AN EXPERIMENT IN DESIGNING AN ECONOMETRIC MODEL TO EXPLAIN SHORT TERM DEMAND FLUCTUATIONS FOR APPLES

Thesis for the Degree of M. S.

MICHIGAN STATE COLLEGE

William A. Cromarty

1953

This is to certify that the

thesis entitled

AN EXPERIMENT IN DESIGNING AN ECONOMETRIC MODEL TO
EXPLAIN SHORT TERM DEMAND FLUCTUATIONS FOR APPLES

presented by

William A. Cromarty

has been accepted towards fulfillment
of the requirements for

Master of Science degree in Agricultural Economics

L. L. Boger
Major professor

Date July 28, 1953

O-169

AN EXPERIMENT IN DESIGNING AN ECONOMETRIC MODEL TO EXPLAIN SHORT TERM DEMAND FLUCTUATIONS FOR APPLES

By

William A. Cromarty

A THESIS

Submitted to the School of Graduate Studies of Michigan
State College of Agriculture and Applied Science
in partial fulfillment of the requirements
for the degree of

MASTER OF SCIENCE

Department of Agricultural Economics

1953

ACKNOWLEDGMENTS

The author wishes to express his gratitude to all those who contributed to the organization of this study and in the preparation of the manuscript.

The assistance of Dr. L. L. Boger in planning and supervising the study was invaluable. His critical review of the material and his encouragements were appreciated at all times.

Of major importance was the guidance and advice given by Dr. Clifford Hildreth of the Cowles Commission, University of Chicago. His discussions on analytical procedure and his contributions toward the development of a preliminary model were of great benefit to the author.

Thanks also are due to Dr. Glenn Johnson for his advice and interest in the project. Numerous improvements and corrections were suggested by him prior to the final preparation of the manuscript.

The author is also indebted to other faculty members and to fellow graduate students for suggestions and contributions.

Finally, thanks are given to the Agricultural Economics department for the opportunity and assistance provided the author as a graduate student.

Errors which may appear in the manuscript are the sole responsibility of the author.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF TABLES (Continued)

CHAPTER I

INTRODUCTION

The development of basic research and the application of new methodology to particular fields remain as major problems facing research workers in economics at this date. The area of statistical demand analysis, which deals with the measurement of mass response in a given market, has undergone continuous experimentation and improvement, as workers have tried to develop and use price forecasting formulae as guides to marketing policies. The following study is another in this area with emphasis on a particular commodity -- apples. The main problem which has arisen in this area centers around seasonal fluctuations in demand. Justification for selecting apples as the commodity to be studied is found in, (1) the importance of apples as a major fruit crop in the United States . . . . farm value of 192 million dollars for the commercial apple crop in 1950,[1] (2) the inadequate conclusions which can be derived from previous attempts to explain short term demand fluctuations coupled with the importance of having sufficient and

---

[1]Anonymous, Agricultural Statistics, United States Department of Agriculture, Washington 25, D. C., p. 188, 1952.

accurate data for this purpose and (3) the relatively better time series data for the apple market as compared with many other agricultural products. This latter reason is important because of the statistical analysis which will be used.

In the past a strong interest has centered around what can be termed the "single equation, least squares" approach and in many cases this has proven to be a very useful tool in economic analysis. Refinements in this particular technique are constantly being made but there are severe limitations to its general application.[2] The usual accepted procedure is to more or less arbitrarily assume one variable as being dependent upon all others with none of the independent variables being significantly influenced by the dependent variable. A line of regression is then fitted by minimizing the sum of the squared deviations of the observations from it. This method further assumes that any errors present in the model are associated with the dependent variable only. A further limitation ascribed to aggregation arises when the product involved is assumed to have only one major use

---

[2]For a discussion on "least-squares" bias see Bennion, E. G. The Cowles Commission Simultaneous Equation Approach: A Simplified Explanation. Review of Economics and Statistics, Vol. 34, pp. 49-56, 1952, or Bronfenbrenner, J., Chapter IX, Sources and Size of Least-Squares Bias In a Two-Equation Model. Hood, W. C. and Koopmans, T. C., Editors. Studies in Econometric Method. John Wiley and Sons, New York, 1953.

and therefore only one market outlet. When the apple market is studied it is apparent that there are several uses and outlets with different characteristics, thus consideration for a method of analysis is needed which permits a study of the short run market fluctuations for the several demands.

Economists in conjunction with statisticians and mathematicians, or econometricians as a separate group have, and are, developing statistical tools which can be applied to data not readily or completely adaptable to the "single equation, least squares" approach. The greatest contribution which has been made in this area has been the development and consideration of complete econometric models.[3] The primary

---

[3]This work has been developed along two lines, (a) the theoretical and intuitive concepts which form a formal and logical background for the construction of econometric models and (b) experimentation and application of such theory using empirical data. Some of the major contributions to the first part have been,

(a) Anderson, T. W. and Rubin, H. Estimation of the Parameters of a Single Equation in a Complete System of Stochastic Equations. Annals of Mathematical Statistics, Vol. 20, pp. 46-63, March, 1949.

(b) Anderson, T. W. and Rubin, H. The A symtotic Properties of Estimates of the Parameters in a Complete System of Stochastic Equations. Annals of Mathematical Statistics, Vol. 21, pp. 570-582, December, 1950.

(c) Rubin, H. Systems of Linear Stochastic Equations. Unpublished Ph. D. Thesis, University of Chicago, 1948, 50 pp.

(d) Cowles Commission for Research in Economics. Statistical Inference In Dynamic Economic Models, edited by Koopmans, T. C. John Wiley and Sons, New York, 1950.

(e) Haavelmo, T. The Probability Approach In Econometrics. Econometrica, Vol. 12 (supp.), July, 1944.

Some of the major contributions in the field of application are, step in this method of analysis is to specify the variables which are relevant to the study and what form the relationships between the variables will take. These relationships between variables result in structural equations, and enough equations must be constructed to explain every variable which is not determined outside of the system being studied. This eliminates the need for assigning one variable as dependent and all others as independent. The structural equations which form the model may be solved simultaneously allowing for the interaction of all included variables.

It is realized that this newer approach also has definite limitations and no claim is made that it can completely replace the older, single equation regression technique which is a special case of the new approach. The brief is held that each is useful in known limited areas of demand analysis

---

(a) Girshick, M. A. and Haavelmo, T. Statistical Analysis of the Demand for Food. Econometrica, Vol. 15: 77 ff.

(b) Klein, L. Pitfalls in the Determination of the Investment Schedule. Econometrica, Vol. 11, pp. 246-258, July-October, 1943.

(c) Allen, S. G. Inventory Fluctuations in Flaxseed and Linseed Oil, 1926-1939. Cowles Commission Discussion Paper: Economics 276, unpublished paper. Cowles Commission for Research in Economics, University of Chicago, Chicago 37, Illinois.

(d) Hildreth, C. and Jarrett, F. Cowles Commission Discussion Paper: Economics 2055, unpublished paper. Cowles Commission for Research in Economics, University of Chicago, Chicago 37, Illinois, November, 1952.

while in a third, and possibly the largest area, the appropriate techniques have not been determined.

In general, statistical difficulties arise and should be dealt with regardless of the technique used. These difficulties concern the availability and accuracy of economic data or what are termed "errors" in the model, the problem of identifying relationships as being demand or supply functions or other behavior or technical relations,[4] and the technical problems of serial correlation and multicollinearity. As far as possible these problems shall be dealt with in this study in a practical manner.

Objectives

The primary objective of this study is to construct an econometric model which will be useful in analyzing seasonal or short-term demand fluctuations in the apple market. The successful attainment of this objective will be reached when the structural equations have been developed to explain the variables which are determined by forces within the apple market.

A second and concurrent objective will be to determine the appropriate data or evidence needed for fitting the

---

[4]Koopmans, T. C. Identification Problems in Economic Model Construction. Econometrica, Vol. 17, No. 2, pp. 125-144, April, 1949.

structural equations and assigning values to the parameters. This evidence must be relevant to the problem and be assembled and classified in such a manner that it is adapted to a solution of the model.

It is not within the scope or purpose of this study to test the reliability of this model by actually fitting the structural equations for the specified periods, but it is most important that the model be in a form that such a fitting may be undertaken with a minimum amount of revision.

Major Hypothesis

The major hypothesis of this study is that by using theory as a framework, and statistical analysis to achieve numerical results, it is possible to isolate and study short-run demand relationships for apples.

Economic theory will be used in forming the structural equations which make up the model. The determination of which variables are relevant is based upon observation of economic behavior, introspection, and consideration of economic relationships on which theorists have reached some agreement and which logically apply to the apple market.

Thus the model will be a system of structural equations formed from the relevant economic variables and will enable one to state and employ all a priori information concerning the problem.

After these equations have been formulated a statistical process of fitting can be adopted. This will permit the replacement of unknown parameters in the equations by numerical values representing average relationships for each period to which the model applies. Future values of unknown variables can then be predicted on the basis of the constructed model.

Basic Assumptions and Beliefs

(a) An assumption is made for simplicity that all equations are linear in known functions (such as logarithms or powers) of the observed variables. This is equivalent to saying that the algebraic forms finally used will be linear in the unknown parameters.

(b) Certain variables are predetermined. That is, certain variables can be regarded as being determined outside of the system under study. Such an assumption is based upon the use of valid economic theory or observed economic behavior.

(c) An assumption is made that all numerical coefficients in the fitted equations represent average relationships and that these relationships have not been abnormal during the time period investigated. A suggestion is made that the "war" years be omitted from an alternate statistical fitting process to see if the parameters vary greatly from those where the "war" years were included. Abnormalities do result inasmuch as the export demand for apples was disrupted and government purchases were significant during this period. Yet it is felt that a more satisfactory model can be developed by first fitting the equations for a period which includes the war years.

(d) It is believed that, where the most desirable data cannot be found, compromises can be made which will not invalidate the conclusions. Assumptions made regarding time lags, linearity in the model, normal distribution of residuals, etc. are sufficient to prevent the actual description of reality within the model. Yet the hope and belief is held that the choice of the model used approximates reality to a degree sufficient for the purposes of the study undertaken.

The complexities involved in dealing with a fully complete model are too great for the human mind to understand. Thus recognition is taken of our limitations and a simpler model is constructed which balances needs against human ability.[5]

Multiple Equations as a Tool in Demand Analysis

Prior to 1934 demand analyses were undertaken with single equation, multiple regression techniques being the

---

[5]See final chapter for a discussion of adjustments necessary to get a "true" model.

main statistical tool used. As previously stated, certain assumptions must be made with the single equation, least squares approach which are in many cases unrealistic and which can be eliminated if a multiple equation, simultaneously determined system is used.

With a system of multiple equations including all important relevant variables it becomes unnecessary to designate one variable as being dependent and all others in the predicting equation as independent. Instead, enough equations are constructed so that it is possible to solve the system for each variable which is to be explained. Such variables are termed endogenous. These endogenous variables depend upon, or are influenced by, other variables (both exogenous and endogenous)[6] within the system and a system is not complete until there are an adequate number of equations to explain each endogenous variable.

Exogenous variables are those which are explained by factors not entering into the relationships being studied. Lagged endogenous variables are in a similar category. Both exogenous and lagged endogenous are termed "predetermined variables". It is necessary to determine which variables

---

[6]Koopmans, T. C. Identification Problems in Economic Model Construction. Econometrica, Vol. 17, No. 2, p. 133, April, 1949.

are relevant and to classify these variables as endogenous or predetermined on the basis of theory or observed economic behavior of consumers and firms.

When a complete model has been developed the "single equation, regression technique" assumption of independence between the predicting variables can be discarded and interdependent relationships are accepted.

Two problems are met when a complete system is to be developed. The first concerns errors in the model and the second is the problem of identification in model construction.

Two types of errors may arise. The first is termed "errors of observation". These arise if the data used are subject to large errors of observation giving inaccurate estimates of the true data. In this study the methods developed by the Cowles Commission at the University of Chicago will be followed in which errors of observation in the exogenous variables are assumed to be small relative to disturbances in equations. Errors of measurement in the endogenous variables are permitted if the disturbances are randomly and normally distributed about the true values of the variables, thus yielding unbiased estimates of the parameters in question.

The second type of error occurs if certain important relevant variables have been omitted from the equations. This source of error occurs if data representing relevant variables cannot be gathered or if the investigator is unable to correctly determine and include all relevant variables. This model is constructed realizing that such errors may be present. But this study assumes that any disturbances caused by errors of omission are randomly distributed and that the mean value of these disturbances is equal to zero. If this assumption holds true, the resultant estimates of the structural coefficients will be unbiased.

Explicit account is taken of the identification problem when a multiple equation model is constructed. Identification, simply stated, means that each structural equation in the model is unique, it being impossible to construct an equation of like form by taking linear combinations of any or all structural equations. Such a test is necessary to accurately determine true demand functions and supply functions. It is not within the purpose of this paper to explain how a mathematical solution to the problem of identification is reached but the criteria necessary for identifying each equation will be stated according to the following method outlined by Koopmans:[7]

"A necessary condition for the identifiability of a structural equation within a given linear model is that the number of variables (counting lagged variables as separate

---

[7] Ibid., p. 135.

variables) excluded from that equation be at least equal to the number (G, say) of structural equations less one. This is known as the order condition of identifiability. A necessary and sufficient condition for the identifiability of a structural equation within a linear model, restricted only by the exclusion of certain variables from certain equations, is that we can form at least one non-vanishing determinant of order G-1 out of those coefficients properly arranged, with which the variables excluded from that structural equation appear in the rank condition of identifiability."

When all structural equations with appropriate variables have been decided upon the identification problem is dealt with. The model can then be classified as over-identified, just-identified, or not-identified.[8] If the model cannot be identified then it is impossible to estimate the coefficients within this system.

In applying the multiple equation method to demand analysis in the apple market the above problems of identification, interdependency and random disturbances are dealt with. For this reason it is felt that less bias will be

---

[8]For a more complete analysis of these identification problems see Tintner, G. Econometrics, John Wiley and Sons, New York, pp. 154-184, 1952.

present than if separate independent equations were to be fitted according to "least squares".

The next step shall be to determine the economic relationships that apply to the production, marketing and consumption of apples and to separate the useful endogenous and exogenous variables. The procedure will then be to specify the relations that determine the current endogenous variables for given values of the other variables to get a complete and practical model.

CHAPTER II

REVIEW OF LITERATURE

Investigations into the marketing of apples have been undertaken on both a descriptive and analytical basis. One of the earlier and more complete studies which provided an insight into the production and marketing of apples was undertaken by Pailthorp and Park.[1] Production, harvesting, storing, utilization, and marketing are all discussed as integral parts of the apple economy. Reference is also made to trends in the industry concerning production, foreign trade, and prices. This study implies that apples, pears, citrus fruits, prunes for drying, and banana imports are competitive in nature although no statistics are used in verification. Factors listed as influencing apple prices are volume of supply, general price level, variety, grade and condition, size of apples, time of year when sales are made, kind of container, origin of supply, market where sold, method of sale and export conditions. Considerable emphasis is placed on the competitive market which exists between

---

[1]Pailthorp, R. R. and Park, J. W., Marketing Apples, United States Department of Agriculture, Bureau of Agricultural Economics, Washington, D. C., Bulletin 474, 1935.

different varieties of apples as judged by the volume of each variety appearing on selected city markets.

Lloyd and Ekstrom[2] undertook a study in the State of Illinois which is typical of the work done in many apple-growing states. They gave some special emphasis to the marketing problems in years of heavy crop. Competition between apples and other fresh fruits was assumed although no coefficients of cross-elasticity were computed or quoted.

W. E. Black[3] in a study of consumer demand for apples noted that factors other than income had little effect on the per-capita amount spent for apples. In each of the three income ranges which his survey covered the same proportion of the food dollar was spent on apples. High income groups had a higher expenditure for apples not because of increases in the quantity bought, but because higher prices were paid.

He found that variations in the demand for apples as measured by quantity, price, or expenditure were not related to variations in the quantity, price, or expenditure of oranges. Statistical techniques in this

---

[2]Lloyd, J. W. and Ekstrom, V. A. Marketing the Illinois Apple Crop, University of Illinois Agricultural Experiment Station, Urbana, Illinois, Bulletin 497, August, 1943.

[3]Black, W. E. Consumer Demand for Apples and Oranges. Cornell University Agricultural Experiment Station, Ithaca, New York, Bulletin 800, 1943.

study were based on variations between classes or groups and no apparent attempt was made to fit a regression of price on consumption or vice versa by using the "least squares" method. M. D. Woodin[4] discussed yearly and seasonal changes in apple prices in New York State. Yearly price changes were associated with the price level of all commodities and the size of the apple crop. He concluded that citrus prices and apple exports had little effect on domestic apple prices. Seasonal price changes were associated with changes in the general price level with a price variation being present between varieties. Woodin used a formal statistical technique in his analysis based on the single equation, least squares approach. X_1, wholesale apple prices (dependent), was explained in terms of X_2, commercial apple production in New York State, X_3, index of wholesale prices of farm products in the United States, and X_4, production of oranges within the United States.

Fox[5] investigated the relationship between X_1, the farm price of apples (dependent), and X_2, production changes.

---

[4]Woodin, M. D. Changes in the Price of Apples and Other Fruits. Cornell University Agricultural Experiment Station. Ithaca, New York, Bulletin 773, December, 1941.

[5]Fox, K. A. Factors Affecting Farm Income, Farm Prices, and Food Consumption. Agricultural Economics Research, Vol. 3, No. 3, pp. 65-82, July, 1951.

The price elasticity here was approximately .80. The regression of farm price on consumer disposable income was also made and an income elasticity of 1.04 was computed. Analysis was again done by fitting single equations by the method of least squares. Fox also succeeded in establishing similar coefficients for other fresh fruits which are possible competitors with apples, i.e. peaches, oranges, lemons. This is perhaps the most complete study on demand elasticities at the present time.

CHAPTER III

ECONOMIC BEHAVIOR OF THE APPLE ECONOMY

The determination of relevant variables can best be accomplished by describing the operation of the apple market. Such a description must be realistic and include the economic behavior of the people as well as the climatic and physical factors which guide producers, processors and consumers. After a preliminary examination of the data, the years 1929-51 inclusive were selected for study.

The production of apples is seasonal in nature. Depending upon the variety, geographical area, and weather conditions, harvesting begins in July of each year and is continued until early November. Varieties are commonly classified as "summer", "fall", and "winter". The harvesting of summer varieties begins in July and is actively carried on until the end of August.[1] These apples are stored for a very short period to permit cooling and distribution to truckers and then move directly into retail markets from packing sheds. The harvest period for fall and winter varieties follows the harvesting

---

[1] Palmer, C. D. and Schlotzhauer, E. O. Apples, Usual Time of Bloom and Harvest. United States Department of Agriculture, Bureau of Agricultural Economics, Washington, D. C., November, 1950.

of summer varieties and extends from late August to early November.[2] These apples may move directly into retail channels from packing sheds as fresh apples or they may serve to meet the demands of processors and exporters. Commercial storage is carried on and reaches a peak by the time the harvest season is completed.[3] The opening and closing dates for processing of apples are August 1 and December 31 respectively,[4] with the most important period being September 1 to December 31. Utilization of apples by processors varies, with drying, canning, freezing, and crushing for vinegar, cider and juice all being important.

Apples are exported from a given year's crop from July through June of the following year. The bulk of those exported are shipped from September through March during the crop year.[5] The volume of exports varies from year to year with from 1 to 17 percent of total United States' production having been exported during the period 1929-51.

---

[2]Pailthorp, R. R. and Park, J. W. Marketing Apples. United States Department of Agriculture, Bureau of Agricultural Economics, Washington, D. C., Bulletin 474, 1935.

[3]Ibid., p. 31.

[4]Anonymous, The Canning Trade Almanac-1952, p. 22. The Canning Trade, Baltimore 2, Maryland, 1952.

[5]Anonymous, Monthly Summary of Foreign Commerce of the United States. United States Department of Commerce, Bureau of Foreign and Domestic Commerce, Washington, D. C., monthly 1929-1951.

Imports of apples into the United States have been small in total volume, never having reached 3 percent of total United States' production during the period 1929-51.

When harvesting has been completed and storage is at a maximum the supply of apples corresponds to the movement from storage and is governed by the keeping quality of the apples as well as current and expected prices. The greatest movement from storage occurs from November through April. By the end of June storage stocks are at a minimum and are considered insignificant for all practical purposes.

From the above description several phenomena are apparent. The data can be aggregated according to definite time periods. This procedure is useful since short-run fluctuations are to be studied. The first period could satisfactorily include the months of July and August. Harvesting begins during this period, fresh apples are available for the retail market and a few may even be exported. Storage stocks at the beginning of this period are at a minimum and storage is not important during these two months. Processing operations likewise are small enough to be considered insignificant.

Again, using considerations based on time of harvesting, marketing and storing, the second time period can be distinguished as including the months of September, October and November. In this period (Period II) the bulk of the crop is harvested -- the fall and winter varieties -- and the harvest is completed by the end of November. Large quantities of apples move into retail markets for consumption in a fresh form and exports of apples rapidly increase in volume. Large quantities of apples also enter the processing plants. Storage is important in this period reaching a peak sometime before the end of November.

The third period includes the months of December, January, February and March. Apples continue to move into retail markets in fresh form and in smaller quantities to export markets and to processors. Harvesting is not carried on within the United States but apples move out of cold storage warehouses to meet demand.

A fourth and final period includes the months of April, May and June. Activity is reduced during this period. Apples continue to move from storage into retail channels and export markets. Processing is insignificant. Storage stocks reach a minimum before the next crop harvest begins in July.

An aggregation by months as indicated above means that data must be similarly aggregated. It is apparent that the economic relationships of periods III and IV are identical. Since the purpose of this study is to explain short-term demand fluctuations there is considerable justification for not combining the two periods. Consequently the data have been aggregated to give separate periods.

Examination of economic relationships between the variables discussed above indicates that four possible demand relationships for apples can be separated. These are 1) demand by retailers for apples in a fresh form, 2) demand for apples to be processed, 3) an export demand for fresh apples, and 4) a demand for apples to be kept in storage.

The physical supply which is available in each period is equal to the beginning amount of apples in storage plus the quantity harvested during that period. Using an inventory relation and the first three of the above demand relationships a supply function can be written as,

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

In the notation used capital letters indicate stocks, while small letters indicate flows. The subscripts m and t indicate respectively the period and year being considered. Crop years beginning July 1 are dealt with rather than calendar years. Thus Period I which includes the first two months (July and August) of the crop year represents the beginning of a new year for analytical purposes.

The above identity states that the physical supply on hand at the beginning of any period, $S_{(m-1)t}$, plus the quantity harvested during that period, q_{mt}, constitute the total physical supply available during any one period. As

shown in equation (1) this supply is equal to the physical stocks on hand at the end of a period, S_{mt}, plus the amounts used for retailing, r_{mt}, processing, a_{mt}, and exporting, e_{mt}. This identity holds for all periods although some of the parameters within it will equal zero during certain periods. In the demand for storage relation to be developed later

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

to give a flow during the $_m$th period rather than beginning or ending stocks. s_{mt} may be negative depending upon the period being considered.

The amount of fresh apples available for consumption during each crop year will be equal to the amount harvested, since no carry-over is present. The quantity of apples harvested can be classified as an exogenous variable. This classification is made since current price has little to do with what is produced. The volume ready at harvest time is affected only by initial investment and production techniques or practices during the growing stage which have little relation to the price received when picking is actually carried on. Irrigation, fertilization, thinning, spraying and pruning may all be carried on and influence the yield, but the degree to which these practices are undertaken is not directly related to the price to be received by farmers. There is the possibility that harvesting will be curtailed

if price is exceptionally low in the fall when harvesting is in progress. In all cases it should pay the producer to harvest his crop if the variable costs of harvesting (i.e. picking, packing, transporting) are being met. Within a limited range the producer can postpone picking or can spot-pick but he is limited in such a practice and this may increase harvesting costs if the usual policy is to remove all apples from the trees at one picking.[6]

There is a high degree of competition in the production of apples as individual producers or small groups of producers have little effect upon the quantity harvested. In this study the supply at time of harvest will be termed exogenous and the rate of harvesting is assumed to be unaffected by current price.

Production figures are based on the quantity of apples which are actually sold. This is equal to total production[7]

---

[6]Pailthorp, R. R. and Park, J. W. <u>Op. cit.</u>, p. 22.

[7]Source 1934-1951: <u>Agricultural Statistics</u>. United States Department of Agriculture, Washington, D. C., Annual 1936-52. Data was adjusted prior to 1934 to get the quantity sold from the commercial areas of 35 states. This corresponds with the method of reporting after 1934.

Source 1929-1933: <u>Fruits (non-citrus) Production, Farm Disposition and Utilization of Sales</u>. United States Department of Agriculture, Bureau of Agricultural Economics, Washington, D. C., CS-27, May, 1948.

less the amount not harvested because of economic or climatic conditions and less the amount used in farm households.[8]

The data on quantity of summer apples harvested were supplied by the International Apple Association (IAA)[9] for the years 1929-31 and 1942-51. For the years 1932-41 extrapolation was made on the basis of IAA data representing the years 1925-31, and 1942-51. This was done by plotting production of summer varieties against total production and fitting a regression line for each of the periods 1925-31 and 1942-51. Extrapolation was then made, assuming that there was a constant change in the production of summer varieties relative to total production during the period

---

[8]Because a portion of the apple crop may not be harvested due to economic conditions, production is not completely exogenous. An additional structural equation could be included showing quantity harvested $\underline{q_{mt}}$ as an endogenous variable being dependent upon the price at time of harvest and the variable costs of harvesting.

The omission of this additional structural equation will cause errors in the estimated regression coefficients of the demand equations. If the residuals in the regression equations are normally distributed and independent the estimates of the coefficients will be unbiased but the standard errors of estimate will be increased. If they are not normally distributed and independent the regression coefficients will also be biased.

The decision was made to omit this equation and gain simplicity. The sacrifice of doing so is the loss in efficiency in estimating structural parameters. However the percent of apples not harvested due to economic conditions has never reached 10% of total production and therefore the loss of efficiency should not be large.

[9]From private correspondence with the Secretary of the International Apple Association (IAA). September, 1952.

1932-41. Though inaccuracies result from this type of estimation, it appears to be the best approximation to reality at this time.

Prior to 1944 the IAA collected production data for all varieties on only that portion of the crop which was consumed fresh. But for all practical purposes this equals the total quantity of summer varieties produced since processing and exporting at this time are unimportant.

Data on the production of fall and winter varieties (Period II) are based upon published material in Agricultural Statistics,[10] and a United States Department of Agriculture publication.[11]

---

[10] Agricultural Statistics. United States Department of Agriculture, Washington, D. C., Annual 1935-1951.

[11] Anonymous. Fruits (non-citrus) Production, Farm Disposition and Utilization of Sales. United States Department of Agriculture, Bureau of Agricultural Economics, Washington, D. C., CS-27, May, 1948.

CHAPTER IV

RETAIL DEMAND FUNCTION

It was noted that four demand relationships are involved in the apple market, and each of the respective quantities demanded (i.e. for retail, processing, export, storage) is considered as a current endogenous variable. That is each is a function of other variables and cannot be considered as being predetermined, but must be explained in terms of other endogenous and exogenous variables.

The first demand function to be determined and for which a structural equation is given is the quantity of apples demanded at the retail level. This demand function is present in each of the four periods. The equation takes the form of

(3) $\phi(r_{mt}, p_{mt}; y_{mt}, r^*_{mt}, r_{(m-1)t}, c_{mt}) = 0$

p_{mt} = average price of apples at the farm for the period m and the year t.

y_{mt} = consumer disposable income for a like period,

r_{mt} = quantity of apples available for consumption during this period,

$r_{(m-1)t}$ = consumption of apples during the immediately preceding period,

r^*_{mt} = average consumption of apples during the same period but for several of the preceding years,

c_{mt} = the price of competing fruits.

Hildreth[1] points out that there is much to be said for writing the equations in an implicit form as above, distinguishing between the endogenous and predetermined variables by, e.g. use of a semicolon. This manner of writing the equation implies that either of the endogenous variables could be considered dependent, or it could be thought of as two endogenous variables appearing in a relationship with several predetermined variables.

The average price of apples per bushel received by farmers is used as the price indicator.[2] This choice was made because of the availability and completeness of these data as compared to those for retail prices and also because of the advantage of having it in this form for prediction purposes.[3]

---

[1] Hildreth, C. and Jarrett, F. Cowles Commission Discussion Paper: Economics No. 2055, unpublished paper. Cowles Commission for Research in Economics, University of Chicago, Chicago 37, Illinois, November, 1952.

[2] This price series was compiled and supplied by United States Department of Agriculture, Bureau of Agricultural Economics, Washington, D. C., 1953.

[3] Where marketing margins are constant farm prices may be used and a simple correlation set up to relate them to retail prices. Where marketing margins are abnormal and data are available it would be more desirable to use retail prices when dealing with consumer demand to get true coefficients of price elasticity. Farm value as a percent of retail value is shown as follows:

The monthly prices have been averaged arithmetically to give an average price for each of the four periods. An average weighted by monthly marketings would be more accurate but data giving apple marketings by months were not available for the years considered. However, when the period is as short as those being used unweighted averages will not differ greatly from weighted averages. p_{mt} is considered an endogenous variable, and it must be possible to explain it in terms of other variables.

Prices affect the quantity taken according to the Marshallian concept which states that the quantity demanded varies inversely with the price. The change in real income caused by price changes can be explained in terms of an income and a substitution affect as outlined by J. R. Hicks.[4] Apples are not considered to be an inferior commodity and therefore consumer reaction to a fall (rise) in apple prices

---

Farm Value as a Percent of Retail Apple Prices 1934-1943

Year	1934	1935	1936	1937	1938	1939	1940	1941	1942	1943
Percent	40	40	42	46	38	40	41	45	48	51

Source: Been, R. O. Price Spreads Between Farmers and Consumers for Food Products 1913-44. United States Department of Agriculture, Bureau of Agricultural Economics, Washington, D. C., Misc. Pub. 576, p. 219, September, 1945.

[4]Hicks, J. R. Value and Capital. Second Edition, Oxford University Press, Chapter III, London, 1948.

will always be to increase (decrease) the quantity bought. This represents the substitution effect. The "income" effect is unimportant in such a case since apples are a small portion of the total expenditure for food and therefore any price decrease in apples causes only a minute increase in real income. The relatively important effect is the substitution effect which reacts according to the Marshallian concept stated above.

Consumer personal disposable income is included as an exogenous variable affecting retail demand for apples since it is determined outside of that system which explains the apple market. There is little reason for considering it as an endogenous variable because of any interdependent effects from producer's income or that of marketing agencies.

Published data on personal disposable income[5] are given by quarters only. These quarters do not coincide with the four periods as outlined previously and an adjustment was made by using personal income which is reported monthly. Quarterly values of personal disposable income were plotted against personal income and a regression line fitted freehand

---

[5]Anonymous. National Income. United States Department of Commerce, Bureau of Foreign and Domestic Commerce, Washington, D. C., 1951 ed.

Also Anonymous. Survey of Current Business. United States Department of Commerce, Office of Business Economics, Washington, D. C., July, 1952 and March, 1953.

for two periods. The first was from January 1929 to January 1943 and the second was from July 1943 to December 1952. Personal income was then aggregated according to the periods used in this study and the corresponding values of personal disposable income were read off the plotted chart. For the period January 1943 to July 1943 observations did not fall on either of the two fitted lines and interpolations were made for these months.

Two additional variables affecting retail demand which can also be classified as predetermined are 1) consumption during the immediately preceding period and 2) average consumption during the same period for several of the preceding years. It is difficult to hypothesize as to the manner in which consumption during the preceding period affects present consumption. Yet, intuitively it is possible to say that cumulated consumption will affect present consumption according to the law of diminishing marginal utility. The consumer's desire for apples will have been partially satisfied if purchases during the preceding period were abnormally large. It is also possible that storage facilities within the household have been partially filled by previous purchases.

The variable r^*_{mt} is included on the grounds that consumers buy according to some previously established habit.

Dusenberry[6] presents a psychological foundation for this argument stating that families will not reduce consumption proportionally with income decreases. Their tendency is to buy according to a past period when satisfactions were maximized. This then assumes that apples are bought not only in reaction to price changes but that an established buying pattern is formed based on knowledge of varieties, quality, product uses, etc. The time lag is arbitrary, but a 3 year moving average is suggested, with the possibility of revisions being made. Thus

$$r^*_{mt} = \frac{r_{m(t-1)} + r_{m(t-2)} + r_{m(t-3)}}{3}$$

Data for these two variables are formed by solving for r_{mt} in the "storage stocks" identity previously given.

$$r_{mt} = S_{m-1}\ t + q_{mt} - S_{mt} - a_{mt} - e_{mt}$$

The final variables affecting consumer demand for apples are the prices of competing fruits. If none of these are considered as being inferior goods a rise (fall) in the price of substitute fruits will result in a rise (fall) in the quantity of apples demanded.[7] Income effects are again considered to be relatively unimportant.

---

[6] Dusenberry, J. S. Income, Employment and Public Policy. Essays in honor of Alvin H. Hansen, W. W. Norton and Company, New York, p. 54, 1948.

[7] Hicks, J. R. Value and Capital. Op. cit., Chapter III, or Prest, A. R. Some Experiments in Demand Analysis, Rev. Economics and Statistics, Vol. 31, pp. 33-49, 1949.

Prices of competing fruits are determined by economic forces outside of the apple market and a function should be included which explains them if a complete model is to be constructed.

Since a model would be extremely complex if the price of each competing fruit was taken as a separate variable an index of prices is used. This index is weighted by the quantity of each fruit marketed by periods for the years 1941-51. If elasticities of demand for each of the competing fruits were known the index could be more accurately computed by weighting those fruits which have a strongly elastic demand more heavily. Monthly marketings of oranges, lemons and grapefruit were supplied through correspondence[8] with the Bureau of Agricultural Economics, as were the prices of all fruits. Monthly marketings of pears, peaches and grapes[9] were obtained from the Market News Service Branch, Production and Marketing Administration of the United States Department of Agriculture.

The decision made on whether a fruit is a competitor or not is quite arbitrary. Research workers[10] have obtained

---

[8]From correspondence with United States Department of Agriculture, Bureau of Agricultural Economics. Op. cit.

[9]Monthly marketings of grapes include only those used in a fresh form and excludes use for production of wine or raisins.

[10]Woodin, M. D. Changes in the Prices of Apples and Other Fruits. Cornell University Agricultural Experiment Station Bulletin 773, December, 1941.

results which would indicate that fresh fruits do not compete closely with each other. In other instances considerable degrees of substitution are shown.[11] While these studies are not necessarily conflicting it does show that considerable uncertainty exists as to the relations between fresh fruits. Intuitively it appears that other fresh fruits do compete with apples for the consumer's money if both are available during the same period. Rather than discard c_{mt} as a variable there is justification for including it unless further studies indicate more clearly a lack of substitutability.

---

[11] Hoos, S. An Investigation on Complementarity Relations Between Fresh Fruits. <u>Journal of Farm Economics</u>, Vol. 23, p. 421.

CHAPTER V

STORAGE DEMAND FUNCTION

Once apples are placed in storage, supply is considered to be an endogenous variable. Supply will be equal to the rate of movement from storage and will be governed by current and expected prices along with other relevant variables. In period I, there will be no demand for storage. In period II, a positive demand will be present while in periods III and IV there will be a negative demand for storing apples, which indicates a movement from storage warehouses to the market. Storage stocks on June 30 are assumed to be zero.

The storage function is considered as,

(4) $\beta_1(s_{mt}, p_{mt}; S_{(m-1)t}, S^*_{mt}, c_{mt}, k_{mt}, g_{(t-1)}) = 0$ where

p_{mt} and c_{mt} have the same meaning as outlined in the retail demand equation,

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

$S_{(m-1)t}$ is the quantity of apples on hand at the beginning of the period,

S^*_{mt} is the average quantity of apples on hand at the end of similar periods during several of the preceding years,

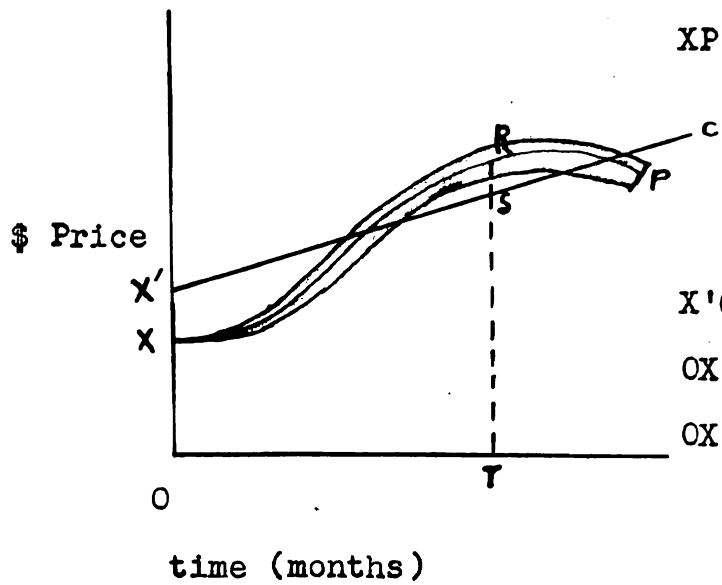
k_{mt} is an index of the costs of storing apples and,

$g_{(t-1)}$ is an index of the seasonal price increase for the previous year.

Current price may have an ambiguous effect upon the demand for storage depending upon expectations. Apples will remain in storage as long as the expected price at some future date is greater than the current price plus storage costs (which include losses from spoilage and a value judgment as to the risk involved). The following simple diagram indicates this process. The price of apples is plotted against time in monthly periods.

Figure I

Period of Investment in Storing Apples



XP - schedule of expected prices with the shaded area indicating a range of uncertainty.

X'C- schedule of storage costs.

OX - current price of apples.

OX'- current price plus handling charge to place apples in storage.

At time OT expected price per bushel is TR and cost per bushel is TS.

Expected profit is then equal to RS and the owner of the apples operating at time O would make the decision to store.

The inclusion of $g_{(t-1)}$ is made on the grounds that the decision to store apples is in part based on the seasonal movement of apple prices during the preceding year. The index, $g_{(t-1)}$ is constructed by taking the ratio of $p_{2,t-1}$ and the average price of apples during the months March, April, and May of the $_{t-1}$ year. This gives a lagged endogenous variable. A large index indicates that a considerable increase in the seasonal price took place during the preceding storage period. Storage operators will react by increasing the present demand for storage with the expectation that conditions will repeat themselves. This variable will be included in Period II only. A refinement in Period III would be possible by considering month to month storage decisions. A variable such as $g_{(t-1)}$ could be constructed using the ratio of last year's price for the present month and last year's average price in March, April and May.

Carry-over stocks[1] of apples $S_{(m-1)t}$ affect present storage demand since it represents a portion of current demand which has been satisfied. (Current demand includes demand by retailers for fresh apples and also the demand for exports and for processing.) In physical terms carry-over

---

[1]Soleau, B. S. United States Department of Agriculture, Production and Marketing Administration, Washington, D. C. Written communication, July 27, 1951.

represents that portion of storage facilities which is not available.

Average storage holdings for the same period during several of the preceding years S^*_{mt} is an arbitrary guide to present storage demand based upon past habits and experience. It may also reflect commitments which storage owners have made legally or through trade experience over a long period of time. Again as in r^*_{mt} a 3 year moving average is used to give

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

The price of competing fruits will partially determine what the current storage demand for apples shall be. If more accurate data were readily available on current and expected supplies of competing fruits, it would be more suitable to use it as an indicator. However, more complete data can be supplied on monthly prices than on monthly supplies. Since price is a function of quantity the substitution of price for quantity is made directly. It is felt that greater inaccuracy might be incurred through observations of the data if supplies were used than is incurred by errors in the variable (shock errors)[2] when price is included as the variable. If the current

[2] See discussion on types of errors, Chapter I.

price of competing fruits is low relative to its normal seasonal value there will be a tendency for current apple prices to be lower and storage operations will be intensified. If however the storage owners have the expectation that future prices of competing fruits will continue to be low the current storage demand for apples will be decreased.

Storage costs influence decisions to store by influencing expected profits. A large percentage of storage costs are fixed and thus increase the demand to store apples, i.e. taxes, buildings, crates, grading machinery, refrigeration equipment. But the variable costs are also very important and decrease the desire to store apples. Labor is important in this category, not only its price but also its availability during the time when apples must be moved from storage warehouses. Extra crates, operational costs for refrigeration units, or rental costs if storage facilities are not owned all serve to decrease the demand for storage. The decision to store is influenced by storage costs in two ways. The first is the level of the initial cost and the second is the storage rate per month once apples have been placed in storage.

If the initial cost is high, fewer apples will go into storage. From the storage costs and November 30 stocks data[3]

---

[3]Soleau, B. S. Op. cit.

a scatter diagram was constructed. There was no indication from this that the initial cost, which includes a handling charge plus a storage charge for the first month, had any effect upon the volume of apples moving into storage. From this the conclusion is drawn that initial charges have not been high enough to deter storage. Once apples have been placed in storage the initial charge will have an influence on the length of the storage period. Since initial cost is a fixed cost a longer storage period will reduce the average storage cost per bushel.

The storage period will be shortened because of the variable cost of month to month storage charges. Storage stocks of February 28 were plotted against initial storage charges plus a three month storage rate per bushel and there is an indication from inspection of the scatter diagram that the amount of apples held in storage is larger when costs of storage were low. An interpretation of this is difficult since price of apples may have had an overshadowing effect, but at least it does not disprove the thesis that the quantity stored varies inversely with storage costs. This latter scatter diagram would indicate that monthly rates per bushel are a more important consideration in the decision to store apples than is the initial storage charge. If the initial charge lengthens the storage period then where storage rates (handling and storing) were highest the quantity of apples in storage should have been greatest. (Inspection of the data reveals that storage rates per bushel have been constant while handling charges have gradually increased from 1929-51). Thus, average total cost and not average fixed cost is the more decisive criteria in storing decisions.

In some cases seasonal storage rates are quoted which offer a discount for long storage periods. These will also induce producers to store for longer periods. In any case one should remember that deterioration in the quality of the apples and the market price will be the important factors in moving apples into or out of storage. Some varieties cannot be stored for long periods while others retain their quality until period IV.[4]

For period II the index of storage costs will include handling charges plus storage costs for one month. This assumes one month of storage in period II. For periods III and IV only a storage rate per month will be used since handling charges have been paid for.

The index of storage costs has been constructed for boxes stored in quantities great enough to get the regular

---

[4]Smock, R. M. Controlled - Atmosphere Storage of Apples. Cornell University Agricultural Experiment Station, Ithaca, New York, Bulletin 759, pp. 18-19, February, 1949.

or discounted rate. Data for the index were gathered through correspondence with storage and warehouse operators in the nine most important apple producing states.[5] Their information was supplemented with storage cost data from several bulletins. From the two sources storage cost figures were derived for 12 of the 22 years studied (1929-51). For the remaining 10 years interpolations were made. The general tone of the correspondence carried on with the warehouse operators was that monthly storage rates had not varied a great deal since 1929. This is possible because of increased storage capacity reducing average fixed costs, constancy in costs of refrigeration equipment needed per bushel stored, and also because of increased efficiency and technology in storing apples.

Gradual increases in the handling charges were noted the range being from 3 cents per bushel in 1929 to 9 cents per bushel in 1951.

Because of the great stability in year-to-year storage rates and the gradual increase in handling charges interpolation should introduce little error into the variable.

---

[5]Washington, New York, Pennsylvania, Michigan, California, Virginia, Ohio, Idaho, and Oregon.

CHAPTER VI

PROCESSING DEMAND FUNCTION

The third demand relationship used in building this model is that for processing. Processing of apples refers to drying, freezing, canning (both whole apples and apple sauce) and other uses which include cider, vinegar and juice. All of these processes were of importance throughout the period studied except for the freezing process which began in the early 1940's. The trend has been for the drying process to decline somewhat in importance relative to the others. Vinegar, cider, and juice have varied in importance during the years, leading one to believe that they are residual or marginal products in processing.

The most important processing period is period II.[1] Period III is of lesser importance while in periods I and IV

---

[1]Processing periods for apples havebeen prepared by the American Can Company as follows:

Opening and Closing Canning Dates for Apples

State	Wash.	New York	Penn.	Mich.	Va.	Ohio	W.Va.	Ore.
Opening Date	Sept.15	Sept.15	Aug.15	Aug. 1	Aug. 1	Sept.15	Aug.15	Sept.15
Closing Date	Dec.31	Dec.31	Dec.31	Nov.30	Dec.31	Dec. 31	Nov.30	Dec.31

Source: The Canning Trade, Baltimore 2, Maryland, Part 2, Vol. 75, p. 222, 1952.

processing is almost non-existent. For the early years studied, data were not available on processing by months. Thus, it was necessary to specify processing operations as being undertaken in period II only. In the future a refinement in these data will be possible.

The following variables are included as part of the processing relationship.

(6) $\gamma(a_{mt}, p_{mt}; d_{mt}, A_{(m-1)t}, c'_{mt}, c''_{mt}) = 0$

a_{mt} represents the quantity of apples demanded by all processors for canning, drying, and freezing.[2]

p_{mt} is the farm price for apples.

d_{mt} is an index of processing costs.

$A_{(m-1)t}$ is an indication of carry-over stocks of processed apples.

c'_{mt} and c''_{mt} represent the prices of competing fruits.

The latter two will differ from c_{mt} because of the fruits included as competitors and the weights given to each.

The farm price of apples influences the demand by processors since this is a variable cost to them which must always be met. If the price is low during the harvest season the quantity of apples demanded will increase being limited

---

[2]Prior to 1934 the quantity used for vinegar, cider, and juice is not reported. Therefore the series for the quantities canned, frozen, and dried is used for all years in the 1929-51 period.

only by the physical capacity of the plant. This results in apples being moved into storage for a short period of time and then being processed out of storage when harvesting has been completed. In some instances it is suggestive because of the constancy of amounts processed that apple prices may not be the major factor influencing the decision to process apples. The fixed costs of operation will result in some processing even though prices may be high. A major consideration of processors at this time will be stocks on hand and a judgment as to how inventories have been moving in the past.

For this reason $A_{(m-1)t}$ has been included as a variable. Processors subjectively or empirically estimate the amount of apples which can be profitably handled in any one canning year. Thus, carry-over will inversely affect the decision on the amount to be processed. Data on estimates of carry-over stocks are not available prior to 1934 but have been supplied by the National Canner's Association[3] for the years 1934-51 for inventories of canned apples and apple sauce. Estimates for 1929-33 were based on the average percentage that carry-over was of total pack for the years 1934-37.

The third factor influencing the processing demand relation is processing costs d_{mt}. This is a variable cost

---

[3]Stier, H. L., Director, Division of Statistics. National Canners Association, 1133 20th St. N.W., Washington, 6, D. C. Written communication, May 26, 1953.

in most plants but may also be considered as a fixed cost in those plants where the labor force is being maintained to process products following the apple season.

In constructing an index for d_{mt} two variable cost factors were decided upon as being representative. These were labor, and packaging materials. This decision was based on published data giving processing costs per hour of plant operation[4] for the years 1948-49. These costs included labor, utilities, supplies and interest on investment for (a) dried apples, (b) canned apples, and (c) frozen apples with sugar. When only labor and packaging materials were considered the combined cost of these two comprised 68% of the total cost in the drying process, 80% in the freezing process and 82% when apples were canned. Consequently these two variable costs were considered as indicative of processing costs.

The weights assigned to labor and packaging were based on the volume of apples going into the canning and drying processes and the importance of labor and packaging costs in each of these processes. The canning process includes canned apples and applesauce, and frozen apples. The period 1947-51 was used as a base period for (a) the percentage of

---

[4]Kaufman, V. F. Costs and Methods for Pie-Stock Apples, as reprinted from Food Engineering, pp. 97-105, December, 1951.

apples going into each process, (b) weekly wage rates of the canning and preserving industry,[5] and (c) the price per thousand of #2½ cans, hot dipped.[6] For the years 1929-30 can prices were estimated on the basis of the relationship between finished steel prices and can prices for the years 1932-39.

The method of weighting was done as follows:

a. For the seasons 1948-49, the percentages that labor and packaging were of the total cost for each process were put on an index basis.

b. The amount of apples canned and dried (1947-51 = 100) were calculated.

c. For each process in (a) multiply the cost indice by the indice in (b) for the corresponding process. Sum these indices for labor and packaging materials. The result will be the weights assigned to labor and packaging.

d. Using 1947-51 = 100 convert weekly rage rates and packaging materials into an index.

e. The index of processing costs d_{mt} then equals;

$$d_{mt} = [(\text{labor weight}) \times (\text{wage relative}_{mt})] + [(\text{packaging weight}) \times (\text{packaging relative}_{mt})]$$

The relative weights assigned were labor = 55.7 and packaging materials = 44.3

---

[5]Anonymous. <u>Monthly Labor Review</u>. United States Department of Labor, Bureau of Labor Statistics, Washington, D. C., monthly 1929-1951.

[6]<u>The Canning Trade Almanac-1952</u>, The Canning Trade, Baltimore 2, Maryland, Part 2, Vol. 75, p. 216, 1952.

The final variables considered as significant in influencing the demand for apples for processing purposes are the prices of competing fruits c'_{mt} and c''_{mt}. As previously noted this differs from c_{mt} according to the fruits included and the weights given each. Again these prices are put in the form of an index for convenience in handling. These prices will have a two-fold effect on the volume of apples processed. A minor influence will be present where processing companies have the opportunity of processing apples or other fruits. In this case a high ratio of apple prices to that of competing fruits will have an inverse effect on the quantity of apples demanded. The more important influence centers around the quantity of competing products processed. When c'_{mt} or c''_{mt} is low the amount of competing fruits processed will be increased. This will result in fewer apples being processed.

The fruits included in the construction of c'_{mt} were California, Washington and Oregon pears (all varieties), California clingstone peaches, and California, Washington and Utah apricots.

Quantity and price data for these fruits were obtained from a Bureau of Agricultural Economics publication.[7] Price

---

[7]Anonymous. Fruits (non-citrus), Production, Farm Disposition and Utilization of Sales, United States Department of Agriculture, Bureau of Agricultural Economics, Washington, D. C., annual 1929-1952.

data were the season annual average prices for each fruit in the areas considered.

The index was again weighted by the value of each fruit consumed during the base period 1947-51 = 100. This implies that the marginal rates of substitution are proportional to the weights in the index. An improvement upon this method of weighting could be made if one knew the elasticities of substitution between apples and each of the competing fruits. It would then be possible to weight those which have a strongly elastic demand more heavily.

The price index was constructed on the basis of 1947-51 - 100.

Another price index for competing fruits c''_{mt} was included since it was felt that the first index c'_{mt} qualified only as a price indicator for those fruits which competed with apples consumed as applesauce or in forms other than pie stock. c''_{mt} would be an indication of the degree of competition for pie stock apples. This latter competitor is mainly in the form of red sour cherries. Prices of this fruit were taken from Agricultural Statistics and Agricultural Prices for the years 1938-51. Prior to 1938 prices were not reported separately for sweet and sour cherries. For these years, 1929-37 the prices used were for twelve states as reported by the Cornell Experiment Station.[8]

---

[8]Carroll, T. F. Cherries, Background Information and Statistics for Fruit Marketing, Cornell University Agricultural Experiment Station, Ithaca, New York, A.E.662, March, 1948.

CHAPTER VII

EXPORT DEMAND FUNCTION

The fourth demand relationship for which a structural equation will be formed is the demand by exporters for fresh apples.

The choice of explanatory variables is a compromise between the most efficient variables as determined by economic theory and the variables for which adequate data are available. The demand relationship has been postulated as follows:

(7) $\Theta(e_{mt}, \bar{p}_{mt}; v_t, w_t, z_t) = 0$

e_{mt} = the quantity of fresh apples exported for a particular period and year,

v_t = the quantity of apples harvested in the main importing countries,

w_t = the volume of apples exported in Canada.

z_t = the index of wholesale prices in the important importing countries.

$\bar{p}_{mt}$ = the export price of U. S. apples.

The form of this equation suggests that it may be non-structural if export prices are given, being wholly a function of conditions in the importing countries. This does not, however, invalidate it as part of the model. If no structural changes occur in this equation it can be used for prediction purposes without considering the remainder of the model. This would correspond to a reduced form equation where $\bar{p}_{mt} \neq f(p_{mt})$, and could be fitted independently. Where $\bar{p}_{mt} = f(p_{mt})$ the rest of the model must be considered in fitting the export demand equation (see final chapter).

The demand for apples for exporting has fluctuated from year-to-year because of demand influences in both the United States and in the importing countries and also because of International Trade policies. The latter effects are random in nature and while some explanation can be given for them, they are not included in the structural equation as influencing factors.

There is also variation from year-to-year in the relative amounts of fresh apples and dried apples exported. However, in this study they have been grouped as total exports since there is an interaction between the domestic demand for fresh apples, processing apples, and the export demand for apples.

Data on the quantity of exports by periods for the years 1929-41 are taken from Department of Commerce monthly publications.[1] For the years 1942-51 data were compiled and

---

[1]Anonymous. Monthly Summary of Foreign Commerce of the United States, Department of Commerce, Bureau of Foreign and Domestic Commerce, Washington, D. C., monthly 1929-41.

supplied by the United States Department of Agriculture.[2] The data on exports include total United States exports of apples regardless of destination. This causes great complexity in the handling of several of the variables in this demand relationship. Consequently, the number of importing countries has been reduced to four, namely the United Kingdom, France, Belgium, and Germany. The importance of each of these has varied during the period under observation due to institutional arrangements, war, and international trade barriers. The United Kingdom, however, has been the major importer of United States apples throughout the years 1929-51. The decision to include the above four countries was based on their relative importance as importers during the period 1934-38. Although no one period can be taken as "normal" these years probably are more representative of trade relationships in apples than any other years which could be chosen. The following table[3] shows United States

---

[2]Burmeister, G., Head, Division of Fruits, Vegetables and Sugar, Office of Foreign Agricultural Relations, United States Department of Agriculture, Washington, D. C. Written communication, September 11, 1952.

[3]Anonymous. The Fruit Situation. United States Department of Agriculture, Bureau of Agricultural Economics, Washington, D. C., p. 9, May, 1940.

average exports of fresh and dried apples by specified countries for the years, 1934-38.

Table 1

United States' Exports of Fresh and Dried Apples to Four Important Countries, Average, 1934-38

Country	United Kingdom	France	Belgium	Germany
Amount in terms of (1000) bu. fresh	4,550	1,960	909	1,394

The Netherlands was omitted because information on its wholesale price index was not complete enough to warrant its inclusion, although their imports, especially of dried apples, were considerable.

The demand by foreign countries for fresh apples is influenced by the size of their domestic crop. This effect has been included in the variable v_t which indicates the aggregate quantity harvested in France, Belgium, Germany and the United Kingdom. Production data by periods are not available. Some experimentation was done to see if a lag of one year should be made but the results indicate that $e_{mt} = e(v_t)$ rather than $e_{mt} = e(v_{(t-1)})$. The figures on production in these specified countries for the period 1937-51 were taken from Agricultural Statistics[4] and

[4]Anonymous. Agricultural Statistics. United States Department of Agriculture, Washington, D. C., annual 1941, 1947, 1951, 1952.

supplemented by material from a Bureau of Agricultural Economics publication[5] for the years prior to 1937. Apples produced for cider or vinegar in the importing countries were omitted since in most cases these are low-grade apples which cannot be efficiently utilized in any other process.

The main competitor of the United States in the export apple market is Canada. This is particularly true if one considers the United Kingdom as the main importing country since Canada has enjoyed preferential tariff treatment for several of the years considered. Thus the volume of apples exported in Canada will influence the quantity of apples which United States exporters will demand. Canadian exports are indicated by the variable w_t. A breakdown by periods is not available at this stage hence annual export figures are used. There appears to be little reason for including w_t as a lagged variable.

Data on the volume of apples exported in Canada for the period 1929-45 were taken from the Canada Year Book[6] and from Agricultural Statistics[7] for the period 1946-1951.

---

[5]Anonymous. Statistics Relating to the Apple Industry. United States Department of Agriculture, Bureau of Agricultural Economics, Washington, D. C., December, 1936.

[6]Anonymous. Canada Year Book. Dominion Bureau of Statistics, Ottawa, Ontario, Canada, annual 1933, 1937, 1941, 1945, 1946.

[7]Agricultural Statistics. Op. cit., annual, 1948, 1950, 1952.

The choice of a demand indicator in importing countries was an index of wholesale prices. As in the domestic retail demand equation it would be more accurate to use personal disposable income figures rather than an index of wholesale prices. However, available data are more reliable in the latter series than in the income series for the selected importing countries. The wholesale price index is however an indication of economic prosperity and tends to reflect purchasing power in the hands of consumers.

To construct a composite wholesale price index for the several countries each individual wholesale price index was weighted by the average volume of apples which it imported from the United States during 1934-38. During those years that imports approximated zero for any one country it was omitted. For the period, 1929-38, all four importing countries were included in the index. For 1939-48 Germany was dropped and for 1940-49, France was omitted. Belgium was excluded for the years 1940-45. All four were again included for the years following their omission until 1951.

The price per bushel for apples consigned to export, $\bar{p}_{mt}$, was computed from Department of Commerce[8] export data.

---

[8]Anonymous. Monthly Summary of Foreign Commerce of the United States. Op. cit., monthly 1929-41, and Burmeister, G. Op. cit. Written communication, July, 1953.

From period I, 1929, through period III, 1931, the total value of fresh apples exported in boxes was divided by the volume shipped, to give an export price per box. This was then adjusted to bushels on the basis that 1 bushel, fresh, is equivalent to 1.09 boxes, fresh. From period IV, 1931 to period V, 1951 the total value exported in bushel baskets was divided by the volume shipped in baskets to give the export price per bushel. For the final three years, 1949-51, the government export payment program tended to encourage apple exports and the export price is functionally related to this government activity. The extent of the government program amounted to payments of $1.18, $1.17 and $1.19 per bushel for the respective years 1949, 1950, and 1951.[9]

It is necessary in this demand relationship to state the limitations which accompany the structural equation as it is set up. Severe restrictions may be placed upon the validity of the structure in any individual year for several reasons. In constructing this relationship attention is given to the economic behavior of the people where political or institutional arrangements are absent. This omits the results of tariff agreements, exchange controls, import

---

[9]Value of purchases as given in Agricultural Statistics. Op. cit., 1951, 1952. Volume of apples exported under the program as given in The Fruit Situation. Op. cit., June, 1952, October, 1951, and October, 1950.

restrictions, war and other unpredictable circumstances as influencing variables.

All of these latter influences have been present at some time or other during the life of this model. The preferential tariff imposed by the United Kingdom in 1932 resulted in a duty of 10 percent ad valorem on all apples imported from sources outside of the British Empire. Two years previous to this the United Kingdom allowed the importation of only the two top grades of apples from the United States from July 7 to November 15 of each year due to an infestation of the apple maggot.

Germany imposed a tariff in 1928 which amounted to approximately 50 cents per box and $1.65 per barrel. Sanitary restrictions were also enforced. In 1934 severe exchange controls were enacted by Germany and the volume of United States apples exported to Germany declined considerably.

France in addition to import duties and sanitary restrictions also established import quotas for apples from the United States which amounted to about two million bushels in the early 1930's.

With the outbreak of the war in 1939 United States' export trade was disrupted and even yet the pre-war level of apple exports has not been reached. At this time Germany was cut off as a market as were Belgium and France once they were dominated by Germany. In addition, the United Kingdom applied severe import controls on the volume of apples entering the country. Following the war and in an attempt to regain old markets the United States' government entered into an export subsidy program for apples for the years 1949-50, 1950-51 and 1951-52.

> "An export payment program of the Department of Agriculture, effective September 11, 1950 has facilitated export of 1950 crop apples. The purpose of this program is to encourage export shipments of the United States apples and to assist in the removal from domestic channels of commerce, those fresh apples which usually were exported prior to World War II. Exports may be made to E.C.A. participating European countries and their dependent overseas territories. Also included are Israel, Egypt, Indonesia, Phillipines, and the Western Hemisphere countries with the exception of Canada, Cuba, Venezuela and Mexico."[10]

The above quotation indicates this type of institutional influence. Exporters shipping apples were paid approximately

---

[10] Anonymous. The Fruit Situation. United States Department of Agriculture, Bureau of Agricultural Economics, Washington, D. C., p. 11, October, 1950.

50 percent of the export sales price f.a.s.[11] United States port but not more than $1.25 per container of approximately one bushel capacity. Along with this attempt to regain markets, there have also been attempts to enter into new market channels in Asiatic and Western Hemisphere countries. If such a trend continues it will be necessary to reconstruct the export demand equation once a stabilized export position has been reached.

An additional factor which affects the demand of exporters for apples is the frequency with which the government makes domestic purchases for other such welfare programs. As in the previous departures from "normal" trading it is also impossible to include this as an explanatory variable since its influence is present only in individual years.

Care must then be exercised in using this demand equation for prediction purposes in the export market since the omitted, random influences may be great enough to cause the results to be in considerable error.

---

[11] Free alongside ship.

CHAPTER VIII

SUMMARY AND CONCLUSIONS

The four structural equations and the identity have been expressed as the structure of the model to be used. These may be expressed implicitly as follows with semi-colons separating the current endogenous and the pre-determined variables.

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

(3) $\alpha(r_{mt}, p_{mt}; c_{mt}, y_{mt}, r_{(m-1)t}, r^*_{mt}) = 0$

(4) $\beta(s_{mt}, p_{mt}; S_{(m-1)t}, S^*_{mt}, c_{mt}, k_{mt}, g_{(t-1)}) = 0$

(6) $\gamma(a_{mt}, p_{mt}; d_{mt}, A_{(m-1)t}, c'_{mt}, c''_{mt}) = 0$

(7) $\theta(e_{mt}, \bar{p}_{mt}; v_t, w_t, z_t) = 0$

These four demand equations plus the identity make up the model. If the form of the functions can be specified a fitting process will result in quantitative approximations being determined for the coefficients in the above relations. These approximations will be unbiased estimates of the true population values. There are limitations in the above model however. As mentioned above (see Chapter III) this model is incomplete since some currently endogenous variables are treated as being exogenous. A complete model would result if c_{mt}, c'_{mt} and c''_{mt} were treated as current endogenous variables and a structural equation constructed for each of them. This involves the construction of a symmetrical model for all competing fruits with current endogenous variables in it including p_{mt}, c_{mt}, c'_{mt}, and c''_{mt}. If a complete symmetrical model for competing fruits could not be constructed a solution for the prices of competing fruits could be made using partially reduced forms. These would involve functions of the form.

$f'(c_{mt}, p_{mt};$ all exogenous variables appearing in the model constructed for competing fruits$) = 0$

$f''(c'_{mt}, p_{mt};$ all exogenous variables appearing in the model constructed for competing fruits$) = 0$

$f'''(c''_{mt}, p_{mt};$ all exogenous variables appearing in the model constructed for competing fruits$) = 0$

This assumes that p_{mt}, c_{mt}, c'_{mt}, and c''_{mt} are the only current endogenous variables appearing in both models.

Such a solution using partially reduced forms to determine the prices of competing fruits would make the present model complete, but present data are insufficient to permit the construction of such a model for competing fruits. It will be noticed that a separate structural equation to explain the behavior of p_{mt} has not been incorporated into the model. It is not necessary since price can be determined with the present structural equations.

With the total quantity available being fixed and the sum of the quantities demanded by retailers, storage operators, processors, and exporters being equal to the available supply, price is determined. In other words consider p_{mt} as the only endogenous variable with quantity being a function of it.

Then $q_{mt} = \delta(p_{mt})$ where $q_{mt} = s_{mt} + r_{mt} + a_{mt} + e_{mt}$ If q_o is considered as the total available supply which must be disposed of then $q_{mt} = q_o$. Such a condition determines price without involving a separate structural equation.

Further adjustments can be made in the present model to get a "true" model. One such adjustment involves the specification of how functional forms may change between periods. In this study identical functions are assumed for all periods but it is possible that changes may take place between periods and structural changes should be made to account for them. For instance a different lag period may apply to endogenous variables as movements are made from one period to another, or certain variables may have an influence at particular time intervals and be irrelevant during others.

An additional adjustment may be made in equation (7) if further attempts are made to approximate the "true" model. This would involve the inclusion of the sales volume of processed goods, h^*_{mt}, over some past period, or it may be that current sales volume affects the demand for apples for processing. h^*_{mt} would then be an endogenous variable and a structural equation including it would be necessary. The data presently available do not permit the inclusion of h^*_{mt} in the current model.

A further improvement may be made by aggregating those varieties of apples which have a similar demand and treating them independently of apples utilized in other forms. This is especially true where certain varieties used mainly for processing are produced during the same period as other varieties consumed in a fresh form.

In Chapter VI the equation involving e_{mt} was termed a "predicting" equation. This corresponds to the special case of the simultaneous approach mentioned in Chapter I. Solution of this equation by "least squares" is permitted and will give unbiased estimates of the parameters in the equation if all predicting variables are exogenous and all disturbances in the equation are attached to e_{mt}. If prediction was the only objective each equation could be solved directly by a "least squares" approach. However, this would not permit one to account for structural changes in some other part of the model. Since each equation in this model is over-identified an indirect solution (conversion to reduced forms) by "least squares" methods is not possible.

While, as previously indicated, estimation of the parameters is not to be undertaken in this phase of the study, the implications involved in selecting a certain parametric form for the equations prior to estimation will be commented upon. An assumption was made in Chapter I that the random residuals have a mean of zero and a variance of 1. The distribution of these random components will vary according to the parametric form which is assumed to apply. Specification of the form which the function will take is made by the use of economic theory which enables one to relate the degree of change which occurs in each variable as another is varied. This specification involves explicit assumptions being made about the distribution which the random residuals will take on with the distribution changing according to the parametric form assumed.

Estimation of the structural coefficients has been investigated using the maximum likelihood[1] approach. The estimates given by such a procedure will tend in probability to the true population values of the structural coefficients as the number of observations which constitute the sample becomes large. Greatest efficiency is attained by using the full information maximum likelihood method whereby a

---

[1]Tintner, G. Econometrics. John Wiley and Sons, New York, pp. 172-184, 1952.

simultaneous solution using all of the variables appearing in all of the equations is undertaken. This method is costly and complex. An alternative is the "limited information, maximum likelihood" method. To estimate any one structural equation, all the variables in the particular equation are included plus all exogenous and lagged endogenous variables appearing in the rest of the system. The loss in efficiency by going from the "full information" to the latter method is not known but the saving in computations, time and money justifies the use of a "limited information" procedure.

In conclusion it is re-emphasized that this is an experiment in designing an econometric model and as such improvements and modifications can be made. The model illustrated is a compromise between a complete explanation of the activities in the apple market (the "true" model) and the limitations imposed by the data available. In spite of these limitations however, the present method makes more complete use of existing theory and is a better aid to the determination of the true structural coefficients than is the "single equation, least squares" approach.

Only through a process of fitting can the reliability of the model be established. Should the empirical relationships which result from the fitting process be acceptable, applications may be made in the prediction of future values of variables which are a part of the model. Such a contribution would be significant in the fields of private or public policy. The belief is held that the development of, and experimentation with, such models as the one developed above will permit greater accuracy and reliability to be established in the field of prediction and thus contributions to the policy field will be made.

BIBLIOGRAPHY

Allen, S. G. Inventory Fluctuations in Flaxseed and Linseed Oil, 1926-1939. Cowles Commission Discussion Paper: Economics 276, unpublished paper. Cowles Commission for Research in Economics, University of Chicago, Chicago, 37, Illinois.

Anderson, T. W. and Rubin, H. The Asymtotic Properties of Estimates of the Parameters in a Complete System of Stochastic Equations. Annals of Mathematical Statistics, Vol. 21, pp. 570-582, December, 1950.

Anderson, T. W. and Rubin, H. Estimation of the Parameters of a Single Equation in a Complete System of Stochastic Equations. Annals of Mathematical Statistics, Vol. 20, pp. 46-63, March, 1949.

Anonymous. Agricultural Prices. United States Department of Agriculture, Bureau of Agricultural Economics, Washington, D. C., annual 1938-51.

Anonymous. Agricultural Statistics. United States Department of Agriculture, Washington, D. C., annual 1936-1952.

Anonymous. Canada Year Book. Dominion Bureau of Statistics, Ottawa, Ontario, Canada, annual 1933, 1937, 1941, 1945, 1946.

Anonymous. The Canning Trade Almanac-1952. The Canning Trade, Baltimore 2, Maryland, Part 2, Vol. 75, 1952.

Anonymous. Conversion Factors and Weights and Measures for Agricultural Commodities and Their Products. United States Department of Agriculture, Production and Marketing Administration, Washington, D. C., May, 1952.

Anonymous. Fruits (non-citrus) Production, Farm Disposition and Utilization of Sales. United States Department of Agriculture, Bureau of Agricultural Economics, Washington, D. C., CS-27, May, 1948.

Anonymous. The Fruit Situation. United States Department of Agriculture, Bureau of Agricultural Economics, Washington, D. C., issues of May, 1940, October, 1950, October, 1951, June, 1952.

Anonymous. Livestock Market News Statistics and Related Data - 1951, United States Department of Agriculture, Production and Marketing Administration, Washington, D. C. Bull. 118, November, 1952.

Anonymous. Monthly Labor Review. United States Department of Labor, Bureau of Labor Statistics, Washington, D. C., monthly, 1929-1951.

Anonymous. Monthly Summary of Foreign Commerce of the United States. United States Department of Commerce, Bureau of Foreign and Domestic Commerce, Washington, D. C., monthly, 1929-1951.

Anonymous. National Income. United States Department of Commerce, Bureau of Foreign and Domestic Commerce, Washington, D. C., 1951.

Anonymous. Statistics Relating to the Apple Industry. United States Department of Agriculture, Bureau of Agricultural Economics, Washington, D. C., December, 1936.

Anonymous. Survey of Current Business. United States Department of Commerce, Bureau of Foreign and Domestic Commerce, Office of Business Economics, Washington, D. C., monthly 1952-53.

Been, R. O. Price Spreads Between Farmers and Consumers for Food Products 1913-44. United States Department of Agriculture, Bureau of Agricultural Economics, Washington, D. C., misc. pub. 576, September, 1945.

Bennion, E. G. The Cowles Commission Simultaneous Equation Approach: A Simplified Explanation. Review of Economics and Statistics, Vol. 34, pp. 49-56, 1952.

Black, W. E. Consumer Demand for Apples and Oranges. Cornell University Agricultural Experiment Station, Ithaca, New York, Bulletin 800, 1943.

Bronfenbrenner, J. Chapter IX, Sources and Size of Least-Squares Bias in a Two-Equation Model. Hood, W. C. and Koopmans, T. C., Editors, Studies in Econometric Method. John Wiley and Sons, New York, 1953.

Burmeister, G., Head, Division of Fruits, Vegetables and Sugar, Office of Foreign Agricultural Relations, United States Department of Agriculture, Washington, D. C., written communication, September 11, 1952.

Carroll, T. F. Cherries, Background Information and Statistics for Fruit Marketing. Cornell University Agricultural Experiment Station, Ithaca, New York, A. E. 662, March, 1948.

Cowles Commission for Research in Economics. Statistical Inference in Dynamic Economic Models, edited by Koopmans, T. C. John Wiley and Sons, New York, 1950.

Dusenberry, J. S. Income, Employment and Public Policy. Essays in honor of Alvin H. Hansen, W. W. Norton and Company, New York, 1948.

Fox, K. A. Factors Affecting Farm Income, Farm Prices, and Food Consumption. Agricultural Economics Research, Vol. 3, No. 3, pp. 65-82, July, 1951.

Fraser, S., Executive Vice-President, International Apple Association, 1302 18th St. N. W., Washington, D. C., written communications, September, 1952 and May, 1953.

Girshick, M. F. and Haavelmo, T. Statistical Analysis of the Demand for Food. Econometrica, Vol. 15, pp. 77 ff.

Haavelmo, T. The Probability Approach in Econometrics. Econometrica, Vol. 12, (supp.), July, 1944.

Hicks, J. R. Value and Capital, second edition. Oxford University Press, London, 1948.

Hildreth, C. and Jarrett, F. Cowles Commission Discussion Paper: Economics 2055, unpublished paper. Cowles Commission for Research in Economics, University of Chicago, Chicago, 37, Illinois.

Hoos, S. An Investigation on Complementarity Relations Between Fresh Fruits. Journal of Farm Economics, Vol. 23, May, 1941.

Kaufman, V. F. Costs and Methods for Pie-Stock Apples. Food Engineering, December, 1951.

Klein, L. Pitfalls in the Determination of the Investment Schedule. Econometrica, Vol. 11, pp. 246-258, July-October, 1943.

Koopmans, C. Identification Problems in Economic Model Construction. Econometrica, Vol. 17, No. 2, pp. 125-144, April, 1949.

Lloyd, J. W. and Ekstrom, V. A. Marketing the Illinois Apple Crop. University of Illinois Agricultural Experiment Station, Urbana, Illinois, Bulletin 497, August, 1943.

Pailthorp, R. R. and Park, J. W. Marketing Apples. United States Department of Agriculture, Bureau of Agricultural Economics, Washington, D. C., Bulletin 474, 1935.

Palmer, C. D. and Schlotzhauer, E. D. Apples, Usual Time of Bloom and Harvest. United States Department of Agriculture, Bureau of Agricultural Economics, Washington, D. C., November, 1950.

Prest, A. R. Some Experiments in Demand Analysis. Review of Economics and Statistics, Vol. 31, 1949.

Rubin, H. Systems of Linear Stochastic Equations. Unpublished Ph. D. Thesis, University of Chicago, 1948, 50 pp.

Smock, R. M., Controlled-Atmosphere Storage of Apples. Cornell University Agricultural Experiment Station, Ithaca, New York, Bull. 759, February, 1949.

Soleau, B. S. United States Department of Agriculture, Production and Marketing Administration, Washington, D. C., written communication, July 27, 1951.

Stier, H. L., Director, Division of Statistics, National Canners Association, 1133 20th St. N. W., Washington, D. C., written communication, May 26, 1953.

Tintner, G. Econometrics. John Wiley and Sons, New York, 1952.

Woodin, M. D. Changes in the Price of Apples and Other Fruits. Cornell University Agricultural Experiment Station, Ithaca, New York, Bulletin 773, December, 1941.

APPENDIX

DATA FOR STRUCTURAL EQUATIONS

Table 2

Apples: Production,[a] by Periods,[b]
Commercial Areas of United States, 1929-51

Year	Period I[c]	Period II[d]
	1,000 Bushels	
1929	4,045	96,147
1930	5,169	114,857
1931	5,287	141,973
1932	4,010	103,742
1933	4,260	100,600
1934	4,100	93,158
1935	5,200	117,203
1936	4,140	86,791
1937	6,110	125,802
1938	4,660	90,823
1939	5,910	111,254
1940	5,200	94,938
1941	6,090	106,872
1942	3,888	108,076
1943	4,011	78,448
1944	4,148	108,964
1945	3,250	60,530
1946	7,383	105,605
1947	8,078	95,498
1948	5,292	79,050
1949	7,544	109,932
1950	5,039	111,077
1951	5,813	90,440

Source: Period I, International Apple Association, Period II, Agricultural Statistics, U.S.D.A., 1952, and Fruits (non-citrus) Production, Farm Disposition, and Utilization of Sales, U.S.D.A., B.A.E., CS-27, May, 1948.

[a]This variable has the symbol q_{mt} and appears in the inventory relation identity.

[b]Periods are constructed on the basis of crop years which extend from July 1 to June 30. Period I includes the months of July and August, Period II includes September, October and November, Period III includes December, January, February, and March, and Period IV includes April, May, and June.

[c]Estimated for 1932-41 according to the relationship between summer production and winter production in 1925-31, and 1942-52.

[d]Adjusted prior to 1934 by taking the "commercial crop sold" as being 90% of "total crop sold" based on the years 1934-38.

Table 3

Apples, Fresh: Storage Stocks[a] at End of Period,[b] United States, 1929-51.

Year	Period II	Period III
	1,000 Bushels	
1929	28,139	7,787
1930	32,580	8,751
1931	34,197	9,729
1932	29,433	8,682
1933	25,128	6,393
1934	30,983	7,926
1935	33,054	11,307
1936	26,486	7,360
1937	36,054	12,039
1938	30,815	9,192
1939	30,988	8,638
1940	33,838	10,530
1941	31,235	8,207
1942	35,761	9,403
1943	25,475	5,436
1944	35,616	11,573
1945	19,940	3,522
1946	33,413	7,593
1947	35,790	10,244
1948	21,836	5,491
1949	33,405	7,074
1950	40,032	12,891
1951	36,074	7,207

Source: 1929-50, U.S.D.A., P.M.A., Transportation and Warehousing Branch.
1951, International Apple Association.

[a]This variable has the symbol S_{mt} and appears in the inventory relation identity and in the storage demand equation, for all periods.

[b]See footnote (b) Table 2.

Table 4

Apples, Fresh: Quantity Available for Consumption,[a] by Periods,[b] United States, 1929-51

Year	Period I	Period II	Period III	Period IV
	1,000 Bushels			
1929	3,484	47,486	15,010	7,123
1930	4,369	57,936	12,998	6,900
1931	4,085	87,403	15,258	7,922
1932	2,871	53,903	13,598	7,372
1933	3,494	55,785	8,832	5,537
1934	3,484	43,757	17,070	6,564
1935	4,335	59,534	15,353	9,749
1936	3,465	40,780	14,906	6,699
1937	5,568	66,026	18,011	9,685
1938	3,750	43,057	13,101	7,434
1939	5,445	61,029	20,637	8,392
1940	5,107	50,261	22,895	10,271
1941	5,732	57,365	20,394	7,467
1942	3,761	54,339	25,424	8,345
1943	3,498	37,699	19,484	4,516
1944	3,955	53,550	24,106	11,115
1945	2,976	29,130	15,492	3,348
1946	7,209	49,642	21,727	6,243
1947	7,559	43,963	24,201	9,859
1948	5,168	45,642	15,656	5,348
1949	7,355	55,484	24,313	6,510
1950	4,784	45,097	25,566	12,290
1951	4,940	36,580	27,045	6,880

Source: Determined from the inventory relation equation. See Chapter III.

[a]This variable has the symbol r_{mt} and appears in the retail demand equation and in the inventory relation identity for all periods.

[b]See footnote (b) Table 2.

Table 5

Apples, Processed[a]: Storage Stocks Beginning Season, and Quantity Processed in Period II,[b] United States, 1929-51

Year	Period I Storage Stocks 1,000 Cases 24/2½'s	Period II Processing 1,000 Bu. Fresh
1929	1,047	14,015
1930	990	13,939
1931	705	11,027
1932	771	11,757
1933	962	13,617
1934	1,200	14,630
1935	1,500	16,878
1936	1,400	14,551
1937	1,400	17,912
1938	2,500	11,154
1939	1,300	16,367
1940	2,000	10,839
1941	1,300	17,814
1942	1,700	17,857
1943	1,472	14,398
1944	385	18,704
1945	352	10,994
1946	277	21,636
1947	2,500	14,691
1948	3,627	11,273
1949	1,493	20,446
1950	3,083	25,272
1951	6,846	16,272

Source: (i) Storage stocks, including canned apples and applesauce, 1934-51, National Canners Association. Data on storage stocks for 1929-33 estimated on basis of the average percentage that storage stocks at the beginning of the processing season were of total amount processed for the years 1934-37.

(ii) Quantity processed data, including canned, dried, and frozen, are taken from Agricultural Statistics, 1952.

[a]This variable has the symbol a_{mt} and appears in the inventory relation identity and the processing demand equation for period II.

[b]See footnote (b) Table 2.

Table 6

Apples: Total Quantity of Net Exports[a] from the United States in Terms of Fresh Apples, by Periods,[b] 1929-51

Year	Period I	Period II	Period III	Period IV
	1,000 Bushels			
1929	561	6,507	5,342	664
1930	800	10,402	10,831	1,851
1931	1,202	9,346	9,210	1,807
1932	1,139	8,649	7,153	1,310
1933	766	6,070	9,903	856
1934	616	3,788	5,987	1,362
1935	865	7,737	6,394	1,561
1936	675	4,974	4,220	661
1937	542	5,810	6,004	2,354
1938	910	5,797	8,522	1,758
1939	465	2,870	1,713	246
1940	93	0	413	259
1941	358	458	2,634	740
1942	127	119	934	1,058
1943	513	876	555	920
1944	193	1,094	937	458
1945	274	466	926	174
1946	174	914	4,093	1,350
1947	519	1,054	1,345	385
1948	124	299	689	143
1949	189	597	2,018	564
1950	255	676	1,575	601
1951	873	1,514	1,822	327

Source: 1929-41, Monthly Summary of Foreign Commerce of the United States, U. S. Dept. of Commerce, monthly, 1929-41.

1942-51, U.S.D.A., Office of Foreign Agricultural Relations.

[a]This variable has the symbol e_{mt} and appears in the inventory relation identity and in the export demand equation for all periods.

[b]See footnote (b) Table 2.

Table 7

Apples, Fresh: Average Price Received by Farmers,[a] by Periods,[b] United States, 1929-51

Year	Period I	Period II	Period III	Period IV
	Dollars Per Bushel			
1929	1.50	1.35	1.50	1.67
1930	1.26	.99	1.04	1.23
1931	.92	.64	.67	.85
1932	.76	.57	.66	.84
1933	.81	.72	.92	1.15
1934	.91	.85	1.00	1.14
1935	.87	.67	.82	.95
1936	.95	.97	1.24	1.52
1937	.97	.65	.68	.72
1938	.78	.80	.95	1.01
1939	.78	.59	.77	1.02
1940	.94	.74	.92	1.07
1941	.90	.90	1.19	1.54
1942	1.34	1.16	1.65	2.42
1943	2.36	2.17	2.84	3.17
1944	2.38	2.07	2.48	2.60
1945	2.86	2.92	3.55	3.78
1946	2.84	2.36	2.74	3.16
1947	2.50	2.25	2.04	1.87
1948	2.17	2.33	2.85	3.06
1949	2.12	1.57	1.74	2.38
1950	2.50	2.10	2.07	1.85
1951	1.93	1.96	2.32	2.80

Source: U.S.D.A., B.A.E.

[a]This variable has the symbol p_{mt} and appears in all demand equations and in all periods.

[b]See footnote (b) Table 2.

Table 8

Personal Disposable Income[a]: Seasonally Adjusted at Annual Rates, by Periods,[b] United States, 1929-51

Year	Period I	Period II	Period III	Period IV
	Billion Dollars			
1929	83.5	82.6	78.5	76.1
1930	72.3	69.8	67.0	66.2
1931	61.4	58.1	54.1	49.0
1932	45.2	44.4	42.6	44.3
1933	47.0	46.8	50.0	51.5
1934	52.1	51.5	54.5	57.7
1935	58.5	59.6	61.1	66.4
1936	68.5	67.6	70.5	73.4
1937	73.5	70.9	76.0	65.0
1938	65.7	66.7	68.3	68.9
1939	69.6	72.1	73.5	73.9
1940	75.6	78.1	83.1	89.0
1941	94.6	97.5	104.7	113.2
1942	121.6	128.4	129.0	130.1
1943	131.2	133.8	141.0	144.8
1944	146.0	148.1	152.4	154.3
1945	154.0	152.0	150.0	155.0
1946	162.4	163.5	166.4	165.8
1947	168.2	179.1	182.8	188.0
1948	193.5	194.0	188.0	185.8
1949	184.0	183.2	195.0	197.7
1950	205.5	211.5	218.2	222.2
1951	224.3	226.6	231.0	232.2

Source: National Income, U.S. Dept. of Commerce, 1951 ed., Survey of Current Business, U.S. Dept. of Commerce, monthly, 1952-53. Livestock Market News Statistics and Related Data - 1951, U.S.D.A., P.M.A., Bull. 118, November, 1952.

[a]This variable has the symbol y_{mt} and appears in the retail demand equation for all periods.

[b]See footnote (b) Table 2.

Table 9

Price Index for Six[a] Fresh Fruits,[b] at Farm Level by Periods,[c] United States, 1929-51[d] (1947-51 = 100)

Year	Period I	Period II	Period III	Period IV
1929	84.8	91.4	160.7	196.2
1930	84.6	87.3	79.2	76.4
1931	45.0	57.5	76.8	73.0
1932	38.7	47.8	62.5	50.4
1933	44.7	48.5	71.6	86.3
1934	55.7	57.6	66.3	61.6
1935	53.9	52.7	82.4	84.7
1936	62.4	61.7	83.3	94.8
1937	68.8	65.2	54.1	49.8
1938	47.1	38.0	42.3	49.3
1939	42.9	38.6	48.9	60.4
1940	49.4	48.6	52.7	55.7
1941	52.9	72.4	64.8	78.5
1942	72.9	89.8	107.1	121.0
1943	99.7	135.2	128.6	135.1
1944	126.8	132.2	143.9	151.2
1945	111.2	127.6	137.5	138.3
1946	114.4	130.6	88.5	87.6
1947	90.8	89.6	75.7	76.3
1948	112.8	98.4	84.6	134.6
1949	93.8	88.3	140.6	120.7
1950	107.3	116.8	110.1	102.6
1951	92.7	104.6	62.0	77.3

Source: U.S.D.A., B.A.E.

[a]The six fresh fruits included in this index are pears, peaches, grapes, lemons, oranges, and grapefruit.

[b]This variable has the symbol c_{mt} and appears in the retail demand equation for all periods and in the storage demand equation for periods II, III and IV.

[c]See footnote (b) Table 2.

[d]Index weighted by monthly marketings of each of the six fruits.

Table 10

Apples, Fresh: Retail Sales, Average of Three Preceding Years,[a] by Periods,[b] United States, 1929-51[c]

Year	Period I	Period II	Period III	Period IV
	1,000 Bushels			
1929	3,867	84,053	11,269	8,313
1930	4,108	59,241	11,445	7,546
1931	4,323	63,464	15,595	7,733
1932	3,979	64,242	14,422	7,315
1933	3,775	66,414	13,951	7,398
1934	3,483	65,697	12,563	6,843
1935	3,283	51,148	13,166	6,391
1936	3,771	53,025	13,752	7,283
1937	3,761	48,024	15,776	7,671
1938	4,456	55,446	16,090	8,711
1939	4,261	49,954	15,339	7,939
1940	4,921	56,704	17,249	8,503
1941	4,767	51,449	18,877	8,699
1942	5,428	56,218	21,308	8,710
1943	4,866	53,988	22,904	8,694
1944	4,330	49,801	21,767	6,776
1945	3,738	48,529	23,005	7,992
1946	3,476	40,126	19,694	6,326
1947	4,713	44,107	20,442	6,902
1948	5,915	40,912	20,473	6,483
1949	6,645	46,415	20,528	7,150
1950	6,694	48,363	21,390	7,239
1951	5,769	48,741	21,845	8,049

Source: Computed from inventory relation identity. See Chapter III.

[a] This variable has the symbol r^*_{mt} and appears in the retail demand equation for all periods.

[b] See footnote (b) Table 2.

[c] In computing r_{mt} from the inventory relation prior to averaging to get r^*_{mt} for the years 1929-31 total annual exports were divided equally between periods II and III since data on exports for the years 1926-1928 were not available by months.

Table 11

Apples, Fresh: Storage Stocks, Average of Three Preceding Years,[a] by Ending Periods,[b] United States, 1929-51

Year	Period II	Period III
	1,000 Bushels	
1929	28,709	8,313
1930	27,603	7,767
1931	30,605	8,310
1932	31,612	8,756
1933	32,070	9,054
1934	29,586	8,268
1935	28,504	7,667
1936	29,722	8,542
1937	30,174	8,864
1938	31,864	10,235
1939	31,118	9,530
1940	32,619	9,956
1941	31,880	9,453
1942	32,020	9,125
1943	33,611	9,380
1944	30,824	7,682
1945	32,284	8,804
1946	27,011	6,844
1947	29,656	7,563
1948	29,714	7,118
1949	30,346	7,775
1950	30,344	7,602
1951	31,758	8,484

Source: U.S.D.A., P.M.A., Transportation and Warehousing Branch.

[a]This variable has the symbol S^*_{mt} and appears in the storage demand relation for periods II, III and IV.

[b]See footnote (b) Table 2.

Table 12

Apples, Fresh: Percent that Average Price Per Bushel Received by Farmers for the Months of March, April, and May was of the Average Price Received During the Preceding Months of September, October, and November,[a] for the United States, 1929-51[b]

Year	Percent
1929	134
1930	119
1931	116
1932	122
1933	137
1934	151
1935	129
1936	131
1937	148
1938	105
1939	125
1940	159
1941	136
1942	158
1943	183
1944	145
1945	123
1946	129
1947	131
1948	84
1949	132
1950	136
1951	90

Source: U.S.D.A., B.A.E.

[a]This variable is given the symbol $g_{(t-1)}$ and appears in the storage demand equation for period II.

[b]The average price received by farmers is averaged for the months of September, October, and November, and again for March, April, and May to get the prices used in determining the percent increase.

Table 13

Apples, Fresh: Storage Costs Per Bushel,[a] by Periods,[b] United States, 1929-51

Year	Period II	Period III	Period IV
	Cents Per Bushel Per Month		
1929	8.8	5.5	5.5
1930	9.2	5.6	5.6
1931	9.6	5.8	5.8
1932	10.1	5.9	5.9
1933	10.5	6.0	6.0
1934	10.2	5.5	5.5
1935	11.0	5.0	5.0
1936	11.0	5.0	5.0
1937	11.0	5.0	5.0
1938	11.0	5.0	5.0
1939	11.3	5.1	5.1
1940	11.5	5.3	5.3
1941	11.8	5.4	5.4
1942	12.1	5.6	5.6
1943	12.4	5.7	5.7
1944	12.6	5.8	5.8
1945	12.9	5.9	5.9
1946	13.0	6.0	6.0
1947	13.0	6.0	6.0
1948	14.0	6.0	6.0
1949	14.0	6.0	6.0
1950	14.0	6.0	6.0
1951	14.0	6.5	6.5

Source: Correspondence with storage and warehouse operators to get data for 12 of the 22 years. Interpolations made for the remaining 10 years.

[a]This variable appears as k_{mt} and appears in the storage equation for periods II, III and IV.

[b]See footnote (b) Table 2.

Table 14

Apples: Index of Processing Costs, United States, 1929-51[a] (1947-51 = 100)

Year	Processing Costs
1929	57.1
1930	55.7
1931	50.6
1932	46.6
1933	44.5
1934	50.4
1935	51.4
1936	51.1
1937	50.7
1938	52.5
1939	52.6
1940	50.4
1941	56.4
1942	61.5
1943	64.9
1944	68.6
1945	70.2
1946	79.2
1947	88.3
1948	94.5
1949	99.8
1950	103.9
1951	117.5

Source: Labor rates are taken from Monthly Labor Review, U.S. Dept. of Labor, Bureau of Labor Statistics, and can prices are taken from The Canning Trade Almanac, The Canning Trade. The index is weighted by the volume of apples going into each of the canning, drying and freezing processes, and by the proportion of total cost made up by labor and packaging costs in each of these processes.

[a]This variable has the symbol d_{mt} and appears in the processing demand relation for period II.

Table 15

Price Index for Fruits Competitive With Canned Apples,[a] for Period II,[b] United States, 1929-51 (1947-51 = 100)

Year	Period II
1929	99.0
1930	35.8
1931	26.3
1932	19.0
1933	30.9
1934	45.2
1935	42.2
1936	41.0
1937	49.8
1938	22.2
1939	35.3
1940	36.9
1941	64.5
1942	89.8
1943	115.2
1944	109.2
1945	108.9
1946	104.0
1947	90.2
1948	114.1
1949	62.0
1950	104.6
1951	125.6

Source: Fruits (non-citrus), Production, Farm Disposition and Utilization of Sales, U.S.D.A., B.A.E.

[a]This variable has the symbol c'_{mt} and appears in the processing demand equation for period II. Fruits included in its construction were California, Washington and Oregon pears, California clingstone peaches, and California, Washington, and Utah apricots.

[b]See footnote (b) Table 2.

Table 16

Cherries, Red Sour: Average Price Per Ton Received by Farmers,[a] United States, 1929-51

Year	Price Dollars Per Ton
1929	136.00
1930	116.00
1931	51.00
1932	32.00
1933	49.00
1934	41.00
1935	49.00
1936	59.00
1937	76.00
1938	56.00
1939	43.00
1940	58.00
1941	97.00
1942	104.00
1943	177.00
1944	165.00
1945	260.00
1946	301.00
1947	199.00
1948	184.00
1949	189.00
1950	131.00
1951	138.00

Source: 1938-51, Agricultural Statistics, U.S.D.A. and Agricultural Prices, U.S.D.A., B.A.E.
1929-37, Cherries, Background Information and Statistics for Fruit Marketing, Cornell Univ. Ag. Exp. Sta., A.E. 662.

[a]This variable has the symbol c''_{mt} and appears in the processing demand relation for period II.

Table 17

Apples, Fresh: Exports by Canada,[a] and Production for United Kingdom, France, Germany, and Belgium,[b] 1929-51

Year	Exports by Canada	Quantity Harvested in France, Belgium,[c] United Kingdom and Germany
	1,000 Bushels	
1929	2,520	73,329
1930	4,535	65,751
1931	3,398	51,770
1932	4,140	57,270
1933	4,880	52,200
1934	8,899	103,100
1935	5,258	50,006
1936	6,407	49,200
1937	5,349	102,900
1938	7,199	67,300
1939	4,152	124,300
1940	2,156	48,700
1941	1,647	58,400
1942	877	45,600
1943	849	113,300
1944	2,983	85,700
1945	1,664	65,100
1946	4,253	79,200
1947	3,414	96,583
1948	2,265	58,699
1949	3,409	87,073
1950	4,731	101,618
1951	3,137	105,856

Source: Canadian exports are taken from the Canada Year Book, Dominion Bureau of Statistics.

Quantity harvested in the European countries data for the years 1929-37 are from Statistics Relating to the Apple Industry, U.S.D.A., B.A.E. and for the years 1938-51 are from Agricultural Statistics, U.S.D.A.

[a]This variable has the symbol w_t and appears in the export demand equation for all periods.

[b]This variable has the symbol v_t and appears in the export demand equation for all periods.

[c]For the years 1929-34 production in Belgium was reported as averaging 1 million bushels per year and for 1934-39 it averaged 1.2 million bushels per year. These production estimates were applied to the individual years making up the average.

Table 18

Wholesale Prices[a]: Index for France, Belgium, United Kingdom, and Germany, Weighted by Average Annual Imports of Apples 1934-38, for the Years 1929-51

Year	Wholesale Prices
1929	42.5
1930	38.1
1931	43.0
1932	30.9
1933	30.5
1934	31.3
1935	32.0
1936	33.9
1937	38.1
1938	35.9
1939	28.2
1940	37.4
1941	35.7
1942	37.5
1943	38.3
1944	39.1
1945	39.6
1946	59.8
1947	54.3
1948	61.9
1949	81.4
1950	117.5
1951	165.2

Source: Wholesale price index from Monthly Bulletin of Statistics, Statistical Office of the United Nations, New York. Average annual imports 1934-38 from The Fruit Situation, U.S.D.A., B.A.E., May, 1940 issue.

[a]This variable has the symbol z_t and appears in the export demand equation for all periods.

Table 19

Apples, Fresh: Average Price Per Bushel for Apples Exported from the United States,[a] by Periods,[b] 1929-51[c]

Year	Period I	Period II	Period III	Period IV
	Dollars Per Bushel			
1929	2.46	2.74	2.51	2.20
1930	2.35	2.10	2.07	2.05
1931	2.12	1.88	1.50	1.48
1932	1.33	1.66	1.41	1.34
1933	1.03	1.62	1.62	1.48
1934	1.14	1.77	1.67	1.91
1935	2.17	2.11	1.81	1.90
1936	1.30	2.01	1.96	1.77
1937	1.50	1.79	1.76	1.66
1938	1.68	2.35	1.38	1.51
1939	1.23	1.71	1.73	1.76
1940	1.31	1.29	1.12	1.33
1941	.91	1.51		
1942				
1943				
1944				
1945				
1946				
1947				
1948				
1949				
1950				
1951				

Source: 1929-41, Monthly Summary of Foreign Commerce of the United States, U. S. Dept. of Commerce 1942-51, U.S.D.A., Office of Foreign Agricultural Relations.

[a]This variable has the symbol $\bar{p}_{mt}$ and appears in the export demand equation for all periods.

[b]See footnote (b) Table 2.

[c]Determined by dividing average value of apples exported in bushel baskets for the period by the number of bushel baskets shipped.

Table 20

Conversion Factors and Weights
and Measures for Apples

1 box weighs 44 lbs.

1 barrel weighs 140 lbs.

1 basket (bushel) weighs 48 lbs.

7 lbs. fresh = 1 lb. dried

66.667 lbs. fresh are equivalent to 1 case 24/2½'s canned

1 case 24/2½'s = 1.45 cases of 24/2's = 1.09 cases of 6/10's

Source: Anonymous, Conversion Factors and Weights and Measures for Agricultural Commodities and Their Products, U.S.D.A., P.M.A., May, 1952.