Staff Paper Series

STAFF PAPER P72-14 MAY 1972

THE U.S. FOOD DEMAND FOR WHEAT BY CLASS

by
Ju Chun Chai

Department of Agricultural and Applied Economics

University of Minnesota
Institute of Agriculture
St. Paul, Minnesota 55101

Staff Paper P72-14 May 1972

THE U.S. FOOD DEMAND FOR WHEAT BY CLASS

Ju Chun Chai

Staff Papers are published without formal review within the Department of Agricultural and Applied Economics

THE U.S. FOOD DEMAND FOR WHEAT BY CLASS

By

Ju Chun Chai

CONTENTS

The U. S. Food Demand for Wheat by Class

by

Ju Chun Chai*

INTRODUCTION

Wheat, the premier food grain in the U. S., differs from other cereal crops in that it is not a homogeneous commodity but a collection of wide range of classes and qualities each distinct in physical characteristics and end uses. This distinction, however, has been often overlooked. Government wheat programs that took inadequate account of such distinction have, at times, resulted in surpluses in certain classes of wheat and shortages in others.

Specifically, the hard red winter wheat from the Southern Great Plains and the white wheat from the Pacific Northwest contributed most to the wheat surplus (primarily in the form of the Commodity Credit Corporation stocks) and to the subsidized exports while the supply of other classes has normally been in close balance with demand. Such supply and demand imbalance among classes of wheat has been largely attributed to the government price support programs which kept price spreads between different types and qualities of wheat much narrower and less variable than was consistent with existing supply-demand conditions.

---

*Ju Chun Chai formerly was a graduate student at the Department of Agricultural Economics at the University of Minnesota, and now with the Economic and Statistical Analysis Division, Economic Research Service, U. S. Department of Agriculture. The author thanks Professors R. P. Dahl, Harold C. Pederson, O. B. Jesness, and James P. Houck of the University of Minnesota for their helpful suggestions throughout the development and completion of this study.

Special export programs (most importantly the PL-480 export disposals) and general export subsidies are two other government programs that further distorted the wheat price structure and intensified the imbalance among wheats, resulting in misallocations of resources and inequities among farmers.[1]

Purpose and Scope of Study

Most economic studies have treated wheat as a single entity with little attention paid to the heterogeneity of this crop and have concluded that the domestic demand for wheat for food use is highly inelastic. Since such estimates are for all wheat they have limited use and are even misleading when applied to analysis of individual classes.

This study investigates the nature of demand peculiar to each class and quantify the economic and physical interrelationships existing among the five major classes of wheat produced in the United States.

Results of this study may bring about a better understanding of the wheat market, and may directly be applied to answer questions related to (1) the expansion potential of domestic food use of wheat by class through price change, (2) a proper distribution of wheat stocks by class as well as the adequacy of total wheat stocks, and (3) the outlook for wheat exports by class, and by country.

---

1 The supply-demand imbalance among classes of wheat and its causes are more fully described in the following articles: Reynold P. Dahl, "Classes of Wheat and The Surplus Problem," The Northwestern Miller, Vol. 266, No. 8, April 16, 1962, pp. 30-34; Dudley J. Russell, President, Atkinson Milling Co., Minneapolis, The Demand for Wheat by Classes, a paper presented to the Marketing Seminar for the Minneapolis Grain Exchange, September 1961; Helen C. Farnsworth, "The Problem Multiplying Effects of Special Wheat Programs," American Economic Review, Vol. LI, May 1961, p. 356.

The findings of this report can also be applied, together with supply response schedules of wheat classes, to the formulation of wheat price support programs that are consistent with supply-demand situations. Since this report deals only with the demand side, such a policy formulation is not specifically explored.

Method of Analysis and the Data

The demand for each class of wheat is assumed to be dependent upon the price and quality of the class, prices and qualities of competing classes, the level of consumer disposable income, the degree of urbanization, and the state of milling and baking technology.

The effects of each of these factors are evaluated and attempts are made to obtain quantitative approximations of their influences. Specifically, price elasticities of demand, price elasticities of substitution, and shifts in demand between the pre-World War II and the post war periods are estimated using the ordinary least-squares approach.

The nature of available data does not permit a complete formulation of all the empirical relations needed to answer all the specific questions. However, such a shortcoming -- a common occurrence in many econometric analyses -- is supplemented by a detailed study of distinctive physical, chemical and baking characteristics of individual classes, special attributes desired for various end uses, substitutability among wheat, and developments in milling and baking technology.

This study is based partly on data from official publications of the U. S. Department of Agriculture. The data on the four wheat utilization outlets -- food, feed, exports, and stocks -- by class for 1929-53 were obtained from the published data of Williams and Wang who derived these data from USDA sources.[2] Using the same procedure, the author extended the data to 1963.

Information received from members of the milling and baking trade supplemented the published data. The source of each data series is indicated by a tabular footnote.

2 H. C. Williams and Yi Wang, Wheat Statistics: Supply and Utilization by Class, Special Circular 96, Ohio Agricultural Experiment Station, Ohio State University, September 1961.

THE WHEAT AND WHEAT FOODS ECONOMY

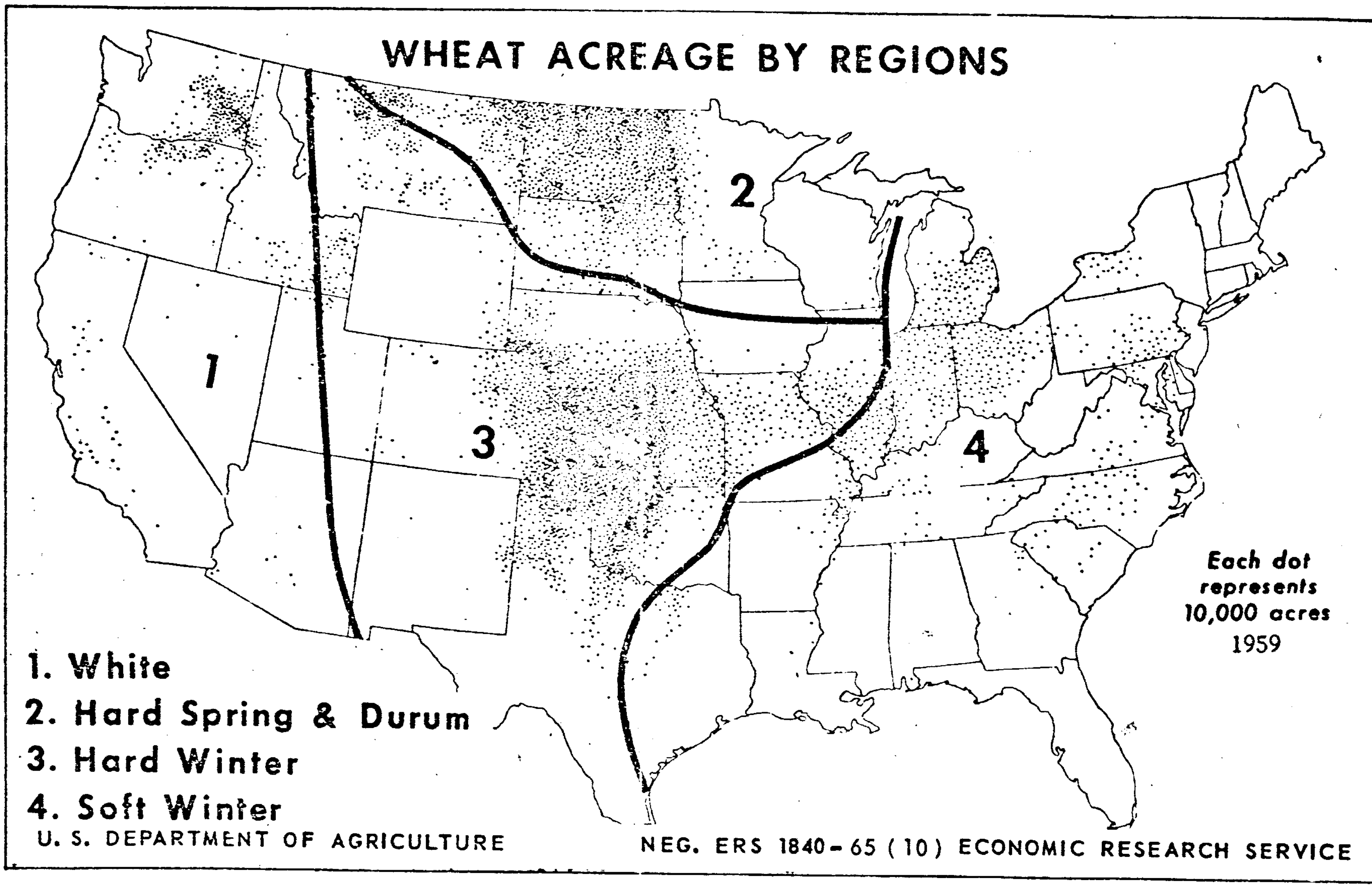
Production and Utilization of Wheat By Class

The following map shows the geographic distribution of wheat by regions. Wheat is planted either in the fall or in the spring with the former called "winter wheat," and the latter, "spring wheat." From this breakdown, wheat is further classified into seven market classes and 15 subclasses.[3] The seven classes are: hard red spring, durum, red durum (feed grade), hard red winter, soft red winter, white, and a mixed (a mixture of various classes). The market class is based on agronomic characteristics specific to the variety grown, whereas the subclass is a rough quality indicator within the class. Within each class and subclasses, there are six grades from number 1 (highest) through number 5 to sample grade (lowest). These grades are established on the basis of such factors as test weight, damaged kernels, moisture, and foreign matter contents.

Federal grain standards indicate general market quality for wheat. But, for the miller who wants specific wheat quality characteristics, federal grain standards alone are inadequate and are normally supplemented by other quality indicators. The most common wheat quality indicator recognized by the milling and baking trade is

---

3 For a complete description of classes, subclasses, and grades, see Handbook of Official Grain Standards of the U. S., Grain Division, AMS, USDA, 1964, pp. 1.1 - 1.11.


WHEAT ACREAGE BY REGIONS
1
2
3
4
1. White
2. Hard Spring & Durum
3. Hard Winter
4. Soft Winter
Each dot represents 10,000 acres
1959
U. S. DEPARTMENT OF AGRICULTURE
NEG. ERS 1840-65 (10) ECONOMIC RESEARCH SERVICE

protein content.[4] It is common practice of the large milling firms to collect samples from various wheat producing areas immediately following harvest in making baking tests to supplement the information more readily available. This enables them to more correctly determine the real value of their subsequent wheat purchases.

Because the miller purchases wheat on the base of certain quality characteristics, the subsequent discussion on the production and utilization will emphasize quality characteristics of the five major classes of wheat.[5]

Hard Red Winter

Production. Hard red winter wheat is the most common type of the United States. The annual average was 326 million bushels, or 42 percent of the total wheat production for the period 1929-41. For 1946-63, annual average production increased to 580 million bushels, 51 percent of total production. The states of Kansas, Oklahoma, Texas, and Nebraska accounted for 34, 16, 12 and 10 percent of the total hard red winter acreage respectively in 1964.

The quantity as well as quality of the protein in hard red winter varies greatly from region to region and year to year. This is attributed to the moisture conditions during the growing season.

4 The presence of appreciable amounts of water-insoluble protein called gluten is the most distinctive quality of wheat that separates it from other cereals. When wheat flour is mixed with water it forms a rubbery substance and holds the gas created by yeast or baking soda, thus producing light textured goods.

5 The production and utilization data are presented in Appendix I.

The higher protein hard red winter grown in fairly dry regions normally has a good quality of gluten and is suited both for the commercial production of white pan-bread and for all-purpose family flour. In a normal year wheats from central and western areas of Kansas and Nebraska, Colorado, South Dakota and Montana are usually classified in this category. Other wheat from parts of Oklahoma, Texas, and New Mexico may be expected to have a similar quality. The lower protein hard red winter wheat grown in the higher moisture areas may be blended or mixed with "stronger" (a trade term referring to high protein content) wheats and then milled into flour acceptable to normal commercial baking procedures. The hard red winter grown in Oklahoma, eastern Kansas and Nebraska, Missouri, Iowa, and Illinois is usually of the latter category. During years of high precipitation much of the crop from these areas may be so low in protein that it is on the borderline of acceptability for milling purposes.

Utilization - The domestic annual utilization of hard red winter averaged 207 million bushels, or 63 percent of the annual production during the 1929-41 period. During the 1946-63 period annual utilization averaged 201 million bushels or 35 percent of production.

Much of the wheat produced in the Southwest is shipped either as grain or as flour to both the East and the West Coast markets. A substantial amount of hard red winter grown in Montana moves to the West Coast markets.

Relatively little hard red winter is used for feed. The annual amount used as feed averaged 37 million bushels in the 1929-41 period, but declined to an average of 20 million bushels for 1946-63.

Annual exports of hard red winter averaged only 34 million bushels for the 1929-41 period, but increased to 263 million bushels in 1946-63. Annual average carryover stocks were 136 and 566 million bushels for the two periods, respectively. Government programs, which have become especially significant since 1938, have played the major role in both increased volume of exports and in carryover stocks. Government exports, for example, accounted for approximately 66 percent of the total hard red winter exports in 1961-63, and the Commodity Credit Corporation owned 92 percent of the total hard red winter stocks in 1955-63.

Hard Red Spring

Production. The annual production of hard red spring increased from 124 million bushels for the 1929-41 period to 183 million bushels for the 1946-63 period. This was about 16 percent of total wheat production for each period.

The states of North Dakota, Montana, and South Dakota accounted respectively for 49, 21, and 17 percent of the total hard red spring acreage in 1964.

Hard red spring regions typically have less than 20 inches of annual precipitation. The better quality hard red spring comes from low rainfall areas of Montana and North Dakota. South Dakota, where precipitation is higher than the other hard red spring states, produces a lower quality hard red spring which consequently commands a lower price than the hard red spring from Montana and South Dakota.

Despite miller's preference, reflected in premium paid for the Montana hard red spring over other hard red winter, Montana farmers have since 1929 shifted markedly from hard red spring to the higher yielding hard red winter. For the years 1958-62, for instance, the hard red winter yield averaged 6 bushels per acre more than hard red spring. During the 1929-64 period, hard red winter wheat acreage in Montana increased from 16 percent to 49 percent of the total wheat acreage, while hard red spring acreage decreased from 82 to 46 percent. Government price support programs for wheat have tended to encourage the farmer toward higher yielding varieties of wheat.

Utilization. Food use for hard red spring in the 1929-41 period averaged 85 million bushels annually or 69 percent of production, and it was 119 million bushels or 63 percent of the production in 1946-63.

Much of this wheat is shipped through the Great Lakes to the large flour mills in Buffalo which serve the eastern population centers. The Midwest spring wheat may also move by barge from various points on the upper Mississippi for export from New Orleans or to flour mills in Chattanooga and other river ports. At these centers it is either milled or used for blending with the weaker local wheat. Rail shipments are made to inland mills or, occasionally, down-river during the winter months. Domestic movements of spring wheat to the southern and the southwestern mills tend to increase when the Southwest has a low protein crop.[6]

Little hard red spring is used for feed. An average of only 14 million bushels annually was used in this manner during the 1929-41 period and it further decreased to a mere 8 million bushels for the 1946-63 period. Hard red spring unfit for human consumption due to weather or insect damage is usually made available as livestock feed.

Average annual exports of hard red spring increased from 2 million bushels in the 1929-41 period to 37 million bushels for the 1946-63 period. Government exports in 1961-63 accounted for only about 23 percent of all hard red spring exports. Annual carryover stocks of hard red spring averaged 32 million bushels during the 1929-41 period and increased to 157 million bushels for the 1946-63 period.

Durum

Production. Annual durum production averaged 32 million bushels or 4 percent of total wheat production during the 1929-41 period, and it remained around 33 million bushels or 3 percent of total wheat production in the 1946-63 period. North Dakota accounted for 84 percent of total durum acreage in 1964. Small amounts were also

---

6 Dudley, J. Russell, President, Atkinson Milling Co., Minneapolis "The Demand for Wheat by Classes", a paper presented to the marketing seminar of the Minneapolis Grain Exchange, September, 1961, pp. 6-7.

grown in South Dakota, Montana, Minnesota, and California. Durum production fell to less than 10 million bushels, far short of domestic food requirements, in 1934, 1936, and 1954 when yields in North Dakota were down to 7, 5, and 4 bushels per acre respectively. The domestic durum shortage was partially overcome with 7 million bushels in 1934 and 9 million bushels in 1936 being imported from Canada.

Utilization. Durum used for food averaged 22 million bushels or 69 percent of total production in 1929-41, and remained about the same at 20 million bushels or 61 percent of the total production in 1946-63. Much of durum is milled into semolina and flour in the Upper Midwest, particularly in Minnesota and Wisconsin, and shipped to other consuming centers. The annual average feed use of durum decreased from 3 million bushels in 1929-41 to 1 million bushels in 1946-64 due to increasing prices of durum relative to other feed grain prices.

Durum exports increased from 3 million bushels in 1929-41 to 6 million bushels in 1946-63. In 1961-63, all durum exports were under commercial terms. Annual stocks averaged 16 million bushels in 1921-41 and remained about the same at 17 million bushels in 1946-63. Approximately 53 percent of durum stocks in 1955-63 were owned by CCC.

Soft Red Winter

Production. Annual average soft red winter wheat production declined from 201 million bushels in 1929-41 to 187 million bushels in 1946-63--the only class of wheat that has registered a decline over the two periods.

In 1964, Indiana, Ohio, and Missouri led soft red winter acreage with 20, 19, and 9 percent of the total, respectively, and the remainder was produced in the Atlantic and the Southern states. The soft red winter regions typically have annual rainfall exceeding 30 inches.

Wheat from the main soft red winter region (Indiana, Ohio, Missouri) is of good pastry flour quality, but wheat from the other soft red winter regions is usually substandard and much of the crop is of feed quality. Even in the main soft red winter region, this wheat is not an important cash crop and is produced rather in the scheme of rotation or for feed and straw. A survey of Ohio wheat producers who were eligible but had not obtained a government non-recourse loan or purchase agreement on their 1955 wheat crop revealed that the largest category of these farmers (23 percent) were not interested in a loan because they used their wheat as feed.[7]

Utilization. Annual average food use of soft red winter declined from 131 million bushels or 65 percent of total production in 1929-63 to 97 million bushels or 52 percent of total production in 1946-63. Historically a substantial amount of soft red winter has been used for feed. Annual feed use was about 48 million bushels in 1929-41 and declined to 34 million bushels in 1946-63.

---

7 Francis B. McCormick and Mervin G. Smith, Wheat Price Programs: Effect and Implication for Ohio, Research Bulletin 866, Ohio Agricultural Experiment Station, Ohio State University, October 1960, p. 24.

Annual exports increased from 2 million bushels in 1929-41 to 44 million bushels in 1946-63, with the various government programs accounting for only 18 percent of the total during the 1958-63 period. Soft read winter stocks averaged 33 million bushels in 1929-41 but declined to 21 million bushels in 1946-63, with stocks owned by CCC accounting to about 36 percent of the total for the 1955-63 period.

White

Production. Annual white wheat production increased from 89 million bushels in 1929-41 to 160 million bushels in 1946-63. The state of Washington accounted for 41 percent of the total white wheat acreage, and Michigan had 18 percent in 1964. In 1929-41 the western white wheat region produced 84 percent of the total; the eastern white wheat regions, the remainder. In the 1946-63 period, the share of the western white wheat region declined slightly to 76 percent; the eastern white wheat region had the remainder.

The western white wheat region produces both soft and hard varieties whereas the eastern white wheat region produces only soft varieties. Hard wheat varieties are grown in the dryer land section of the western white wheat region and were important wheat types before the war, at times averaging about 30 percent of the total white wheat acreage. In recent years they have accounted for only about 15 percent of the total acreage.

Utilization. Annual food use averaged 45 million bushels or 51 percent of the total production in 1921-41 and declined to 43 million bushels or 27 percent of the total production in 1946-63.

On the West Coast, hard white blended with the stronger hard wheats from Montana and the Southwest for bakery flour. Soft white is used for pastry flour or as an all-purpose family flour. The white wheats from New York and Michigan also have good pastry qualities.

At times, relatively large amounts of white wheat have been used for feed, averaging 15 million bushels in 1929-41 and 14 million bushels in 1946-63. The percentage of white wheat fed on farms has been higher in the eastern white wheat region than in the western white wheat region: 33 percent in the eastern region as compared with 11 percent in the western region in 1929-41; and 14 percent in the East compared with 4 percent in the western region in 1946-63.

Annual white wheat exports increased from 20 million bushels in 1929-41 to 93 million bushels in 1946-63. In 1961-63 approximately 54 percent of white wheat exports were made under government programs. Stocks increased from an annual average of 22 million bushels in 1921-41 to 45 million bushels in 1946-63. In 1955-63, CCC owned about 89 percent of total stocks.

Wheat Foods and Quality Desired[8]

In examining the domestic demand for each of the five classes of wheat it is essential to consider the specific wheat properties required for each type of wheat food.

Bread

Bread as used here refers to the several types of commercially baked bread produced in the United States.

Whole wheat bread, hearth bread, and rolls. These are commonly referred to as speciality breads. They are often made with nonpan-supported dough and require exceptionally strong wheat of 14 to 17 percent protein. Hard red spring is ideal for these products. When the available hard red spring wheat is unusually high in protein, hard red winter of 10-15 percent protein is blended with it to provide "mellowness" in the flour. The mills in the Northwest and Buffalo commonly use Montana hard red winter for this purpose. The mills in the Southwest often purchase North Dakota or Montana hard red spring to blend with Kansas, Texas, or other Southwest hard red winter.

---

8 Based largely on : Interview with Dudley J. Russell, Vice-President, Archer Daniels Midland Company, Minneapolis, September 20, 1965; and Mark Barmore, "What Do We Mean By Quality," Proceedings of Fourth Annual Workshops on Wheat Marketing in the Pacific Northwest, Institute of Agricultural Science, Washington State University, Pullman, Washington, February, 1965.

White Bread. White bread can be made from several types and grades of flour[9] depending on the bread desired and the eating habits of the people in the market area served. Generally, a 12.5 to 14.5 percent protein wheat is used for white bread.

Spring Standard Patents are used primarily by the retail baker and consist of 100 percent hard red spring or may be a blend of 20 to 30 percent hard red winter. The use of hard red winter takes place only when hard red spring is too strong and needs to be mellowed for a normal performance in the bakery. Buffalo or other eastern mills may use soft red winter for mellowing and the West Coast mills may use hard white.

Spring Intermediate or Short Patents are used by the commercial bakers and institutions wanting a particularly high quality bread. Hard red spring flour tends to give superior quality bread with a large volume which offsets the usually high price of hard red spring. Breads from hard red spring also have longer shelf life and better "springiness" both of which are essential for the present-day market. Use of hard red winter in this flour is about the same as for Spring Standard Patents.

Bakery Blends consist of hard red spring and hard red winter and are used by most pan-bread bakers. Bakeries buy the two types separately, or more commonly have the mills do the blending for them.

---

9 There are three major grades of flour in the United States. Straight flour is the basic flour, representing in different mills from 69 to 75 percent of wheat. When a Straight flour is further refined, it produces refined flour called Patents, and the remnants called Clears. The miller would produce 95, 90, 80 and in some cases as low as 60 percent Patents. As the Patents are shortened, the percentage of protein, ash, acidity, and fibers declines.

The percentage of hard red spring and hard red winter varies considerably. Common blends from the Northwest in a normal year may be 50-50 or even 30 percent hard red spring and 70 percent hard red winter, depending on price differentials and quality characteristics. The Southwest mills will ordinarily acquire lesser quantity of hard red spring to save freight.

Hard Winter Patents are commonly used by the large commercial bakers for white-pan-bread, particularly in the hard red winter regions. This flour is usually 100 percent hard red winter but when the hard red winter available to a particular mill is unusually strong, about 10 percent or more of soft red winter may be substituted. If the hard winter is unusually weak, hard red spring may be added to maintain normal baking characteristics.

<u>Dark and Rye Breads</u>.[10] Spring Clears are used by bakers to blend with rye or other dark speciality flours which by themselves have little or no strength. The gluten in Spring Clear is needed to "carry" these other more or less inert ingredients. High protein Winter Clears may be substituted but are usually less satisfactory.

<u>All-Purpose Family Flour</u>

The protein level of this flour is between bread and pastry flours. Generally, wheat of 10.5 to 13 percent protein is used for the production of all-purpose flour. In the North, particularly

---

10 Rye bread usually contains no more than 30 percent rye and at least 70 percent wheat.

in the large cities, where most home baking is done with yeast leavening, this flour is made from hard red winter or blends of hard red winter and hard red spring. In the South, where most home baking is done with chemical leavening, this flour tends to be lower in protein and may contain various blends of hard red winter and soft red winter.

Pastry

Crackers. Cracker flour is usually made from the eastern soft white because of its color and gluten characteristics. Some soft red winter and the mellower hard red winter may be substituted. Cracker flour requires relatively strong wheat of 9.5 to 11.5 percent protein so that it can go through a fermentation process, yet mellow enough so that it would not cause an excessive breakage in the final product.

Cookies. Cookie flour varies from region to region depending on the type of wheat produced. Soft red winter is usually used, but some white or mellow hard red winter may be substituted. Cookie flour requires relatively low protein wheat of 8-10 percent because this low protein flour provides a better spread in the cookies.

Cakes. Low protein rather than high protein wheat produces quality cakes. Wheat of a protein level of about 8.5 is best suited for this flour. Cake flour is milled almost entirely from soft red winter, but with the advent of the "air classification milling",[11] hard red winter could successfully be made into a certain type of cake flour such as angel cake mixes.

Alimentary Pastes

Alimentary pastes refer to such wheat foods as macaroni, noodles and spaghetti, and are made primarily from durum.[12] But when durum was in short supply, hard red winter, particularly the variety Nebred from South Dakota or Nebraska, has been partially substituted for durum.

Wheat Cereals

Wheat cereals are generally made from hard wheat but some soft wheat may also be used.

---

11 See page 24 for detailed description of the air classification milling.

12 Noodles can be made from other than durum wheat. Oriental noodles are made principally from white or other soft wheat. A major portion of soft white shipped into the Orient from the West Coast is made into oriental noodles.

Demand Shifters

I. Income and Urbanization

The Household Food Consumption Survey conducted by the U.S. Department of Agriculture in 1955 showed that the quantity consumed of various wheat foods differs by income and urbanization (table 1).

Bread

Per capita consumption of bakery bread tended to increase with increases in income for both urban and farm households. Urban households consumed more commercial bread, particularly whole wheat and other speciality breads, than farm households. Such relationships have an important effect on the type of wheat demanded. Increased demand for whole wheat and other speciality and commercial breads tend to increase demand for hard wheats, especially hard red spring.

Flour

Flour other than Mixes. Per capita consumption of flour declined sharply with increases in income. Farm families consumed more than 2.5 times as much flour as did urban families at all income levels. It appears that farm households bought more all-purpose flour and baked their bread at home instead of purchasing it from the bakery shop. This implies that decreased family flour consumption resulting from a higher degree of urbanization and income tends to reduce the demand for soft wheats.

Prepared Mixes. There are, prepared-mixes for cakes, pancakes and waffles, biscuits, and pie crusts. Per capita consumption of

Table 1.--Wheat products: Consumption per person at home in a week, by urbanization and income, United States, April-June 1955

Urbanization category and 1954 Household Income after Tax	Bread			Flour other than mixes	Prepared flour mixes	Macaroni spaghetti noodles	Breakfast cereals	Crackers	Rolls	Biscuits and muffins	Cakes	Pie	Other a/
	White	Whole wheat and other	Total										
	Pounds												
Farm b/													
$2,000-2,999	1.05	.10	1.15	1.79	.14	.09	.08	.12	.05	.01	.09	.01	.12
$3,000-3,999	1.09	.10	1.19	1.55	.17	.10	.10	.13	.03	.02	.06	.03	.15
$4,000-4,999	1.16	.14	1.30	1.40	.19	.09	.11	.15	.04	.02	.06	.01	.17
$5,000-5,999	1.26	.17	1.43	1.11	.20	.10	.11	.16	.05	.02	.06	.03	.14
$6,000-7,900	1.22	.16	1.38	1.22	.19	.10	.11	.13	.06	.02	.04	.02	.18
Urban c/													
$2,000-2,999	1.11	.21	1.32	.67	.15	.15	.07	.11	.06	.02	.11	.05	.16
$3,000-3,999	1.26	.21	1.47	.50	.17	.15	.08	.14	.06	.03	.11	.08	.24
$4,000-4,999	1.28	.26	1.50	.39	.21	.16	.08	.14	.08	.03	.10	.06	.25
$5,000-5,999	1.28	.32	1.60	.43	.21	.15	.09	.14	.07	.03	.15	.07	.25
$6,000-7,900	1.33	.31	1.64	.32	.23	.13	.09	.16	.08	.04	.17	.10	.28

a/ Includes cookies, doughnuts, sweet buns, coffee cakes, etc.
b/ Farm-operating household.
c/ In communities with population of 2,500 or more and in fringe areas of large cities.

Source: Based on data in Food Consumption of Households in the United States, Household Food Consumption Survey Report No. 1, 1956, quoted in Wheat Situation, ERS, USDA, April, 1957.

prepared-mixes increased with increases in income for both urban and farm households, but differed little between urban and farm households at any given level of income. Prepared-mixes have, to a large degree, replaced the use of cake flour and all-purpose flour but the net effect of the increased demand for prepared-mixes appears to have increased the demand for soft red winter.

Macaroni, Spaghetti, and Noodles

Per capita consumption of alimentary pastes varied little with respect to income but was about 1.5 times higher for urban households than for farm households. Therefore, the higher degree of urbanization, not higher income, appears to have a greater impact on shifting the demand for durum.

Other Wheat Foods

Other wheat foods considered here are breakfast cereals, biscuits and muffins, crackers, rolls, cakes, pies, and other miscellaneous goods such as cookies and doughnuts.

Income had little effect upon per capita consumption of these wheat foods. On the other hand, per capita consumption of these items, with the exception of breakfast cereals, was higher for the urban than for the farm households. While the degree of urbanization did have differential effects upon the type of wheat demanded, the total amount of these items accounted for only a small portion of total wheat food consumption, and therefore, the effect of urbanization upon the types of wheat demanded for these foods appear to be moderate.

II. Changes in Milling and Baking Technology

The differentiation of wheat by class and quality became important with changes in milling and baking techniques. When porridge was the most general method of cereal utilization, the type of wheat or even the type of cereal made little difference to the users. With the introduction of milling and baking, distinctions are made between different types of wheat. Prior to 1900 when milling was still in its crude stage, millers preferred soft wheats to hard wheats, but with the advent of roller-milling, hard wheats became the preferred bread wheats. In recent years this trend in demand has been further promoted by the shift away from home baking to commercial baking.

Air classification milling and the continuous dough-mixing process are two of the major technological developments that have contributed to shifts in demand.

Air Classification Milling

In 1957 the Pillsbury Company first adopted air classification milling in the U.S. The principle of this milling process is to separate the finer protein fractions from the rest of the flour by use of air-currents. Through this process either soft red winter or hard red winter could be used in making the high protein fractions for strengthening bread flour and the low protein fractions for angel food cake mixes.

At present air classification milling capacity is rather small. In 1966 the milling capacity using this process was 56,000 cwt., accounting for only about 6 percent of the 1966 U.S. total milling capacity of 942,287 cwt.[13] Of this 56,000 cwt. capacity, 35,000 cwt. were used for hard red winter wheat and 21,000 cwt. were used for soft red winter. In terms of wheat equivalent, the air classification mills can annually convert 12 million bushels of soft red winter and 20 million bushels of hard red winter into various types of high and the low protein flours.[14]

This milling process has the potential of increasing the demand for hard red winter and soft red winter at the expense of hard red spring and can break up the physical barriers that have retarded the substitutability among the different classes of wheat. However, the impact of this process on the demand for various classes has been moderate due to a relatively small present size of the air classification milling capacity.

Furthermore, the extent to which air classification will be used in the future may be limited by economic and quality considerations. First, the major reason for the installation of an air classification mill is to use local wheat for all types of wheat products, thus eliminating the costs of transporting wheat of different classes and qualities from other regions. The potential savings in

---

13 Data on air classification milling capacity in the U.S. were obtained through interview with Del Pratt, Quality Control Manager, the Pillsbury Company, Minneapolis, September 2, 1966.

14 Full capacity annual operation represents the daily milling capacity times 253 days of operation.

transportation, however, are limited in the U.S. because 80 percent of the population lives in areas where only 30 percent of the wheat is produced.[15] Second, the quality of air classified wheat flour is not satisfactory in certain uses.

L. E. Collier comments:

> It has been established that air classified hard wheat flours, which have been brought into identical focus with typical soft wheat flours by the removal of protein are not completely interchangeable with respect to the baked product. Conversely, the upgrading of soft wheat flours by the inclusion of a percentage of high protein fraction obtained from air classification will not serve the baker well enough though all important chemical and physical components of the two flours are the same.[16]

Third, the disposal of a large quantity of the very low protein fractions becomes a severe limitation to the amounts of wheat that can be air classified.

Unless these limitations be removed simultaneously--the possibility of which is remote--the air classification milling process may only be adopted on a limited scale.

<u>The Continuous Dough Mixing Process</u>

About 25 percent of the white pan-bread in 1966 was produced by this process as compared with 30 percent in 1964.[17] This process

---

15 H. Wayne Bitting and Robert O. Rogers, "Utilization of Wheat for Food", <u>Agricultural Economic Research</u>, Vol. 15, No. 2, April 1963, p. 62.

16 Letter from L. E. Collier, General Superintendent, the Toledo Mill National Biscuit Company, Toledo, May 12, 1966.

17 Interview with Edward Stone, Quality Control Manager, International Milling Company, Minneapolis, September 22, 1966.

uses hard red spring or hard red winter of about the same protein level as is required for the conventional baking process. However, hard red winter typically has a shorter mixing time than that of hard red spring, and therefore is preferred by the users of the continuous dough mixing process. The adoption of this process by large bakers may therefore tend to increase the demand for hard red winter at the expense of hard red spring.

The Shift Away from Home Baking

The commercial production of bread and rolls accounted for approximately 42 percent of total wheat used for food in 1959, reflecting the extensive reliance of consumers on commercial bread rather than on home baked bread (table 2).

The subject of home baking was covered in detail for the first time in the 1955 Household Food Consumption survey. This study showed that 96 percent of urban families and 85 percent of farm families purchased their bread rather than baking it at home.[18]

The consumption of commercial bread and rolls increased from 11,468 million pounds in 1947 to 13,154 million pounds in 1958, an increase of 1,686 million pounds or in terms of wheat equivalent 25,852,000 bushels (table 3).[19]

Assuming that the same total amount of bread was consumed in 1947 as in 1958, the 1,686 million pounds represents a shift from home baking to commercial baking and a shift in demand away from soft wheats to the hard wheats. All-purpose family flours average

18 William R. Askew, "Bread Consumption in the United States," Wheat Situation, ERS, USDA, February, 1962, p. 22.

19 Conversion factor used: (1) 1.5 pounds of bread/one pound of flour; (2) 2.3 bushels of wheat/cwt. of flour.

Table 2.--Domestic utilization of wheat products: Estimated uses of hard, soft and durum wheat, by type of product consumed, 1959

Product	Hard	Soft	Durum	Total	Percent of total: Hard a/	Soft a/	Durum a/	Total
	Million bushels	Million bushels	Million bushels	Million bushels	Percent	Percent	Percent	Percent
Bread	200.15	---	---	200.15	100.0	---	---	40.0
Rolls	10.27	---	---	10.27	100.0	---	---	2.0
Biscuits & muffins	---	2.87	---	2.87	---	100.0	---	0.6
Crackers	3.40	18.53	---	21.93	15.5	84.5	---	4.4
Cakes	---	6.11	---	6.11	---	100.0	---	1.2
Pies	---	2.52	---	2.52	---	100.0	---	0.5
Other sweet goods	11.38	8.10	---	19.48	58.4	41.6	---	3.9
Alimentary pastes	8.20	---	22.00	30.20	27.2	---	72.8	6.0
Flour:								
All purpose	85.57	72.33	---	157.90	54.0	46.0	---	31.6
Whole wheat	2.38	---	---	2.38	100.0	---	---	0.5
Cake	---	12.21	---	12.21	---	100.0	---	2.4
Prepared mixes	---	22.34	---	22.34	---	100.0	---	4.5
Wheat cereals	9.65	1.99	---	11.64	82.9	17.1	---	2.3
Total	331.00	147.00	22.00	500.00				100.0

a/ Wheat type composition

Source: Based on data in H. Wayne Bitting and Robert O. Rogers "Utilization of Wheat for Food," Agricultural Economics Research, Vol. 15, No. 2, April, 1963, p. 62.

Table 3.--Bread and rolls: Production by manufacturing bakeries, calendar years, 1947, 1954, and 1958 a/

Product	Production					
	Total			Per Capita b/		
	1947	1954	1958	1947	1954	1958
	Million pounds	Million pounds	Million pounds	Pounds	Pounds	Pounds
Bread						
White (pan and hearth)	8,827	9,212	9,688	61.9	57.9	56.5
Wheat (whole, cracked, other dark wheat, etc.)	893	996	689	6.3	6.2	4.0
Rye and pampernickle	613	620	494	4.3	3.9	2.9
Specialty (raisin, diet, protein, etc.)	192	328	630	1.3	2.1	3.7
Total	10,525	11,156	11,501	73.8	70.1	67.1
Bread type rolls (hamburger, weiners, parkerhouse, etc.)	943	1,502	1,653	6.6	9.4	9.6
	11,468	12,658	13,154	80.4	79.5	76.7

a/ Excludes single outlet retail bakeries.

b/ Based on July 1 population eating from civilian supplies.

Source: Askew, p. 24.

about 54 percent hard wheat and 46 percent soft wheat. If this flour had been used to bake the 1,686 million pounds at home rather than commercially, soft wheat consumption would have been higher by about 12 million bushels in 1958 than in 1947. In other words, soft red winter and white wheat demand declined while hard red spring and hard red winter demand increased by approximately 12 million bushels over a span of 11 years as a result of the substitution of commercial baking for home baking.

Prepared Flour Mixes

Although prepared-mixes appeared on the market in the early 1940's, they have gained a wide consumer acceptance only with the improvement in their quality in the mid-1950's. Data on prepared-mixes are available beginning from the 1947 census year and a breakdown by types of mixes beginning from the 1954 census year (table 4).

Shipments of prepared-mixes increased from 12.7 million cwt. (11.7 million bushels in wheat equivalent) in 1947 to 18.9 (17.3 million bushels in wheat equivalent) in 1958.[20] Of the five categories of prepared-mixes, cake mixes registered the largest increase, rising 24 percent from 5.7 million cwt. in 1954 to 7.1 million cwt. in 1958.

The increased use of prepared-mixes represents an increased demand for soft wheats, especially for soft red winter. In terms of

20 Conversion factors used: (1) 0.4 pounds of flour = one pound of prepared-mixes (the flour content of prepared-mixes ranges from 25-45 percent); (2) 2.3 bushels of wheat/cwt. of flour.

wheat equivalent, the demand for soft wheat increased by 5.7 million bushels as a result of increased use of prepared-mixes between 1947 and 1958. However, this increase may have caused a corresponding decrease in the demand for soft wheat as a result of lessened needs for cake and family flour.

Assuming that homemakers used the same amount of these five categories of wheat food in 1947 as they did in 1958, and that family flour consisting of 54 percent hard wheat and 46 percent of soft wheat was used to bake the increase of 6.2 million cwt. of these items, the consumption of hard wheat would have been higher by 3.1 million bushels in 1958. In other words, the demand for soft wheat increased by 3.1 million bushels between 1947 and 1958 as a result of the increased use of prepared-mixes. However, prepared-mixes simply replaced cake flour and the estimated increase of 3.1 million bushels should be adjusted downward considerably. Although there is no information whereby a proper adjustment could be made, the increased use of prepared-mixes is believed to have definitely increased the demand for soft red winter.

In summary, the effects of previously described demand shifters have been an overall increase in demand for high protein wheats at the expense of low protein wheats. This overall shift in demand occurred in spite of developments in milling and baking technology that favor the use of low protein wheats.

Table 4.--Prepared flour mixes: Manufacturers shipments and interplant transfers, census years 1947, 1954, and 1958.

Mix	1947	1954	1958
	Thousand cwt.		
Pancake and waffle	a/	2,895	2,978
Cake	a/	5,675	7,069
Biscuits	a/	1,576	1,735
Pie crust	a/	839	708
Other	a/	5,782	6,366
Total	12,701	16,767	18,856

a/ No breakdown reported.

Source: U. S. Department of Commerce, Bureau of the Census, Census of Manufacturers: 1958, Industry and Product Reports, Flour and Flour Mixes Industries, MC (P)-20D-3, quoted in Wheat Situation, ERS, USDA, June, 1960, p. 28.

STATISTICAL ANALYSIS OF THE DEMAND FOR WHEAT BY CLASSES

Results of the Statistical Analysis[21]

I. Demand by Classes

Quantitative analysis of the domestic wheat food market is based on an economic model--a rather simplified description of the actual behavior of the market discussed in the preceeding chapter. It is generally hypothesized that the demand for each class of wheat for food depends principally upon the prices and qualities of the wheat class and of competing classes. Furthermore, developments in the milling and baking industry, the degree of urbanization, and the level of consumer income have differential long-run effects on the demand for individual classes of wheat.

Although there is a considerable quality difference existing within a class, because of the data limitations, each of the five major classes of wheat is treated as a separate homogeneous entity.

The analysis is based on annual crop year data. The wheat crop year runs from July to June, but this demarcation is somewhat arbitrary, because the crop harvest begins in late May in the extreme southwestern area of the winter wheat region and ends in late October or early November in the extreme Northern Great Plains of the spring wheat area. Because winter wheat predominates, the July-June crop year has been chosen; but it should be kept in mind that the spring wheat crop, for which the appropriate crop year

21 See Appendix II for statistical estimates of the demand relations and the data used.

is September-August, is sufficiently important to prevent July 1 from being a wholly satisfactory dividing line.

The data period covers 31 crop years beginning with July 1929 and ending with June 1964, with the exception of the World War II years (from July 1941 to June 1946). The war years are excluded from the analysis due to abnormal wartime effects on the wheat market.

It is believed that the degree of urbanization, and technological developments in milling and baking have caused changes in the structure of the wheat food market. To take account of this structural change, the 1-0 variable is used: 0 for the prewar years 1929-41, and 1 for the post-war years 1946-63. Although there has been a continuous change in technology and urbanization, no drastic structural shift has occurred in miller's demand for wheat by classes.

Consumption of each class of wheat is expressed in totals rather than on a per capita basis because the interest is centered on the effect of price and other variables on the total consumption.

The price for each class is represented by that for a standard grade at a specific location believed to best reflect the price of the class. It should be remembered, however, that the grade and quality distribution of wheat within a class varies so greatly from year to year that changes in price reported for a standard grade may not be truly representative. Since there is no average price for all wheat, the price of all wheat is approximated by the average price of all classes and grades at the six markets (Chicago, Minneapolis, Kansas City, St. Louis, Omaha, and Duluth). Price series are deflated by the Bureau of Labor Statistics Wholesale Price Index for all commodities (1957-59=100) to allow for effects of changes in the general price level.

Deflated per capita disposable income is purported to serve a triple purpose in this study. It is, in addition to income, a measure of milling and baking technology, and of urbanization. Ideally, three seperate measures would be desirable, but they are not available. A time trend variable may be employed to capture the development in milling and baking technology, and the degree of urbanization, but the time and income variables are so highly intercorrelated that they would create the familiar problem of high intercorrelation. Furthermore, the addition of a time trend variable reduces another degree of freedom.

A priori knowledge does not suggest a particular functional form. In this study linear equations are used because they provided a better fit, in terms of coefficients of determination, than did logarithmic equations.

Tables 5, 6, 7, 8 and 9 summarize the empirical results in terms of elasticity coefficients. Results of the six sets of statistical estimates were generally satisfactory. The sign and magnitudes of the estimated coefficients were quite similar among the six sets, and appear generally consistent with economic theory and the earlier discussion of competitive demand relationships among wheats.

For purposes of exposition, only one set of numerical values of estimated coefficients will be selected in the subsequent discussion.

Demand for Hard Red Winter

Hard red winter is the most versatile of all wheat. Because of its extreme variability in protein level (ranging from 10 to 17 percent) hard red winter competes with hard spring and hard white wheat for bread flour, and it substitutes for soft red winter and soft white for all-purpose and pastry flours.

Price elasticities of demand for hard red winter wheat were -1.8 for the 1929-41 period, and -0.7 for the 1946-63 period, meaning that an increase of one percent in the price of hard red winter reduced the demand for hard red winter wheat by 1.8 percent in the prewar period and 0.7 percent in the postwar period (table 5). The higher price elasticity indicated for the prewar years may have been due to a more widespread use and substitution between hard red winter and soft red winter in all-purpose family flour.

Cross elasticities of demand for hard red winter with respect to the price of hard red spring were 0.5 for the prewar period, and 1.5 for the postwar period, meaning that a one percent increase in the price of hard red spring increased the demand for hard red winter by 0.5 percent in the prewar period and 1.5 for the postwar period. Such results may have been attributed to improvements in the quality of hard red winter in the Southwest and the Northern

Table 5.--Coefficients of elasticities: Food consumption of hard red winter with respect to price and income variables, selected periods

Period	Equation number	Price				Income
		HRW	HRS	SRW	White	
1929-41	(1)	-1.779	0.492	1.116	0.188	0.108
	(2)	-0.993	0.227	0.798	0.056	0.147
1946-63	(3)	-0.732	1.530	0.014	-0.796	0.343
	(4)	-0.535	1.446	0.049	-0.713	0.314
1929-41 and 1946-63	(5)	-1.373	0.560	0.575	0.160	0.176
	(6)	-0.913	0.178	0.406	-0.067	0.245

SOURCE: Computed at the point of means from the demand equations in Appendix II.

Plains, thereby making hard red winter more acceptable as a substitute for the hard red spring in the production of bread flour.[22]

Cross elasticities of hard red winter demand with respect to the price of soft red winter decreased from 1.1 in 1929-41 to 0.01 in 1946-63. The decline in elasticity is reasonable because the substitution potential between the two classes has been reduced due to a smaller quantity of all-purpose family flour being used since the war.

None of the cross elasticities of hard red winter demand with respect to the price of white wheat was statistically significant. It is believed that the price of white wheat has little effect on the demand for hard red winter.

Income elasticities--a composite measure of income, urbanization and technology--ranged from 0.1 in 1929-41 to 0.3 in 1946-63.

Signs of the dummy variable coefficients were negative, an indication of a downward shift in the demand for hard red winter wheat. The average consumption of hard red winter declined by about 6 million bushels over the two periods.

The actual and computed values of hard red winter consumption based on equation (5) are plotted in figure 1. The consumption of hard red winter fluctuated considerably during the 1929-41 period primarily as a result of drought in the hard red winter region in 1932-35. Total food consumption of hard red winter reached about

---

22 For a discussion of improvements in the hard red winter quality, see Distribution of Varieties and Classes of Wheat in the United States in 1959, Statistical Bulletin No. 272, ARS, USDA, November, 1960, p. 4.

240 million bushels in 1931 when 514 million bushels were produced, a record for the 1929-41 period. That year, hard red winter was the most discounted class. A large quantity of the Southwest hard red winter was milled by the traditionally hard red spring millers in Minneapolis, and more than the usual amount of hard red winter was milled in Buffalo. In 1940 a substantial mount of good quality hard red winter was regarded as an acceptable substitute for hard red spring and the use of hard red winter increased. On the other hand, in 1951 when hard red winter production declined as a result of heavy acreage abondonment, more hard red spring was used in the bread flour blend.

It is noted that the consumption of hard red winter has increased in the latter part of the 1946-63 period. A part of such an increase may have been contributed by the preference for hard red winter wheat in air classification milling and in the continuous-dough-mixing process.

Demand for Hard Red Spring

Hard red spring has more specialized uses than has hard red winter. This wheat, the protein level of which ranges approximately from 12 to 15 percent, is used primarily for speciality or other pan-bread flours. Although some hard red spring is used for all-purpose flour in the hard red spring region, this wheat normally does not compete with soft red winter in the manufacture of all-purpose or pastry flours. The Montana hard red spring competed

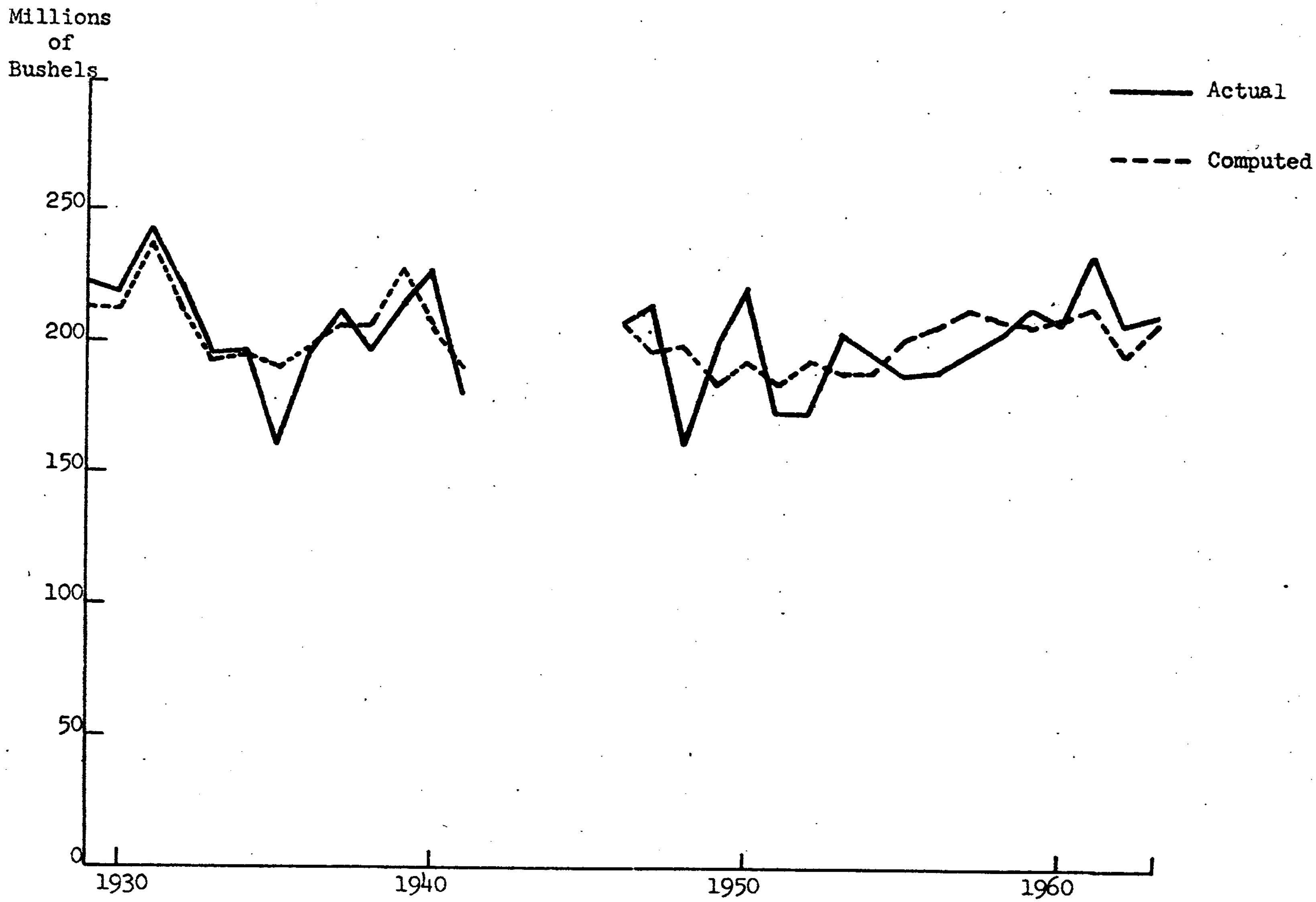


Figure 1.--Domestic food consumption of hard red winter: actual and computed, 1929-41 and 1946-63

Computed values based on equation (5).

with the Pacific Northwest hard white for bread flour prior to World War II, but such competition decreased as the Montana wheat production shifted from hard red spring to hard red winter. Direct price elasticities of demand for hard red spring were -1.7 for the prewar period and -1.8 for the postwar period. Cross elasticities of the demand for hard red spring with respect to the price of hard red winter were 1.4 before the war and 1.9 after the war. Higher direct and cross elasticities indicated for the postwar years mean that the substitutability between the two classes has increased since the war, agreeing with the result indicated by the hard red winter demand relations (table 6).

Both positive and negative signs were indicated for the cross elasticities of demand for hard red spring with respect to the price of soft red winter. However, none of the coefficients were statistically significant. This result is expected: A distinctive quality difference between the two classes does not readily permit a satisfactory substitution. Therefore, the two may be regarded as independent commodities.

Cross elasticities of hard red spring demand with respect to the price of white were 0.9 for the prewar period and 0.03 for the postwar period. Such a decline coincides with reduced availability of hard red spring wheat for blending as Montana shifted from hard red spring to hard red winter production.

A positive sign on the dummy variable coefficient indicates that the demand for hard red spring has shifted upward over the two periods. This result is reasonable because the average food

Table 6.--Coefficients of elasticities: Food consumption of hard red spring with respect to price and income variables, selected periods

Period	Equation number	Price: HRW	Price: HRS	Price: SRW	Price: White	Income
1929-41	(7)	1.389	-1.700	-0.455	0.713	-0.488
	(8)	0.651	-1.089	0.041	0.873	-0.506
1946-63	(9)	1.921	-1.827	-0.473	0.497	0.523
	(10)	1.259	-2.707	-0.284	0.032	0.193
1929-41 and	(11)	1.159	-1.410	-0.154	0.228	-0.186
1946-63	(12)	0.326	-0.980	-0.059	0.451	-0.155

SOURCE: Computed at the point of means from the demand equations in Appendix II.

consumption of hard red spring increased by 34 million bushels between the two periods.

Actual and computed values of hard red spring consumption based on equation (11) are plotted in figure 2. Consumption of hard red spring fluctuated considerably in 1929-41. It declined in 1931, 1934, and 1936 when low yields severely reduced the production of this crop. Consumption also declined in 1937 when hard red spring quality was poor and the relatively better quality of hard red winter of that year substituted for hard red spring.

Since the war, hard red spring consumption has shifted upward and showed less variability, particularly after 1953. In 1946, a shortage of milling quality hard red winter prompted the use of a substantial quantity of hard red spring. In 1961, when production of hard red spring suffered severely due to drought in the Northern Plains, more than the usual amount of hard red winter was substituted for hard red spring.

The consumption of hard red spring declined slightly in the latter part of the 1946-63 period. This may be attributable to the cessation of the shift away from home baking and the developments in air classification milling and the continuous-dough mixing process.

Demand for Durum Wheat

Durum has a highly specialized market and is used only for alimentary pastes. But when this crop was in short supply, hard red winter and occasionally even some hard red spring have been substituted for durum. The price elasticities of demand for durum were

-0.9 for the prewar period and -1.5 for the postwar period (table 7). The cross elasticities of durum demand with respect to the price of hard red winter increased from 0.3 to 0.4 between the two periods. These results coincide with increasing use of hard red winter wheat for durum wheat by the milling industry since the war. It is believed that a higher durum price relative to hard red winter price would induce a substitution of hard red winter for durum, but a change in hard red winter price by itself does not necessarily induce a substitution of hard red winter for durum.

The price variable for hard red spring was included only for equations (17) and (18). The coefficients on both equations were small and statistically non-significant, indicating an independent commodity relationship. This result supports information provided by the milling industry; That the miller tends to substitute the lower priced hard red winter instead of the higher priced hard red spring.

Both income and dummy variable coefficients had inconsistent signs and were statistically non-significant, indicating that the two factors had little effect on the food demand for durum. Although the total consumption of alimentary pastes has been increasing as a result of urbanization and product promotions, the total amount of durum milled did not increase because varying amounts of other wheat had been substituted for durum.

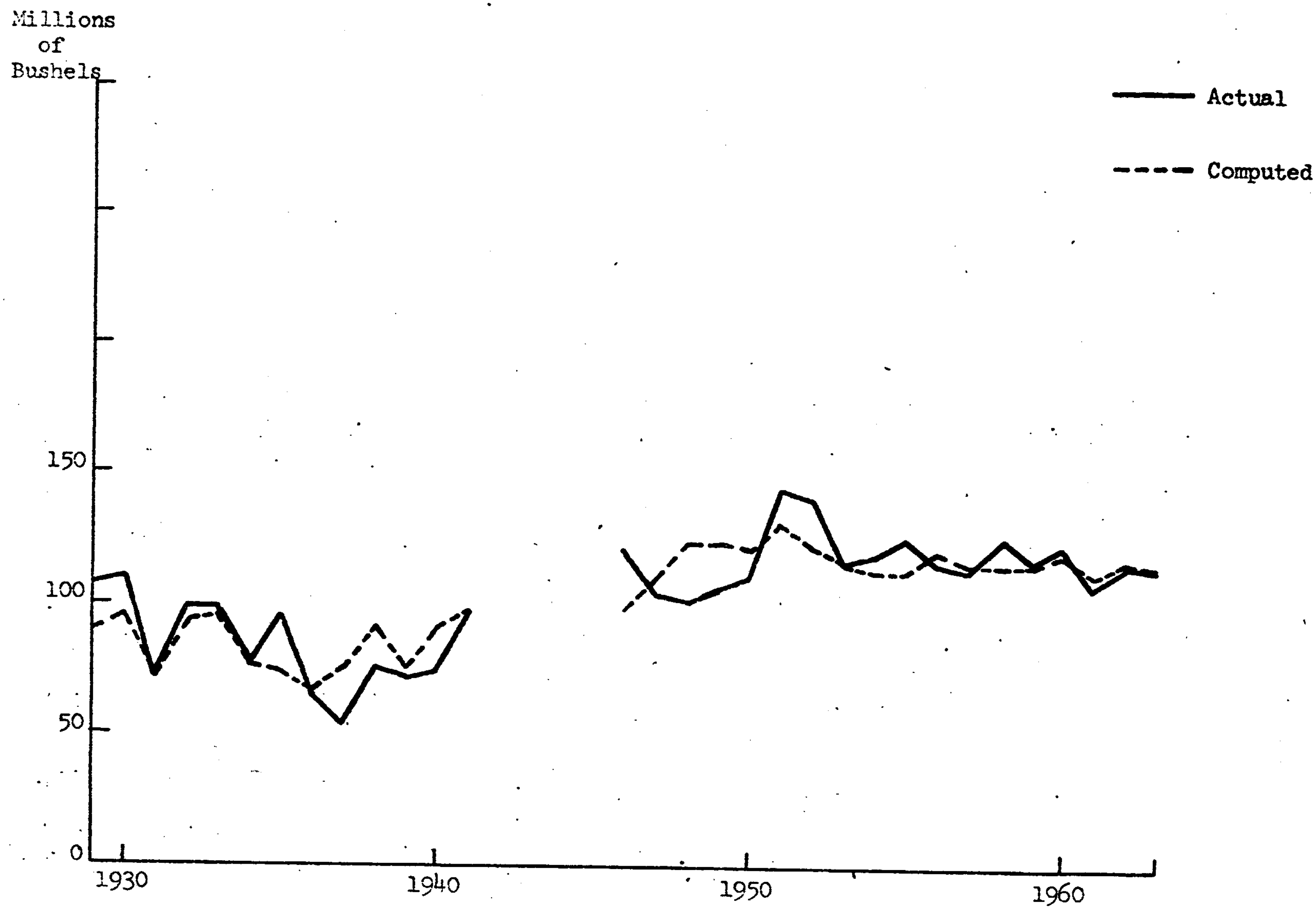


Figure 2.--Domestic food consumption of hard red spring: actual and computed, 1929-41 and 1946-63

Computed values based on equation (11).

Table 7.--Coefficients of elasticities, food consumption, of durum with respect to price and income variables, selected periods

Period	Equation number	Price			Income
		HRW	HRS	Durum	
1929-41	(13)	0.321	---	-0.919	0.106
	(14)	-0.932	---	-1.500	0.225
1946-63	(15)	0.428	---	-1.478	-0.958
	(16)	0.231	---	-1.525	0.158
1929-41 and 1946-63	(17)	0.729	-0.138	-1.362	-0.233
	(18)	-0.631	-0.215	-1.747	0.080

SOURCE: Computed at the pount of means from the demand equations in Appendix II.

The actual and computed values from equation (17) and plotted in figure 3. Over the period 1929-41 the durum consumption shows relatively moderate fluctuations. It declined in 1931, 1933, 1934 and 1936 when durum production declined due to low yields. In 1946-63, durum consumption fluctuated considerably due to a severe physical shortage, particularly in 1953, 1954, and 1961.

Demand for Soft Red Winter

Soft red winter is the only wheat suited for cake flours. This wheat is also used for all purpose family flour or blended with hard red winter for bread flour in the soft red winter region.

Prcie elasticities of demand for soft red winter declined from -0.7 to -0.2 between the two periods, a trend consistent with declining amount of soft red winter used in family flour. Income elasticities for soft red winter increased from 0.1 to 0.4 with the higher elasticity indicated for the postwar years (table 8).

Signs on the dummy variable coefficients were negative, meaning that the demand for soft red winter shifted downward since the war. This result agrees with a decrease in average soft red winter consumption by 33 million bushels between the two periods.

The actual and computed values of soft red winter consumption from equation (23) are plotted in figure 4. The consumption of soft red winter showed a larger variability in 1929-41. This was the period in which the price and demand for soft red winter was strong relative to the postwar period.

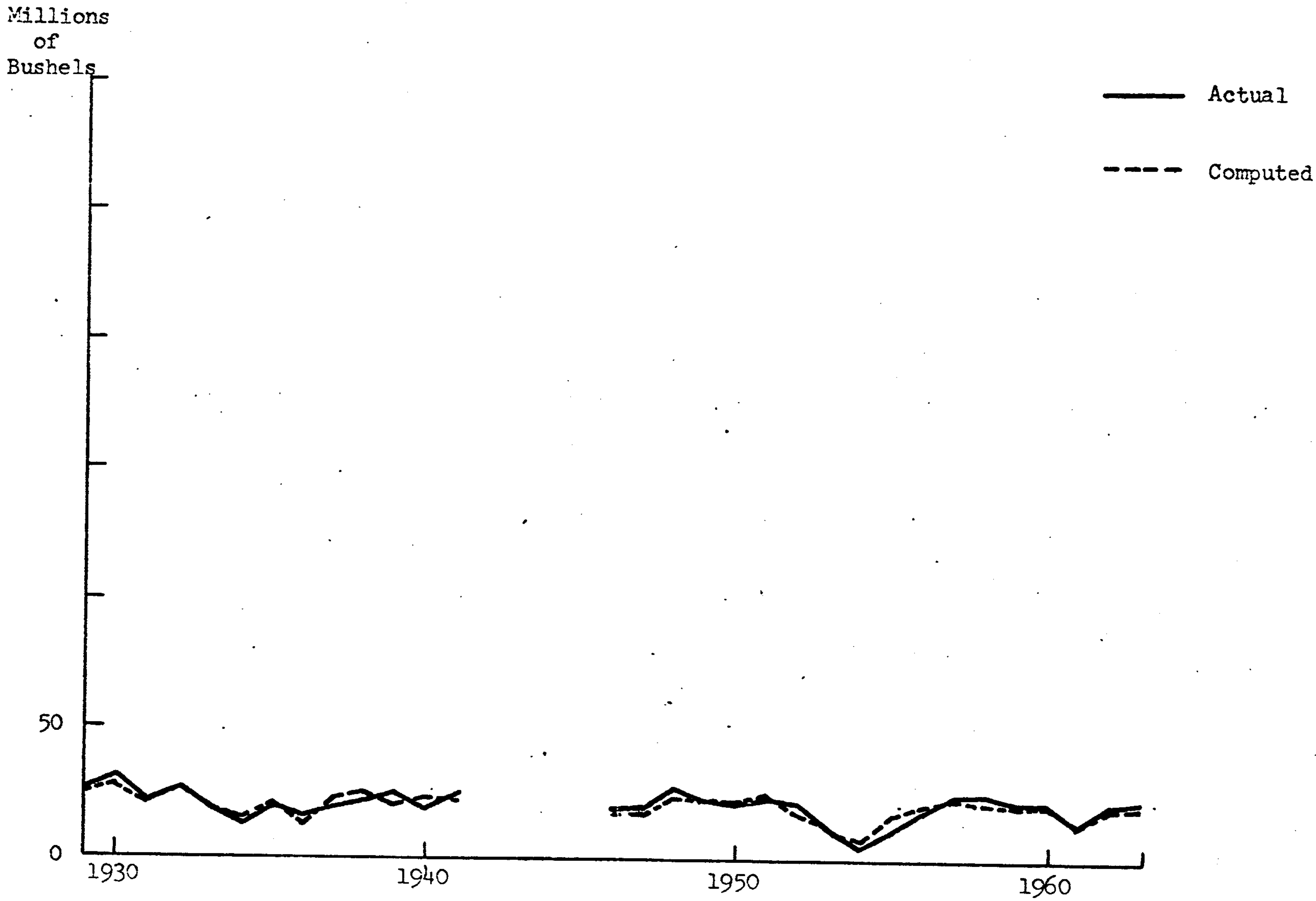


Figure 3.--Domestic food consumption of durum: actual and computed, 1929-41 and 1946-63

Computed values based on equation (17).

Table 8.--Coefficients of elasticities: Food consumption of soft red winter with respect to price and income variables, selected periods

Period	Equation number	Price				Income
		HRW	HRS	SRW	White	
1929-41	(19)	0.053	0.632	-0.702	---	0.106
	(20)	0.289	0.726	-0.374	---	0.027
1946-63	(21)	-0.519	0.450	-0.210	---	0.441
	(22)	0.019	2.197	-0.294	---	0.954
1929-41 and 1946-63	(23)	-0.228	1.003	-0.366	-0.613	0.321
	(24)	0.072	0.898	-0.258	-0.182	0.392

SOURCE: Computed at the point of means from the demand equations in Appendix II.

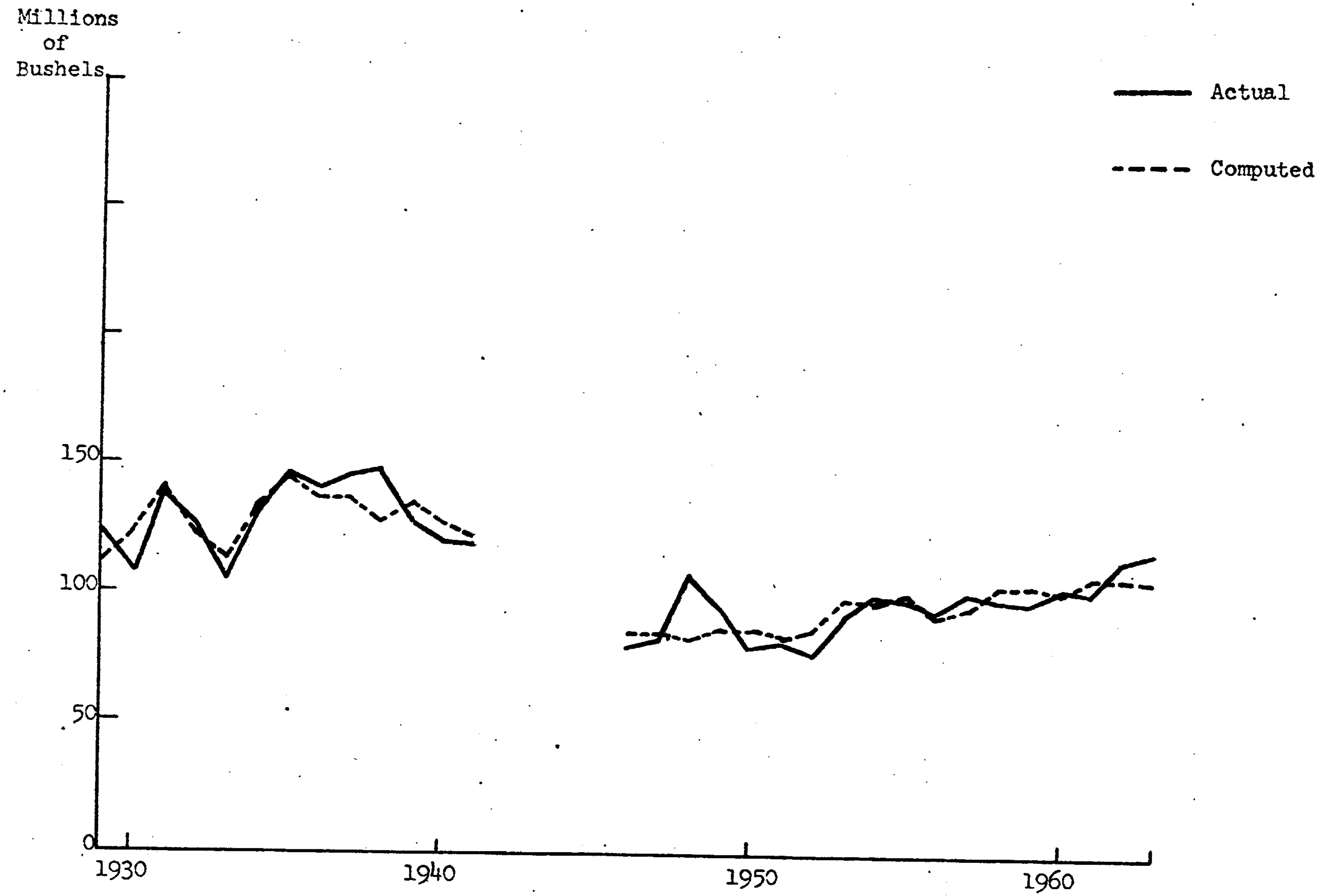


Figure 4.--Domestic food consumption of soft red winter: actual and computed, 1929-41 and 1946-63

Computed values based on equation (23).

The consumption of soft red winter declined below 100 million bushels during the earlier part of 1946-63 period. It has tended to increase as a result of the increased use of soft red winter for air classification and in prepared-mixes in the latter part of the period, particularly since 1960.

Demand for White Wheat

Soft white is primarily used for pastries such as crackers and ice cream cones. Substitution between soft red winter and soft white is physically possible, but occurs only infrequently because of the high cost of transporting the Pacific Northwest white wheat to the Eastern market. Hard white, by contrast, is blended with hard red winter or hard red spring for the production of bread flour on the West Coast.

Price elasticities of demand for white wheat were -1.7 for the prewar period and -0.1 for the postwar period. Because white wheat was more extensively used in bread and all-purpose flours during the prewar years, the result appears reasonable.

Cross elasticities of demand for white wheat with respect to the price of hard red winter increased from 0.6 to 1.6 between the two periods. This suggests that a greater substitutability existed between the two classes after the war. Such a relationship is plausible because more hard red winter became available for substitution after the war as Montana shifted from hard red spring to hard red winter (table 9).

Table 9.--Coefficients of elasticities: Food consumption of white with respect to price and income variables, selected periods

Period	Equation number	Price: HRW	HRS	SRW	White	Income
1929-41	(25)	0.618	1.761	---	-1.748	0.261
	(26)	0.644	1.431	---	-1.661	0.418
1946-63	(27)	1.649	-1.360	---	-0.125	-2.848
	(28)	1.360	-3.021	---	-0.841	-3.173
1929-41 and 1946-63	(29)	2.808	0.072	-1.661	-0.218	-0.983
	(30)	2.681	0.643	-1.220	-0.572	-1.433

SOURCE: Computed at the point of means from the demand equations in Appendix II.

Cross elasticities of demand for white wheat with respect to the price of hard red spring was 1.8 for the prewar years, consistent with the results obtained for the hard red spring wheat demand relations. These were the years, when substantial amounts of hard red spring wheat from Montana were available and substituted for white wheat in the Pacific Northwest.

The actual and computed values of white wheat consumption from equation (29) are plotted in figure 5. In 1933-36, when production of both hard red winter and hard red spring was drastically reduced due to severe drought, a large amount of white was substituted for the hard wheats. During that period, an active eastward shipment of white wheat took place, prompted by a considerable price differential between the Pacific northwest white wheat and the eastern wheat. In 1937-41, as the production of hard wheats returned to normal, the eastward movement of white wheat declined. Some white wheat was still shipped eastward because it was still sold at a discount relative to other wheats, with the exception of 1939 when a large white wheat sale to the Orient made the white wheat price unattractive to the eastern buyers.

The 1946-63 period was characterized by high prices for white wheat relative to those for other classes and by declining domestic consumption. The average price (deflated) of white wheat increased from \$1.83 in 1929-41 to \$2.41 in 1946-63, or a \$0.58 increase, the highest price increase of all wheats. The consumption of white wheat

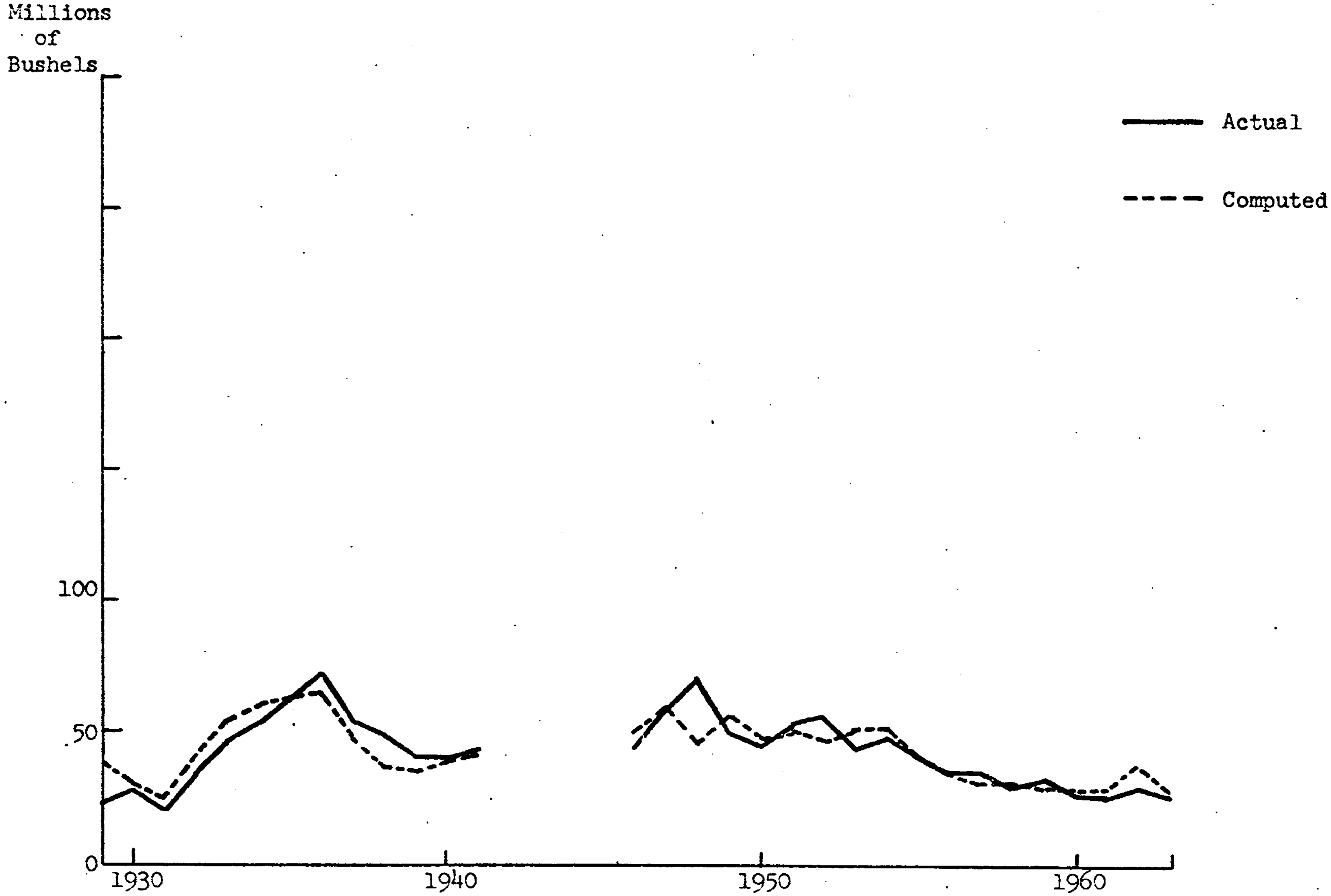


Figure 5.--Domestic food consumption of white: actual and computed, 1929-41 and 1946-63

Computed values based on equation (29).

was still relatively high in the earlier part of the 1946-63 period when the white wheat price was still comparable to soft red winter and hard red winter prices. But in the later period, consumption declined sharply as the price of white became increasingly unattractive to the miller.

II. Price Relationships Among Wheat

Certain price relationships demonstrate competitiveness among related commodities. In the theory of competing goods, it is generally conceded that prices of all closely competing goods must move together. An increase in the demand for one normally results in a simultaneous increase in the demand for the other. As a result, prices for both increase. If the prices of a group of commodities all change in equal proportion, then that group of commodities can be treated logically as if they were but a single commodity; that is, a perfect substitute relationship prevails among that group of commodities.[23]

Since the classification of wheat by the five major classes is rather arbitrary, a further investigation on substitutive relationships among wheats based on their physical and baking characteristics is desired. However, lacking the quantity data to obtain demand equations, simply price correlation coefficients were used to measure the competitive relationships among wheats.

---

23 H. O. A. Wold and L. Jureen. Demand Analysis, (New York: John Wiley and Sons, Inc., 1953), p. 109.

A matrix of simpl price correlation coefficients of the 13 grades of wheat was computed (table 10). The time period covered, 180 monthly average prices beginning from July 1946 to June 1961, was conditioned by the availability of data, but is believed to satisfactorily represent the price relationships that generally have existed since the war.

The results indicate that the price movements and average prices of a certain grade were more closely related to that of the grades outside of the class than within the class. For example, the price movement and average price of No. 1 dark northern spring, ordinary protein, at the Minneapolis market was more closely related to those of No. 2 hard red winter, 13 percent protein, at Kansas City Market than to those of No. 1 dark northern spring, 15 percent protein at the Minneapolis market. This may be attributed to the fact that the first two grades have similar physical and baking characteristics and they can be substituted for each other, whereas No. 1 dark northern spring, 15 percent protein is particularly suited for speciality bread flours and is traded in a distinct market of its own.

No. 2 hard red winter at the Chicago market and various grades of soft red winter show higher simple price correlation coefficients than occurs between No. 2 hard red winter, Chicago and other hard red winter grades. Such results appear plausible because the protein level of hard red winter at the Chicago market is usually closer to soft red winter than to the other hard red winter grades.

Table 10.—Thirteen types and grades of wheat: average price, standard deviation, and simple price correlation coefficient, average monthly price, July 1946-June 1961 *

Wheat Type	G_1	G_2	G_3	G_4	G_5	G_6	G_7	G_8	G_9	G_{10}	G_{11}	G_{12}	G_{13}
	cents												
Average Price	232	238	249	226	231	223	238	267	224	222	213	224	214
	cents												
Standard deviation	18	20	25	18	20	23	21	52	24	24	24	19	24
G_1	1.00	.97	.85	.79	.92	.77	.79	.49	.77	.78	.77	.78	.79
G_2		1.00	.90	.75	.92	.69	.78	.61	.69	.69	.68	.76	.66
G_3			1.00	.63	.84	.61	.69	.60	.60	.60	.59	.65	.60
G_4				1.00	.82	.71	.80	.44	.65	.67	.64	.97	.63
G_5					1.00	.83	.84	.56	.81	.81	.79	.83	.80
G_6						1.00	.72	.14	.95	.96	.94	.72	.94
G_7							1.00	.42	.72	.74	.70	.84	.71
G_8								1.00	.09	.06	.05	.45	.08
G_9									1.00	.98	.97	.68	.96
G_{10}										1.00	.98	.69	.97
G_{11}											1.00	.67	.99
G_{12}												1.00	.66
G_{13}													1.00

Source: Computed from data in Grain Market News, Grain Division, Consumer and Marketing Service, U.S.D.A., (published weekly).

* See next page.

The following are the listing and symbolic representation of 13 subclasses and grades of wheat: 3 grades from the hard red spring class; 3 grades from the hard red winter class; 3 grades from the soft red winter class; 3 grades from the white class; and 1 grade from the durum class.

G_1	=	No. 1 dark northern spring, ordinary protein, Minneapolis
G_2	=	No. 1 dark northern spring, 13% protein, Minneapolis
G_3	=	No. 1 dark northern spring, 15% protein, Minneapolis
G_4	=	No. 1 hard red winter, ordinary protein, Portland
G_5	=	No. 2 hard red winter, 13% protein, Kansas City
G_6	=	No. 2 hard red winter, Chicago
G_7	=	No. 1 hard white, Portland
G_8	=	No. 2 hard amber durum, Minneapolis
G_9	=	No. 2 soft red winter, St. Louis
G_{10}	=	No. 2 soft red winter, Chicago
G_{11}	=	No. 2 soft red winter, Toledo
G_{12}	=	No. 1 soft white, Portland
G_{13}	=	No. 2 soft white, Toledo

Generally, the simple price correlation coefficient table appears to be a satisfactory reference for the degrees of substitutability among various classes and grades of wheat.

SUMMARY AND CONCLUSIONS

This study was prompted by the need for an economic analysis of domestic food consumption of wheat, by classes, in the United States. Hitherto, most published demand studies treated wheat as a single entity with an obvious lack of consideration that wheat is a heterogeneous commodity--each class of wheat generally having different quality characteristics and distinctive end uses. Government wheat programs, which were initiated in 1929 and have become particularly active since 1938, also treated various classes and qualities of wheat more or less uniformly without due regard for their quality distinctions. At times, this has resulted in a severe imbalance between the supply and demand for wheat by classes.

Five major classes of wheat are produced in the United States. Hard red winter, produced largely in the Southwest Plains, is used primarily for family flour and commercial bread flour. Hard red spring, produced in the Northern Plains, is best suited for commercial bread flour and specialty bread flours. Durum production is concentrated in North Dakota and is principally used for alimentary pastes such as spaghetti, macaroni, and noodles. Soft red winter, produced widely in the Cornbelt and the East, is generally used for pastry and family flours. White wheat has both hard and soft varieties. The Pacific Northwest is the principal white wheat region and produces both hard and soft varieties. Some soft white is also produced in Michigan and New York. Hard white is usually blended with other hard wheats to make bread flour on the West Coast.

Soft white is primarily used for such pastry goods as crackers and ice cream cones.

The demand for each class of wheat is dependent upon the price and quality of the class, prices and qualities of competing classes, per capita consumer disposable income, the degree of urbanization, and the level of milling and baking technology. Substitution of one class of wheat for another in the manufacture of certain types of wheat flour is possible within the limits of physical properties, but it is by no means unlimited.

The results of the analysis indicate that hard red spring, hard red winter, and durum wheat have a high price elasticity of demand, whereas soft red winter and white wheat have a low price elasticity of demand. Such findings have practical implications concerning the potential for expanding domestic food use of individual classes of wheat. It suggests, for instance, that lowering the price of hard red spring, or hard red winter, or durum wheat individually would result in increased food use. On the other hand, the potential for expanding the food use of soft red winter or white wheat by lowering their prices is more limited. These results may be of particular interest to the regional wheat commissions as well as to the producers of wheat.

The degrees of substitution differ substantially between various classes of wheat. It can be concluded, based on the statistical results together with information obtained from the milling industry, that hard red winter and hard red spring substitute easily in the production of bread flour, that low protein hard red and soft red winter substitute in the production of family flour, that hard red winter can be blended with durum in alimentary pastes, and that inspite of their physical and chemical similarity, white wheat and soft red winter seldom substitute for each other because of the high cost of transporting these two types.

These findings have important implications concerning the often discussed national emergency wheat carryover stocks. Because substitutability among wheat classes is not perfect, consideration should be given to the mix of wheat stocks as well as to total wheat stock needs.

Findings also show that the shift away from home baking has exerted the greatest impact on wheat demand by classes. More reliance on commercial baking appears to have had the effect of shifting the demand by about 37 million bushels to hard red spring from soft red winter. A further increase in the demand for hard wheats as a result of this trend is unlikely in the U.S. because already over 90 percent of all breads are supplied by commercial bakeries. Such findings, however, have a significant implication for the export potentials of the U.S. wheat classes. As the wheat importing countries increase their demand for bakery flour--usually due to the decline in home baking as in many European countries or due to the expanding baking industry as in Japan--the demand for hard wheats, particularly hard red spring and the high protein hard red winter will be strengthened at the expense of low protein wheats. Such shifts in import demand are already taking place in the European markets, the Japanese market, and elsewhere. These countries import either Canadian or U.S. hard wheats and blend them with their local low protein wheat in order to meet the protein requirements for commercial baking needs.

Other demand shifters--income, urbanization, the developments in the milling and baking technology--are thought to have had a variety of effects on the demand for different types of wheat, but often the effect of one type of demand shifter has been mitigated by the opposite effects of the other demand shifters. Therefore, the aggregate effects generally do not appear significant.

Another important application of this study is to relate the findings to the question of misallocation and inequities existing in the wheat economy as a result of supply-demand imbalance among wheat classes. This requires an additional estimation of supply schedules of wheat classes and meshing them with appropriate demand schedules. Since this report deals only with the demand side, a full analysis can not be advanced. But it is obvious from the previous discussion that the extreme complexity of the demand interrelationships among wheats point up the difficulty of formulating and even more difficult task of administering a set officially fixed prices such as wheat price support levels that would not cause the supply-demand imbalance among wheat classes. A prescription for workable wheat price policy requires knowing in advance before the planting season, the supply-demand conditions of the numerous wheat types and qualities. Obviously, weather conditions and other extraneous factors, together with our misreading of the dynamic wheat market, can easily upset our best projections. Under such a circumstance, a return to free market prices may yet be the best policy option that could bring about a more efficient resource allocation consistent with consumer preference.

Appendix I

Table 1.--Production and utilization of hard red winter, 1929-63

Year Beginning July	Production	Utilization			
		Used for Food	Used for Feed	Exports	Stocks
	- - - - - - - - - - million bushels - - - - - - - - - -				
1929	373	223	20	83	123
1930	404	219	61	60	152
1931	514	243	73	82	238
1932	279	221	44	20	201
1933	177	195	23	3	126
1934	207	197	35	2	68
1935	205	161	21	2	56
1936	264	197	35	3	38
1937	381	212	35	72	62
1938	396	197	43	70	116
1939	315	214	30	22	136
1940	324	229	32	6	160
1941	396	181	30	20	291
1942	486	242	89	22	317
1943	364	218	154	21	113
1944	468	180	74	37	109
1945	521	195	76	196	37
1946	582	208	52	225	28
1947	744	216	54	238	110
1948	648	163	30	230	167
1949	541	203	31	109	252
1950	459	219	28	182	214
1951	382	175	25	249	97
1952	723	175	20	183	395
1953	504	204	18	78	560
1954	489	196	15	124	677
1955	416	189	12	164	691
1956	446	191	12	254	648
1957	425	197	9	220	613
1958	838	204	13	259	940
1959	618	215	12	292	1,008
1960	794	209	13	423	1,104
1961	754	235	15	487	1,085
1962	537	209	6	440	936
1963	545	212	3	565	668

Source: 1929-53, Williams and Wang; 1954-63 computed.

Table 2.--Production and Utilization of hard red spring, 1929-63

Year Beginning July	Production	Utilization			
		Used for Food	Used for Feed	Exports	Stocks
	- - - - - - - - - -	million bushels	- - - - - - - - - -		
1929	146	107	11	3	88
1930	157	112	28	1	86
1931	73	73	17	-	49
1932	190	99	22	-	98
1933	107	99	14	-	74
1934	53	79	9	-	26
1935	107	97	12	-	34
1936	52	65	8	-	17
1937	101	54	12	3	30
1938	155	78	16	4	71
1939	116	73	10	5	82
1940	158	76	12	4	136
1941	202	100	15	2	206
1942	206	109	47	2	205
1943	227	168	77	7	151
1944	236	152	34	9	112
1945	221	140	34	44	39
1946	215	124	24	32	31
1947	220	105	20	34	48
1948	226	103	11	39	79
1949	169	108	11	14	86
1950	207	111	12	45	106
1951	256	146	13	87	117
1952	181	141	7	17	128
1953	217	118	7	11	195
1954	145	120	6	28	172
1955	184	128	5	29	185
1956	178	118	4	35	196
1957	167	114	3	38	203
1958	233	126	4	46	251
1959	151	118	4	50	219
1960	188	124	4	32	237
1961	116	109	3	42	187
1962	175	118	2	39	195
1963	161	116	1	50	182

Source: 1929-53, Williams and Wang; 1954-63 computed.

Table 3.--Production and utilization of durum, 1929-63

Year Beginning July	Production	Utilization			
		Used for Food	Used for Feed	Exports	Stocks
	- - - - - - - - - -	- million bushels	- - -	- - -	- - -
1929	57	28	4	16	32
1930	60	32	11	12	30
1931	22	22	5	5	14
1932	42	27	5	2	16
1933	18	19	3	-	8
1934	7	13	1	-	5
1935	25	20	2	-	7
1936	9	16	1	-	3
1937	29	20	2	-	5
1938	41	22	2	2	16
1939	33	25	2	-	18
1940	33	20	2	-	25
1941	41	25	2	1	34
1942	42	28	6	1	27
1943	34	20	8	1	14
1944	30	20	3	1	8
1945	33	22	4	1	5
1946	36	19	3	3	9
1947	45	21	2	11	10
1948	46	28	1	3	18
1949	39	24	1	1	25
1950	38	22	1	9	24
1951	36	24	1	14	15
1952	23	23	1	3	7
1953	14	13	-	-	5
1954	5	6	-	-	2
1955	20	12	-	1	7
1956	39	19	-	11	13
1957	40	25	-	1	25
1958	22	26	-	1	18
1959	21	23	-	1	12
1960	34	22	-	6	20
1961	21	17	-	16	5
1962	70	22	-	4	46
1963	51	24	-	29	41

Source: 1929-53, Williams and Wang; 1954-63 computed.

Table 4.--Production and utilization of soft red winter, 1929-63

Year Beginning July	Production	Utilization			
		Used for Food	Used for Feed	Exports	Stocks
	- - - - - - - - - - - - million bushels - - - - - - - - - - - -				
1929	165	124	24	4	27
1930	181	108	61	4	22
1931	263	139	69	3	59
1932	160	127	43	-	31
1933	162	105	36	-	36
1934	188	132	44	-	31
1935	202	147	38	-	26
1936	204	142	44	-	14
1937	250	147	53	5	36
1938	226	149	63	5	28
1939	195	134	45	3	24
1940	207	122	50	3	40
1941	204	121	49	2	54
1942	149	77	116	1	29
1943	125	37	194	1	18
1944	203	72	140	5	19
1945	208	59	136	54	11
1946	183	82	71	26	8
1947	210	84	74	32	16
1948	211	107	45	27	16
1949	203	98	46	21	29
1950	162	81	46	28	26
1951	148	83	43	23	16
1952	193	79	38	40	38
1953	231	93	37	56	70
1954	185	102	30	62	50
1955	173	100	25	69	17
1956	187	96	28	60	10
1957	159	103	18	30	6
1958	195	100	26	43	21
1959	161	99	22	41	10
1960	190	104	21	54	12
1961	202	103	26	56	24
1962	157	115	8	40	5
1963	219	119	5	80	4

Source: 1929-53, Williams and Wang; 1954-63 computed.

Table 5.--Production and utilization of white, 1929-63

Year Beginning July	Production	Utilization			
		Used for Food	Used for Feed	Exports	Stocks
	million bushels				
1929	83	23	11	38	21
1930	85	28	18	30	22
1931	70	21	16	32	15
1932	85	34	15	10	32
1933	88	47	14	21	29
1934	71	54	13	8	16
1935	89	64	11	5	17
1936	101	74	12	9	11
1937	113	56	14	27	20
1938	102	51	17	30	19
1939	82	43	13	19	20
1940	93	43	16	24	24
1941	99	45	19	7	46
1942	86	39	48	10	41
1943	94	35	77	15	21
1944	123	49	49	2	31
1945	125	59	47	30	8
1946	136	46	28	46	8
1947	140	59	28	30	12
1948	164	71	18	33	27
1949	146	51	20	38	33
1950	153	47	21	74	30
1951	166	53	21	102	11
1952	186	56	16	77	38
1953	207	45	14	75	104
1954	160	49	11	64	135
1955	142	41	9	87	133
1956	154	36	10	193	42
1957	160	36	7	118	34
1958	174	30	8	98	65
1959	176	33	10	128	65
1960	151	28	8	138	38
1961	142	27	10	120	21
1962	155	30	5	122	13
1963	166	27	2	136	6

Source: 1929-53, Williams and Wang; 1954-63, computed.

Table 6.--Production, and on-farm-feed use of white wheat by region, 1929-63

Year Beginning July	Production: West[1]	Production: East[2]	On Farm Feed Use: West	On Farm Feed Use: East
	- - - - - - - - - thousand bushels - - - - - - - -			
1929	77	10	7	2
1930	75	12	11	5
1931	62	15	10	6
1932	75	13	10	4
1933	69	12	7	4
1934	59	11	7	4
1935	75	17	6	5
1936	82	15	7	4
1937	89	18	8	5
1938	89	18	8	6
1939	68	15	7	5
1940	72	18	8	6
1941	91	17	10	6
1942	79	17	9	6
1943	77	12	9	5
1944	97	24	9	8
1945	94	29	7	9
1946	110	24	7	6
1947	100	33	6	9
1948	113	43	6	11
1949	94	43	6	10
1950	105	38	5	9
1951	116	38	6	8
1952	128	44	5	8
1953	155	52	5	7
1954	110	36	4	5
1955	93	34	3	4
1956	100	36	3	4
1957	111	32	3	3
1958	116	44	4	3
1959	118	37	4	3
1960	116	35	3	2
1961	102	40	3	2
1962	124	31	3	1
1963	128	38	2	1

- Continued

Table 6.--Continued

1/ Includes Arizona, California, Colorado, Idaho, Nevada, Montana, New Mexico, Oregon, Utah, Washington, and Wyoming.

2/ Includes Michigan, Missouri, New Jersey, New York, North Carolina, Ohio, Pennsylvania, and Tennessee.

SOURCE: 1929-53, Williams and Wang, Ibid; 1954-63, computed.

A Note on Disaggregation of Wheat Data by Class: Wheat data published by the USDA, in a large measure, are for total wheat. Data relating to the utilization of wheat as an aggregate for each of the four major outlets; namely, food, feed, exports, and stocks, are published in the Wheat Situation, ERS, USDA. In addition, data on total wheat used for seed and industrial purposes are available. For individual classes of wheat, figures on stocks, production, imports, exports, and domestic disappearance are available. But the data on domestic disappearance are the sum of food, feed, seed, and industrial uses.

To disaggregate domestic disappearance, a set of assumptions are made and they are stated in the appropriate places in the subsequent discussion (for a detailed description of the disaggregation procedures see Williams and Wang, Ibid. pages 1-9).

Farm disposition of wheat by type is published annually for each state in Agricultural Statistics, USDA. Since these data are for all wheat, an assumption is made that the percentage distribution of the utilization of wheat, by class, is the same as the percentage distribution of wheat acreage by class.

A quinquennial survey of the percentage distribution of varieties and classes since 1919 is reported in Distribution of the Varieties and Classes of Wheat in the United States. The yearly distribution within the five-year intervals is estimated by assuming a linear trend over the two periods.

The farm disposition data--(1) seed, (2) feed for livestock on farm where grown, (3) home use, and (4) sold--are then aggregated to obtain annual total farm utilization by class and type of utilization.

The disaggregated data, together with data relating to supply, stocks, and exports, by class, make it possible to obtain a more comprehensive division in the utilization. This is done by subtracting exports, carryover, wheat fed on farm, and seed use from total supply, leaving a figure roughly equal to food consumption plus commercial feed, industrial use, and any errors. The final food consumption data, by class, are computed by adjusting the sum of rough food consumption data equal to the published total food consumption data, by distributing the difference over all classes on the basis of the annual percentage of each of the rough food consumption to total rough food consumption.

Appendix II -- The Data Series

Year Beginning July	Domestic Food Use a/				
	HRW	HRS	Durum	SRW	White
	- - - - - - - - - - million bushels - - - - - - - - - -				
1929	223	107	28	124	23
1930	219	112	32	108	28
1931	243	73	22	139	21
1932	221	99	27	127	34
1933	195	99	19	105	47
1934	197	79	13	132	54
1935	161	97	20	147	64
1936	197	65	16	142	74
1937	212	54	20	147	56
1938	197	76	22	149	51
1939	214	73	25	134	43
1940	229	76	20	122	43
1941	181	100	25	121	45
1946	208	124	19	82	46
1947	216	105	21	84	59
1948	163	103	28	107	71
1949	203	108	24	98	51
1950	219	111	22	81	47
1951	175	146	24	83	53
1952	175	141	23	79	56
1953	204	118	13	93	45
1954	196	120	6	102	49
1955	189	128	12	100	41
1956	191	118	19	96	36
1957	197	114	25	103	36
1958	204	126	26	100	30
1959	215	118	23	99	33
1960	209	124	23	104	28
1961	235	109	17	103	27
1962	209	118	22	115	30
1963	212	116	24	119	27

Appendix II -- The Data Series - Continued

Year Beginning July	Price b/				
	HRW	HRS	Durum	SRW	White
	- - - - - - - - - - cents per bushel - - - - - - - - - -				
1929	230	250	228	250	225
1930	161	173	165	175	152
1931	118	178	190	130	140
1932	143	171	163	154	138
1933	244	252	285	260	197
1934	239	283	337	229	198
1935	240	288	258	217	185
1936	274	333	355	251	242
1937	235	271	227	239	184
1938	163	184	167	163	156
1939	175	230	218	178	190
1940	191	209	214	191	177
1941	234	230	243	230	201
1946	316	354	351	327	306
1947	310	355	356	302	308
1948	249	270	267	249	250
1949	259	284	275	229	262
1950	263	283	277	253	257
1951	251	259	260	231	250
1952	247	266	311	230	254
1953	245	277	376	207	249
1954	255	288	422	221	254
1955	234	266	299	215	235
1956	230	252	269	219	251
1957	217	242	243	215	228
1958	193	223	235	180	201
1959	199	225	245	186	199
1960	193	215	230	183	203
1961	204	239	319	194	209
1962	224	246	254	194	216
1963	211	233	234	200	207

Appendix II -- The Data Series - Continued

Year Beginning July	Price / Six Market Price x 100 b/				
	HRW	HRS	Durum	SRW	White
1929	98.44	106.65	97.62	105.65	95.98
1930	98.58	106.36	101.17	107.66	93.39
1931	85.29	128.85	137.93	94.37	101.63
1932	89.48	107.02	101.76	96.49	85.97
1933	96.49	97.78	112.94	103.07	77.85
1934	92.19	109.13	129.82	88.43	76.20
1935	105.21	126.25	113.23	95.19	81.16
1936	99.84	121.29	129.54	91.58	88.28
1937	104.42	120.42	100.66	106.31	81.84
1938	100.14	113.02	103.00	100.14	95.85
1939	86.05	112.79	106.98	87.21	93.02
1940	97.27	106.76	109.13	97.27	90.15
1941	102.47	100.64	106.13	100.64	87.83
1946	93.47	104.65	103.75	96.60	90.34
1947	91.40	104.46	104.82	88.86	90.68
1948	96.44	104.36	103.48	96.44	96.87
1949	96.52	105.90	102.77	85.34	97.86
1950	97.35	105.04	102.48	93.94	95.22
1951	101.46	104.38	104.80	93.11	101.05
1952	94.66	102.00	119.14	88.13	97.51
1953	91.83	103.96	141.18	77.67	93.45
1954	91.93	103.96	152.06	79.52	91.55
1955	91.03	103.55	116.50	83.51	91.44
1956	92.86	101.68	108.82	88.65	101.26
1957	93.56	104.44	104.87	92.69	98.35
1958	90.40	104.38	109.97	84.34	94.13
1959	89.73	101.39	110.36	83.89	89.73
1960	91.23	101.65	109.18	86.59	96.00
1961	87.46	102.39	136.52	83.19	89.59
1962	93.52	102.66	106.40	81.05	90.19
1963	95.93	105.88	106.34	90.95	94.12

Appendix II -- The Data Series - Continued

Year Beginning July	Disposable c/ Income/Cap.	Dummy Variable
	dollars	
1929	1,148	0
1930	1,044	0
1931	974	0
1932	671	0
1933	809	0
1934	887	0
1935	961	0
1936	1,073	0
1937	1,131	0
1938	1,034	0
1939	1,106	0
1940	1,186	0
1941	1,373	0
1946	1,741	1
1947	1,542	1
1948	1,554	1
1949	1,561	1
1950	1,663	1
1951	1,668	1
1952	1,694	1
1953	1,749	1
1954	1,744	1
1955	1,830	1
1956	1,887	1
1957	1,887	1
1958	1,856	1
1959	1,919	1
1960	1,918	1
1961	1,946	1
1962	1,998	1
1963	2,034	1

a/ 1929-53, Williams and Wang; 1954-63, computed.

b/ Computed from data in Agricultural Statistics, USDA (publish (published annually).

c/ Based on total civilian population eating out of civilian supplies, January 1, Computed from data in Agricultural Statistics, USDA (published annually).

Appendix II-A.--Food demand for wheat by classes, specified periods

Demand for	Equation number	Constant term	Price of: Hard red winter	Price of: Hard red spring	Price of: Durum	Price of: Soft red winter	Price of: White	Income per capita	1-0 variable	R^2	S	D.W.
Hard red winter												
1929-41:												
Model I	(1)	182.6	-1.808	0.432	---	1.124	0.206	0.022	---	0.75	14.17	2.99
			(0.564)	(0.296)		(0.474)	(0.372)	(0.030)				
Model II	(2)	228.1	-3.583	0.521	---	2.279	0.143	0.029	---	0.75	14.16	2.97
			(1.228)	(0.564)		(0.979)	(0.996)	(0.034)				
1946-63:												
Model I	(3)	128.9	-0.617	1.160	---	0.013	-0.665	0.039	---	0.51	14.72	1.87
			(0.756)	(0.473)		(0.299)	(0.574)	(0.038)				
Model II	(4)	64.98	-1.859	3.770	---	0.139	-1.657	0.035	---	0.51	14.74	1.96
			(1.890)	(3.252)		(0.786)	(1.541)	(0.027)				
1929-41 and 1946-63:												
Model I	(5)	191.1	-1.247	0.451	---	0.542	0.150	0.024	-12.90	0.40	16.75	2.18
			(0.374)	(0.231)		(0.266)	(0.271)	(0.020)	(20.14)			
Model II	(6)	325.2	-3.252	0.440	---	1.281	-0.162	0.054	-23.70	0.48	15.56	2.39
			(0.754)	(0.517)		(0.633)	(0.565)	(0.018)	(15.96)			
Hard red spring												
1929-41:												
Model I	(7)	140.7	0.720	-0.759	---	-0.233	0.410	-0.050	---	0.52	16.24	1.50
			(0.646)	(0.339)		(0.543)	(0.426)	(0.035)				
Model II	(8)	71.30	1.150	-1.269	---	0.060	1.048	-0.052	---	0.50	16.58	1.48
			(1.439)	(0.066)		(1.147)	(1.038)	(0.040)				
1946-63:												
Model I	(9)	42.15	0.843	-0.725	---	-0.175	0.217	0.031	---	0.28	11.39	1.48
			(0.585)	(0.366)		(0.231)	(0.444)	(0.030)				
Model II	(10)	297.9	2.318	-3.686	---	-0.422	0.041	0.011	---	0.32	11.11	1.80
			(1.425)	(2.452)		(0.593)	(0.990)	(0.020)				
1929-41 and 1946-63:												
Model I	(11)	119.7	0.552	-0.588	---	-0.075	0.111	-0.013	37.47	0.73	12.92	1.21
			(0.288)	(0.178)		(0.205)	(0.209)	(0.015)	(15.53)			
Model II	(12)	139.5	0.599	-1.254	---	-0.098	0.563	-0.011	29.12	0.71	13.29	1.55
			(0.644)	(0.442)		(0.541)	(0.482)	(0.016)	(13.64)			

Continued -

Appendix II-A.--Food demand for wheat by classes, specified periods - Continued

Demand for	Equation number	Constant term	Price of: Hard red winter	Price of: Hard red spring	Price of: Durum	Price of: Soft red winter	Price of: White	Income per capita	1-0 variable	R^2	s	D.W.
Durum												
1929-41:												
Model I	(13)	33.06	0.035 (0.044)	---	-0.087 (0.033)	---	---	0.002 (0.006)	---	0.64	3.57	1.74
Model II	(14)	86.33	0.355 (0.199)	---	-0.313 (0.093)	---	---	0.005 (0.007)	---	0.58	2.86	1.09
1946-63:												
Model I	(15)	62.14	0.037 (0.032)	---	-0.106 (0.015)	---	---	-0.011 (0.006)	---	0.80	2.72	1.28
Model II	(16)	43.41	0.084 (0.333)	---	-0.299 (0.068)	---	---	0.002 (0.006)	---	0.65	3.59	1.24
1929-41 and 1946-63:												
Model I	(17)	38.32	0.069 (0.043)	-0.012 (0.045)	-0.102 (0.016)	---	---	-0.003 (0.004)	4.532 (3.116)	0.72	3.09	1.59
Model II	(18)	74.04	-0.236 (0.153)	0.056 (0.117)	-0.327 (0.055)	---	---	0.001 (0.004)	-2.129 (3.535)	0.61	3.56	1.22
Soft red winter												
1929-41:												
Model I	(19)	119.0	0.034 (0.436)	0.351 (0.198)	---	-0.447 (0.335)	---	0.013 (0.020)	---	0.58	11.36	1.80
Model II	(20)	7.796	0.659 (0.537)	1.083 (0.311)	---	-0.673 (0.673)	---	0.003 (0.017)	---	0.72	9.277	2.13
1946-63:												
Model I	(21)	80.36	-0.211 (0.425)	0.165 (0.305)	---	-0.091 (0.192)	---	0.025 (0.023)	---	0.48	9.56	1.14
Model II	(22)	-252.1	0.032 (0.959)	2.766 (1.938)	---	-0.405 (0.501)	---	0.053 (0.017)	---	0.49	9.42	1.41
1929-41 and 1946-63:												
Model I	(23)	120.8	-0.114 (0.212)	0.442 (0.131)	---	-0.188 (0.151)	-0.314 (0.154)	0.025 (0.011)	-39.93 (11.41)	0.84	9.49	1.83
Model II	(24)	147.4	0.140 (0.466)	1.215 (0.320)	---	-0.447 (0.391)	-0.239 (0.349)	-0.030 (0.011)	-48.75 (9.861)	0.83	9.61	1.61

Continued -

Appendix II-A.--Food demand for wheat by classes, specified periods - Continued

Demand for	Equation number	Constant term	Price of: Hard red winter	Price of: Hard red spring	Price of: Durum	Price of: Soft red winter	Price of: White	Income per capita	1-0 variable	R^2	S	D.W.
White												
1929-41:												
Model I	(25)	4.948	0.136 (0.179)	0.336 (0.161)	---	---	-0.428 (0.241)	0.011 (0.020)	---	0.70	10.41	1.56
Model II	(26)	21.87	0.505 (0.669)	0.713 (0.371)	---	---	-1.410 (0.569)	0.018 (0.025)	---	0.65	11.46	2.17
1946-63:												
Model I	(27)	156.8	0.293 (0.242)	-0.218 (0.163)	---	---	-0.022 (0.196)	-0.068 (0.013)	---	0.88	5.07	2.12
Model II	(28)	294.4	1.014 (0.586)	-1.664 (1.060)	---	---	-0.413 (0.428)	-0.076 (0.009)	---	0.89	4.82	1.81
1929-41 and 1946-63:												
Model I	(29)	37.49	0.545 (0.195)	0.0124 (0.120)	---	-0.339 (0.139)	-0.044 (0.142)	-0.029 (0.010)	8.895 (10.50)	0.68	8.73	1.47
Model II	(30)	31.53	2.042 (0.453)	0.266 (0.311)	---	-0.826 (0.380)	-0.294 (0.339)	-0.042 (0.011)	31.65 (9.583)	0.63	9.34	1.54

NOTE: Model I uses actual prices, whereas Model II uses the ratio of individual wheat price to the average price for all wheat. Standard errors are in parentheses. The estimated standard error of regression is denoted by S, the coefficient of multiple determination by R^2, and the Durbin-Watson statistics by D.W.

BIBLIOGRAPHY

Books

Hildreth, C and F. G. Jarrett. A Statistical Study of Livestock Production and Marketing. John Wiley and Sons, Inc., New York. 1955.

Jasny, N. Competition Among Grains. Stanford University, California. 1940.

Schultz, H. The Theory and Measurement of Demand. University of Chicago Press, Chicago. 1938.

Wold. H. O. A. and L. Jureen. Demand Analysis. John Wiley and Sons, Inc., New York. 1953.

Articles

Askew, W. R. "Bread Consumption in the United States." Wheat Situation. USDA. February 1962.

Bitting, H. W. and R. O. Rogers. "Utilization of Wheat for Food." Agricultural Economics Research. Vol. 15. No. 2. April 1963.

Bosland, C. C. "Forecasting the Price of Wheat." American Statistical Association Journal. Vol. 21. 1926.

Dahl, R. P. "Classes of Wheat and the Surplus Problems." The Northwestern Miller. Vol. 266, No. 8. April 1962.

Farnsworth, H. C. "The Problem Multiplying Effects of Special Wheat Programs." American Economic Review. Vol. Ll. May 1961.

Folz, W. E. "Public Law 480 and Pacific Northwest Wheat." Proceedings of the Fourth Annual Workshop on Wheat Marketing in the Pacific Northwest. Washington State University, Institute of Agriculture Science. February 1965.

Houck, J. P. "A Look at Flexibilities and Elasticities." Journal of Farm Economics. Vol. 48. No. 2. May 1966.

Lehfeldt. R. A. "The Elasticity of Demand for Wheat." Economics Journal. Vol. 24. 1914.

McClave, G. C. "Its the Wheat Plus Intelligent Milling." Commercial West. July 18, 1959.

Meinkin, K. W. The Demand and Price Structure for Wheat. Technical Bulletin No. 1136. USDA. November 1955.

Schnittker, J. A. Wheat Problems and Programs in the United States, 1933-1960. University of Missouri, North Central Regional Publication 118. September 1960.

Wetmore, J. M., et al. Policies for Expanding the Demand for Farm Products in the United States. Part 1. History and Potentials. University of Minnesota. Agricultural Experiment Station Technical Bulletin 231. April 1959.

Williams, H. C. and Y. Wang. Wheat Statistics: Supply and Utilization by Class. Ohio State University. Ohio Agricultural Experiment Station Special Circular 96. September 1961.

Zeleny, L. Wheat Strength and the Sedimentation Test. AMS - 422, USDA. November 1960.

Periodicals

Agricultural Statistics. USDA. (published annually)

Crop Production. Statistical Reporting Service. USDA.

Distribution of the Varieties and Classes of Wheat in the United States. (published quinquennially since 1919)

Grain Market News. Grain Division. Consumer and Marketing Service. USDA. (published weekly)

Physical, Chemical, Milling, and Baking Properties of Carlot Receipts of Wheat. Grain Division. AMS. USDA. (published annually)

Wheat Situation. ERS. USDA. (published quarterly)

Wheat Studies. Vol. 1 - 20. Stanford University. 1924-1944.

Public Documents

United States Department of Agriculture. Official Grain Standards of the United States. USDA. 1964.

United States Department of Commerce. Climatological Data. Vol. 15, No. 13. 1965.

Quirk, T. "Data for Millers." The Northwestern Miller, Vol. 272, No. 1. January 1965.

Rojko, A. S. "Time Series Analysis in Measurement of Demand." Agricultural Economic Research, Vol. XIII, No. 2. USDA. April 1961.

Russell, D. J. The Demand for Wheat by Classes. A paper presented to the marketing seminar at the Minneapolis Grain Exchange. September 1961.

Schruben, L. W. Substitution and the Demand for Wheat by Classes. A paper presented to the marketing seminar at the Minneapolis Grain Exchange. August 1962.

Taylor, A. E. "The Contractility of Wheat Acreage in the United States." Wheat Studies. Vol. VI, No. 4, Stanford University, February 1930.

Warren, G. F. and F. A. Pearson. Interrelationships of Supply and and Price. Cornell University. New York Agricultural Experiment Station Bulletin 466. 1928.

Working, Holbrook. "The Elasticities of Demand for Wheat." Econometrica. Vol. 5, 1937.

Reports

Brandow, E. G. A Statistical Analysis of Apple Supply and Demand. Pennsylvania State University. Agricultural Economics and Rural Sociology Report 2. 1956.

Foote, R. J. Analytical Tools for Studying Demand and Price Structures. Agricultural Handbook No. 146. USDA. August 1958.

Fox, K. A. The Analysis of Demand for Farm Products. Technical Bulletin 1081. USDA. 1953.

Fox, K. A. and J. F. Cooney. Effects of Intercorrelation Upon Multiple Correlation and Regression Measures. AMS - 341. USDA. 1950.

Harston, C. R. Marketing High Protein Wheat in the Northern Great Plains. Montana State College. Agricultural Station Bulletin No. 527. 1957.

McCormick, F. B. and M. G. Smith. Wheat Price Programs: Effect and Implication for Ohio. Ohio State University. Ohio Agricultural Experiment Station. Research Bulletin 866. October 1960.