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THE DEMAND AND PRICE STRUCTURE FOR OATS, BARLEY, AND SORGHUM GRAINS
MEINKEN, K W.

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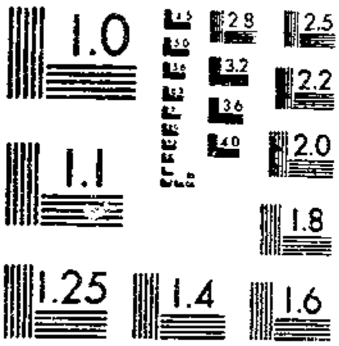

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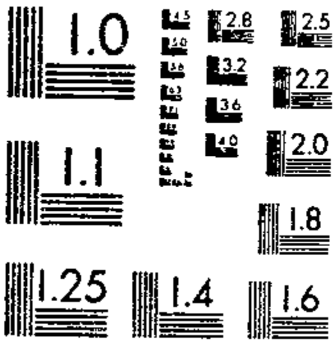

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The Demand and Price Structure for Oats, Barley, and Sorghum Grains[1]

By Kenneth W. Meinken
Agricultural Economic Statistician
Bureau of Agricultural Economics

CONTENTS

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SUMMARY

The three feed grains—oats, barley, and sorghum grains—normally represent about a fifth of the total concentrates fed to livestock. From 1946 to 1950 they contributed respectively 15, 3, and 2 percent of the total. Contributions of these grains to the quantity of feed consumed by livestock are more important from a regional viewpoint than nationally. This is particularly true for barley and sorghum grains which as a rule are produced in areas where production of corn is comparatively unimportant.

Oats are produced mainly in the North Central region—leading States are Iowa, Minnesota, Illinois, and Wisconsin. In 1951 production for these States represented 51 percent of the United States total. In recent years 25 to 30 percent of the crop has been sold, and the remainder fed or utilized as seed on farms where grown.

Production of barley is concentrated in the West North Central region and California—leading States are North Dakota, South Dakota, Minnesota, and California. In 1951, production for these States represented 60 percent of the United States total. In recent years 57 to 63 percent of the crop has been sold.

Production of sorghum grains is even more concentrated than is production of oats and barley, centered as it is in the semiarid parts of the Southwest. The principal producing States are Texas, Kansas, and Oklahoma. In 1951 production for these States represented 91 percent of the United States total. Sales by farmers of this grain have averaged about 65 percent of the crop in recent years.

Since 1920 production of these three feed grains has trended steadily upward except for the drought years in the 1930's, when production was materially reduced. The increase in production of oats has come wholly as a result of the increase in yield, as harvested acreage decreased slightly. For barley and sorghum grains, a combination of increased yield and acreage has resulted in an increase in production substantially greater than that for oats or corn. Much of the increase in production of these two grains has gone into nonfeed uses, including exports. This is in contrast to corn and oats where the increase has been absorbed largely as feed by the expanding livestock industry.

Year-to-year variations in planted acreage and yield show that there are distinctive differences between individual grains as a result of the different roles they hold in the agricultural economy as a whole and of their geographic distribution. Variations in yield for sorghum grains are substantially greater than those for barley and oats, because production is concentrated in a region where climatic conditions are hazardous. The greater stability in yields of oats and barley comes partly from the fact that their production is more widely distributed. The roles that barley and sorghum grains play as "catch crops" and as substitutes for certain cash crops contribute to greater year-to-year variation in planted acreage than for oats and corn, which are produced mainly for the relatively stable livestock industry.

Normally about 85 to 90 percent of the oats, half of the barley, and 55 to 60 percent of the sorghum grains produced are utilized domestically as feed for livestock. The remainder of these grains is utilized as human food in many diversified forms, for industrial use, for seed, and for export. The principal nonfeed use of oats other than for seed is for breakfast foods. Exports of oats are normally small. The barley used in production of malt accounts for a large share of the nonfeed use of this grain. Exports are more important for barley than for oats, particularly in California where most of these exports originate. In recent years, exports have been a major outlet for sorghum grains, but food and industrial uses have also been substantial. The United States is normally a net exporter of all feed grains, but in years when either production was very small or unusual demand conditions existed, imports have exceeded exports.

PRICE RELATIONSHIPS.—Prices of feed, in the aggregate, are determined mainly by supplies of feed available, numbers of animals to be fed, and prices of livestock and livestock products. Prices of the three grains and of corn are closely correlated, reflecting the fact that the four feeds can be used interchangeably in most livestock feeding. Thus an analysis of the principal factors that affect the price of any one of these feed grains becomes, in effect, an analysis of the factors that affect the prices of all feed grains. Practically all of the year-to-year variation in the prices of the three main feed grains is associated with variations in prices of corn and in the supply of each grain relative to the supply of corn.

The quantities of oats and barley used for nonfeed purposes apparently are little affected by their prices. As the value of these grains used for industrial purposes is generally low in relation to the price of the final product, this is not surprising. Barley and oats used for food are relatively cheap in relation to alternative foods, even when their prices are higher than normal in relation to the general price level. Nonfeed uses apparently move up and down mainly with special factors which affect the demand for the end products. As use for feed is the largest single item of utilization for all three grains, factors connected with the feed-livestock economy are the principal ones that affect the prices of these grains.

From July to October the bulk of each crop is harvested, and normally more than 55 percent is sold. Statistical analyses of prices during these months however; are particularly difficult. A method developed by Foote (*7*),[2] based on regression analysis, was used. By this process, weights for the components of supply that affect July to October prices can be determined from the data. When all series are expressed in millions of tons, the relative weights (which add to 1) in the analysis for prices of oats are as follows: New-crop production of oats plus carryover should be multiplied by about 0.57, July 1 stocks of corn by about 0.19,

[2] Italic numbers in parentheses refer to Literature Cited, p. 98.

and the prospective new-crop production of corn by about 0.24. The new-crop supply of barley was found to have no significant effect on prices of oats. For the July-October study of barley prices, it was determined that new-crop production of barley should be weighted by about 0.55, the supply of oats by 0.20, July 1 stocks of corn by 0.11, and prospective new-crop production of corn by 0.14. A similar analysis for prices of corn is given in Foote (7).

Logic suggests that the supply of any commodity would affect its price (ton for ton) more than would supplies of competing commodities. The weights obtained in all three studies are in agreement with this consideration.

For oats, the composite supply factor, together with the prices of livestock and livestock products for these months and production of livestock for July to December, explained 77 percent of the year-to-year variation in July to October prices from 1922 to 1942. The composite supply factor for barley, together with prices and production of livestock and livestock products, explained 81 percent of the year-to-year variation in July to October prices of barley for the same period.

The elasticities of demand for oats and barley at the local market level, as indicated by the July to October analyses, are respectively —0.5 and —0.4, indicating an inelastic demand for these grains. These coefficients compare with the value of —0.6 for corn obtained by Foote. The differences are not statistically significant. All three coefficients may reflect more nearly the elasticity of demand for all feed grains and possibly for all feed concentrates.

Prices of all feed grains are affected by demand factors in about the same way and the locational aspects and relative feeding values ordinarily remain constant over time. Thus the principal variables that influence year-to-year variations in the relationship of their prices to prices of corn are relative supplies. The supply of oats relative to the supply of corn explained 77 percent of the year-to-year variation in the November to May price of oats relative to the November to May price of corn from 1922 to 1942. Production of barley in the West North Central region relative to the supply of corn explained 67 percent of the year-to-year variation in the price of barley (for the West North Central States) relative to the price of corn for the same period.

Relative prices of sorghum grains presented a more complex problem as the locational difference in production of sorghum grains versus production of corn necessitated additional variables. Although 69 percent of the year-to-year variation in prices of sorghum grains relative to prices of corn was explained by production of sorghum grains relative to the supply of corn, the addition of animal units fed in Texas, Kansas, and Oklahoma and production of corn in these same States relative to the United States production of corn improved the analysis. These three variables together explained 79 percent of the variation in relative prices for the years 1932 to 1942.

The statistical analyses of actual and relative prices of these grains, based on the interwar period, appear to be valid in the postwar period.

OTHER STATISTICAL ANALYSES RELATING TO OATS, BARLEY, AND SORGHUM GRAINS.—Prices of these grains tend to decline during the period of heavy marketing and to rise as the marketing season progresses. Seasonal variation for prices of oats and barley follow similar patterns, reflecting their nearly identical production and marketing periods. The monthly pattern of prices of sorghum grains follows more closely the seasonal variation in prices of corn, as the production and marketing period for sorghum grains approaches that for corn. Prices of oats vary more widely during the marketing season than do prices of the other grains, and the seasonal pattern for oats has tended to change over time. The changing pattern for prices of oats is the result of a changing pattern of farm marketings. Seasonal variation for all three grains is less than that for corn. Seasonal patterns of these grains by regions also are discussed.

Prices of these grains vary regionally, reflecting chiefly costs of transportation from surplus-producing to deficit areas. Prices of oats and barley are lowest in the West North Central region and highest in the outer fringe of States that border the Atlantic and Pacific Coasts. Regional variation is greatest for oats, resulting mainly from the higher transportation cost per unit of value. Relationships between terminal market prices and United States average prices received by farmers and between principal producing States and terminal markets through which they normally are marketed also are shown.

SUPPORT PROGRAMS.—Price support programs have been in effect in every crop year since 1940 for barley and sorghum grains, and since 1945 for oats. Quantities pledged for price-support loans were negligible in 1940 to 1947, but in 1948, 1949, and 1950 substantial quantities were placed under price-support because of some reduction in demand and large feed grain crops in 1948 and 1949. Data concerning price-support operations are shown.

ECONOMIC IMPORTANCE OF THE THREE GRAINS

Oats, barley, and sorghum grains together are second only to corn as a feed. In the 1950-51 feeding year they represented about a fourth of the total grains and a fifth of the total concentrates fed to livestock. The combined value of these three grains accounted for about 8 percent of the value of all crops produced by farmers in 1951 and was exceeded only by corn, hay, wheat, and cotton. Of the estimated 336 million acres harvested in 1951, 54 million, or 16 percent, were devoted to the production of the three grains. The livestock industry of the United States depends to a considerable extent on the production of these grains.

Among the feed grains, oats is second to corn in importance. Oats represented 17 percent of the combined farm value of all feed grains produced by farmers from 1946 to 1950, compared with 74 percent for corn, the leading feed grain in the United States. Barley represented 6 percent of the total farm value of the four feed grains, and sorghum grains accounted for 3 percent.

Geographic Distribution and Trends in Acreage, Yield, and Production

Although for the entire country the combined value and production of these three grains is less than that of corn, these grains are of major importance in the feed-livestock economy of some geographic areas. In many regions the climate prevents successful growth of corn. In these regions substitute crops are produced. Different climates call for different crops and different methods of cultivation. Although physical factors may be looked upon as the principal determinant of the location and distribution of a crop, economic and various secondary factors are also important. The areas of production of these feed grains relative to corn are shown in figure 1. Barley and sorghum grains are produced largely outside the Corn Belt, while production of oats is concentrated in the Corn Belt.

The position of oats relative to that of corn is not comparable with that of barley or the sorghums. The primary center of production of oats coincides with that of corn. Barley and sorghum grains are produced in areas to which they are well suited ecologically and corn is not. In general, the best ecological conditions for oats are found north of the Corn Belt. The explanation for the concentration of production of oats within the Corn Belt lies in the fact that corn cannot be produced year after year on the same land without reduction in yield and deterioration of the land. For optimum results, rotation must be practiced along with other preferred agricultural practices. Many crops have been found that fit into the rotation with corn, but in many areas oats are most economical.

Oats are produced in every State of the Union. Iowa, Minnesota, Illinois, and Wisconsin together comprise the principal producing area. These four States produced 51 percent of the United States production in 1951. Other important producing States are South Dakota, North Dakota, Nebraska, Michigan, Indiana, Missouri, and Ohio. The combined production of these 11 States accounted for 83 percent of the 1951 production.

Temperature, rainfall, and length of growing season preclude commercial production of corn in the northern parts of Michigan, Wisconsin, Minnesota, the central and western areas of South Dakota, and in most of North Dakota. Barley is better suited ecologically to these areas and is more practicable than corn or oats; the primary center of barley production is located in this area. Secondary factors also are important in determining the acreage of barley in these areas, particularly in the Dakotas and Minnesota, where acreage may decrease or increase depending on the success or failure of wheat seeding. A statistical analysis for 1943-52 indicates that 86 percent of the variation in planted acreage of barley in 7 principal producing States of the North Central region—North Dakota, South Dakota, Minnesota, Nebraska, Wisconsin, Michigan, and Iowa—was associated with

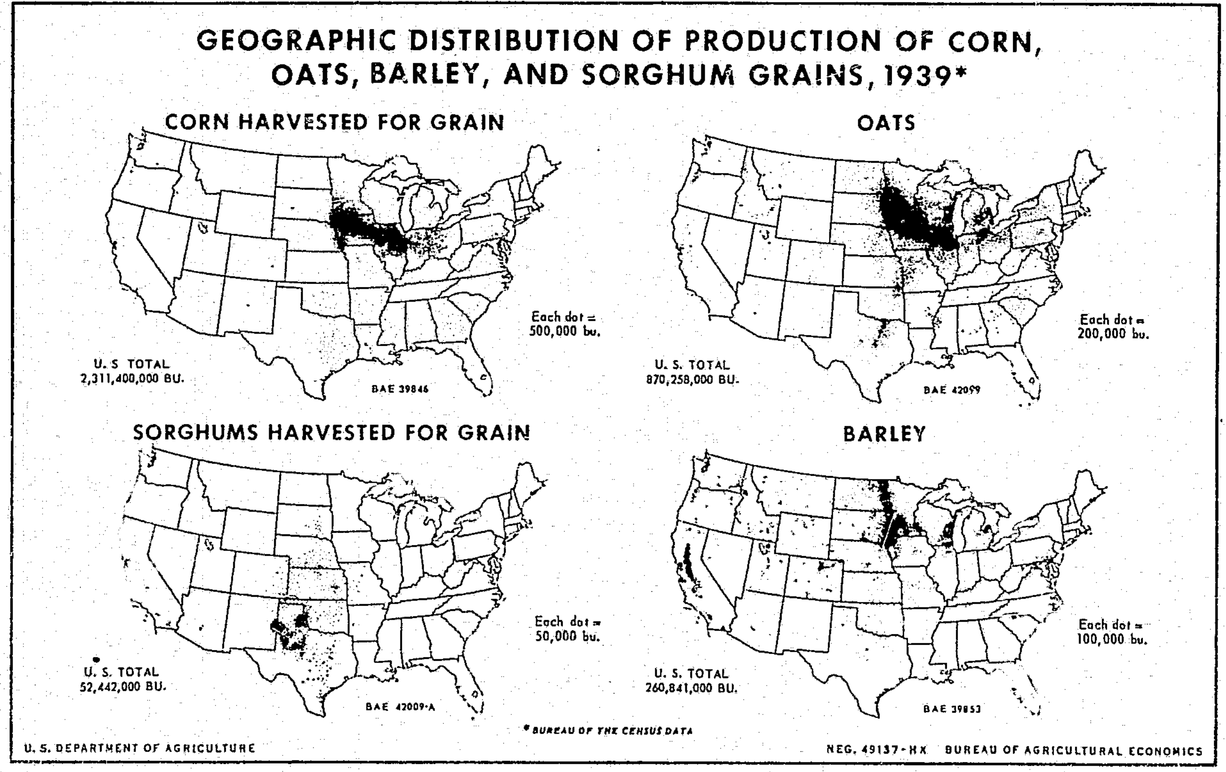

FIGURE 1.—Production of corn and oats is concentrated in the Corn Belt. Sorghums harvested for grain and barley are produced in areas to which corn is not well suited. In these areas they hold a position in the feed–livestock economy similar to that of corn in the Corn Belt.

variations in oats planted in these States and spring wheat planted in North Dakota, South Dakota, and Minnesota. This relationship reflects the overlapping of the barley-producing areas with those of spring wheat and oats.

In the spring wheat area, barley serves as a "catch crop" or alternative for spring wheat and in the areas that produce oats it serves as a substitute for oats in rotation with corn. In these States oats compete with spring wheat to a limited extent only, on the basis of a similar analysis, reflecting the greater geographic separation of their respective areas of production. In California—a secondary center for production of barley—physical factors are more favorable to production of barley than to production of any other cereal grain; as a result, barley is the principal feed grain produced in the State. Barley also is produced to a considerable extent throughout the Mountain and Western States.

Barley was produced in 40 of the 48 States in 1951. Production of barley was more diversified than production of sorghum grains but less than that of oats. In recent years North Dakota has been the main producing State but in 1950 and 1952 it was exceeded by California. North Dakota, South Dakota, California, and Minnesota together normally account for about 50 percent of the United States production. Other important producing States are Nebraska, Colorado, Montana, Idaho, Oregon, Kansas, and Wisconsin. In 1951 these 11 States represented 82 percent of the production.

In the semiarid parts of Texas, Oklahoma, and Kansas, corn is often subject to failure. For this reason the need for a substitute feed grain was recognized early in the agricultural development of this region. The feed grain that best fulfilled the requirements of the area was sorghum grain. Sorghum grains, although largely a cash crop, hold a position in the feed-livestock economy of this area similar to that of corn in the more humid North Central region. Sorghum grains also serve as a "catch crop," as the acreage planted varies with abandonment of winter wheat acreage and the success or failure of cotton planting. A statistical analysis covering 1929-52 indicates that 81 percent of the variation in planted acreage of sorghums for all purposes was associated with variations in acreage of winter wheat harvested in Texas, Oklahoma, and Kansas and of cotton in cultivation on July 1 in Texas and Oklahoma.

Production of sorghum grains is not so widely distributed as that of other feed grains, as it is grown mainly in the more arid regions of the Southwest. In 1951, this grain was produced in only 16 States, production being concentrated in 3—Texas, Kansas, and Oklahoma. These 3 States accounted for 91 percent of the total United States production in 1951. Texas is the leading producing State, followed by Kansas and Oklahoma. Other States of importance are California, New Mexico, Colorado, Nebraska, and Arizona. These 5 States accounted for 7 percent of the 1951 production.

Year-to-year fluctuations in production and yields per acre for the three grains and for corn tend to move with each other, principally as a result of common weather factors. From 1921 to 1950, 47 percent of the year-to-year variation in total production of oats, barley, and sorghum grains was associated with changes in production of corn. A 1-percent change in production of corn was associated, on the average, with a 0.8 percent change in the same direction in production of the other feed grains. As these grains are affected to a considerable extent by common factors, such as weather and economic conditions, this relationship would be expected. Long-term trends in production also are similar, reflecting primarily somewhat similar trends in yield. The percentage variation and direction for any one year, however, may not be the same nor do the longer term trends for the three grains necessarily move identically with each other.

From 1920 to 1950, production increased for all three grains but the rate of increase differed considerably. Using average production for 1920-24 as a base, average production of oats in 1946-50 increased by 10 percent; average production of barley by 79 percent; and average production of sorghum grains by 113 percent. The percentage increase in yields per acre of each grain was about the same. These increases were: 16 percent for barley, 14 percent for oats, and 12 percent for sorghum grains. Sorghum grains showed the greatest increase in acreage with a gain of 97 percent; barley increased by 54 percent, and oats declined by 4 percent.

Although year-to-year variations in yield reflect forces over which farmers in general have little or no control, variations in planted acreage are to a large extent based on decisions by farmers. The degree of variation in planted acreage reflects, among other things, the stability of demand for the commodity, the number of alternative crops that can be produced on the land, and weather at planting time. Year-to-year variations in planted acreage of these grains reflect the respective roles that corn, oats, barley, and sorghum grains play in the feed-livestock economy and in the agricultural economy as a whole. For 1930-50, the average change from the preceding year, ignoring direction of change, for corn, oats, barley, and sorghum grains was 3.4, 4.0, 10.0, and 14.5 percent, respectively. Corn and oats are primary crops. They are produced essentially as the basic raw material for the relatively stable livestock industry and are thus affected principally by factors connected with the feed-livestock economy and the requirements of rotation. Therefore, the year-to-year percentage changes in planted acreage are small. Barley and sorghum grains serve dual roles; that is, they are produced to a considerable extent as feed for livestock in areas to which corn and oats are not suited but their role as "catch crops" or alternatives for other cash crops results in greater year-to-year percentage variations in acreages planted.

Year-to-year fluctuations in yield per acre have been much greater for sorghum grains than for barley and oats, because production of the latter is concentrated in three States. Correlation of yields among adjacent areas or States tends to be higher than for more distant areas. In general, the wider the distribution of a crop the greater is the tendency for yields per acre in one area to offset those in another and to give greater stability to the United States average yield of these grains as a whole. Yields of barley for 1920-51 show a smaller year-to-year percentage fluctuation than do those of oats and sorghum grains. Explaining this tendency are the two widely separated concentrated producing areas and the generally wide distribution of the crop. Oats show the second largest variation, although they are more widely grown than barley. This is to be expected, as the bulk of the crop is produced in one area and more distant regions would not be expected wholly to offset conditions in the main producing area. Data on production, acreage, and yield per acre from 1900 to 1952 are given in table 1.

Except for year-to-year variations reflecting weather and other unusual factors, production of oats showed no consistent trend either upward or downward from 1900 through about 1941. More recently production has been larger, reflecting mainly an increase in yield per acre.

From 1920 to 1929 production of barley increased rather rapidly, principally as a result of increased acreage. Mainly because of unfavorable weather, production was reduced considerably in some years during the 1930's, but then increased to a peak in 1942. Barley is the only feed grain whose production has tended to decrease in recent years. Acreage has followed a pattern similar to that for production. Yields per acre increased during the 1920's, were reduced by unfavorable weather in some years in the 1930's, but have since shown a tendency to increase.

Production of sorghum grains varied considerably from year to year during the decade of the 1920's, but for the period as a whole no pronounced trend was evident. In 1930 to 1936, production was reduced sharply, reflecting mainly decreased yields per acre caused by severe weather. From 1937 through 1951 the trend was rather sharply upward. Acreage of sorghum harvested as grain increased steadily from 1930, when 3.5 million acres were harvested, to 1950, when a record 10.3 million acres were harvested. Acreage remained fairly constant in 1920-29, averaging slightly more than 4 million acres a year. Year-to-year fluctuations in yield have been large, reflecting variations in weather and the concentration of production. Yields per acre from 1920 to 1929 showed no definite trend. From 1930 to 1936 yields were mostly below the average of the 1920's, and they reached a low of 8 bushels an acre in the drought year 1934. Since this low point, yields have trended upward, reaching a record high of 23 bushels in 1950.

Flow Chart for Oats, Barley, and Sorghum Grains

Figure 2 illustrates the movement of these grains from time of harvest to sale of the finished products to consumers. For purposes of comparison, corn and other concentrates fed to livestock are included in the diagram. The sizes of the various boxes and channels indicate the relative volume of movement or utilization based on data for 1946-50. The box in the lower portion of the diagram measures the total concentrates fed to livestock, and its individual sections indicate the relative contributions of the various concentrates.

Most oats and barley are sown in the spring and mature in summer. In the South and in California, oats and barley normally are sown in fall or winter and mature earlier than the spring-sown portion of the crop. The production period for sorghum is roughly comparable to that for corn—it is planted and harvested later than the small grains. Upon harvest, all of the grains move either directly into marketing channels or into storage. The marketing season for oats and barley begins in June, the peak month of sales by farmers usually being August. For sorghum grains, the first sales by farmers are in July and the peak month is November. Percentages of sorghum grains and barley sold by farmers are relatively greater than the percentage of oats. In recent years about 65 percent of the sorghum grains crop, between 57 and 63 percent of the barley crop, and 25 to 30 percent of the oat crop have been sold by farmers.

Varying quantities of the individual grains are retained as seed or fed to livestock on or near farms where they are grown. Of the commercially sold grain, some is sold directly as grain for feed or is used in mixed feeds. The remainder of the commercial supply is used for the manufacture of various food and nonfood products and for export.

Importance of the Three Grains for Livestock Feed

In recent years oats, barley, and sorghum grains have accounted for about 20 percent of the total concentrates fed to livestock. Corn has accounted for about 60 percent, and other grains and byproduct feeds have made up the remainder. These three grains can be fairly readily substituted for corn in feeding livestock. Jennings (*12*) computed the feed-unit value of these grains and other feeds relative to that of corn for all types of livestock under average conditions in the United States and when fed to each of the various types of livestock. According to Jennings, on the average, 100 pounds of barley is equal to 95 pounds of corn, 100 pounds of oats is equal to 90 pounds of corn, and 100 pounds of sorghum grains has the same value as 100 pounds of corn. The value of these grains as a substitute for corn varies with the type of livestock to which the grain is fed and with the form in which it is fed. Their relative values when fed to different kinds of livestock and for the United States as a whole are shown in table 2. The high substitution ratio of oats, barley, and sorghum grains for corn has enabled farmers to produce livestock efficiently throughout the United States.

Most of the production of these grains is utilized as feed. In recent years about 55 to 60 percent of the production of sorghum grains has been utilized as feed, about half of the production of barley, and 85–90 percent of the production of oats. In 1926–50, oats, barley, and sorghum grains accounted on the average for

TABLE 1.—*Oats, barley, and sorghum grains: Acreage harvested, yield per harvested acre, and production, 1900–52*

Year	Oats			Barley			All sorghums for grain		
	Acreage	Yield	Production [1]	Acreage	Yield	Production [1]	Acreage	Yield	Production [1]
	Million acres	*Bushels*	*Million bushels*	*Million acres*	*Bushels*	*Million bushels*	*Million acres*	*Bushels*	*Million bushels*
1900	31.0	30.5	945.5	4.7	20.5	96.6			
1901	30.9	25.9	799.8	5.0	24.9	123.8			
1902	31.4	34.3	1,076.9	5.5	26.7	146.2			
1903	32.2	27.5	885.5	6.2	24.0	149.3			
1904	32.7	30.9	1,011.6	6.6	25.2	166.1			
1905	33.4	33.0	1,104.4	6.7	25.8	171.6			
1906	33.7	30.4	1,022.7	6.7	26.6	179.1			
1907	34.4	23.3	801.1	6.9	22.0	150.6			
1908	34.3	24.2	829.3	7.4	23.1	170.8			
1909	35.1	28.9	1,013.9	7.7	22.5	173.1			
1910	36.8	30.0	1,106.2	7.5	18.9	142.4			
1911	37.1	23.8	885.5	7.6	19.1	145.1			
1912	37.2	36.3	1,353.3	7.5	26.1	196.9			
1913	37.2	27.9	1,039.1	7.7	20.7	158.8			
1914	37.2	28.7	1,066.3	7.7	23.2	177.7			
1915	38.8	37.0	1,435.3	7.3	28.4	207.0			
1916	39.1	29.1	1,139.0	7.6	20.9	159.2			
1917	41.6	34.7	1,442.5	8.5	21.6	182.2			
1918	42.5	33.6	1,428.6	9.2	24.5	225.1			
1919	39.6	27.9	1,106.6	6.6	19.9	131.1			76.3
1920	42.7	33.8	1,444.3	7.4	23.0	171.0			90.3
1921	45.5	23.0	1,045.3	7.1	18.8	132.7			73.2
1922	40.3	28.5	1,147.9	6.6	23.2	152.9			51.2
1923	40.2	30.5	1,227.2	7.2	22.2	159.0			63.4
1924	41.9	33.8	1,416.1	7.0	23.5	165.3			63.1

1925	44.2	31.8	1,405.3	8.2	23.5	192.5	....	....	58.9
1926	42.9	26.9	1,152.9	7.9	21.0	166.0	....	....	72.7
1927	40.4	27.1	1,093.2	9.5	25.3	239.1	....	....	83.4
1928	40.1	32.7	1,312.9	12.7	25.8	328.4	....	....	79.0
1929	38.2	29.2	1,112.9	13.6	20.7	280.6	3.5	14.2	50.0
1930	39.8	32.0	1,274.6	12.6	23.9	301.6	3.5	10.8	37.6
1931	40.2	28.0	1,124.2	11.2	17.9	200.3	4.4	16.2	71.9
1932	41.7	30.1	1,254.6	13.2	22.7	299.4	4.4	15.0	66.1
1933	36.5	20.2	736.3	9.6	15.9	152.8	4.4	12.5	54.4
1934	29.5	18.5	544.2	6.6	17.8	117.4	2.4	8.0	19.2
1935	40.1	30.2	1,210.2	12.4	23.2	288.7	4.6	12.5	57.6
1936	33.7	23.6	792.6	8.3	17.7	147.7	2.8	10.8	30.3
1937	35.5	33.1	1,176.7	10.0	22.3	221.9	4.9	14.2	69.9
1938	36.0	30.2	1,089.4	10.6	24.2	256.6	4.7	14.3	67.2
1939	33.5	28.6	957.7	12.7	21.8	278.2	4.8	11.2	53.3
1940	35.4	35.2	1,246.5	13.5	23.0	311.3	6.4	13.5	85.8
1941	38.2	31.0	1,182.5	14.3	25.4	362.6	6.0	18.9	113.5
1942	38.2	35.2	1,342.7	17.0	25.3	429.5	6.0	18.3	109.7
1943	38.9	29.3	1,139.8	14.9	21.7	322.9	6.9	15.9	109.5
1944	39.7	28.9	1,149.2	12.3	22.5	276.3	9.4	19.7	185.0
1945	41.7	36.5	1,523.9	10.5	25.5	267.0	6.3	15.2	96.1
1946	42.8	34.5	1,477.6	10.4	25.5	265.1	6.7	15.9	106.0
1947	37.9	31.1	1,176.1	11.0	25.7	281.9	5.5	17.0	93.2
1948	39.3	36.9	1,450.2	11.9	26.5	315.5	7.3	18.0	131.4
1949	39.2	32.0	1,254.9	9.9	24.0	237.1	6.6	22.5	148.3
1950	40.7	34.6	1,410.5	11.2	27.2	303.5	10.3	22.6	223.3
1951	36.5	36.2	1,321.3	9.4	26.9	254.3	8.5	18.9	160.2
1952[2]	38.6	32.8	1,268.3	8.3	27.5	227.0	5.1	16.4	83.3

[1] Computed from unrounded data.

[2] Preliminary.

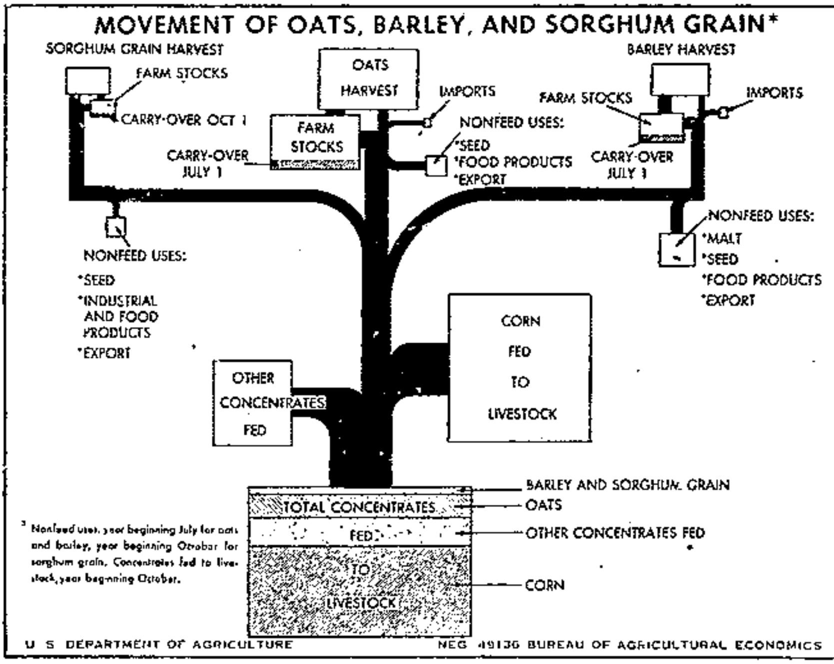

Figure 2.—In 1946-50, 89 percent of the oat crop, 50 percent of the barley crop, and 57 percent of the sorghum grains crop were fed to livestock. The remainder was utilized for various food and industrial products and for export.

slightly more than a fifth of the total concentrates fed to livestock, the percentage ranging from 14 percent in 1933 to 24 percent in 1940. The relative position of each grain, however, was less constant than was the aggregate total. Oats consistently held its position whereas sorghum grains increased in importance and barley decreased.

Nonfeed Uses

Varying quantities of the remaining supply of these grains are utilized in breakfast foods, malt, and flour; for the manufacture of alcohol, alcoholic beverages, and starch; for export; and for seed. Barley has the largest percentage utilization for domestic nonfeed purposes of any feed grain. Its largest use is for production of malt. A small quantity of barley is used in prepared baby foods and in the manufacture of pearled barley. The principal nonfeed use of oats, other than for seed, is for breakfast foods. A small quantity of oats is used in making oatmeal crackers and cookies. Before 1942, practically all of the sorghum grains produced was fed; since then, its use for alcohol and other industrial products has steadily increased. Since World War II, exports have increased in importance. Food uses are relatively unimportant in the disposition of the crop, although

TABLE 2.—*Oats, barley, and sorghum grains: Relative feeding value compared with corn when fed to different kinds of livestock* [1]

Grain	Kind of livestock							
	Dairy cows	Fattening cattle	Wintering beef cattle	Hogs	Fattening lambs	Horses and mules	Poultry	Average
	Percent	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
Corn	100	100	100	100	100	100	100	100
Oats	95	85	100	85	90	90	75	90
Barley	100	88	100	91	87	95	80	95
Sorghum grains	100	92	100	90	100	95	105	100

[1] From Jennings (*12*).

the quantity used for food has been increased by the opening at Corpus Christi, Tex., of a wet-processing plan which produces starch and starch products.

Normally the United States is a net exporter of feed grains. Although the quantity varies greatly from year to year, in recent years exports have accounted for a substantial part of the total utilization of barley and sorghum grains. Exports of oats usually are quite small. In general, the years in which imports of these grains exceeded exports were either drought years or years such as 1943-45 in which unusual conditions of demand existed, and 1949-51 so far as oats are concerned.

Nonfeed uses are discussed in greater detail under each grain.

Price Relationships Among the Several Feed Grains

As with other farm products, prices of oats, barley, and sorghum grains fluctuate from year-to-year, month-to-month, day-to-day, and even hour-to-hour. To the uninitiated, these gyrations or fluctuations in price over time may not appear to bear any relation to each other nor to have any apparent causal factors, particularly in the shorter periods of time. Those familiar with agricultural prices often assign the cause to changes in the general level of supply and demand. This is an oversimplification. In general, variations in prices may result from the following factors: (1) Variations caused by differences in grade and location, (2) normal seasonal variation, and (3) changes in general conditions of supply and demand. Of these factors, demand is the most difficult to define and measure. For this reason, greater stress is placed in this bulletin upon analysis of changes in demand as they affect price in the period of time studied.

Demand for these grains is derived from the demand for the end products in which they are utilized. For example, the demand for barley is primarily the sum of demands for its use as feed for livestock and for products in which malt is used. Secondary demands, such as those for export and storage, are also important. Further complicating the problem is the fact that demand may increase or decrease because of changes in the prices of substitute grains, such as corn and oats, both of which compete in the feed market with barley.

In the aggregate, prices of feed are determined by forces with which most agriculturists are familiar—the levels of feed supplies, the number of animal units fed, and the prices of livestock and livestock products. These relationships are illustrated in figure 3.[3] The physical items are shown in boxes; the economic items, in circles. Arrows indicate the direction of the causal effects. Most of the variation in prices of feed grains can be explained by variations in the above variables. For 1921-42, Foote, Klein, and Clough (*8*, pp. 36–39) found that more than 90 percent of the variation in prices of corn could be explained by these variables. As the index of feed-grain prices is closely correlated with prices

[3] For a detailed discussion of the economic implications of this diagram, see Foote, Klein, and Clough (*8*, pp. 20–30).

of corn, much of the variation in the index may be explained by the same variables. When simple correlation analyses were run between the price of corn and prices of oats, barley, and sorghum grains, respectively, the degree of association, as measured by the coefficient of determination in each analysis, was more than 0.80.[4] Therefore, the same variables that would explain variations in either the index of feed-grain prices or prices of corn also would explain most of the variation in the prices of oats, barley, and sorghum grains.

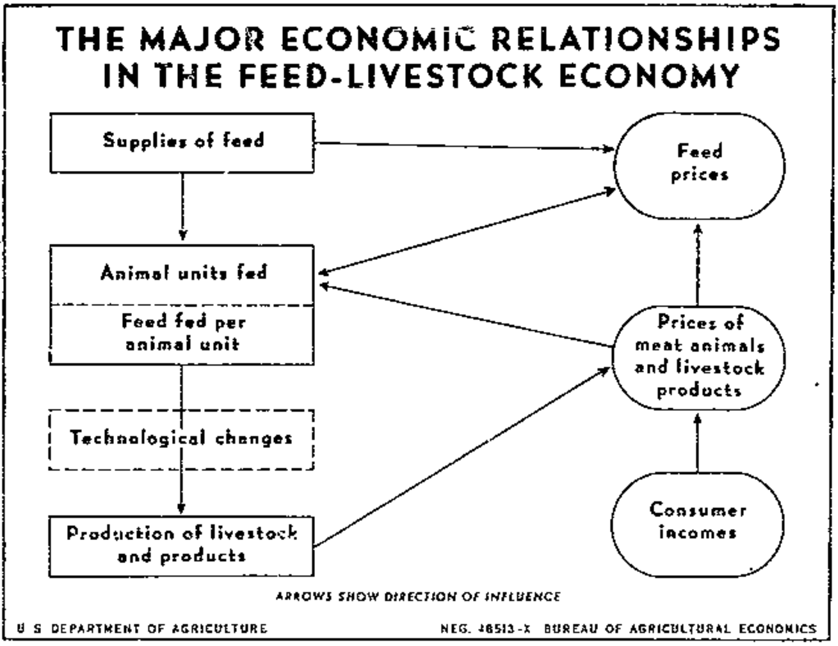

FIGURE 3.—Supplies of feed, animal units fed, and prices of feed and livestock and livestock products are closely related. This diagram indicates the basic nature of these relationships.

In the sections devoted to statistical analyses of factors that affect the prices of oats and barley during their heavy marketing periods, essentially the same variables are used. The one exception is that the supplies of competing grains are weighted according to their importance as determined by a multiple-regression analysis on price after the effect of livestock prices and animal units fed have been taken into account. The sum of the weighted supply factors is used as the supply variable. Animal production units and the index of prices of livestock and livestock products are used as joint factors of demand. For the period November to May, factors that cause deviations from the price of corn are discussed. The heavy marketing period for sorghum grains approximately coincides with that of corn. For this reason the

[4] Foote, Klein, and Clough (*8*, p. 48).

discussion of prices of sorghum grains is limited to explaining deviations from the price of corn.

In attempting to explain deviations of the price of a particular feed grain from the price of corn, several methods of analysis are open to an investigator. The price of sorghum grains, for example, may be expressed as a ratio to the price of corn. This price ratio then becomes the dependent variable and factors that will explain variations in the ratio may be sought. Under this method the problem is not to explain or determine causes of variations in the absolute or actual price but to explain changes in relative prices.

An alternate method involves use of the price of sorghum grains as the dependent variable, the price of corn as the principal independent variable, and other factors—such as relative supplies—that are believed to affect the price of sorghum grains as the remaining independent variables. The inference here is that the price of corn is a basic factor influencing prices of sorghum grains. Many price analysts have used this approach in studying prices of the minor feed grains. For example, Bennett expressed the price of ground oats at Utica, N. Y., in terms of the price of cornmeal and the relative supplies of corn and oats. He says: "For the most part, the price of corn affected the price of oats, although probably the oats price affected the corn price slightly. This is because corn has been about 4 times as important a feed in the United States as oats" (*2*, p. 55). Shepherd also says that "Fluctuations in oats values are a result, not a cause, of fluctuations in corn values" (*19*, p. 310).

This interrelationship of feed prices, coupled with the fact that the three minor feed grains are dominated by corn, makes analysis of a particular grain difficult. The relationship is further obscured by the fact that changes in the supply of one frequently is in the same direction as the others. The closeness of the relationship of prices of the four feed grains is a function of the extent to which they can be substituted for one another. Clearly if these grains were perfect substitutes, that is, if they were identical in time. form, and location, no deviations in price could be expected. This is not the case. Factors that affect actual and relative prices are discussed in detail in subsequent sections.

SPECIAL FACTORS THAT AFFECT THE PRICE OF OATS

The importance of oats as a feed grain has been reflected in the studies of price and demand that have been devoted to this grain. The more important investigations of the prices of oats include those by Moore (*14*) in 1914, Killough (*13*) in 1925, Warren and Pearson (*26*) in 1928, Schultz (*17*) in 1938, and Bennett (*2*) in 1944.

Economic Importance of Oats Other Than As A Grain

The importance of oats in our agricultural economy is not indicated by the returns per acre that farmers receive for this grain. In this sense, oats are relatively unprofitable. In many years they may be produced at an apparent loss. The inducement for producing oats lies not so much in their cash value as in their value to farmers in their crop rotation systems. The factors that account for the general preference for oats over other small grains in rotations in many areas are: (1) The yield of oats is less influenced by the preceding crop than is the yield of such crops as wheat and barley; (2) oats are a good nurse crop for grasses and legumes; and (3) labor requirements for this crop do not conflict with demands for labor by corn and some other crops. Also oat straw is valuable as roughage for livestock. Because of its greater palatability and softer texture, it is generally considered superior for this purpose to barley or wheat straw.

Relative Variability of Specified Disposition Items

The supply and distribution of oats from 1926 to 1951 may be seen in table 3. Quantities used for feed, stocks, and export show larger year-to-year fluctuations than do quantities used for seed or in the manufacture of breakfast foods and other food products.

The four sections in figure 4 show the relationship between prices of oats, after adjusting them for the general price level, and the quantities of oats used for feed, storage, net exports, and breakfast foods and seed. The quantity of oats used for breakfast foods and seed is related hardly at all to the price of oats. This is not unreasonable, as oats used for food are relatively cheap in relation to other foods even when the price of oats is unusually high. Nor is the demand for oats as seed influenced to any great extent by variations in the price of oats. Exports also appear to be affected significantly by factors other than domestic price.

But when the price of oats is relatively high, use of the grain for feed declines, and when the price is relatively low, its use for feed increases. This is true also for ending stocks. As feed uses represent about 75 percent of the total disposition of oats, the principal factors that affect the price of oats are those connected with the feed-livestock economy. The total demand for oats can be thought of as a combination of the demands for feed, for domestic nonfeed uses, for storage, and for export.

Exports of oats normally are small, both in relation to the size of the crop and to exports of other feed grains. The lesser importance of oats in international trade is largely explained by the fact that oats are less valuable by volume than are other feed grains. During the interwar period, the United States was normally a net exporter except in years of short crops. In 1939-51, however, this pattern changed. In every crop year except 1941, 1946, and 1947 imports exceeded exports. This is in contrast to corn, barley, and sorghum grains, whose exports continued to exceed imports by substantial margins.

The physical composition of oats relative to that of corn, sorghum grains, and barley prohibits use of oats for production of alcohol and starch. As a result, industrial utilization of oats is negligible.

TABLE 3.—*Oats: Supply and disposition, United States, 1926–52*

Year beginning July	Supply: Carry-over, July 1[1]	Supply: Production	Supply: Imports[2]	Supply: Total supply[3]	Disposition: Breakfast foods[4]	Disposition: Seed	Disposition: Feed, other uses, and waste[5]	Disposition: Exports[6]	Disposition: Domestic disappearance[3]
	Million bushels	*Million bushels*	*Million bushels*	*Million bushels*	*Million bushels*	*Million bushels*	*Million bushels*	*Million bushels*	*Million bushels*
1926	259	1,153	(7)	1,412	41	95	1,092	[8] 9	1,229
1927	171	1,093	(7)	1,265	45	95	1,002	[8] 6	1,137
1928	118	1,313	(7)	1,431	42	95	1,095	11	1,227
1929	188	1,113	(7)	1,301	42	100	997	5	1,139
1930	157	1,275	1	1,432	45	105	1,105	1	1,255
1931	177	1,124	(7)	1,301	41	107	995	2	1,144
1932	153	1,255	(7)	1,407	38	103	1,028	4	1,168
1933	234	736	(7)	971	34	95	711	(7)	839
1934	130	544	16	690	31	102	478	(7)	610
1935	79	1,210	(7)	1,289	29	99	880	1	1,007
1936	281	793	(7)	1,073	28	94	861	(7)	982
1937	91	1,177	(7)	1,267	28	93	927	11	1,047
1938	209	1,089	1	1,299	29	90	980	4	1,099
1939	196	958	11	1,164	30	92	894	(7)	1,015
1940	148	1,246	10	1,405	31	98	1,052	(7)	1,180
1941	223	1,183	1	1,407	31	102	1,076	1	1,208
1942	194	1,343	59	1,596	41	103	1,208	(7)	1,352
1943	250	1,149	81	1,480	41	105	1,123	(7)	1,269
1944	208	1,149	69	1,426	46	110	1,036	(7)	1,187
1945	234	1,524	24	1,782	48	111	1,315	18	1,474
1946	290	1,478	1	1,769	44	100	1,331	[9] 20	1,475
1947	274	1,176	2	1,452	44	104	1,110	[9] 11	1,249
1948	182	1,450	19	1,651	40	103	1,200	[9] 18	1,339
1949	290	1,255	20	1,565	37	110	1,195	[9] 12	1,338
1950	211	1,410	30	1,652	38	100	1,218	[9] 3	1,353
1951	202	1,321	62	1,675	38	101	1,249	[9] 2	1,388
1952[10]	283	1,268	[11] 75	1,626					

[1] Farm and terminal market stocks only prior to 1943.
[2] Includes grain-equivalent of oatmeal.
[3] Computed from unrounded numbers.
[4] Used in production of oatmeal and other cereal preparations.
[5] Residual.
[6] Grain only.
[7] Less than 500,000 bushels.
[8] Includes re-exports.
[9] Includes exports for military relief feeding abroad.
[10] Preliminary.
[11] Partly estimated.

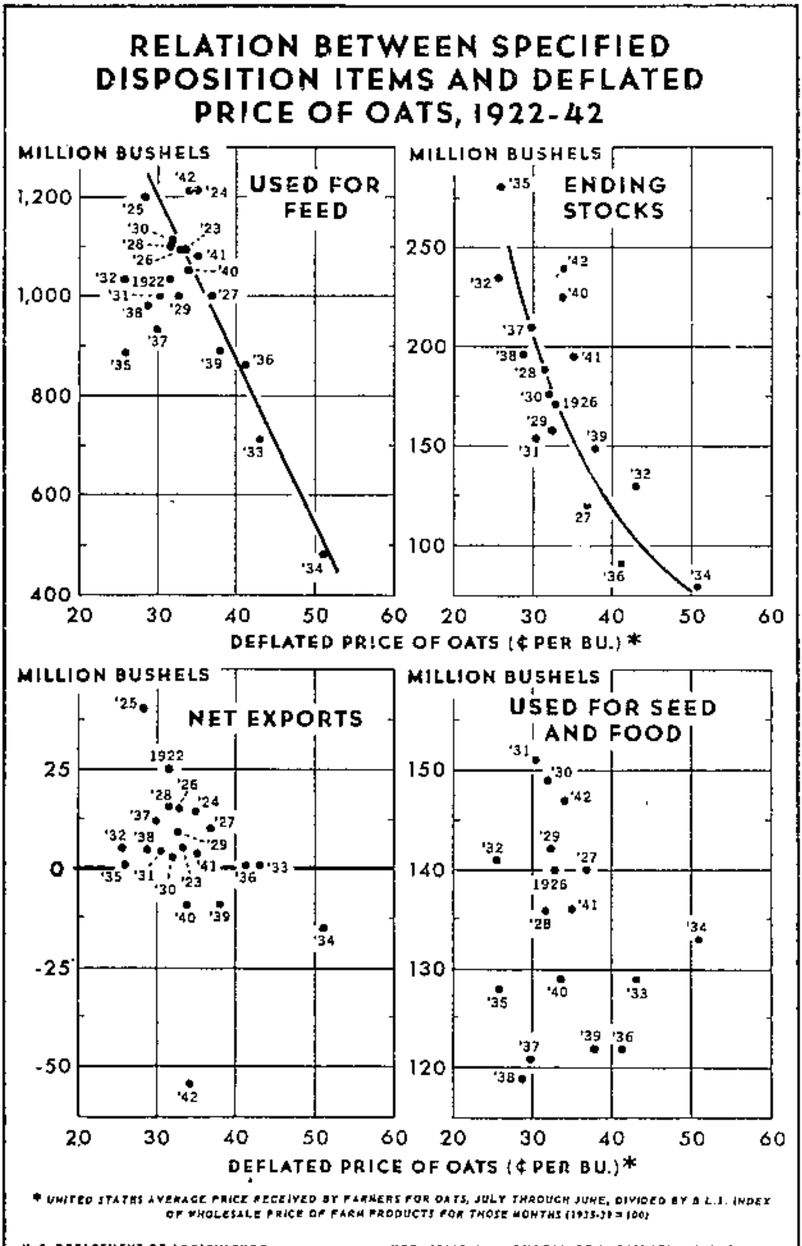

FIGURE 4.—Use of oats for feed apparently varies to some extent with its price; it is large when prices are relatively low and small when prices are relatively high. Ending stocks show a similar relationship. Use of oats for seed and food, and in most years for export, is only slightly related to price.

Long-Term Changes in Demand for Oats for Feeding

Oats long have been considered the premium feed for horses and mules—the standard with which other feeds are usually compared. The decline in numbers of horses and mules on farms in the United States poses the question: Has the total demand for oats declined?

Many agricultural analysts have answered this question in the affirmative. To quote a few: T. W. Schultz says: "Oats are usually considered the ideal horse feed; but as the influx of tractors, automobiles, and trucks has reduced the number of horses and mules about a fourth since 1920, the demand for oats has consequently declined" (*18*, p. 46). Burtis adds: "With the decline in numbers of horses on farms, the demand for oats was reduced . . ." (*4*, p. 87). But Bennett says: "Those who insist on the necessity of large numbers of horses as a market for oats overlook the fact that oats are probably as valuable for feeding other kind of livestock as for feeding horses" (*2*, p. 52). Stanton says: "The use of the automobile and the tractor has greatly decreased the demand for oats as horse feed. However, that portion of the crop formerly consumed by horses now is being fed, at least in part, to young stock and dairy cattle" (*21*, p. 2).

The number of horses and mules on farms reached a peak in the 1910 decade and has since declined steadily. During that decade, the number of horses and mules on farms on January 1 averaged 26 million. In the 1940 decade the average was 11 million, a decline of 58 percent. If the demand for oats as a superior feed for horses and mules were a major part of the total demand, either the supply of oats would decline with the decline in the number of horses and mules, or the price of oats relative to corn would be expected to decline. That the decline in numbers of workstock has affected the demand for all feed cannot be denied, but that it chiefly has affected the demand for oats is not borne out by existing data on prices and supply.

A statistical test commonly used to determine whether the mean of one group of observations differs significantly from the mean of another was used to find whether oats declined in value relative to corn between 1910-20 and 1940-50. The mean of the price ratios for the November to May average farm price per bushel of corn and oats in 1910–20 was compared with the mean for 1940-50. The mean ratios for these two periods were similar—60.2 and 61.2 respectively. The difference is not statistically significant.

Figure 5 shows the November to May average farm price of a bushel of oats relative to the November to May farm price of a bushel of corn, and the supply of oats (production plus July 1 stocks plus imports) relative to the supply of corn (production plus October 1 stocks plus imports) for 1910–51. This chart indicates that, in addition to a cyclical pattern, the value of oats relative to that of corn has fluctuated from year to year, but that no significant long-term change in the price ratio has occurred. The chart also indicates that changes in the relative price of oats are associated with changes in the relative supplies of oats. This relationship is discussed in greater detail in the section devoted to statistical analyses of factors that cause the price of oats to deviate from the price of corn from November to May.

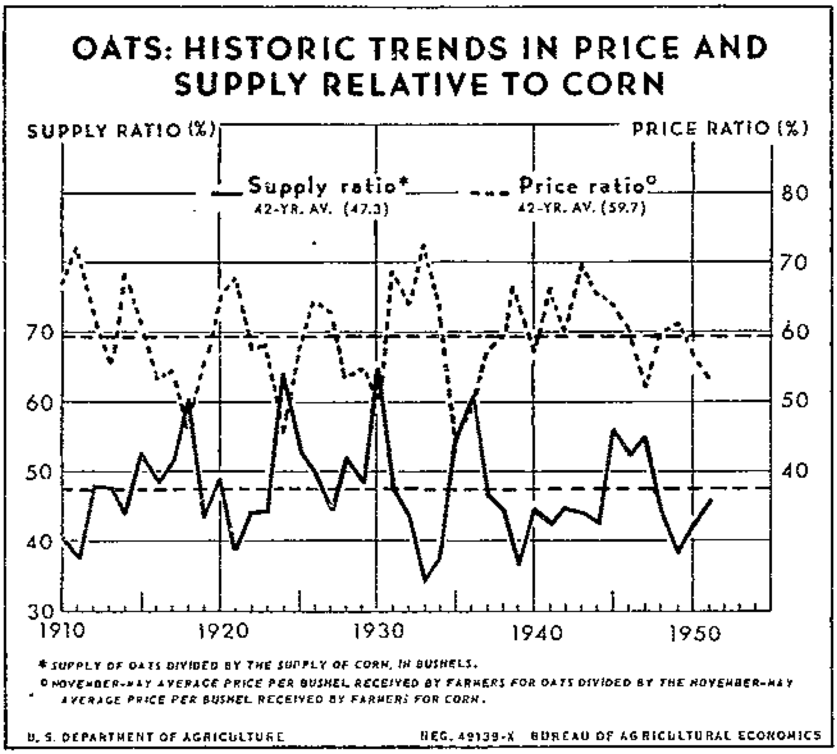

FIGURE 5.—The long-term relationships shown here confirm the analysis of trends in price and supply of oats relative to corn which indicated that the effect of the decline in numbers of horses and mules on farms on the demand for oats has been largely offset by an increase in demand for other uses.

STATISTICAL ANALYSES OF FACTORS THAT AFFECT PRICES FROM JULY TO OCTOBER

In an earlier section we learned that prices of feed are mainly determined by the three factors: Supplies of feed, animal units fed, and prices of livestock and livestock products. As prices of oats are closely associated with the index of feed prices, the same variables can be expected to explain most of the variations in prices of oats. The principal problem that arises in analyzing any particular feed grain is how to treat the supply variable. From July to October, the bulk of the oat crop is marketed, new-crop barley can be fed, and the prospective size of the new corn crop begins to influence prices. Existing supplies of old-crop corn, which can be represented approximately by July 1 stocks, are also important. The problem is essentially statistical—How to weight these various components of the supply variable?

The method used in ascertaining the appropriate weights is identical with the method used by Foote (*7*) in an analogous study of factors that affect the price of corn from June to September. Essentially this method involves relating the price of oats, after adjusting for the effects of animal units fed and prices of livestock and livestock products, to the various supply components which are believed to affect the price of oats. The final regression coefficients obtained from a series of iterative analyses are used to obtain weights for the components of the supply variable.

Based on this multiple-regression analysis, the following weights apply (after converting each variable to million tons): 0.19 times July 1 stocks of corn, excluding stocks under loan or owned by the Commodity Credit Corporation on the following October 1; plus 0.24 times an average of the July 1, August 1, and September 1 Crop Reporting Board estimates of the size of the new corn crop; plus 0.57 times the supply (July 1 stocks plus production) of oats, excluding stocks under loan or owned by CCC on October 1. The supply of barley did not influence significantly the price of oats and therefore it is not included in the composite supply variable. This variable is designed to give an estimate of the "free" supplies of feed available for feeding during this period, and also to allow for indicated price-making effects of the prospective new crop of corn.

These regression coefficients (weights) were tested statistically to learn whether they differed significantly from each other.[5] The differences were found to be significant at about the 13-percent level; that is, differences as large as were obtained would be expected to occur about 13 times in 100 if the regression coefficients were in fact equal. Many research workers require a level of significance of 5 percent or less, but this method of weighting the components of the supply factor was retained as the weights appeared logical.

As the animal-units-fed series is not available by quarters, the series given in Jennings (*11*) on livestock production units was used instead. Based on the analysis by Foote (*7*), data for the July-September and the October-December quarters were combined with equal weights. The third independent variable used in the analysis was an average of the index numbers of prices received by farmers for livestock and livestock products for July to October.

Of the total year-to-year variation in the price of oats, 77 percent was associated with variations in these variables. This figure is nearly identical with that obtained by Foote in his analysis of factors affecting the price of corn from June to

[5] For a description of this test, see Foote (*7*).

September, using similar variables. This accords with the thesis that particular prices of feed grains are determined by similar factors. The low percentage explained in both these analyses (and for barley in a later section) for this season is typical of feed grains. Statistical analyses for other seasons, particularly from November to May, yield more refined results. To some extent this is accounted for by changing prospects of new-crop corn, which are not fully compensated for by the variables included. Also, in years of small carryover, the prospect of large crops for the year does not influence price to the same extent that it does when year-end stocks are large. In years of short supplies particularly, variations in nonfeed demands may affect significantly the price during the last quarter of the marketing year. No allowance was made for these factors in the analyses.

The analysis was based on year-to-year change, after converting all of the data to logarithms. The effects of specified percentage changes from the preceding year of each of the independent factors on prices of oats are shown in table 4. The range shown for each variable is approximately equal to the range from 1922 to 1951. Data on which the analysis was based are found in table 5. If the effects of all three factors on the price of oats are desired, they can be determined by multiplying the separate ratios together. The final result should be multiplied by 0.981 to allow for the average shift in demand over time.

For example, suppose the weighted supply variable is expected to be 20 percent above that of the preceding year, prices of livestock and products 10 percent above, and livestock production units 5 percent above. Then the analysis indicates that the price of oats would be expected to be roughly 21 percent below the preceding year, based on these three factors. This percentage is obtained in the following computations:

$$0.69 \times 1.10 \times 1.06 \times 0.981 \times 100 = 79 \qquad 100 - 79 = 21.$$

When the percentage change from the preceding year, as indicated by table 4, is multiplied by the actual price in the preceding year, to estimate the expected price in the year for which the forecast is made, there is a 65- to 70-percent chance that the estimated price will differ from the actual price by not more than 18 percent, and a 95-percent chance that it will differ by not more than 40 percent.

Figure 6 shows the price of oats, adjusted for the remaining variables, against each of the independent variables in turn. Data for 1922–42 used in the analysis are shown as dots and data for the war and postwar years as x's. Each section shows the relevant partial regression curve, based on a mathematical analysis. The curvilinear nature of these reflects the fact that the analysis was based on logarithms. The graph in the lowest section of the chart shows the result obtained when the unexplained residuals were plotted against time. This section of the chart indicates that no significant change in the nature of the relationships has taken place over time.

TABLE 4.—*Oats: Relation between year-to-year changes in July-to-October prices received by farmers and a specified supply variable, July-to-October prices of livestock and livestock products, and July-to-December units of livestock production on farms* [1]

RATIO TO PRECEDING YEAR

X_0' Estimated price of oats [2]	X_1 Supply variable [3]	X_0' Estimated price of oats [2]	X_2 Prices of livestock and livestock products [4]	X_0' Estimated price of oats [2]	X_3 Production of livestock [5]
2.08	0.70	0.71	0.70	....	....
1.82	.75	.76	.75	....	....
1.58	.80	.80	.80	0.76	0.80
1.41	.85	.85	.85	.82	.85
1.24	.90	.90	.90	.87	.90
1.12	.95	.95	.95	.94	.95
1.00	1.00	1.00	1.00	1.00	1.00
.92	1.05	1.05	1.05	1.06	1.05
.82	1.10	1.10	1.10	1.13	1.10
.76	1.15	1.15	1.15	1.19	1.15
.69	1.20	1.20	1.20	....	....
.64	1.25	1.25	1.25	....	....
.58	1.30	1.29	1.30	....	....
.55	1.35	1.34	1.35	....	....
.50	1.40	....	....	....	....

[1] When the other independent variables in the analysis remain at the previous year's level. From an analysis based on first-differences of logarithms, 1922–42.

[2] Computed from the following equation when all variables are expressed as first-differences of logarithms:

$$X_0' = -0.0083 - 2.0377X_1 + 0.9832X_2 + 1.2527X_3$$

The following values also relate to this analysis:

$s_{b_{01.23}} = 0.287$	$s_{0.123} = 0.073$	$r^2_{03.12} = 0.194$
$s_{b_{02.13}} = .246$	$r^2_{01.23} = .748$	$R^2_{0.123} = .769$
$s_{b_{03.12}} = .618$	$r^2_{02.13} = .485$	

NOTE.—The constant value in the regression equation does not differ significantly from zero.

[3] See text for method of obtaining this series.

[4] Index numbers of prices received by farmers for livestock and livestock products (1910–14 = 100).

[5] From Jennings (*11*), livestock production in terms of production units.

DEMAND ELASTICITY.—The elasticity of demand is a coefficient which measures the percentage change in consumption that is related to a given change in price. This coefficient can be estimated by taking the reciprocal of the price flexibility as shown by an analysis in which prices are used as the dependent variable. This economic concept of elasticity is important. If the demand for a product is elastic (if it has an elasticity greater than 1), the total value received from a given quantity marketed will increase as the quantity marketed increases. If the demand is inelastic (if

TABLE 5.—*Oats: Actual and computed prices per bushel and related variables, 1921–51*

Year	Price (July to October)		X_1 Supply[2]	X_2 Price received by farmers for livestock and products (July to October)[3]	X_3 Units of livestock production (July to December)[4]
	Actual X_0	Computed[1] X_0'			
	Cents	*Cents*	*Million tons*		*Millions*
1921	31.9	....	37.0	122.5	....
1922	34.9	38.2	34.7	125.0	....
1923	38.8	35.2	34.4	126.8	....
1924	48.6	38.9	33.3	128.5	79.1
1925	40.3	46.2	36.4	151.3	78.6
1926	37.6	48.0	33.5	150.3	80.5
1927	44.8	46.6	30.0	143.3	84.4
1928	42.6	37.1	34.1	161.8	82.2
1929	43.6	47.9	31.6	159.8	81.9
1930	34.9	36.4	30.6	127.3	81.7
1931	20.8	23.8	32.5	94.5	85.2
1932	15.0	13.5	35.1	73.8	84.3
1933	32.9	23.2	28.1	74.8	83.6
1934	46.8	54.9	20.6	85.5	69.7
1935	28.0	34.6	27.4	115.0	69.8
1936	41.2	43.1	23.4	119.3	75.3
1937	32.2	26.0	29.8	130.0	73.5
1938	22.1	25.4	31.9	111.8	77.7
1939	28.4	25.3	30.7	106.3	85.9
1940	27.6	27.6	30.9	110.0	83.9
1941	36.0	34.6	32.9	147.5	89.6
1942	43.3	41.0	36.3	177.0	102.6
1943	68.7	54.6	36.1	198.3	114.3
1944	69.3	55.3	35.6	193.3	97.3
1945	61.5	63.4	39.3	211.0	100.5
1946	78.2	60.3	41.7	258.3	94.7
1947	101.0	125.3	34.4	294.0	92.2
1948	73.5	78.3	40.4	330.0	90.9
1949	60.0	59.5	41.9	272.5	96.1
1950	73.3	71.6	39.9	293.3	98.1
1951	78.4	85.0	40.3	336.3	102.4

[1] Computed from the equation shown in footnote 2, table 4.
[2] See text for components of supply variable and weights assigned.
[3] Index numbers, 1910–14 = 100.
[4] From Jennings (*11*).

it has an elasticity less than 1), the total value decreases as the quantity marketed increases. If the elasticity of demand is 1, or unit elastic, the total value remains constant as marketings vary.

In the above multiple-regression analysis, a 2.0-percent change in the price of oats was associated with a 1-percent change in the opposite direction in the weighted supply variable. The reciprocal of this price flexibility yields a figure of —0.5, indicating an inelastic demand for oats.[6] This coefficient, however, does not represent the "true" elasticity of demand for oats, as the supply variable is a composite containing other feed supplies. It may

[6] Schultz (*17*, p. 461) indicates that the elasticity of demand for oats is between —0.5 and —0.6.

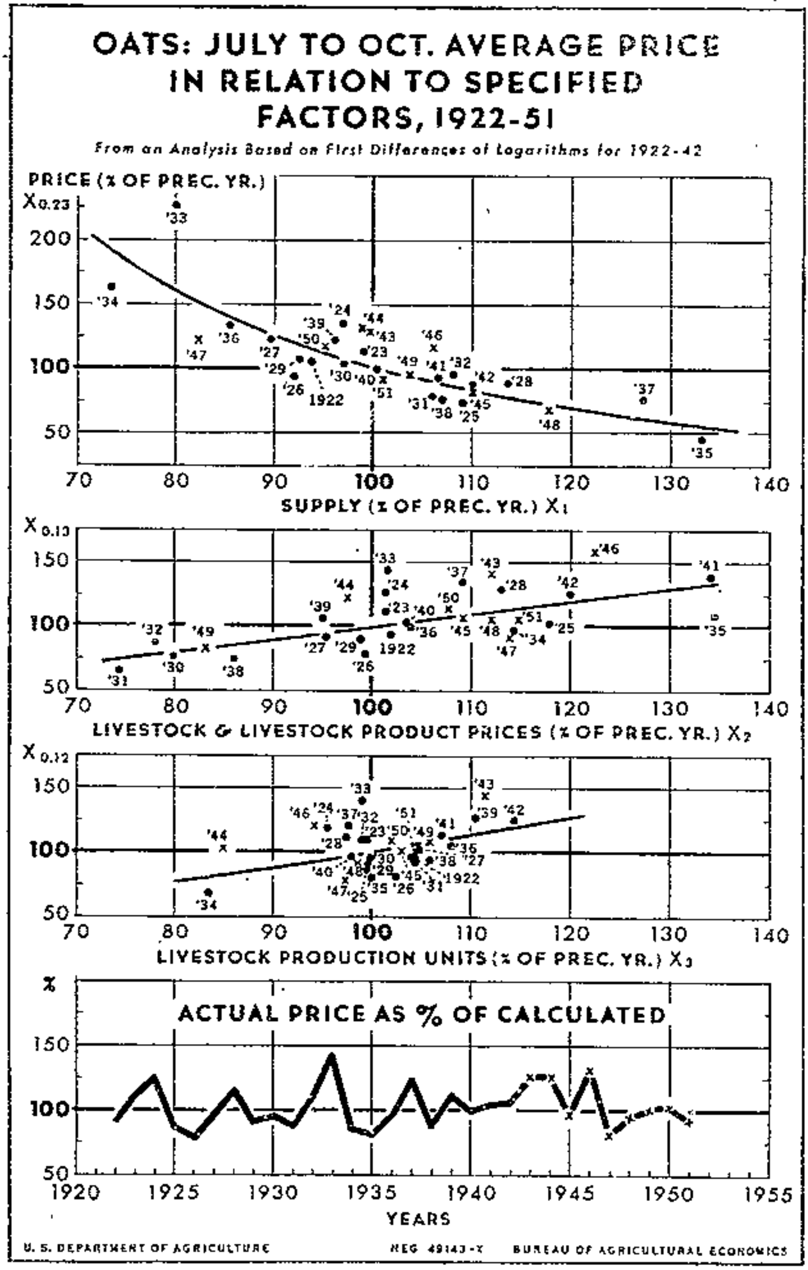

FIGURE 6.—The three factors—weighted supply of feed grains, prices of livestock and livestock products, and units of livestock production—explained 77 percent of the year-to-year variation in the price of oats in 1922-42. Apparently these relationships have remained unchanged since the end of World War II.

represent essentially the demand elasticity for total feed grains. The true elasticity for oats alone probably would be higher. It would reflect the elasticity of demand for feed as such, plus the elasticity of substitution of oats for other feeds.

The relationship between price and the supply variable discussed above applies only if there is no change in units of livestock production or in prices of livestock and livestock products. In practice, the number of animal units fed tends to respond to a change in supplies of feed. This response comes about more quickly than does the resulting change in livestock prices, as a lag occurs between the time feed is fed and the time the livestock products produced therefrom are sold. Thus, over a period of a few months, the demand for oats and other feed grains probably is more elastic than is indicated above. Over a longer period, the effects of the change in animal units on the price may be about offset by the opposite effects of the change in livestock prices.

Statistical Analyses of Factors that Cause Deviations from Prices of Corn from November to May

Over the years, the ratio of the price of a bushel of oats to the price of a bushel of corn has been rather constant. When the November to May average farm price of oats was compared with the November to May average farm price of corn for 1921–42, the price of oats, on the average, was 59 percent of the price of corn. This ratio fluctuated from a low of 0.46 in 1924 to a high of 0.73 in 1933. The question that arises is: Why is a bushel of oats relative to corn worth different amounts in different years?

This ratio is not equal to that which would be obtained by comparing calendar-year prices or in comparing months other than November to May. Seasonal variations in prices occur for both corn and oats. Unless adjustment is made for this, the price ratio for any given set of months will deviate from the ratio for a full year to the extent that the seasonal variation between the prices of corn and of oats differs. For November to May, corn is seasonally low in price while oats are seasonally high; therefore, the 1921–42 average November to May price ratio of 0.59 is higher than the average annual ratio for the same years.

The most logical variable to use in explaining these variations in the price ratio is the supply of oats relative to the supply of corn. When the price of oats is high relative to that of corn, the supply of oats relative to the supply of corn would be expected to be low. Results of the analysis relating the price ratio to the supply ratio show that from 1922 to 1942, 77 percent of the year-to-year variation in the price ratio was associated with variation in the supply ratio.

When the price of oats is expressed as a function of the price of corn and the supply ratio for the same years, the analysis shows that 96 percent of the year-to-year variation in the price of oats is associated with variations in these two variables. Variations in the price of corn are associated with 84 percent of the variation in the price of oats; the addition of the supply ratio to the analysis brings this percentage to 96.

Both analyses were based on first differences of logarithms. Table 6 contains the data used in these analyses. The variables used in the two methods were as follows:

Method 1:

X_0—Ratio of the November to May price per bushel received by farmers for oats to the November to May price per bushel received by farmers for corn.

X_1—Ratio of the supply of oats (production plus July 1 stocks plus imports) to the supply of corn (production plus October 1 stocks plus imports).

Method 2:

X_0—Price per bushel received by farmers for oats, average for November to May.

X_1—Price per bushel received by farmers for corn, average for November to May.

X_2—Same as X_1 in method 1.

There are two objections to using method 2 in forecasting actual prices of oats: (1) The price of corn must first be forecast and (2) relating a price of one commodity to that of a close substitute does not take into consideration the basic factors that influence the prices of both commodities. Both these criticisms may be avoided by substituting for the price of corn in this equation the coefficients obtained by Foote (7) in his analysis of factors that affect the price of corn from November to May. Before substituting these coefficients in the equation

$$X_0 = -0.0007 + 0.982X_1 - 0.717X_2$$

the constant value is omitted as it does not differ significantly from 0 and the regression coefficient for X_1 of 0.982 is changed to 1 as it does not differ significantly from one.[7] The coefficients obtained by Foote are now substituted and the equation reads

$$X_0 = 0.004 - 2.36X_1 + 1.94X_2 + 1.13X_3 - 0.717X_4$$

where X_1 is the supply of feed concentrates, X_2 the number of grain-consuming animal units, X_3 the index of prices of livestock and livestock products, and X_4 the supply of oats relative to the supply of corn. November to May average prices computed from this equation are shown in the second column in table 6.

The effects of specified ratios to the preceding year of each of these independent factors on prices of oats are shown in table 7. The range shown for each variable is approximately equal to that which prevailed from 1922 to 1951. The effects of all four factors on prices of oats can be determined by multiplying the separate ratios together. The final result should be multipled by 1.004 to allow for the average shift in demand over time. For an example of such a computation see page 25.

For method 1, the effects of specified ratios to the preceding year of the supply ratio on the price ratio are essentially the same as shown in the last two columns in table 7 for actual prices. The percentage change from the preceding year, as indicated by the last two columns in table 7, can be multiplied by the actual price ratio in the preceding year to give an estimate of the expected price ratio in the year for which a forecast is being made. There is a 65- to 70-percent chance that the estimated price ratio will

[7] The following statistical coefficients were obtained from this analysis:

$s_{0.12} = 0.035$	$s_{b_{02.1}} = 0.095$	$r^2_{01.2} = 0.961$
$s_{b_{01.2}} = 0.047$	$R^2_{0.12} = 0.961$	$r^2_{02.1} = 0.758$

TABLE 6.—*Oats and corn: Average price per bushel received by farmers and supply, 1921–52*

Year beginning November	Price (November to May)					Supply		
	Oats		Corn	Percentage oats is of corn [2]		Oats, July 1 [4]	Corn, October 1, [5]	Percentage oats is of corn [2]
	Actual	Calculated [1]		Actual	Calculated [3]			
	Cents	*Cents*	*Cents*	*Percent*	*Percent*	*Million bushels*	*Million bushels*	*Percent*
1921	34	...	51	67	...	1,244	3,199	38.89
1922	42	47	73	58	62	1,260	2,870	43.90
1923	44	38	76	58	57	1,301	2,941	44.24
1924	49	46	108	46	44	1,483	2,314	64.09
1925	39	43	69	57	52	1,519	2,849	53.32
1926	43	48	66	64	59	1,412	2,831	49.88
1927	52	48	83	63	70	1,265	2,836	44.61
1928	44	47	83	53	56	1,431	2,760	51.85
1929	42	47	78	55	56	1,301	2,664	48.84
1930	31	29	60	51	45	1,432	2,221	64.48
1931	23	22	33	69	63	1,301	2,744	47.41
1932	15	16	23	64	73	1,407	3,201	43.96
1933	33	28	45	73	76	971	2,785	34.87
1934	53	76	83	64	68	690	1,824	37.83
1935	26	29	56	46	49	1,289	2,385	54.05
1936	51	44	106	49	43	1,073	1,785	60.11
1937	29	27	51	57	58	1,268	2,710	46.79
1938	26	29	44	59	59	1,299	2,911	44.62
1939	36	30	55	67	68	1,164	3,166	36.77
1940	33	34	58	57	58	1,405	3,146	44.66
1941	49	46	74	66	59	1,407	3,297	42.68
1942	54	57	90	60	64	1,596	3,560	44.83
1943	78	64	112	70	61	1,480	3,354	44.13
1944	71	75	107	66	71	1,426	3,325	42.89
1945	73	61	115	64	55	1,782	3,185	55.95

TABLE 6.—*Oats and corn: Average price per bushel received by farmers and supply, 1921–52*—Continued

Year beginning November	Price (November to May)					Supply		
	Oats		Corn	Percentage oats is of corn[2]		Oats, July 1 [4]	Corn October 1, [5]	Percentage oats is of corn[2]
	Actual	Calculated[1]		Actual	Calculated[3]			
	Cents	*Cents*	*Cents*	*Percent*	*Percent*	*Million bushels*	*Million bushels*	*Percent*
1946	83	91	138	60	67	1,769	3,389	52.20
1947	115	126	220	52	58	1,452	2,639	55.02
1948	72	79	120	60	61	1,651	3,729	44.27
1949	72	68	118	61	66	1,565	4,052	38.62
1950	88	93	155	57	57	1,652	3,904	42.32
1951	90	94	167	54	54	1,675	3,639	45.89
1952	80	....	147	54	....	[6]1,626	[6]3,794	[6]42.86

[1] Computed from the following equation when all variables are expressed as first differences of logarithms:

$$X_0' = (0.004 - 2.36X_1 + 1.94X_2 + 1.13X_3) - 0.717X_4.$$

Variables used in this equation are shown in table 7.

[2] When prices are expressed in cents per bushel. Percentage would be less if prices were expressed in dollars per ton.

[3] Computed from the following equation when all variables are expressed as first differences of logarithms:

$$\text{Price ratio} = -0.0003 - 0.7253X_1$$

where X_1 is the supply ratio.

[4] Stocks of oats on August 1, 1921-25, and on July 1, 1926 to date. Stocks in all positions, including interior mill, elevator, and warehouse stocks, 1943 to date.

[5] Stocks of corn on November 1, 1921-25, and on October 1, 1926 to date. Stocks in all positions, including interior mill, elevator, and warehouse stocks, 1943 to date.

[6] Preliminary.

TABLE 7.—*Oats: Relation between year-to-year changes in November to May prices received by farmers and supply of all feed concentrates, animal units fed during the year, November to May prices of livestock, and the supply of oats relative to the supply of corn* [1]

RATIO TO PRECEDING YEAR

X'_0 Estimated price of oats [2]	X_1 Supply of all feed concentrates	X'_0 Estimated price of oats [2]	X_2 Animal units fed during the year	X'_0 Estimated price of oats [2]	X_3 Prices of livestock [3]	X'_0 Estimated price of oats [4]	X_4 Supply of oats relative to that of corn
2.32	0.70	....	....	0.67	0.70	1.29	0.70
1.97	.75	....	....	.72	.75	1.23	.75
1.69	.80	....	....	.78	.80	1.17	.80
1.47	.85	0.73	0.85	.83	.85	1.12	.85
1.28	.90	.82	.90	.89	.90	1.08	.90
1.13	.95	.91	.95	.94	.95	1.04	.95
1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
.89	1.05	1.10	1.05	1.06	1.05	.97	1.05
.80	1.10	1.20	1.10	1.11	1.10	.93	1.10
.72	1.15	1.31	1.15	1.17	1.15	.91	1.15
.65	1.20	....	....	1.23	1.20	.88	1.20
.59	1.25	....	....	1.29	1.25	.85	1.25
.54	1.30	....	....	1.35	1.30	.83	1.30
.49	1.35	....	....	1.40	1.35	.81	1.35
.45	1.40	....	....	1.46	1.40	.79	1.40
....	....	....	....	....	....	.77	1.45

[1] When the other independent variables in the analysis remain at the previous year's level. From analyses based on first differences of logarithms, 1922–42.
[2] Based on an analysis by Foote (7). See text.
[3] Index numbers of prices received by farmers for livestock and livestock products (1910–14 = 100).
[4] Based on analyses described in the text.

differ from the actual price ratio by not more than 8 percent and a 95-percent chance that it will differ by not more than 17 percent. The following statistical coefficients relate to this analysis when all variables are converted to first differences of logarithms:

$$X_0 = -0.0003 - 0.725X_1{}^{5}$$

$$s_{0.1} = 0.034 \qquad s_{b_{01}} = 0.031 \qquad r^2_{01} = 0.771$$

where X_1 is the supply ratio.

Figure 7 shows the relationship between the price ratio and the supply ratio, in terms of percentage of preceding year, for the first method. The regression curve, based on the mathematical analysis, has been drawn. Data for 1922–42 used in the analysis are shown as dots and data for the war and postwar years are shown as x's. The lower section of this chart represents the result of plotting the unexplained residuals against time.

Figure 7 indicates that the war and postwar relationships between the price and supply ratios have not changed. Therefore, the regression equation based on 1922–42 would give results for the war and postwar years comparable with those obtained in the prewar analysis. No long-time trend is evident that from 1922 to 1951 the value of oats relative to that of corn declined or increased. Only year-to-year fluctuations in the relative price of oats occur and these are primarily associated with fluctuations in the supply ratio. This confirms the deductions reached in the analysis of the decline in numbers of workstock discussed on page 22.

As the relationship between the price ratio and the supply ratio is not perfect, factors other than those owing to random causes or errors in the original data may influence the price ratio. An analysis was run, using the quality of the corn crop as an additional factor affecting the price ratio. (Year-to-year variations in the quality of corn are relatively large, but those in the quality of oats are relatively small.) Results from this analysis indicate that the quality of the corn crop, when the criterion of quality is taken as the percentage of receipts grading number 1, 2, and 3 at representative markets, does not significantly affect the price ratio. This is in contrast to the results obtained by Bennett (*2*). He found that the quality of the corn crop significantly affected the price ratio. But Bennett's study is not perfectly analogous with the analysis used here, as he compared the price of ground oats with the price of cornmeal in Utica, N. Y. Quality of the corn crop may affect prices of particular grades of oats at certain markets. Average prices at the farm level, however, do not appear to be influenced significantly by this factor.

Elasticity of Substitution.—Elasticity of substitution is a coefficient that measures the percentage change in the ratio of the quantities of substitutable goods consumed which is related to a given percentage change in the ratio of the prices of these goods. In more common terms, this coefficient measures the increased or decreased share of the market taken by a given commodity (within the framework of a fixed, expanded, or contracted total

[5] The constant value in the regression equation does not differ significantly from zero.

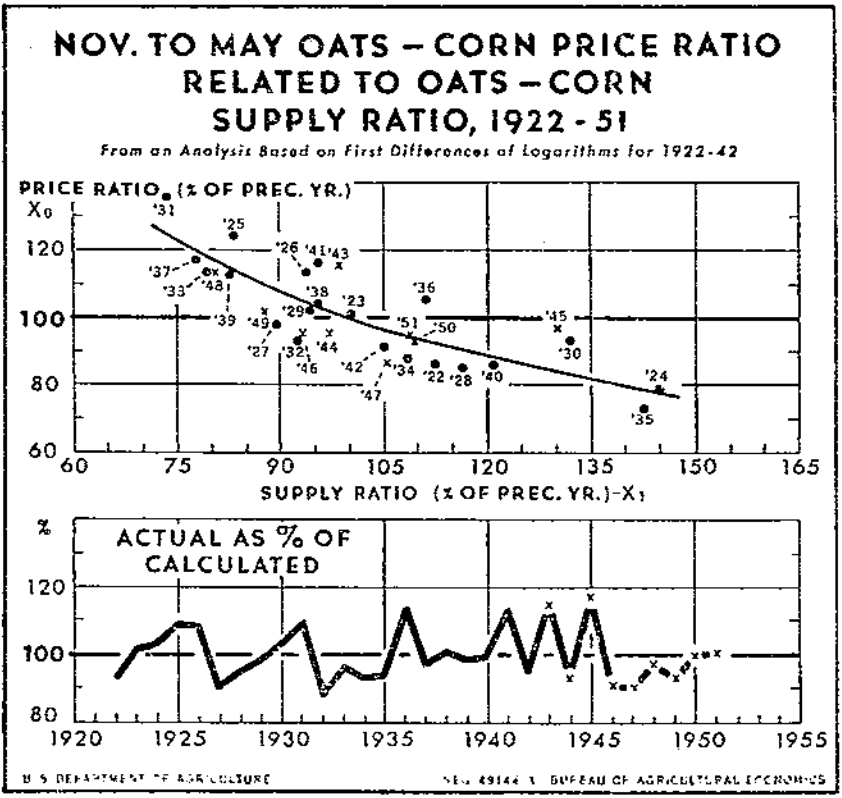

FIGURE 7.—The supply of oats relative to the supply of corn explained 77 percent of the year-to-year variation in the price of oats relative to the price of corn in 1922–42. There appears to be no significant trend in these corn-oats supply-price relationships, although prices of oats have been relatively low in most of the postwar years.

market) when the price of the commodity decreases or increases relative to competing commodities. This coefficient can be estimated by taking the reciprocal of the relative price flexibility as given by an analysis in which relative prices are used as the dependent and relative supplies as the independent variable. The larger the coefficient (the more elastic), the more easily can a commodity be substituted for the competing commodity; conversely, the lower the coefficient (the less elastic) the harder it will be to substitute the commodity.

In the above regression analysis, a 1-percent change in the relative supply variable was associated with a 0.73 percent change in the opposite direction in the relative price of oats. Taking the reciprocal of this relative price flexibility yields a value of —1.4, indicating that oats may be substituted fairly readily for corn. A comparison of this coefficient with comparable coefficients for barley and sorghum grains is shown on page 72, together with a discussion of why they differ.

SPECIAL FACTORS THAT AFFECT PRICES OF BARLEY

Few investigations of the factors that influence the price and demand for barley have been made. Although barley is not a major crop in the total agricultural economy, it is important in several regions, and it is the principal raw material of the malting industry. But despite its regional importance and its position in the malting industry, the author has found only two published studies that deal in detail with price and demand for this grain. Of the two, one by Braun (*3*) in 1931 discusses the factors that affect the California barley industry. The second, by Schultz (*17*) in 1938, is on a national level. It deals principally with mathematical investigations of the factors that affect the quantity of barley demanded and the interrelationships of its price with those for feed grains and hay. A general discussion of the position of barley in the agricultural economy and its principal uses appeared in the 1922 Yearbook of Agriculture (*22*). A further study, with emphasis on the historical and geographical evolution of this grain, is found in Weaver (*27*).

Geographic Shifts in Production

During most of the years since 1900, the West North Central region has produced more than 50 percent of the barley grown in the United States. The Western region (dominated by California) was second, contributing on the average about 30 percent from 1900 to 1952. The East North Central region ranked third; it averaged about 13 percent of the total. The North Atlantic, South Atlantic, and South Central regions supplied negligible quantities, but their importance has steadily increased. Table 8 shows production of barley by regions and regional production as a percentage of total United States production, in terms of 5-year averages.

The chief geographic shifts in production of barley, as table 8 indicates, have occurred in recent years. From 1900 to 1939, as a rule, the relative quantities contributed by each region remained fairly constant, despite the large variations in production in the period as a whole. The West North Central region, which before 1945 had been the main producing area, has declined in importance. In 1952 less than 40 percent of the United States production originated in this region. The closely adjoining barley-producing areas of the East North Central region experienced an even greater decline. From 1900 to 1939 this region normally produced about 16 percent of the total, but in 1952 its production was only 3.4 percent. Offsetting the decline in these two regions to some extent have been the substantial increase in the Western region during the last decade and the continued increase in the North Atlantic and South Atlantic regions. The South Central region, which had gained steadily in importance from 1900 to 1944, declined abruptly in the postwar period.

The steady long-term rise in production of barley in the Western region, including irrigated areas of the Southwestern Great Plains, reflects the greater suitability of this grain to the climate

TABLE 8.—*Barley: Production and percentage distribution, by regions, averages 1900–52*

Period	Region						Total
	North Atlantic	East North Central	West North Central	South Atlantic	South Central	Western	
Average	*Million bushels*	*Million bushels*	*Million bushels*	*Million bushels*	*Million bushels*	*Million bushels*	*Million bushels*
1900–04	3.3	22.8	71.8	0.2	0.4	38.0	136.4
1905–09	2.8	25.7	95.1	.3	.4	44.8	169.0
1910–14	2.9	23.2	89.4	.3	.7	47.7	164.2
1915–19	4.4	30.2	99.1	.4	1.6	45.3	180.9
1920–24	3.9	24.3	83.4	.4	4.6	39.5	156.2
1925–29	5.8	40.2	138.0	.8	4.8	51.7	241.3
1930–34	6.0	35.2	114.8	2.1	4.9	51.3	214.3
1935–39	6.1	31.3	129.5	3.2	7.0	61.6	238.6
1940–44	7.0	25.2	181.4	6.0	17.4	103.5	340.5
1945–49	7.8	11.7	116.3	6.8	7.3	123.4	273.3
1950–52	9.1	11.8	105.2	7.5	4.0	123.9	261.6
1900–52	5.4	25.6	111.2	2.5	4.8	66.4	216.0
	Percentage distribution						
	Percent	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
1900–04	2.4	16.7	52.6	0.1	0.3	27.8	100.0
1905–09	1.6	15.2	56.3	.2	.2	26.5	100.0
1910–14	1.8	14.1	54.5	.2	.4	29.1	100.0
1915–19	2.4	16.7	54.8	.2	.9	25.0	100.0
1920–24	2.5	15.6	53.4	.3	2.9	25.3	100.0
1925–29	2.4	16.7	57.2	.3	2.0	21.4	100.0
1930–34	2.8	16.4	53.6	1.6	2.3	23.9	100.0
1935–39	2.6	13.1	54.3	1.3	2.9	25.8	100.0
1940–44	2.1	7.4	53.2	1.8	5.1	30.4	100.0
1945–49	2.8	4.3	42.6	2.5	2.7	45.2	100.0
1950–52	3.5	4.5	40.0	2.9	1.5	47.4	100.0
1900–52	2.4	12.8	52.1	1.0	1.9	29.8	100.0

of these areas and the similar increase in grain-consuming animal units. In the North Central region barley faces stronger competition from other small grains, particularly wheat and oats. On page 6 it was noted that 86 percent of the variation in planted acreage of barley from 1948 to 1952 in seven principal producing States in this region was associated with variations in spring wheat planted in North Dakota, South Dakota, and Minnesota and oats planted in the seven States. Apparently during these years wheat and oats displaced barley in these States to a considerable extent.

Relative Variability of Specified Disposition Items

Table 9 shows the supply and disposition of barley from 1910 to 1952. The quantities used for malting purposes and for seed vary relatively little from year to year, after allowance for trend and the effects of Prohibition, reflecting the rather constant demand for these purposes. The remaining uses—feed, export, and ending stocks—vary substantially from year to year.

Scatter diagrams similar to those shown in figure 4 indicate that little or no relationship exists between nonfeed uses and price of barley; special factors probably determine the quantities taken for these purposes. Quantities used for feed show a relatively close association with the price of barley and, as feed uses represent the largest single item of utilization, factors connected with the feed-livestock economy mainly affect the price of barley. As prices tend to be high when supplies of barley are low and low when supplies are high, the quantity of barley demanded for storage, other things being equal, varies inversely with the price of barley. The total demand for barley may be thought of as a combination of demands for feed, for domestic nonfeed uses, for export, and for storage.

Long-Term Changes in Demand for Barley for Feed and for Malting

Barley differs from corn and oats in that a substantially smaller percentage of the crop is used for feeding livestock. Producers of barley depend upon the malting industry for disposition of a large portion of the crop. This was particularly true before the 18th amendment was enacted on January 29, 1919. This amendment directly affected production of barley and also marked a turning point in the position of barley in the agriculture of the United States.

Up to the enactment of this law, barley was produced primarily for the malting industry and only secondarily for feed in most areas of the country. The 1903 Yearbook of Agriculture (*22*, p. 618) states: "Except on the Pacific Coast barley is not extensively used as a feed in the United States, doubtless owing to the fact that it is in such demand for brewing purposes that it is high in price wherever it is grown. However, it is frequently possible to secure at a low cost, grain which is off color, owing to rain or fog during harvest, and which for this or some other reason, is unfit for brewing, but valuable as feed." Data on the quantities of barley utilized as feed and in production of malt are given in table 9.

A further factor that retarded production of barley as a feed grain was the characteristically barbed beards, which not only made the crop difficult to handle but had detrimental effects on livestock as well. The extent to which this factor had served to retard production of barley for feed is stated by Weaver (*27*, p. 39) : "Although a quantitive measurement of the total effect would be impossible to obtain, it is certain that one of the leading elements that always militated against the spread of barley as a general farm crop has been the roughly barbed beards, which have made this cereal so disagreeable to handle. The farmer was not only reluctant to cope with the barley beard at harvest time himself, if it was possible for him to grow other types of grain for feed, but he had abundant evidence that the rough awns were annoying, as well as often dangerous, to his animals. For many years as a result, the superior feeding qualities of this grain were either not recognized or ignored." Along the same lines, Harlan (*9*, p. 4–5) says: "That it is not more widely grown now is due to two causes: (1) Its rough awns make it an unpleasant crop to handle, and its value as a stock feed has not been realized by the farmers east of Montana; and (2) the brewing trade until recently so dominated the eastern markets that buyers of feedstuffs did not think of barley as a feed crop."

Although the stage had been set by the 18th amendment for the reorientation of barley as a feed grain in the agricultural economy, the transition was made possible only by the plant breeders. Intensive research in various agricultural experiment stations resulted in the development of several new and improved varieties, characterized chiefly by high yields and absence of the annoying barbed awns. Response by farmers to these new varieties was rapid and widespread. Production increased from the low level of 149 million bushels in 1919–23 to 281 million bushels in 1929, an increase of 89 percent. Although production increased in all regions of the country during this period, the increase that occurred in the West North Central region overshadowed the increase in the United States as a whole. In this region, where barley had previously been produced principally for the malting trade, production increased from 76 to 174 million bushels. All of this increased production, plus a good part of the previous production, was utilized for feed or entered export channels, as quantities used for malting were materially reduced from 1919 through 1931.

With repeal of the 18th amendment on December 5, 1933, the malting industry again became a factor in the demand for barley. Barley used for malt increased steadily from the low prohibition levels. In recent years it has averaged close to 100 million bushels. The effect of prohibition on the price of barley is discussed on page 49.

TABLE 9.—*Barley: Supply and disposition, United States, 1910–52*

Year beginning July	Supply				Disposition [4]						
	Carry-over [1]	Production	Imports [2]	Total supply [3]	Used in producing malt: For alcohol and alcoholic beverages	Used in producing malt: For other purposes [5]	Seed	Feed, other uses, and waste [6]	Exports [2]	Domestic disappearance [3]
	Million bushels	*Million bushels*	*Million bushels*	*Million bushels*	*Million bushels*	*Million bushels*	*Million bushels*	*Million bushels*	*Million bushels*	*Million bushels*
1910	9	142	([7])	152	66	8	14	49	10	137
1911	5	145	3	153	65	8	14	63	2	149
1912	3	197	([7])	200	68	8	14	79	18	169
1913	12	159	([7])	172	69	8	14	66	7	156
1914	8	178	([7])	186	61	8	13	69	29	151
1915	6	207	([7])	213	59	8	14	89	31	170
1916	12	159	([7])	172	80	8	15	43	20	147
1917	5	182	1	188	35	8	17	94	29	154
1918	5	225	([7])	230	24	10	12	135	29	180
1919	20	131	([7])	152	8	10	13	79	35	111
1920	6	171	([7])	177	8	10	13	103	27	134
1921	16	133	([7])	148	6	12	12	85	28	115
1922	6	153	([7])	159	6	11	13	101	22	130
1923	7	159	([7])	166	6	11	13	117	14	147
1924	5	165	([7])	171	6	10	15	106	29	136
1925	6	192	([7])	199	6	11	15	125	30	157
1926	11	166	([7])	177	5	12	17	117	20	151
1927	7	239	([7])	246	5	14	22	155	39	196
1928	11	328	([7])	339	4	15	26	208	60	254
1929	25	281	([7])	306	5	15	24	219	24	263
1930	18	302	1	321	4	17	24	245	11	290
1931	20	200	2	222	3	15	25	163	5	207

1932	9	299	1	310	11	10	25	224	9	271
1933	30	153	5	188	42	7	21	80	6	150
1934	32	117	18	167	53	5	24	62	4	145
1935	18	289	8	315	62	4	22	152	10	240
1936	64	148	29	241	69	4	22	120	5	214
1937	22	222	6	250	61	4	21	113	18	199
1938	33	257	3	293	57	3	25	145	11	231
1939	51	278	3	332	57	3	26	191	5	277
1940	50	311	2	364	58	4	26	213	2	301
1941	60	363	2	425	69	4	32	246	3	352
1942	70	429	27	527	79	6	28	321	2	434
1943	120	323	41	485	85	6	23	292	3	406
1944	76	276	38	390	97	6	19	169	5	290
1945	95	267	6	368	83	7	19	191	9	300
1946	59	265	4	328	88	7	19	141	[8] 16	256
1947	56	282	1	339	93	7	21	142	[8] 24	262
1948	52	316	12	380	91	6	18	137	[8] 28	252
1949	101	237	18	356	87	6	22	141	[8] 22	255
1950	80	304	14	397	95	6	18	144	[8] 40	264
1951	94	254	13	361	87	6	15	148	[8] 31	256
1952[9]	73	227	[10] 25	325	....	....	....	....	....	....

[1] Stocks on August 1 until 1934, July 1 thereafter. Farm and terminal market stocks only prior to 1943.

[2] Includes grain equivalent of malt.

[3] Computed from unrounded numbers.

[4] Prior to 1934, disposition data for some years based on data compiled by Grain Branch, Production and Marketing Administration.

[5] Principally for food.

[6] Residual.

[7] Less than 500,000 bushels.

[8] Includes exports for military relief feeding abroad.

[9] Preliminary.

[10] Partly estimated.

Foreign Trade for Barley

Exports of barley have been of greater relative importance in the disposition of the crop than is true for corn and oats. Barley exports have exceeded those of oats in most years. In a few years they even exceeded those of corn. Normally imports are substantially smaller than exports. From 1920 through 1952, they averaged less than half as large. Imports exceeded exports in only 6 years. Two of these were years of poor harvest and the remaining four were war years when demand was unusual. Exports and imports for these years are shown in table 9.

Exports of barley have a dominant influence in certain regions. The three chief producing regions of the United States, in order of importance, are the West North Central, Western, and East North Central. Minnesota, North Dakota, California, South Dakota, Wisconsin, Nebraska, and Kansas account for most of the United States production, and for a large part of the barley that enters commercial channels. California ranks first as a commercial producing State. On the average more than 80 percent of the crop produced there was sold from 1921 to 1941, as compared with 41 percent for Minnesota, the second ranking State. Although they produced only about 12 percent of the total crop during these years, sales by California farmers represented 27 percent of total sales by farmers in this country. A substantial part of the California barley sold is exported, largely through the port of San Francisco. Exports from California during this period, on a June-May crop-year basis, on the average accounted for about 30 percent of the total California disappearance (used for seed, local malting, local feed and waste, eastern shipments, and exports). Exports from California for 1921–50 are given in table 10, together with production and sales by farmers. Comparison of these export data with those in table 9 indicates that most of the barley exported from the United States originates in California. These two tables are not strictly comparable as United States exports are on a July-to-June basis and California exports are on a June-to-May basis.

Most of the barley exported from the United States, other than that from California, originates in the surplus areas of the West North Central region and moves through various United States lake ports. Barley not exported directly from these points moves eastward and is exported from Atlantic ports. Some barley normally moves south to Gulf ports for export.

Statistical Analyses of Factors That Affect Prices from July to October, West North Central Region

From July to October the price of barley is influenced by current and prospective feed supplies, animal units fed, and prices of livestock and livestock products. As with oats and corn, the supply variable presents a complicated problem. The price of barley during the July-to-October period is influenced not only by its supply but by the new-crop supply of oats, the stocks of

TABLE 10.—*Barley: Production, sales by farmers, and exports, California, 1921–50*

Year beginning June	Production	Sales by farmers	Exports [1]
	Million bushels	*Million bushels*	*Million bushels*
1921	26	21	18
1922	30	22	16
1923	27	19	10
1924	17	11	9
1925	29	22	12
1926	26	19	12
1927	24	17	9
1928	27	22	10
1929	29	24	11
1930	34	29	10
1931	16	12	5
1932	41	37	9
1933	26	21	7
1934	26	21	5
1935	39	34	10
1936	31	26	6
1937	29	25	8
1938	29	24	7
1939	34	29	4
1940	34	30	1
1941	26	20	1
1942	44	38	1
1943	36	31	1
1944	40	35	2
1945	42	36	3
1946	49	43	7
1947	45	39	10
1948	50	43	15
1949	51	46	9
1950	60	55	23

[1] From SEMI-ANNUAL BARLEY REVIEW (*23*). Includes shipments of whole and rolled barley to Hawaii, beginning 1931.

old-crop corn, and the anticipated size of the new corn crop.

The method used to determine the appropriate weights for the several supply components is identical with the method used in the preceding section to determine the factors that affect the price of oats from July to October (see p. 24). When each item is expressed in million tons, the analysis indicates that the supply of barley should be weighted by 0.55. The supply of oats should be weighted by 0.20, stocks of corn by 0.11, and the estimate of the new crop of corn by 0.14. As would be expected, these coefficients indicate that the supply of barley should be weighted heavily in the analysis for barley, whereas it appeared to have no significant effect on the price of oats in the analysis for oats. Other changes in the coefficients appear to be equally logical. These weights were tested to ascertain whether they differed significantly from each other. The differences were found to be significant at the 5-percent level.

Relating the actual July-to-October price of barley to the weighted supply variable, the index of prices of livestock and livestock products, and the animal production units indicated that 81 percent of the variation in the price of barley was associated with variations in these variables. The remaining statistical coefficients pertaining to this analysis yielded results comparable to those obtained in the July-to-October analysis of the price of oats. In general, variations in the supply variable cause most of the year-to-year variations in the price of barley. On the average, a 1-percent variation in supply, after allowing for the effects of other factors in the analysis, results in a 2.4-percent change in price in the opposite direction; a 1-percent change in the price of livestock and livestock products is associated with a change in price of about 1.2 percent in the same direction; a 1-percent change in units of livestock production has a similar effect.

The analysis was based on year-to-year change, after converting all of the data to logarithms. The effects on the price of barley of specified ratios to the preceding year, for each independent factor, are shown in table 11. The range shown for each variable is approximately equal to that which prevailed from 1922 to 1951. The analysis was based on 1922–42. The effects of all three factors on the price of barley can be obtained by multiplying the respective ratios together. The final result should be multiplied by 0.99 to allow for the average shift in demand over time. (See page 25 for a detailed example of the use of a similar table.) Data on which the analysis was based are shown in table 12.

The ratio to the preceding year, as indicated by table 11, can be multiplied by the actual price in the preceding year to estimate the expected price in the year for which a forecast is being made. There is a 65- to 70-percent chance that the estimated price will differ from the actual price by not more than 22 percent and a 95-percent chance that it will differ by not more than 50 percent.

Examination of charts, similar to those in figure 6, indicate that interwar relationships apply in the postwar years.

DEMAND ELASTICITY.—In the above multiple-regression analysis, a 1-percent change in the supply variable was associated with an opposite change of 2.4 percent in the price of barley. Taking the reciprocal of this price flexibility yields a figure of —0.4, which indicates an inelastic demand for barley. Comparable values for oats and corn are given in table 13, together with the regression coefficients from which they were computed and their standard errors.

A statistical test adapted from Rao (*16*, pp. 112–114) was performed to ascertain whether the differences between these price flexibilities, and the respective regression coefficients obtained in each analysis for animal production units and prices of livestock and products, were statistically significant.[9] Results from this test indicate that these coefficients do not differ significantly. That is, changes in the supply variable, and each of the two demand factors, probably act upon prices of each grain in about the same way.

[9] This test is described in the Appendix.

TABLE 11.—*Barley: Relation between year-to-year changes in July-to-October prices received by farmers and a specified supply variable, July to October prices of livestock and livestock products, and July to December units of livestock production on farms*[1]

RATIO TO PRECEDING YEAR

X'_0 Estimated price of barley[2]	X_1 Supply variable[3]	X'_0 Estimated price of barley[2]	X_2 Price of livestock and livestock products[4]	X'_0 Estimated price of barley[2]	X_3 Production of livestock[5]
2.44	0.78	0.66	0.70	....	....
1.71	.80	.77	.80	0.77	0.80
1.35	.90	.88	.90	.88	.90
1.00	1.00	1.00	1.00	1.00	1.00
.84	1.10	1.12	1.10	1.12	1.10
.64	1.20	1.24	1.20	1.24	1.20
.57	1.30	1.36	1.30	....	....
.45	1.40	1.48	1.40	....	....
.39	1.50	....	....	....	....

[1] When the other independent variables in the analysis remain at the previous year's level. From an analysis based on first-differences of logarithms, 1922–42.

[2] Computed from the following equation when all variables are expressed as first-differences of logarithms:

$$X_0' = -0.004 - 2.406X_1 + 1.174X_2 + 1.170X_3$$

The following values also relate to this analysis:

$s_{b_{01.23}} = .294$	$s_{0.123} = 0.088$	$r^2_{03.12} = 0.132$
$s_{b_{02.13}} = .295$	$r^2_{01.23} = .798$	$R^2_{0.123} = .808$
$s_{b_{03.12}} = 0.729$	$r^2_{02.13} = .483$	

NOTE.—The constant value in the regression equation does not differ significantly from zero.

[3] See text for method of obtaining this series.

[4] Index numbers of prices received by farmers for livestock and livestock products (1910–14 = 100).

[5] From Jennings (*11*) — livestock production in terms of production units.

Again, these various demand elasticities do not represent the true elasticities of demand for these grains, since the supply variables are composite ones that contain other supplies of feed. These coefficients probably reflect essentially the demand elasticity for total feed grains. The true elasticity for each grain would be higher, as it would reflect the elasticities of demand for feed as such, plus the elasticities of substitution of each grain for other feeds.

Although the statistical test indicates that the price flexibilities, with respect to supply, in the three analyses do not differ significantly, the higher value obtained for barley is not illogical. Total demand for barley, as mentioned previously, is the sum of demands for feed, storage, export, food uses, and for malting. Demands for the latter two items are quite inelastic, and the quantities taken for these purposes represent a significantly larger proportion of utilization of barley than do the fe^d and industrial uses

TABLE 12.—*Barley: Actual and computed price per bushel and related variables, 1921–51*

Year	Price (July to October)		Supply X_1 [2]	Price received by farmers for livestock and products (July to October) X_4 [3]	Units of livestock production (July to December) X_4 [4]
	Actual X_0	Computed X'_0 [1]			
	Cents	*Cents*	*Million Tons*		*Millions*
1921	37.0	....	19.5	122.5	....
1922	38.4	45.1	18.4	125.0	....
1923	42.9	39.5	18.2	126.8	....
1924	62.0	45.4	17.4	128.5	79.1
1925	57.9	58.8	19.1	151.3	78.6
1926	49.1	71.9	17.5	150.3	80.5
1927	60.7	55.3	16.6	143.2	84.4
1928	55.6	45.9	19.5	164.8	82.2
1929	48.5	65.6	18.0	159.8	81.9
1930	36.6	40.7	17.2	127.3	81.7
1931	25.0	25.4	17.6	94.5	85.2
1932	15.9	13.8	19.8	73.8	84.3
1933	39.6	29.7	15.3	74.8	83.6
1934	70.2	78.8	14.1	85.5	69.7
1935	33.8	43.6	15.6	115.0	69.8
1936	77.8	69.8	12.2	119.3	75.3
1937	49.4	40.9	16.2	130.0	73.5
1938	30.9	35.8	17.7	114.8	77.7
1939	33.7	33.6	17.4	106.3	85.9
1940	32.8	34.6	17.3	110.0	83.9
1941	40.5	39.3	19.0	147.5	89.6
1942	51.3	45.8	21.0	177.0	102.6
1943	93.0	71.6	20.3	198.3	114.3
1944	99.0	81.6	19.5	193.3	97.3
1945	98.5	97.2	20.7	211.0	100.5
1946	135.0	99.0	22.1	258.3	94.7
1947	183.3	227.2	18.7	294.0	92.2
1948	118.0	137.5	22.0	330.0	90.9
1949	102.0	97.5	22.2	272.5	96.1
1950	118.5	122.7	21.4	293.3	98.1
1951	107.3	140.8	21.7	336.3	102.4

[1] Computed from the equation shown in footnote 2, table 11.
[2] See text for components of supply variable and weights assigned.
[3] Index numbers, 1910–14 = 100.
[4] From Jennings (*11*).

for corn. Furthermore, the West North Central region normally shows the lowest feed-grain prices and the largest percentage variations in price of any geographic area. This is because of its surplus nature and its location with respect to principal markets. Probably contributing to greater flexibility of price for both barley and oats during the summer-fall season, as compared with corn, is the fact that July to October is the period of heaviest marketings for these crops and prices are adjusted to the new supply of these grains.

TABLE 13.—*Effect of a 1-percent change in supply on prices of corn, oats, and barley, percentage of preceding year* [1]

Price analysis	Price flexibility		Indicated elasticity
	Coefficient	Standard error	
	Percent	*Percent*	
Corn (June-September) [2]	—1.59	0.34	—0.63
Oats (July-October) [3]	—2.04	.29	— .49
Barley (July-October) [3]	—2.41	.29	— .41

[1] When the other independent variables in the analysis remain at the previous year's level. From analyses based on first differences of logarithms, 1922–42.
[2] Coefficient obtained by Foote (7).
[3] See text.

STATISTICAL ANALYSES OF FACTORS THAT CAUSE DEVIATIONS FROM PRICES OF CORN FROM NOVEMBER TO MAY IN THE MIDDLE WEST

The price of barley in the West Central region as a percentage of the United States average price of corn fluctuated from a low of 48 in 1930 to a high of 103 in 1946. As with oats, the major causal factor associated with year-to-year changes in its relative price appeared to be the production of barley in the West North Central region relative to the United States supply of corn. When production of barley in this region was high in relation to the supply of corn, the price of barley was low relative to that of corn. Based on a logarithmic first-difference analysis for 1922–42, 67 percent of the variation in the price ratio was associated with changes in the supply ratio. A 1-percent change in the supply ratio during this period was associated with an opposite change of 0.45-percent in the price ratio. When the price of barley is expressed as a function of the price of corn and the supply ratio, 91 percent of the variation in the price of barley is associated with fluctuations in these two variables. The coefficient of determination between barley and corn prices is 0.73; the addition of the supply ratio to the analysis brings this coefficient to 0.91.

The variables used in these two methods of analysis are as follows:

Method 1:

X_7—Ratio of the West North Central region average price per bushel received by farmers for barley to the United States average price per bushel received by farmers for corn, average of November to May.

X_1—Ratio of production of barley in the West North Central region to supply of corn in the United States (production plus October 1 stocks plus imports).

Method 2:[10]

X_0—West North Central average price per bushel received by farmers for barley, average for November to May.

X_1—United States average price per bushel received by farmers for corn, average for November to May.

X_2—Same as X_1 in method 1.

For method 1, the following tabulation shows effects on the price ratio of specified ratios to the preceding year in the supply ratio:

RATIO TO PRECEDING YEAR

X'_0 Estimated relative price of barley [1] [2]	X_1 Production of barley relative to supply of corn
1.51	0.40
1.26	.60
1.11	.80
1.00	1.00
.92	1.20
.86	1.40
.81	1.60
.77	1.80
.73	2.00
.70	2.20
.67	2.40
.65	2.60
.63	2.80
.61	3.00
.59	3.20
.57	3.40

[1] From an analysis based on first differences of logarithms, 1922–42.

[2] Computed from the following equation when all variables are expressed as first-differences of logarithms:

$$X_0 = 0.0103 - 0.4526X_1$$

The following values also relate to this analysis:

$s_{b_{01}} = 0.073$ $s_{0.1} = 0.067$ $r^2_{01} = 0.668$

NOTE—The constant value in the regression equation does not differ significantly from zero.

The range shown is approximately equal to that which prevailed from 1922 to 1951. Data on which this analysis was based are given in table 14.

When the ratio to the preceding year, as indicated by this tabulation, is multiplied by the actual price ratio in the preceding year to give an estimate of the expected price ratio in the year for which a forecast is being made, there is a 65 to 70-percent chance that the estimated price ratio will differ from the actual price ratio by not more than 17 percent and a 95-percent chance that it will differ by not more than 36 percent.

Figure 8 shows the relationship between the price and supply ratios, both in terms of percentage of preceding year and in deviations from average. In the middle section of this chart the unexplained deviations from the analysis based on percentage of preceding year are plotted against time. Data for 1922–42 used in the analysis are shown as dots and data for the war and postwar years are shown as x's. The regression curve based on the mathematical analysis is plotted in the top section of figure 8. The three

[10] The following equation and statistical coefficients were obtained from this analysis:

$$X_0 = 0.011 - 0.931X_1 - 0.468X_2$$

$s_{b_{01.2}} = 0.093$ $s_{0.12} = 0.068$ $r^2_{02.1} = 0.673$

$s_{b_{02.1}} = .077$ $r^2_{01.2} = .849$ $R^2_{0.12} = .912$

NOTE—The constant value in the regression equation does not differ significantly from zero.

lines shown in the lower section were drawn in freehand to illustrate certain shifts which have occurred.

The upper section in figure 8 shows that the relationship between the price ratio and the supply ratio in terms of year-to-year change is fairly stable. But an analysis on this basis tends to obscure the shift in the relationship that occurred from 1921 to 1927, although the constant value in the regression equation based on first-differences indicates that such a shift took place. After allowance for changes in the supply ratio, the price ratio apparently increased on the average by 2.4 percent a year. This upward shift to the right is clearly illustrated in the lower section. From 1919 to 1923 prices of barley in the Midwest were unusually low as a result of the enactment of the 18th amendment, even though production of barley was below average both in absolute terms and in relation to corn. By 1924 the effect of prohibition on the price of barley had largely worn off.

A growing awareness by farmers of the feeding value of barley, coupled with the introduction of several improved varieties in the midtwenties, strengthened the demand for barley relative to corn. By 1928 this gradual shift to the right had reached a point at which production of barley was 2½ times as large as in 1922 and even larger in relation to corn. This resulted in a price relative to that of corn only 2 percent less than the price ratio in 1922. The repeal of the 18th amendment in 1932 apparently did not affect the relation of the price of barley to the price of corn. In the early thirties the increased demand by the brewing industry was probably offset by the substantial decline in exports from the previous high level of the late twenties. Thus, the relation between prices of barley and those of corn appears from the lower chart to have remained fairly stable since 1927. Variations in the supply ratio explain most of the fluctuations in the price ratio.

ELASTICITY OF SUBSTITUTION—A 1-percent change in the supply ratio was associated with a 0.45 percent change in the opposite direction in the price ratio. Taking the reciprocal of this relative price flexibility yields a value of —2.2. This indicates that barley may be substituted fairly readily for corn for most feeding purposes. The comparable coefficient for oats was —1.4. The larger value for barley indicates that it may be substituted for corn more readily than oats. This is in line with the feeding values of these two grains relative to corn (see p. 15). These coefficients are discussed in greater detail on page 72.

The method (see p. 30) used to estimate actual prices of oats from November to May could be used to estimate prices of barley. Certain modifications are necessary, however. In the equation

$$X'_0 = 0.011 + 0.931X_1 - 0.468X_2$$

the constant value differs substantially from 0, although the difference is not statistically significant. The constant value is logical, reflecting the shift in demand during the 1920's, but the regression coefficient for X_1, 0.931, is not consistent with expectations. To check this coefficient, the analysis was extended to

TABLE 14.—*Barley and corn: Average price per bushel received by farmers and supply, October 1, 1921–52*

Year	Price (November to May)			Supply		
	Barley (West North Central region)	Corn (United States)	Percentage barley is of corn [1]	Production of barley in West North Central region	Supply of corn in United States, Oct. 1 [2]	Percentage barley is of corn [1]
	Cents	*Cents*	*Percent*	*Million bushels*	*Million bushels*	*Percent*
1921	37	51	73.7	65.7	3,199	2.05
1922	45	73	61.7	79.8	2,870	2.78
1923	49	76	64.1	82.9	2,941	2.82
1924	71	108	65.5	97.3	2,314	4.21
1925	48	69	70.2	104.1	2,849	3.66
1926	56	66	84.7	74.9	2,831	2.65
1927	70	83	84.0	137.2	2,836	4.84
1928	50	83	60.1	199.5	2,760	7.23
1929	45	78	57.6	174.2	2,664	6.54
1930	29	60	47.9	183.0	2,221	8.24
1931	32	33	95.8	107.4	2,744	3.91
1932	16	24	69.9	174.3	3,201	5.44
1933	41	45	90.2	69.5	2,785	2.50
1934	81	83	97.1	39.7	1,824	2.18
1935	33	56	58.4	179.1	2,385	7.51
1936	88	106	83.5	60.4	1,785	3.38
1937	47	51	92.6	119.6	2,710	4.41
1938	32	44	71.3	140.1	2,911	4.81
1939	41	55	75.2	148.3	3,166	4.68
1940	38	58	65.4	170.3	3,146	5.41
1941	54	74	73.4	214.4	3,297	6.50
1942	64	90	71.0	236.9	3,560	6.66
1943	106	112	94.2	165.4	3,354	4.93

1944	96	107	90.3	110.9	3,325	3.60
1945	109	115	95.0	119.2	3,185	3.74
1946	143	138	103.4	115.5	3,389	3.41
1947	203	220	92.1	127.6	2,639	4.83
1948	101	120	84.1	142.2	3,729	3.81
1949	114	118	96.4	77.1	4,052	1.90
1950	130	155	84.0	118.4	3,904	3.03
1951	120	167	72.0	117.6	3,639	3.24
1952	120	147	81.6	[3]79.7	[3]3,794	[3]2.10

[1] When prices are expressed in cents per bushel. Percentage would be less if prices were expressed in dollars per ton.

[2] Stocks of corn on November 1, 1921–25, and on October 1, 1926–51. Stocks in all positions, including interior mill, elevator, and warehouse stocks, 1943 to date.

[3] Preliminary.

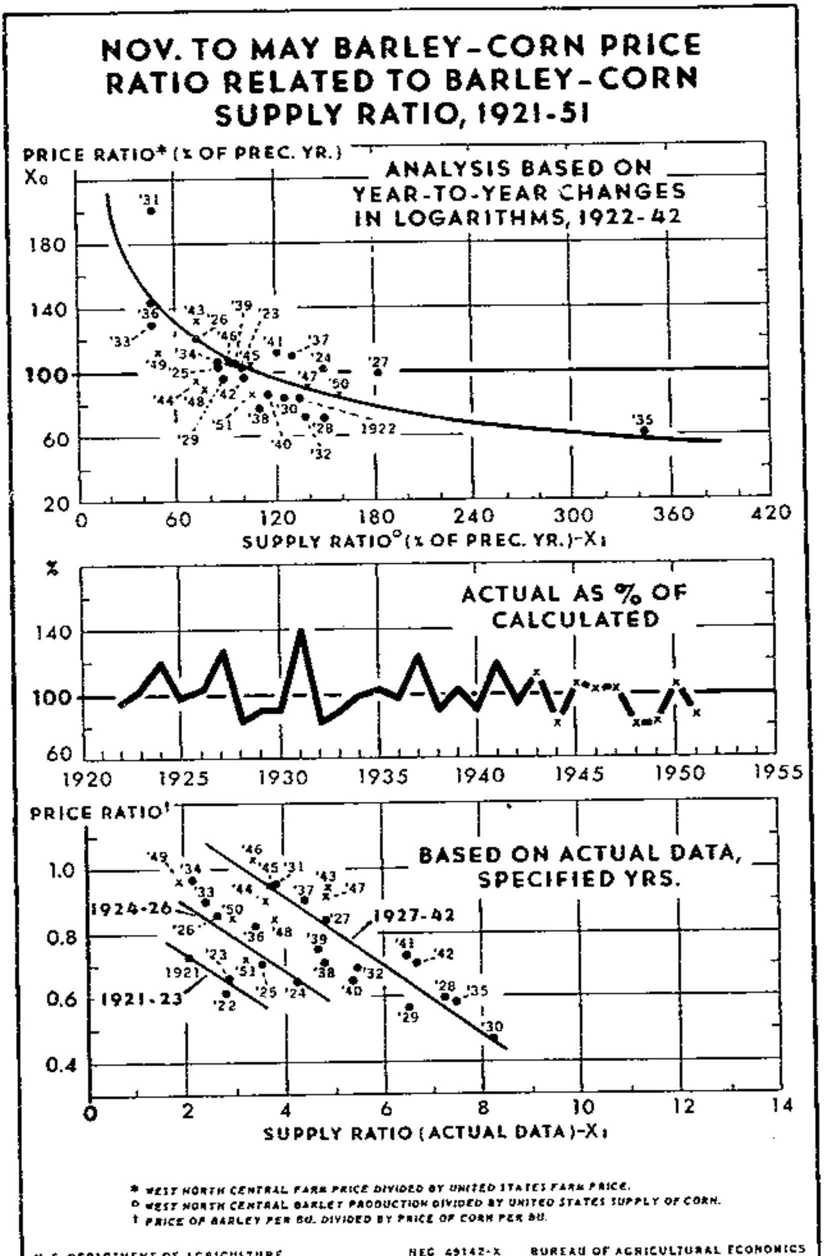

FIGURE 8.—From 1922 to 1942 production of barley in the West North Central region in relation to the United States supply of corn explained 67 percent of the year-to-year variation in the price of barley in this region relative to the United States average price of corn. Since the end of World War II, other factors have been important. Shifts in the relation over time are indicated in the lower section of this chart.

include 1946 to 1951. Results from this analysis yielded a regression coefficient for X_1 of 0.998. Changes in the other coefficients were not significant. On the basis of this extended analysis, the regression coefficient for X_1 is assumed to be 1. The constant value, 0.011, although substantial, is omitted as it reflects a trend that is no longer operating. If Foote's coefficients for corn are substituted, the following equation results:

$$X_0' = 0.004 - 2.36X_1 + 1.94X_2 + 1.13X_3 - 0.47X_4$$

where X_1 is the supply of total feed concentrates, X_2 the number of grain-consuming animal units, X_3 the index of prices of livestock and livestock products, and X_4 production of barley in the West North Central region relative to the United States supply of corn.

The statistical analyses of West North Central prices of barley, relative and actual, yield results that are less refined than those obtained in comparable analyses for oats and sorghum grains. The following factors partly explain these relatively poor results: (1) As the lower section in figure 8 illustrates, the demand for barley increased from 1921 to 1927 and was stabilized roughly by 1928.[11] This also is indicated by the constant value in the regression equation for method 1; (2) 1934, 1936, 1948, 1949, 1950, and 1951, in the lower section, show substantially lower relative prices than would have been expected under the relative supplies existing in these years. These deviations are closely associated with unusually heavy imports in these years. As the factors that caused the shifts that occurred in the 1920's could not be expressed by a statistical series and as large imports have occurred in only a relatively few years, these factors were not included in the statistical analyses. Consequently, results were not as accurate as those for the other grains. Also, year-to-year fluctuations in the demand for barley for malting purposes probably are a further cause of deviations not explained by the analysis.

Factors That Affect Prices of Barley in California

California normally ranks as the second most important barley producing State. From 1921 to 1942, production in California averaged 27 percent as large as production in the West North Central region and represented 12 percent of the total United States production. California is far from the primary center of production and in most years it has depended to a large extent upon export markets for disposition of the crop. Therefore, a separate analysis of factors that affect California prices is warranted.

The analyses discussed here are based on average prices received by farmers from August through March, 1921–42, or in the case of first-difference analyses, 1922–42. By August, prices in California and the West North Central region largely have adjusted

[11] Confirming these results, Schultz (*17*, p. 483) found that the demand for barley increased rapidly from 1923 to 1929.

to the effect of the new crop. Thus factors affecting prices in these regions for any particular year can best be studied by confining the analyses to these months.

For 1921–42, prices of barley in California relative to prices in the West North Central region ranged from a low of 74 percent in 1934 to a high of 173 percent in 1924 and averaged 137 percent for the entire period. This higher relative price reflects the feed-deficit position of California and the higher relative prices of livestock and livestock products in that State. Year-to-year changes in the price of California barley have followed fairly closely year-to-year changes in prices of barley in the West North Central region. Based on a logarithmic first-difference analysis for 1922–42, 76 percent of the variation in prices for California was associated with fluctuations in the West North Central price. On the average, a 1-percent change in the price of barley in this region was associated with a change of 0.67 percent in the price of California barley. This smaller proportional change bears out the principle that prices of agricultural commodities tend to change by smaller proportional amounts in deficit areas than in surplus areas. When the analysis was run in arithmetic terms, a change of 1 cent per bushel in the West North Central price was associated with a change of 0.8 cent in the California price.

When the California price was expressed as a ratio to the West North Central price and related to production in California relative to production in the West North Central region, 78 percent of the year-to-year variation in the price ratio was associated with fluctuations in this variable.[12] The addition of exports from California and grain-consuming animal units fed in the State as variables failed to improve the results significantly. When the California price was expressed as a function of the West North Central price and the production ratio, 94 percent of the variation in the California price was associated with fluctuations in these two independent variables.[13] These analyses were based on 1922–42, after all variables were converted to first differences of logarithms. Apparently only relative production during these years measurably influenced the California price relative to the West North Central price.

A scatter diagram of the relationship between relative prices and relative production indicates that in the years 1921–25 the

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[12] The following equation and statistical coefficients were obtained in this analysis, when all variables are expressed as first differences of logarithms:

$$X_0' = -0.013 - 0.443X_1$$

$s_{b_{01}} = 0.54$ $s_{0.1} = 0.053$ $r^2_{01} = 0.78$

NOTE—The constant value in the regression equation does not differ significantly from zero.

[13] The following equation and statistical coefficients were obtained in this analysis, when all variables are expressed as first differences of logarithms:

$$X'_0 = -0.010 + 0.840X_1 - 0.369X_2$$

$s_{0.12} = 0.043$ $s_{b_{02.1}} = .050$ $r^2_{01.2} = .941$

$s_{b_{01.2}} = .050$ $R^2_{0.12} = 0.941$ $r^2_{02.1} = .753$

NOTE—The constant value in the regression equation does not differ significantly from zero.

price ratios did not have the same relationship to the production ratios as did observations for the remaining years. In the West North Central region prices of barley were abnormally related to prices of corn during these same years. This resulted from the reduced demand for barley by the malting industry. Apparently, and not illogically, as only a small percentage of the California crop was ever utilized for domestic malting purposes, prohibition affected barley prices in California very little if at all.

Since 1948 the price ratios have been somewhat higher in relation to the production ratios. This may reflect the greater effect of imports of Canadian barley on prices in the West North Central region than on prices in California. Table 15 shows production and prices of barley in California as a percentage of the West North Central region for 1921–52.

Factors associated with price differentials between barley for feed and for malting are discussed in the section on "Price Differences in Central Markets Because of Grades."

SPECIAL FACTORS THAT AFFECT PRICES OF SORGHUM GRAINS

In contrast to the many studies of the factors that affect prices of corn and oats and the two studies that apply to prices of barley, there are apparently no published studies of prices of sorghum grains. Some unpublished price studies may have been made, but the published material that is available deals almost exclusively with the agronomy of sorghum grains and with their products and uses. This scarcity of price studies reflects the earlier minor importance of this grain from the national viewpoint. During the last decade, however, sorghum grains have increased in importance as feeds and also as an export commodity. Industrial uses also have increased. With this widening of the market for sorghum grains, interest in the factors that affect the price and demand for this grain has increased.

Geographic Shifts in Production

Production of sorghum grains is concentrated mainly in Texas, Oklahoma, and Kansas. The three States normally produce 85 to 90 percent of all sorghum grains produced in the United States. California, New Mexico, Colorado, Nebraska, and Arizona also produce this grain. These five States normally account for slightly less than 10 percent of the United States production.

Although during the last 20 years production has increased in all main producing States, Texas has shown the largest relative gain. From 1946 to 1950, this State produced 63 percent of the Nation's crop, as compared with 56 percent from 1935 to 1939. Kansas has held about steady while Oklahoma and other producing States have declined in relative importance. Table 16 indicates the relative position of the three chief producing States and changes in production from 1929 to 1952.

The increasing prominence of Texas in production of sorghum grains resulted partly from the decline in cotton acreage in this

TABLE 15.—*Barley: Price per bushel received by farmers and production in California as a percentage of price and production in the West North Central region, 1921–52*

Year beginning	Price (August to March)	Production
	Percent	*Percent*
1921	170	39
1922	163	38
1923	159	32
1924	173	17
1925	141	28
1926	110	34
1927	146	17
1928	149	14
1929	147	17
1930	139	19
1931	162	15
1932	173	24
1933	103	38
1934	74	66
1935	120	22
1936	86	51
1937	122	25
1938	141	21
1939	115	23
1940	122	20
1941	164	12
1942	128	19
1943	117	22
1944	112	33
1945	111	35
1946	103	40
1947	94	34
1948	113	35
1949	106	60
1950	101	51
1951	140	36
1952	131	68

State. Much of this acreage was diverted to sorghum. Several other factors also stimulated expansion of sorghum acreage: (1) The favorable export position of Texas relative to that of production centers for corn and other grains; (2) the increasing realization of farmers that the feeding value of sorghum grains is nearly equal to that of corn and that it is better suited as a crop to this area; and (3) the opening in 1949 in Corpus Christi, Tex., of a large wet-processing plant with a capacity of about 6 million bushels a year. These factors contributed to a wider market and an increasing demand for the State's sorghum grains.

CHANGES IN DOMESTIC USES OF SORGHUM GRAINS

Before World War II practically the entire crop was utilized as feed, and only about 25 percent was sold by farmers. In the postwar years, sorghum grain utilized as feed has increased in quantity but has decreased in importance as a disposition item. From 1946 to 1950, only 60 percent of the crop was utilized as feed, and sales by farmers increased to 66 percent of production. The increasing importance of sorghum grains as a cash crop is associated with the increase in industrial uses and the expansion of exports.

Although sorghum grains are primarily thought of as a livestock feed, they are equally valuable as a raw material for food and in making industrial alcohol. Ball and Rothgeb (*1*, p. 3,) say "The natural uses of sorghum grains are as feed for stock, including poultry; as food for people; and in making industrial alcohol." Its use as food has not gained in importance but according to Edwards and Curtis, (*5*, p. 29): "The early white settlers in the semi-arid regions of the United States depended heavily on grain sorghums as an important source of food, especially in years of severe drought when corn and wheat failed."

Utilization of sorghum grains for human food in the United States other than for wet milling probably does not exceed a million bushels a year. Since 1945, however, much of the grain exported has been utilized as food by importing countries, particularly India and certain European countries stricken by World War II.

Industrial uses and products are almost as varied as those for corn. Its physical composition compares favorably with that of corn—its protein content is slightly higher, its starch content is about the same, and its oil content is slightly lower. Principal industrial uses of grain sorghums are alcohol, distilled spirits, and starch.[11] Table 17 shows the supply and disposition of the grain from 1929 to 1951.

Implications of the increases in industrial uses and in exports of sorghum grains are discussed in detail in the section devoted to statistical analyses of the factors that cause deviations from corn prices from November to May.

Foreign Trade for Sorghum Grains

The export demand for sorghum grains has increased considerably in the post-World War II period. From 1946 to 1950, exports on the average amounted to 38 million bushels and represented 27 percent of the total disappearance. Before 1944 exports of sorghum grains were negligible. From 1920 to 1944, exports were less than a million bushels in each year except 1930 and 1931, when 1.7 and 7.5 million bushels respectively were exported. Imports have never been large.

Associated with this increase in exports are: (1) The price of sorghum grains in relation to that of corn and other feed grains has been unusually low, and (2) the center of production is near ports. The fact that sorghum grains may be utilized directly as human food as well as for livestock feed and conditions existing in Asia probably have been factors also.

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[11] For a more detailed discussion of products and uses see 1950-51 Yearbook of Agriculture (*22*, pp. 349-52) and Edwards and Curtis (*5*).

TABLE 16.—*Sorghum grains: Production and percentage distribution, in specified States, 1929–52*

Year	Production					Percentage distribution				
	Texas	Oklahoma	Kansas	Other States	United States[1]	Texas	Oklahoma	Kansas	Other States	United States
	Million bushels	*Million bushels*	*Million bushels*	*Million bushels*	*Million bushels*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
1929	24	9	11	6	50	48	18	22	12	100
1930	19	5	8	6	38	49	13	21	17	100
1931	38	11	15	8	72	53	16	20	11	100
1932	34	11	13	7	66	52	17	20	11	100
1933	25	10	12	7	54	46	18	23	13	100
1934	10	5	1	4	19	51	25	3	21	100
1935	36	8	4	9	58	62	14	8	16	100
1936	20	2	1	7	30	66	7	3	24	100
1937	38	10	11	11	70	54	14	16	16	100
1938	33	8	13	13	67	49	13	19	19	100
1939	25	6	8	14	53	48	10	15	27	100
1940	34	10	24	17	86	40	12	28	20	100
1941	58	9	22	25	114	51	8	19	22	100
1942	60	11	20	19	110	54	10	18	18	100
1943	74	6	17	13	110	68	5	15	12	100
1944	99	15	49	22	185	54	8	26	12	100
1945	59	8	18	12	96	62	8	18	12	100
1946	72	7	11	16	106	68	7	11	14	100
1947	65	5	11	12	93	70	5	12	13	100
1948	74	8	29	20	131	57	6	22	15	100
1949	85	8	30	25	148	57	6	20	17	100
1950	145	18	45	27	233	62	8	19	11	100
1951	72	17	57	14	160	45	10	36	9	100
1952[2]	48	4	19	12	83	58	5	23	14	100

[1] Based on unrounded figures.

[2] Preliminary.

TABLE 17.—*Sorghum grains: Supply and disposition, United States, 1929–52*

Year beginning October	Supply			Disposition				
	Carry-over [1]	Production	Total	Seed	Food and industrial uses [3]	Feed, other uses, and waste [4]	Exports [5]	Domestic disappearance [2]
	Million bushels	*Million bushels*	*Million bushels*	*Million bushels*	*Million bushels*	*Million bushels*	*Million bushels*	*Million bushels*
1929	......	50	......	1	......	49	([6])	50
1930	......	38	......	2	......	34	2	36
1931	......	72	......	2	......	63	8	64
1932	......	66	......	2	......	64	([6])	66
1933	......	54	......	2	......	52	([6])	54
1934	......	19	......	2	......	17	([6])	19
1935	......	58	......	2	......	56	([6])	58
1936	......	30	......	2	......	28	([6])	30
1937	......	70	......	2	......	67	1	69
1938	......	67	......	3	......	65	([6])	67
1939	......	53	......	3	......	50	([6])	53
1940	......	86	......	3	([6])	83	([6])	86
1941	......	114	......	2	([6])	111	([6])	114
1942	......	110	......	3	1	106	([6])	110
1943	......	110	......	3	10	97	([6])	109
1944	......	185	......	2	48	129	5	180
1945	......	96	......	2	9	84	1	95
1946	......	106	......	2	5	75	24	82
1947	7	93	100	2	10	65	17	77
1948	7	131	138	2	4	74	40	79
1949	19	148	167	2	10	63	32	76
1950	60	233	293	2	37	141	75	180
1951	38	160	198	2	13	112	62	127
1952 [7]	10	83	93	......	......	......	......	......

[1] Stocks in all positions on October 1. Not reported before 1947.
[2] Computed from unrounded data.
[3] Principally alcohol and distilled spirits. Includes an allowance for wet-processing since mid-1949.
[4] Residual.
[5] Calendar year following, 1929–33; year beginning October, 1934 to date.
[6] Less than 500,000 bushels.
[7] Preliminary.

Statistical Analyses of Factors That Cause Deviations from Prices of Corn from November to May

As the production and marketing period for sorghum grains coincides approximately with that of corn and as prices received by farmers before 1932 are not available, the statistical analyses of prices of sorghum grains are confined to discussion of the factors that cause deviations from prices of corn from November to May. The two methods of analyses discussed on page 18 were used to explain sorghum prices. Both analyses were based on year-to-year change, after converting all the data to logarithms. The years included were 1932–42. The variables used in the two methods were as follows:

Method 1:

X_0—Ratio of the November to May price per 100 pounds received by farmers for sorghum grains to the November to May price per bushel received by farmers for corn.

X_1—Ratio of supply of sorghum grains (production) to supply of corn (production plus October 1 stocks plus imports).

X_2—Ratio of production of corn in Texas, Oklahoma, and Kansas to United States production.

X_3—Number of grain-consuming animal units fed in Texas, Oklahoma, and Kansas, year beginning October, in millions.

Method 2:

X_0—Price per 100 pounds received by farmers for sorghum grains, average for November to May.

X_1—Price per bushel received by farmers for corn, average for November to May.

X_2—Same as X_1 in method 1.

X_3—Same as X_2 in method 1.

X_4—Same as X_3 in method 1.

A comparison of United States average prices received by farmers for sorghum grains and for corn is in effect a comparison of regional prices of two competing commodities. This is because the United States average price is computed by weighting State prices by production. Thus, the United States average prices of corn and sorghum grains represent mainly prices of corn in the Corn Belt and prices of sorghum grains in Texas, Oklahoma, and Kansas. Variations in regional factors of supply and demand can therefore be expected to affect the price ratio. The United States production of sorghum relative to the United States supply of corn chiefly affects deviations of sorghum prices from those of corn. This variable alone explains 69 percent of the variations in the price ratio. Inclusion of the two additional variables—production of corn in Texas, Oklahoma, and Kansas relative to the United States production and animal units in Texas, Oklahoma, and Kansas—explains much of the remaining variation. Neither of these variables had a statistically significant effect, but, as the signs of the respective regression coefficients were in line with expectations, these variables were retained in the analysis. The three variables together explained 79 percent of the year-to-year variation in the United States average farm price of sorghum grains relative to the United States average farm price of corn.

Results from method 2 indicate that most of the year-to-year variation in the price of sorghum grains is associated with variations for the price of corn and the other independent variables. This is to be expected as almost 80 percent of the deviations in the price of sorghum grains from the price of corn was explained by the independent variables in method 1. Method 2 merely expresses the variables somewhat differently.

For method 1, table 18 shows the effects on the price ratio of specified ratios to the preceding year in the specified variables. Ranges shown for the variables approximately equal that which prevailed from 1932 to 1951. The effects of all three factors on the price ratio can be found by multiplying the separate ratios together. The final result should be multiplied by 0.980 to allow for the average shift in demand over time.

The ratio to the preceding year, as indicated by table 18, can be multiplied by the actual price ratio in the preceding year to estimate the expected price ratio in the year for which a forecast is being made. There is a 65- to 70-percent chance that the estimated price ratio will differ from the actual price ratio by not more than 10 percent and a 95-percent chance that it will differ by not more than 22 percent.

The upper three sections in figure 9 show the price ratio, adjusted for the remaining variables, against each independent variable in turn for method 1. In each section, the relevant partial regression curve, based on the mathematical analysis, was drawn. In the fourth section the unexplained residuals were plotted against time. Data for 1932–42 used in the analysis are shown as dots, and data for World War II and postwar years are shown as x's. The lower section shows the simple relationship between the price and supply ratios in terms of actual data.

The calculated value for the year 1943 does not approach the actual value as closely as do the calculated values for the other years shown in the first three sections of figure 9. In an analysis of this kind, calculated values for some years frequently deviate widely from actual values. This reflects the influence of factors that were not included in the analysis. In this case, however, a shift in the relationship between these two variables is evident when the price ratio is related to the supply ratio in terms of actual data. The lower section of figure 9 shows these two variables plotted against each other for 1932–51. A regression curve based on a regression analysis for 1932–42 was drawn as a solid line. Data for 1943–51 are shown as x's and a dotted line on a freehand basis has been drawn through them. This chart indicates that a permanent shift in the relationship occurred in 1943; that is, in the war and postwar years higher prices of sorghum grains relative to corn are associated with given relative supplies than in 1932–42.

Three factors partially explain this shift. As mentioned previously, utilization of sorghum grains for industrial uses was negligible before 1943. Since 1943, however, substantial quantities have been used for this purpose. Beginning in 1943 and continuing through 1951, exports of sorghum grains have been considerably

TABLE 18.—*Sorghum grains: Relation between year-to-year changes in November to May price received by farmers relative to the November to May price of corn and production relative to the supply of corn on October 1, production of corn in Texas, Oklahoma, and Kansas relative to production in the United States, and number of grain-consuming animal units fed in Texas, Oklahoma and Kansas during the year beginning October* [1]

RATIO TO PRECEDING YEAR

X'_0 Estimated relative price of sorghum grains [2]	X_1 Production of sorghum grains relative to supply of corn	X'_0 Estimated relative price of sorghum grains [2]	X_2 Production of corn in 3 States relative to United States production	X'_0 Estimated relative price of sorghum grains [2]	X_3 Number of grain-consuming animal units
1.19	0.50	...	...	...	...
1.14	.60	1.13	0.60	...	...
1.10	.70	1.09	.70	...	...
1.06	.80	1.06	.80	0.91	0.80
1.03	.90	1.04	.90	.95	.90
1.00	1.00	1.00	1.00	1.00	1.00
.98	1.10	.98	1.10	1.04	1.10
.95	1.20	.96	1.20	1.08	1.20
.94	1.30	.94	1.30	...	...
.92	1.40	.92	1.40	...	...
.90	1.50	.91	1.50	...	...
.89	1.60	.89	1.60	...	...
.87	1.70	...	...	...	...

[1] When the other variables in the analysis remain at the preceding year's level. From an analysis based on first differences of logarithms, 1922–42.

[2] Computed from the following equation when all variables are expressed as first-differences of logarithms:

$$X_0' = -0.009 - 0.26X_1 - 0.25X_2 - 0.45X_3$$

The following statistical coefficients relate to this analysis:

$R^2_{0.123} = 0.79$ $s_{b_{01.23}} = 0.17$ $s_{b_{02.13}} = 0.10$

$r^2_{01.23} = .53$ $s_{b_{03.12}} = .04$ $s_{b_{03.12}} = .36$

$r^2_{02.13} = .21$ $r^2_{03.12} = .26$

NOTE.—The constant value in the equation does not differ significantly from zero.

greater than during the prewar period. Furthermore, production of corn in Texas, Oklahoma, and Kansas from 1946 to 1950 was only 92 percent of the production from 1938 to 1942. The decline was greatest for Texas, where production for the latter period was only 69 percent of the 1938–42 production. The combined effect of these three items partially explains the failure of World War II and postwar data to adhere to the same relationship that existed from 1932 to 1942. Support prices for sorghum grains relative to those for corn during the postwar period may also have been a factor.

As the basic analysis was run in terms of year-to-year changes, only the year 1943 (the year in which the shift occurred) deviated widely from the calculated value. If actual data had been used

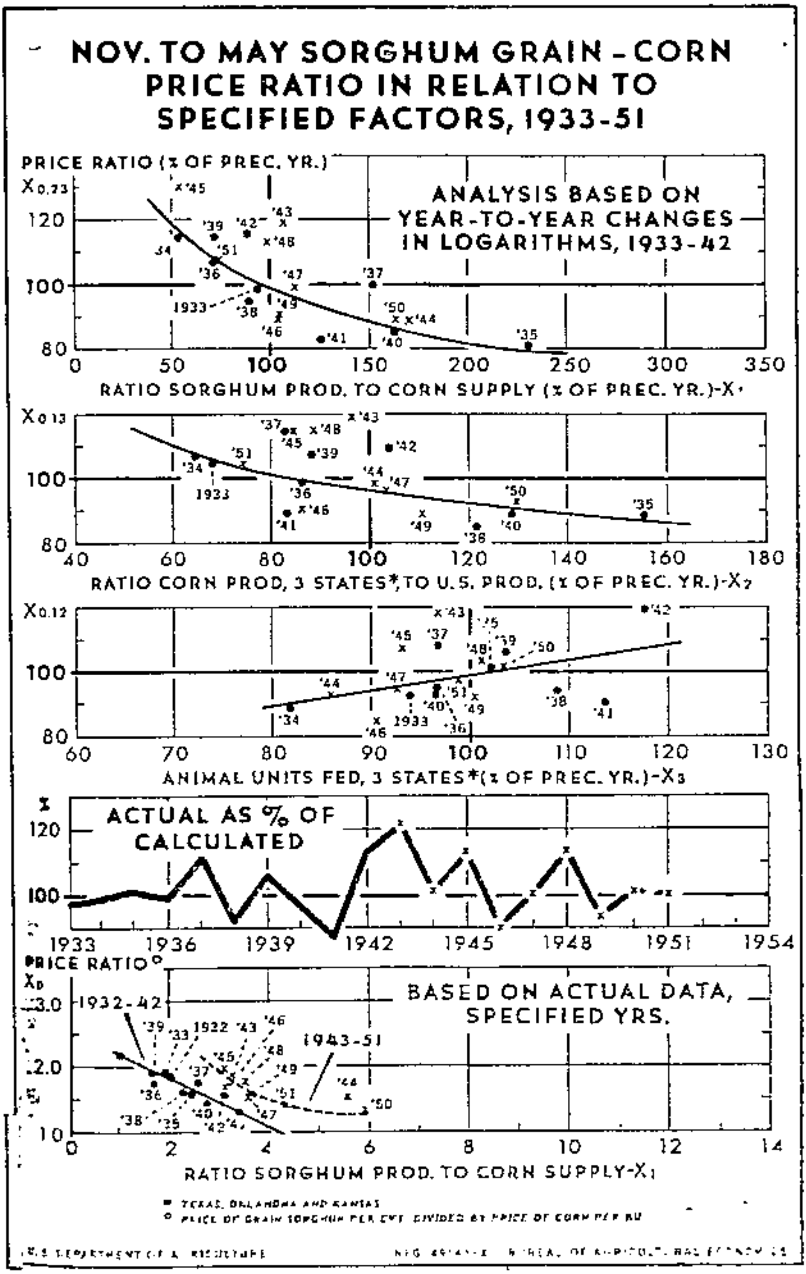

FIGURE 9.—The three factors presented in the upper 3 sections of the chart explained 79 percent of the year-to-year variation in the ratio of the price of sorghum grains to the price of corn in 1932–42. With the exception of 1943, when a permanent shift occurred, in terms of year-to-year variations these relationships have apparently remained unchanged. The lower section in the figure indicates the shift.

in running the analysis, calculated prices, based on relationships from 1932 to 1942, would have deviated widely from actual prices not only in 1943 but in all of the war and postwar years, and particularly in 1944 and 1950.

ELASTICITY OF SUBSTITUTION.—In the regression analysis for method 1, a 1-percent change in the supply ratio was associated with a 0.26 percent change in the opposite direction in the price ratio. Taking the reciprocal of this relative price flexibility yields a value of —3.9, which indicates that sorghum grains may be substituted readily for corn. The comparable coefficients for oats and barley were —1.4 and —2.2, respectively. The larger value for sorghum grains indicates that it may be substituted even more readily for corn than can barley or oats. This is in line with the feeding values of these three grains relative to corn. (See p. 15). These coefficients are discussed in greater detail on page 72.

As with oats and barley, November to May actual prices may be computed, using the analysis developed under method 2, by substituting for X_1—the price of corn—in the equation

$$X_0' = -0.0008 + 0.88X_1 - 0.34X_2 - 0.27X_3 + 0.42X_4$$ [15]

the coefficients obtained by Foote (7) in his analysis of factors that affect the price of corn. As the constant value in the above equation does not differ significantly from zero, it is omitted. The regression coefficient for X_1, 0.88, is retained as such because it differs substantially from 1.[16] If Foote's coefficients are substituted the following equation results:

$$X_0' = 0.88\ (0.004 - 2.36X_1 + 1.94X_2 + 1.13X_3) - 0.34X_4 - 0.27X_5 + 0.42X_6$$

For this equation, X_1 is the supply of all feed concentrates for the year beginning October, X_2 the number of grain-consuming animal units fed for the same period, X_3 prices of livestock and products during November to May, X_4 ratio of production of sorghum grains to supply of corn, X_5 ratio of production of corn in Texas, Oklahoma, and Kansas to United States production of corn, and X_6 grain-consuming animal units fed in Texas, Oklahoma, and Kansas during the year beginning October. Actual and calculated prices are found in table 19, together with data used in methods 1 and 2.

The effects of all six factors on the price of sorghum grains may be found as follows: (1) Express each of the independent variables as a ratio to the preceding year and locate the appropriate line in the respective tables; (2) multiply the appropriate ratios for

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[15] The following statistical coefficients pertain to this analysis:

$R^2_{0.1234} = 0.98$	$s_{b_{03.124}} = 0.16$	$r^2_{02.134} = 0.02$
$s_{0.1234} = .04$	$s_{b_{04.123}} = .34$	$r^2_{03.124} = .35$
$s_{b_{01.234}} = .10$	$r^2_{01.234} = .94$	$r^2_{04.123} = .23$
$s_{b_{02.134}} = .12$		

[16] This value does not differ from 1 by a statistically significant amount but in this case a value substantially less than 1 is logical, reflecting the fact that prices in deficit areas tend to change by smaller proportional amounts than in areas of surplus. Extension of the years included in the analysis to 1946–51 yielded a regression coefficient for X_1 of 0.90. With the added degrees of freedom, the difference between this and 1 was almost significant at the 5-percent point.

the first 3 factors (found in table 7, page 33) together, multiply the result by 1.009 to allow for the average shift in demand over time, and by 0.88 to allow for the less than proportional change in prices of sorghum grains; and (3) multiply this computed figure by the appropriate ratios for the respective factors found in table 20.

Suppose the supply of feed concentrates is expected to be 20 percent above that of the preceding year, animal units fed 5 percent above, prices of livestock and livestock products 10 percent above, production of sorghum grains relative to supply of corn 20 percent above, production of corn in Texas, Oklahoma, and Kansas relative to the United States production 10 percent below, and animal units fed in these States unchanged. The analysis then indicates that the price of sorghum grains would be roughly 32 percent below the price in the preceding year. This percentage is obtained from the following computation:

$$0.65 \times 1.10 \times 1.11 \times 1.009 \times 0.88 \times 0.94 \times 1.03 \times 1.00 \times 100 = 68$$
$$100 - 68 = 32$$

The percentage change from the preceding year, as indicated by this method, can be multiplied by the actual price in the preceding year to estimate the expected price in the year for which a forecast is being made. There is a 65- to 70-percent chance that the estimated price will differ from the actual price by not more than 24 percent.

COMPARISON OF COEFFICIENTS OBTAINED FROM THE PRICE STUDIES FOR THE THREE GRAINS

Certain theoretical considerations are set forth here and the relation of the results obtained in the various analyses to these considerations are discussed. The statistical price analyses run in the preceding sections are based, with some modifications, upon these considerations. The discussion presupposes acquaintance with the basic concepts of multiple and partial regression and correlation. The more important conclusions and practical applications were discussed in previous sections.

Before going further into the discussion, certain theoretical criteria are needed if the results are to be properly evaluated. 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 demand for the other. As a result prices for both increase. An increase in supply of one with a resulting decrease in its price also decreases the price of the other. In the July to October analyses of the prices of oats and barley, it was shown that changes in the two demand factors used in each analysis about equally affected prices of the individual grains. Weights derived for the components of the supply variables in the two studies indicate that supplies of competing grains affect the price of the particular grain in question.

TABLE 19.—*Sorghum grains: Average price per 100 pounds received by farmers and related variables, 1932–52*

Year beginning	Price (November to May): Sorghum grains: Actual	Price (November to May): Sorghum grains: Calculated [1]	Price (November to May): Corn, per bushel	Price (November to May): Percentage sorghum grains is of corn: Actual	Price (November to May): Percentage sorghum grains is of corn: Calculated [2]	X_4 Percentage sorghum grains production is of corn supply, October 1	X_5 Percentage corn production in Texas, Oklahoma, and Kansas is of United States production	X_6 Number of grain-consuming animal units fed, Texas, Oklahoma, and Kansas [3]
	Cents	*Cents*	*Cents*	*Percent*	*Percent*	*Percent*	*Percent*	*Million*
1932	[4]43	...	24	182	...	2.06	10.41	19.0
1933	86	71	45	190	194	1.95	7.09	17.8
1934	183	242	83	220	223	1.05	4.55	14.6
1935	89	92	56	160	157	2.42	7.05	14.0
1936	182	176	106	172	174	1.70	6.18	14.4
1937	89	80	51	175	157	2.58	5.11	13.9
1938	71	88	44	161	175	2.31	6.20	15.2
1939	104	82	55	191	180	1.68	5.46	15.7
1940	86	88	58	147	152	2.73	7.04	15.1
1941	97	112	74	131	150	3.41	5.84	17.2
1942	144	125	90	159	141	3.08	6.06	20.2
1943	209	159	112	186	152	3.27	5.87	19.6
1944	161	155	107	151	148	5.56	5.90	16.8
1945	226	209	115	196	175	3.02	4.98	15.7
1946	234	256	138	170	189	3.13	4.30	14.2
1947	342	320	220	156	155	3.53	4.43	13.1
1948	216	222	120	179	158	3.52	3.93	13.3
1949	187	181	118	159	170	3.66	4.35	13.3
1950	206	199	155	133	131	5.98	5.63	13.8
1951	252	273	167	151	151	4.40	4.19	13.6
1952	267	...	147	182	...	[5]2.20	[5]3.36	...

[1] Computed from the following equation when all variables are expressed as first differences of logarithms: Price of sorghum grains $= 0.88\ (0.004 - 2.36X_1 + 1.94X_2 + 1.13X_3) - 0.34X_4 - 0.27X_5 + 0.42X_6$. The first 3 independent variables are shown in table 7, page 33.

[2] Computed from the following equation when all variables are expressed as first differences of logarithms: Price ratio $= -0.009 - 0.26X_4 - 0.25X_5 + 0.45X_6$.

[3] Year beginning October.

[4] Partially estimated by author.

[5] Preliminary.

TABLE 20.—*Sorghum grains: Relation between year-to-year changes in November to May price received by farmers and production of sorghum grains relative to supply of corn, production of corn in Texas, Oklahoma, and Kansas relative to United States production, and animal units fed in Texas, Oklahoma, and Kansas during the year beginning October* [1]

RATIO TO PRECEDING YEAR

Estimated price of sorghum grains	Production of sorghum grains as a percentage of corn supply	Estimated price of sorghum grains	Corn production in 3 States as a percentage of United States production	Estimated price of sorghum grains	Number of animal units fed in 3 States
1.26	0.50	....	....	....	....
1.19	.60	1.15	0.60	....	....
1.13	.70	1.10	.70	....	....
1.08	.80	1.06	.80	0.91	0.80
1.04	.90	1.03	.90	.96	.90
1.00	1.00	1.00	1.00	1.00	1.00
.97	1.10	.97	1.10	1.04	1.10
.94	1.20	.95	1.20	1.08	1.20
.92	1.30	.93	1.30	....	....
.89	1.40	.91	1.40	....	....
.87	1.50	.90	1.50	....	....
.85	1.60	.88	1.60	....	....
.84	1.70	....	....	....	....

[1] When the other variables in the analysis remain at the level of the preceding year. From an analysis based on first differences of logarithms, 1922–42. See description of method 2 in text.

If the competing goods were perfect substitutes—if they were identical in form, time, and place—prices would move perfectly together. Changes in factors of demand would result in identical price responses for each and a changed supply of one would affect the price of each by the same amount. In multiple regression analyses, with price as the dependent variable, the regression coefficients for the demand variables in both analyses would be identical and the regression coefficients (or weights) for the supply variables in each analysis also would be identical. If the price of one was expressed as a ratio to the price of the other, the ratio always would be 1, regardless of the ratio between the supplies of the two commodities. If the price ratio was related to the supply ratio in a linear regression analysis, the constant (a) value would be 1 and the regression coefficient for the supply ratio would be 0, thus giving rise to an infinitely large elasticity of substitution.

But suppose a given quantity of one resulted in a 10-percent larger output than the same quantity of the other in any given end use, regardless of the level of substitution. Suppose also that the demand functions had the following form:

$$\text{(I)}\ P_1 = -b_{11}Q_1 - b_{12}Q_2$$
$$\text{(II)}\ P_2 = -b_{21}Q_1 - b_{22}Q_2$$

Then $b_{11} > b_{12}$, $b_{12} = b_{21}$, $b_{21} > b_{22}$, $\frac{b_{11}}{b_{12}} = \frac{b_{21}}{b_{22}} = = 1.10$, $b_{11}b_{22} = b^2_{12}$, and P_1 always equals 110 percent of P_2 [$P_1 = 1.10 (P_2)$] regardless of the values of Q_1 and Q_2.

This is clear from the example that follows. Suppose the following coefficients are substituted in equations (I) and (II):

$$\text{(Ia)} \quad P_1 = 1100 - 110Q_1 - 100Q_2$$
$$\text{(IIa)} \quad P_2 = 1000 - 100Q_1 - 90.91Q_2$$

Note that for these values, $b_{11}b_{22} = b^2_{12}$. If in these equations the given values of Q_1 and Q_2 are substituted, price ratios are obtained as follows:

Q_1	Q_2	$\frac{Q_1}{Q_2}$	P_1	P_2	$\frac{P_1}{P_2}$
1	1	1.0	890	809.09	1.10
1	2	.5	790	718.18	1.10

Similar results are obtained for any value of Q_1 and Q_2.

If this price ratio were related to the supply ratio in a linear regression analysis, the constant value would always be 1.10 and the regression coefficient again would be 0, thus giving rise to an infinitely large elasticity of substitution. This is the common interpretation of the theory of substitute goods.

In certain cases, however, the relative contribution of a substitute commodity to the total output depends on the relative size of its consumption or use. For example, Henry and Morrison (*10*, p. 494) say with regard to oats as a substitute for corn in feeding hogs, "Ground oats are worth about as much as corn per 100 pounds when forming a rather small part of the ration, but when fed in large amounts, they are worth much less than corn, . . ." and, "Numerous experiments have shown that oats have the highest value for pigs when ground oats form not over one-fourth of the ration. When thus fed to replace part of the corn in 20 trials with pigs in dry lot, the addition of ground oats increased the rate of gain a trifle."

In such cases, the relationship between the price ratio $(\frac{P_1}{P_2})$ and the supply ratio $(\frac{Q_1}{Q_2})$ results in a regression coefficient for the supply ratio less than 0, and an elasticity of substitution less than infinity. In the notation used above, b_{11} would still be greater than b_{12}, b_{12} could still equal b_{21}, but $b_{11}b_{22}$ *must be greater than* b^2_{12} to satisfy the requirement that the price ratio varies inversely with the supply ratio. Suppose that the following coefficients are substituted in equations (Ia) and IIa):

$$\text{(Ib)} \quad P_1 = 1100 - 110Q_1 - 100Q_2$$
$$\text{(IIb)} \quad P_2 = 1000 - 100Q_1 - 110Q_2$$

Note that $b_{11}b_{22}$ now is greater than b^2_{12}.

Substituting in the equations under these conditions, the following price ratios are obtained:

Q_1	Q_2	$\frac{Q_1}{Q_2}$	P_1	P_2	$\frac{P_1}{P_2}$
1	1	1.0	890	790	1.127
1	2	.5	790	680	1.162
1	3	.3	690	570	1.211

Under these circumstances, $\frac{P_1}{P_2}$ varies inversely with $\frac{Q_1}{Q_2}$.[17]

Results obtained in the November to May relative price studies are consistent with the indication by Henry and Morrison that this is the case with respect to feed grains.

These three possibilities may be further illustrated through the use of input-output relationships, as illustrated in figure 10. In this figure, the vertical and horizontal axes *simultaneously* measure input of feed and output of livestock products. For simplicity of presentation, livestock products are assumed to be measured in units such that 1 pound of corn yield 1 unit of product.

If the ration is composed of 100 pounds of corn, the output is 100 units. If the ration is composed of, say, 80 pounds of corn and 20 pounds of a perfect substitute, the output is still 100 units by definition. Thus any combination of corn and a perfect substitute will yield 100 units of product, so long as the total input is 100. In this case, the output function is the straight line (A) illustrated, intersecting the Y and X axes respectively at 100. Under this condition, the demand functions for corn and the perfect substitute would be equivalent to those discussed in the first case referred to on page 67, and the elasticity of substitution would be infinite.

If corn were worth 110 percent of some other substitute, at all levels of relative supply, the output curve would intersect the Y axis at 100 and the X axis at 90.91, as shown by the straight line (B). The demand functions for corn and the substitute would be similar to that illustrated by equations (Ia) and (IIa). Again the elasticity of substitution would be infinite.

If corn (or, conversely, the substitute) possessed varying values depending on the level of relative supply, the output function

[17] Ezekiel (*6*, p. 179) found the ratio of the retail price of pork to the retail price of beef to be significantly correlated (inversely) with the ratio of the supply of pork to the supply of beef. Schultz (*17*, p. 584), using the same data, determined the following demand functions for beef and pork:

$$P_b = 77.4 - 13.3Q_b - 4.3Q_p + 0.49I$$
$$P_p = 68.8 - 5.4Q_b - 7.5Q_p + 0.48I$$

where P_b and P_p are composite retail prices of beef and pork, respectively, in cents per pound, Q_b and Q_p are total consumption of federally inspected beef and pork, respectively, in billions of pounds, and I is an index of payrolls lagged by 3 months. If I is assumed to be constant, and given values of Q_b and Q_p are substituted in these equations, the following results are obtained:

Q_b	Q_p	$\frac{Q_b}{Q_p}$	P_b	P_p	$\frac{P_b}{P_p}$
1	1	1.0	59.8	55.9	1.07
1	2	.5	55.5	48.4	1.15
1	3	.3	51.2	40.9	1.25

It should be noted that in the above demand functions $b_{11} > b_{12}$, $b_{12} \simeq b_{21}$, and $b_{11}b_{22} > b^2_{12}$, in the notation used in equations (I) and (II).

would be curvilinear as illustrated by the curve (C) on the chart. The demand functions for corn and the substitute in question would take the form shown by equations (Ib) and (IIb), and the elasticity of substitution would be less than infinity. The rate that productivity (or utility) increases or decreases per unit of input for the substitute commodity from any given level of relative supply determines the elasticity of substitution at that level.

Table 21 shows the relationship of a 1-percent change in the relative supply of each grain to its price ratio. These values are the regression coefficients for the relative supply variables obtained in the respective November-to-May studies. Elasticities of substitution shown in this table are the reciprocals of these values.[18] They suggest that sorghum grains can be substituted more readily for corn than can oats or barley. To illustrate these coefficients more clearly, the regression curves from the three mathematical analyses of deviations of November-to-May prices of oats, barley, and sorghum grains from November-to-May prices of corn were plotted in figure 11, together with the hypothetical curve (horizontal straight line) for a perfect substitute for corn. As these various regression curves approach the perfect substitution model, the regression coefficients become smaller and the elasticities of substitution larger. The hypothetical perfect substitute has an infinitely large elasticity of substitution.[19]

Thus far, these coefficients have been discussed in terms of differences in form; that is, differences in feeding values. Differences in location and in their relative values for nonfeed uses also affect the regression coefficients and the elasticities of substitution.

To determine whether location was a factor the analyses were rerun, using relative prices at terminal markets as the dependent variables, rather than relative average United States farm prices, and the same independent variable, relative supplies. Results in the analysis for oats yielded a regression coefficient identical with that obtained when farm prices were used as the dependent variable. Results in the sorghum grains analysis yielded a coefficient almost identical with the original analysis, and the regression coefficient obtained for barley did not differ significantly from the original. These results suggest that location does not greatly affect the elasticities of substitution for these grains.

As these grains are used largely for feed and their prices are primarily influenced by forces connected with the feed-livestock economy, the different demands for nonfeed uses probably influence the regression coefficients only slightly.

The absolute size of these crops might also affect the regression coefficients to some extent. For example, a 1-percent change in the relative supply of oats involves a considerably greater quantity of grain than does a 1-percent change in the relative supply of sorghum grains. The effect of this factor is difficult to

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[18] For a discussion of certain problems involved in the statistical estimation and the economic interpretation of this coefficient, see Morrissett (*15*).

[19] The curves in figure 11 would be expected to be mirror images of those in figure 10, but any straight line in figure 10 would correspond to a horizontal line in figure 11.

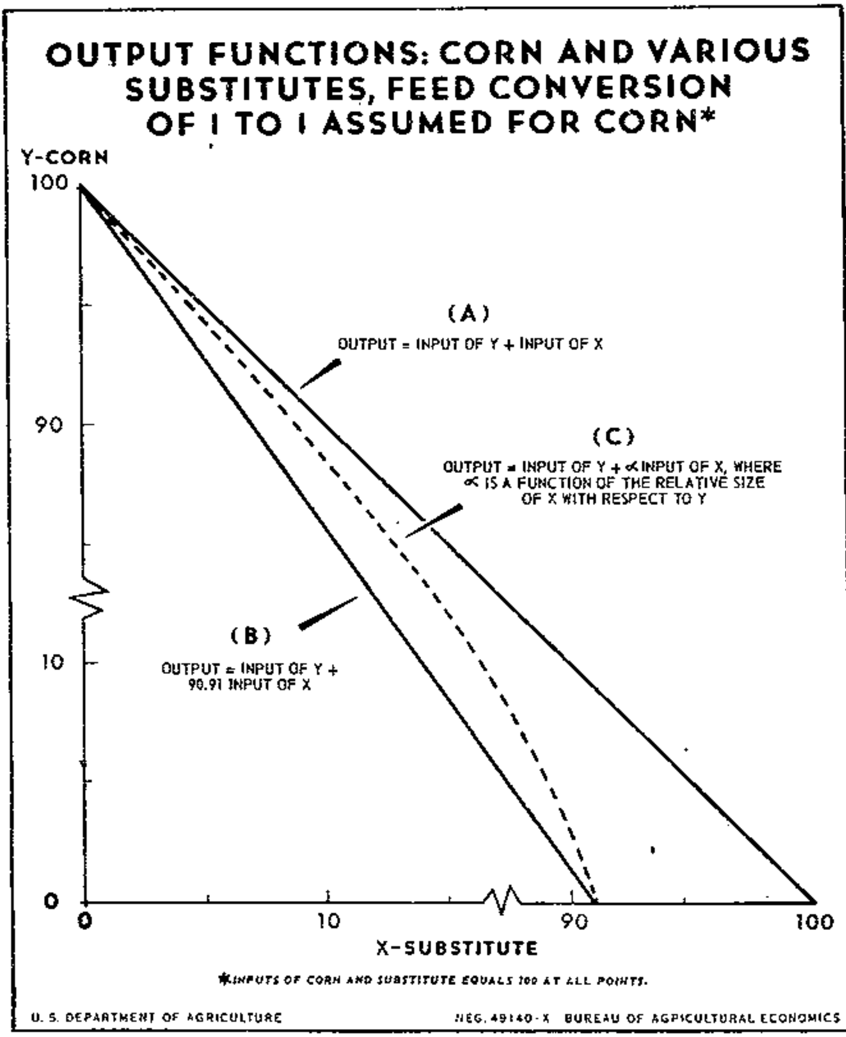

FIGURE 10.—Functions A and B illustrate perfect substitutes for corn, the feeding value of the substitute grain in function A being equal to 1 pound of corn at all levels of substitution and in function B, to 0.909 pounds of corn at all levels of substitution. Function C illustrates the case of a substitute grain possessing varying feeding values relative to corn, depending on the level of substitution.

measure. Feeding practices on individual farms, which determine relative productivity, are difficult to translate into national averages.

The regression coefficients from which the elasticities of substitution were computed were tested by a statistical method adapted from Rao (*16*, pp. 112–114) to learn whether the differences between the relative price flexibilities were statistically significant. Results from this test indicate that these coefficients differ significantly from each other.[20] Thus it can be inferred that the ease of substitution of the various grains for corn, as indicated by the elasticities of substitution, differs significantly.

TABLE 21.—*Regression coefficients and indicated elasticities of substitution obtained from November to May relative price studies for oats, barley, and sorghum grains*

Item	Effect of 1-percent change in the supply-ratio on the price-ratio		Elasticity of substitution [1]
	Regression coefficient	Standard error	
	Percent	*Percent*	
Oats	—0.73	0.09	—1.38
Barley	— .45	.07	—2.21
Sorghum grains	— .26	.10	—3.91
Perfect substitute	0	—	∞

[1] Reciprocal of the regression coefficient.

The regression coefficients between relative prices and relative supplies differed significantly from zero, indicating that these grains are not perfect substitutes for corn. These results are supported by the fact that the regression coefficients (or weights) for the supply factors in the several analyses of the factors that affect prices of feed grains in summer differ. Table 22 contains the regression coefficients (weights) for the June to September analysis by Foote (7) of factors that affect the price of corn and the July-to-October studies of prices of oats and barley found in the preceding sections. The animal-production unit series and the years included are identical for each study. But the series on prices of livestock and livestock products are an average of June to September for the corn study and July to October for the oats and barley studies. The dependent variable, the price of corn, in the corn study also differs slightly from those in the analyses of oats and barley. It is an average of the prices received by farmers for June through September, while those in the oats and barley studies are an average of July-to-October prices. These minor differences are believed to detract only slightly from the comparability of these three studies.

In these analyses, the various supply components are combined additively, whereas the basic demand equation is of a logarithmic type. The weights for the several supply components were determined statistically in such a way that the multiple correlation coefficient for the basic equation was as large as possible.[21] The separate coefficients or weights for each component are compared

[20] See Appendix for a discussion of this test.
[21] For a further discussion of the use of this method, see Foote (7).

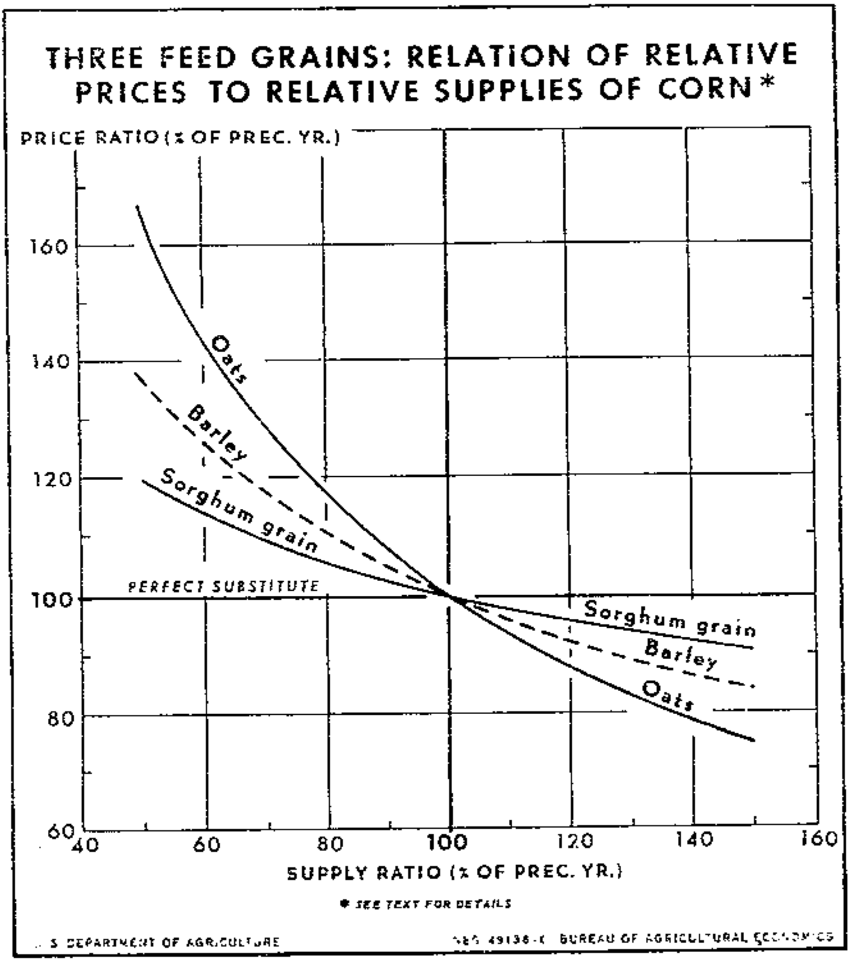

FIGURE 11.—As substitute goods approach perfect substitutability, the effect of relative supplies on relative prices approaches zero and the elasticity of substitution increases. Based on the statistical relationships illustrated in this chart, sorghum grains can be more readily substituted for corn in most feeding operations than can oats or barley.

in table 22 in order to relate these coefficients to the model (equations Ib and IIb) discussed above.

In each analysis the regression coefficient associated with the supply of the commodity whose price is the dependent variable is larger than the coefficients of the other commodities that compete with it. This is consistent with the facts discussed in previous sections. Furthermore, the standard errors associated with the regression coefficients for the two demand variables are large enough to keep the differences between the coefficients for the three analyses from being statistically significant.[22] This would

[22] The method used to make this test is described in the Appendix.

be expected. The results could not be expected to approach the precision suggested by equations (Ib and IIb) because: (1) The July-to-October analyses were designed to take into consideration factors of supply, both realized and prospective, that influence prices and, (2) the dependent variables were first differences of actual prices in cents per bushel (as contrasted with cents per pound). For these reasons, the coefficients equivalent to b_{12} do not equal those equivalent to b_{21}, although the differences are not statistically significant. In all cases, however $b_{11}b_{22}$ is greater than b^2_{12}.

These two sets of analyses confirm the view that the four feed grains compete with each other but that they are not perfect substitutes. This is consistent with available experimental evidence on feeding.

SEASONAL VARIATION IN PRICES OF OATS, BARLEY, AND SORGHUM GRAINS

Prices of the three grains tend to decline when the crop is harvested and to rise as the marketing season progresses. This monthly pattern of prices is common to most agricultural commodities; it is termed "seasonal variation." It arises principally from differences between time of production and time of consumption, although other factors may contribute to the normal seasonal pattern. Seasonal variation in prices of oats and barley follow similar patterns, which reflect the nearly identical production and marketing periods. The monthly pattern of prices of sorghum grains follows more closely the seasonal variation in prices of corn than those of oats or barley. The production and marketing periods for sorghum grains more closely approach those of corn than those of oats or barley. Of the three grains, the price of oats varies most widely, the price of sorghum grains is second, and the price of barley varies least. Seasonal variation for all three grains is less than that for corn, larger than for the food grains, and smaller than for such perishable commodities as eggs, fruits, and vegetables.

United States Average Prices Received by Farmers

Two factors appear to be mainly responsible for the seasonal variation in prices received by farmers for the three grains. First are the heavy marketings during the season when the bulk of the crop is harvested. Monthly marketings by farmers for the four feed grains, expressed as a percentage of each year's crop sold by farmers, were plotted in figure 12, together with their respective indexes of seasonal variation for prices. The inverse relationship between marketings and seasonal variation in prices is shown. Many farmers dispose of their crop as it is harvested to avoid the costs of handling and storage. As figure 12 indicates, this period of heavy marketings is July through October for oats and barley and September through January for sorghum grains. The difference in marketing seasons for the four grains apparently explains most of the differences in seasonal variation in prices.

TABLE 22.—*Corn, oats and barley: Relative weights by which specified components of the supply of feed grains should be mutiplied to obtain a composite supply factor for use in analyses of factors that affect their respective prices* [1]

Item	Months covered by analysis	Component of supply								Total weight
		Stock of corn, July 1		Prospective new crop of corn		New-crop supply of				
						Oats		Barley		
		Weight	Standard error [2]	Weight	Standard error [2]	Weight	Standard error [2]	Weight	Standard error [2]	
Corn [3].........	June to September	0.64	0.11	0.16	0.06	[4]0.10	0.13	[4]0.10	0.13	1.00
Oats [5].........	July to October...	.19	.11	.24	.06	.57	.17	0	....	1.00
Barley [5]........	....do............	.11	.08	.14	.04	.20	.18	.55	.42	1.00

[1] When all components are expressed in tons.
[2] Based on standard errors of respective regression coefficients.
[3] Based on relative size of the regression coefficients from analyses discussed on pages 24 and 43, respectively. (7).
[4] These components were combined in the analysis for corn.
[5] Based on relative size of the regression coefficients of the analyses discussed on pages 24 and 43, respectively.

The second factor, which is closely related to the first, is the cost of storage. The longer a commodity is held, the greater are the costs incurred. Costs normally associated with storage are interest and insurance, handling charges, cost of the space used, losses from insects and rodents, and any deterioration in quality. To the extent that the grains lose moisture, as corn does during storage, costs are incurred, for a given lot of grain weighs less at the end of the storage period than at the beginning. In terms of total value, this is generally at least compensated for by the increase in quality if the grain is properly stored.

Table 23 shows the indexes of seasonal variation in prices for the three grains and for corn, together with indexes of seasonal variation for oats, barley, and sorghum grains relative to corn. The lower section of table 23 indicates that prices of oats and barley are highest relative to corn from November through May and lowest from June through October. The wide range in these index numbers for oats and barley reflects the wide difference in the marketing periods for these grains and for corn. The index for sorghum grains relative to corn shows less variation because the respective marketing periods are similar.

Examination of monthly ratios of prices to a 12-month moving average from 1908 through 1951 indicated that a moving seasonal index should be used for oats. From 1908 through about 1920, prices of oats normally reached their lows in either October or November; since about 1930 prices of oats have typically reached their low for the year during August. Similarly, in the earlier period the peak months occurred in either May or June. Now the period of highest prices typically occurs from January through April. This seasonal pattern has changed gradually, averaging only about one-fourth of 1 percent a year from 1909 to 1950 for August, the month in which the greatest change occurred. Table 23 shows indexes of seasonal variation in prices of oats for 1910, 1920, 1930, 1940, and 1950, derived from a mathematically fitted linear trend covering ratios to a 12-month moving average, centered, for July 1908 through June 1951. Other years can be obtained by interpolation.

This changing pattern of prices reflects the changing pattern of marketings of oats by farmers in the United States. Data on monthly sales of oats by farmers are available for 1924 to 1947 only. But even this limited period indicates the trend of earlier and larger summer marketings. In the years 1924–28, on the average, farmers sold in June, July, and August 30 percent of the total quantity sold. For 1943–47, on the average, farmers sold 40 percent during these months, an increase of almost a third. The quantities sold from September through December decreased correspondingly. In the earlier period, 39 percent was sold, while from 1943 to 1947 only 27 percent was disposed of in these months. Presumably this trend began earlier than 1924 and has continued since 1947. This hypothesis is borne out by the prices for those periods for which data on monthly sales are not available.

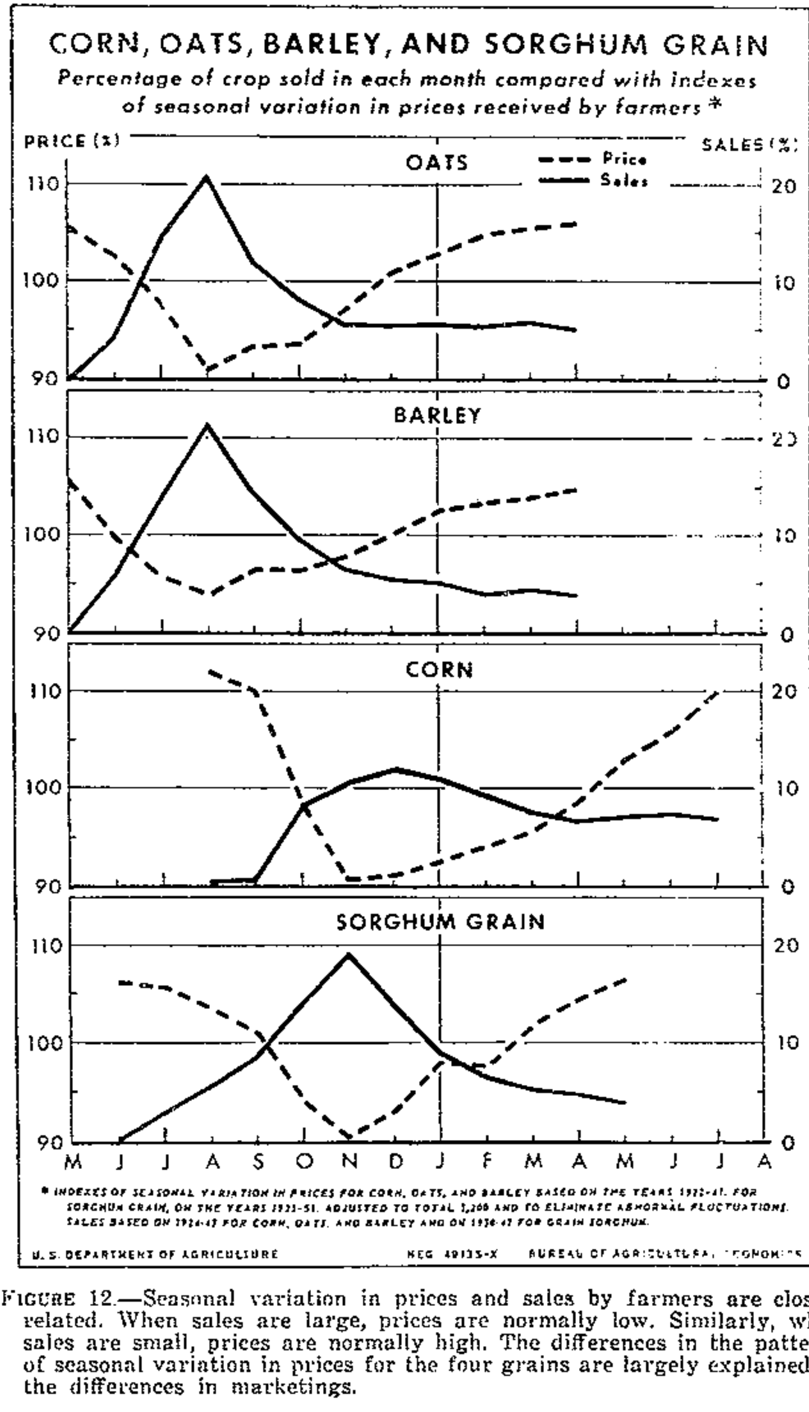

FIGURE 12.—Seasonal variation in prices and sales by farmers are closely related. When sales are large, prices are normally low. Similarly, when sales are small, prices are normally high. The differences in the patterns of seasonal variation in prices for the four grains are largely explained by the differences in marketings.

TABLE 23.—*Index numbers of seasonal variation in average prices received by farmers for oats, barley, sorghum grains, and corn, United States* [1]

Item	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
ACTUAL												
Oats: [2]												
1910	97	100	103	105	*108*	107	105	100	94	93	*93*	95
1920	99	102	104	105	*107*	105	103	97	94	*93*	94	97
1930	101	104	104	105	*106*	103	101	94	*94*	94	95	99
1940	103	*106*	105	105	105	101	99	*91*	93	94	97	101
1950	106	*108*	105	105	104	100	96	*88*	93	94	98	103
Barley [3]	102	103	104	105	*106*	100	96	*94*	96	96	98	100
Sorghum grains [3]	98	97	102	104	*106*	106	106	103	101	94	*90*	93
Corn [3]	92	94	95	98	103	106	110	*112*	110	98	*91*	91
RELATIVE TO CORN [4]												
Oats	113	*114*	110	106	100	94	87	*78*	84	95	107	112
Barley	*110*	109	108	106	102	94	86	*83*	87	98	108	109
Sorghum grains	106	104	*106*	106	103	100	96	92	*91*	95	99	102

[1] Italic numbers indicate high and low values for the year based on unrounded data.

[2] Ratios to 12-month moving average centered, adjusted for trend and to total 1,200. Based on 1908–51.

[3] Average of ratios to 12-month moving average centered, adjusted to total 1,200 and to eliminate abnormal fluctuations. Based on 1922–41 for corn and barley, 1933–51 for sorghum grains.

[4] Barley, sorghum grains, and 1950 oats index of seasonal variation divided by corn index, adjusted to total 1,200.

Seasonal variation in prices of other grains shows no indication of a change over time, although data on monthly marketings of corn, barley, and sorghum grains indicate that farmers now tend to dispose of the bulk of their marketings slightly earlier in the crop year. This trend has not been great enough, however, to affect materially the seasonal variation in prices of these grains. Thus, the indexes based on 1922–41 for corn and barley are valid currently.

These various indexes convey or imply a degree of precision that is not found in the actual data. Prices of any of the three grains deviate substantially from their normal patterns of seasonal variation during any one year. A short crop of oats following a large crop results in contraseasonal or less than seasonal price movement from May through September. Rapid changes in demand, either deflationary or inflationary, also distort the normal pattern. Similarly, the prices of oats, barley, and sorghum grains relative to prices of corn vary, depending upon the degree to which relative supplies deviate from normal. Again using oats as an example, if production of oats is very large or stocks of corn very low, the price of oats relative to the price of corn is unusually low in summer and the increase in the price of oats relative to the price of corn is greater than normal in fall and early winter. In general, the extent to which prices of oats, barley, and sorghum grains deviate from their average relationship to prices of corn depends upon the extent to which relative supplies and other factors, such as marketings, deviate from normal. Changes in demand, however, do not ordinarily affect these *relative* prices. As pointed out previously, factors of demand affect all the feed grains in about the same way.

Seasonal Variation by Major Regions

Seasonal variation differs from region to region to the extent to which climate differs enough to result in different production and marketing periods. As most of the United States supply of sorghum grains is produced in Texas, Oklahoma, and Kansas, regional index numbers are not needed for this item. Oats and barley, however, are produced in significant quantities in nearly all regions of the country. Seasonal variation for barley in the West North Central region, the principal producing area, is compared with seasonal variation in California and Colorado, two secondary producing States. Seasonal variation in prices of oats in the West North Central region is compared with that in Texas. Table 24 contains these State and regional indexes of seasonal variation, together with the index for the United States as a whole.

Three aspects are brought out by these seven indexes: (1) The Colorado index for barley, the Texas index for oats, and to some extent the California index for barley show a substantially greater range in seasonal variation than do either the West North Central or United States indexes for oats and barley; (2) the high and low months for Texas oats and California barley are earlier than the high and low months found in the West North

Central and United States indexes; (3) the West North Central and United States indexes for barley and oats show a smaller than expected seasonal increase from September to October. The first aspect reflects the importance of barley and oats in the area and conversely the lesser importance of corn. The second aspect shows the effect of climate on prices through an earlier production and marketing season, and the third reflects the effect of prices of corn on prices of barley and oats.

In California, Colorado, and Texas, corn is less important in the feed-livestock economy than in the North Central region. The effect of corn on oats and barley may be illustrated by the West North Central indexes for oats and barley and the Texas and Colorado indexes for these grains, respectively. In the West North Central region corn first is marketed in quantity in October and corn prices drop substantially in this month. This decline apparently has a depressing effect on West North Central prices of oats and barley where corn is the major feed grain. It has little or no effect on prices of Colorado barley, of Texas oats, or California barley where corn is relatively less important. As prices of corn are seasonally high and prices of oats and barley are at their seasonal low point in summer, prices of corn tend to strengthen prices of oats and barley in the West North Central region in summer and to depress them in winter when the price of corn is low and prices of oats and barley are high. This has a dampening effect on prices of oats and barley in the West North Central region, particularly from September to October, and results in relatively "flat" indexes of seasonal variation. Because corn is less important in Colorado, Texas, and California, prices in these States are affected less by prices of corn and hence the seasonal variation in prices of oats and barley is larger.

EFFECT OF LOCATION ON DIFFERENCES IN PRICE

Prices received by farmers for agricultural commodities vary considerably from one section of the country to another. For some commodities, prices in one State may be twice as high as those in another. By and large these geographic variations in prices result from regional surpluses and deficits. In regions in which production is greater than consumption, prices normally are considerably lower than in deficit areas. The differentials among surplus areas reflect principally relative proximity to deficit areas and major markets. Although costs of transportation between surplus and deficit areas account for most of the differential, variations in quality also may contribute to the spread. Regional differences in price vary considerably from year to year. They reflect changes in production of the commodity and other substitute commodities in the different areas, shifts in factors of demand, and changes in methods and costs of transportation. Also in some years for certain crops they reflect Government support programs which may influence prices more in some regions than in others.

Overall Pattern

Figure 13 shows iso-price maps for corn, oats, barley, and

TABLE 24.—*Oats and barley: Index numbers of seasonal variation in average prices received by farmers, United States and selected States and regions, average 1922–41* [1]

Area	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
OATS												
United States	103	105	105	*106*	106	102	98	*91*	93	93	97	101
West North Central region	104	106	107	*107*	106	103	97	*89*	92	92	96	101
Texas	107	110	*110*	108	107	91	*84*	88	93	97	101	104
BARLEY												
United States	102	103	104	105	*106*	100	96	*94*	96	96	98	100
West North Central region	103	105	105	105	*107*	100	94	*93*	95	95	97	101
California	*107*	103	100	101	101	*92*	94	95	98	101	104	104
Colorado	99	101	104	107	*110*	107	98	*92*	93	94	97	98

[1] Average of ratios to 12-month moving average centered, adjusted to total 1,200 and to eliminate abnormal fluctuations. Italic numbers indicate high and low values for the year based on unrounded data.

sorghum grains based on prices received by farmers by crop-reporting districts for 1932–41. These maps were prepared with the assistance of the Farm Credit Administration.

As these maps indicate, prices of oats and barley are lowest in the heavy producing areas of the West North Central region and highest in the outer fringe of States that border the oceans and the Republic and Gulf of Mexico. Prices in intervening States are usually somewhere between. The level of prices is roughly proportional to proximity to the coast, but the pattern is interrupted by the mountains and by local surplus areas outside this region. This pattern of prices for oats and barley closely approaches that of corn. It mirrors the overlapping surplus-production areas for oats and corn, and the close proximity of surplus areas for barley and corn. Similar factors of demand for feed grains also contribute to the similarity in regional price differences. The greater regional variations in prices of oats in terms of cents per bushel is largely explained by the higher transportation costs per unit of value. Regional prices for sorghum grains differ from those of other feed grains because of wider geographic differences between surplus producing areas for sorghum grains and those for the other three grains. Prices of sorghum grains are lowest in the surplus areas of Texas, Oklahoma, Kansas, and adjoining areas of New Mexico, where most of the crop is produced. From the three major producing States westward, prices increase along the southern tier of States bordering the Republic of Mexico, where sorghum grains are important feed grains. Prices increase in more northern and eastern States, reaching their highest levels in Missouri and Arkansas.

Relationships Between United States Average Prices Received by Farmers and Prices at Terminal Markets

The normal relation between average prices received by farmers in the United States and prices for a particular grade at a given terminal market is of interest from several standpoints. Terminal market prices, in most instances, are quoted daily, whereas an estimate of the average price received by farmers is available for only about the 15th of each month. Use of such a relationship indicates the probable level of prices received by farmers for other parts of the month. United States average prices for the three grains are compared with prices at leading terminal markets. Prices received by farmers in leading producing States also are compared with prices at terminal markets through which they normally market.

Oats.—Table 25 shows certain statistical relationships between the price received by farmers for oats and the price of No. 3 White oats at Chicago by months, based on 1923–41 and 1947–51. To obtain a price for Chicago approximately comparable to that received by farmers an average of the quotations for the 12th, 13th, and 14th of each month at Chicago was used. The factors given are designed to estimate the price received by farmers from the Chicago price. Factors given in columns 1 and 2 of

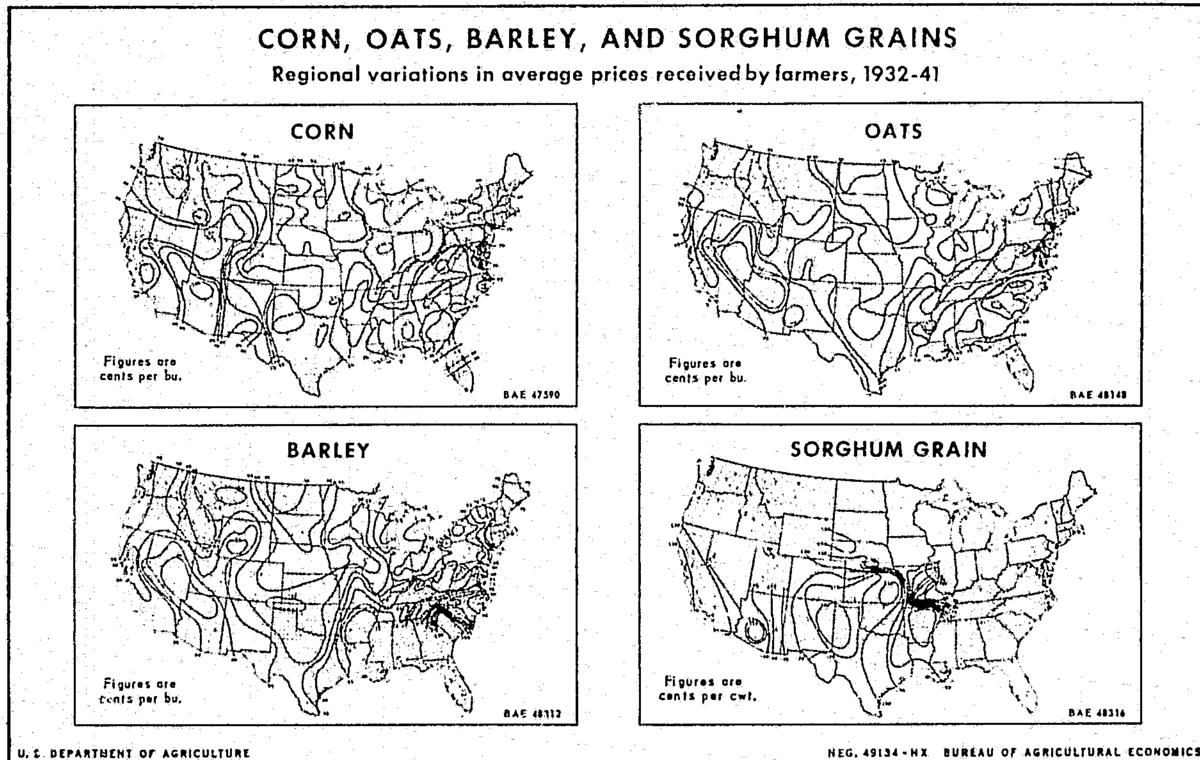

FIGURE 13.—Regional variation in prices reflect surplus and deficit areas. Prices are normally low in surplus areas and high in deficit areas. The similarity in regional variation for corn, oats, and barley reflects the overlapping surplus and deficit areas. The dissimilar pattern for sorghum grains reflects the separation of surplus areas for this grain as compared with the others.

TABLE 25.—*Oats: Relation of price received by farmers to price of No. 3 White, Chicago, based on 1923–41 and 1947–51* [1]

Month	Factor by which the Chicago price is multiplied [2]	Factor to be added to the Chicago price [3]	Average error of estimate when this relationship is used [4]	Percentage of variation in the two series which is associated [5]
		Cents	*Cents*	*Percent*
January	0.923	—0.18	1.77	99.8
February	.907	1.34	2.42	98.9
March	.888	3.57	3.71	99.3
April	.921	1.14	2.43	99.0
May	.923	1.28	3.19	98.2
June	.900	1.85	2.76	98.6
July	.925	—.26	1.93	99.1
August	.938	.11	1.89	99.1
September [6]	.897	.40	2.11	98.4
October [7]	.864	3.12	2.46	98.7
November [7]	.864	1.72	1.91	99.3
December [7]	.909	—.23	2.14	99.2

[1] Price received by farmers on 15th of the month; price at Chicago, average of quotations for the 12th, 13th, and 14th of the month.
[2] Simple regression coefficient with the price received by farmers as the dependent variable.
[3] Constant value (a) in the regression equation.
[4] Standard error of estimate.
[5] Coefficient of determination times 100.
[6] Excludes 1947.
[7] Excludes 1951.

the table must both be used in determining the comparable price at the farm (or local market) level.

Table 26 shows the relationships between the August prices received by farmers in Iowa and Illinois and the August price of No. 3 White oats at Chicago and between the August Minnesota farm price and the August price of No. 3 White oats at Minneapolis, based on 1923–41 and 1947–51. The relationship between the August price of No. 3 White oats at Minneapolis and Chicago for the same years is also shown. Movement of oats is heavy in August, hence its selection for comparison. Prices at Chicago and Minneapolis are averages of the quotations for the 12th, 13th, and 14th of the month. Iowa and Illinois farm prices are related to Chicago prices, and Minnesota farm price to Minneapolis prices to reflect the normal movement of oats from these States to terminal markets.

BARLEY.—Table 27 shows certain statistical relationships between the price farmers receive for barley and the price of No. 3 barley at Minneapolis by months, based on 1923–41 and 1947–51. To obtain a Minneapolis price as nearly comparable as possible to that received by farmers, an average of quotations for the 12th, 13th, and 14th of each month at Minneapolis was again used. As for oats, the factors found in this table are designed to estimate the price received by farmers from the Minneapolis price.

Table 28 shows the statistical relationship between the prices received by farmers in August in North Dakota, South Dakota, and Minnesota, and the August price of No. 3 barley at Minneapolis, based on 1923–41 and 1947–51. Much of the barley sold by farmers in these States moves through Minneapolis. Marketings by farmers in this region are heavy in August. To obtain a price for Minneapolis as nearly comparable as possible to that received by farmers, an average of the quotations for the 12th, 13th, and 14th of the month at Minneapolis was again used.

SORGHUM GRAINS.—Table 29 shows similar relationships between the December United States average price received by farmers for sorghum grains, the December prices received by farmers in Texas, Oklahoma, and Kansas for sorghum grains, and the December average price of No. 2 Yellow Milo at Kansas City. These relationships are based on 1933–51. The factors given are designed to estimate the price received by farmers from the Kansas City price. Factors given in columns 1 and 2 of the table must both be used in determining the comparable price at the farm (or local market) level.

Although comparable relationships between the United States average farm price and the Kansas City price for other months were not computed, the factors shown for December can be used to estimate other periods during the year with little likelihood

TABLE 26.—*Oats: Relation of price of No. 3 White, Chicago and Minneapolis, to specified prices, based on August 1923–41 and 1947–51* [1]

Related price	Factor by which related price is multiplied [2]	Factor to be added to related price [3]	Average error of estimate when this relationship is used [4]	Percentage of variation in the two series which is associated [5]
RELATION TO CHICAGO PRICE				
		Cents	*Cents*	*Percent*
Received by farmers:				
Iowa	0.987	—5.91	1.88	99.2
Illinois	.985	—4.44	1.49	99.5
No. 3 White, Minneapolis	1.005	—1.57	1.87	99.2
RELATION TO MINNEAPOLIS PRICE				
Received by farmers:				
Minnesota	.929	—3.34	1.48	99.4

[1] Price received by farmers 15th of the month; price at terminal markets, average of quotations for the 12th, 13th, and 14th of the month.

[2] Simple regression coefficient with the related price as the dependent variable.

[3] Constant value (a) in the regression equation.

[4] Standard error of estimate.

[5] Coefficient of determination times 100.

TABLE 27.—*Barley: Relation of price received by farmers to price of No. 3, Minneapolis, based on 1923–41 and 1947–51* [1]

Month	Factor by which the Minneapolis price is multiplied [2]	Factor to be added to the Minneapolis price [3]	Average error of estimate when this relationship is used [4]	Percentage of variation in the two series which is associated [5]
		Cents	*Cents*	*Percent*
January	0.773	3.32	6.69	97.6
February	.790	2.36	7.44	96.2
March	.756	5.87	7.50	96.5
April	.763	5.11	7.26	96.7
May	.760	5.47	7.35	96.3
June	.731	7.47	8.37	95.2
July	.716	7.34	7.38	95.8
August	.753	5.22	7.22	95.7
September	.793	1.63	8.73	94.4
October	.765	4.56	7.51	96.0
November	.758	4.43	7.12	96.8
December	.796	2.36	7.67	96.6

[1] Price received by farmers on 15th of the month; price at Minneapolis, average of quotations for 12th, 13th, and 14th of the month.
[2] Simple regression coefficient with the price received by farmers as the dependent variable.
[3] Constant value (a) in the regression equation.
[4] Standard error of estimate.
[5] Coefficient of determination times 100.

of obtaining errors exceeding the standard error indicated for December. To the extent that different seasonal variations in price exist for the United States and the Kansas City series, consistently wider spreads in some months and narrower in others may be found. These differences are believed to be minor.

PRICE DIFFERENCES IN CENTRAL MARKETS BECAUSE OF GRADES

OATS

Cash prices for the different grades of oats are based primarily on their foreign matter content, although many other grading factors are considered also. These include test weight per bushel, percentage of sound cultivated oats, and spoilage. Moisture is not so important in grading oats as it is in grading corn, except that oats which contain more than 16-percent moisture must be graded sample and for those grades that contain between 14.5 and 16 percent moisture, the word "tough" must precede the grade.

Test weight per bushel is not important in determining price differentials among grades. In recent years most inspected receipts have had a test weight per bushel of 35 pounds or more, while the minimum test weight for No. 1 oats is 32 lbs. In the last decade the trend toward a higher percentage of receipts grading heavy or better (test weight per bushel of 35 lbs., or more) and grading No. 1 and No. 2 was consistent. Table 30 shows the percentage of inspected receipts grading heavy and better and No. 2 or better for the crop-years 1938–50.

TABLE 28.—*Barley: Relation of price received by farmers in North Dakota, South Dakota, and Minnesota to price of No. 3, Minneapolis, based on August 1923–41 and 1947–51* [1]

Price received by farmers	Factor by which the Minneapolis price is multiplied [2]	Factor to be added to the Minneapolis price [3]	Average error of estimate when this relationship is used [4]	Percentage of variation in the two series which is associated [5]
		Cents	*Cents*	*Percent*
North Dakota....	0.850	—11.90	8.45	95.4
South Dakota.....	.813	—6.85	7.75	95.8
Minnesota........	.938	—8.47	5.25	98.5

[1] Price received by farmers on 15th of the month; price at Minneapolis, average of quotations for 12th, 13th, and 14th of the month.
[2] Simple regression coefficient with the price received by farmers as the dependent variable.
[3] Constant value (a) in the regression equation.
[4] Standard error of estimate.
[5] Coefficient of determination times 100.

TABLE 29.—*Sorghum grains: Relation of price received by farmers, specified States, to price of No. 2 Yellow Milo, Kansas City, based on December 1933–51*

Price received by farmers	Factor by which the Kansas City price is multiplied [1]	Factor to be added to Kansas City price [2]	Average error of estimate when this relationship is used [3]	Percentage of variation in the two series which is associated [4]
		Cents	*Cents*	*Percent*
United States.....	0.872	—4.106	6.79	99.2
Texas............	.867	—5.478	10.43	98.2
Oklahoma........	.863	2.823	9.00	98.7
Kansas...........	.903	—11.145	7.90	99.1

[1] Simple regression coefficient with the price received by farmers as the dependent variable.
[2] Constant value (a) in the regression equation.
[3] Standard error of estimate.
[4] Coefficient of determination times 100.

Table 31 shows the minimum test weight per bushel and maximum foreign material for the various grades of cash oats compared with the average price paid from 1946 to 1950. Comparisons were made using No. 2 White oats as the basic grade with prices, test weight, and foreign-matter content of the other grades expressed as a percentage of those for No. 2 White. Premiums and discounts in cents per bushel for these grades from No. 2 also are shown in this table. Price quotations for each marketing year represent an average for all days on which 2 or more cars of each grade were sold. Such quotations were available for 149 days in 1946 and for 201 days in 1947, the other years falling within this range. Average price relationships between grades can be studied more accurately by this method than by comparing monthly average prices. For some grades the latter might be based on only one or two quotations taken from different periods during the month.

Comparison of test weights and foreign-material content with prices reveals close agreement for all grades with foreign-material content and little or none with test weight. As mentioned above, this lack of agreement between relative prices and relative test weights reflects the fact that, on the average, in these 5 years 75 percent of the inspected receipts had a test weight of 35 pounds or more.

The apparent close agreement between foreign-material content and prices does not mean that this is the only grade factor that determines price differentials. All factors are generally taken into consideration in determining such differentials.

Barley for Feed

Prices for the different grades of barley are based primarily on their percentage content of sound barley and test weight per bushel. Other grading factors—heat-damaged kernels, foreign material, broken kernels, and black barley—are also considered.

Table 32 shows the sound barley content and test weight per bushel for the various grades of cash barley compared with the average price paid from 1946 to 1950. Comparisons were made using No. 3 barley as the basic grade, with prices, sound barley content, and test weight per bushel for the other grades expressed as a percentage of those for No. 3. Premium and discounts from

TABLE 30.—*Oats: Percentage of inspected receipts grading No. 2 or better and heavy or better at approximately 75 markets, 1938–51*

Year beginning July	Percentage of inspected receipts grading—	
	No. 1 and No. 2	Heavy and extra heavy
	Percent	*Percent*
1938	37.6	11.6
1939	34.5	32.0
1940	54.3	57.1
1941	46.9	24.1
1942	43.4	42.1
1943	32.3	46.5
1944	29.8	60.4
1945	51.0	66.3
1946	58.3	47.7
1947	57.7	64.2
1948	64.8	81.3
1949	77.3	69.4
1950	70.0	86.7

Compiled from ANNUAL BARLEY AND OATS SUMMARY (24).

No. 3 in cents per bushel also are shown. As for oats, the price quotations for each marketing year represent an average for all days on which 2 or more cars of each grade were sold. Such quotations were available for 20 days in 1949 and 69 days in 1947. Other years fell within this range.

Comparison of these two grade factors with relative prices indicates a close agreement for all grades with sound barley content and slightly less agreement with test weight. For grades 4 and 5 association of both grade factors with relative prices is relatively close. For grades 1 and 2, the premiums apparently are more closely related to sound barley content than to test weight. This probably reflects the fact that considerable barley grading Nos. 1 and 2 is used for malting. For this use, soundness is more important than test weight. Most of the barley grading 4 and 5 is used for feeding. For this use test weight and soundness probably are about equally important.

Malting Barley

Malting grades of barley normally bring a premium over comparable grades of feeding barley. This reflects the higher quality standards of these special grades. In cents per bushel, premiums for any malting grade over any feed grade have varied considerably from year to year. From July to November, 1934 through 1950, No. 2 Malting barley commanded, on the average, a premium of 9.9 cents a bushel above No. 3 barley, ranging from a high of 20 cents in 1942 to a low of 4 cents in 1940. These deviations from the average, however, apparently are not related to factors that might logically be expected to be associated with them. Prices for the grades on which the above comparisons were based were taken at Minneapolis on all days from July to November when 2 or more cars each of No. 2 Malting and Nos. 2 and 3 barley were sold.

A multiple-regression analysis was run. The spread between the price of No. 2 Malting barley and No. 3 barley was used as the dependent variable. Receipts of malting grade barley and utilization of barley for malting purposes were used as the two independent factors for 1934 to 1950, omitting the World War II years. Results of this analysis indicated that the dependent variable and the two independent variables were not related. A second analysis was run using the same dependent variable and the barley used for malt series but expressing receipts of malting barley as a percentage of total receipts. Expressing malting receipts in this way yields an estimate of the quality of the crop. Here again, results indicated that no relationship existed between dependent and independent variables.

Sorghum Grains

Moisture content is the principal factor associated with prices for the different grades of sorghum grains. However, other grade factors such as test weight per bushel, spoilage, and foreign material also are considered.

TABLE 31.—*Oats, White: Specified grade characteristics and average price in relation to No. 2, by grades, Minneapolis, 1946–50*

Grade	Minimum test weight per bushel[1]		Maximum limits of foreign material[1]		Price in relation to No. 2, year beginning July[3]											
					Percentage						Premium and discount per bushel					
	Actual	Percentage of No. 2	Actual	Percentage of No. 2[2]	1946	1947	1948	1949	1950	Average 1946–50	1946	1947	1948	1949	1950	Average 1946–50
	Pounds	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Cents*	*Cents*	*Cents*	*Cents*	*Cents*	*Cents*
No. 1	32	106.7	2	101.0	100.8	100.6	101.2	100.8	101.0	100.9	0.7	0.7	0.9	0.6	0.8	0.7
No. 2	30	100.0	3	100.0	100.0	100.0	100.0	100.0	100.0	100.0	0	0	0	0	0	0
No. 3	27	90.0	4	99.0	99.1	99.1	98.6	98.9	98.6	98.9	-.8	-1.0	-1.0	-.8	-1.2	-1.0
No. 4	24	80.0	5	97.9	98.0	97.4	96.9	97.5	96.9	97.3	-1.7	-3.0	-2.3	-1.8	-2.6	-2.3

[1] From HANDBOOK OF OFFICIAL GRAIN STANDARDS (*25*).

[2] Maximum limits for each grade subtracted from 100 and values of grades 1, 3, and 4 computed as a percentage of the value for No. 2.

[3] Simple average for all days on which 2 or more cars of each grade were sold.

TABLE 32.—*Barley: Specified grade characteristics and average price in relation to No. 3, by grades, Minneapolis, 1946–50*

Grade [1]	Minimum limits of [2]				Price in relation to No. 3, year beginning July [3]											
	Test weight per bushel		Sound barley		Percentage						Premium and discount per bushel					
	Actual	Percentage of No. 3	Actual	Percentage of No. 3	1946	1947	1948	1949	1950	Average 1946–50	1946	1947	1948	1949	1950	Average 1946–50
	Pounds	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Cents*	*Cents*	*Cents*	*Cents*	*Cents*	*Cents*
No. 1	47	109.3	95	105.6	101.9	102.2	105.1	103.0	106.4	103.7	3.3	5.1	6.7	4.1	9.5	5.7
No. 2	46	107.0	93	103.3	100.0	99.4	103.5	101.9	102.6	101.5	0	-1.4	4.6	2.6	3.8	1.9
No. 3	43	100.0	90	100.0	100.0	100.0	100.0	100.0	100.0	100.0	0	0	0	0	0	0
No. 4	40	93.0	80	88.9	95.6	94.3	87.5	89.8	88.4	91.1	-7.6	-12.9	-16.3	-13.9	-17.2	-13.6
No. 5	35	81.4	70	77.8	84.9	83.3	81.0	78.2	81.1	81.7	-26.3	-38.1	-24.8	-29.7	-28.0	-29.4

[1] Not otherwise designated.
[2] From HANDBOOK OF OFFICIAL GRAIN STANDARDS (*25*).
[3] Simple average for all days on which 2 or more cars of each grade were sold.

TABLE 33.—*Milo maize, Yellow: Specified grade characteristics and price in relation to No. 3, by grades, Kansas City, 1946–50*

Grade	Maximum moisture permitted[1]	Equivalent minimum dry matter		Price in relation to No. 3, year beginning October[2]											
				Percentage						Premium and discount per bushel					
		Actual	Percentage of No. 3	1946	1947	1948	1949	1950	Average 1946–50	1946	1947	1948	1949	1950	Average 1946–50
	Percent	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Cents*	*Cents*	*Cents*	*Cents*	*Cents*	*Cents*
No. 1	14	86	102.4	101.4	101.2	102.6	101.8	101.5	101.7	3.8	4.3	5.8	3.7	3.4	4.2
No. 2	15	85	101.2	101.2	101.1	102.5	101.3	101.3	101.5	3.2	4.0	5.7	2.6	3.0	3.7
No. 3	16	84	100.0	100.0	100.0	100.0	100.0	100.0	100.0	0	0	0	0	0	0
No. 4	18	82	97.6	97.9	98.3	97.6	98.3	99.0	98.2	−5.1	−6.7	−5.0	−3.5	−2.2	−4.5

[1] From HANDBOOK OF OFFICIAL GRAIN STANDARDS (25).

[2] See text for method of computation.

TABLE 34.—*Oats, barley, and sorghum grains: Farm loan rate and season average price per bushel for oats and barley and per hundredweight for sorghum grains and quantity placed under price support, 1940–50*

Year	Loan rate		Season average price	Quantity placed under price support [1]			
	National average	Percentage of parity		Loans	Purchase agreements	Total	Percentage of production
	Dollars	*Percent*	*Dollars*	*1,000 bushels*	*1,000 bushels*	*1,000 bushels*	*Percent*
OATS							
1945	0.48	70	0.67	2,933	....	2,933	0.19
1946	.53	74	.81	788	....	788	.05
1947	.63	69	1.05	244	....	244	.02
1948	.70	70	.73	14,705	8,691	23,396	1.61
1949	.69	70	.66	30,281	10,725	41,006	3.27
1950	.71	75	.79	14,611	363	14,971	1.06
1951	.72	75	.84	12,820	305	13,125	.99
1952	.78	80	....	[2]17,177	[2]4,303	[2]21,480	[2]1.69
BARLEY							
1940	.35	44	.40	7,499	....	7,499	2.41
1941	.45	57	.53	16,297	....	16,297	4.49
1942	.55	60	.63	15,199	....	15,199	3.54
1943	.75	76	.99	761	....	761	.24
1944	.85	81	1.04	3,302	....	3,302	1.20
1945	.80	75	1.02	1,027	....	1,027	.38
1946	.83	75	1.36	491	....	491	.19
1947	1.03	73	1.70	337	....	337	.12
1948	1.15	75	1.15	30,962	18,298	49,260	15.61
1949	1.09	72	1.04	28,439	4,512	32,951	13.90
1950	1.10	75	1.18	29,629	991	30,620	10.09
1951	1.11	75	1.24	16,326	695	17,021	6.69
1952	1.22	80	....	[2]7,503	[2]2,389	[2]9,892	[2]4.36

TABLE 34.—*Oats, barley, and sorghum grains: Farm loan rate and season average price per bushel for oats and barley and per hundredweight for sorghum grains and quantity placed under price support, 1940–50*—Continued

SORGHUM GRAINS

Year	Loan rate		Season average price	Quantity placed under price support[1]			
	National average	Percentage of parity		Loans	Purchase agreements	Total	Percentage of production
	Dollars	*Percent*	*Dollars*	*1,000 hundred-weight*	*1,000 hundred-weight*	*1,000 hundred-weight*	*Percent*
1940	.54	35	.85	44	....	44	.09
1941	.71	46	.98	191	....	191	.30
1942	.98	55	1.39	68	....	68	.11
1943	1.52	73	2.04	26	....	26	.04
1944	1.70	83	1.63	4,601	....	4,601	4.44
1945	1.65	79	2.12	6	....	6	.01
1946	1.72	80	2.48	309	....	309	.52
1947	2.12	76	3.27	42	....	42	.08
1948	2.31	77	2.29	19,409	2,853	22,262	30.26
1949	2.09	70	2.00	43,743	3,531	47,274	56.92
1950	1.87	65	1.88	33,292	488	33,780	25.86
1951	2.17	75	2.36	8,310	47	8,357	9.32
1952	2.38	80	....	[2]1,857	[2]210	[2]2,067	[2]4.41

[1] Compiled from reports of the Production and Marketing Administration.

[2] Preliminary.

TABLE 35.—*Oats, barley, and sorghum grains: Disposition of amounts placed under price-support, 1940–52*

OATS

Crop of	Loans				Purchase agreements				Total[2]	
	Placed under price support[1]	Redeemed by farmers	Delivered to CCC	Resealed	Placed under price support	Redeemed by farmers	Delivered to CCC	Resealed	Placed under price support[1]	Delivered to CCC[3]
	Million bushels	*Million bushels*	*Million bushels*	*Million bushels*	*Million bushels*	*Million bushels*	*Million bushels*	*Million bushels*	*Million bushels*	*Million bushels*
1945	2.9	2.9	...	...	...	...	...	...	2.9	...
1946	.8	.8	...	...	...	...	...	...	.8	...
1947	.2	.2	...	...	...	...	...	...	.2	...
1948	14.7	3.8	9.5	1.4	8.6	[4]2.1	6.1	0.4	23.4	16.9
1949	30.3	26.3	2.4	1.6	10.7	[4]10.4	.2	.1	41.0	3.0
1950	14.6	14.2	.4	(5)	.4	[4].4	(5)	(5)	15.0	.4
1951	12.8	12.3	.5	(5)	.3	[4].3	(5)	(5)	13.1	.5
1952	[6]17.2	...	...	...	[6]4.3	...	...	...	[6]21.5	...

BARLEY

Crop of	Loans: Placed under price support[1]	Loans: Redeemed by farmers	Loans: Delivered to CCC	Loans: Resealed	Purchase agreements: Placed under price support	Purchase agreements: Redeemed by farmers	Purchase agreements: Delivered to CCC	Purchase agreements: Resealed	Total[2]: Placed under price support[1]	Total[2]: Delivered to CCC[3]
1940	7.5	7.0	0.1	0.4	...	...	...	...	7.5	0.1
1941	16.3	13.6	.7	2.0	...	...	...	...	16.3	.7
1942	15.2	15.1	.1	...	...	...	...	...	15.2	.1
1943	.8	.8	...	...	...	...	...	...	.8	...
1944	3.3	3.1	.2	...	...	...	...	...	3.3	.2
1945	1.0	1.0	(7)	...	...	...	...	...	1.0	(7)
1946	.5	.5	...	...	...	...	...	...	.5	...
1947	.3	.3	...	...	...	...	...	...	.3	...
1948	31.0	4.7	24.0	2.3	18.3	[4]4.7	12.8	.8	49.3	40.6
1949	28.4	12.4	14.8	1.2	4.5	[4]3.8	.6	.1	33.0	16.2
1950	29.6	26.4	3.2	(5)	1.0	[4].9	.1	(5)	30.6	3.5
1951	16.3	14.4	1.9	(5)	.7	[4].6	.1	(5)	17.0	2.2
1952	[6]7.5	...	...	...	[6]2.4	...	...	...	[6]9.9	...

TABLE 35.—*Oats, barley, and sorghum grains: Disposition of amounts placed under price-support, 1940–52*—Continued

SORGHUM GRAINS

Crop of	Loans				Purchase agreements				Total [2]	
	Placed under price support [1]	Redeemed by farmers	Delivered to CCC	Resealed	Placed under price support	Redeemed by farmers	Delivered to CCC	Resealed	Placed under price support [1]	Delivered to CCC [3]
	Million cwt.	*Million cwt.*	*Million cwt.*	*Million cwt.*	*Million cwt.*	*Million cwt.*	*Million cwt.*	*Million cwt.*	*Million cwt.*	*Million cwt.*
1940	(8)	(8)	...	...	...	...	...	...	(8)	...
1941	0.2	0.2	...	...	...	...	...	...	0.2	...
1942	.1	.1	...	...	...	...	...	...	.1	...
1943	(8)	(8)	...	...	...	...	...	...	(8)	...
1944	4.6	2.7	1.9	...	...	...	...	...	4.6	1.9
1945	(8)	(8)	...	...	...	...	...	...	(8)	...
1946	.3	.3	...	...	...	...	...	...	.3	...
1947	(8)	(8)	...	...	...	...	...	...	(8)	...
1948	19.4	.3	19.1	(5)	2.9	[4].7	2.2	(5)	22.3	21.5
1949	43.7	.7	42.7	.3	3.5	[4].2	3.3	...	47.3	46.9
1950	33.3	23.5	9.8	(5)	.5	[4].5	...	(5)	33.8	9.8
1951	8.3	8.1	.2	(5)	(8)	(4) (8)	...	(5)	8.4	.2
1952	[6]1.9	...	...	...	[6].2	...		...	[6]2.1	...

[1] Quantity placed under loan excludes grains from purchase agreement put under reseal program.

[2] Totals computed from unrounded data.

[3] Includes deliveries shown as "delivered to CCC" from original program, deliveries from reseal program, and overdeliveries as determined by final measurement of farm-stored grain when delivered to CCC.

[4] Placed under purchase agreement, but not delivered to CCC or sealed for loan.

[5] Loans were not extended.

[6] Preliminary.

[7] Less than 50,000 bushels.

[8] Less than 50,000 cwt.

Compiled from reports of the Production and Marketing Administration.

Table 33 shows the minimum dry-matter content for the various grades compared with the average price paid from 1946 to 1950. Comparisons were made using No. 3 Yellow Milo as the basic grade. Prices and minimum dry-matter content for the other grades were expressed as a percentage of those for No. 3. Premium and discounts in terms of cents per 100 pounds for the other grades from No. 3 also are shown.

The method used to obtain crop-year average prices of the various grades of sorghum grains differs slightly from that used for oats and barley. Receipts at Kansas City, where prices for the different grades were compared, are not large enough to provide an adequate number of days on which 2 or more cars of each grade were sold to obtain an accurate yearly average. To avoid this difficulty, days on which 1 or more cars of grades 1, 2, and 3 were sold were used to obtain yearly average prices from which premiums for grades 1, 2 and 3 were computed. Days on which 1 or more cars of grades 3 and 4 were sold were used to obtain the discount of grade 4 from grade 3. Thus, an equal number of days or the same days are not necessarily represented in the yearly averages for all grades by this method. However, the spreads for grades 1, 2, and 4 from 3 in percentages and cents per 100 pounds probably are nearly the same as those that would have been obtained had prices of all grades been taken on the same days. Days on which 1 or more cars of grades 1, 2, and 3 were sold ranged from 10 in 1948 to 58 in 1950. Days on which 1 or more cars of grades 3 and 4 were sold ranged from 1 in 1948 to 24 in 1946, the other years falling within these respective ranges.

Comparison of these relative dry-matter contents with relative prices reveals substantial agreement for grades 1, 2, and 4 in all years. The premium for No. 1 is not quite as high as one would expect solely on the basis of dry-matter content. Other quality factors may be equally important for this grade.

SUPPORT PROGRAMS FOR OATS, BARLEY, AND SORGHUM GRAINS

Under authority contained in the Agricultural Adjustment Act of 1938, as amended, and subsequent agricultural acts, support programs have been in effect in each crop year since 1940 for barley and sorghum grains, and since 1945 for oats. Quantities pledged for price-support loans were comparatively small from 1940 to 1947 for all three grains. They reflected the strong demand for feed grains during World War II and the short crops in 1947. During these years Government programs functioned primarily as a short-term loan program in which farmers received loans on relatively small quantities. Later they paid off the loans and redeemed their grain. From 1948 through 1950, however, substantial quantities were placed under price-support because of some reduction in demand and the large feed-grain crops in 1948 and 1949. With stronger demand and smaller production, the quantity placed under price-support from the 1950 crops declined from the high level reached in 1949. However, it was still substantially higher than in the earlier period.

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Support prices in the post-World War II years have been higher for all three grains than in the early years of support operations. This reflects the increases in parity prices and in the percentage of parity at which prices have been supported. Tables 34 and 35 contain data concerning price-support operations for oats, barley, and sorghum grains.

Administration of the support programs for these grains was similar to that for corn. Before 1947 support operations consisted only of nonrecourse loans by the Commodity Credit Corporation to eligible producers. Under this type of loan, if a loan is defaulted the producer is not liable for any deficiency arising from sale of the collateral other than that caused by deficiencies in grade, quality, or quantity of collateral delivered. They are charged interest only for the periods the loans are in effect.

Beginning with the 1947 program, purchase agreements also have been available to producers. Under this price-support method the producer signs an agreement with the Corporation in which he is given the option to offer to the Corporation during a specified period not in excess of a certain number of bushels of grain of an eligible grade and quality. He is not obligated to deliver any grain at all, but in no event may he deliver more than the quantity stipulated in the agreement. As no inspection of the grain is made by the Corporation at the time the agreement is signed, the producer must assume the responsibility for keeping the grain in condition and eligible for price support. When delivering grain the price he receives is the applicable support price at the point of delivery. Through the use of this method, those farmers who do not require immediate funds may retain their grain and sell it commercially when they believe the market to be advantageous.

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APPENDIX [23]

Two tests of significance were applied in connection with certain groups of analyses developed in this bulletin. So far as the author is aware they have not been previously used. They represent slight modifications of tests discussed by Snedecor (*20*, pp. 257–262) and Rao (*16*, pp. 112–114). As readers not trained in mathematical statistics might have difficulty in developing the specific formulas needed, the tests are outlined in detail here. In addition to the purposes for which they are used in this bulletin, the tests could be used to ascertain whether regression analyses run for separate months differ significantly from each other.

Test Designed to Ascertain Whether the Corresponding Regression Coefficients in Three or More Multiple-Regression Equations All Are Equal

This test was applied to analyses of factors that affect the price of corn, oats, and barley, respectively, in summer (see pp. 3-4). In each analysis, a composite supply factor based on the iterative approach discussed in Foote (*7*) was developed and used as an independent variable. Two additional independent variables were used in each analysis—livestock production and prices of livestock and livestock products. The hypothesis to be tested was that each of the three independent variables affected prices of corn, oats, and barley similarly. The following equations more definitely indicate the nature of the hypothesis:

(1.1) $X_0' = a' + b'_{01.23}X_1' + b'_{02.13}X_2 + b'_{03.12}X_3$

(1.2) $X_0'' = a'' + b''_{01.23}X_1'' + b''_{02.13}X_2 + b''_{03.12}X_3'$

(1.3) $X_0''' = a''' + b'''_{01.23}X_1''' + b'''_{02.13}X_2 + b'''_{03.12}X_3'$

where

X_0' is the price of corn during June to September,

X_0'' is the price of oats during July to October

X_0''' is the price of barley during July to October,

X_1', X_1'', and X_1''' are the respective weighted supply variables,

X_2 is the production of livestock during July to December, and

X_3 and X_3' are the average prices of livestock and products for the months to which the respective X_0's apply.

The hypothesis to be tested is that the following relationships hold simultaneously:

(2) $b'_{01.23} = b''_{01.23} = b'''_{01.23} = \ddot{b}_{01.23}$

$b'_{02.13} = b''_{02.13} = b'''_{02.13} = \ddot{b}_{02.13}$

$b'_{03.12} = b''_{03.12} = b'''_{03.12} = \ddot{b}_{03.12}$

The following steps are involved in making the test:

1. For each of the three analyses, compute the unexplained sum of squares. In each case, this will equal $\Sigma (X_0 - \overline{X}_0)^2 (1-R^2_{0.123})$. Add the results. The degrees of freedom attached to this sum of squares is N–P, where N is the total number of observations in the several analyses and P is the number of restrictions, that is the number of coefficients involved in the 3 equations in (1). In this case, each analysis was based on 20 years. Hence, N = 60, and P = 12 (9 regression coefficients plus 3 constant terms).

[23] This section was written by Richard J. Foote, Supervisory Analytical Statistician, based on notes developed by Eugene E. Hixson, Mathematical Statistician, both of the Bureau of Agricultural Economics.

2. Combine the respective sums of squares and cross-products, *after correcting for the respective means,* for the three analyses. In the notation used above

$$\Sigma \ddot{x}_0^2 = \Sigma x_0'^2 + \Sigma x_0''^2 + \Sigma x_0'''^2, \text{ etc.}$$

Rerun the analysis, using these totals in obtaining the regression coefficients. Compute the unexplained sum of squares for the combined analysis, which will equal $\Sigma \ddot{x}_0^2 \; (1-\ddot{R}^2_{0.123})$. The degrees of freedom attached to this sum of squares is N–6, the 6 representing the three regression coefficients from the combined analysis plus the 3 constant terms for the separate equations.

3. Subtract the result in step 1 from that in step 2 and divide by the difference between the respective degrees of freedom. In this case, the difference in degrees of freedom is 6 [N–6 — (N–12)]. This represents the mean square resulting from differences among the regression coefficients in the three analyses.

4. Divide the final result in step 1 by the degrees of freedom attached to it, namely N–12, in this case. This represents the error or remainder mean square.

5. Compute the ratio between the mean square in step 3 and the mean square in step 4, and compare this with the tabular values in an F table, using 6 and N — P degrees of freedom. If the ratio obtained is larger than the tabular value at the 5-percent point, the differences between the regression coefficients from the respective equations are statistically significant and the hypothesis is rejected. In this case, the ratio was smaller than the tabular value, as would have been expected, and the hypothesis was accepted.[24]

Test Designed to Ascertain Whether a Particular Set of Regression Coefficients in Three or More Regression Equations Are Equal

This test was applied to analyses of factors that affect the ratio of prices of oats, barley, and sorghum grains, respectively, to prices of corn (see page 71). In each analysis, the respective supply ratio was used as an independent variable. The hypothesis to be tested was that the regression coefficients for the supply ratio was identical for the three analyses. The test was complicated somewhat by the fact that two of the regression equations involved only a single independent variable, whereas the third involved three. The three equations can be written as follows:

(3.1) $X_0' = a' + b_{01}X_1'$

(3.2) $X_0'' = a'' + b_{01}''X_1''$

(3.3) $X_0''' = a''' + b'''_{01.23}X_1''' + b_{02.13}X_2 + b_{03.12}X_3$

where

X_0' is the ratio between the price of oats and the price of corn,

X_0'' is the ratio between the prices of barley and that of corn,

X_0''' is the ratio between the price of sorghum grains and that of corn,

X_1', X_1'', and X_1''' are the ratios between the supply of the respective items and of corn, and X_2 and X_3 are related variables.

---

[24] Had we wished to include in (2) the hypothesis that $a' = a'' = a''' = \bar{a}$, the same test could have been used, except that deviations from a common mean would have been used in step 2 and the degrees of freedom attached to it would be N–4, the 4 representing the three regression coefficients from the combined analysis plus the one constant term. The divisor in step 3 then would be 8 [N–4 — (N–12)], and appropriate adjustments would be required in step 5.

The hypothesis to be tested is that the following relationship holds:

$$(4)\quad b_{01}' = b_{01}'' = b_{01.23}''' = \ddot{b}_{01.23}$$

The steps involved are the same as those given above, except that the sums of squares and cross-products involving X_2 and X_3 in step 2 are based only on the variables from equation (3.3), and P = 8 (5 regression coefficients plus 3 constant terms). The divisor in step 3 equals 2 [N–6 — (N–8)], and in step 4 equals N — 8. Appropriate adjustments are made in step 5. In this case, the ratio between the mean square in step 3 and that in step 4 was larger than the tabular value at the 5-percent point, as would have been expected, and the hypothesis was rejected.

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