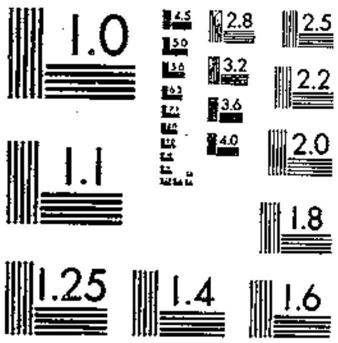
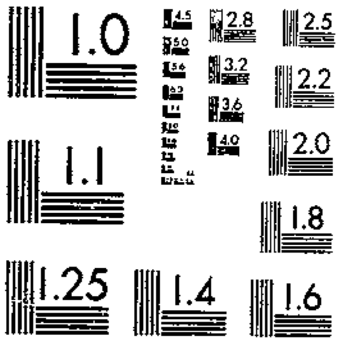
TB 1380 (1967) USDA TECHNICAL BULLETINS UPDATA
DEMAND AND PRICE ANALYSIS FOR POTATOES
HEE, O 1 OF 2

START



MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A



MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

PREFACE

This bulletin describes the major demand and price relationships for potatoes in the four seasonal markets. It includes certain background material on economic relations within the potato economy and examines historical trends in prices and consumption of potatoes. Also it summarizes a number of statistical analyses designed to provide measurements of elasticity, competitive behavior, and substitutability for different crops of potatoes. Finally, it furnishes estimates of prices and consumption for different crops of potatoes for the period of analysis, 1947-60; and comparisons of actual and predicted values for 1961, 1962, and 1963.

An evaluation was made of the predictive ability of each of the four statistical models. Qualitative and quantitative tests were made of the accuracy of predictions from the respective models for 1961, 1962, and 1963, all beyond the period of fit. These are critical tests of a model's forecasting ability. They furnish a measure of determining how well the models were able to predict both direction of change and absolute values of the price and consumption variables.

This bulletin is intended to aid extension workers, Government officials, agricultural economists, representatives of farm organizations, and members of the industry, in obtaining a better understanding of the pricemaking influences in the potato economy.

Information and assistance were obtained from many specialists in the U.S. Department of Agriculture. Special acknowledgment is made to Anthony S. Rojko, formerly Head, Price Research and Methods Section, Economic Research Service, for assistance in preparation of the manuscript for publication. The author also is particularly indebted to Donald S. Kuryloski, Economic Research Service, who made several major subject-matter contributions in the later stages of development.

Paul J. Nelson, Jr. and Allen B. Paul of the Economic Research Service provided information that improved the sections on substitution and competition and on storage demand. Ernest J. Holcomb, Consumer and Marketing Service, Oakley M. Frost, Statistical Reporting Service, and Will M. Simmons, Economic Research Service, aided in clarifying many portions of the report.

CONTENTS

JULY 1967

SUMMARY

The effects of important factors in the potato economy are estimated in this study in four statistical models, all on a national level. The four models include a utilization model for the late summer and fall crop and three models for the early crops (winter and early spring, late spring, early summer). The basic difference between the late summer and fall model and the early-season models is that in the former the emphasis is on utilization of a specified crop, while in the latter it is on competition and substitutability between different types of potatoes in the three early markets.

The analyses in this study are designed (1) to give quantitative measurements of price and demand relationships for the different seasonal crops of potatoes, (2) to give estimates of price and income elasticities for each crop, (3) to examine price and demand for potatoes by use, (4) to provide a basis for measurement of degree of competition and substitutability between different crops of potatoes, and (5) to predict the values of certain economic variables in the potato industry.

Some of the findings and conclusions relating to consumer demand for different types of potatoes with respect to prices and income are as follows:

Consumer response during 1947-60 varied from an elastic demand of -2.6 for winter and early spring potatoes to a markedly inelastic demand of -0.2 for late summer and fall potatoes. Thus, winter and early spring potatoes may be said to have a unique demand because of the seasonality factor. During the same period, consumption of late spring potatoes tended to increase 0.6 percent on the average for each 1 percent decrease in farm prices, assuming no change in the other factors. Also, consumption of early summer potatoes tended to increase 0.7 percent when farm price decreased 1 percent.

During 1947-60, changes in disposable income appeared to have little or no effect on consumer response for the important late summer and fall crop of potatoes. For the other seasonal crops of potatoes, reasonable estimates of income elasticities were obtained, but in most instances the income coefficients were not statistically significant. In addition, there appeared to be some relationship between the price of substitute foods (processed vegetables) and consumption of late summer and fall potatoes, but the relationship was not statistically significant at an acceptable probability level.

Cross elasticities were used to measure the degree of competition and substitutability between different crops of potatoes in different early markets. The results showed a positive and relatively high cross elasticity for each crop of potatoes competing in a given seasonal market. It is concluded that a moderate to substantial degree of substitution takes place in a seasonal market between the dominant and competing crops of potatoes. But among none of the early crops were the cross elasticities as high as the direct elasticities. This suggests that some degree of differentiation exists between different types of potatoes.

Potatoes are grown primarily for food, and under normal conditions the order of utilization is (1) food, (2) livestock feed, and (3) starch.

Assuming no change in demand relationships, short-run variations in supply are distributed among the different outlets according to the comparative price elasticities of demand. This study showed that price elasticities for different utilizations of late summer and fall potatoes during 1947-60 were: Starch, -1.0; livestock feed, -0.5; and food, -0.2. Utilization is most variable in the outlet with the highest elasticity, which is starch; and least variable in the outlet with the lowest elasticity, which is food.

The statistical models generally gave satisfactory predictions for years beyond the period of fit. Comparisons for 1961, 1962, and 1963 showed that the late summer and fall model was the most accurate in predicting both direction of change and absolute values of the dependent variables. Equations in this model, fitted by least squares, correctly predicted the direction of change in each of 15 observations. Also, for this model, predictions of absolute values for prices and consumption were reasonably accurate.

Among the early-season models, the late spring model showed the greatest accuracy in predicting both direction of change and absolute values of the dependent variables for 1961, 1962, and 1963. Equations in this model correctly predicted four out of six directions of change and also gave relatively close estimates for prices of both late spring and storage potatoes. The winter and early spring model and the early summer model gave slightly less satisfactory predictions.

Graphic analysis of the actual and estimated values showed that the models generally were able to estimate both wide swings and narrow swings in farm prices for seasonal potato crops with the same relative accuracy.

DEMAND AND PRICE ANALYSIS FOR POTATOES

By Olman Hee, Agricultural Economic Statistician,
Economic and Statistical Analysis Division,
Economic Research Service

INTRODUCTION

Factors affecting the price and demand for potatoes on a national level are identified and measured statistically, by use and by seasonal crops, in this bulletin. One or more seasonal crops may be supplied to a seasonal market. The seasonal markets examined are: Winter and early spring, late spring, early summer, and late summer and fall. In the analysis of each of the early markets (the first three listed), competition between different types of potatoes is described. For late summer and fall potatoes, no competition exists from other seasonal potatoes during September-December. For this crop, in addition, the interrelationships between food, livestock feed, and starch are considered. Background information on basic changes and trends in consumption and prices of potatoes is included to provide a basis for evaluating the results of the statistical analyses.

This bulletin also examines possible differences in demand for fresh and processed potato products, even though some of these products are still too new to permit collection of historical data for formal statistical analysis.

Price structure and demand structure for potatoes have usually been studied separately in the past. Forty years ago, Waugh (61) 1/ used regression analysis to predict the price for New Jersey potatoes. This early study and others, such as one by Holbrook Working (66) on Minnesota potatoes, were mainly concerned with explaining price movements and predicting prices. In 1938, 14 years after the early price forecasting studies, Schultz (35) made an extensive statistical study of demand for several farm commodities, including potatoes. Schultz showed that since price elasticity of demand for total potatoes was far less than unity, a relatively large crop was worth less than a small one. These early studies recognized the importance of changes in the level of demand and prices due to consumer income and other factors, such as the general price level. However, often lacking suitable data, such as disposable income, they had to rely largely on indices of industrial production for a shift variable.

Fox (12), using data for 1922-41, confirmed earlier results with respect to the inelastic nature of demand for total U.S. potatoes. His studies indicated the necessity of recognizing different uses for potatoes. One of the objectives was to estimate demand relationships for potatoes for food at the retail level. For this reason, consumption and retail price were used in a formulation of demand for total potatoes. For obtaining demand relationships for other vegetables and fruits Fox used farm price and production. Disposable income was used as a shift variable in the analyses.

Recent studies, including those of Dalrymple (7), Meinken (27), and Shuffett (38), measured the effects on farm prices of supplies of

---

1/ Underscored numbers in parentheses refer to items in the Literature Cited, page 99.

two or more different types (crops) of potatoes. Meinken's analysis for New Jersey potatoes measured the effect of competing supplies from Long Island on the price of New Jersey potatoes. Shuffett's study measured the effects of early and intermediate production and January 1 storage stocks of potatoes on January-July average price received by farmers.

Gray, Sorenson, and Cochrane (15) studied demand and price relationships for potatoes as a basis for evaluating the effects of the price support program. Using an assumed price elasticity of demand (based on studies prior to the 1940's), they compared the changes in demand that occurred during 1942-50 with those that would have taken place if prices had remained at 1938-41 levels. Their study also considered proposals for increasing the demand elasticity for potatoes, as well as a price support plan and an alternative pricing plan for potatoes which were proposed as a means to reduce production and price variations.

Simmons (39), in a 1962 study, analyzed the impact of alternative Government programs on the elasticity of demand for potatoes. His primary concern was the problem of unstable prices and incomes faced by potato growers. He attributed the instability to the low demand elasticity for potatoes and the large year-to-year variations in production relative to the small yearly changes in demand. He presented results from several regressions which related prices to potato supplies, and potato acreage to price, using data for the period after World War II. These analyses were for the four seasonal crops and for selected producing areas.

In 1962, Zusman (68) presented an econometric analysis of the market for California early potatoes. Although his primary interest was to evaluate economic policies of concern to California potato growers and to predict the California market, the 14-equation model which he fitted embraced the U.S. potato industry. The model basically determined how the supply of the U.S. late summer and fall crop, the California late spring crop, and the late spring crop from other States was distributed among the total U.S. demand for potatoes for food and nonfood uses. Also, it divided the marketing year into (1) a winter market, September through February, and (2) a spring market, March through August. This model was fitted by two-stage least squares and by direct least squares where appropriate. The model was used to analyze the static and dynamic nature of the California potato market. Further uses of the model were made to evaluate the economic policy of California potato growers and to predict the California market for potatoes.

The present study differs from the foregoing studies in a number of ways, including the following:

(1) A utilization model is formulated and statistically fitted for late summer and fall potatoes which assumes an interrelation between uses of potatoes for food, feed, and starch.

(2) Three early-season models are formulated which are designed to statistically measure competition between early potatoes and storage potatoes.

(3) An analysis is made of price-consumption relationships in a single demand relation for late summer and fall potatoes to demonstrate nontechnical methods.

(4) Economic and statistical assumptions are given which are basic to the choice of the particular model adopted and to the determination of the method of statistical analysis.

(5) For particular models, several different estimation procedures, including limited information, two-stage least squares, reduced-form and ordinary least squares methods are used to estimate the coefficients in the economic relations.

(6) From these equations, estimates of price and income elasticities are obtained for the different crops of potatoes that compete in each seasonal market--winter and early spring, late spring, early summer, and late summer and fall.

(7) Predictions, and tests of these predictions, are made from the statistical models for price and consumption of the different types of potatoes in each seasonal market, for years beyond the period of analysis, 1961, 1962, and 1963. The predictions, and the tests, are made with respect to both direction of change, and values obtained. These statistical analyses, unless otherwise stated, are based on observations for the postwar period.

ECONOMIC IMPORTANCE AND LOCATION OF THE POTATO INDUSTRY

The annual potato crop in 1963, in total value of production, ranked seventh among all field crops grown in the United States and used directly or indirectly for food. The total farm value of potatoes produced in that year was $483 million (52). (In 1964, the total farm value of potatoes was $840 million, the highest in three decades, due to an unusually small crop.) In recent years, potatoes, in terms of volume, have ranked first in the United States among crops utilized chiefly for food in their initial state.

Of the 239 million hundredweight of potatoes produced in 1964, about 83 percent was used for food either in fresh or processed form (55). Secondary outlets for potatoes were livestock feed, starch, and flour (4 percent of production in 1964, compared with 8 percent in 1963). Use in these outlets varies directly with production. The amount diverted into these uses is influenced in some years by Government diversion programs. About 9 percent of the 1964 crop was used for seed. This use shows relatively little variation from year to year. Shrinkage, waste, and loss made up about 4 percent of the production. Exports and imports, never large, involve trade mostly with Canada.

Potatoes are produced in every State. Because of their bulkiness and resulting high cost of transportation, production tended at first to locate near consuming centers. However, with greater specialization and the need for power-type equipment for low-cost, efficient operation, potato growing has become a large-scale commercial enterprise. Because of this and improved methods of storing and marketing potatoes, production is now becoming concentrated in specialized potato producing areas. For example, one-third of all the potatoes in the United States are produced in Idaho and Maine, States which are distant from the ultimate consumers living in metropolitan areas. Idaho and Maine, and a few other areas, have a comparative advantage in the production of potatoes.

Trends in Production of Seasonal Crops

Potatoes are harvested in all seasons of the year. Different States are principal suppliers in the different seasons (fig. 1). The tabulation below shows how the USDA Statistical Reporting Service classifies the different seasonal crops according to the usual time of harvest:

Seasonal Category	Usual Time of Harvest
Winter	January, February, and March
Early spring	April 1 to May 15
Late spring	May 16 to June 30
Early summer	July 1 to August 15
Late summer	August 16 to September 30
Fall	October, November, and December

The beginning and closing dates for these seasons are approximations and there is some overlapping. The above classification has been in effect since 1956 (52). Prior to that time the Crop Reporting Board used only three major seasonal categories: Early, intermediate, and late.

Early Crops

The early crops--winter, early spring, late spring, and early summer--have remained an important part of total U.S. production from the early 1930's to date. In 1962-64, early crops comprised 16 percent of total U.S. production (22 percent of total food use) (52). About half of these potatoes were from the late spring crop. From 1947 to 1964, planted acreage of all early crops declined by more than one-half, yield per acre increased by over three-quarters, and total production declined by about a seventh (table 1). Most of the decline was in the early summer crop.

Winter and early spring crops.--Florida produced 66 percent of the winter and early spring crop in 1962-64; California, 32 percent; and Texas the small remainder. California winter potatoes are largely marketed locally. This group accounts for about 3 percent of total U.S. production but comprises 13 percent of consumption during January-April. During 1947-64, winter and early spring production rose rapidly from 4.1 million hundredweight to a peak of 11.2 million hundredweight in 1957, and remained between 7 and 9 million in the last few years of the period. Most of the increase was in Florida. Production in Florida rose from 1.9 million hundredweight in 1947 to a peak of 7.6 million hundredweight in 1957, and has been around 5 to 6 million recently.

Late spring crop.--Of the total late spring crop, California, in 1962-64, produced 65 percent; Alabama and North Carolina together, 20 percent; Arizona, 10 percent; and 7 States in the South produced the remaining 5 percent. Although late spring potatoes account for about a tenth of total U.S. production, they make up a little over one-half of the supply available for food during May-June; storage supplies constitute somewhat less than one-half of May-June supplies, and Florida potatoes largely account for the remainder. During 1947-64 production of late spring potatoes, although showing substantial annual fluctuations, remained at essentially the same level--about 24 million hundredweight (table 1).

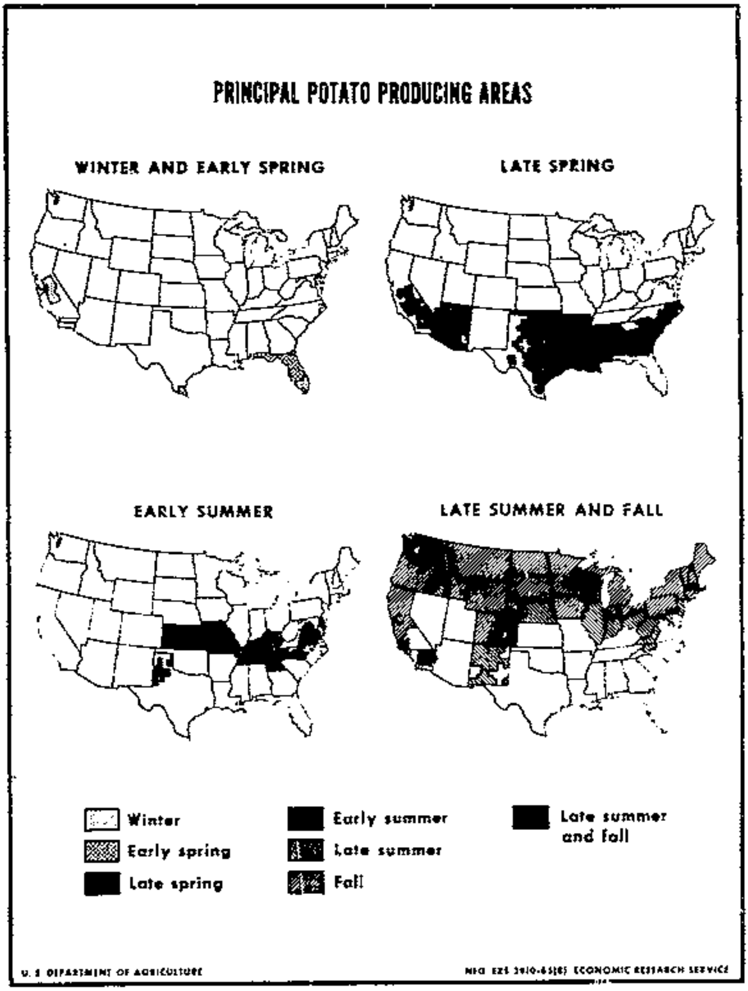


Figure 1

California potatoes are marketed in all major cities in the East. The bulk of the California late spring crop is sold for table stock. Because of the extended storage season for fall potatoes, California late spring potatoes are encountering growing competition from fall potatoes marketed fresh as well as from processed potatoes.

Early summer crop.--Early summer potatoes contribute almost one-half of total consumption during the early summer marketing period. They comprise about 5 percent of annual U.S. production. Since 1948, production of early summer potatoes has fluctuated from 10 to 15 million hundredweight. The Eastern Shore of Virginia produced about 25 percent of the early summer crop during 1962-64; California, 20 percent; Delaware and Texas together, 30 percent; and scattered areas in the East, Southeast, and Central States, 25 percent.

Table 1.--Potatoes: Trend in production of early crops, by seasonal category and principal State in each category, 1947-64 1/

Year	Winter and early spring: Florida	Winter and early spring: Total 2/	Late spring: California 3/	Late spring: Total 3/	Early summer: Virginia, all areas	Early summer: Total	Total 3 seasons
	Mil. cwt.	Mil. cwt.	Mil. cwt.	Mil. cwt.	Mil. cwt.	Mil. cwt.	Mil. cwt.
1947	1,942	4,124	14,044	23,217	5,324	18,584	45,925
1948	2,212	4,404	17,860	27,478	6,336	19,142	51,024
1949	3,205	5,108	15,436	25,496	4,313	13,592	44,196
1950	3,351	5,409	16,547	28,360	4,450	14,040	47,809
1951	3,774	5,885	10,787	20,499	3,842	12,237	38,621
1952	4,589	5,895	13,315	22,355	2,601	9,908	38,158
1953	6,144	7,822	16,997	27,706	3,485	11,928	47,456
1954	5,839	7,552	12,771	22,087	2,682	11,167	40,806
1955	6,080	8,975	16,843	23,992	3,648	14,001	46,968
1956	6,766	9,282	13,824	21,840	3,422	11,622	42,744
1957	7,610	11,198	18,025	27,084	2,784	11,348	49,630
1958	5,977	9,674	14,553	23,671	3,299	14,007	47,352
1959	4,916	7,145	14,625	22,644	2,891	13,372	43,161
1960	4,535	6,753	16,916	26,451	4,326	14,637	47,841
1961	5,810	9,607	19,012	27,753	4,552	15,496	52,856
1962	4,633	7,593	13,856	21,690	3,508	12,685	41,968
1963	6,268	9,000	15,246	23,847	3,270	12,622	45,469
1964 4/	5,180	7,857	13,432	20,248	2,614	11,492	39,597

1/ Data represent gross production.
2/ Data for 1947-48 include estimates for California winter potatoes.
3/ Data for 1947-48 show a breakdown of California early potatoes into winter and late spring potatoes.
4/ Preliminary.

Compiled from Potatoes, 1866-1950 [46]; Potatoes, 1866-1953 [51]; Potatoes and Sweetpotatoes, 1954-1959 [52] and supplements; and from records of the U. S. Economic Research Service.

The early summer crop must be marketed shortly after harvest. As a result, this crop may suffer severe price problems in years of heavy production. Production areas in the Southeast, especially in the Appalachians, are essentially noncommercial farming operations.

Late Summer and Fall Crop

The late summer and fall crop combined comprises over four-fifths of total potato production in the United States. Part of this crop can be carried through a 6- to 8-month storage period, and it is a dominant market influence during the major portion of the year. These potatoes are the sole influence from mid-August through December. As storage potatoes, they are still a dominant force from January through April, although early potatoes exert some influence. Storage potatoes exert a lesser influence through late spring; recently some storage potatoes have been marketed as late as July.

Production of late potatoes is widely dispersed through the upper half of the United States with the bulk of production in highly specialized producing areas. Together, Idaho and Maine produce about two-fifths of the total of late summer and fall tonnage. If production in Minnesota and North Dakota is included, the proportion of production in the four States is one-half of the total. Other important producing States are New York, Washington, Colorado, Wisconsin, Oregon, California, Michigan, and Pennsylvania, in that order.

During 1947-64, production increased by about a fourth to a level of around 225 million hundredweight, even though acreage was down by one-quarter (table 2). Most of the increase in production was in the Western States, particularly in Idaho.

Eastern Region.--During 1962-64 the Eastern Region produced an average of 76 million hundredweight of potatoes, about one-third of the late summer and fall crop total (table 2). Production in the East declined substantially immediately following the end of the price-support program in 1950. However, production after that time showed no significant trend.

About half of the potatoes in the East are produced in Maine. As in the region, production in Maine in 1955-64 showed no significant trend. The gains in the potato processing industry in this area apparently were largely offset by a decline in the sale of table stock.

The more southerly areas of the Eastern producing region begin to market potatoes in mid-August. New Jersey marketings are at peak in August, New York (Long Island) marketings tend to peak in October, and Pennsylvania marketings are heaviest in December. Maine marketings tended to peak in March and April for potatoes sold out of storage. However, in recent years, the peak has been less pronounced; relative increases in marketings have occurred near the end of the season. For example, in 1962-64, Maine marketings in May-June were 28 percent of total marketings for January-June, but only 12 percent during 1951-53.

Central Region.--The Central Region produced an average of a little over 50 million hundredweight of potatoes during 1962-64, about one-fourth of the late summer and fall crop. After declining substantially in the years immediately following the price-support period, production in 1955-64 rose by about 30 percent.

Table 2.--Potatoes: Trend in production of late summer and fall crops combined, by region, and by principal State in each region, 1947-64 1/

Year	Eastern 2/		Central 2/		Western 2/		Total all regions 2/
	Maine	Total	Minnesota-North Dakota	Total	Idaho	Total	
	Mil. cwt.	Mil. cwt.	Mil. cwt.	Mil. cwt.	Mil. cwt.	Mil. cwt.	Mil. cwt.
1947	39,060	79,605	21,765	48,439	17,160	55,985	184,029
1948	45,045	89,178	21,888	54,258	27,360	74,522	217,958
1949	42,228	85,828	21,885	51,965	21,790	58,511	196,304
1950	38,016	85,802	22,632	56,661	30,516	68,840	211,303
1951	27,000	63,975	15,329	39,586	23,055	53,594	157,155
1952	32,007	67,907	16,302	41,775	26,929	63,255	172,937
1953	34,839	71,386	18,278	44,480	30,690	68,357	184,223
1954	29,046	67,023	23,312	47,820	26,608	63,898	178,741
1955	34,968	73,016	16,098	37,248	33,188	70,464	180,728
1956	41,748	80,360	24,014	48,092	33,730	74,596	203,048
1957	37,812	72,906	17,923	38,873	39,018	81,113	192,892
1958	36,603	76,817	25,970	50,238	45,568	92,490	219,545
1959	34,263	70,033	24,017	48,037	42,408	84,568	202,638
1960	33,663	72,894	27,687	52,974	43,078	83,726	209,594
1961	37,000	77,705	28,052	56,532	57,734	106,501	240,738
1962	38,955	78,037	27,049	54,508	46,319	92,190	224,735
1963	37,630	75,082	27,488	52,556	53,466	98,623	226,261
1964 3/	39,875	73,891	20,094	45,848	39,515	80,067	199,806

1/ Data represent gross production. 2/ Data for 1947-48 are for 29 late States; data for 1949-64 are for 26 fall States; late summer production includes quantities harvested and marketed from August 15 to September 30 for New Jersey, Maryland, Virginia, North Carolina, and New Mexico. 3/ Preliminary.

Compiled from Potatoes, 1866-1950 [46]; Potatoes, 1866-1953 [51]; Potatoes and Sweetpotatoes, 1954-1959 [52] and supplements; and from records of the U.S. Economic Research Service.

Most of the production increase in this region during 1955-64 occurred in Minnesota and North Dakota, primarily in the Red River Valley. During 1962-64, production in these two States averaged 25 million hundredweight and comprised about half of the regional production. Although the gains in production in these two States were mainly associated with increased processing activity, improved storage facilities extended the marketing season in the area. Production also rose in Wisconsin because of new land development and in Michigan because of more processing.

The peak of marketings for Minnesota and North Dakota potatoes ranges from January through April. Marketings from Wisconsin and Michigan tend to peak in August-October but volume of marketings continues moderately heavy through March.

Western Region.--During 1962-64, the Western Region produced an average of about 90 million hundredweight of potatoes or about two-fifths of the late summer and fall crop total. Of the three regions, production increased the most in the Western Region (table 2).

Most of the production increase occurred in Idaho, where output more than tripled in the postwar period. Production averaged about 46 million hundredweight during 1962-64, comprising somewhat over half of the region's production.

Unquestionably, the sharp gains in potato production are in part associated with the increase in processing demand. Processing facilities for potatoes have grown rapidly, particularly in Idaho, which has by far the greatest number of freezing and dehydrating plants in the Northwest. In 1965-66, increased processing facilities were constructed in the state of Washington. About one-third of all freezing and dehydrating plants in the United States are located in the Northwest. Ample water for irrigation, and the opening up of new lands, were further developments that contributed to sharp increases in production in this region.

Marketings of Washington potatoes tend to peak during September-October; Oregon, Colorado, and Idaho marketings are relatively large from October through the following spring (54). Idaho potatoes tend to compete heavily in certain periods with potatoes grown in the Eastern and Central Regions. In 1962-64, in New York City and some other Eastern cities, unloads of Idaho origin during September-November were greater than unloads of Maine origin. In Chicago and in some other Midwestern cities, unloads of Idaho origin were about equivalent to unloads of Minnesota and North Dakota origin during March-April and exceeded them during May-June.

ECONOMIC RELATIONS WITHIN THE POTATO INDUSTRY

The purpose of this section is fourfold. First, the major economic relationships in the potato economy are identified. Second, a simplified price-consumption relationship is discussed and the nature of this relationship is verified by graphic analysis. Third, the nature of the demand for potatoes is discussed and the results of some of the statistical analyses are presented. Fourth, the nature of the competition between the seasonal potato crops is evaluated. The discussion on these four points involves relatively simple economic and statistical relationships; a more technical presentation is made in later sections of the bulletin.

Major Economic Relationships

The potato industry is more complex than is generally assumed and any analysis involving the study of its economic structure needs some systematic method to ferret out the relevant elements. Figure 2 illustrates the major economic relations that apply to the late summer and fall crop of potatoes. A similar set of relations could be developed for the other potato crops.

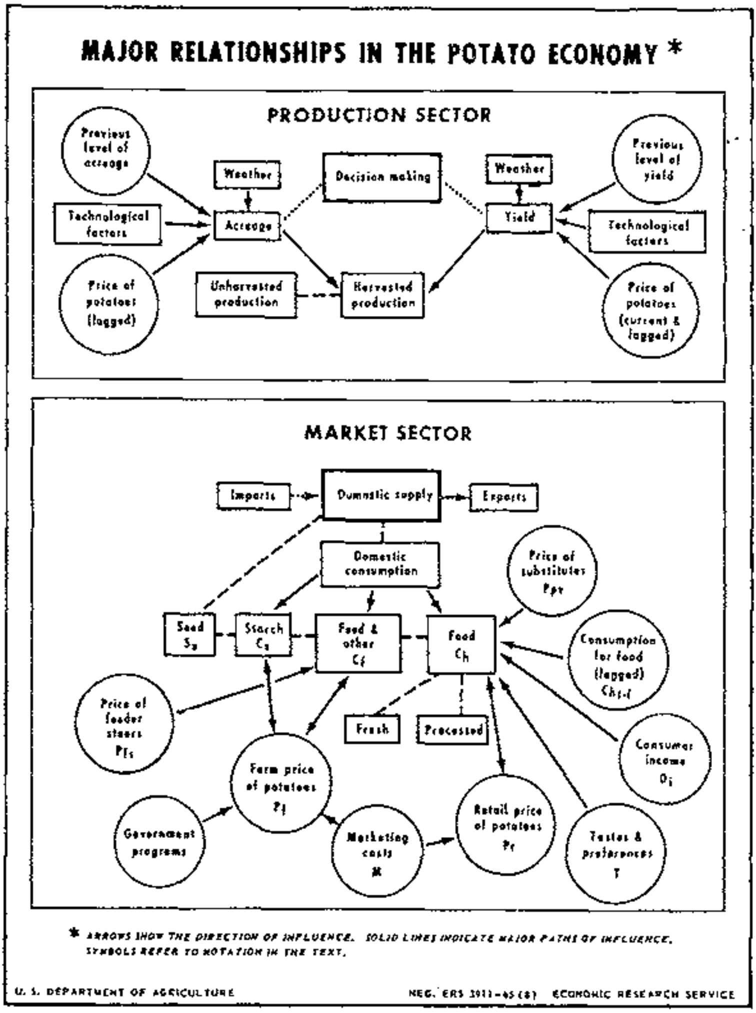


Figure 2

The potato industry may be grouped into a production sector and a marketing sector. In figure 2, the influences which are essentially physical, such as the production of potatoes, are represented by boxes, whereas influences which are primarily economic are shown in circles. The solid lines with arrows connecting the various items indicate the more important factors; broken lines without arrows indicate interrelated physical quantities; and dotted lines indicate relations between decision-making and operation. Arrows are used to indicate the principal direction of influence of each factor. Double-pointed arrows connect the variables that are believed to be jointly determined. The relative sizes of the boxes and circles do not necessarily indicate their relative importance.

As indicated in the production sector of figure 2, production is a composite of acreage and yield of potatoes per acre, each influenced by a set of factors. The number of acres planted to potatoes is influenced by past prices for potatoes, previous level of acreage, the state of technology, weather, and other factors that change slowly over time. Studies (18) have shown that potato growers respond to prices by varying not only potato acreage, but also certain inputs such as fertilizer, that affect yield per acre. Also, current levels of yield are associated with previous levels of yield. Other factors affecting yield are technology and weather. Statistical analyses for 1930-41 and 1951-56 showed that the elasticity of acreage for late summer and fall potatoes with respect to the previous year's price was in the neighborhood of 0.12. The elasticity of yield for the same crop of potatoes with respect to the previous year's price was about 0.10.

The market sector illustrates that potatoes are utilized in several ways (fig. 2). Sorting of potatoes into different lots by grades and sizes results in channeling the higher quality potatoes into food (and seed) and the less preferred grades and sizes into livestock feed and starch. As indicated by the double arrows in the diagram, prices and consumption for food, livestock feed, and starch are interrelated and factors affecting any one of these also indirectly affect the others in this group.

Variables that relate to the general economy, such as consumer disposable income, prices and quantities of competing foods, and tastes and preferences, are largely independent of the potato economy. Changes in these external or exogenous variables, however, affect changes in prices and consumption of potatoes. The study of current or projected behavior of prices and consumption of potatoes requires that estimates be made of the exogenous variables.

Figure 2 gives clues to the type of relationships needed to explain price and consumption of late summer and fall potatoes. The underlying assumptions for this and other seasonal potato models are given in the section on Statistical Models and Estimation.

The symbols in the boxes and circles refer to the variables included in the late summer and fall statistical model. The variables are identified on pages 116-123. Not all of the factors that appear in the diagram were used in the statistical model because of lack of data, and those with minor effects were excluded to keep the model statistically manageable.

Price-Consumption Relationships

The relation between prices and consumption of potatoes can be studied by simple research tools, such as graphic analysis, or by more sophisticated methods. The latter usually involve the formulation of statistical models and the processing of data on high-speed electronic computers. Fairly elaborate mathematical methods are frequently needed to give precise statistical measurements of price and demand relationships. But simple price-consumption relationships, worked out by graphic analysis, give the research worker a quick, preliminary research tool by which he can analyze the data and observe firsthand the relationships between the variables (62).

In this section a simplified relationship between the price and consumption of late summer and fall potatoes is graphically presented, allowing for the effects of certain exogenous variables such as consumer income, consumption of competing vegetables, and a time factor. The economic relationships given in figure 2 were the bases for selecting the important shift variables. The price-consumption relationship which is graphically presented is a net relationship and essentially traces out a Marshallian demand curve (26, pp. 96-99). A brief description of the variables involved in a price-consumption relation for late summer and fall potatoes is given in the following paragraphs.

Variables

Retail prices.--Retail prices for fresh potatoes are reported monthly by the Bureau of Labor Statistics (BLS). Prices are collected in 46 cities for potatoes of No. 1 grade, of the variety selling in greatest volume during the current month in the cities surveyed. Late summer and fall potatoes are sold in greatest volume from August through April.

The BLS retail price data are not completely consistent with consumption data for seasonal potato crops. Although the Statistical Reporting Service reports fresh market and processing utilization for the total U.S. potato crop, no such breakdown is available for the late summer and fall or other seasonal potato crops. However, this limitation appeared to have little effect on the regression analyses.

Potato consumption.--Conceptually, a good measure of consumption of potatoes for food by the civilian population in the United States would be a survey of consumers taken at frequent intervals to permit establishing a time series on consumption. However, such surveys are done infrequently and only for a short period of time, such as a week. Estimates of potato consumption used in this study are derived figures. They are computed by beginning with annual production data and subtracting from production the disappearance for all nonfood uses to arrive at an annual consumption estimate for each seasonal crop. Data on nonfood uses are available from utilization and disposition reports issued by the Statistical Reporting Service (48, 52). Annual gross consumption is divided by civilian population to get per capita consumption.

Consumption of late summer and fall potatoes for food varies much less than production. One of the reasons is that potatoes are a staple item in the diet. Despite variation in supplies and prices, consumers generally use about the same quantity of potatoes every year. Because of changes in acreage and yield, annual production of late summer and fall potatoes during 1950-64 varied from 1 to 25 percent. The production not used for food (and seed) moves into such outlets as livestock feed, starch, and waste.

Consumer income.--Traditionally, consumer income has been used as a demand shifter in statistical analyses. Income is assumed to affect the potato economy but not to be materially affected by it. However, for the postwar period statistical analyses designed to measure the effects of consumer income on price and consumption of potatoes from time series data have given inconclusive results. In many instances, the results have indicated little, if any, income effect.

A cross-section analysis of data contained in the 1955 Household Food Consumption Survey (47) indicates that consumption of potatoes was less in the bottom one-third of the income groups than for any other income group studied. However, consumption increased for every income class interval studied in this group up to $4,000, and it was about the same for all income groups between $4,000 and $8,000. For incomes over $8,000, consumption dropped slightly over 10 percent. Because of these divergent consumer responses to income, it may not be particularly meaningful to test hypotheses regarding aggregate income-consumption (or income-price) relationships. One interesting observation from the 1955 Food Consumption Survey is that families in the lowest income group purchased about 15 percent less potatoes than families in the middle-income group and 5 percent less than families in the highest income group. Further, the fact that families in the lowest income groups show gradually increasing consumption for each increase in income would suggest that potatoes are not an "inferior good."

Quantity of processed vegetables.--Preliminary graphic analysis suggested that processed vegetables, such as canned and frozen peas and sweet corn, might be a substitute food for potatoes. Processed vegetables are convenient and permit variety in food planning. Also, retail prices of processed vegetables are relatively stable while prices of many other foods vary substantially. This might tend to encourage purchases of processed items over that of others.

Time trend.--Certain changes in consumption and prices--such as those resulting from changes in tastes and preferences, changes in technology which can affect demand as well as supply, and changes in composition of foods in the market basket--take place slowly over time. Time trend may be used as an exogenous variable in a regression analysis to take account of these changes.

Waugh (63) in a recent publication showed that most of the variation in prices of individual foods and of total food was associated with changes in consumption and consumer income. But he also noted that, in some cases, formulations relating price and consumption of foods could be improved by taking account of time trend. This is true if a continuous shift in demand takes place gradually over a prolonged period of time. But as Manderscheid (25) has indicated, the assumption that the effect of changes in taste and preferences on consumption is gradual over time may be inadequate. However, his studies indicate that for some foods this assumption may still serve as a reasonable first approximation even though the demand curve may have shifted in several abrupt changes.

267-387 O - 67 - 2

Graphic Analysis

The relationships of the variables discussed above to price of potatoes can be illustrated by graphic analysis (fig. 3). The graphic analysis assumes that the retail price of potatoes is related to consumption of potatoes, consumer income, consumption of processed vegetables, and a trend factor. The data used in this analysis are on a crop year basis. Retail price of potatoes and disposable income are deflated by the BLS consumer price index, 1947-49=100. The income and consumption variables are on a per capita basis. In this simplified analysis no account was taken of competing supplies or prices of other crops of potatoes. The analysis covers the postwar period, 1948 through 1963.

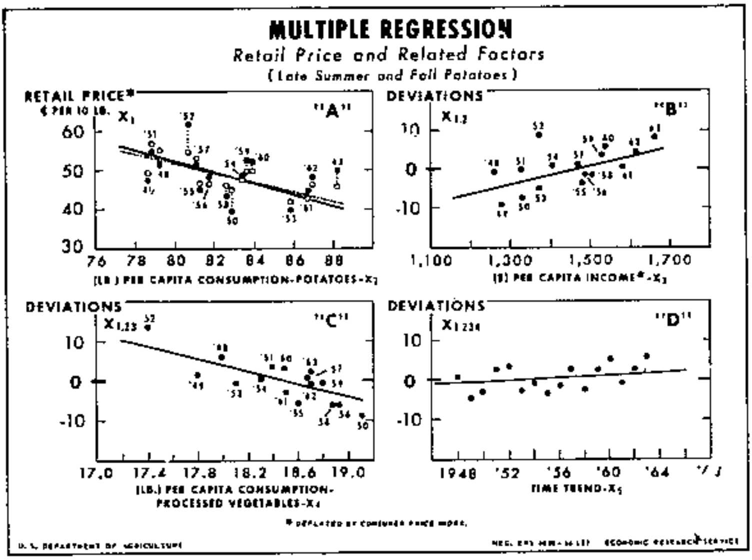


Figure 3

In section A of figure 3, values of retail price for each year are plotted on the vertical axis against values of per capita consumption of potatoes for corresponding years. That is, each black dot represents some combination of price and consumption for a given year. The solid line shows the line of average relationship between retail price and consumption of late summer and fall potatoes and represents the "best" line of fit that could be drawn freehand.

Next, deviations from the line of average relationship in section A for each year are plotted against the data for income for corresponding years in section B. This is done to see if income can explain any of the variation (deviations from line of relationship in section A) in prices not explained by consumption. Again, a line of average relationship is drawn. The deviations now represent that part of the variation in price that cannot be explained by consumption and consumer income.

Deviations from the line of average relationship in section B are then plotted against per capita consumption of processed vegetables in section C. The line of average relationship in section C represents the net relationship between price of potatoes and consumption of processed vegetables, after allowing for the effects of consumption of potatoes and consumer income. Next, the deviations in section C are plotted against time in section D, and again a line is drawn through the scatter. To complete the initial procedure the deviations from the line of relationship in D are plotted as deviations from the line of average relationship in section A (shown as open circles).

The next step is to see whether a new line would give a better fit. The broken line is such a line; it shows the net relationship between price and consumption, after allowing for the effects of changes in disposable income, per capita quantity of processed vegetables, and time trend. The open circles show the net scatter between the variables and represent the deviations fror.. the net relationship that could not be explained by the four explanatory variables.

One apparent observation in section A is that a straight line appears to fit the data as well or better than any other type of curve. This suggests that the form of the relationship is a linear function. This information is recognized in choosing the form of the data used in fitting the statistical model for late summer and fall potatoes, discussed in a later section. Based upon the regression line in section A, we would expect an approximate change of 1.5 cents per 10-pound bag in retail price for a change of 1 pound in consumption for food, in the opposite direction. Adding the years 1961, 1962, and 1963 to the analysis caused the price-consumption line to become considerably flatter than the line which fitted the earlier years of the postwar period.

The line of average relationship in section B indicates a tendency for prices of late summer and fall potatoes to rise with increases in income. For the first part of the period, i.e. for 1948-53, the scatter appears to be greater around the line than for the remainder of the period. Examination of the original data (black dots) in section A shows that this was the period of greater than average variation in retail prices.

As expected, the slope of the average line of net relationship in section C shows a negative slope. It indicates that when quantity of processed vegetables was relatively high, retail price of potatoes tended to decline. Increased supplies of processed vegetables result in lower prices and increased consumption. Since processed vegetables may be substitutes for potatoes, an increase in consumption of these products may adversely affect consumption of late summer and fall potatoes.

In section D, the slope of the trend line, fitted freehand, is barely observable. The indication is that deflated prices for fresh potatoes during 1947-64 were not associated with any significant changes in tastes and preferences. This aspect is discussed further in the section on consumption and price trends in connection with relative stability of demand for late summer and fall potatoes.

The relationships developed in this graphic analysis may be used to predict the retail price of potatoes, if information on consumption of potatoes, consumption of processed vegetables, and consumer income is known or can be estimated by other means. For example, suppose that for the 1965-66 crop year, we estimated as follows: Per capita consumption of potatoes, 86 pounds; per capita disposable income, $1,839; and per capita consumption of processed vegetables, 18.8 pounds. From section A we read off a retail price of 44 cents per 10-pound bag, which corresponds to consumption of 86 pounds. From section B we add

9 cents, for the effect of income, to this figure. Next, from section C we deduct 3 cents for the effect of consumption of processed vegetables, and section D indicates that we add 1 cent for trend. This gives us an estimate of 51 cents per 10-pound bag. The actual deflated retail price for 1965-66 turned out to be 52.6 cents. In this case, the lines of average relationship gave a good estimate.

Nature of Demand

In the preceding pages, a relationship between price and consumption for late summer and fall potatoes was indicated from the graphic analysis. The line of average relationship drawn in section A of figure 3 might be regarded as a market demand curve for late summer and fall potatoes at the retail level. It showed various prices consumers were willing to pay for different quantities of potatoes, while holding other factors such as income at some constant level. As expected from economic theory, smaller quantities are associated with high prices and larger quantities with low prices. Similar demand functions could be graphically constructed for other seasonal crops. Each would most likely appear somewhat different depending on the nature of demand for each.

Elastic and Inelastic Demand

To permit comparisons among commodities and to evaluate the demand for these commodities, it is often convenient to express in percentage terms the change in consumption connected with a change in price. Thus, a 10-percent drop in price may result in a 10-percent rise in the quantity demanded. In this case the percentage drop in price is equal to the percentage rise in purchases; economists term this "unit elasticity" of demand. It implies a constant total revenue. If the percentage increase in quantity purchased is greater than the percentage decline in price, demand for the commodity is elastic and as price falls total revenue increases. But if the percentage increase in consumption is less than the percentage decrease in price, demand is inelastic and total revenue declines as price falls.

The factors that determine whether different types of potatoes have an elastic or inelastic demand are: (1) The number of uses for the commodity, (2) the number and closeness of substitutes, (3) the strength of preferences for particular foods, and (4) the importance of the expenditure for that food in relation to the food budget.

In general, the commodities that have many uses tend to have more elastic demands. Also, commodities that have close substitutes tend to have elastic demands.

Price elasticity of demand for a given crop of potatoes is not the same at all marketing levels. The demand for potatoes is more inelastic at the farm level than at the retail level. The difference depends on the level of marketing services performed. Price elasticity at the farm level becomes progressively smaller relative to price elasticity at retail as the level of marketing charges increases.

A classification of price elasticities for potatoes by seasonal category is given in table 3. This classification summarizes, in general terms, the elasticities implied in the statistical results presented in the section on Statistical Models and Estimation. This table illustrates the wide range of differences in price elasticity of demand for different types of potatoes. It shows that early potatoes exhibit a much

Table 3.- Classification of relative price elasticities for potatoes, by seasonal category, and by form (fresh or processed), postwar period, United States 1/

Seasonal category	Fresh form	Processed form 3/
Winter and early spring	Elastic	Elastic
Late spring	Moderately inelastic	Elastic
Early summer	Moderately inelastic	Elastic
Late summer and fall: 2/		
Full season	Markedly inelastic	Elastic
January-April	Markedly inelastic	Elastic
May-June	Elastic	Elastic

1/ Evaluation of elasticities takes the following form: Elastic, elasticity coefficient ≥ 1; moderately inelastic, elasticity coefficient ≥ 0.5 but < 1.0; markedly inelastic, elasticity coefficient > 0.0 but < 0.5.

2/ Regression analysis for the full season includes quantities and prices of late summer and fall potatoes for August-April. The regression for fall (storage) potatoes (January-April) is for quantities and prices included in the winter and early spring market. The regression for fall (storage) potatoes (May-June) is for quantities and prices included in the late spring market.

3/ From statistical analysis of price and consumption relationships for frozen french fries based on quarterly data, 1956-63, which showed a price elasticity greater than -1.0 (analysis not shown).

higher price elasticity than late potatoes over the entire storage season. But price elasticity for storage potatoes in the winter and spring is higher than in the fall. This is as expected, since storage potatoes compete fairly closely with early potatoes in winter and spring, but have the total market to themselves in the fall.

Demand in Different Utilizations

Different uses of potatoes have different price elasticities of demand. Also, the price elasticities of demand in the different uses may change over time. Figure 4 shows the utilization pattern for late summer and fall potatoes. Also, it illustrates changes in elasticities of demand and utilization patterns between two periods. It attempts to approximate the demand curves for starch, C_{s2}, for livestock feed, C_{f2}, and for food, C_{h2}, during the postwar period, 1947-60. Similar demand curves are shown for the same three uses (C_{s1}, C_{f1}, and C_{h1}) for 1921-41. These hypothetical demand curves were drawn to reflect the average situation that prevailed during these two periods. They indicate in general terms the elasticities obtained from statistical analyses. 2/ Within the range of the average of the economic variables, the implied elasticities obtained from regression analysis for 1947-60 were -1.0 for potatoes used for starch, -0.5 for livestock feed, and -0.2 for food. For 1921-41 the price elasticities obtained were -0.25 for starch, -0.8 for feed, and -0.25 for food. Since the demand curves are linear, these elasticities apply in a statistical sense only to the portion of the curve in the neighborhood of the average values of the economic variables.

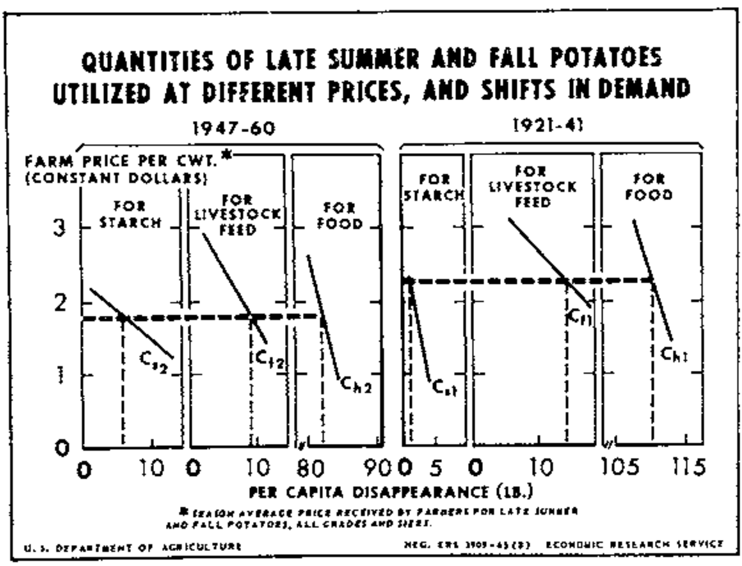


Figure 4

2/ The statistical analyses for 1947-60 begin on page 40. The analyses for 1921-41 are not published in this bulletin.

The horizontal broken lines in figure 4 represent the average price received by farmers for late summer and fall potatoes for each of the two periods. The average price was $1.80 per hundredweight during 1947-60 and $2.27 during 1921-41. For the purposes of this example, the same price is used for all outlets. In actual practice the grades and sizes of potatoes going into each outlet are not the same. Therefore, a more realistic diagram might use some equivalent price for each outlet or a price that took account of these differences. The broken vertical lines which intersect the price lines and the different demand curves represent the average quantity of potatoes going into each use in the two periods. The average annual per capita use for 1947-60 was 6.1 pounds for starch, 9.2 pounds for livestock feed, and 81.9 pounds for food. For 1921-41, average per capita use was 1.0 pound for starch, 14.2 pounds for livestock feed, and 110.5 pounds for food.

Because of differences in price elasticity, the effect of changes in potato production (supply) is not the same in all uses. An increase in supply will result in a relatively larger increase in that use having the greater price elasticity. Thus, an increase in production of potatoes in any year results in a relatively large increase in use for starch, a moderate increase in the use for livestock feed and a slight increase in the use for food. For example, referring to the left-hand portion of figure 4, an increase in production would result in the lowering of the broken price line. It can be observed that as the price line is lowered, the quantity for starch will increase faster than the quantity for livestock feed during 1947-60, and in turn, use for livestock feed will increase at a faster rate than food use. As expected, if prices rise because of a decrease in supply, use for starch will fall most rapidly and a decline of lesser proportions will also occur in the use for livestock feed. And, as suggested by the relative differences in the slopes of the demand curves, if prices of potatoes rise substantially, the lower use categories may be eliminated.

So far, we have been considering short-run adjustments in utilization and associated differences in elasticities. In the longer run, other considerations are reflected in the utilization pattern. The biggest shift (in absolute terms) in utilization from 1921-41 to 1947-60 was the substantial drop in per capita consumption of potatoes for food. In relative terms, the biggest shift was the decline in the use of potatoes for livestock feed. On the other hand, there was a gain in use of potatoes for starch. In addition, while the price elasticity of demand for potatoes for food remained about the same and that for livestock feed changed only moderately, the demand for starch became considerably more elastic. The increase in price elasticity for starch probably resulted from greater plant capacity and from USDA supplementary payments under potato diversion programs, which permitted heavier use for starch in years of excessive production.

Substitution and Competition in Early Potato Markets

The four seasonal markets--late summer and fall, winter and early spring, late spring, and early summer--are identified with time of sale of potatoes, whether from production directly or from storage stocks. Some potato crops, particularly the more perishable, are marketed for final use immediately after harvest. Most of the late summer and fall crop is first stored and then marketed for final use from storage.

Figure 5 shows approximately when the different potato crops are marketed for final use and identifies the period in which supplies of one crop compete with supplies of another crop. The first and by far the largest is the late summer and fall crop. It is the only crop marketed during the fall (September through December). In the winter and early spring market (January through April) this crop (as storage potatoes) competes with early potatoes marketed during winter and early spring. In May and June (the late spring market), diminishing supplies of storage potatoes compete with early potatoes harvested and marketed during late spring. In the early summer market (July-August), early summer potatoes compete with late spring potatoes in July and with the coming late summer and fall crop in August.

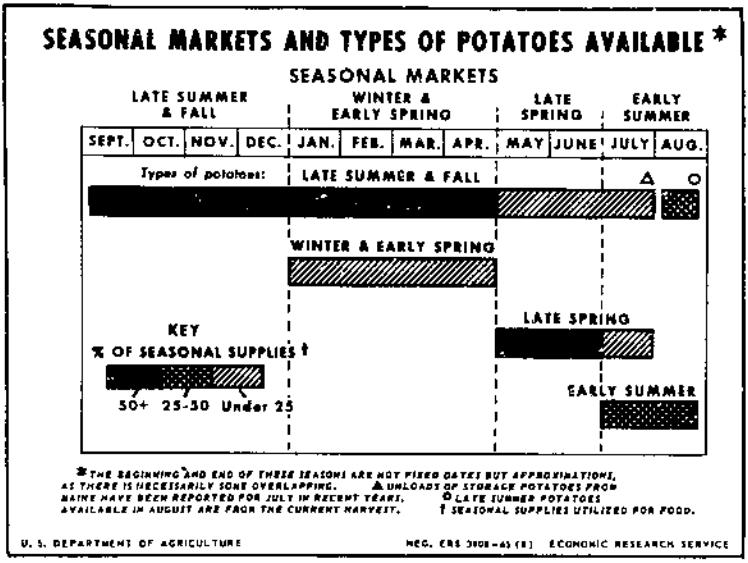


Figure 5

The following discussion specifies the characteristics of a seasonal potato market and suggests a set of criteria which may be used to determine the degree of substitution among the different types of potatoes (also, see (20)).

Characteristics of A Seasonal Potato Market

As indicated, various early-crop potatoes are available at retail markets during different seasons from January through August. Each of the early potato crops appears for a limited time because of a short harvest season and high perishability.

In the earliest seasonal market (winter and early spring), early crop potatoes from Florida and Southern California compete with relatively large supplies of storage potatoes, widely available in the northern tier of States. In the late spring market, supplies of late spring potatoes, mostly from California and the Southeastern States, compete with lesser supplies of storage potatoes, chiefly from Idaho and Maine. In the early summer market, early summer potatoes (primarily from Virginia, Delaware, and Texas) compete with limited supplies of late-maturing late spring potatoes and early-maturing late summer potatoes.

Although the different potato crops are produced in different parts of the country, interregional shipments of potatoes within a season make possible competition in a single economic market. Shipments from Western areas to Midwestern and Eastern metropolitan centers have been much greater than shipments from East to West. Different seasonal markets may find different degrees of penetration of the various potato crops. The extent of dominance of a particular potato crop varies by seasons. Figure 5 identifies the dominant potato crop in each seasonal market. In the winter and early spring market, fall (storage) potatoes constitute more than 90 percent of supplies. In the late spring market, late spring potatoes make up just over 50 percent of total volume. In the early summer market, early summer potatoes typically account for about 50 percent of supplies. During the September-December period, late summer and fall potatoes constitute essentially the entire supply.

Marketings of late summer and fall potatoes are distributed so that certain regions tend to market them in a succeeding pattern. This tends to produce an even flow of supplies to the principal markets. For example, in 1963 and 1964, unloads in the New York City wholesale market were moderately large in August for western-grown potatoes from Washington, and eastern-grown potatoes from Long Island (N.Y.). Supplies from these States generally increased through October and then declined somewhat. From September through December the market was supplied from the late summer and fall crop alone. Maine and Idaho potatoes appeared in volume from November through spring. In 1964 and 1965, marketings from Long Island declined in volume in the spring, but marketings from Maine continued heavy through June, and those from Idaho were heavy through May. During this period, diminishing supplies of storage stocks competed with early potatoes.

In the Chicago wholesale market for the same period (1963-65), unloads of late summer and fall potatoes from Washington and Wisconsin were moderately heavy in August. Lighter volume unloads from these States followed in October-December. In the latter months, potato unloads from North Dakota and Idaho appeared in greatest volume, followed by lesser volume unloads from Minnesota. During these months the market was supplied solely from the late summer and fall crop. For 1964 and 1965, spring unloads, January through May, from North Dakota were about one-third greater than those from Idaho and 2.5 times greater than those from Minnesota. Diminishing supplies of storage stocks competed with early potatoes from the spring potato-producing States.

Substitution Between Different Types of Potatoes

Potatoes are not a homogeneous product. Potatoes sold in different seasonal markets differ (1) in outward appearance and internal qualities, (2) in selling price, and (3) in promotional efforts to gain consumer acceptance. Consumer preferences for certain types of potatoes may be influenced by attributes of outward appearance, such as "russet" skin or "smooth" skin. Or preferences may arise through anticipated qualities of the cooked potato, such as "mealy" or "moist." Different promotional practices are in evidence for different varieties, qualities, sizes, and grades of potatoes. Direct promotional efforts are exhibited through brand names and packaging. Consumers in winter and early spring are made aware that early potatoes are offered in the retail stores. Because of a unique demand, this crop of potatoes is higher priced than storage potatoes.

Consumers recognize differences and pay higher prices for potatoes of their choice. Thus, different crops of potatoes may be considered differentiated products selling at different prices. For example, in recent years, wholesale prices on the New York market for winter and early spring potatoes averaged four-fifths higher than prices for storage potatoes of good quality.3/ Also, wholesale prices for Western Russet potatoes on the New York market averaged 2 times higher than prices for Maine Round White potatoes of good quality. Varietal characteristics have been given as the explanation for consumer preference for many differentiated products (4).

In the present study, competition between different crops of potatoes is examined by testing for the degree of substitution between early potatoes and storage supplies in each of the seasonal potato markets. Certain criteria are needed to evaluate the degree of competition and substitution. W. W. Cochrane (5) sets up the following criteria for evaluating competition between differentiated but closely competing products: First, if price of a given product is affected significantly by supplies of a competing product, then sellers of these products are in competition and operate in the same economic market. Second, there must be common attributes, including external forces which tend to link two or more products into the same market pattern.

The first type of evaluation can be carried out on the basis of cross elasticities of the respective products. Products that are highly competitive have cross elasticities that are high and positive. Products that are not close substitutes have cross elasticities that are small, approaching zero. Closely competing products have nearly equivalent direct and cross price elasticity coefficients, but of different sign. For the second type of evaluation, such exogenous forces as disposable income, marketing costs, and underlying trends are expected to affect prices and consumption of potatoes similarly. However, in the latter case, caution must be exercised, as many products are affected similarly but are not substitutes.

Bishop (3) suggests that both direct and cross elasticities of demand must be evaluated to determine competition between products.4/

3/ Average wholesale price, January through April, 1960-64, on the New York wholesale market was $6.16 per hundredweight for winter and early spring potatoes, compared to $3.42 per hundredweight for storage potatoes for the same period. Average wholesale price, for the same period, on the New York wholesale market was $5.52 per hundredweight for Western Russet potatoes, compared to $2.73 per hundredweight for Maine Round White potatoes.

4/ Direct price elasticity is defined as

$$E_{ii} = \frac{\partial q_i}{\partial p_i} \cdot \frac{p_i}{q_i}$$ where $\frac{\partial q_i}{\partial p_i}$ is the change in quantity, q_i, of the i^{th} commodity associated with a unit change in price, p_i, of the i^{th} commodity.

Cross price elasticity is defined as

$$E_{ij} = \frac{\partial q_i}{\partial p_j} \cdot \frac{p_j}{q_i}$$ where $\frac{\partial q_i}{\partial p_j}$ is the change in quantity, q_i, of the i^{th} commodity associated with a unit change in price, p_j, of the j^{th} commodity.

A simplified analysis follows, utilizing the criteria relating to direct and cross elasticities for application to results from regression analysis. Estimates of direct price elasticities are compared with estimates of cross price elasticities in each of the three early markets to determine the extent of competition among different types of potatoes. More detailed results from the statistical analyses are reported in the section beginning on page 40. Because the elasticities used in the following evaluation are estimates based on regression analysis, they are not precise. Hence, the conclusions based on similarities and differences of elasticities must also be of a general nature.

Winter and Early Spring Market

The direct price elasticity for winter and early spring potatoes was found to be -2.6, indicating an elastic demand for this type of potatoes. Cross price elasticity with respect to the price of storage potatoes (January-April) was 2.0. Comparison of direct and cross price elasticities indicates that storage potatoes compete quite closely with winter and early spring potatoes. Thus, there is a substantial degree of substitution of winter and early spring potatoes for storage potatoes.

Late Spring Market

The direct price elasticity for late spring potatoes was found to be -0.6, indicating a moderately inelastic demand for this type of potatoes. Cross price elasticity with respect to price of storage potatoes (May-June) was 0.4. The comparison between direct and cross price elasticities indicates that the two types of potatoes are in fairly close competition. This suggests a moderate to substantial degree of substitution of late spring potatoes for storage potatoes.

Early Summer Market

The direct price elasticity for early summer potatoes was found to be -0.7, indicating a moderately inelastic demand for this type of potatoes. Cross price elasticity of early summer potatoes with respect to price of late spring potatoes was 0.4, and with respect to price of late summer potatoes, 0.3. From these results it appears that the cross elasticity for early summer potatoes with respect to prices of competing crops (late spring and late summer) is considerably lower than the direct price elasticity. These results suggest only a moderate degree of substitution of early summer crop potatoes for competing types of potatoes.

CONSUMPTION AND PRICE TRENDS

The research employed in a demand study involves the analysis of the shifts in demand as well as the level of demand. Shifts in demand can be studied in a preliminary way by graphs or tables, which show relative movements in price and consumption over time. If the retail price of a food commodity increases and consumption remains essentially the same, we may assume an upward shift in demand. If retail prices remain the same and consumption increases, again we may assume an upward shift in demand. Further, trends in the retail value (price x consumption) also provide some clues to what is happening to demand.

Retail prices, adjusted for the general price level, for late summer and fall potatoes (August-April) maintained about the same level from

1950 to date. Consumption of late summer and fall potatoes was relatively stable through 1960, but has increased a little since then. Viewed from the standpoint of relative price and consumption trends, the relatively stable retail price and the slight increase in consumption indicate a slight upward shift in demand for this seasonal crop, probably due to processing.

Trends in Consumption of Potatoes

Per capita consumption of potatoes followed a persistent downtrend during the first half of the present century, declining from 198 pounds in 1910 to only a little more than half that amount by 1950.

Previous studies attributed the long-term decline in consumption to several factors. Scott and Mumford (36) in a 1949 study mentioned the following: (1) A rising standard of living associated with increasing incomes, (2) increased availability of other vegetables and a desire for variety in the diet, (3) a lesser need for high-calorie foods in present-day occupations, and (4) progressive urbanization of the U.S. population. Gray, Sorenson, and Cochrane (15) in a 1954 study included (1) declining immigration of people accustomed to heavy potato consumption, (2) the "fight from calories" explanation, and (3) variations of a "present-day civilization" argument, consisting of the following: Apartment dwellers have little storage space for potatoes, modern housekeepers prefer convenience foods requiring little preparation, and modern housewives with outside jobs have little time for meal preparation. Gray, et al. (15), emphasized that each explanation may be only a partial answer and may be interrelated or overlapping. The decline was near the leveling-off point at the time these studies were made.

While these factors still may be affecting potato consumption somewhat, it appears that their influence has weakened materially. Total per capita consumption of potatoes has shown no significant trend since 1950 (fig. 6).

Recent Developments

Since 1950, there appears to be little relationship between total consumption of potatoes and rising incomes. There are, however, differing consumer responses with respect to purchases of potatoes for households with high, medium, and low incomes. Households in the low-income group tend to buy more potatoes with increases in income and households in the high income group tend to buy less (47).

During 1920-30, the increased availability of other vegetables appeared to be a factor affecting total consumption of potatoes. Due to improved methods and facilities for handling and transporting perishable commodities, fresh vegetables became available in large supply during all months of the year. Output of canned and frozen vegetables increased steadily. Although the production and per person use of processed vegetables continued to rise, consumption of fresh vegetables has declined moderately and since 1950 there has been no significant trend in total per capita consumption of vegetables (table 4).

Although some misunderstanding may still exist, the belief that potatoes are a high-calorie ("fattening") food has been largely dispelled. Fincher and others (6, 10, 60) have emphasized the nutritional value of potatoes. More particularly, they have shown that diets in general

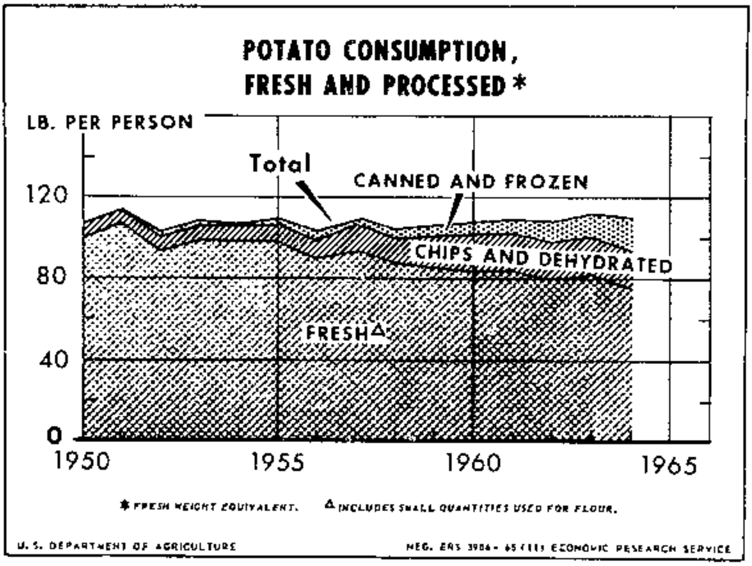


Figure 6

Potato consumption, fresh and processed, 1950-64 1/

Year	Fresh	Chips and dehydrated	Canned	Frozen	Total 2/
	Pounds	Pounds	Pounds	Pounds	Pounds
1950	100.0	5.7	0.3	0.3	106.3
1951	106.8	6.0	.2	.6	113.6
1952	93.8	6.7	.5	.9	101.9
1953	99.1	7.3	.6	.8	107.8
1954	98.1	7.6	.3	1.1	107.1
1955	98.1	8.4	.6	1.8	108.9
1956	90.3	9.0	.6	2.9	102.8
1957	94.2	11.7	.6	2.9	109.4
1958	87.6	12.9	.6	3.4	104.5
1959	86.2	14.9	.5	4.9	106.5
1960	84.4	16.8	.6	6.4	108.2
1961	84.4	17.4	.7	6.8	109.3
1962	80.4	17.9	.6	9.2	108.1
1963	81.8	19.1	.5	10.7	112.1
1964 3/	75.1	20.3	.6	14.0	110.0

1/ Fresh weight equivalent.
2/ Calendar year.
3/ Preliminary.

are apt to be deficient in ascorbic acid (vitamin C). Potatoes are rich in this nutrient. Further, nutritionists have pointed out that potatoes contain sizable amounts of important minerals, such as calcium and phosphorus. Dissemination of these findings may have helped to stabilize the use of potatoes in individual diets.

A significant development in recent years has been the appearance on the market of a great variety of processed potato products. Consumer environment in the postwar period has been favorable for purchases of convenience foods. The increased availability of processed potato pro- 'ucts neatly fits into this pattern. When the housewife shops today, she uys not only food (nutrients), but also marketing services, such as stor-

Table 4.- Commercially produced vegetables: Civilian per capita consumption, 1950-64

Year	Fresh equivalent				
	Total fresh and processed	Fresh 1/	Processed 2/		
			Total	Canned	Frozen
	Pounds	Pounds	Pounds	Pounds	Pounds
1950	199.2	115.2	84.0	76.6	7.4
1951	200.8	111.9	88.9	79.6	9.3
1952	199.7	111.6	88.1	76.8	11.3
1953	200.2	109.1	91.1	79.4	11.7
1954	196.2	107.2	89.0	76.8	12.2
1955	198.7	105.1	93.6	80.5	13.1
1956	202.3	107.0	95.3	81.5	13.8
1957	202.0	106.4	95.6	81.4	14.2
1958	201.6	103.7	97.9	82.7	15.2
1959	200.9	102.9	98.0	82.6	15.4
1960	205.2	105.8	99.4	83.5	15.9
1961	204.5	104.9	99.6	83.5	16.1
1962	206.7	102.8	103.9	86.2	17.7
1963	207.8	102.9	104.9	87.8	17.1
1964 3/	204.3	98.7	105.6	87.2	18.4

1/ Excluding melons. 2/ Data include pickles and sauerkraut in bulk; exclude canned and frozen potatoes, canned sweetpotatoes, canned baby foods, and canned soups. 3/ Preliminary.

Compiled from The Vegetable Situation, October 1965 [58].

age, food preparation time, and packaging. A USDA study (8) showed that income elasticity for marketing services is markedly higher than income elasticity for food. The convenience foods, of which processed potato products are a striking example, are increasing in popularity.

Although total per capita consumption of potatoes has been fairly steady since the early 1950's, there have been continued shifts in the forms used. Consumption of fresh potatoes declined from 100 pounds per person in 1950-52 to about 80 pounds in 1962-64. Population gains were sufficient to maintain total fresh sales through 1961. But subsequently, total fresh food use has declined. Many segments of the potato industry are aware that better marketing practices, such as closer grading and sizing, improved packaging, and more careful handling, are necessary to slow the trend away from sales of fresh potatoes. Pusateri (33) discussed recommendations for production and marketing of high-quality fresh potatoes.

Per capita use of processed potato products increased from 6 pounds (fresh equivalent basis) in 1950-52 to about 30 pounds in 1963-64, with large increases in all leading forms. Use of chips and dehydrated items increased from 5 to about 19 pounds, or about 2.8 times; canned products increased from 0.4 to 0.5 pound, or one-fourth; and frozen products increased from 0.6 to 11 pounds, or 17 times. The relatively large increase in consumption of frozen products reflects popularity with the institutional trade, where convenience, uniformity of quality, and portion control are particularly important requirements. Frozen food pack statistics for 1964 (30) indicate that about two-thirds of the output of frozen french fries and other frozen products are put up by food manufacturers in institutional and bulk containers. It appears that most of the supplies of dehydrated products also move into restaurant and institutional outlets.

Though data on sales of frozen french fries in restaurants are not available, data on sales of all food by away-from-home eating places give an indication of the importance of the restaurant trade. Away-from-home eating places reported an increase in food sales from $9.4 billion in 1956 to $15.7 billion in 1965, or 68 percent (41). Even after allowing for a 16 percent increase in the consumer price level, it can be seen that the volume of food eaten away from home by the people in this country has increased substantially.

Substitution of other starchy foods, although frequently mentioned, does not appear to have made any important inroads on potato consumption. The following section discusses production or consumption of these possible substitutes.

Trends in Consumption of Related Foods

Figure 7 shows trends from 1950 to 1964 for annual per capita consumption of potatoes, commercial vegetables, and all cereal products. Per capita consumption of potatoes and commercial vegetables was about maintained during this period but consumption of total cereal products declined almost 15 percent.

Like potato consumption and for generally similar reasons, total per capita consumption of vegetables remained at about the same level for 1950-64. There appears to be no relation between total vegetable consumption and rising incomes. Also, the convenience aspect of processed vegetables has notably increased their use, with an associated

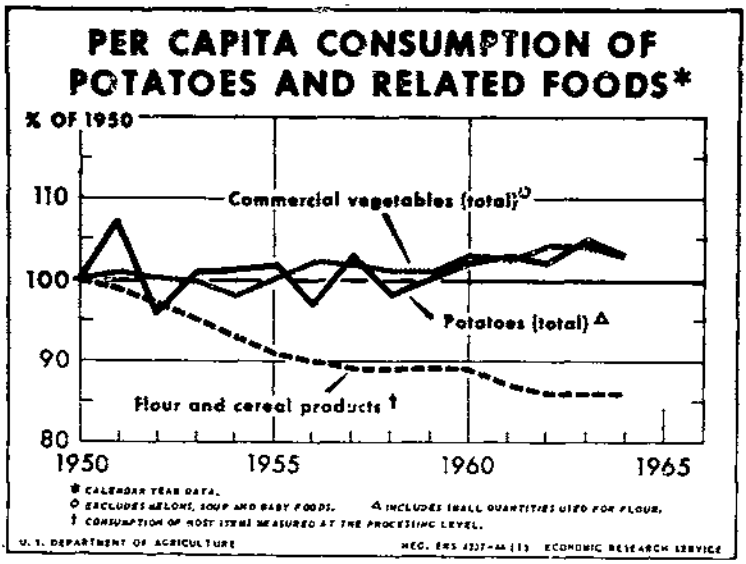


Figure 7

Potatoes and related food categories: Index numbers of per capita consumption, 1950-64 1/

1950 = 100

Year	Consumption per capita		
	Total potatoes	Total commercial vegetables 2/	Total cereal products
1950	100	100	100
1951	107	101	99
1952	96	100	97
1953	101	100	95
1954	101	98	93
1955	102	100	91
1956	97	102	90
1957	103	102	89
1958	98	101	89
1959	100	101	89
1960	102	103	88
1961	103	103	87
1962	102	104	86
1963	105	104	86
1964	103	103	86

1/ All data are calendar year estimates.
2/ Excludes melons. Includes fresh and processed, fresh weight basis.

Compiled from data in the Vegetable Situation, October 1965, (58), from U.S. Food Consumption, (56) and from records of the U.S. Economic Research Service.

decline in consumption of fresh vegetables. Housewives increased their purchases of canned vegetables almost 15 percent during 1950-64, from an already relatively high level, and purchased 2 1/2 times more frozen vegetables in 1964 than in 1950.

During 1947-64, per capita consumption of total cereal products declined but consumption trends differed among individual products. Production of rice for food, although only one-sixteenth as large in volume as potatoes, increased approximately 30 percent. Due to a desire for variety in foods in conjunction with more internationality in cooking, rice has found increased use by American housewives in food planning.5/ The advent of "instant" rice products, popularized as convenience foods, added to total rice consumption.

Production of semolina flour, from which macaroni and noodles are made, although highly irregular from 1950-52 to 1962-64, declined about 30 percent from the beginning to the end of the period. Production of wheat flour declined about one-sixth during the same period. Per capita consumption of semolina flour in the United States is slightly smaller than that of rice. Thus, though semolina flour and rice are sometimes thought of as substitutes for potatoes, the American diet contains less than one-eighth as much of these products as of potatoes.

Trends in Prices of Potatoes and Related Foods

After 1950, retail prices of potatoes increased a little more than the consumer price indexes for all food and for all consumer goods and services (fig. 8). Prices for food eaten away from home rose progressively higher during the period compared to prices for all food (59). The price increase for potatoes over time reflects the higher cost of existing marketing services as well as improvements in marketing. From 1950 to 1964, the cost of marketing services for potatoes rose slightly more than 90 percent while that for all food rose about 40 percent.

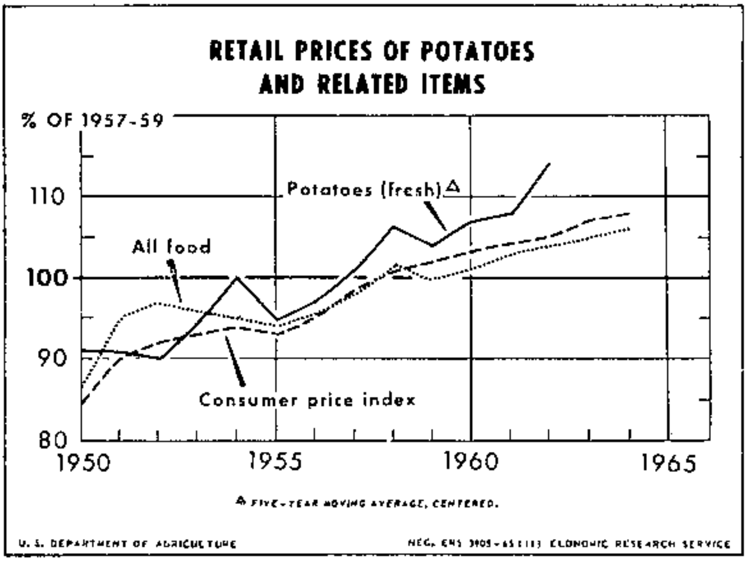


Figure 8

5/ Of interest is the comparison of starch content of rice with that of potatoes. Tables of food values in the 1959 Yearbook of Agriculture (50, pp. 252-262) show that 1 cup of boiled rice (1 serving) contains 45 grams of carbohydrates (starch) while 1 medium-boiled or baked potato (1 serving) contains only 21 grams.

287-387 O - 67 - 3

Table 5.- Index numbers of retail prices for potatoes and related foods, 1950-64 1/

(1957-59=100)

Year	Potatoes		Vegetables		Cereals and bakery products
	Fresh 2/	Frozen french fries	Fresh 4/	Processed 5/	
	Index	Index	Index	Index	Index
1950	74	3/	78	96	79
1951	81	3/	91	107	86
1952	122	3/	93	104	88
1953	89	3/	88	105	90
1954	86	3/	85	104	92
1955	93	3/	91	98	93
1956	111	3/	94	100	95
1957	94	98	98	98	98
1958	103	103	101	101	100
1959	104	99	101	101	101
1960	118	101	99	102	103
1961	104	100	96	107	105
1962	105	96	106	106	108
1963	108	93	106	105	109
1964	133	92	110	106	110

1/ All data are calendar year estimates.

2/ Variety of potatoes, U. S. No. 1 grade, sold in greatest volume within season.

3/ Data not collected prior to 1957.

4/ Estimated for 7 important vegetables. Potatoes, sweetpotatoes, and melons excluded.

5/ Canned only.

Compiled from reports of the U. S. Bureau of Labor Statistics [43] and from records of the U. S. Economic Research Service.

Table 6.--Farm, wholesale, and retail prices and price spreads for potatoes, 1950-64 1/

Year	Price per hundredweight--			Price spread per hundredweight--			Ratio of farm to retail prices
	Farm 2/	Wholesale 3/	Retail 4/	Farm-wholesale	Wholesale-retail	Farm-retail	
	Dol.	Dol.	Dol.	Dol.	Dol.	Dol.	
1950	1.77	3.36	4.29	1.59	0.93	2.52	0.41
1951	2.08	3.81	4.71	1.73	.90	2.63	.44
1952	3.79	5.76	7.06	1.97	1.30	3.27	.54
1953	1.85	3.66	5.09	1.81	1.43	3.24	.36
1954	1.78	3.54	4.98	1.76	1.44	3.20	.36
1955	1.94	3.92	5.40	1.98	1.48	3.46	.36
1956	2.62	4.69	6.48	2.07	1.79	3.86	.40
1957	1.57	3.50	5.46	1.93	1.96	3.89	.29
1958	1.87	3.81	5.99	1.94	2.18	4.12	.31
1959	1.91	3.71	6.05	1.80	2.34	4.14	.32
1960	2.43	4.39	6.87	1.96	2.48	4.44	.35
1961	1.63	2.71	6.02	1.08	3.31	4.39	.27
1962	1.69	2.80	6.05	1.11	3.25	4.36	.28
1963	1.70	2.73	6.23	1.03	3.50	4.53	.27
1964 5/	2.71	4.23	7.57	1.52	3.34	4.86	.36

1/ All prices and spreads are on a calendar year basis. 2/ Annual average prices received by farmers for potatoes on a farm product equivalent basis (adjustment at farm level for losses through shrinkage and spoilage in marketing) equal to 10.42 pounds of potatoes at farm for every 10 pounds bought at retail. 3/ Compiled from reports of wholesale prices for Irish (white) potatoes delivered to New York and Chicago, weighted by respective unloads in those cities. 4/ Annual average of retail prices for potatoes in leading cities. Retail prices previous to January 1955 are adjusted from quotations for 15 pounds of potatoes to quotations for a 10-pound equivalent, based on relative prices for the two product weights for December 1954. (Factor of 0.6594 used as ratio of price of 10 pounds to price of 15 pounds.) 5/ Preliminary.

Compiled from Farm-Retail Spreads for Food Products, 1947-64 [57], and Wholesale Prices and Price Indexes [42].

The rise in retail prices for fresh potatoes during 1950-64 nearly paralleled the rise in prices of other fresh vegetables (table 5). The approximately equivalent price increases for these products indicate similar relative demand and supply conditions.

Table 5 shows that retail prices of frozen french fries remained fairly stable from 1957 to 1964, but dropped off slightly in the last 3 years of the period. The negligible change in prices of processed potato products was due in part to technological advances and cost efficiencies on the supply side.

From 1950 through 1963 the overall price index for cereal foods rose at about the same rate as that for fresh potatoes (table 5). From 1955 to 1964, the rise in the index of prices for white bread was almost equivalent to that for potatoes, while prices of wheat flour and rice rose much more slowly.

Trends in Farm, Wholesale, and Retail Prices

Different trends in potato prices can be observed at various marketing levels during 1950-64 (table 6). Retail prices increased substantially while wholesale prices showed a moderate decline. Farm prices for potatoes showed little trend apart from considerable year-to-year fluctuations. Farm prices exceeded $2 per hundredweight during 1951, 1952, 1956, 1960, and 1964.

The retail price of potatoes increased from $5.23 per hundredweight (52 cents per 10-lb. bag) in 1950-54 to $6.55 per hundredweight in 1960-64, or 25 percent. For the same period, the pecentage increase in the wholesale-retail price spread was substantially larger than the percentage increase in retail price. By contrast, the farm-wholesale price spread declined moderately. The increase in the wholesale-retail price spread for potatoes over the period had the effect of increasing retail price by $1.19 per hundredweight, decreasing wholesale price by $0.59, and decreasing farm price by $0.20 per hundredweight. Based on these relationships, most of the increase in marketing spreads was passed on to the consumer.

A USDA study (45, p. 22) indicated that retailers do not always allocate marketing costs among different foods in the produce department on the basis of cost to them. That is, retailers may be more concerned with covering costs for the entire produce department, irrespective of the "true" individual marketing cost of any single item. The study indicated that certain items, such as potatoes and sweetpotatoes, frequently reflect higher retail price spreads than other food items in the produce department. In 15 to 20 stores studied, potatoes had higher retail spreads in relation to their corresponding share of operating costs than 4 other principal items.

Since farm prices for potatoes during 1950-64 showed no significant trend, and both wholesale-retail spread and retail prices increased, there was a decline in the farmer's share of the consumer's dollar (table 6). From 1950-54 to 1960-64, the farmer's share for potatoes dropped from 42 percent to about 30 percent. This decline of about 12 percent in the share of the consumer's dollar compares with a decline of 8 percent for that of all food. Comparison of trends in the farmer's share between potatoes and individual food items can be made but probably is not too useful, because each food product shows varying trends in marketing services (57).

Shepherd (37, pp. 62-63) has shown that the size and relative fixity of the spread between farm and retail prices affects the elasticity of demand for a commodity at the farm level. The wider the marketing spread, the more inelastic is demand at the farm relative to demand at retail.

THE POTATO PROCESSING INDUSTRY

Growth in 1955-64

The outlook for demand for potatoes was not encouraging up to 1955-64. Low-carbohydrate foods such as beef, broilers, leafy vegetables, and fruits were benefiting from a growing economy, while potatoes were experiencing a continuing downtrend in per capita demand. The desire for variety in the diet and other factors responsible for changes in spending patterns, discussed in the section on Consumption and Price Trends, resulted in consumption of fewer potatoes. Per capita consumption was 198 pounds in 1910; it dropped to 132 pounds in 1930, and to 106 pounds in 1950. But the rapid increase in use of processed potato products in the mid-1950's halted the decline in per capita potato consumption. In 1955-64, per capita use varied from year to year, holding within a range of 103 to 112 pounds.

For the 1964 crop year, a total of 66.5 million hundredweight of raw potatoes was utilized for processed food items. This was about 34 percent of all potatoes used for food. Quantities used for individual items were as follows (in millions of hundredweight): Potato chips, 28.8; dehydrated, 10.8; frozen french fries, 20.5; other frozen products, 3.2; canned potatoes, 1.7; and other canned products (hash, stews, soups), 1.5.

The rapid expansion in the potato processing industry since World War II is one of the significant developments in the food field. For example, production of potato chips has increased about fourfold. Moreover, 15 years ago, potato flakes were unheard of and potato granules, which preceded potato flakes, were still undergoing experiment. Today, potato processing plants operate in most major producing areas of the United States, and market more than 30 different potato products. According to the National Potato Council, the retail value of processed potato products in recent years has approached the retail value of potatoes sold fresh (31).

Potato processing today, in general, is characterized by a marked improvement in the quality of existing products, and the rapid development and successful introduction of a wide variety of new frozen and dehydrated products. Many of the changes brought about in potato processing have resulted from the combined efforts of research in industry and Government.

Although potato chip sales have surpassed sales of other processed potato products during the past 20 years, a growing variety of processed products has been made available on the market. Some idea of the variety of products now available is given in table 7. Frozen items are available in greatest number but the number and variety of dehydrated products is increasing rapidly. Of the frozen products, frozen french fries, patties, and hash browns are found in almost every food market. Of the dehydrated products, instant mashed (both flakes and granules), diced, scalloped, and au gratin potatoes are available in almost all food stores. Several products, such as frozen mashed, frozen whipped, and frozen

Table 7.--Classification of Processed Potato Products

Frozen Products

French fries (regular and crinkle-cut)
Patties
Shredded
Hash brown
Diced
Mashed
Whipped
Stuffed baked
Rissole
Au gratin
Delmonico
Scalloped
Dutch potato salad
Small whole potatoes
Roasted
Cottage fried
Boiled
Pancakes
Dumplings
Knishes
Blintzes
Pirogen
Hashed in cream
Soup
Potatoes and peas in cream sauce
Dehydrofrozen
- Diced
- Mashed

Dehydrated Products

Instant mashed
- Granules
- Flakes

Diced for preparing hash brown potatoes and general purposes dishes, and for remanufacture in canned hash and stews.

Slices) for preparing salad, hash
Chiplets) brown, casserole, and other
Shreds) general-purposes dishes.

Scalloped
Au gratin
Salad mix
Pancake mix

Flour--for potato bread, doughnuts, crackers, and other specialty baked goods and breading material.

Starch

Regular and chemically modified potato starches for use in paper manufacture, textile sizing, and food processing.

Potato Chip Products

Regular and crinkle-sliced
Barbecue-flavored
Cheese-flavored
Smoke-flavored
Dip-chips
Snack-chips
Shoestring potatoes

Prepeeled Products

For fresh delivery to restaurant trade.

Whole potatoes
French fry cuts
Oil-blanched
Hash Brown
Salad

Canned Products

Whole potatoes
Sliced
Shoestring
Hash
Stew
Salad (American and German style)
Chowder
Soup
Pancakes
Strained (baby food)
Au gratin

Experimental Products

Chip bars
Chip confections (candy-flavored)
Sponge dehydrated
Puffs
Nuts
"Instant" dehydrated
Dip sticks

Table 8.--Number and location of plants producing different processed potato products, June 30, 1964 1/

Processed product	East	Central	West		Total
			Northwest	Other	
Chips	140	139	2/	2/	358
Frozen items	38	18	25	10	91
Dehydrated	---	---	---	---	3/28
Flakes	6	6	5	0	17
Granules	0	0	3	0	3
Diced	0	0	4	1	5

1/ Compilation reflects plant numbers as of 1963-64 crop year. Additional facilities have subsequently been constructed.
2/ Total for all West was 79 plants. No further breakdown is available.
3/ Includes one plant in Northwest producing both granules and flakes. Also includes 2 plants in Northwest for which form of product is unknown.

Compiled from Irish Potatoes--Utilization of 1963 Crop With Comparisons, U. S. Department of Agriculture, Statistical Reporting Service (Pot. 1-3), September 1963 [55] and from records of the U. S. Economic Research Service, and Consumer and Marketing Service.

french fried potatoes are commonly used in TV dinners. Specialty items such as frozen knishes, blintzes, dumplings, and canned potato pancakes, have had more limited distribution. Many experimental products, chiefly potato chip bars, potato "nuts," potato "puffs," and "dipsticks," are currently under development.

Treadway (40, pp. 12-13) has shown that not all of the research on potato processing is concerned with the development of new products and new processes. Substantial improvement in the quality and properties of well-established food products may in many cases increase sales as much as development of an entirely new product.

Mercker (29, pp. 17-20) has stated that, on the basis of recent experience, further growth in the potato processing industry is likely to be influenced by: (1) Quality improvement of existing forms, (2) new product development, and (3) the anticipation of a growing economy and increased consumer incomes.

Location of the Potato Processing Industry

Table 8 shows for 1963-64 the location of plants producing processed potato products by geographic areas, as reported by the Statistical Reporting Service and other USDA agencies. The table shows that 358 plants in the United States were producing potato chips. Most of these plants were located in areas of distribution, in part because of the limited shelf life of the finished product.

Also, table 8 shows that there were 91 plants producing frozen products and 28 plants producing dehydrated products. Of the 28 plants, the following numbers were manufacturing the products specified: Flakes, 17 plants; granules, 3; diced, 5; flakes and granules, 1; and unclassified, 2.

In contrast to the chipping industry, processors of frozen and dehydrated products tend to locate plants in areas of concentrated production where they are able to obtain ample supplies of potatoes of a desired quality. Most processors do some preseason contracting to assure forthcoming supplies. Some of the larger firms grow at least part of their supply, and some own or control storage facilities.

Relation Between Fresh and Processed Markets

Although fresh and processor buyers in a given area represent two different markets, they are related in the sense that they depend on the same grower groups for their supply of potatoes. The quantity of potatoes going to each of the two markets is determined chiefly by the relative prices paid by buyers in the respective markets, including contract negotiations.

Except for potatoes conditioned for chipping, growers presumably switch sales from fresh buyers to processor buyers, and conversely, for a few cents per hundredweight. Volume of potatoes channeled to each outlet will adjust with changes in the relative prices offered.

A large share of the volume of potatoes going to processors is under contract. Negotiations generally begin at or before planting time. The contract is for specific quantities of the raw product at a given price. In general, the contract is for fieldrun potatoes, specifying that

50 percent of the supplies shall be U.S. No. 1 grade, and providing premiums or discounts for each 1 percent deviation from that grade. In some instances the processor assumes responsibility once the potatoes are placed in storage. In other cases, the grower bears responsibility until time of delivery.

Some processors operate in both sectors of the market. These firms ship preferred grades and sizes to the fresh market and process the remainder. The decision of the processor to market fresh potatoes depends upon the spread between the wholesale price of the fresh item relative to the prospective wholesale price for the processed product, allowing for such considerations as variable handling costs and continuity of sales.

Processors have been more successful in penetrating the institutional market than the retail market. About two-thirds of the annual supply of frozen and dehydrated potato products moves to the restaurant and institutional trade, where convenience and timesaving features of the processed products are important considerations (30). Since these attributes are becoming increasingly important to the housewife, a strong potential is indicated for processed potatoes in the retail market.

STATISTICAL MODELS AND ESTIMATION

In the pages that follow, four statistical models, consistent with economic theory, are developed to explain the demand and price structure for the potato industry. The four models represent the following seasonal markets: Late summer and fall, winter and early spring, late spring, and early summer. Both the single-and multiple-equation approaches are used to statistically estimate the coefficients in the economic relations formalized in the models. The statistical analyses are based on data for 1947-60. The statistical relationships indicated by these analyses are then used to make estimates of prices and consumption of the different types of potatoes during the period of fit and to predict values of these variables for 1961, 1962, and 1963.

Basic Assumptions

The economic and statistical assumptions used in formulating the economic relations are basic to the choice of the particular model adopted and of the method of statistical analysis used in quantifying the model. Below is a discussion of the important assumptions (many of which are based on preliminary analysis given in previous sections) associated with the four basic models used in this study.

The basic assumptions used in the utilization model for the late summer and fall crop are as follows:

(1) Production of late summer and fall potatoes is affected only slightly by current prices. Production plans are made chiefly before the planting season; therefore supply becomes fixed.

(2) Potatoes are not a homogeneous product; therefore, different quality and size characteristics may lead to diversion of certain potatoes to lower valued uses.

(3) Allowance is not made for substitution effects between storage (late summer and fall) potatoes and early potatoes. During September-December, only one type of potatoes (late summer and fall) appears in the Nation's commercial markets. Competitive behavior and substitution between storage potatoes and early potatoes are analyzed in alternative studies, based on individual seasonal markets.

(4) Consumption of potatoes for food is not highly correlated with production because varying quantities of potatoes are channeled into nonfood uses. Changes in consumption in some seasons have been in the opposite direction from changes in production.

(5) The margin between retail prices and farm prices is affected by changes in cost of marketing services.

(6) Relationships among the variables are linear in actual numbers.

This model permits the analyst to estimate the demand for potatoes for food, for livestock feed, and for starch. Also it enables one to estimate farm price and retail price for late summer and fall potatoes.

The basic difference between the late summer and fall model and the other three seasonal models is that in the former the emphasis is on utilization of one crop while in the latter it is on competition between seasonal crops. As a result, the following modifications in assumptions are needed for the early crops:

(1) These models do not develop separate demand functions for nonfood uses because of lack of adequate data. However, the demand function used is essentially a derived demand for food as the data are adjusted for nonfood uses.

(2) It is possible to measure competitive behavior and substitution between storage potatoes and different types of early crop potatoes.

(3) The total demand for a storable commodity in any given period is the demand for "use" within that period plus the demand for storage.

(4) Prices of early potatoes in one seasonal market are largely independent of prices in another seasonal market. Moreover, the price effects, if any, are carried over by the supply of storage potatoes carried forward into the next seasonal market.

The early-season models permit the analyst to estimate the demand for food for the following types of potatoes: Winter and early spring, marketed during January-April; late spring, marketed during May-June; early summer, late spring, and late summer, marketed during July-August. Also, estimates can be derived for farm price for each of these types of potatoes.

Fitting Procedures

From the single-and multiple-equation approaches used to estimate the coefficients, estimates of elasticities are computed.

Fox (12, p.11) has emphasized that for many agricultural commodities, where consumption (or production) can be assumed to be given, estimates of price elasticity of demand can be made by use of the single-equation least squares method. He points out that in such cases price has been used as the dependent variable in the demand equation. On the other hand, when prices and consumption of potatoes are determined jointly, as they may be within given seasonal potato markets, estimates of the parameters in the structural demand equations must be derived by a statistical method that allows for this simultaneity. For jointly determined variables, estimates obtained by the least squares technique may not give unbiased estimates (see, for example, Haavelmo (16) and Koopmans (23).)

However, it is not always clear which fitting procedure will give "unbiased" estimates of the coefficients, as the real world never exactly fits into the statistical mold. For example, either the single- or multiple-equations approach might be applicable for the late summer and fall model. To the extent that separate demands for food, feed, and starch in the utilization model can be identified, and to the extent that each demand competes with the other for the same total supply of potatoes, then consumption in each outlet can be said to be jointly determined. Under these circumstances, consumption in one use is affected by, and in turn affects, consumption in the other uses. In this case, a statistical model must be used which allows for the simultaneity between the jointly determined consumption variables. The limited information method and the method of two-stage least squares allows for this interrelationship among the consumption variables. On the other hand, it can be argued that an order of priority exists in channeling potatoes to different uses, with use for food (and seed) having the highest priority. As a result, to a large extent the amounts used for starch and livestock feed, including quantities diverted under Government programs, are determined only after food needs have been satisfied. In this case, a single-equation method can be used to estimate the price-consumption relationships.

So far, the concern has been whether the statistical method gives unbiased estimates of the structural coefficients. However, a most important test of a statistical model is its ability to predict or forecast values of the economic variables. While our knowledge of adequacy of method for estimating structural coefficients may be adequate, very little is known about the relative merits of the different methods in forecasting. For this reason, several methods were used in quantifying the economic models so that the relative merits of each could be tested.

As indicated by Koopmans (22), when the simultaneous approach is used to handle equations that contain more than one endogenous variable, it is necessary to establish conditions of identifiability with respect to given formulations in a system of equations. It is sometimes impossible to estimate coefficients in certain structural equations with the data available. Such equations are said to lack identifiability and are termed underidentified. Identifiable equations may be just identified or overidentified. In the present analysis, all of the equations fitted by the limited information method are overidentified.6/

6/ A rule of thumb or "counting rule" establishes the conditions necessary for identifiability. If the number of variables in the system (endogenous plus all predetermined variables, counted separately) minus the number of variables in a particular equation is greater than the number of endogenous variables in the system less one, we have an overidentified equation. Futher rules on identification are given in Friedman and Foote (14, p. 29).

Results of the statistical analysis are given in equation form. The regression coefficients represent changes in price or consumption associated with given changes in income, prices of competing supplies, and other variables. Direct and cross price elasticities of demand are computed from these regression coefficients so that comparisons can be made between elasticities for different types of potatoes.

Wold and Jureen (65, pp. 28-42) have shown that, whether regression equations are used for prediction or for causal analysis, it is known that there will be deviations from the exact relation due to disturbance factors not specified. Important variables may be omitted either because they are not available or because their importance is not realized. Therefore, we can expect nonindependence in the error terms. This nonindependence takes the form of autocorrelation. To test the effects of nonindependence in the error terms the Durbin-Watson statistic is used for all equations fitted by least squares.

Late Summer and Fall Model

The total demand for late summer and fall potatoes is made up of several individual demands. The most important for this crop are the demands for (1) food, (2) livestock feed, and (3) starch manufacture. The late summer and fall model formulates a set of economic relations which takes into account these different demands or uses for potatoes. These structural relations are fitted statistically to measure the relationship between consumption in these three demand outlets and economic factors affecting consumption. From the structural equations, price and income elasticities of demand are computed for the food equation, and price elasticities of demand are obtained for the nonfood equations. These elasticities facilitate comparisons of the demand characteristics of the three outlets. The model also is designed to permit the analyst to estimate prices for late summer and fall potatoes at the retail and farm levels.

Statistical Relations

Consistent with economic theory and the assumptions stated in the preceding sections, five statistical relations are formulated. These include separate demand relations for each demand outlet, a farm-retail price relation, and a consumption-production identity.

Demand relations can be formulated at any marketing level---farm, wholesale, retail-- or some other intermediate level. However, as a rule, demand relations should be formulated at the marketing level at which the key decisions regulating economic flows are made. This model assumes that the demand for potatoes consumed as food is generated at the consumer level and that factors affecting the demand for food should be identified as close to the consumer level as possible. Therefore, the retail price of potatoes is used in the demand relation for use as food. On the other hand, the farm price for potatoes is closer to the point of decision-making for use in livestock feed. Thus, the economic variables used in this relation are identified at the farm level. In the case of utilization for starch, a price series at the manufacturing level would be desirable. But such a series is not available, and consequently the farm price is used.

Because of interest in estimating and forecasting the farm price of potatoes and because food use is the principal determinant of price, a farm-retail price relationship is formulated. In addition, an identity is needed to assure that total supplies of potatoes are exhausted.

Taking into account these general considerations, the following relations pertaining to the demand and price structure for late summer and fall potatoes are specified:

Demand for food

$$C_h = a_1 + b_{11}P_r + c_{11}D_i + c_{12}C_{h_{t-1}} + c_{13}D_u + c_{14}P_{pv} + c_{15}T + u_1 \quad (1)$$

Demand for feed

$$C_f = a_2 + b_{21}P_f + c_{21}P_{fs} + c_{22}D_u' + c_{23}T + u_2 \quad (2)$$

Demand for starch

$$C_s = a_3 + b_{31}P_f + c_{31}C_{fr} + c_{32}D_u' + c_{33}T + u_3 \quad (3)$$

Farm-retail price relationships

$$P_f = a_4 + b_{41}P_r + c_{41}M + u_4 \quad (4)$$

Identity

$$C_h + C_f + C_s = Q - (S_e + R) \quad (5)$$

In these relations, the a's represent the constant term, the b's represent structural coefficients associated with endogenous variables, and the c's represent structural coefficients associated with predetermined variables. The u's represent random error terms and those variables not identified or specified.

Variables

The economic variables that enter into the structural model are described below. All variables used in this analysis are expressed in actual values. Data for price and income variables are in constant 1947-49 dollars. All variables relate to the seasonal period, August-April, and for the years 1947-60, unless otherwise stated.

The following variables are assumed to be endogenous or jointly determined in this model: 7/

C_h = Apparent per capita consumption of late summer and fall potatoes for food; pounds.

C_f = Per capita use of late summer and fall potatoes for livestock feed; pounds.

C_s = Per capita use of late summer and fall potatoes for starch; pounds.

7/ Endogenous variables are those variables that are jointly determined by the system of equations. Values of these variables are assumed to be correlated with the unexplained residuals in the structural equation in which they occur.

P_r =Retail price of potatoes, August through April, as reported by the Bureau of Labor Statistics, divided by BLS consumer price index, August-April, 1947-49=100; cents per 10 pounds.

P_f =Season average price received by farmers for late summer and fall potatoes at point of first sale out of farmers' hands, divided by index numbers of wholesale prices of all commodities, August-April, 1947-49=100; dollars per hundredweight.

The following variables are assumed to be predetermined in this model: 8/

$C_{h_{t-1}}$ =Apparent per capita consumption of late summer and fall potatoes for food, lagged 1 year; pounds.

C_{f_r} =Percentage of all late summer and fall production processed into food products.

P_{f_s} =Index numbers of price of feeder steers, October 1, divided by index numbers of wholesale prices of all commodities, August-April, 1947-49=100.

D_i =Per capita consumer disposable income, July-June, divided by BLS consumer price index, July-June, 1947-49=100; dollars.

P_{p_v} =Index numbers of retail prices of processed vegetables, August-April, divided by BLS consumer price index, August-April, 1947-49=100.

D_u =Dummy variable (0 in 1947-55 and 1 in 1956-60) for potatoes used for food.

D_u' =Dummy variable (0 in 1947-55 and 1 in 1956-60) for potatoes used for feed and starch.

M =Index numbers of cost of marketing late summer and fall potatoes, divided by BLS index of wholesale prices of all commodities, January-December, 1947-49=100.

T =Time trend; linear, 1947=1.

$Q-(Se+R)$ =Total supply of potatoes available for food, livestock feed and starch.

Results of Statistical Analyses

The late summer and fall model assumes that the total supply of potatoes is channeled into the different uses on the basis of relative prices. It further assumes that equivalent prices among the different outlets must be maintained if equilibrium is to exist at any given time. Thus, prices and consumption in each outlet are jointly determined. Therefore, to obtain unbiased coefficients in the structural demand relations, the statistical analysis used to estimate these coefficients

---

8/ Predetermined variables consist of exogenous variables and lagged values of endogenous variables. Exogenous variables are those variables whose values are determined outside the system of equations under consideration.

must allow for simultaneity between the jointly determined quantities and prices. The simultaneous equations approach allows for this joint determination. Thus, estimates of structural coefficients were obtained by fitting the equations to actual data for 1947-60 by the limited information method and the two-stage least squares method. The same equations also were fitted by least squares. 9/ Results of these analyses are shown below. Numbers in parentheses under the regression coefficients are the respective standard errors.

Limited Information Estimates: 10/

Consumption for food

$$C_h = \underset{}{27.320} - \underset{(0.138)}{0.343}\, P_r + \underset{(0.00404)}{0.00037}\, D_i + \underset{(0.219)}{0.586}\, C_{h_{t-1}} + \underset{(0.213)}{0.143}\, P_{pv} + \underset{(3.830)}{4.387}\, D_u + \underset{(0.883)}{0.903}\, T \quad (6)$$

Consumption for livestock feed

$$C_f = 17.465 - \underset{(0.723)}{2.585}\, P_f - \underset{(0.014)}{0.008}\, P_{fs} + \underset{(0.919)}{1.418}\, D_u' - \underset{(0.125)}{0.450}\, T \quad (7)$$

Consumption for starch

$$C_s = 16.698 - \underset{(1.597)}{4.251}\, P_f - \underset{(0.493)}{0.665}\, C_{f_r} + \underset{(1.981)}{4.227}\, D_u' + \underset{(0.613)}{0.199}\, T \quad (8)$$

Farm-to-retail price relationship

$$P_f = 29.445 - \underset{(0.781)}{0.236}\, P_r - \underset{(0.287)}{0.149}\, M \quad (9)$$

9/ Several statistical methods were used to estimate the coefficients in the respective equations, because insufficient empirical research has been done to permit a priori judgment as to the best method of fitting a model for estimating and forecasting potato consumption and prices.

10/ In fitting the equations, the time trend and dummy variables were omitted from the M_{zz} matrix for all the equations. It has been shown that often, when a variable is only a crude approximation of the true behavior, as the time variable is for changing tastes and preferences, and the dummy variable is for a change in structure, more consistent results are obtained when these variables are omitted from the M_{zz} matrix. For further details regarding the handling of particular variables in the system, see Friedman and Foote (14, pp. 66, 70, 74). Hildreth and Jarrett (21, pp. 69-70) have shown that the method of limited information allows some predetermined variables to be dropped from the matrix of predetermined variables for the entire system, provided sufficient predetermined variables are used to provide identification.

Two-stage least squares estimates:

Consumption for food

$$C_h = \underset{}{25.991} - \underset{(0.167)}{0.398}\,P_r + \underset{(0.04615)}{0.00213}\,D_i + \underset{(0.253)}{0.629}\,C_{h_{t-1}} + \underset{(0.244)}{0.120}\,P_{pv} + \underset{(4.148)}{4.980}\,D_u + \underset{(1.008)}{0.901}\,T \quad (6a)$$

Consumption for livestock feed

$$C_f = 17.438 - \underset{(0.718)}{2.568}\,P_f - \underset{(0.015)}{0.009}\,P_{f_g} + \underset{(0.915)}{1.417}\,D_u' - \underset{(0.124)}{0.449}\,T \quad (7a)$$

Consumption for starch

$$C_s = 17.472 - \underset{(1.724)}{4.594}\,P_f - \underset{(0.422)}{0.615}\,C_{f_r} + \underset{(2.086)}{4.219}\,D_u' + \underset{(0.651)}{0.119}\,T \quad (8a)$$

Farm-retail price relationship

$$P_f = 3.835 + \underset{(0.016)}{0.058}\,P_r - \underset{(0.012)}{0.046}\,M \quad (9a)$$

Least squares estimates:

Consumption for food

$$C_h = 30.970 - \underset{(0.078)}{0.193}\,P_r - \underset{(0.03256)}{0.00437}\,D_i + \underset{(0.166)}{0.470}\,C_{h_{t-1}} + \underset{(0.169)}{0.205}\,P_{pv} + \underset{(2.976)}{2.778}\,D_u + \underset{(0.714)}{0.910}\,T \quad (6b)$$

$d = 2.624$* $\qquad R^2 = .72$

Consumption for livestock feed

$$C_f = 16.248 - \underset{(0.505)}{1.844}\,P_f - \underset{(0.013)}{0.014}\,P_{f_g} + \underset{(0.825)}{1.383}\,D_u - \underset{(0.109)}{0.398}\,T \quad (7b)$$

$d = 3.090$* $\qquad R^2 = .72$

Consumption for starch

$$C_s = 12.069 - \underset{(1.038)}{2.202}\,P_f - \underset{(0.393)}{0.963}\,C_{f_r} + \underset{(1.655)}{4.274}\,D_u + \underset{(0.473)}{0.678}\,T \quad (8b)$$

$d = 2.962$* $\qquad R^2 = .74$

*Inconclusive test for serial correlation in the residuals.

Farm-to-retail price relationship

$$P_f = 4.400 + \underset{(0.011)}{0.057}\, P_r - \underset{(0.010)}{0.051}\, M \qquad (9b)$$

d = 1.607 Δ $R^2 = .88$

Δ No serial correlation in the residuals.

Utilization for seed, largely from the late summer and fall crop, has been fairly constant over time. Since the variability in utilization for seed is probably equal to or less than the error associated with the data, it was not treated as a variable to be estimated in the statistical models. However, an exploratory analysis was conducted for utilization for seed to determine the major factors that affect this outlet. 11/

The Durbin-Watson statistic (d) was used to test for serial correlation in the unexplained residuals. The presence of serial correlation stems from (1) the extent to which the residuals reflect errors in the data and the extent to which they reflect omitted variables, and (2) the nature of the omitted variables. Another possible cause of serial correlation in the residuals is an incorrect specification of the form of the relation (65). For equations (6b), (7b), and (8b), we cannot make any exact statement as to presence of serial correlation since the degree of correlation is in the inconclusive range of the test. For equation (9b) the test indicates no serial correlation.

The analyses for consumption of late summer and fall potatoes for food, livestock feed, and starch show that separate demands do exist for each of the three utilizations. Satisfactory coefficients were obtained for the basic variables in the equations fitted by the simultaneous equations technique, indicating that consumption and prices for food and nonfood were interrelated and jointly determined. However, reasonable results also were obtained when the least squares method was used.

Higher values of the structural coefficients for retail price in the food equation and for farm price in the nonfood equations were obtained by the limited information and two-stage least squares methods than by the least squares method. But they were not significantly different in all three methods when the difference was judged in relation to the standard error of the regression coefficients.

11/ The following equation for utilization for seed was fitted by least squares to actual data for 1947-60:

$$S_e = 11.481 + \underset{(0.496)}{1.062}\, P_f + \underset{(0.532)}{0.569}\, P_{f_{t-1}} - \underset{(0.023)}{0.031}\, Y_{e_{t-1}} + \underset{(0.120)}{0.118}\, T \qquad (10)$$

d = 1.440* $R^2 = .70$

where--

S_e = Apparent per capita utilization of late summer and fall potatoes for seed; pounds.

P_f = Season average price received by farmers for late summer and fall potatoes, divided by index numbers of wholesale prices of all commodities, August-April, 1947-49; dol./cwt.

$P_{f_{t-1}}$ = P_f lagged 1 year.

$Y_{e_{t-1}}$ = Index of technological factors.

The price elasticity for utilization for seed was found to be -0.19.

267-387 O - 67 - 4

Consumption for food

Retail price and consumption in the previous period were found to be the important variables that measurably affect consumption of late summer and fall potatoes for food. Results for the food equation, fitted by the limited information method, indicated that a 1-cent change in the retail price of late summer and fall potatoes was followed by a 0.34-pound change in consumption in the opposite direction, when all other factors were held constant. The least squares estimate of the coefficient of retail price was 0.19. Thus, a higher coefficient was obtained by the simultaneous equations method. A 1-pound change in consumption in the previous year was followed, on the average, by a 0.6-pound change in the same direction in consumption in the current year.

The coefficient associated with price of processed vegetables, P_{pv}, had the right sign in all analyses but was found to be statistically nonsignificant at an acceptable probability level. The effect of per capita disposable income on consumption of late summer and fall potatoes was positive but the relationship was statistically nonsignificant. Results from other regression analyses (not shown) also indicate that the use of disposable income as a demand shifter in time series analysis for the postwar period has not been entirely satisfactory, mostly because the differing effects of the various income groups are partially offsetting. Cross-section data from the 1955 Food Consumption Survey (47) shows that consumption of potatoes increases from the low income level to the middle income level and declines from the middle income level to the highest income level. That is, for each of the three income levels, we find different consumer responses.

Time trend in the food equation showed a positive sign. For this equation, however, time trend was not statistically significant at the usually accepted probability level. Although no statistically significant trend was established for per capita use of all potatoes for food, significant and largely offsetting trends in consumption of fresh potatoes and processed potatoes can be observed from 1956, when Statistical Reporting Service data first became available, to 1964.

A dummy variable (0 and 1) was introduced into the food equation to determine whether any abrupt change in structure had occurred because of the shift from fresh to processed use, which could not be explained by the time variable. The coefficient for the dummy variable was positive, but not statistically significant at an acceptable probability level. Consumption of processed potatoes apparently did not increase more abruptly in any single year or group of years than the counterpart decrease in consumption of fresh--at least not enough so that the rate of change was statistically different in one subperiod from that in another.

Consumption for livestock feed

Farmers traditionally have fed potatoes to livestock to utilize low-grade potatoes withheld from food channels. The incentive to feed potatoes stems from the relatively large quantity of nutrients obtained per unit of expenditure. As a matter of interest, it has been demonstrated that cattle fed low-grade potatoes do best when feeding of potatoes is continuous (1).

Farm price of potatoes and time trend were the important variables affecting the consumption for livestock feed in all three analyses. The coefficients for each of these variables were significant at the 5 percent probability level. The feed equation, fitted by limited information, indicated that a 2.6-pound change in per capita use of potatoes for livestock feed was associated, inversely, with a $1 change in farm price, assuming no change in the other factors.

Normally, heavy supplies of potatoes at harvest tend to bring low prices for potatoes over the entire season in each individual use. But as prices fall to low levels, relatively more potatoes are diverted to nonfood uses than to food use. Because of the prohibitive cost of transporting low-grade potatoes, demand for potatoes for livestock feed is important only in areas where numbers of livestock are relatively high. Usually, low-grade potatoes utilized for livestock feeding which must be transported from one farm to another are valued at slightly more than the cost of transportation from point of sale to point of destination.

The relationships indicate that a unit change in the index of price of feeder steers, October 1, was on the average followed by a 0.01-pound change in the opposite direction in per capita consumption of potatoes for livestock feed, holding potato prices and other factors constant. When the price of feeder steers is low around harvest time, and supplies of potatoes are relatively large, more potatoes will be fed to livestock to get cheap gains. Potatoes will tend to be substituted more for feed grains for livestock feeding when price of potatoes is low relative to price of feed grains. Although the coefficient for price of feeder steers does not differ from zero by a statistically significant amount in any of the analyses, the relationships derived appear logical.

All methods of analyses indicated that a decrease in use of potatoes for livestock feed had occurred. The greatest volume of potatoes diverted to livestock feeding occurred during 1947-50, i.e., early in the period of analysis. Subsequently, during the period studied, in only 1 year (1956) did diversion to this outlet equal the 1947-50 average. The regression coefficients associated with the time factor for each method of fit were statistically significant at the 5 percent probability level. The coefficient for the dummy variable (statistically significant at the 10-20 percent level) suggests that some change in structure occurred for consumption for feed.

Consumption for starch

The coefficients for the starch equation, fitted by limited information, indicated that farm price of potatoes, volume of potatoes processed for food, and changes in the utilization structure were the important variables affecting use of potatoes for starch. For 1947-60, a 4.2-pound per capita change in use of potatoes for starch was, on the average, associated inversely with a $1 change in farm price. The response of utilization for starch to price, in either absolute or percentage terms, was somewhat greater than the comparable response of utilization for feed. This would indicate that utilization for starch appears to be considerably more variable than utilization for livestock feeding, following changes in production. This may be due in part to the institutional setting of each of these outlets. Even though there are relatively few starch plants, they operate in volume in the two principal producing States, Maine and Idaho. When production is relatively large, these plants tend to operate at capacity; and when production is down, starch operations are curtailed. Feeding of potatoes takes place in more States, and feeding patterns tend to be more continuous.

Volume of potatoes processed for food, Cf_r, could be expected to have some effect on use for starch because frequently field-run potatoes are used in each of these two utilizations. The analysis showed that a 0.6 to 0.7-pound per capita change in the volume of potatoes processed for starch was associated with a unit change in the opposite direction in the quantity of potatoes processed for food. The coefficient for this variable was statistically significant only in the least squares analysis.

The coefficient for the dummy (0-1) variable, which represents a change in utilization structure, was significantly different from zero at the 10-percent probability level. The statistical results indicate that utilization for starch was a little higher in the late 1950's compared to earlier years.

Farm-retail price relationships

Analysis was made of the relationship between farm and retail prices for late summer and fall potatoes during 1947-60. The equation relating farm price to retail price, fitted by the limited information method, gave highly unsatisfactory coefficients for the retail price and marketing cost variables. When the equation was fitted by two-stage least squares, the coefficients appeared reasonable and the signs obtained were consistent with economic theory. This also was true for the least squares fit. The equation, as fitted by two-stage least squares, indicated that a change of 5.8 cents in farm price was associated directly, on the average, with a change of 10 cents in retail price.

The reason that farm prices for potatoes change less in absolute terms than retail prices is that farm prices are lower than retail prices by the amount of the marketing spread. From the equation of price relationships, fitted by two-stage least squares, it was found that a change of 5 cents per hundredweight in farm price of late summer and fall potatoes was associated, inversely, with a change of 1 percentage point in marketing costs. Thus, prices for potatoes at the farm level are sensitive to changes in marketing costs. This furnishes statistical evidence for the framework developed in an earlier section (see p. 32) with respect to the decline in the farmer's share of consumer expenditures for potatoes in the postwar period.

Demand Elasticities

Table 9 presents elasticities of demand with respect to price for utilization of potatoes for food, livestock feed, and starch. Also shown are elasticities of demand with respect to income for utilization of potatoes for food. Only the elasticities computed from the statistical results of the limited information method and the least squares method are shown. The results from the two-stage least squares method were very close to those from the limited information method. Price and income elasticities for potatoes for food are at the retail level. Price elasticities for potatoes utilized for livestock feed and starch are at the farm level.

Demand elasticity for food

The estimate of elasticity of demand obtained by the simultaneous approach for food during 1947-60 was -0.2. That is, a 0.2 percent change in per capita consumption was associated with a 1 percent change in retail price, in the opposite direction, while holding income and other

Table 9.- Late summer and fall potatoes: Estimates of price and income elasticities based on single- and multiple-equation models, by type of analysis, based on data for 1947-60 1/

Analysis	Demand elasticity with respect to-- 2/			
	Price		Income	
	Value	Standard error	Value	Standard error
	Percent	Percent	Percent	Percent
Limited information method: 3/				
Consumption for food	-0.21	0.08	4/0.07	0.70
Consumption for feed	- .51	.14	---	---
Consumption for starch	-1.01	.38	---	---
Least squares method: 5/				
Consumption for food	- .12	.05	4/-.07	.56
Consumption for feed	- .34	.10	---	---
Consumption for starch	- .52	.26	---	---

1/ Variables used in these analyses are described on pp. 116-123.
2/ Computed at the mean values of the economic variables for the period of analysis.
3/ Estimates using the limited information method are based on demand equations (6) through (8).
4/ Coefficient does not differ significantly from zero when tested at the 10 percent probability level.
5/ Estimates using the least squares method are based on demand equations (6b) through (8b).

factors constant. A price elasticity of -0.2 indicates that late summer and fall potatoes for food have a markedly inelastic demand. This compares with a price elasticity of demand of -0.3, obtained by the limited information method for the pre-World War II period (analyses not shown). When the food equation for 1947-60 was fitted by the least squares method, a price elasticity of -0.1 was obtained. The elasticity estimate of -0.2 obtained by the limited information fit probably is the best estimate describing the demand structure for potatoes for food use.

Elasticity estimates may differ between various studies because of inclusion or exclusion of certain factors. For example, somewhat different results might be expected, depending on whether a time factor and dummy variable are added to the equation or not. However, in the present case, equations reqresenting the demand for food which excluded time trend and the dummy variable gave price elasticities that were not very different from those given by equations which included them (analyses not shown). Time trend and the dummy variable, when included in the food equation, increased the R^2 from .62 to .72.

To determine the importance of processed vegetables as a substitute for potatoes, this variable was included in the analysis. The cross elasticity with respect to price of processed vegetables was found to be 0.24 (not shown in table). The elasticity coefficient with respect to price of processed vegetables is of approximately the same magnitude as the elasticity coefficient for price of late summer and fall potatoes. This implies that processed vegetables could be a good substitute for potatoes. However, the cross elasticity coefficient is not significant at an acceptable probability level. This confirms what other researchers have found with respect to food substitutes for potatoes: Consumption-price relationships are not statistically significant with respect to substitutability between potatoes and other food groups.

The income elasticity coefficient of 0.07 obtained for consumption of late summer and fall potatoes does not differ significantly from zero. This means that changes in the overall average of income, for the period of analysis, appear to have little or no effect on consumption. In contrast, the income elasticity coefficient computed from analyses (not shown) for 1921-41 was 0.42. As mentioned previously, the use of average income in time series analysis does not allow for differing consumer responses based on low, medium, and high incomes. Also, it is hard to separate, statistically, the effects of income, price level, and time trend in the postwar period because of high intercorrelation between each of these variables.

Demand elasticity for livestock feed

The estimate of elasticity of demand for livestock feed for 1947-60, obtained by the limited information method, was -0.5. That is, a 0.5 percent change in use for livestock feed was associated with a 1 percent change in farm price, in the opposite direction, holding all other factors constant. This shows that the demand for late summer potatoes for livestock feed is more elastic than demand for food use. This is logical, because livestock feeders who make decisions with respect to feeding potatoes or feed grains are relatively sensitive to price changes. In addition, any Government program that provides incentives for this use, when prices are low, increases the elasticity of demand in this use.

In earlier years it appeared that potatoes for livestock feed became more inelastic over time. For the pre-World War II period, the elasticity of demand for potatoes for livestock feed, when the coefficients were computed at the mean values of the economic variables, was -0.8. For the last 5 years of that period, 1937-41, a price elasticity coefficient of -0.6 was computed. For the postwar period the elasticity of demand for this use was fairly stable at -0.5. That is, the computed elasticity for values of the variables during 1956-60 was not very different from the computed elasticity for values of the variables for 1947-51. The indication is that in the postwar period, production of potatoes has become highly commercialized compared to that of the pre-World War II period. The chief reason for the lesser response by cattle feeders in the postwar period appears to be that fewer cattle are being fed on fewer but larger potato farms.

Demand Elasticity for Starch

The estimate of elasticity of demand for starch for late summer and fall potatoes, obtained from the limited information fit, was -1.01. This means that a 1.01 percent change in consumption for starch was associated with a 1 percent change in farm price in the opposite direction, holding all other factors constant. Thus, it appears that demand for starch manufacture is somewhat more elastic than demand for livestock feed. The relatively higher price elasticity for starch manufacture suggests that starch plants operate at less than capacity during periods of low production and high potato prices. Conversely, starch plants tend to operate at or near capacity during periods of high production and low prices.

Winter and Early Spring Model

The competitive behavior and ease of substitution between winter and early spring potatoes and storage potatoes during January-April are statistically examined in this model. In addition, as all storage pototoes are not consumed during these months, the demand for storage, i.e., the holding of potatoes for consumption in a later period, is also measured. The general assumptions relating to early-season models were stated earlier, beginning on p. 38.

In the winter and early spring market, early potatoes, chiefly from Florida and California, compete with storage potatoes from Idaho, Maine, and the majority of the Northern States. The high perishability of winter and early spring potatoes requires growers and shippers to market them soon after harvest. Winter and early spring potatoes are the first early potatoes to reach the market. Thus, consumers are looking for the "new" potatoes, thereby creating a unique demand for these potatoes. The amount of winter and early spring potatoes consumers will buy depends on the price of these potatoes relative to the price of storage potatoes. Historically, prices for winter and early spring potatoes have been higher than prices for storage potatoes.

About 60 percent of fall (storage) potatoes are available for consumption after January 1. Thus, these are the predominant potatoes consumed during January-April. During 1947-60, average per capita consumption of winter and early spring potatoes in January-April was 4.2 pounds, while that of storage potatoes was 27.6 pounds.

Statistical Demand Relations

Consistent with economic theory and the assumptions stated in the preceding sections, a set of relations is formulated which takes into account the interrelationships among demands for potatoes in the winter and early spring market. These relations include (1) demand for winter and early spring potatoes for food, (2) demand for storage potatoes for food during January-April, and (3) demand for fall potatoes for storage, to be consumed in a later period.

The specific model which takes into account the interactions among the various demands is represented by equations (11) through (14):

<u>Demand for winter and early spring potatoes for food</u>

$$P_{s_1} = a_1 + b_{11}Q_{s_1} + b_{12}P_{f_1} + c_{11}D_1 + c_{12}M_1 + c_{13}T + u_1 \qquad (11)$$

<u>Demand for storage potatoes for food</u>

$$P_{f_1} = a_2 + b_{21}C_{f_1} + b_{22}P_{s_1} + c_{21}D_1 + c_{22}M_1 + c_{23}T + u_2 \qquad (12)$$

<u>Demand for storage (fall potatoes)</u>

$$S_t = a_3 + b_{31}P_{smc} + c_{31}C_{fr_1} + c_{32}S_j + u_3 \qquad (13)$$

<u>Identity</u>

$$C_f + S_t + R = S_j - G_f \qquad (14)$$

In these relations the jointly determined or endogenous variables are P_{f_1}, P_{s_1}, C_{f_1}, and S_t. The predetermined or exogenous variables are D_1, M_1, Q_{s_1}, $P_{s_{mc}}$, C_{fr_1}, S_j, and T. The a's represent the constant term, the b's represent structural coefficients associated with endogenous variables, and the c's represent structural coefficients associated with the predetermined variables. The u's represent random error terms and those variables not indentified or specified.

Equations (11) and (12) represent the demands for winter and early spring potatoes and for storage potatoes, respectively. They include the usual factors explaining shifts in demand, such as price of substitutes, consumer income, and the time variable. In addition, they include a marketing cost variable to allow for changes in marketing costs since the farm price is used in this analysis. The use of this variable conceptually shifts the retail demand function to the farm level. A preferable demand function would include a retail price, but a series on retail prices for seasonal potato crops is not available.

Equation (13) is the demand relation for storage stocks of potatoes carried over to spring. It is hypothesized that the quantity stored at a particular point in time, say May 1, is determined by sustained changes in monthly prices received by farmers, volume processed into food, and initial stocks of potatoes on hand at the beginning of the storage period. 12/ During January-April, storage potatoes consumed for food, disposition under Government programs, quantity of storage stocks on May 1, and disappearance for miscellaneous use, shrinkage, and loss must equal total storage stocks of potatoes on January 1. This relation is given as an identity in equation (14).

Variables

All variables used in this model are expressed as actual values. Data for the price and income variables are in constant 1947-49 dollars. All variables relate to a seasonal period (January-April) except marketing costs, which represent cost of marketing services for a calendar year. Disposition under Government programs, G_f, did not occur in all individual years, 1947-60, and therefore was not treated as an endogenous variable.

The variables assumed to be endogenous in this model are:

P_{s_1} = Season average price received by farmers for winter and early spring potatoes, divided by BLS consumer priced index, January-April, 1947-49=100; dollars per hundredweight.

P_{f_1} = Simple average of monthly prices received by farmers for fall (storage) potatoes, January-April, divided by BLS consumer price index, 1947-49=100; dollars per hundredweight.

C_{f_1} = Apparent per capita consumption of fall (storage) potatoes for food, January-April; pounds.

S_t = Estimated per capita quantity of fall potatoes in storage, chiefly for food, May 1; pounds.

The variables assumed to be predetermined in this model are:

Q_{s_1} = Apparent per capita consumption of winter and early spring potatoes; pounds.

D_1 = Per capita disposable income, 1st quarter, divided by BLS consumer price index, January-April, 1947-49 = 100; dollars.

M_1 = Index numbers of cost of marketing potatoes, divided by BLS index of wholesale prices of all commodities, January-December, 1947-49=100.

Ps_{mc} = Sustained monthly price change for potatoes at the farm level, in one direction only, November-April, divided by BLS index of wholesale prices of all commodities, November-April, 1947-49 = 100; cents per hundredweight.

12/ Further discussion on demand for storage and the underlying assumptions is given in the appendix on pp. 104.

C_{fr_1} = Percentage of total food utilization of potatoes processed into food products.

G_f = Per capita disposition under Government programs of fall (storage) potatoes.

S_j = Estimated per capita storage stocks of fall potatoes, January 1; pounds.

R = Per capita disappearance of potatoes for miscellaneous uses, shrinkage and loss, January-April.

T = Time trend; 1947=1.

Results of Statistical Analyses

Estimates of the structural coefficients in the demand relations (11) and (12) were obtained by the limited information, two-stage least squares, and ordinary least squares methods. The period of analysis was 1947-60, and the analyses were run with data in arithmetic terms. The storage demand relation (13) was fitted by least squares only as it contained only one endogenous variable. The results of these analyses are presented below. Numbers in parentheses are the standard errors of the respective regression coefficients.

Limited information estimates:

Demand for winter and early spring potatoes for food

$$P_{s_1} = 3.088 - \underset{(0.206)}{0.017}\, Q_{s_1} + \underset{(0.381)}{1.120}\, P_{f_1} + \underset{(0.00069)}{0.00054}\, D_1 - \underset{(0.054)}{0.030}\, M_1 + \underset{(0.169)}{0.013}\, T \qquad (15)$$

Demand for fall (storage) potatoes for food

$$P_{f_1} = 18.743 - \underset{(0.170)}{0.339}\, C_{f_1} + \underset{(0.274)}{0.582}\, P_{s_1} - \underset{(0.00554)}{0.00402}\, D_1 - \underset{(0.048)}{0.046}\, M_1 + \underset{(0.162)}{0.179}\, T \qquad (16)$$

Two stage least squares estimates:

Demand for winter and early spring potatoes for food

$$P_{s_1} = 4.800 - \underset{(0.174)}{0.068}\, Q_{s_1} + \underset{(0.294)}{0.857}\, P_{f_1} - \underset{(0.00151)}{0.00117}\, D_1 - \underset{(0.046)}{0.018}\, M_1 + \underset{(0.145)}{0.033}\, T \qquad (15a)$$

Demand for fall (storage) potatoes for food

$$P_{f_1} = 14.584 - \underset{(0.121)}{0.273}\, C_{f_1} + \underset{(0.215)}{0.636}\, P_{s_1} - \underset{(0.00443)}{0.00336}\, D_1 - \underset{(0.036)}{0.031}\, M_1 + \underset{(0.126)}{0.142}\, T \qquad (16a)$$

Least squares estimates:

Demand for winter and early spring potatoes for food

$$P_{s_1} = \underset{}{6.022} - \underset{(0.164)}{0.105}\, Q_{s_1} + \underset{(0.231)}{0.669}\, P_{f_1} - \underset{(0.00551)}{0.00239}\, D_1 - \underset{(0.043)}{0.010}\, M_1 + \underset{(0.138)}{0.047}\, T \qquad (15b)$$

$d = 1.612$* $\qquad R^2 = .76$

Demand for fall (storage) potatoes for food

$$P_{f_1} = 9.351 - \underset{(0.053)}{0.188}\, C_{f_1} + \underset{(0.156)}{0.698}\, P_{s_1} - \underset{(0.00369)}{0.00257}\, D_1 - \underset{(0.025)}{0.013}\, M_1 + \underset{(0.096)}{0.096}\, T \qquad (16b)$$

$d = 2.191$ Δ $\qquad R^2 = .88$

Demand for storage (fall potatoes)

$$S_t = -10.867 - \underset{(0.008)}{0.020}\, P_{smc} + \underset{(0.085)}{0.261}\, C_{fr1} + \underset{(0.115)}{0.281}\, S_j \qquad (17)$$

$d = 2.274$ Δ $\qquad R^2 = .70$

* Inconclusive test for serial correlation in the residuals.
Δ No serial correlation in the residuals.

The Durbin-Watson statistic (d) tests the unexplained residuals from an equation fitted by least squares to see if successive values--the residual this year compared with the residual last year--are correlated. For equations (16b) and (17) the test shows that no serial correlation exists in the residuals. For equation (15b), the test is inconclusive.

The results from the three methods of fit indicate that winter and early spring potatoes are in direct competition with storage potatoes in the winter and early spring market. With the exception of the coefficient associated with supplies of winter and early spring potatoes (Q_{s1}) in equation (15), the price and quantity variables are statistically significant at the 10 percent probability level in all analyses. Also, for equation (15) the simple correlation coefficient, -0.64, between quantity (Q_{s1}) and price (P_{s1}) of winter and early spring potatoes (analysis not shown), was significant. But, as indicated, supplies of winter and early spring potatoes had no significant effect on price when the effect of all variables in the model are considered. It may be that the effect of own supplies (i^{th} commodity) is masked and hard to identify because consumption of winter and early spring potatoes (i^{th} commodity) makes up only about one-seventh of total per capita consumption during January-April.

The relationships indicated that a 1-pound change in per capita consumption of storage potatoes (January-April) was followed, on the average, by a 34-cent change in own price in the opposite direction. The coefficient for consumption of storage potatoes was significant at the 10 percent probability level. Since storage potatoes dominate the winter and early spring market, the relationships between price and consumption were close, as expected.

The analyses indicated a positive relationship between consumer income and price of winter and early spring potatoes. This would indicate that housewives tend to purchase more winter and early spring potatoes as income increases, and this in turn tends to increase the price. The coefficient for income, however, was not statistically significant at an acceptable probability level.

For storage potatoes, results obtained by the limited information method indicated a negative relationship between consumer income and own price. However, the coefficient was not significant at the 10 percent probability level. The high intercorrelation between the independent variables in the equation may have reduced the significance of the income coefficient. As shown by Fox and Cooney (13), high intercorrelation between independent variables may mean lower reliability for individual regression coefficients and may even result in a change of sign in a regression coefficient.

The trend coefficients in equations (15), (15a), and (15b) suggest that there has been little net trend in the price of winter and early spring potatoes. The trend coefficients for price of storage potatoes (January-April) were generally larger than their standard errors in all of the analyses and showed a positive trend. However, none of the trend coefficients were statistically significant at an acceptable probability level. Since there appears to be no statistically significant net trend in prices or in consumption of winter and early spring potatoes, one can conclude that during 1947-60, January-April, demand for this seasonal type of potatoes was essentially stable.

In the storage relation, sustained monthly price changes had a significant effect on quantity of potatoes held in storage May 1 (S_t). The relationship indicated that storers tended to sell after an extended price increase and tended to hold after an extended price decline. During 1947-60, a change of 0.20 pound per capita in May 1 storage stocks was associated inversely with a sustained month-to-month change of 1 cent in price of storage potatoes (November-April). The coefficient for sustained month-to-month change in prices was statistically significant at the 5-percent probability level. The other explanatory variables, i.e., volume of processing, C_{fr1}, and storage stocks on January 1, S_t, also were significant at the 5 percent probability level. As volume of processing increased, quantity of potatoes held in storage on May 1 increased. This was expected since efficient plant operations require sufficient storage supplies to continue processing through spring. Though marketings of storage potatoes in all years studied were heavy during January-April, sustained price changes had the effect of speeding up or slowing down out-of-storage movement.

Demand Elasticities

The relationships discussed in the previous section describe the structure of the winter and early spring market in terms of unit changes in price, consumption, and other variables. The discussion that follows

Table 10.- Consumption and storage relationships for potatoes (January-April): Estimates of price and income elasticities based on single- and multiple-equation models by type of analysis, based on data for 1947-60 1/

Analysis and type of potatoes	Price elasticities 2/				Income elasticities 2/	
	Direct		Cross			
	Value	Standard error	Value	Standard error	Value	Standard error
	Pct.	Pct.	Pct.	Pct.	Pct.	Pct.
Limited information method: 3/						
Winter and early spring	4/-2.63	3.19	2.07	0.70	4/0.32	0.38
Storage (marketed for food)	- .21	.10	.17	.08	4/-.34	.51
Least squares method: 5/						
Winter and early spring	4/-4.26	6.65	1.99	.69	---	---
Storage (marketed for food)	- .37	.10	.38	.08	4/-.50	.67
In storage, May 1	- .56	.22	---	---	---	---

1/ Variables used in these analyses are described on pp. 119-120.
2/ Computed at the mean values of the economic variables for the period of analysis.
3/ Estimates obtained by the limited information method are based on demand equations (15) and (16).
4/ Coefficient does not differ significantly from zero when tested at the 10 percent probability level.
5/ Estimates obtained by the least squares method are based on demand equations (15b), (16b), and (17).

centers on elasticity measures designed to indicate the degree of competition and substitution between winter and early spring potatoes and storage potatoes. Elasticities were computed only for the analyses fitted by limited information and least squares methods. As can be seen from the coefficients in the equations, elasticities computed from the two-stage least squares estimates would be fairly close to those obtained from the limited information estimates.

Price elasticities

Estimates of price elasticities of demand were obtained for winter and early spring potatoes, storage potatoes marketed in January-April, and May 1 storage stocks (table 10). The elasticity coefficient obtained by the limited information fit of equation (15) indicates that a 1 percent change in price of winter and early spring potatoes was followed by a 2.6 percent change in consumption, in the opposite direction, holding income and other factors constant. Based on the least squares method of fit, the elasticity was -4.3. The results point to an elastic demand for winter and early spring potatoes.

The cross elasticity obtained by the limited information approach was 2.0 for winter and early spring potatoes with respect to the price of storage potatoes. The values for direct and cross price elasticities, 2.6 and 2.0, respectively, for winter and early spring potatoes indicated that a general case of substitutability existed between the two types of potatoes. But the apparent difference in the two elasticity measures suggests that housewives regard winter and early spring potatoes and storage potatoes as differentiated products. Consumer preferences for certain types of potatoes in the winter and early spring market result in price differentials between them.13/

For storage potatoes (January-April) the estimate of direct elasticity, based on the limited information method, was -0.2. This elasticity coefficient is equivalent to the elasticity coefficient of -0.2 obtained for late summer and fall potatoes for the entire season. Accordingly, storage potatoes during January-April are assumed to be markedly inelastic. This result agrees with preliminary analyses which showed that storage potatoes heavily dominate supplies during this season.

The cross elasticity obtained by the limited information method was 0.2 for storage potatoes with respect to the price of winter and early spring potatoes, which also is inelastic. The cross elasticities for winter and early spring potatoes and storage potatoes (January-April), 2.0 and 0.2, respectively, were significantly different. However, probably not too much importance should be attached to the differences in these cross elasticities since the levels of the quantity series differ significantly.

Price elasticity of demand for storage stocks was found to be -0.6. That is, a 1 percent change in the price of storage potatoes was followed by a 0.6 percent change in storage stocks, in the opposite direction, all other factors held constant. Thus, the percentage change in storage

---

13/ Average wholesale price, January through April, 1960-64, on the New York wholesale market was $6.06 per hundredweight for Florida potatoes and $6.28 per hundredweight for California winter potatoes, compared with $3.42 per hundredweight for storage potatoes for the same period.

holdings was less than the percentage change in price, which implies that demand for storage is inelastic. As a result, total inventory value of storage stocks declines as price falls.

Income Elasticities

Estimates of income elasticity based on the limited information method suggested that a 1 percent change in consumer disposable income was followed by a 0.3 percent change in the same direction in consumption of winter and early spring potatoes, holding all other factors constant. This result appears to confirm the belief that, as incomes rise, housewives tend to buy more winter and early spring potatoes.

The estimate of income elasticity based on the limited information method suggested that a 1 percent change in consumer disposable income was followed by a 0.3 percent change in the opposite direction in consumption of storage potatoes, January-April. This income coefficient compares with a zero income elasticity coefficient obtained for late summer and fall potatoes over the entire marketing season. However, the coefficient was not statistically significant at an acceptable probability level. As mentioned previously, the use of average income in time series analysis to explain changes in price or consumption of potatoes is not very meaningful. Cross-section analysis shows that consumer responses differ with different levels of income.

Late Spring Model

In the late spring market, early California potatoes and potatoes from the Southeastern States compete with storage potatoes chiefly from Maine and Idaho. By this time of year, supplies of storage potatoes have dwindled and the dominant potatoes for the United States as a whole are late spring potatoes. Average per capita consumption of late spring potatoes during late spring for 1947-60 was about 15.5 pounds per person, and of storage potatoes (May-June), about 4 pounds per person. Improved storage facilities for fall potatoes and other technological improvements have resulted in increased late season use of storage potatoes. In 1958-60, per capita consumption of storage potatoes (May-June) was 5.0 pounds, an increase of 1.9 pounds from the levels of 1951-53. During this same period, per capita consumption of late spring potatoes declined 1.4 pounds to an average of 14.0 pounds in 1958-60. These consumption figures are averages for the United States as a whole; the relative importance of supplies of late spring potatoes and storage potatoes depends on the location of the market. For example, in many Northern and Eastern cities, storage potatoes are still the dominant type of potatoes in late spring.

Structural Demand Relations

The theory of individual consumer demand for two closely competing commodities specifies that the quantities consumed of each depend on its own price, the price of competing commodities, and other common factors such as income and tastes.

To illustrate, the quantity of late spring potatoes or storage potatoes consumed (May-June) depends upon price of late spring potatoes, price of storage potatoes, consumer income, and other factors. Furthermore, the theory specifies that the individual demands may be summed to equal total demand for potatoes in the late spring market. For example, the aggregate demand relations may be written as follows:

Demand for late spring potatoes

$$Q_{s_2} = f(P_{s_2}, P_{f_2}, D_2, M_2, T, u_1) \quad (18)$$

Demand for storage potatoes (May-June)

$$Q_{f_2} = f(P_{s_2}, P_{f_2}, D_2, M_2, T, u_2) \quad (19)$$

where Q_{s2} represents consumption of late spring potatoes; Q_{f2} the consumption of storage potatoes; P_{s2}, the farm price for late spring potatoes; P_{f2}, the farm price for storage potatoes; D_2, disposable income; M_2, marketing costs; and T, the time variable. The u's represent random disturbances due to unspecified influences. The marketing cost variable is included in the demand relation when retail prices are not available, as in this case. As in the other analyses, the time variable is used to represent gradual changes in tastes over time.

Results of Statistical Analyses

In the late spring market, the supply of potatoes (from the late spring crop and from storage) available for consumption in any given year is fixed. Thus, prices of potatoes in any given year in this market, after allowing for other factors such as consumer income, are determined by the volume of potatoes marketed. Furthermore, prices of late spring and fall potatoes are jointly determined as they both are affected by the same supplies of potatoes. Therefore, any statistical method used to quantify the coefficients in the structural demand relations (18) and (19) must take into account the joint determination of the prices of late spring and prices of storage potatoes (May-June). As both of these equations are just identified, the reduced-form method of fitting structural equations can be used.14/ The reduced-form equations corresponding to the structural demand relations (18) and (19) are as follows:

$$P_{s_2} = f(Q_{s_2}, Q_{f_2}, D_2, M_2, T, u_3) \quad (20)$$

$$P_{f_2} = f(Q_{s_2}, Q_{f_2}, D_2, M_2, T, u_4) \quad (21)$$

14/ The method consists of three steps: (1) The structural equations are algebraically transformed into reduced-form equations so that each endogenous variable is expressed as a function of all predetermined variables, (2) the reduced-form equations are fitted by least squares, and (3) the regression results are then algebraically transformed back into the original structural equations. Meinken, Rojko and King (28, p. 734) show the algebraic relationships between the coefficients in the structural and reduced-form equations.

In this form, P_{s2} and P_{f2} are the endogenous variables, each expressed as a function of all the predetermined variables. Equations in this form are frequently called price-estimating equations to distinguish them from the structural demand equations. Sometimes they are called demand equations as they are concerned with factors affecting the demand and price structure.

As equations (20) and (21) each have only one endogenous variable, they may be fitted by least squares. This was done using actual data for 1947-60. Data for the price and income variables are in constant 1947-49 dollars. All variables relate to May-June, except marketing costs, which represents cost of marketing services for a calendar year. In this model, the index of wholesale prices of all commodities was taken to represent index of marketing costs. The statistical results are presented in equations (22) and (23). Numbers in parentheses under the coefficients are the respective standard errors.

Late spring potatoes

$$P_{s_2} = 10.332 - \underset{(0.060)}{0.464}\, Q_{s_2} - \underset{(0.056)}{0.362}\, Q_{f_2} + \underset{(0.00326)}{0.00427}\, D_2 - \underset{(0.025)}{0.043}\, M_2 - \underset{(0.092)}{0.101}\, T \qquad (22)$$

$d = 3.238$* $R^2 = .92$

Storage potatoes (May-June)

$$P_{f_2} = 10.521 - \underset{(0.124)}{0.301}\, Q_{s_2} - \underset{(0.116)}{0.518}\, Q_{f_2} + \underset{(0.00673)}{0.00337}\, D_2 - \underset{(0.051)}{0.056}\, M_2 - \underset{(0.190)}{0.035}\, T \qquad (23)$$

$d = 2.765$* $R^2 = .78$

*Inconclusive test for serial correlation in the residuals.

Variables

The variables for this model are defined as follows:

P_{s2} = Season average price received by farmers for late spring potatoes divided by BLS consumer price index, May-June, 1947-49=100; dollars per hundredweight.

P_{f2} = Season average price received by farmers for storage potatoes, May-June, divided by BLS consumer price index, May-June, 1947-49=100; dollars per hundredweight.

267-287 O - 67 - 5

Qs_2 = Apparent per capita consumption of late spring potatoes; pounds.

Qf_2 = Apparent per capita consumption of storage potatoes (May-June) for food; pounds.

D_2 = Per capita disposable income, 2nd quarter, divided by BLS consumer price index, 1947-49=100; dollars.

M_2 = Index numbers of wholesale prices of all commodities; 1947-49=100.

T = Time trend; 1947=1.

The Durbin-Watson statistic (d) tests the unexplained residuals from an equation fitted by least squares to see if successive values are serially correlated. For the two equations in this analysis the test was inconclusive.

Results of the analysis show that late spring potatoes do compete with storage potatoes in the late spring market. All of the price-quantity coefficients in equations (22) and (23) were statistically significant at the 5 percent probability level. The relatively high values of the coefficients of multiple determination for the equations in this model indicated that the exogenous variables tended to explain a large portion of the variation in farm prices of late spring potatoes and storage potatoes (May-June).

Price-consumption relationships in equation (22) indicated that a 1-pound change in per capita consumption of late spring potatoes was, on the average, followed by a change in farm price of 46 cents per hundredweight in the opposite direction, all other factors held constant.

Relationships in the same equation indicated that a 1-pound change in per capita consumption of storage potatoes (May-June) was, on the average, followed by a change in farm price for late spring potatoes of 36 cents per hundredweight in the opposite direction. Thus, the relatively large influence of competing supplies on the price of late spring potatoes indicates that fairly close competition exists between these two types of potatoes. Each is identified with the same economic market. However, price of late spring potatoes is affected substantially more by supply of those potatoes than by competing supplies. This indicates that consumers recognize these as two different types of potatoes. Furthermore, each type of potatoes sells at different prices.15/

The coefficients of the variables in each equation reflecting the influence of consumer income and marketing costs on prices of late potatoes and storage potatoes were similar. The coefficients for time trend were different. The criterion for identification of an economic market, e.g., late spring market, assumes that external influences, such as disposable income, marketing costs, and time trend, affect the demand structure of two seasonal types of potatoes similarly.

15/ Average wholesale prices for May-June, 1960-64, on the New York wholesale market were $5.82 per hundredweight for Western Long White potatoes, compared to $3.72 per hundredweight for storage potatoes. About the same relative difference existed for retail prices per hundredweight on the New York retail market between Western Long White potatoes and storage potatoes for the same period.

The negative trend coefficients, -0.10 and -0.04 respectively for the late spring and storage potato equations, indicate a decline in deflated prices over time. The standard errors, however, are large. Per capita consumption of late spring potatoes dropped slightly but actual (undeflated) prices of late spring potatoes showed no significant trend. This indicates no major change in overall demand. However, it is likely that demand for late spring potatoes for different uses, i.e., processing or fresh market, has changed in the various areas.

Demand Elasticities

Table 11 presents price and income elasticities applicable to the late spring market. These elasticities were computed from coefficients in demand equations (not shown) similar to equations (18) and (19). The coefficients in the demand equations are derived algebraically from regression equations (22) and (23).

Price elasticities

Table 11 indicates that a 1 percent change in price of late spring potatoes was followed, on the average, by a 0.6 percent change in consumption, in the opposite direction, holding income and other factors constant. The results point to a moderately inelastic demand for late spring potatoes. The cross elasticity for late spring potatoes with respect to price of storage potatoes was 0.4.

The values for direct and cross price elasticities for late spring potatoes, -0.6 and 0.4 respectively, indicate that substitutability exists between the two types of potatoes. But the apparent difference between the two values shows that consumers make a distinction between late spring potatoes and storage potatoes.

The cross elasticities for late spring potatoes and storage potatoes, 0.4 and 1.3, were significantly different. However, probably not too much importance should be attached to the differences in these cross elasticities since the levels of the quantity series differ significantly.

The direct elasticity, -1.9, shown for storage potatoes (May-June) appears considerably higher than the direct elasticity of -0.2, obtained from the food equation in the late summer and fall model. A number of plausible explanations can be made. For example, the direct and cross price elasticities obtained from the late spring model indicate that a substantial degree of substitutability exists between late spring potatoes and storage potatoes. Where substitution in demand is relatively great, the indications point to an elastic demand. On the other hand, the high direct elasticity for storage potatoes (May-June) may be more apparent than real. The substantial difference in direct elasticities obtained between storage potatoes in May-June and storage potatoes in all seasons may be simply due to arithmetic--a relatively small consumption rate in May-June, as against a relatively large consumption rate for the whole year.

Early Summer Model

As with the other early-season models, the objective is to measure the substitution effects between the dominant and other seasonal types of potatoes marketed in the early summer market (July-August).

Table 11.- Consumption relationships for potatoes (May-June): Estimates of price and income elasticities of demand, based on data for 1947-60 1/

Analysis and type of potatoes	Price elasticities 2/				Income elasticities 2/	
	Direct		Cross			
	Value	Standard error	Value	Standard error	Value	Standard error
	Pct.	Pct.	Pct.	Pct.	Pct.	Pct.
Reduced-form method: 3/						
Late spring 4/	-0.59	0.08	0.38	0.06	5/0.38	0.29
Storage (marketed for food) 6/	-1.88	.42	1.32	.54	5/ .48	.94

1/ Variables used in this analysis are described on p. 121.
2/ Computed at the mean values of the economic variables for the period of analysis.
3/ Equations (18) and (19) are just identified and thus were fitted by the reduced-form method.
4/ Coefficients are algebraically derived from reduced-form equation (22) fitted by least squares.
5/ Coefficient does not differ significantly from zero when tested at the 10 percent probability level.
6/ Coefficients are algebraically derived from reduced-form equation (23) fitted by least squares.

In this market, early summer potatoes compete for food use with late-maturing late spring potatoes and early-maturing late summer potatoes. Specifically, early summer potatoes, chiefly from the Virginia Eastern Shore, California, Delaware, and Texas, compete with (1) late spring potatoes from California, Arizona, Alabama, and North Carolina, and (2) late summer potatoes from a majority of the Northern States.

During 1947-60, about half of all potatoes entering the early summer market were early summer potatoes; about 15 percent were late spring potatoes; and 35 percent were late summer potatoes. Annual consumption of potatoes per person in the early summer market during this same period averaged 8.6 pounds for early summer potatoes, 2.8 pounds for late spring potatoes, and 6.3 pounds for late summer potatoes. The interrelationships among own prices, own quantities, and prices of competing potatoes for early summer, late spring, and late summer potatoes are examined in this model. Maturity and timing of shipments of late spring and late summer potatoes vary from one year to the next, and have marked influences on consumption and prices of the in-between, early summer crop.

Structural Demand Relations

Substitution and competitive behavior among the three types of potatoes in the early summer market are taken into account in equations (24) through (26):

Demand for early summer potatoes

$$P_{s_3} = a_1 + b_{11}Q_{s_3} + b_{12}P_{s2(s)} + b_{13}P_{l_s} + c_{11}D_3 + c_{12}M_3 + c_{13}T + u_1 \qquad (24)$$

Demand for late spring potatoes in early summer

$$P_{s2(s)} = a_2 + b_{21}Q_{s_2} + b_{22}P_{s_3} + c_{21}D_3 + c_{22}M_3 + c_{23}T + u_2 \qquad (25)$$

Demand for late summer potatoes in early summer

$$P_{l_s} = a_3 + b_{31}Q_{l_s} + b_{32}P_{s_3} + c_{31}D_3 + c_{32}M_3 + c_{33}T + u_3 \qquad (26)$$

In these relations the endogenous variables are P_{s_3}, $P_{s2(s)}$, P_{l_s}, and the predetermined variables are Q_{s_3}, Q_{s_2}, Q_{l_s}, D_3, M_3, and T.

Variables

All variables used in this analysis are expressed in actual values. Data for the price and income variables are in constant 1947-49 dollars.

All variables relate to a seasonal period (July-August) except marketing costs, which represents a calendar year. The description of the variables follows:

P_{s3} = Season average price received by farmers for early summer potatoes, divided by BLS consumer price index, July-August, 1947-49=100; dollars per hundredweight.

$P_{s_{2(s)}}$ = Average price received by farmers for late spring potatoes, July-August, divided by BLS consumer price index, July-August, 1947-49=100; dollars per hundredweight.

P_{l_s} = Average price received by farmers for late summer potatoes, July-August, divided by BLS consumer price index, July-August, 1947-49=100; dollars per hundredweight.

Q_{s3} = Apparent per capita consumption of early summer potatoes for food; pounds.

Q_{s2} = Apparent per capita consumption of late spring potatoes for food; pounds.

Q_{l_s} = Apparent per capita consumption of late summer potatoes for food; pounds.

D3 = Per capita disposable income, 3rd quarter, divided by BLS consumer price index, July-August, 1947-49=100; dollars.

M_3 = Index numbers of cost of marketing potatoes, divided by BLS index of wholesale prices of all commodities, January-December; 1947-49=100.

T = Time trend; 1947=1.

Results of Statistical Analyses

Estimates of coefficients in relations (24) through (26) were obtained by the limited information, two-stage least squares, and ordinary least squares methods. The analyses were based on actual data in arithmetic terms for 1947-60. As in other seasonal markets, farm price was used as the dependent variable in all demand relations, since retail price by type of potatoes was not available. Numbers in parentheses under the coefficients are the respective standard errors.

Limited information estimates:

Demand for early summer potatoes.

$$P_{s3} = \underset{}{-2.139} - \underset{(0.059)}{0.107\,Q_{s3}} + \underset{(0.204)}{0.639\,P_{s2(s)}} + \underset{(0.395)}{0.501\,P_{l_s}} + \underset{(0.00190)}{0.00339\,D_3} \qquad (27)$$

$$-\underset{(0.023)}{0.010\,M_3} - \underset{(0.056)}{0.0101\,T}$$

Demand for late spring potatoes in early summer

$$P_{s2(s)} = 9.163 - \underset{(0.453)}{0.284}\, Q_{s2} + \underset{(0.522)}{1.791}\, P_{s3} - \underset{(0.00046)}{0.00109}\, D_3 - \underset{(0.061)}{0.052}\, M_3 + \underset{(0.040)}{0.043}\, T \qquad (28)$$

Demand for late summer potatoes in early summer

$$P_{l_s} = 1.285 - \underset{(0.226)}{0.156}\, Q_{l_s} + \underset{(0.267)}{0.495}\, P_{s3} + \underset{(0.00060)}{0.00056}\, D_3 + \underset{(0.038)}{0.005}\, M_3 - \underset{(0.222)}{0.097}\, T \qquad (29)$$

Two-stage least squares estimates:

Demand for early summer potatoes

$$P_{s3} = 5.000 - \underset{(0.291)}{0.208}\, Q_{s3} + \underset{0.255)}{0.783}\, P_{s2(s)} - \underset{(0.198)}{0.197}\, P_{l_s} + \underset{(0.00731)}{0.00241}\, D_3 - \underset{(0.110)}{0.046}\, M_3 - \underset{(0.208)}{0.110}\, T \qquad (27a)$$

Demand for late spring potatoes in early summer

$$P_{s2(s)} = 9.163 - \underset{(0.454)}{0.284}\, Q_{s1} + \underset{(0.521)}{1.791}\, P_{s3} - \underset{(0.00047)}{0.00109}\, D_3 - \underset{(0.062)}{0.052}\, M_3 + \underset{(0.040)}{0.043}\, T \qquad (28a)$$

Demand for late summer potatoes in early summer

$$P_{l_s} = 1.285 - \underset{(0.229)}{0.156}\, Q_{l_s} + \underset{(0.269)}{0.495}\, P_{s3} + \underset{(0.00060)}{0.00056}\, D_3 + \underset{(0.038)}{0.005}\, M_3 - \underset{(0.224)}{0.097}\, T \qquad (29a)$$

Least squares estimates:

Demand for early summer potatoes

$$P_{s3} = -3.380 - \underset{(0.032)}{0.096}\, Q_{s3} + \underset{(0.129)}{0.706}\, P_{s2(s)} + \underset{(0.130)}{0.507}\, P_{l_s} + \underset{(0.00168)}{0.00362}\, D_3 - \underset{(0.015)}{0.004}\, M_3 - \underset{(0.050)}{0.108}\, T \qquad (27b)$$

$d = 2.635^*$ $\qquad$ $R^2 - .98$

Demand for late spring potatoes in early summer

$$P_{s2(s)} = \underset{}{6.950} - \underset{(0.042)}{0.071\, Q_{s2}} + \underset{(0.103)}{0.546\, P_{s3}} - \underset{(0.00226)}{0.00239\, D_3} - \underset{(0.016)}{0.023\, M_3} + \underset{(0.074)}{0.071\, T} \qquad (28b)$$

$d = 1.773^*$ $\qquad R^2 = .96$

Demand for late-summer potatoes in early summer

$$P_{ls} = 2.341 - \underset{(0.178)}{0.075\, Q_{ls}} + \underset{(0.086)}{0.756\, P_{s3}} - \underset{(0.00383)}{0.00142\, D_3} + \underset{(0.028)}{0.004\, M_3} - \underset{(0.150)}{0.016\, T} \qquad (29b)$$

$d = 2.619^*$ $\qquad R^2 = .92$

* Inconclusive test for serial correlation in the residuals.

The statistical results indicate that early summer, late spring, and late summer potatoes do compete in the early summer market. The coefficients of multiple determination for each demand equation fitted by least squares indicate that the explanatory variables accounted for over 90 percent of the variation in farm price for all seasonal potato crops marketed in early summer.

The coefficients obtained by the limited information method indicated that a 1-pound change in per capita consumption of early summer potatoes was followed inversely, on the average, by an 11-cent change in price of early summer potatoes. When the same relation was fitted by least squares, the relationship between price and consumption of early summer potatoes was improved and this coefficient was significant at the 5 percent probability level. Since early summer potatoes comprise the greatest share of supplies in the early summer market, the price-consumption relationship for these potatoes was close, as expected.

Use of income as a variable to represent shifts in demand did not give statistically significant coefficients. The reasons for the poor income-consumption relationships were given in the immediately preceding sections.

Demand Elasticities

Table 12 presents price and income elasticities applicable to the early summer market. Elasticities are computed only for the coefficients obtained by the limited information method and the least squares method.

Table 12.- Consumption relationships for potatoes (July-August): Estimates of price and income elasticities based on single- and multiple-equation models, by type of analysis, and based on data for 1947-60 1/

Analysis and type of potatoes	Price elasticities 2/						Income elasticities 2/	
	Direct		Cross elasticity (a)		Cross elasticity (b)			
	Value	Standard error	Value	Standard error	Value	Standard error	Value	Standard error
	Pct.	Pct.	Pct.	Pct.	Pct.	Pct.	Pct.	Pct.
Limited information method: 3/								
Early summer 4/	5/-0.67	0.37	0.44	0.14	6/0.28	0.22	6/0.52	0.35
Late spring 7/	6/- .52	.83	.89	.26	---	---	-.18	.08
Late summer 7/	6/- .48	.70	5/.29	.16	---	---	6/ .24	2.40
Least squares method: 8/								
Early summer 4/	- .75	.25	.54	.10	.32	.08	.39	.14
Late spring 7/	6/-1.04	.62	1.35	.25	---	---	6/-.81	.81
Late summer 7/	6/-1.01	2.40	.92	.10	---	---	6/1.32	5.28

1/ Variables used in these analyses are described on pp. 122-123.
2/ Computed at the mean values of the economic variables for the period of analysis.
3/ Based on coefficients in equations (27) through (29).
4/ Computed from an equation in which cross elasticity (a) is with respect to price of late spring potatoes and cross elasticity (b) is with respect to price of late summer potatoes.
5/ Coefficient differs significantly from zero when tested at the 12 percent probability level.
6/ Coefficient does not differ significantly from zero when tested at the 10 percent probability level.
7/ Computed from an equation in which cross elasticity (a) is with respect to price of early summer potatoes.
8/ Based on equations (27b) through (29b).

Price elasticities

Estimates of price elasticity of demand obtained by the limited information method given in table 12 indicate that a 1 percent change in price of early summer potatoes was followed, on the average, by a 0.7 percent change in consumption, in the opposite direction, holding income and other factors constant.

The results point to a moderately inelastic demand for early summer potatoes. The cross elasticity with respect to price of late spring potatoes obtained from equation (27) was 0.4, and from the same equation with respect to price of late summer potatoes, 0.3. The values obtained for direct and cross price elasticities indicate that a general case of substitutability exists among the three types of potatoes. But the cross elasticities obtained for early summer potatoes are relatively lower than they were for other early-season markets. This suggests a relatively lesser substitution effect of early summer potatoes for late spring potatoes and late summer potatoes than for competing types of potatoes in the other early-season markets. The finding of relatively low cross elasticities for early summer potatoes is a little surprising, since all of the seasonal types of potatoes competing in the early summer market are perishable. Consumers were not expected to be able to differentiate as well between types of perishable potatoes as between early potatoes and storage potatoes.

Direct and cross price elasticities for late spring potatoes (July-August) obtained from equation (28), -0.5 and 0.9, respectively, indicate that consumers tend to substitute late spring potatoes for early summer potatoes more readily than the other way around. The high positive cross elasticity gives strong evidence of substitutability. The apparent difference between direct and cross price elasticities for late spring potatoes implies that consumer preferences exist and these result in different selling prices for the different types of potatoes. A caution should be given on the size of the cross elasticity coefficient in equation (28). The differences in levels of the quantity series and the price series for late spring potatoes and early summer potatoes may have contributed to an unreasonably high cross elasticity coefficient.

The values for direct and cross price elasticities for late summer potatoes (July-August) obtained from equation (29) were -0.5 and 0.3, respectively. Again, they indicate that substitutability exists between late summer potatoes and early summer potatoes. As with early summer potatoes and late spring potatoes, the apparent difference between the direct and cross elasticities points to differentiation between the two types of potatoes. The least squares analyses for equations (28b) and (29b) yielded direct and cross price elasticity coefficients for late spring potatoes and late summer potatoes that seemed unreasonably high.

As in the other seasonal markets, different prices were received at the wholesale level for different seasonal crops of potatoes. 16/

16/ Average wholesale prices for 1960-64, on the New York wholesale market, were $3.58 per hundredweight for early summer potatoes, $5.94 per hundredweight for late spring potatoes marketed in July-August, and $2.70 per hundredweight for late summer potatoes marketed in July-August. The lower average price for late summer potatoes marketed in July-August may have been due in part to the tendency for prices to decline over the summer as harvest increases.

DEMAND ELASTICITIES FROM OTHER STUDIES

Most previous statistical studies of demand for potatoes considered principally the total U.S. potato crop (all seasons) as the subject for research. Results of many of these studies are shown in table 13. The markets for potatoes were considered as a single market, with an overall average of prices and quantities for total potatoes. Potatoes were treated as a standardized commodity with no disaggregation for seasonal types of potatoes or for individual demands for different uses. The relatively recent studies of Shuffett (38) and Zusman (68) were the first to divide the total U.S. potato crop into "winter" and "spring" markets.

Estimates of price elasticity of demand obtained by previous researchers from regression analysis for the total U.S. crop ranged from -0.16 to -0.39. These studies analyzed price and quantity data for the pre-World War II period. Fox obtained an income elasticity of demand for total U.S. potatoes for the pre-World War II period of approximately 0.8. When seasonality of production was disregarded, as it was in most of the earlier studies, the demand for potatoes appeared to be markedly inelastic.

Shuffett (38) found price elasticities of demand of -0.47 for the early and intermediate crops, -0.25 for the late crop, and about -0.30 for total U.S. potatoes. He attributed the higher elasticity coefficient obtained for total U.S. potatoes, compared to that for the late crop, to inclusion of early potatoes, for which the demand was more elastic, in the former analysis.

Gray, Sorenson, and Cochrane (15) and Simmons (39) developed theoretical analyses in their research on problems of instability in potato prices and income to farmers. Both studies suggested plans which would provide for a more elastic demand or some means of stabilizing supplies. The studies noted, however, that there may be important differences in supply-price relationships by season, area, and State. The Gray, Sorenson, and Cochrane study indicated that little was known at the time their report was published about substitutability between potatoes from different producing areas.

Zusman gave price flexibility coefficients for four types of potatoes: (1) Winter, (2) storage--carried over to spring, (3) California early, and (4) other early States. The reciprocals of price flexibility are often taken to represent elasticities of demand. In table 13, demand elasticities have been computed from Zusman's price flexibility coefficients. Price elasticity for winter (storage) potatoes from Zusman's study is considerably lower than those obtained by earlier research workers. Zusman noted that previous studies had used gross production as the quantity variable, whereas he used disappearance for food, and the use of latter data may have produced this result. Also, his study indicated that demand for late summer and fall potatoes for nonfood use is more elastic than the demand for food.

Zusman used an unusual procedure for computing price flexibilities for (1) California spring potatoes, (2) other early spring potatoes, and (3) storage potatoes carried over to spring. He adjusted the price flexibility coefficients at the mean value of the aggregate of total supplies of potatoes in spring. He stated that his purpose for this procedure was to permit comparison with results of earlier

Table 13.--Potatoes: Elasticities of demand with respect to price and income, by type of analysis, for specified periods

Method of analysis and study	Form of data	Period of analysis	Quantity measure	Time trend coefficient	Demand elasticity with respect to--			
					Own price		Income	
					Value	Standard error	Value	Standard error
Least squares:								
Schultz (35), 1/								
Total potatoes	Logarithms	1915-29	Consumption	-0.002	-0.32	0.02	---	---
Fox (12)								
Total potatoes	do.	1922-41	Production	---	- .26	.02	2/ 0.83	0.23
do.	do.	1922-41	Consumption	---	- .22	.03	---	---
Gray, Sorenson, and Cochrane (15) 3/								
Total potatoes	do.	1910-42	Consumption	- .35	- .39	(4)	---	---
do.	do.	1923-41	do.	---	- .16	(4)	---	---
Shuffett (38), 5/ 6/								
Early and intermediate	do.	1920-41	Production	---	- .47	.08	.46	.25
Late	do.	1920-41	do.	---	- .25	.02	.35	.09
Total	do.	1920-41	do.	---	- .28	.02	.42	.08
Simmons (39), 6/								
Eastern region	Actual data	1951-60	do.	---	- .13	.05	---	---
Central region	do.	1951-60	do.	---	- .16	.11	---	---
Maine	do.	1951-60	do.	---	- .32	.07	---	---
Minn.-N. Dak.	do.	1951-60	do.	---	- .64	.40	---	---
Two-stage least squares:								
Zusman (68), 6/								
Winter	do.	1930-58	Consumption	- .008	- .14	.09	---	---
Storage-carried over to spring	do.	1930-58	do.	---	- .71	.19	---	---
California early	do.	1930-58	do.	---	- .29	.13	---	---
Other early	do.	1930-58	do.	---	- .56	.19	---	---

1/ Prices received by farmers deflated by index of U.S. industrial production. 2/ Derived from income flexibility. 3/ Price undeflated in these equations. 4/ Not available. 5/ Price undeflated in all equations. 6/ Results relating to demand are given in the original study as price and income flexibility coefficients. Derivation of price and income elasticities of demand from coefficients in this table is subject to the cautions given with regard to such derivations by Meinken, Rojko, and King (28, pp. 732-734).

studies. The use of total supplies in spring for computation of the price flexibilities at their mean values gives a quite different price flexibility (and price elasticity of demand) from that derived by use of the mean value of the relevant single quantity variable. Computation by the former procedure tends to overstate the value of the price flexibility coefficient (understate the value of the price elasticity of demand).

None of the studies discussed here analyzed all of the interrelationships in the different seasonal potato markets which are implied in published data on seasonal categories provided by the Statistical Reporting Service. The most recent studies, however, made different attempts to allow for competing supplies of potatoes. In this manner, improved estimates of own price-consumption relationships were obtained by allowing for cross price-consumption relationships. In the present study, each seasonal market is examined individually, and statistical estimates are obtained of price and income elasticities for each of the different types of potatoes that compete in each of the three early-season markets.

PREDICTION FROM STATISTICAL MODELS

A very important function of a statistical model is its ability to correctly predict variables for years beyond the period of fit. For instance, an analyst may want to obtain projections of per capita consumption, retail price, or farm price of late summer and fall potatoes, for 1, 2, or 5 years ahead. Or he may be interested in estimating farm price or consumption of early potatoes. In addition, policymakers or members of the industry may be interested in forecasting direction of change in prices and consumption of potatoes.

This section evaluates the statistical models for their ability to correctly predict direction of change in prices and consumption and to correctly estimate absolute values of the endogenous variables beyond the period of fit. This can be done since the models were fitted using data for 1947-60, and data are available for years beyond 1960 for testing the soundness of the relationships.

Tables 14 through 17 show, for 1961, 1962, and 1963, comparisons between actual values of the endogenous variables and the estimated values for these same variables obtained by using different estimating equations. The same comparisons for the period of fit, 1947-60, are shown in the appendix, tables 22 through 25.

A qualitative test is used to evaluate the accuracy of prediction of direction of change for 13 endogenous variables for 1961, 1962, and 1963, contained in the 4 statistical models. The form of the test is a probability function which yields p successes and q failures equally by chance, in predicting ahead.

A quantitative test is used to determine how closely the predicted values for the 13 endogenous variables approximate the actual (observed) values. Variance ratios (unexplained variation as a ratio of total variation) are used to test the accuracy of prediction of the absolute values. For this test, the lower the variance ratio, the better the prediction. In addition, estimates evaluated by qualitative and quantitative means are classified by method of estimation, to determine which method yields the best results.

Table 14.--Model of late summer and fall potato market: Actual and predicted values of the endogenous variables, 1961-63

Item and year	Actual	Predicted: Reduced-form equations: Limited information 1/	Predicted: Reduced-form equations: Least squares 2/	Predicted: Structural equations: Limited information 3/	Predicted: Structural equations: Two-stage least squares 4/	Predicted: Structural equations: Least squares 5/
	Pounds	Pounds	Pounds	Pounds	Pounds	Pounds
Consumption for food, per capita, C_h:						
1961	86.67	88.47	85.56	87.88	85.26	86.74
1962	86.94	88.05	85.96	87.84	85.14	86.80
1963	88.25	89.91	87.38	88.52	88.87	87.31
Consumption for livestock feed, per capita, C_f:						
1961	10.63	8.23	10.42	8.69	8.64	8.66
1962	8.29	7.21	10.22	7.60	7.55	7.73
1963	7.69	7.19	10.66	6.83	6.79	7.20
Consumption for starch, per capita, C_s:						
1961	8.54	6.94	7.19	7.63	7.72	7.13
1962	6.12	4.47	4.94	5.03	5.10	4.63
1963	6.25	5.09	5.33	4.42	4.36	4.76
	Dollars	Dollars	Dollars	Dollars	Dollars	Dollars
Farm price per hundredweight, P_f:						
1961	1.06	0.87	1.42	1.22	1.25	1.18
1962	1.28	1.44	1.55	1.41	1.35	1.30
1963	1.44	1.19	1.52	1.28	1.42	1.36
	Cents	Cents	Cents	Cents	Cents	Cents
Retail price per 10 pounds, P_r:						
1961	45.0	43.2	50.6	46.6	43.9	43.2
1962	48.2	47.6	46.3	44.9	46.4	46.4
1963	49.9	45.8	45.8	48.3	48.2	48.6

1/ Limited information estimates obtained by algebraic transformation of endogenous variables in equations (6) through (9).

2/ Least squares estimates obtained by fitting the endogenous variable as a function of all the predetermined variables in the model.

3/ Limited information estimates are from structural equations (6) through (9).

4/ Two-stage least squares estimates are from equations (6a) through (9a).

5/ Direct least squares estimates are from equations (6b) through (9b).

Table 15.--Model of winter and early spring potato market: Actual and predicted values of the endogenous variables, 1961-63

Item and year	Actual	Predicted				
		Reduced-form equations		Structural equations		
		Limited information 1/	Least squares 2/	Limited information 3/	Two-stage least squares 4/	Least squares 5/
Farm price per hundredweight:	Dollars	Dollars	Dollars	Dollars	Dollars	Dollars
Winter and early spring potatoes, P_{s1}						
1961	1.81	2.09	2.30	2.05	2.14	2.14
1962	2.15	1.43	2.16	1.58	1.78	1.85
1963	1.87	1.81	1.52	1.82	1.91	1.90
Storage potatoes (January-April), P_{f1}						
1961	1.33	1.89	1.24	0.96	1.00	1.02
1962	0.89	0.72	1.43	0.99	1.08	1.16
1963	1.11	1.06	1.01	0.72	0.81	0.90
Fall potatoes in storage, per capita, May 1, S_t	Pounds	Pounds	Pounds	Pounds	Pounds	Pounds
1961	10.67	---	---	---	---	12.18
1962	13.10	---	---	---	---	13.44
1963	12.54	---	---	---	---	13.22

1/ Limited information estimates obtained by algebraic transformation of endogenous variables in equations (15) and (16).

2/ Least squares estimates obtained by fitting the endogenous variable in equations (15b) and (16b) as a function of all the predetermined variables in the model.

3/ Limited information estimates are from structural equations (15) and (16).

4/ Two-stage least squares estimates are from equations (15a) and (16a).

5/ Direct least squares estimates are from equations (15b), (16b) and (17).

Table 16.--Model of late spring potato market: Actual and predicted values of the dependent variables, 1961-63

Item and year	Actual	Predicted
		Reduced-form equation-least squares
Farm price per hundredweight:	Dollars	Dollars
Late spring potatoes, P_{s_2} 1/		
1961	1.34	1.23
1962	1.83	2.00
1963	1.37	1.74
Storage potatoes (May-June), P_{f_2} 2/		
1961	1.01	1.08
1962	1.13	0.86
1963	0.85	0.84

1/ Least squares estimates obtained by fitting the endogenous variable in equation (22) as a function of all the predetermined variables in the model. 2/ Least squares estimates obtained by fitting the endogenous variable in equation (23) as a function of all the predetermined variables in the model.

Table 16.--Model of late spring potato market: Actual and predicted values of the dependent variables, 1961-63 -- Continued

Item and year	Actual	Predicted
		Ordinary least squares
Per capita disappearance:	Pounds	Pounds
Late spring potatoes, Q_{s_2} 3/		
1961	15.47	15.29
1962	11.90	12.33
1963	12.87	13.69
Storage potatoes (May-June), Q_{f_2} 4/		
1961	5.45	5.10
1962	8.17	6.45
1963	7.72	6.85

3/ Least squares estimates obtained by fitting equation (18).
4/ Least squares estimates obtained by fitting equation (19).

267-387 O - 67 - 6

Table 17.--Model of early summer potato market: Actual and predicted values of the endogenous variables, 1961-63

Item and year	Actual	Predicted				
		Reduced-form equations		Structural equations		
		Limited information 1/	Least squares 2/	Limited information 3/	Two-stage least squares 4/	Least squares 5/
Farm price per hundredweight:	Dollars	Dollars	Dollars	Dollars	Dollars	Dollars
Early summer potatoes, P_{s_3}						
1961	1.34	1.78	1.72	1.10	0.99	1.04
1962	1.67	1.94	1.82	1.69	1.49	1.67
1963	1.54	1.34	1.10	1.78	1.34	1.80
Late spring potatoes, $P_{s_{2(s)}}$ 6/						
1961	1.34	1.93	1.94	1.00	1.00	1.45
1962	1.75	1.83	2.10	1.35	1.35	1.63
1963	1.69	1.18	1.47	1.54	1.54	1.48
Late summer potatoes, P_{l_s} 6/						
1961	1.04	1.76	1.33	1.38	1.38	1.00
1962	1.35	1.80	1.72	1.60	1.60	1.24
1963	1.61	1.38	1.32	1.47	1.47	1.10

1/ Limited information estimates obtained by algebraic transformation of the endogenous variables in equations (27) through (29).

2/ Least squares estimates obtained by fitting the endogenous variable in equations (27b) through (29b) as a function of all the predetermined variables in the model.

3/ Limited information estimates are from structural equations (27) through (29).

4/ Two-stage least squares estimates are from equations (27a) through (29a).

5/ Direct least squares estimates are from equations (27b) through (29b).

6/ The estimated values of $P_{s_{2(s)}}$ and P_{l_s} from the limited information fit and the two-stage least squares fit of the structural equations are identical because the coefficients obtained in the equations fitted by each of the two methods were identical.

Qualitative Test of Predicted Values

The qualitative test gives a measure for determining how well the statistical models were able to predict direction of change. This is one of the critical tests of the model's structure. The first step is to count the number of correct predictions of direction of change for each endogenous variable for 1961, 1962, and 1963. Successes of prediction are compared to the probability of getting that number of correct predictions by chance alone. If the actual price of a particular type of potatoes increases from year t-1 to year t, the estimate for t is correct if it too is higher than the actual price of potatoes in year t-1. Likewise, if the price of potatoes declines from year t-1 to year t, the prediction for t is correct if it too is less than the actual t-1 price.

Let p be the probability of getting a corect prediction of the direction of change (= ½) and q the probability of getting an incorrect one (= ½). Further, let 1961, 1962, 1963 be the years for which predictions are to be made. The terms in the binomial expansion $(p + q)^3$ give the probability of getting 0, 1, 2, and 3 correct predictions in the test. The probability of getting as many as 2 correct predictions out of 3 is the sum of the probabilities of getting 2 and 3. Likewise, the probability of getting 1 correct prediction out of 3 is the sum of the probabilities of getting 1, 2, and 3. Thus, we are dealing with cumulative sums of at least that many successes. 17/

Table 18 presents results of the comparison of the accuracy of predictions from the four statistical models with the probabilities of obtaining correct predictions by chance alone. The estimated values were computed from single and multiple equations fitted by alternative methods. Also, this table shows the total number of correct predictions for each statistical model.

In table 18, comparisons are made of the correct number of predictions for a variable among the different methods of fit. In making these comparisons, two considerations are important: (1) What information is needed to make predictions when all of the different methods of fit are considered, and (2) should comparisons be limited only to methods using the same amount of information?

The first two columns in table 18 show the number of correct predictions of direction of change obtained by using the reduced-form method of fitting simultaneous equations. The parameters of the limited information reduced-form equation were algebraically derived from the parameters in the structural equations. Those in the least squares reduced-form equations were fitted directly. In using the reduced-form equations, only values of the variables which were classified as predetermined variables were used to make estimates of the endogenous variables.

17/ The partial sum of the expansion of the binomial $(p + q)^n$ was used in the computation of the probabilities where the expansion terms are

$$q^n + nq^{n-1}p + \frac{n(n-1)}{2} q^{n-2} p^2 + \frac{n(n-1)(n-2)}{2 \cdot 3} q^{n-3} p^3$$

$$+ \dots + \frac{n(n-1)(n-2)\dots(n-r+1)}{2 \cdot 3 \dots r} q^{n-r} p^r + \dots + p^n$$

Table 18.--Number of correct predictions of direction of change in values of the endogenous variables in the the potato economy, and related probabilities, by statistical model and alternative methods of fit, 1961-63 1/

Model and endogenous variables 2/	Method of fit									
	Reduced-form equations				Structural equations					
	Limited information		Least squares		Limited information		Two-stage least squares		Least squares	
	Number correct	Probability	Number correct	Probability	Number correct	Probability	Number correct	Probability	Number correct	Probability
Late summer and fall model:	13	0.0037	11	0.059	10	0.15	13	0.0037	15	0.00003
C_h	2	.50	3	.12	2	.50	2	.50	3	.12
C_f	3	.12	2	.50	3	.12	3	.12	3	.12
C_s	3	.12	3	.12	2	.50	2	.50	3	.12
P_f	2	.50	2	.50	2	.50	3	.12	3	.12
P_r 3/	3	.12	1	.88	1	.88	3	.12	3	.12
Winter and early spring model:	4	.34	3	.66	2	.89	2	.89	4	.75
P_{s_1}	1	.88	2	.50	1	.88	1	.88	1	.88
P_{f_1}	3	.12	1	.88	1	.88	1	.88	1	.88
S_t	(4)	(4)	(4)	(4)	(4)	(4)	(4)	(4)	2	.50
Late spring model:	(5)	(5)	4	.34	(5)	(5)	(5)	(5)	(5)	(5)
P_{s_2}	(5)	(5)	2	.50	(5)	(5)	(5)	(5)	(5)	(5)
P_{f_2}	(5)	(5)	2	.50	(5)	(5)	(5)	(5)	(5)	(5)
Early summer model:	4	.75	5	.50	6	.25	7	.09	7	.09
P_{s_3}	2	.50	2	.50	2	.50	3	.12	2	.50
$P_{s_2(s)}$	1	.88	2	.50	2	.50	2	.50	3	.12
P_{1s}	1	.88	1	.88	2	.50	2	.50	2	.50

1/ From year t-1 to year t.

2/ Number of correct predictions and related probabilities given by model and by endogenous variables within each model.

3/ Explanation for derivation of estimated values for P_r given in footnotes to table 19.

4/ Ordinary least squares estimates alone were obtained for this equation since it contained only 1 endogenous variable.

5/ Least squares reduced-form estimates alone were obtained for these equations since they were "just identified."

Of all statistical models fitted, the late summer and fall model appeared to give the greatest number of correct predictions of direction of change for 1961, 1962, and 1963, in both absolute and percentage terms. The equations used to estimate the consumption variables, C_h, C_f, and C_s, gave the greatest number of correct predictions for all different methods of fit. However, the equations used to estimate the price variables, P_f and P_r, gave substantially correct predictions of direction of change for the two-stage least squares, limited information reduced-form equations, and ordinary least squares methods of fit. The structural equations fitted by least squares gave correct predictions of direction of change for every endogenous variable for every year of prediction. The probability of obtaining 3 correct predictions out of 3, as was obtained for each endogenous variable in this model, by chance alone, is 0.12. The probability of obtaining 15 correct predictions out of 15, as was obtained from estimates derived from this model, by chance alone, is 0.00003.

For the period of prediction, 1961-63, the winter and early spring model did not do much better in predicting direction of change than could be done by chance. The structural equations, using three different methods of fit, were able to predict direction of change correctly 1 out of 3 times for P_{s1} and for P_{f1}. Almost as many correct predictions could have been derived by tossing coins. However, the reduced-form equations for obtaining estimates for P_{s1} and P_{f1}, in the aggregate, correctly predicted 3 out of 6 and 4 out of 6 directions of change, respectively.

Estimates for the late spring model for 1961-63 showed that the reduced-form equations fitted by least squares correctly predicted 4 out of 6 directions of change. The direction of change for each of the individual endogenous variables, P_{s2} and P_{f2}, was correctly predicted 2 times out of 3. The reduced-form equations were the only equations fitted for the late spring model since the system of equations was "just identified." (See p.39for criteria of identification.)

For 1961-63 the structural equations in the early summer model fitted by limited information, two-stage least squares, and ordinary least squares correctly predicted 6 out of 9, 7 out or 9, and 7 out of 9 directions of change, respectively. For these methods of fit, the early summer model thus approached the late summer and fall model in giving satisfactory indications of direction of change for prices of different types of potatoes. The reduced-form equation did less well in predicting direction of change. Even so, the reduced-form equations did better in predicting direction of change than random predictions based upon chance. Based upon all methods of fit, the equations for estimating P_{s3} did the best in predicting direction of change correctly, followed by the equations for estimating $P_{s2(s)}$ and P_{1_s}. Estimates for P_{s3} from reduced-form equations did nearly as well as those from structural equations in correctly predicting direction of change.

Quantitative Test of Predicted Values

The quantitative test assumes that the variation among the estimated values is minimized relative to the total variation in the actual values. For this test the variance ratio (unexplained variation as a ratio of total variation) was used to validate the model. This is the second critical test of the model's structure. Alternative types of tests are given by Maki and Crom (24).

Table 19.--Endogenous variables in the potato economy: Total variation, and ratio of unexplained variation to total variation, by statistical model and alternative methods of fit, for specified periods 1/

Period and model	Endogenous variable	Total variation 2/	Ratio of unexplained variation to total variation 3/				
			Reduced-form equations		Structural equations		
			Limited information	Least squares	Limited information	Two-stage least squares	Least squares
1947-60							
Late summer and fall model:							
Consumption of potatoes for food (pounds)	C_h	60.72	0.24	0.07	0.42	0.29	0.28
Consumption of potatoes for livestock feed (pounds)	C_f	21.00	.19	.08	.35	.35	.28
Consumption of potatoes for starch (pounds)	C_s	91.59	.13	.05	.09	.04	.26
Farm price for potatoes, (dollars)	P_f	4.30	.5[illegible]	.23	.4[illegible]	.13	.12
Retail price for potatoes, 10 lb. 4/ (cents)	P_r	480.14	.53	.42	.32	.19	.22
Winter and early spring model:							
Farm price, winter and early spring potatoes (dollars)	P_{s_1}	6.65	.3[illegible]	.30	.35	.26	.24
Farm price, storage potatoes, Jan.-April (dollars)	P_{f_1}	6.00	.42	.39	.24	.30	.12
Storage stocks, fall potatoes, May 1 (pounds)	S_t	76.65	(5)	(5)	(5)	(5)	.30
Late spring model:							
Farm price, late spring potatoes (dollars)	P_{s_2}	6.94	(6)	.08	(6)	(6)	(6)
Farm price, storage potatoes, May-June (dollars)	P_{f_2}	10.70	(6)	.22	(6)	(6)	(6)
Early summer model:							
Farm price, early summer potatoes (dollars)	P_{s_3}	10.37	.94	.40	.02	.23	.02
Farm price, late spring potatoes, July-Aug. (dollars)	$P_{s_2(s)}$	9.29	.52	.30	.1[illegible]	.16	.04
Farm price, late summer potatoes, July-Aug. (dollars)	P_{l_s}	7.25	.83	.49	.16	.16	.08

See footnotes at end of table.

Continued -

Table 19.--Endogenous variables in the potato economy: Total variation, and ratio of unexplained variation to total variation, by statistical model and alternative methods of fit, for specified periods 1/ -Continued

Period and model	Endogenous variable	Total variation 2/	Ratio of unexplained variation to total variation 3/				
			Reduced-form equations		Structural equations		
			Limited information	Least squares	Limited information	Two-stage least squares	Least squares
1961-63							
Late summer and fall model:							
Consumption of potatoes for food (pounds)	C_h	1.42	5.09	2.08	1.65	3.95	0.64
Consumption of potatoes for livestock feed (pounds)	C_f	4.83	1.49	2.61	1.03	1.10	.92
Consumption of potatoes for starch (pounds)	C_s	3.71	1.79	1.09	1.45	1.42	1.73
Farm price for potatoes (dollars)	P_f	.07	1.71	3.00	1.00	.59	.28
Retail price for potatoes, 10 lb. 4/ (cents)	P_r	12.38	2.70	4.16	1.20	.57	.29
Winter and early spring model:							
Farm price, winter and early spring potatoes (dollars)	P_{s_1}	.07	8.57	5.14	5.43	3.57	2.86
Farm price, storage potatoes, Jan.-April (dollars)	P_{f_1}	.10	3.40	3.10	3.00	2.40	2.10
Storage stocks, fall potatoes, May 1 (pounds)	S_t	3.22	(5)	(5)	(5)	(5)	1.07
Late spring model							
Farm price, late spring potatoes (dollars)	P_{s_2}	.15	(6)	1.20	(6)	(6)	(6)
Farm price, storage potatoes May-June, (dollars)	P_{f_2}	.04	(6)	2.00	(6)	(6)	(6)
Early summer model							
Farm price, early summer potatoes (dollars)	P_{s_3}	.06	5.17	6.00	2.00	3.17	2.33
Farm price, late spring potatoes, July-Aug. (dollars)	$P_{s_2(s)}$	.10	5.20	5.30	3.00	3.00	.71
Farm price, late summer potatoes, July-Aug. (dollars)	P_{ls}	.16	4.81	1.88	1.25	1.25	1.69

1/ Equations fitted to actual data for 1947-60. See tables 14-17 for estimated values of the variables for 1961-63 and tables 22-25 for estimated values of the variables for 1947-60.

2/ Total variation = $\sum_{t=1}^{14} (X - \bar{X})^2$ for 1947-60; $\sum_{t=1}^{3} (X \quad \bar{X})^2$ for 1961-63.

3/ Unexplained variation = $\sum_{t=1}^{14} (X - X')^2$ for 1947-60; $\sum_{t=1}^{3} (X - X')^2$ for 1961-63.

4/ Limited information estimates obtained by algebraic transformation of equation (9); two-stage least squares estimates obtained by algebraic transformation of equation (9a); ordinary least squares estimates obtained by direct fit of variables contained in equation (9b) with P_r dependent (analysis not shown); and estimates from reduced-form equations obtained by (1) algebraic transformation of endogenous variables and then fitting by limited information and (2) fitting directly by least squares (analysis not shown).

5/ Ordinary least squares estimates alone were obtained for this equation since it contained only 1 endogenous variable.

6/ Least squares reduced-form estimates alone were obtained for this equation since it was "just identified." (See p. 39 for criteria of indentification.)

Table 19 shows the total variation present in the endogenous variables in the potato economy and the ratio of the unexplained variation to the total variation. The meaning of this ratio is as follows: If the factors used in the statistical relationship can explain all the variation in the endogenous variable, then the amount left unexplained is zero and the ratio is zero. On the other hand, if the factors cannot explain any variation during the period of fit, then the ratio becomes 1.0. Therefore, for the period of fit, 1947-60, the closer the ratio is to zero, the better the model--or the method of fit--is for estimating.

For years beyond the period of fit, deviations of the estimates from their mean can be greater than deviations of the actual values from their mean, and therefore the variance ratio can exceed 1.0. In table 19, the ratios are shown for both the period of analysis, 1947-60, and for years beyond the period of analysis, 1961-63.

As indicated in table 19, comparisons can be made of variance ratios obtained for an endogenous variable from different methods of fit. In making these comparisons, consideration should be given both to the information needed to make estimates of the endogenous variables and to fitting procedures which use the same amount of information. The two lefthand columns of variance ratios are obtained from estimates using the reduced-form equations for fitting simultaneous equations.

The parameters of the limited information reduced-form equations were algebraically derived from the parameters in the structural equations, while those in the least squares reduced-form equations were directly fitted. In using these reduced-form equations, only values of the predetermined variables were used to make estimates of the endogenous variables. Thus, one useful purpose of the reduced-form equations is to yield estimates of certain endogenous variables that are subsequently used in making estimates from structural equations.

In making predictions, predetermined or exogenous variables used in reduced-form equations are not given but must be estimated by some means. As a rule, estimates for many of the variables usually classified as predetermined, such as consumer income, can be obtained readily from various Government agencies. And total production or supply of potatoes which has been assumed as predetermined could be estimated from a supply equation based on factors which existed in a previous period.

However, the reduced-form equations as shown cannot use information supplied by other endogenous variables that might appear in the structural equations. In this case, it might be more feasible to use the structural equations directly, particularly if they contain the major predetermined variables. In addition, a stronger relationship may exist between the respective endogenous variables in the structural equations than between an endogenous variable and any one of the predetermined variables. The three right-hand columns of variance ratios are used to test the ability of the structural equations to estimate directly the values of a single endogenous variable.

For 1961-63, based on variance ratios given in table 19, the late summer and fall model, among all models fitted and over all methods of fit, most accurately predicted the values of the endogenous variables. For this model, over all methods of fit, the equations for the price variables, P_f and P_r, appeared to give better estimates than the equations for the consumption variables, C_h, C_f, and C_s. Based on this test, estimates for farm price, P_f, and retail price, P_r, from equations fitted by ordinary least squares were substantially better than estimates for the other variables.

For the period of fit, 1947-60, the ratios indicate that the reduced-form equations for the late summer and fall model gave the best estimates of C_h, consumption for food. However, for the years beyond the period of fit, 1961-63, the structural equations, fitted by least squares, gave the best estimates for this variable. But the structural equations require the price of potatoes, a key endogenous variable, to be known and given. Comparison of the ratios among the methods of fit indicates that the relationship between consumption and price of late summer and fall potatoes appears more stable over time than the relation between consumption and the exogenous variables used in the analysis.

The structural equations fitted by least squares and two-stage least squares gave relatively low variance ratios for P_f, farm price, and P_r, retail price, for 1961-63. But the comparison between them and the ratios obtained from the reduced-form equations can be misleading. The structural equations show the relation between farm price, retail price, and marketing costs. Thus, the results using the structural equations simply indicate that farm and retail prices tend to remain closely related over time except for changes in marketing costs. On the other hand, the reduced-form equations for estimating farm price take into account the influence of basic demand factors.

The ratios for estimates obtained from the reduced-form equations for 1961-63 indicate that these are reasonable equations for estimating P_f in view of the relatively low total variation resulting for that variable. The ratios indicate that of the two reduced-form equations, the limited information reduced-form equation appears to be better in estimating P_f in years beyond the period of fit.

For the period of prediction, 1961-63, as measured by the variance ratios in table 19, over all methods of fit, the winter and early spring model did not do nearly so well as the late summer and fall model in predicting values of the endogenous variables. This was due principally to the small range existing in the actual values; as seen from the table of variance ratios, the total variation in P_{s1} and P_f, for 1961-63 was very small. For example, differences from the mean for actual prices for 1961-63 for P_{s1} averaged only 13 cents, while differences of actual prices from the mean for the same variable for the immediately preceding 3 years, 1958-60, averaged 38 cents. The relatively low total variation for each of P_{s1} and P_{f1} for 1961-63 resulted in unusually high variance ratios.

For the winter and early spring model, the ratios for 1961-63 were somewhat smaller for estimates of P_{s1} and P_{f1} from structural equations than for estimates from reduced-form equations. However, each structural equation contains the price of the competing types of potatoes. The lower ratios obtained from fitting the structural equations may be due to inclusion of this variable. In this case, own price and prices of the substitute potatoes tended to be more closely related than own price and own quantity. For both the period of fit, 1947-60, and the period of prediction, 1961-63, the structural equations fitted by ordinary least squares gave better predictions of prices than the limited information and two-stage least squares fits.

For the period of prediction, 1961-63, as measured by the variance ratios, equations for the late spring model gave better estimates than those in the winter and early spring model. As seen in table 19, reasonable estimates were obtained for both P_{s2} and P_{f2} from the equations contained in the late spring model. The predetermined variables, Q_{s2} and Q_{f2}, in both of the "just identified" equations in this model were statistically significant at the .05 probability level in both equations and this undoubtedly contributed to accuracy in prediction.

The early summer model, as measured by the variance ratios, did very well in providing estimates for P_{s3}, $P_{s2(s)}$, and P_{ls} from structural equations for the period of fit, 1947-60. For all three endogenous variables, the variance ratios computed from results of structural equations averaged lower than that for any other model. But for the period of prediction, 1961, 1962, and 1963, with the exception of the winter and early spring model, the ratios computed were higher than those for any other model.

The early summer model gave lower ratios for 1961-63 for estimates obtained from structural equations than for estimates obtained from reduced-form equations. In general, of the three endogenous variables, P_{ls} showed the smallest ratio, based on all three methods of fit. The changing relative importance of supplies of early summer, late spring and late summer potatoes in the early summer market (July-August) in the early 1960's may be the cause of the substantially higher ratios for P_{s3}, $P_{s2(s)}$, and P_{ls} for 1961-63 compared with 1947-60.

An important consideration in evaluating the ratios given in table 19 is the number of years available for prediction. If the number of years (observations) for comparison between actual and estimated values is relatively small, such as 3, the ratios of unexplained variation to total variation will usually be larger than if a larger number of years (observations) is used. This is due to the problems associated with a small sample.

Graphic Analysis of Predicted Values

Comparison between the actual and computed values can also be shown graphically. These are plotted for 1947 through 1963 in figures 9 through 14 for specified endogenous variables in the potato economy.

Figure 9 shows that estimated values for 1947-50 and 1954-63 of C_h, consumption for food, closely approximate the pattern of actual values. For these years, even though production of late summer and fall potatoes was more than sufficient to supply requirements for food, the food equation estimated changes in consumption fairly accurately. The long-term estimation of C_h appeared to be as good as the short-term estimates. Values obtained from 1956 through 1963 indicated, on the basis of both long-term and short-term estimates, that the model did well in forecasting the changes that occurred during the period. For 1947-63, the ordinary least squares method of fit appeared to do a better job of estimating than the limited information structural equations fit.

Figures 10 and 11 indicate that the equations did a pretty good job of estimating farm price and retail price of late summer and fall potatoes for 1947-63. Only for the crop years 1954-56 and 1960 are notable differences found between estimated and actual values. The

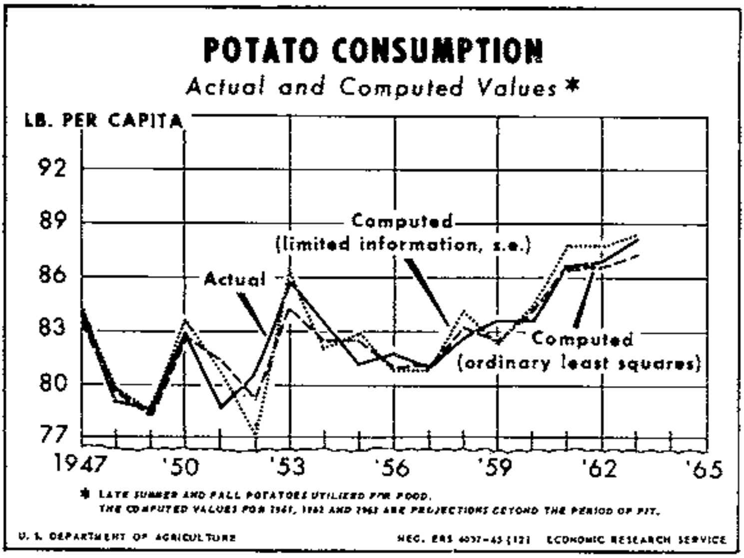


Figure 9

actual prices by months, for the stated years, as reported by the Statistical Reporting Service, tended to show wide fluctuations which are hard to capture from annual data. These two diagrams indicated that the statistical model is able to do as well (or better) in correctly estimating wide swings in farm and retail prices as in estimating narrow swings or relatively small changes. With few exceptions, prices estimated by both two-stage least squares and ordinary least squares were very similar.

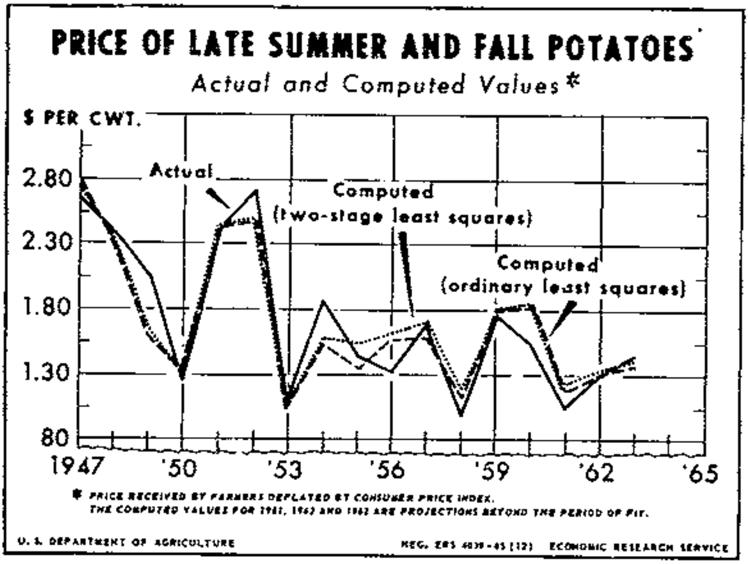


Figure 10

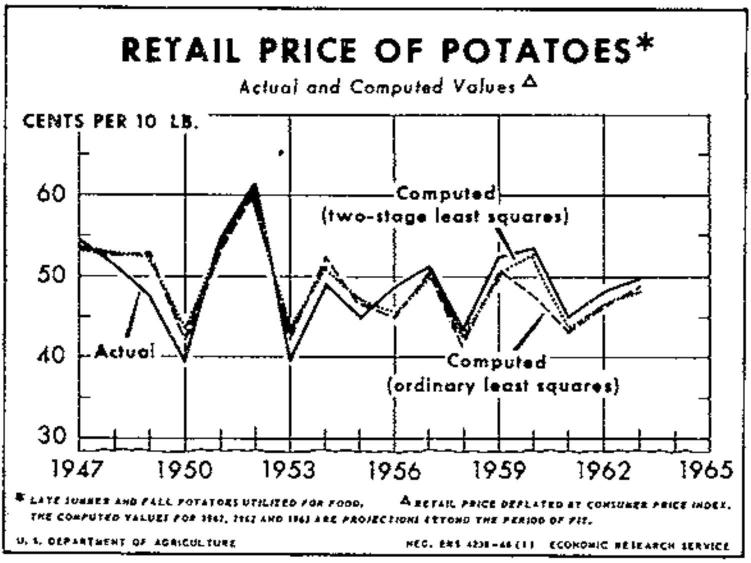


Figure 11

Figure 12 shows that estimated prices for winter and early spring potatoes were close to the actual values in most years for the 1947-63 period. The occasional year-to-year divergence probably was due mainly to unusually sharp changes in anticipated production of late spring potatoes, which in turn affected prices of both winter and early spring potatoes and remaining storage supplies. The model did about as well in predicting long-term changes as in predicting short-term changes, such as 1 year. The model was able to make fairly close estimates for the gradual downturn in price of winter and early spring potatoes between 1947 and 1954. Estimates obtained by limited information structural equations for winter and early spring potatoes were similar to those obtained by ordinary least squares. But for the period of prediction, 1961-63, the estimates obtained by the ordinary least squares method were closer to the actual values.

In figure 13, the estimates of price of late spring potatoes for the period of analysis, and for the period of prediction, 1961-63, show a reasonably close fit. Coefficients for the explanatory variables in equation (24), Q_{s2} and Q_{f2}, were statistically significant at the .001 probability level. Thus, the highly satisfactory coefficients obtained from fitting the equations in this model probably were the basis for obtaining the close estimates.

The estimated values in figure 14 for price of early summer potatoes conformed very closely to the actual values for the period of fit, 1947-60. For the period of prediction, 1961-63, however, the estimated values obtained from both limited information structural equations and ordinary least squares were consistently low in 1961, and consistently high in 1963. The predicted values for 1961-63 suggest that, due to the changing relative importance of early summer, late spring, and late summer potato supplies in the early summer market, a change may be required in the structural coefficients, through inclusion of more recent data.

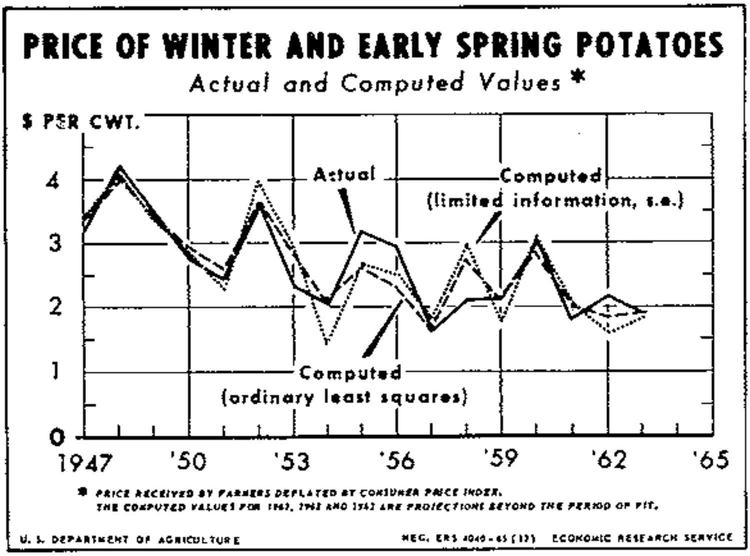


Figure 12

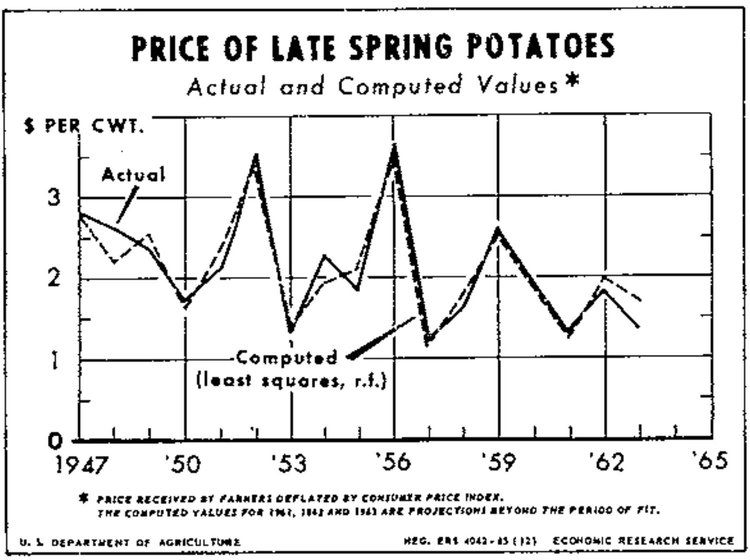


Figure 13

A further consideration in appraising the results of the analysis relates to the test for serial correlation in the residuals. It can be shown that serious errors and bias may result if the residuals are autocorrelated. Durbin and Watson (9) devised approximate tests for autocorrelation in successive residuals of least squares regression equations. In this study, the technique is used only to test equations fitted by the least squares method. Results of the test for equations used to estimate 13 endogenous variables are given in table 20.

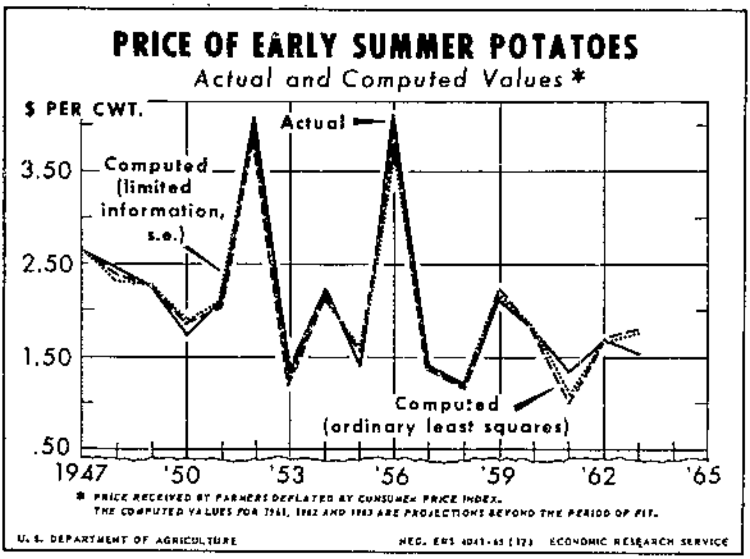


Figure 14

In using the Durbin-Watson test the following statistic is computed

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

where d_t is the unexplained residual for observation t and d_{t-1} is the unexplained residual for the observation lagged 1 year.

The two computed values d and 4-d′ relate to the two tails of the sampling distribution; d′ relating to positive serial correlation, and 4-d′ to negative serial correlation. If d′ or 4-d′ is less than the lower bound of critical values found in the Durbin-Watson table of significance points, the indication is that the residuals may be serially correlated, either positively or negatively. If both d′ and 4-d′ are greater than the upper bound in the table of significance points, the indication is that there is no serial correlation. If neither of the computed values is less than the lower bound, but one of them lies between the lower bound and the upper bound, the test is inconclusive. The test does not apply as well to equations that use lagged values of the dependent variable. For equation (6b), which contains 1 lagged independent variable, the test is used only to give an approximation of the degree of serial correlation.

Results of the Durbin-Watson test show that the 13 equations fitted by least squares in the four statistical models meet the condition of serial independence in the residuals fairly well. There are no cases which indicate a positive serial correlation; there are 12 cases in which the test is inconclusive; and there is 1 case where no serial correlation is indicated. For equations used to estimate P_{s1}, P_{f1}, S_t, P_{f2}, P_{s3}, P_{ls}, $P_{s2(s)}$, P_f, and P_r, the d statistic is at the upper end of the inconclusive range. For all of the equations fitted in the four statistical models,

Table 20.--Test for serial correlation in the residuals of 13 equations fitted by the least squares method

Endogenous variable	Durbin-Watson statistic	
	d'	4-d'
P_{s1}	* 1.61	2.39
P_{f_1}	* 2.19	1.81
S_t	* 2.27	1.73
P_{s_2}	* 3.24	.76
P_{f_2}	* 2.76	1.24
$P_{s_{2(s)}}$	* 1.77	2.23
P_{s_3}	* 2.63	1.37
P_{l_s}	* 2.62	1.38
C_h	* 2.62	1.38
C_f	* 3.09	.91
C_s	* 2.96	1.04
P_f	△ 1.61	2.39
P_r	* 1.05	2.95

* Inconclusive test for serial correlation in the residuals.

△ No serial correlation in the residuals.

estimates of the parameters in the equations would be expected to be statistically efficient, capable of estimating the true variance, and subject to valid t- and F-tests.

INFLUENCE OF GOVERNMENT PROGRAMS

Various Government programs, both Federal and State, have been used since the 1930's in efforts to bring more stability to the potato industry. Historically, these Government activities can be broadly classified:

(1) Purchase and diversion programs for potatoes, beginning in 1934, provided for payment of export subsidies, payment to encourage domestic utilization in lower grade uses, and the purchase of potatoes for distribution through school lunch programs and to eligible institutions.

(2) Soil conservation payments made in conjunction with acreage allotment programs from 1938 through 1941, in which potatoes were classified as a soil-depleting crop; besides conservation of the soil, attempts were made to bring production into balance with domestic and export demand.

(3) Price support programs, 1942-50, made Commodity Credit Corporation funds available for support operations through commodity loans, purchases, or other operations.

(4) Federal and State marketing agreements and orders, initiated in the 1930's but of much greater importance in the postwar period, were intended to maintain minumum standards of quality and to bring about orderly marketing.

(5) Special activities connected with USDA food distribution programs such as the Plentiful Foods and Food Stamp Programs.

The various Government programs differed considerably in terms of magnitude of operations. During 1934-42, quantities of potatoes involved in purchase and diversion operations were nominal compared to the volume handled in connection with price support operations during World War II and the immediate postwar period. For example, in each of 4 years under price supports--1946, 1948, 1949, and 1950--the volume of potatoes removed from commercial channels was four times greater than the combined total of purchases and diversions made during 1934-42. The diversion programs in operation in most years since 1950 have involved considerably less volume than that under the price-support program. Quantities removed from commercial channels after the price-support period averaged less than 12 million hundredweight per crop year compared with an average of 35 million hundredweight during the years of price support.

In the following sections, brief descriptions are given of Government programs by time periods and their effect on potato prices and industry structure.

267-387 O - 67 - 7

TB 1380 (1967) USDA TECHNICAL BULLETINS UPDATA
DEMAND AND PRICE ANALYSIS FOR POTATOES
HEE, O 2 OF 2

Pre-World War II Programs (1934-42)

Before World War II, limited purchase and diversion operations were carried out for potatoes under provisions of Section 32 of the Agricultural Act of 1935. Section 32 programs were designed to remove excess supplies to the degree compatible with outlets available for utilization of the surplus. Program activity generally was concentrated in those areas where excess supplies were a particularly acute problem rather than prorating purchases among all producing States. Provisions were made by the USDA (1) to purchase potatoes for school lunch and welfare distribution, and (2) to encourage diversion of surplus potatoes from the primary food market to such secondary uses as starch, flour, and livestock feed.

The fundamental purposes of the Section 32 programs were to remove temporary surpluses, stabilize markets, and improve prices. However, there was no direct attempt to guarantee price levels for potatoes. Further, since growers had no advance knowledge as to whether a Government program would be instituted, or the probable extent of program activities, Section 32 programs probably were not an important influence in production decisions.

The first use of the Federal marketing order approach occurred in 1934 when marketing and license plans were entered into by growers of early- and intermediate-crop potatoes. The program affected only the 1934 crop and was terminated in April 1936. Subsequently, three late-crop producing areas adopted marketing agreements and orders for the 1937 crop which provided for Federal-State inspection of all shipments, and prohibited interstate shipment of cull potatoes produced in the areas covered by the agreements. Orders later were instituted in several North Central and Western areas to regulate marketing of the 1942 crop. Because of strong wartime demands, however, these orders were not used until 1947.

In 1938 potatoes were included in an acreage allotment program which was designed to lessen the exploitive use of land for soil-depleting crops. Soil conservation payments were made to farmers who received potato acreage allotments. In distributing acreage allotments to individual farmers, meeting the soil conservation needs of each farm and providing an equitable share of the market for each producer were principal considerations.

Government programs in this earlier period did not appear to affect price greatly. 18/ Government expenditures on surplus removal operations in the years of greatest activity amounted to less than 3.5 percent of the crop value. The programs appeared to increase aggregate income by a slightly larger amount than Government expenditures.

18/ For a more detailed account of the objectives, means, and extent of Government activities during the price-support period and earlier years, see Gray, Sorenson, and Cochrane (15, pp. 34-52).

Price Support Operations (1942-50)

With the advent of World War II and resulting stronger demands for agricultural products, the emphasis on Government programs shifted from removal of excess supplies to stabilization or expansion of supplies. Legislation was developed which required the Secretary of Agriculture to support prices of those commodities for which he encouraged expanded production. Minimum support rates were specified, generally in relation to parity. Potato prices were supported at 92 percent of parity in 1943, at 90 percent from 1944 to 1948, and at 60 percent in 1949 and 1950. Legislation enacted in March 1950 provided that for the 1951 crop year and thereafter, no price support would be available for Irish potatoes unless marketing quotas were in effect. The Secretary of Agriculture does not have the authority to proclaim marketing quotas for potatoes, and the Department of Agriculture has not operated a potato price-support program since 1950.

Price-support operations for potatoes during this period were carried out primarily by the Commodity Credit Corporation. The methods used included purchases and loans to growers and dealers. In addition, Section 32 funds were used to divert potatoes to secondary uses, chiefly livestock feed.

Government price-support operations had a significant impact on the potato industry. Some effects of the program, such as relative price stability, must be considered temporary. But other effects, especially on acreage and yield, and on location ofproduction, were more permanent. The response to the price-support program was greatest in the specialized potato areas, reflecting their comparative advantage in production and more general recognition of the need for more sophisticated marketing services. The reduction in price risk speeded up the process of relocation of production from unspecialized to specialized areas. Prices during the price-support period, when deflated by index of prices received by farmers, averaged about the same as prices in the 8 preceding years, similarly deflated. However, annual variation was much less under the price support program.

On the demand side, Gray, et al. (15), concluded in a 1954 study that consumers obtained potatoes at a lower average price than they would have under a free market. The study showed that when demand is highly inelastic, consumers pay less for a constant supply than for an equivalent fluctuating supply averaged out over the years. Also, it might be argued that under free market conditions, supply of potatoes would not have expanded during the war. Demand for potatoes, on the other hand, appeared to go up. The combination of an unchanged supply and a rise in demand probably would have resulted in a higher price to consumers than the pre-support equilibrium price.

Government Programs - 1950 to the Present

Government programs since 1950 have been much more limited in scope than those of the price-support era and have been primarily concerned with bringing supply into balance with market requirements.

These programs have included: (1) Acreage marketing guides, to encourage necessary adjustments in production, (2) Federal and State marketing agreements and orders, to regulate the quality and volume of potatoes shipped to market, and (3) Section 32 diversion or purchase programs, to stimulate utilization of potatoes in the lower grade uses, and for purchases of surplus potatoes for distribution to schools and institutions.

Acreage-marketing guides are issued by the Department of Agriculture for all seasonal potato crops. The fundamental concept of the guides program is that, given the best information available, the grower will make intelligent decisions that will be in his own best interest and that of the industry. Compliance with the guides is voluntary. Probably because the grower feels that he as an idividual producer cannot affect the market price, plantings have tended to exceed the recommended levels. The areas of specialized potato production have tended to exceed the guide recommendations much more than other areas.

Marketing orders and agreements have been operative largely in States producing late-crop potatoes. With a marketing order the industry regulates handling and marketing mainly by prescribing the grade, size, quality, and maturity of potatoes that can be sold. The orders are designed to place a better product on the market, achieve more orderly marketing, and result in higher prices and incomes to potato growers. In general the marketing orders have been regarded favorably by the industry.

Government purchases of potatoes for distribution have been relatively small. Outlets for utilizing the acquired potatoes are limited. Also, it is probable that donations, in effect, replace commercial sales to some extent. Under Section 32 authority, 369,000 hundredweight of 1953 crop potatoes, 417,000 hundredweight from the 1961 crop, and 4,900 hundredweight from the 1963 crop were purchased for use in school lunches and distribution to other outlets. Expenditures for these purchases amounted to $488,000, $697,000, and $8,100, respectively.

Diversion programs for potatoes have been operative in many marketing seasons since the end of the price-support program. The Government's policy generally has been to operate these programs on a year-to-year basis and only upon urgent request from growers in distressed areas. The objective of the program is to divert less desirable potatoes to nonfood uses. Payments were made for diversion of potatoes of U.S. No. 2 grade or better; no payments were made on culls.

About 65 percent of the potatoes diverted during 1953-64 qualified for diversion payments (table 21). Quantities diverted ranged from 1.2 million hundredweight in the 1954 crop year to 29.3 million hundredweight in 1961. Net costs of the diversion program varied from $217,000 in 1954 to $10.1 million in 1961.

Diversion activity was largely concentrated in areas that were using marketing agreements and orders. Diversion was heaviest in years of unusually large supplies, and some of the potatoes that were diverted probably would not have been marketed anyway. Nevertheless, the diversion program, by removing potatoes from commercial trade channels, had an effect upon prices received by farmers.

In addition to those programs specially oriented to potatoes, other more general USDA activities such as the Plentiful Foods and Food Stamp programs have affected potato marketing to some extent.

The Plentiful Foods Program is designed to stimulate the movement of food products in heavy supply through cooperative USDA- industry

Table 21--Potatoes: Summary of diversions to livestock feed, starch, and flour, 1953-65 1/

Crop year	Quantity					Expenditures 2/		
	Livestock feed		Starch and flour		Total	Livestock feed (spec. A)	Starch and flour (spec. A)	Total
	Spec. A	Culls	Spec. A	Culls				
	1,000 cwt.	1,000 cwt.	1,000 cwt.	1,000 cwt.	1,000 cwt.	1,000 dol.	1,000 dol.	1,000 dol.
1953	3/	3/	2,525	859	3,384	3/	884	884
1954	3/	3/	723	498	1,221	3/	217	217
1955	846	600	6,339	2,390	10,175	367	2,815	3,182
1956	1,689	1,687	10,915	4,379	18,670	669	4,330	4,999
1957	1,585	2,299	3,771	4,448	12,103	704	1,710	2,414
1958	9,716	3,299	7,984	2,457	23,456	4,267	3,194	7,461
1959	4/	4/	4/	4/	4/	4/	4/	4/
1960	3/	3/	2,358	976	3,334	3/	1,237	1,237
1961	8,937	4,060	10,498	5,770	29,265	4,704	5,380	10,084
1962	739	838	2,517	2,142	6,236	342	1,013	1,355
1963	1,051	1,387	1,875	1,376	5,689	467	853	1,320
1964	4/	4/	4/	4/	4/	4/	4/	4/
1965	4/	4/	4/	4/	4/	4/	4/	4/

1/ From reports of USDA Consumer and Marketing Service, Fruit and Vegetable Division. 2/ Payments were made on specification A potatoes only. 3/ No potatoes diverted to livestock feed. 4/ No diversion program in operation.

informational and promotional activities. The principal techniques are: (1) The publication of a monthly plentiful foods list, which goes to food distributors, food editors, and food service operators, and (2) special merchandising programs to encourage the movement of a particular food through the market. The monthly plentiful foods list included potatoes repeatedly when they were in relatively heavy supply in 1961, 1962, and 1963.

The Food Stamp Program was initiated on a pilot basis in mid-1961 and tested in eight economically depressed areas in the United States. The purpose of the test was to determine whether such an approach could provide better nutrition for needy families, and to pave the way for making more effective use of our food supply. Reese and Adelson (34) showed that participating families in a major city increased their consumption of potatoes moderately during the initial survey period (April-May 1961 to September-October 1961). However, in a rural county surveyed in the same general area, but where the families were using more foods produced at home, or received as gifts or pay, consumption of potatoes during the program period did not increase.

LITERATURE CITED 19/

(1) ALLENDER, CHESTER R.
1948. POTATOES FOR LIVESTOCK FEED. U.S. Dept. Agr. Misc. Pub. 676. 45 pp., illus.

(2) BADGER, HENRY T.
1962. THE IMPACT OF TECHNOLOGICAL CHANGE ON MARKETING COSTS AND GROWERS RETURNS. U.S. Dept. Agr. Mktg. Res. Rpt. 573. 31 pp., illus.

(3) BISHOP, ROBERT L.
1952. ELASTICITIES CROSS-ELASTICITIES AND MARKET RELATIONSHIPS. Amer. Econ. Rev. 42: 779-803.

(4) CHAMBERLIN, EDWARD H.
1958. THE THEORY OF MONOPOLISTIC COMPETITION. 7th ed. Cambridge, Harvard University Press.

(5) COCHRANE, WILLARD W.
1957. THE MARKET AS A UNIT OF INQUIRY IN AGRICULTURAL ECONOMICS RESEARCH. Jour. Farm Econ. 39: 21-39.

(6) COFER, ELOISE, GROSSMAN, EVELYN, AND CLARK, FAITH.
1962. FAMILY FOOD PLANS AND FOOD COSTS. U.S. Dept. Agr. Home Econ. Res. Rpt. 20, 54 pp., illus.

(7) DALRYMPLE, DANA G.
1959. PREDICTING AUGUST POTATO PRICES AT PLANTING TIME. Univ. Conn. (Storrs). Progress Rpt. 29. 47 pp., illus.

(8) DALY, REX F.
1956. THE LONG RUN DEMAND FOR FARM PRODUCTS. Agr. Econ. Res. 8: 73-91.

(9) DURBIN, J. AND WATSON, G.S.
1950. TESTING FOR SERIAL CORRELATION IN LEAST SQUARES REGRESSION. I. Biometrika. 37: 409-428.

(10) FINCHER, LILLIAN J.
1957. POTATOES--FACTS FOR CONSUMER EDUCATION. USDA Agr. Inf. Bul. 178. 30 pp., illus.

(11) FOOTE, R.J.
1958. ANALYTICAL TOOLS FOR STUDYING DEMAND AND PRICE STRUCTURES. U.S. Dept. Agr. Handb. 146. 217 pp.

(12) FOX, KARL A.
1958. ECONOMETRIC ANALYSIS FOR PUBLIC POLICY. Ames. Iowa. Iowa State Univ. Press. 288 pp.

19/ An asterisk following the year of publication indicates that reports for earlier years also were used.

(13) ———————, AND COONEY, JAMES F., JR.
1959. EFFECTS OF INTERCORRELATION UPON MULTIPLE CORRELATION AND REGRESSION MEASURES. U.S. Dept. Agr. AMS-341. 28 pp., illus.

(14) FRIEDMAN, JOAN, AND FOOTE, RICHARD J.
1955. COMPUTATIONAL METHODS FOR HANDLING SYSTEMS OF SIMULTANEOUS EQUATIONS. U.S. Dept. Agr. Handb. 94. 109 pp., illus.

(15) GRAY, ROGER W., SORENSON, VERNON L., and COCHRANE, WILLARD W. 1954. AN ECONOMIC ANALYSIS OF THE IMPACT OF GOVERNMENT PROGRAMS ON THE POTATO INDUSTRY OF THE UNITED STATES. Univ. Minn. Agr. Expt. Sta. Tech. Bul. 211. 239 pp., illus.

(16) HAAVELMO, TRYGVE
1943. THE STATISTICAL IMPLICATIONS OF A SYSTEM OF SIMULTANEOUS EQUATIONS. Econometrica 11: 1-12.

(17) HANES, JOHN K.
1961. MARKETING MARGINS FOR FALL POTATOES. U.S. Dept. Agr. Mktg. Res. Rpt. 450. 2? pp., illus.

(18) HEE, OLMAN
1958. THE EFFECT OF PRICE ON ACREAGE AND YIELD OF POTATOES. Agr. Econ. Res. 10: 131-141, illus.

(19) ———————
1961. STORAGE DEMAND FOR A PERISHABLE: POTATOES. Jour. Farm Econ. 43: 1410-1411.

(20) ———————
1964. A SEASONAL POTATO MARKET: AREA OF COMPETITIVE BEHAVIOR. Jour. Farm Econ. 46: 1321-1325.

(21) HILDRETH, CLIFFORD AND JARRETT, F. G.
1955. A STATISTICAL STUDY OF LIVESTOCK PRODUCTION AND MARKETING. Cowles Commission for Research in Economics. Monogr. 15, 156 pp., illus.

(22) KOOPMANS, TJALLING C.
1949. IDENTIFICATION PROBLEMS IN ECONOMIC MODEL CONSTRUCTION. Econometrica 17: 125-144.

(23) ———————
1950. STATISTICAL INFERENCE IN DYNAMIC MODELS. Cowles Commission for Research in Economics. Monogr. 10, 438 pp.

(24) MAKI, WILBUR R. AND CROM, RICHARD J.
1965. EVALUATION OF ALTERNATIVE MARKET ORGANIZATIONS IN A SIMULATED LIVESTOCK MEAT ECONOMY. Iowa State Univ. Agr. and Home Econ. Exp. Sta. Res. Bul. 541, 41 pp., illus.

(25) MANDERSCHEID, LESTER C.
1964. SOME OBSERVATIONS ON INTERPRETING MEASURED DEMAND ELASTICITIES. Jour. Farm Econ. 46: 128-136.

(26) MARSHALL, ALFRED R.
1920. PRINCIPLES OF ECONOMICS. 8th ed. 871 pp., illus. London.

(27) MEINKEN, KENNETH W.
1957. FACTORS THAT AFFECT PRICE AND DISTRIBUTION OF NEW JERSEY POTATOES. N.J. Agr. Expt. Sta. (in cooperation with Maine Agr. Expt. Sta.) Bul. 786, 44 pp., illus.

(28) ————— , ROJKO, ANTHONY S., AND KING, GORDON A.
1956. MEASUREMENT OF SUBSTITUTION IN DEMAND FROM TIME SERIES DATA - A SYNTHESIS OF THREE APPROACHES. Jour. Farm Econ. 38: 711-735.

(29) MERCKER, ALBERT E.
1964. INDUSTRY OUTLOOK FOR FRESH POTATOES AND FOR PROCESSED POTATO PRODUCTS. Proceedings of the 14th Annual National Potato Utilization Conference, under auspices of Wash. State Univ., July 20-22, 1964. Yakima.

(30) NATIONAL ASSOCIATION OF FROZEN FOOD PACKERS
1964. FROZEN FOOD PACK STATISTICS. ANNUAL REPORT. Washington, D.C. 52 pp.

(31) NATIONAL POTATO COUNCIL
1963. THE 1963-64 POTATO MARKETING OUTLOOK. Report of the Executive Director, A.E. Mercker. 13 pp. Washington, D.C.

(32) PASOUR, E.C., JR., AND SCHRIMPER, R.A.
1964. THE EFFECT OF LENGTH OF RUN ON MEASURED DEMAND ELASTICITIES. Jour. Farm Econ. 47: 774-788.

(33) PUSATERI, FRANCIS P.
1964. FUNDAMENTALS OF DEVELOPING A SOUND MARKETING PROGRAM FOR FRESH POTATOES. Yearbook of the Potato Growers Association of California, Bakersfield, Calif., 1964. 132., illus.

(34) REESE, ROBERT B. AND ADELSON, SADYE F.
1962. FOOD CONSUMPTION AND DIETARY LEVELS UNDER THE PILOT FOOD STAMP PROGRAM. U.S. Dept. Agr. Agr. Econ. Rpt. 9. 17 pp., illus.

(35) SCHULTZ, HENRY
1938. THE THEORY AND MEASUREMENT OF DEMAND. Univ. Chicago. 817 pp., illus.

(36) SCOTT, FORREST E. and MUMFORD, HERBERT W., JR.
1949. PROBLEMS IN MARKETING POTATOES. Preliminary Results of Some Recent Research. U.S. Dept. Agr. 60 pp., illus.

(37) SHEPHERD, GEOFFREY S.
1963. AGRICULTURAL PRICE ANALYSIS. Ames, Iowa. Iowa State Univ. Press, 328 pp., illus.

(38) SHUFFETT, D. MILTON
1954. THE DEMAND AND PRICE STRUCTURE FOR SELECTED VEGETABLES. U.S. Dept. Agr. Tech. Bul. 1105. 133 pp., illus.

(39) SIMMONS, WILL M.
1962. AN ECONOMIC STUDY OF THE U.S. POTATO INDUSTRY. U.S. Dept. Agr. Agr. Econ. Rpt. No. 6. 83 pp., illus.

(40) TREADWAY, R.H.
1962. NEW DEVELOPMENTS IN PROCESSED POTATO PRODUCTS. Vegetable Growers Association of America Annual Convention. Indianapolis, Ind. 15 pp.

(41) U.S. BUREAU OF THE CENSUS
1965* MONTHLY RETAIL TRADE: January 1965.

(42) U.S. BUREAU OF LABOR STATISTICS
1965* WHOLESALE PRICES AND PRICE INDEXES. GROUP 1-FARM PRODUCTS 1963-64.

(43) ———
1965* RETAIL PRICES OF FOOD, 1964-65. U.S. Dept. Labor Bul. 1301 and supplements. 49 pp., illus.

(44) U.S. DEPARTMENT OF AGRICULTURE
1948. POTATO PREFERENCES AMONG HOUSEHOLD CONSUMERS. Misc. Pub. 667, 117 pp.

(45) ———
1953. PRODUCE DEPARTMENT - SPACE UTILIZATION, GROSS MARGINS, AND OPERATING COSTS. Mktg. Res. Rpt. 36. 38 pp., illus.

(46) ———
1953. POTATOES: ACREAGE, PRODUCTION, VALUE, FARM DISPOSITION, JANUARY 1 STOCKS, 1866-1950. Statis. Bul. 122. 109 pp.

(47) ———
1955. FOOD CONSUMPTION OF HOUSEHOLDS IN THE UNITED STATES. Household Food Consumption Survey Rpt. 1. 196 pp.

(48) ———
1956. POTATOES AND SWEETPOTATOES: REVISED ESTIMATES BY STATES; ACREAGE, YIELD, PRODUCTION, PRICE, VALUE, FARM DISPOSITION, STOCKS, 1949-1955, and SUPPLEMENTS. Statis. Bul. 190, 31 pp.

(49) ———
1957. POTATOES AND SWEETPOTATOES: USUAL DATES FOR PLANTING, HARVESTING AND MARKETING. Handb. 127, 16 pp., illus.

(50) ———
1959* YEARBOOK OF AGRICULTURE. FOOD., pp. 252-262, illus.

(51) ———
1959. POTATOES: BY STATES; ACREAGE, YIELD, PRODUCTION, PRICE, VALUE, FARM DISPOSITION, AND TOTAL STOCKS, 1866-1953. Statis. Bul. 251. 95 pp.

(52) ———
1961. POTATOES AND SWEETPOTATOES, BY STATES AND SEASONAL GROUPS: ACREAGE, YIELD, PRODUCTION, PRICE, VALUE, FARM DISPOSITION AND STOCKS, 1954-1959, AND SUPPLEMENTS. Statis. Rpt. Serv. Bul. 291. 41 pp.

(53) ——————

1965.* MARKETING AND TRANSPORTATION SITUATION. MTS-156, February 1965, 43 pp.

(54) ——————

1965.* FRESH FRUIT AND VEGETABLE UNLOADS IN EASTERN AND MIDWESTERN CITIES. Consumer and Mktg. Serv. Rpt. 3 and 5 (1964). 143 pp. and 139 pp.

(55) ——————

1965.* IRISH POTATOES,.....UTILIZATION OF 1964 CROP WITH COMPARISONS. 3 pp.

(56) ——————

1965. U.S. FOOD CONSUMPTION. Statis. Bul. 364, 194 pp., illus.

(57) U.S. ECONOMIC RESEARCH SERVICE

1965.* FARM-RETAIL SPREADS FOR FOOD PRODUCTS. U.S. Dept. Agr. Misc. Pub. 741 and supplement ERS-226. 45pp.

(58) ——————

1965.* VEGETABLE SITUATION.

(59) ——————

1965.* NATIONAL FOOD SITUATION.

(60) WATT, BERNICE K., AND MERRILL, ANNABEL L.

1963. COMPOSITION OF FOODS. U.S. Dept. Agr. Handb. 8. 189 pp.

(61) WAUGH, FREDERICK V.

1923. FACTORS INFLUENCING THE PRICE OF NEW JERSEY POTATOES ON THE NEW YORK MARKET. New Jersey Dept. Agr. Cir. 66. 26 pp.

(62) ——————

1957. GRAPHIC ANALYSIS IN AGRICULTURAL ECONOMICS. U.S. Dept. Agr. Handb. 128. 69 pp., illus.

(63) ——————

1964. DEMAND AND PRICE ANALYSIS--SOME EXAMPLES FROM AGRICULTURE. U.S. Dept. Agr. Tech. Bul. 1316. 94 pp., illus.

(64) WESSON, WILLIAM T.

1958. THE ECONOMIC IMPORTANCE OF FUTURES TRADING IN POTATOES. U.S. Dept. Agr. Mktg. Res. Rpt. 241. 42 pp., illus.

(65) WOLD, HERMAN AND JUREEN, LARS

1953. DEMAND ANALYSIS. Stockholm. 358 pp., illus.

(66) WORKING HOLBROOK

1925. FACTORS AFFECTING THE PRICE OF MINNESOTA POTATOES. Univ. Minn. Agr. Exp. Sta. Tech. Bul. 29. 40 pp.

(67) ——————

1948. THE THEORY OF THE INVERSE CARRYING CHARGE IN FUTURES MARKETS. Jour. Farm Econ. 30: 1-28.

(68) ZUSMAN, PINHAS

1962. ECONOMETRIC ANALYSIS OF THE MARKET FOR CALIFORNIA EARLY POTATOES. Hilgardia 33: 539-668, illus.

APPENDIX

Demand for Storage

The total demand for potatoes in early seasons of the year includes demand by consumers for potatoes for food plus demand by storers for changes in storage holdings. The demand for storage arises to accommodate the imbalance between production schedules and desired consumption plans. Decision-making by storers of potatoes involves (1) the quantity to store, (2) the timing of movement out of storage, and (3) the change in value of stocks for specified time intervals (19). As the storage season for potatoes progresses, changes in market price become known to the storer. Thus, recent price movements are assumed to be a principal factor in storage decisions. For example, one can hypothesize that market prices for potatoes are observed by storers periodically, perhaps daily. For relatively large changes in price over short periods it can be assumed that substantially increased activity in movement of storage supplies occurs. For smaller changes in price over longer periods, the direction and magnitude of sustained price change influences storage movement. This will be discussed in this section.

Other important factors believed to affect storage holdings are (1) volume of storage potatoes used by processors and (2) initial quantities of fall potatoes available for storage.

Thus, the structural relation for demand for storage stocks of fall potatoes can be written

$$S_t = a_1 + b_1 \sum_{i=1}^{5} (P_i - P_{i-1}) + b_2 C_{fr_1} + b_3 S_j + U_t \qquad (30)$$

where —

S_t = Estimated quantity of potatoes in storage May 1, chiefly for food; million hundredweight.

$\sum_{i=1}^{5} (P_i - P_{i-1})$ = A constructed price variable, representing sustained monthly price changes in one direction only, for potatoes at the farm level, for the period November through April, divided by index of consumer prices, 1947-49=100; cents per hundredweight. Values of i designate price, P, in the particular month: i=1=December, i=2=January................i=5=April. Monthly price changes in any storage season are included only if at least two consecutive changes occur in the same direction.

C_{fr_1} = Percentage of total food utilization of potatoes processed into food products.

S_j = Estimated per capita storage stocks of potatoes, January 1, as reported by Statistical Reporting Service; pounds.

U_t = Residual term in period t.

Analysis of storage stocks of potatoes at any point in time is concerned with amount of stocks held. Thus, analysis of storers' behavior considers how storage holdings change in response to sustained price changes in a given direction. Pasour and Schrimper (32), basing their study on demand elasticities for apples, have shown that when a current price change was accompanied by a change in price expectations in the same direction, a given change in price was found to have a greater effect on the expected rate of return for short periods --from 1 to 2 months-- than for longer periods. Part of this result is due to the larger proportion of total demand arising from storage activities for short periods than for longer periods. From this they concluded that movement of storage stocks responds more to price change in the short run than in the long run. Also they indicated that one can easily conceive of the situation where a change in current price would be accompanied by a change in the opposite direction in price expectations in future periods. A stock relation where a current price change is accompanied by a change in price expectations in the same direction is given by

$$S_t = f(P_t > 0);\ g(P_{t+1} > 0) \tag{31}$$

where --

P_t = farm price of potatoes in the current period

P_{t+1} = farm price of potatoes in the future period

Similarly, a stock relation where a current price change is accompanied by a change in price expectations in the opposite direction is expressed as

$$S_t = f(P_t > 0);\ g(P_{t+1} < 0) \tag{32}$$

In practice, a price change in a very short time period is often viewed as being temporary. Or, the price change in the current period holds greater weight in decision-making than an expected price change in the future. This provides the impetus for changes in storage holdings of potatoes. However, decision-makers may revise their expectations upward or downward, based largely on the direction and magnitude of sustained price movements and the magnitude of the most recent change. When prices have moved in one direction for an extended period and the most recent price change is small, there is considerable likelihood that price expectations will change in the opposite direction. In practice, data on flow of stocks indicate that a recent small change in monthly prices following a sustained price change of substantial magnitude has been followed by a change in price expectations.

The rationale for the hypothesis of a change in price expectations in the opposite direction stems from the following:

The assumption is that higher prices now influence storers to <u>sell</u> potatoes <u>now</u> for a relatively high net return, rather than waiting <u>and</u> <u>consequently</u> risking a lower or zero net return. Increased sales now will be followed by a decline in price. Conversely, low prices now influence storers to <u>hold</u> potatoes in storage <u>now</u> with the expectation of a higher net return at <u>some</u> future date. Decline <u>in</u> storage movement now is expected to be followed by a rise in price.

We assume the following to hold:

$$[p_i > P_{\bar{x}}] \rightarrow [q_i > Q_{\bar{x}}] \rightarrow [r_i > R_{\bar{x}}] \rightarrow [p_i < P_{\bar{x}}] \tag{33}$$

where —

P_i = current price

$P_{\bar{x}}$ = season average price

q_i = current sales out of storage holdings

$Q_{\bar{x}}$ = average sales in a subperiod

r_i = current net return (over and above marginal cost of storage)

$R_{\bar{x}}$ = average net return (over and above marginal cost of storage)

As a practical matter, except in extreme cases, storers do not hold all of their potatoes for long periods and sell none, or sell all of their potatoes in 24 hours and have none to store thereafter. A more realistic assumption is that marketings are at fairly high levels and continuous during much of the storage season, but sustained price changes have the effect of speeding up or slowing down out-of-storage movement.

No special account has been taken of futures trading in potatoes in the analysis of storage demand. Yet storage is affected to some extent by users of the futures market, whose actions may alter the timing and rate of movement of potatoes.

Futures prices themselves, which represent the composite judgment of traders as to the probable cash prices at the respective maturity dates of the contracts, have an effect on the demand for storage.

Futures trading facilitates storage of potatoes by providing a vehicle for hedging. Hedging is used as a means of reducing price risk. When the storer sells potatoes short under the selected futures contract, he knows what his price will be; consequently, he may store more potatoes than if he had to assume the full price risk.

Wesson (64) has shown that changes in cash prices for Maine potatoes at local shipping points were generally associated with similar changes in prices of potato futures contracts on the New York Mercantile Exchange. This association is represented by the legal right of delivery that futures contracts always have; with a few exceptions (one of which is mentioned below), the carrying charge accounts for most of the difference between cash and futures prices.

In general, the actions of grower-shippers or others who carry out hedging transactions in potatoes may be expressed as follows:

$$(F_{t+1} - C_t) - M + X = 0 \qquad (34)$$

where —

F_{t+1} = futures contract price for delivery in period t+1.

C_t = cash price in period t.

M = marginal cost per unit of rent for storage space, handling charges, interest, insurance and spoilage.

X = marginal convenience yield.

Futures prices may not always be higher than cash prices. As stated by Working (67), it is possible to have a situation which represents "inverse carrying charges" (where the futures price is below the cash price, or prices of deferred futures are below those of near futures). The marginal convenience yield enters as a strong factor. This situation may occur where an "unexpected increase in demand" for current use develops.

Tables of Actual and Estimated Values

Tables 22 through 25 give actual and estimated values of the endogenous variables used in each of the four statistical models. The estimates are derived from both structural equations and reduced-form equations for the late summer and fall, winter and early spring and early summer models. For the late spring model, only the reduced-form equations fitted by least squares were used to obtain estimates, since the equations were "just identified" (see p. 39 for criteria of identification).

Comparison of the actual and estimated values for the period of fit (1947-60) in effect tests the explanatory ability of the statistical models. Thus, in this sense the variables in the models attempt to "explain" why changes have taken place in the past. Changes occurring in 1947-60 were great enough to provide a challenging test of the explanatory ability of the four seasonal models. Government programs for disposal of potatoes were in force during 1947-50. Almost no Government programs were in operation in 1951, 1952, and 1959. Changes in location of production were significant. Also, changes in cost and technology occurred during this period. The four statistical models were found to be very satisfactory for explaining the demand and price structure for the potato economy, given certain stated economic and statistical assumptions.

Data Used in Four Statistical Models

The data used in fitting the respective statistical models are given in tables 26 through 29. The variables for each of the models have been defined in the respective sections that discuss the structural demand relations for the given model. Symbols for each variable are given in the boxheads of tables 26-29 so that identification of the variables in the tables can be made with variables given in the structural relations. The data generate a measure of "real price" at the retail and farm market levels since actual retail and farm prices are divided by the BLS consumer price index. Also, the data are used as a measure of "real purchasing power" by dividing actual consumer disposable income by the BLS consumer price index. The measure of "real marketing costs" is obtained by dividing marketing costs by the index of wholesale prices of all commodities. This is because wholesale prices are assumed to be the best indicator of changes in marketing costs resulting from changes in the general price level.

Per capita consumption series are obtained by dividing the quantity series by population eating out of civilian food supplies. Per capita disposable personal income is computed by dividing total income by total population, including armed forces overseas.

In general, data for each statistical model begin with different initial seasons. Data for the late summer and fall model begin with August 15; for the winter and early spring model, January 1; for the late spring model, May 1; and for the early summer model, July 1.

Table 22.—Model of late summer and fall potato market: Actual and estimated values of the endogenous variables, 1947-60 1/

Item and Year	Actual	Estimated				
		Reduced-form equations		Structural equations		
		Limited information	Least squares	Limited information	Two-stage least squares	Least squares
	Pounds	Pounds	Pounds	Pounds	Pounds	Pounds
Consumption for food, per capita, C_h:						
1947	84.18	83.88	84.53	83.58	83.62	83.46
1948	79.23	79.52	78.75	79.71	79.67	79.81
1949	78.59	77.29	79.15	78.64	78.69	78.53
1950	82.81	83.09	82.23	83.48	83.87	82.66
1951	78.79	79.26	78.85	80.89	80.67	81.47
1952	80.57	81.05	81.05	77.34	80.17	79.35
1953	85.80	84.61	85.14	86.33	86.94	84.68
1954	83.39	81.84	82.92	82.09	81.98	82.37
1955	81.21	81.52	81.51	82.94	83.08	82.53
1956	81.74	82.61	81.77	80.75	80.71	80.88
1957	80.95	79.85	80.87	80.76	80.62	81.15
1958	82.61	84.15	83.50	84.07	84.35	83.32
1959	83.59	82.86	82.45	82.39	82.36	82.46
1960	83.63	85.52	84.09	84.12	84.01	84.41
Consumption for livestock feed, per capita, C_f:						
1947	9.09	9.27	9.44	9.38	9.39	9.69
1948	10.18	9.58	9.95	9.46	9.46	9.56
1949	10.27	10.49	10.25	9.99	9.99	9.99
1950	10.95	11.10	10.83	11.43	11.41	10.73
1951	7.09	6.98	6.79	7.76	7.77	7.86
1952	7.94	9.00	8.34	6.89	6.90	7.46
1953	9.77	10.23	9.99	11.01	11.00	10.61
1954	9.21	9.00	8.71	8.36	8.36	8.52
1955	8.79	8.59	8.98	9.01	9.01	8.94
1956	11.14	10.43	10.61	10.38	10.38	10.28
1957	7.58	8.63	7.81	8.91	8.91	9.05
1958	9.94	9.50	10.19	10.09	10.08	9.64

1/ See footnotes at end of table 14.

- Continued

Table 22.--Model of late summer and fall potato market: Actual and estimated values of the endogenous variables, 1947-60 1/--Continued

Item and Year	Actual	Estimated				
		Reduced-form equations		Structural equations		
		Limited information	Least squares	Limited information	Two-stage least squares	Least squares
	Pounds	Pounds	Pounds	Pounds	Pounds	Pounds
Consumption for livestock feed, per capita, C_f:						
1959	9.06	7.72	8.57	7.63	7.64	7.85
1960	8.16	7.68	7.70	7.86	7.88	8.06
Consumption for starch per capita, C_s:						
1947	3.12	3.25	3.12	3.44	3.39	3.73
1948	4.44	4.70	3.99	4.50	4.47	4.67
1949	5.23	7.32	5.08	5.52	5.58	5.16
1950	8.63	8.21	9.08	8.75	9.02	7.09
1951	1.84	1.48	2.21	2.77	2.66	3.46
1952	6.97	5.42	6.39	6.47	6.44	3.79
1953	6.47	7.20	7.07	8.49	6.69	7.13
1954	4.11	5.87	4.34	4.82	4.73	5.38
1955	5.31	5.20	4.83	5.90	5.93	5.70
1956	10.96	10.83	11.30	10.74	10.74	10.75
1957	7.47	7.53	7.42	7.99	7.90	8.54
1958	10.63	9.53	9.63	10.50	10.62	9.79
1959	4.37	5.43	5.75	5.28	5.20	5.74
1960	5.70	4.30	5.03	4.62	4.67	4.31
	Dollars	Dollars	Dollars	Dollars	Dollars	Dollars
Farm price, per hundredweight, P_f:						
1947	2.65	2.62	2.49	2.75	2.75	2.79
1948	2.40	2.29	2.52	2.67	2.33	2.35
1949	2.05	2.08	1.97	1.97	1.63	1.59
1950	1.26	0.65	1.39	1.57	1.32	1.30

1/ See footnotes at end of table 14. - Continued

267-387 O - 67 - 8

Table 22.--Model of late summer and fall potato market: Actual and estimated values of the endogenous variables, 1947-60 1/--Continued

Item and Year	Actual	Estimated				
		Reduced-form equations		Structural equations		
		Limited information	Least squares	Limited information	Two-stage least squares	Least squares
	Dollars	Dollars	Dollars	Dollars	Dollars	Dollars
Farm price, per hundredweight, P_f:						
1951	2.43	3.30	2.77	1.74	2.46	2.47
1952	2.72	1.99	2.01	2.35	2.53	2.49
1953	1.07	1.10	1.44	1.32	1.08	1.03
1954	1.87	1.76	1.71	1.28	1.58	1.53
1955	1.46	1.69	1.76	2.35	1.53	1.34
1956	1.33	0.90	1.28	1.55	1.62	1.57
1957	1.38	2.30	1.74	1.57	1.72	1.57
1958	0.98	0.85	1.01	1.13	1.22	1.16
1959	1.77	1.96	1.56	1.65	1.81	1.76
1960	1.55	1.70	1.58	1.43	1.86	1.81
	Cents	Cents	Cents	Cents	Cents	Cents
Retail price, per 10-pounds, P_r:						
1947	54.4	53.5	51.6	54.8	53.5	53.4
1948	51.4	51.8	54.3	52.6	52.6	52.6
1949	47.7	51.6	45.7	47.4	52.2	53.0
1950	39.6	40.7	41.7	38.3	43.6	42.1
1951	54.6	59.3	58.8	51.7	53.2	53.5
1952	61.5	50.6	51.5	59.9	58.2	60.1
1953	39.7	44.7	45.3	40.8	43.3	42.2
1954	48.9	49.6	47.0	46.4	51.3	52.1
1955	44.9	49.0	49.1	48.6	47.0	46.8
1956	48.6	43.2	47.2	49.5	45.6	45.0
1957	51.1	53.8	51.9	46.2	49.9	50.5
1958	43.3	43.1	43.4	49.7	42.8	41.7
1959	52.4	51.0	50.5	47.3	50.1	50.6
1960	53.2	49.1	53.2	48.2	52.7	47.9

1/ See footnotes at end of table 14.

Table 23.--Model of winter and early spring potato market: Actual and estimated values of the endogenous variables, 1947-60 1/

Item and year	Actual	Estimated: Reduced-form equations: Limited information	Estimated: Reduced-form equations: Least squares	Estimated: Structural equations: Limited information	Estimated: Structural equations: Two-stage least squares	Estimated: Structural equations: Least squares
	Dollars	Dollars	Dollars	Dollars	Dollars	Dollars
Farm price, per hundredweight:						
Winter and early spring potatoes, P_{s1}:						
1947	3.17	3.49	3.41	3.34	3.34	3.34
1948	4.19	4.48	3.88	4.09	4.01	3.95
1949	3.54	4.20	3.33	3.45	3.45	3.44
1950	2.77	2.67	2.73	2.83	2.88	2.92
1951	2.46	1.97	2.87	2.31	2.47	2.58
1952	3.67	3.81	3.99	3.97	3.78	3.63
1953	2.38	2.75	2.84	3.00	2.90	2.83
1954	2.08	2.51	1.60	1.49	1.80	2.03
1955	3.17	3.19	2.81	2.71	2.67	2.63
1956	2.99	2.21	3.51	2.50	2.41	2.34
1957	1.67	1.61	1.44	1.78	1.81	1.84
1958	2.04	2.34	2.34	2.95	2.84	2.75
1959	2.15	2.47	1.68	1.77	1.95	2.09
1960	2.94	2.88	2.77	3.03	2.92	2.84
Storage potatoes (January-April), P_{f1}:						
1947	2.10	2.13	2.10	2.05	2.03	2.01
1948	2.92	3.29	3.28	3.30	3.25	3.17
1949	2.62	3.31	2.40	2.40	2.46	2.53
1950	1.93	1.91	2.03	1.84	1.85	1.87
1951	1.32	1.19	1.48	1.10	1.17	1.26
1952	2.98	2.62	3.12	3.14	3.72	2.94

1/ See footnotes at end of table 15.

- Continued

Table 23.--Model of winter and early spring potato market: Actual and estimated values of the endogenous variables, 1947-60 1/-- Continued

Item and Year	Actual	Estimated: Reduced-form equations: Limited information	Estimated: Reduced-form equations: Least squares	Estimated: Structural equations: Limited information	Estimated: Structural equations: Two-stage least squares	Estimated: Structural equations: Least squares
	Dollars	Dollars	Dollars	Dollars	Dollars	Dollars
Farm price, per hundredweight:						
Storage potatoes (January-April), P_1:						
1953	2.19	1.75	1.79	1.91	1.8[illegible]	1.79
1954	0.85	1.04	1.25	0.78	1.40	1.07
1955	1.91	2.70	2.74	1.71	1.83	1.97
1956	1.66	1.43	1.98	1.97	1.99	2.01
1957	1.08	0.83	0.96	1.37	1.29	1.20
1958	2.10	1.4	1.32	2.[illegible]2	2.36	2.03
1959	0.94	1.48	1.42	1.13	1.16	1.21
1960	2.05	2.06	1.67	1.31	1.44	1.60
	Pounds	Pounds	Pounds	Pounds	Pounds	Pounds
Fall potatoes in storage, per capita, May 1, S_t:						
1947	5.82	---	---	---	---	6.9[illegible]
1948	[illegible]	---	---	---	---	[illegible].10
1949	3.01	---	---	---	---	4.5[illegible]
1950	7.45	---	---	---	---	[illegible]
1951	[illegible].2[illegible]	---	---	---	---	[illegible].8[illegible]
1952	1.71	---	---	---	---	2.61
1953	5.42	---	---	---	---	7.03
1954	9.83	---	---	---	---	9.05
1955	8.07	---	---	---	---	6.96
1956	4.76	---	---	---	---	4.46
1957	9.28	---	---	---	---	9.17
1958	[illegible].27	---	---	---	---	6.[illegible]8
1959	8.66	---	---	---	---	10.49
1960	[illegible].59	---	---	---	---	7.53

1/ See footnotes at end of table 15.

Table 24.--Model of late spring potato market: Actual and estimated values of the endogenous variables, 1947-60 1/

Item and year	Actual	Estimated: Reduced-form equation - least squares
	Dollars	Dollars
Farm price, per hundredweight:		
Late spring potatoes, P_{s_2}		
1947	2.80	2.94
1948	2.61	2.21
1949	2.38	2.55
1950	1.71	1.61
1951	2.10	2.37
1952	3.51	3.42
1953	1.34	1.47
1954	2.28	1.98
1955	1.85	2.12
1956	3.64	3.58
1957	1.22	1.17
1958	1.60	1.81
1959	2.60	2.53
1960	1.99	1.88
Storage potatoes (May-June), P_{f_2}		
1947	2.45	2.94
1948	2.84	2.15
1949	2.92	3.04
1950	1.85	1.64
1951	1.31	1.59
1952	3.93	3.56
1953	1.26	1.84
1954	1.19	1.34
1955	2.62	1.78
1956	2.97	3.29
1957	0.78	0.98
1958	1.12	1.30
1959	1.85	1.91
1960	2.08	1.80

1/ See footnotes at the end of table 16.

Table 25.--Model of early summer potato market: Actual and estimated values of the endogenous variables, 1947-60 1/

Item and year	Actual	Estimated				
		Reduced-form equations		Structural equations		
		Limited infor-mation	Least squares	Limited infor-mation	Two-stage least squares	Least squares
	Dollars	Dollars	Dollars	Dollars	Dollars	Dollars
Farm price, per hundredweight:						
Early summer potatoes, P_{s_3}						
1947	2.62	2.94	2.38	2.66	2.63	2.67
1948	2.46	2.15	2.40	2.30	2.08	2.33
1949	2.25	2.34	1.79	2.27	2.18	2.29
1950	1.74	1.87	2.32	1.92	1.94	1.88
1951	2.06	2.73	2.88	2.10	2.75	2.03
1952	3.98	2.11	3.06	4.01	3.32	4.07
1953	1.38	1.23	1.50	1.27	1.73	1.21
1954	2.22	2.64	2.73	2.16	2.25	2.17
1955	1.41	2.70	1.31	1.56	1.91	1.55
1956	4.10	2.88	2.34	3.84	3.23	3.94
1957	1.40	1.42	1.65	1.43	1.52	1.37
1958	1.20	2.47	2.07	1.20	1.43	1.17
1959	2.13	2.19	2.26	2.21	2.26	2.24
1960	1.79	0.99	1.04	1.80	1.54	1.80
Late spring potatoes, (July-August) $P_{s_{2(s)}}$						
1947	3.08	3.11	2.66	2.83	2.83	2.72
1948	2.39	2.42	2.51	2.83	2.83	2.44
1949	2.21	2.47	2.00	2.13	2.13	2.33
1950	1.63	1.75	2.02	1.47	1.47	1.64
1951	2.13	2.53	2.74	1.36	1.36	2.28
1952	3.81	1.71	2.72	3.97	3.97	3.71
1953	1.24	0.93	1.42	1.11	1.11	1.39

1/ See footnotes at end of table 17.

- Continued

Table 25.--Model of early summer potato market: Actual and estimated values of the endogenous variables, 1947-60 1/-- Continued

Item and year	Actual	Estimated				
		Reduced-form equations		Structural equations		
		Limited information	Least squares	Limited information	Two-stage least squares	Least squares
	Dollars	Dollars	Dollars	Dollars	Dollars	Dollars
Farm price, per hundredweight:						
Late spring potatoes, (July-August) $P_{s_{2(s)}}$						
1954	2.31	2.80	2.75	2.08	2.08	2.18
1955	1.39	2.81	1.72	1.26	1.26	1.86
1956	3.82	2.83	3.08	3.96	3.96	3.52
1957	1.46	1.23	1.55	1.44	1.44	1.35
1958	1.36	3.05	2.37	1.28	1.28	1.59
1959	2.48	2.46	2.45	2.24	2.24	2.32
1960	2.49	1.16	1.42	3.10	3.10	2.08
Late summer potatoes, (July-August) P_{1_s}						
1947	2.41	2.56	2.10	2.39	2.39	2.36
1948	2.25	2.09	2.33	2.23	2.23	2.15
1949	2.08	2.12	1.69	2.07	2.07	2.09
1950	1.79	1.61	2.10	1.54	1.54	1.47
1951	1.45	2.16	2.29	1.83	1.83	1.78
1952	3.48	1.94	2.50	2.86	2.86	3.28
1953	0.99	1.42	1.43	1.49	1.49	1.25
1954	1.74	2.02	2.17	1.81	1.81	1.85
1955	0.97	2.02	0.85	1.38	1.38	1.14
1956	2.91	1.97	2.39	2.57	2.57	3.09
1957	1.27	1.24	1.34	1.22	1.22	1.06
1958	0.96	1.65	1.63	1.01	1.01	0.94
1959	1.51	1.63	1.71	1.60	1.60	1.63
1960	1.71	1.14	1.00	1.52	1.52	1.41

1/ See footnotes at end of table 17.

Table 26.--Data used in the 5-equation late summer and fall model for potatoes, 1947-60

Year	Consumption of late summer and fall potatoes for — Food 1/ C_h	Livestock feed 2/ C_f	Starch 3/ C_s	Consumption of late summer and fall potatoes for food, lagged 1 year $C_{n_{t-1}}$	Percent of late summer and fall production processed into food products C_{f_r}	Supply of late summer and fall potatoes for food, feed, and starch 4/ $Q-(S_e+R)$
	Million hundred-weight	Million hundred-weight	Million hundred-weight	Million hundred-weight	Percent	Million hundred-weight
1947	121.3	13.1	4.5	131.6	3.3	138.9
1948	116.0	14.9	6.5	121.3	3.6	132.2
1949	117.1	15.3	7.8	116.0	4.6	140.2
1950	124.8	16.5	13.0	117.1	5.1	154.3
1951	120.0	10.8	2.8	124.8	6.9	133.6
1952	124.8	12.3	10.8	120.0	6.6	147.9
1953	135.3	15.4	10.2	124.8	7.6	160.9
1954	134.0	14.8	6.6	135.3	8.3	155.4
1955	133.1	14.4	8.7	134.0	9.6	156.2
1956	136.5	18.6	18.3	133.1	9.8	173.4
1957	137.7	12.9	12.7	136.5	12.0	163.3
1958	143.0	17.2	18.4	137.7	13.0	178.6
1959	147.2	14.2	7.7	143.0	16.1	169.1
1960	149.7	14.6	10.2	147.2	18.8	174.5

See footnotes at end of table.

-Continued

Table 26.--Data used in the 5-equation late summer and fall model for potatoes, 1947-60 -Continued

Year	Price of late summer and fall potatoes—		Index numbers (1947-49=100) of—			
	Farm, per hundredweight 5/	Retail, per 10 lb. bag 6/	Price of feeder steers, October 1 7/	Retail prices of processed plate vegetables	Cost of marketing late summer and fall potatoes	Consumer disposable income, July-June
	P_f	P_l	P_{f_s}	P_{pv}	M	D_i
	Dollars	Cents				Billion dollars
1947	2.68	54.1	93.7	101.8	89.6	179.1
1948	2.48	53.0	109.6	101.2	102.5	192.4
1949	2.01	48.2	96.7	97.0	107.9	195.1
1950	1.41	42.5	129.8	114.3	108.7	218.5
1951	2.75	61.4	156.6	113.1	114.1	232.8
1952	3.01	70.1	110.7	116.7	119.1	247.4
1953	1.18	45.6	70.5	114.3	122.0	254.2
1954	2.06	56.0	87.3	108.3	123.0	263.4
1955	1.63	51.6	83.8	108.3	122.6	284.1
1956	1.55	57.4	77.2	107.1	126.0	301.8
1957	1.99	62.4	95.6	107.7	133.0	312.4
1958	1.17	53.6	121.8	110.7	133.9	328.6
1959	2.11	65.7	116.4	108.3	132.4	343.8
1960	1.85	67.6	99.3	114.3	132.5	355.7

See footnotes at end of table.

- Continued

Table 26.--Data used in the 5-equation late summer and fall model for potatoes, 1947-60 -Continued

Year	Consumer price index, 1947-49=100 (January-December)		Index numbers of wholesale prices, 1947-49=100 (January-December)		Population, January 1 (following year)	
	August-April	July-June	August-April	January-December	Eating out of civilian supplies	Total
					Million	Million
1947	99.5	99.6	101.2	96.4	144.1	145.5
1948	103.2	103.1	103.4	104.4	146.4	148.0
1949	101.1	101.2	98.1	99.2	149.0	150.6
1950	107.2	107.4	111.7	103.1	150.7	153.1
1951	112.4	112.4	113.1	114.8	152.3	155.8
1952	114.0	114.0	110.5	111.6	154.9	158.4
1953	115.0	115.0	110.5	110.1	157.7	161.1
1954	114.5	114.5	110.1	110.3	160.7	164.0
1955	114.8	114.9	111.9	110.7	163.9	166.8
1956	118.1	118.3	116.2	114.3	167.0	169.8
1957	122.0	122.2	118.6	117.6	170.1	172.7
1958	123.8	123.8	119.4	119.2	173.1	175.9
1959	125.5	125.6	119.4	119.5	176.1	178.6
1960	127.0	127.2	119.6	119.6	179.0	181.5

1/ Consumption for food includes fresh, chips, canned, dehydrated and frozen. 2/ Includes shrinkage and waste on farms where grown. 3/ Estimates taken from supply and distribution tables, 1947-50; from crop disposition reports, 1951-55; and from Utilization of Annual Crop with Comparisons, 1956-60. 4/ Q represents gross production; S_e represents utilization for seed; and R represents Government activities, net exports and military procurement. 5/ Season average price received by farmers. 6/ From reports of Bureau of Labor Statistics. Retail prices previous to January 1955 were adjusted from a 15-pound basis to a 10-pound basis. 7/ Index of prices per hundredweight of stocker and feeder steers, good, 500-800 pounds, Kansas City.

Table 27.--Data used in the 4-equation winter and early spring model for potatoes, 1947-60

Year	Consumption of winter and early spring potatoes 1/ Q_{s_1}	Consumption of fall (storage) potatoes for food, January-April 2/ C_{f_1}	Storage stocks: Fall potatoes in storage, January 1 S_j	Storage stocks: Fall potatoes in storage, May 1 3/ S_t	Percent of total food utilization processed into food products $C_{f_{r_1}}$	Prices received by farmers per hundredweight — Winter and early spring potatoes P_{s_1}	Prices received by farmers per hundredweight — Fall (storage) potatoes, January-April 4/ P_{f_1}	Prices received by farmers per hundredweight — Sustained monthly price change for fall (storage) potatoes, November-April 5/ $P_{s_{mc}}$
	Million hundred-weight	Million hundred-weight	Million hundred-weight	Million hundred-weight	Percent	Dollars	Dollars	Cents
1947	2.1	39.0	115.3	8.2	3.5	2.94	1.95	+26.0
1948	2.5	37.5	93.1	9.6	4.7	4.23	2.95	+42.0
1949	4.7	38.4	110.0	4.4	5.9	3.61	2.67	+60.0
1950	5.2	39.9	106.4	11.1	6.9	2.79	1.95	-15.0
1951	5.9	45.2	111.6	12.5	8.1	2.70	1.45	+30.0
1952	5.9	38.7	69.2	2.6	8.5	4.14	3.37	+86.0
1953	7.8	40.3	81.2	8.4	8.4	2.95	2.50	-51.0
1954	7.6	46.4	91.8	15.5	9.8	2.39	.98	-54.0
1955	9.0	46.3	88.2	13.0	10.4	3.62	2.18	+18.0
1956	9.3	45.0	86.0	7.8	12.3	3.44	1.91	+140.0
1957	10.7	44.9	100.6	15.5	13.4	1.98	1.28	-37.0
1958	9.3	42.2	92.7	15.8	16.0	2.49	2.58	+61.0
1959	6.8	51.2	107.9	15.0	18.4	2.66	1.16	-17.0
1960	6.8	54.1	99.4	11.6	20.5	3.69	2.58	+134.0

1/ Adjustment made, 1947-50, for removal of potatoes under Government programs.

2/ Derived in the following manner: (a) Start initially with storage stocks reported January 1, (b) adjust for disappearance under Government programs, largely for feed, (c) adjust for disappearance under private disposal for seed, feed, starch, net exports, and military purchases, (d) adjust this estimate by the ratio of shipments of storage potatoes, January 1-April 30, to total shipments of storage potatoes, January 1-June 30.

3/ Derived by the same method given in footnote 2 except for (d) carry out the following step: Use ratio of shipments, May 1-June 30 to total shipments January 1-June 30, to determine share of storage potatoes on hand May 1.

-Continued

Table 27.--Data used in the 4-equation winter and early spring model for potatoes, 1947-60 - Continued

Year	Consumer disposable income, 1st quarter D_1	Index numbers of cost of marketing potatoes, 1947-49=100, January-December M_1	Disposition of storage potatoes under Government programs, January-April G_f	Disappearance of potatoes for miscellaneous uses, shrinkage and loss, January-April R	Consumer price index, 1947-49=100, (January-December) January-April	Index of wholesale prices, 1947-49=100 (January-December)		Population January 1	
						November to April 6/	January-December	Eating out of civilian supplies	Total
	Billion dollars		Million hundred-weight	Million hundred-weight				Million	Million
1947	167.5	89.6	28.3	39.8	92.8	93.0	96.4	140.9	142.8
1948	179.5	102.5	8.3	37.7	100.9	102.7	104.4	144.1	145.5
1949	190.6	107.9	31.6	35.6	102.1	102.2	99.2	146.4	148.0
1950	200.9	108.7	25.5	29.9	100.6	98.1	103.1	149.0	150.6
1951	219.8	114.1	25.2	28.7	109.8	114.3	114.8	150.7	153.1
1952	232.1	119.1	—	27.9	112.7	112.8	111.6	152.3	155.8
1953	250.0	122.0	—	32.5	113.6	109.9	110.1	154.9	158.4
1954	254.6	123.0	—	29.9	114.9	110.5	110.3	157.7	161.1
1955	263.8	122.6	—	28.9	114.3	110.1	110.7	160.7	164.0
1956	283.1	126.0	.8	32.4	114.7	112.2	114.3	163.9	166.8
1957	302.5	133.0	6.2	34.0	118.8	116.7	117.6	167.0	169.8
1958	311.4	133.9	5.6	29.1	122.9	118.9	119.2	170.1	172.7
1959	329.6	132.4	7.8	33.9	123.8	119.5	119.5	173.1	175.7
1960	344.0	132.5	3.6	30.1	125.7	119.4	119.6	176.1	178.6

4/ Weighted average of prices received by farmers for January-April.

5/ Sustained monthly price change in a given direction. November and December data are for the previous year. See text and appendix for explanation.

Table 28.-Data used in the 2-equation late spring model for potatoes, 1947-60

Year	Consumption of late spring potatoes 1/ Q_{s_2}	Consumption of fall (storage) potatoes for food, May-June 2/ Q_{f_2}	Prices received by farmers, per hundredweight — Late spring potatoes P_{s_2}	Prices received by farmers, per hundredweight — Fall (storage) potatoes May-June 3/ P_{f_2}	Consumer disposable income, 2nd quarter D_2	Index numbers of wholesale prices of all commodities 1947-49=100 M_2	Consumer price index, 1947-49=100 (January-December) May-June	Population April 1 — Eating out of civilian supplies	Population April 1 — Total
	Million hundredweight	Million hundredweight	Dollars	Dollars	Billion dollars			Million	Million
1947	22.4	4.0	2.67	2.30	164.8	96.4	94.3	141.8	143.4
1948	23.6	4.8	2.65	2.92	188.8	104.4	103.2	144.6	146.0
1949	25.3	2.3	2.43	2.98	190.2	99.2	102.5	147.0	148.6
1950	25.6	6.3	1.74	1.88	201.7	103.1	101.6	149.6	151.1
1951	20.5	7.7	2.33	1.45	226.4	114.8	110.8	150.7	153.7
1952	22.4	1.5	3.97	4.45	235.6	111.6	113.2	152.7	156.4
1953	27.7	4.6	1.53	1.44	252.8	110.1	114.2	155.5	159.0
1954	22.1	9.4	2.62	1.37	254.8	110.3	115.0	158.4	161.8
1955	24.0	8.0	2.12	3.00	272.0	110.7	114.3	161.5	164.6
1956	21.8	4.6	4.21	3.44	288.8	114.3	115.8	164.6	167.5
1957	27.1	8.8	1.46	.93	308.0	117.6	119.8	167.7	170.5
1958	23.7	9.3	1.98	1.39	314.2	119.2	123.6	170.8	173.4
1959	22.6	9.0	3.23	2.30	338.0	119.5	124.1	173.8	176.4
1960	26.4	7.4	2.51	2.63	349.6	119.6	126.3	176.8	179.2

1/ Adjustment made, 1947-50, for removal of potatoes under Government programs.

2/ Derived by the same method as given in footnote 2, table 27, except for (d) carry out the following step: Use ratio of shipments May-June to total shipments January-June to determine the share of storage potatoes used for food, May and June.

3/ Weighted average of prices received by farmers for May-June.

Table 29.--Data used in the 3-equation early summer model for potatoes, 1947-60

Year	Consumption of early summer potatoes for food 1/ Q_{s_3}	Consumption of late spring potatoes for food 1/ Q_{s_2}	Consumption of late summer potatoes for food 2/ Q_{1_s}	Prices received by farmers, per hundredweight — Early summer potatoes P_{s_3}	Late spring potatoes 3/ $P_{s_2(s)}$	Late summer potatoes 4/ P_{1_s}
	Million hundred-weight	Million hundred-weight	Million hundred-weight	Dollars	Dollars	Dollars
1947	16.0	22.4	11.6	2.50	2.94	2.30
1948	14.6	23.6	12.0	2.57	2.50	2.35
1949	12.1	25.3	12.2	2.28	2.24	2.11
1950	11.8	25.6	14.5	1.80	1.68	1.85
1951	11.6	20.5	12.1	2.29	2.36	1.61
1952	9.6	22.4	10.9	4.54	4.35	3.97
1953	10.9	27.7	11.4	1.58	1.42	1.14
1954	10.7	22.1	12.7	2.56	2.66	2.00
1955	13.0	24.0	11.6	1.62	1.59	1.11
1956	10.2	21.8	12.4	4.79	4.47	3.40
1957	10.0	27.1	12.0	1.69	1.76	1.53
1958	12.5	23.7	12.2	1.49	1.69	1.19
1959	12.2	22.6	9.9	2.66	3.09	1.88
1960	13.3	26.4	8.2	2.26	3.15	2.16

1/ Adjustment made, 1947-50, for removal of potatoes under Government programs.
2/ Estimated from disappearance data by applying the ratio of shipments July-August to total shipments to get share of consumption for July-August.

Table 29.--Data used in the 3-equation early summer model for potatoes, 1947-60 — Continued

Year	Consumer disposable income, 3rd quarter D_3	Index numbers of cost of marketing potatoes 1947-49 = 100 M_3	Consumer price index, 1947-49=100 (January-December)		Index numbers of wholesale prices, 1947-49=100 (January-December)	Population July 1	
			July-August	January-December		Eating out of civilian supplies	Total
	Billion Dollars					Million	Million
1947	172.3	89.6	95.6	95.5	96.4	142.6	144.1
1948	194.7	102.5	104.6	102.8	104.4	145.2	146.6
1949	188.6	107.9	101.5	101.7	99.2	147.6	149.2
1950	210.2	108.7	103.3	102.8	103.1	150.2	151.7
1951	229.5	114.1	110.9	111.0	114.8	151.1	154.4
1952	241.1	119.1	114.2	113.5	111.6	153.4	157.0
1953	253.8	122.0	114.8	114.4	110.1	156.0	159.6
1954	256.8	123.0	115.1	114.8	110.3	159.1	162.4
1955	277.7	122.6	114.6	114.5	110.7	162.3	165.3
1956	295.2	126.0	116.9	116.2	114.3	165.3	168.2
1957	312.7	133.0	120.9	120.2	117.6	168.4	171.2
1958	321.8	133.9	123.8	123.4	119.2	171.4	174.1
1959	338.8	132.4	124.8	124.6	119.5	174.5	177.1
1960	351.7	132.5	126.6	126.4	119.6	177.4	179.8

3/ Weighted average prices received by farmers for late spring potatoes, July-August.
4/ Weighted average prices received by farmers for late summer potatoes, July-August.

U. S. GOVERNMENT PRINTING OFFICE : 1967 O - 267-387

END