	+0.02	-0.36
1949	12.31	3.04	+0.72	+0.61
1950	12.51	3.03	-0.54	-0.25
1951	12.82	3.12	+0.91	+0.60
1952	13.20	3.11	+0.47	+0.17
1953	11.93	2.95	+0.02	0.00
1954	10.23	2.32	+0.23	+0.15
1955	10.43	2.53	-0.08	+0.05
1956	11.15	2.68	+0.56	+0.36
1957	10.92	2.51	+0.23	+0.62
1958	11.51	2.42	-0.16	-0.22
1959	11.77	2.75	+0.57	+0.42
1960	12.34	2.91	+0.80	+0.60
1961	11.21	2.83	+0.69	+0.55

[1] $$S^*_{mt} = \frac{S_{m(t-1)} + S_{m(t-2)} + S_{m(t-3)}}{3}$$

[2] The average farm price for September, October, and November was used to represent prices in period I since storage would occur only in the latter part of period I.

Sources: Tables 3, 10, and 17.

Table 10. U.S. population by period, 1947-1961.[1]

Crop Year	Period I	Period II	Period III
		--- millions ---	
1947	144.5	145.5	146.2
1948	147.1	148.1	148.8
1949	149.7	150.7	151.3
1950	152.2	153.2	153.9
1951	154.9	155.9	156.6
1952	157.5	158.5	159.3
1953	160.2	161.2	162.0
1954	163.0	164.1	164.8
1955	165.8	166.9	167.7
1956	168.7	169.9	170.7
1957	171.7	172.8	173.6
1958	174.6	175.8	176.7
1959	178.2	179.5	180.2
1960	181.2	182.4	183.2
1961	184.2	185.3	186.1

[1]Population estimates are published monthly. A simple monthly average was computed to obtain the population estimate in each period.

Source: Economic Statistics Bureau of Washington, D.C., The Handbook of Basic Economic Statistics, monthly.

Table 11. Consumer and Wholesale Price Indices, 1947-1961, by period.[1]

Crop Year	Consumer Price Index Period I	Consumer Price Index Period II	Consumer Price Index Period III	Wholesale Price Index Period I	Wholesale Price Index Period II	Wholesale Price Index Period III
			1947-1949 = 100			
1947	97.0	100.2	102.0	99.6	103.9	104.9
1948	103.9	101.8	101.4	106.8	102.0	99.4
1949	101.0	99.9	100.6	97.5	97.1	99.2
1950	104.0	108.9	110.7	107.2	115.0	115.8
1951	111.7	112.8	113.1	113.7	112.8	111.5
1952	114.2	113.8	114.1	111.5	109.8	109.6
1953	115.1	115.0	114.9	110.5	110.5	110.6
1954	114.8	114.3	114.3	110.1	110.0	110.2
1955	114.8	114.6	115.5	111.2	112.1	114.1
1956	117.3	118.4	119.7	115.1	116.8	117.2
1957	121.1	122.4	123.6	118.1	119.0	119.3
1958	123.8	123.7	124.1	119.1	119.4	119.9
1959	125.2	125.6	126.3	119.3	119.4	119.7
1960	126.9	127.5	127.5	119.5	119.8	118.8
1961	128.2	128.4	129.1	118.8	119.5	119.0

[1]Consumer and wholesale price indices are reported on a monthly basis. A simple monthly average was computed to obtain the index for each period.

Source: U.S. Department of Commerce, Survey of Current Business and Business Statistics.

Table 12. Per capita deflated Consumer Disposable Income, seasonally adjusted at annual rates, by period, United States, 1947-1961.[1]

Crop Year	Period I y_{1t}	Period II y_{2t}	Period III y_{3t}
		--- dollars ---	
1947	1,239	1,227	1,259
1948	1,262	1,257	1,237
1949	1,225	1,300	1,316
1950	1,335	1,307	1,320
1951	1,329	1,312	1,319
1952	1,340	1,368	1,381
1953	1,363	1,359	1,356
1954	1,369	1,399	1,444
1955	1,470	1,486	1,503
1956	1,502	1,503	1,511
1957	1,501	1,472	1,464
1958	1,495	1,510	1,542
1959	1,524	1,524	1,536
1960	1,531	1,522	1,545
1961	1,562	1,575	1,589

[1]Consumer Disposable Income (reported on a quarterly basis) was deflated by the Consumer Price Index (1947-49 = 100). Consumer Disposable Income in period I, y_{1t}, is a weighted average of income in the third and fourth quarters of year t. y_{2t} is a weighted average of income in the fourth quarter of year t and the first quarter of year t + 1.

Source: U.S. Department of Commerce, Survey of Current Business and Business Statistics.

Table 13. Per capita deflated Personal Consumption Expenditures, seasonally adjusted at annual rates, by period, United States, 1947-1961.[1]

Crop Year	Period I y'_{1t}	Period II y'_{2t}	Period III y'_{3t}
1947	1,206	1,191	1,187
1948	1,173	1,185	1,194
1949	1,200	1,225	1,244
1950	1,275	1,245	1,200
1951	1,202	1,215	1,229
1952	1,237	1,275	1,284
1953	1,266	1,259	1,270
1954	1,285	1,321	1,350
1955	1,376	1,385	1,385
1956	1,377	1,387	1,387
1957	1,388	1,360	1,356
1958	1,372	1,399	1,427
1959	1,423	1,431	1,450
1960	1,435	1,441	1,436
1961	1,451	1,468	1,477

[1]Personal consumption expenditures (reported on a quarterly basis) were deflated by the Consumer Price Index, 1947-49 = 100. Personal Consumption Expenditures in period I, y'_{1t}, is a weighted average of Personal Consumption Expenditures for the third and fourth quarter of any year t. y'_{2t} is a weighted average of Personal Consumption Expenditures in the fourth quarter of year t and the first quarter of year t + 1.

Source: U.S. Department of Commerce, Survey of Current Business and Business Statistics.

Table 14. Indices of processing costs included in the processing demand relationship.

Crop Year	Constructed Index[1] d_{1t}	Intermediate Goods & Services d'_{1t}
	1947-1949 = 100	
1947	91.2	94
1948	94.5	103
1949	110.7	103
1950	101.5	106
1951	106.5	116
1952	109.2	116
1953	114.6	119
1954	117.2	120
1955	117.8	121
1956	122.8	126
1957	126.6	132
1958	128.1	134
1959	123.8	136
1960	126.0	138
1961	129.5	138

[1] See Chapter IV for method of construction.

Sources: (a) The Constructed index of processing costs was based on labor and can costs. Labor costs were taken from, U.S. Department of Labor, Monthly Labor Review. Can costs were obtained from The Almanac of the Canning, Freezing, Preserving Industries.

(b) The Index of Intermediate Goods and Services was taken from the U.S. Department of Agriculture, The Marketing and Transportation Situation, May, 1962.

Table 15. Fresh apples, exports and imports by period, 1947-1961, thousands of bushels.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	Period I (July - Nov.)			Period II (Dec. - Mar.)			Period III (Apr. - June)		
Crop Year	Exports	Imports	Col 1 less Col 2	Exports	Imports	Col 4 less Col 5	Exports	Imports	Col 7 less Col 8
1947	1,144	949	195	1,388	301	1,087	348	5	343
1948	452	767	-315	747	1,027	-280	250	158	92
1949	738	589	149	1,943	952	991	384	394	- 10
1950	748	686	62	1,679	808	871	614	499	115
1951	1,359	521	838	1,868	396	1,472	325	101	224
1952	528	789	-261	440	901	-461	324	137	187
1953	447	630	-183	613	716	-103	434	209	225
1954	617	457	160	1,059	522	537	378	114	264
1955	634	503	131	1,111	932	179	475	136	339
1956	731	344	387	856	231	625	249	312	- 63
1957	1,442	376	1,066	3,434	526	2,908	531	72	459
1958	832	368	464	1,170	584	586	449	260	189
1959	1,103	322	781	2,328	325	2,003	433	97	336
1960	993	394	599	1,436	416	1,020	347	185	162
1961	1,590	261	1,329	2,886	439	2,447	420	170	250

Sources: Correspondence with A. Clinton Cook, Chief Commodity Analysis Branch, Fruit and Vegetable Division, Foreign Agricultural Service and U.S. Department of Agriculture, Foreign Agricultural Trade of the United States, monthly.

Table 16. Processing apples, undeflated and deflated season average farm price, 1947-1961, dollars per ton.

Crop Year	Canning and Freezing	All Processing	Canning and Freezing	All Processing
	dollars/ton (undeflated)		dollars/bushel (deflated)	
1947	53.50	29.90	1.29	0.72
1948	46.30	31.80	1.04	0.71
1949	35.10	22.40	0.86	0.55
1950	50.20	33.80	1.12	0.76
1951	32.00	24.20	0.68	0.51
1952	57.70	43.80	1.24	0.94
1953	80.80	62.70	1.75	1.36
1954	68.90	52.00	1.50	1.13
1955	44.20	34.50	0.95	0.74
1956	66.60	53.60	1.39	1.12
1957	44.50	34.50	0.90	0.70
1958	35.80	29.40	0.72	0.59
1959	42.80	34.10	0.86	0.69
1960	57.40	48.90	1.15	0.98
1961	44.20	38.70	0.89	0.78

Source: Prices published by U.S. Department of Agriculture, Crop Reporting Board, SRS. Wholesale Price Index Taken from Table 11.

Table 17. Fresh apples, average price per bushel (undeflated) per month, 1946-1961.

Year	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June
1946	3.04	2.31	2.32	2.26	2.27	2.33	2.35	2.46	2.64	2.60	2.55	2.60
1947	1.82	1.84	2.19	1.91	1.90	1.81	1.45	1.40	1.29	1.17	1.41	1.69
1948	2.01	2.02	2.03	2.00	2.14	2.31	2.50	2.49	2.44	2.19	1.71	2.33
1949	1.89	1.65	1.50	1.14	1.17	1.27	1.37	1.41	1.49	1.58	1.97	2.41
1950	2.41	2.06	2.03	1.67	1.60	1.70	1.56	1.42	1.24	1.09	1.06	1.53
1951	1.89	1.88	1.80	1.69	1.89	2.01	2.12	2.06	2.20	2.36	2.87	2.87
1952	2.47	2.36	2.38	2.43	2.58	2.78	2.78	2.68	2.82	2.82	3.01	2.96
1953	2.73	2.72	2.56	2.60	2.66	2.68	2.62	2.68	2.53	2.58	2.55	2.75
1954	2.41	2.40	2.39	2.38	2.38	2.58	2.45	2.42	2.39	2.50	2.60	2.72
1955	2.37	2.40	2.25	1.96	2.07	2.06	2.03	1.98	1.77	1.87	2.09	2.07
1956	2.52	2.29	2.46	2.44	2.51	2.64	2.66	2.67	2.70	2.74	3.02	3.32
1957	2.57	2.41	2.17	1.89	1.75	1.63	1.63	1.42	1.49	2.06	2.05	2.37
1958	2.39	2.18	2.09	1.51	1.84	1.82	1.84	1.95	1.88	1.93	1.57	1.46
1959	1.33	2.98	2.23	2.01	2.08	2.17	2.24	2.28	2.33	2.39	2.76	2.88
1960	2.44	2.57	2.63	2.50	2.60	2.69	2.73	2.83	2.86	3.07	3.61	3.47
1961	2.76	2.50	2.43	2.19	2.27	2.35	2.38	2.48	2.53	2.88	3.07	3.01

Source: U.S. Department of Agriculture Crop Reporting Board Statistics, Statistical Bulletin No. 253, June, 1959, for 1946-1948, Supp. No. 2 Ag. Prices, July, 1961, for years 1949-1959, and Agricultural Prices, monthly for 1960-1961.

Table 18. U.S. per capita sales of fresh oranges by period, 1947-1961, in pounds.

Crop Year	Period I	Period II	Period III
1947	13.75	16.11	10.95
1948	11.56	14.96	8.60
1949	9.54	12.05	7.90
1950	8.65	13.43	9.23
1951	9.50	13.60	9.45
1952	8.22	13.87	8.99
1953	9.31	13.07	7.63
1954	7.94	13.23	7.44
1955	7.33	12.85	7.89
1956	6.92	11.54	7.15
1957	6.91	9.89	4.05
1958	4.64	10.49	5.77
1959	6.13	11.62	5.36
1960	3.82	9.33	4.65
1961	4.07	8.89	4.69

Sources: Annual sales of fresh oranges are estimated by the Crop Reporting Board. Unpublished data from the U.S. Department of Agriculture were used in estimating sales by period.