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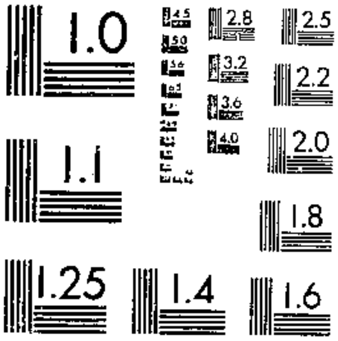
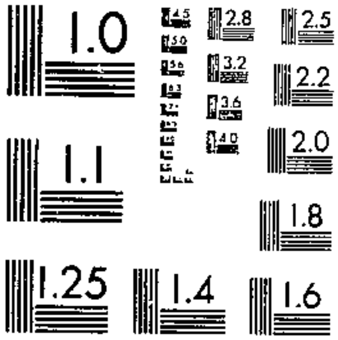


MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A



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

PREFACE

This bulletin discusses in detail the statistical and analytical aspects of a number of studies referred to in Technical Bulletin 1061 entitled, "The Demand and Price Structure for Corn and Total Feed Concentrates" by Richard J. Foote, John W. Klein, and Malcolm Clough. Designed to supplement that bulletin, it is expected that this bulletin will be of interest mainly to research workers and to commodity analysts who are acquainted with the use of multiple regression techniques. The economic interpretations and applications of these analyses were covered in Technical Bulletin 1061 and are not repeated here. Sufficient background information is included, however, to indicate the economic reasoning involved in determining the variables to be included and the particular form of equations to be used. Four major interlocking equations are discussed; together these represent the principal interrelationships within the feed-livestock economy. The econometric aspects of this system of equations are discussed in "A Four-Equation Model of the Feed-Livestock Economy and Its Endogenous Mechanism" by Richard J. Foote, published in the February 1953 issue of the Journal of Farm Economics.

In addition to the system of equations mentioned, for which the price effects apply essentially to the November to May period of heavy marketings of corn, an analysis of the factors that affect prices of corn from June to September was developed. The solution of this problem involved the use of an iterative approach. The several supply components were combined on an additive basis, with weights equal to certain partial regression coefficients, and the resulting variable was used with certain other variables in a logarithmic equation. This approach was later used successfully in a number of similar cases. The method is discussed in detail in this bulletin. Certain other analyses mainly relating to corn are discussed also.

The research on which this report is based was carried on under authority of the Agricultural Marketing Act of 1946 (RMA, Title II). Information was obtained from many specialists within the Department of Agriculture. Suggestions made by Malcolm Clough and Karl Fox, both of the Bureau of Agricultural Economics, were particularly helpful. Data were assembled and most of the statistical computations were made by Elizabeth Ruiz; the remainder were made by Floretta L. Downes or under the supervision of Viola E. Culbertson.

Technical Bulletin No. 1070 **June 1953**

Statistical Analyses Relating to the Feed-Livestock Economy [1]

by

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Contents

SUMMARY AND CONCLUSIONS

Four related analyses were developed which together describe the principal economic forces that affect the feed-livestock economy during the period when marketings of corn are heaviest. These indicate: (1) Factors that affect the price of corn from November to May; (2) factors that affect the number of animal units fed during the October to September marketing year; (3) factors that affect production of livestock and livestock products; and (4) factors that affect prices of livestock and livestock products. In each case, equations based on first differences of logarithms for 1922–42 or as close thereto as available data permit are given, and the variables were chosen in such a way as to make the several analyses as nearly comparable as possible.

The four equations taken together imply an inner structure which, in the absence of other factors such as weather, would

[1] Submitted for publication March 26, 1953.

generate an endless series of observations on price and production for successive years on the basis of specified initial conditions. These equations can be used in sequence to follow through the effects of changes in supplies of feed or in consumer income on production of livestock and on feed and livestock prices, or they may be used to study the effects over time of specified support programs for corn.

The three variables—total supply of feed concentrates, grain-consuming animal units fed on farms, and prices received by farmers for livestock and livestock products—explained 92 to 95 percent of the variation in prices received by farmers for corn from November to May for the years included in the analyses. On the average, a 1-percent change in supply of feed concentrates was associated with a change in the opposite direction of 2.4 percent in the price of corn; a 1-percent change in number of animal units was associated with a change in the same direction of 1.9 percent in the price of corn; and a 1-percent change in prices of livestock and livestock products was associated with a change in the same direction of 1.1 percent in the price of corn. The elasticity of demand indicated by this analysis is practically identical to that indicated for certain other analyses which apply to the four major feed grains. Thus this elasticity coefficient is believed to reflect essentially the demand for total feed grains and possibly for total feed concentrates. Because of the ease with which other feeds can be substituted for corn, the demand for corn as such, if it could be determined separately by statistical means, would be expected to be more elastic than the −0.4 indicated by this analysis.

The three factors—total supply of feed concentrates, prices received by farmers for corn, and those received for livestock and livestock products—explained 78 to 86 percent of the variation in number of grain-consuming animal units fed on farms during the October to September corn-marketing year. Each of the price series applies to the calendar year during which the crop year begins. On the average, a 1-percent change in each of these factors was associated with a change of 0.2 percent in the number of animal units fed. This change was in the same direction for supply of feed and prices of livestock and livestock products and in the opposite direction for prices of corn (or feed).

The number of animal units fed on farms explained 71 to 77 percent of the variation in production of livestock and livestock products for sale or home consumption, a 1-percent change in animal units being associated on the average with an 0.6 percent change in sales. Total concentrates fed to livestock were used as a separate variable, but this variable had no statistically significant effect. It does have a statistically significant effect on live-weight *production* of livestock and livestock products. The dependent variable used in these analyses essentially reflects sales of these products.

The two variables—production of livestock and livestock products for sale and home consumption and personal disposable income—explained 96 percent of the variation in prices received by farmers for livestock and livestock products. On the average, a 1-percent change in sales was associated with a change in price in the opposite direction of 2.1 percent and a 1-percent change in income was associated with a change in price in the same direction of 1.5 percent.

From June to September, new-crop oats and barley can be fed and the prospective size of the new corn crop begins to affect prices. The supply of old-crop corn, which can be represented approximately by stocks on July 1, also is important. A method was developed, based on regression analysis, by which the weights for these several components of supply can be determined from the data. When all variables are expressed in million tons, appropriate weights are as follows: 3.2 for stocks of corn, 0.8 for the indicated new crop of corn, and 0.5 for the supply of new-crop oats and barley. This supply factor, together with the production of livestock from July to December and the price of livestock and livestock products from June to September, accounted for three-fourths of the variation in prices received by farmers for corn from June to September. On the average, a 1-percent change in supply was associated with a change in price in the opposite direction of 1.6 percent; a 1-percent change in livestock production was associated with a change in price of 0.7 percent in the same direction; and a 1-percent change in livestock prices was associated with a change in price of 0.8 percent in the same direction.

These factors accounted for a smaller part of the variation in corn prices in summer than did similar factors in the heavy marketing period from November to May. The lower percentage explained may reflect: (1) The fact that changing prospects for the oncoming crop have a less stable effect on prices than do crops already harvested; (2) the fact that in years of short supply, the prospect of a large crop for the following year does not influence price to the same extent that it does when year-end stocks are large; and (3) the fact that changes in nonfeed demands for corn, such as demands for export or for use by the wet- or dry-processing industries, affect prices of corn significantly in some years during the last quarter of the marketing year.

The three variables—prices received by farmers for feed grains, number of grain-consuming animal units fed during the year, and prices received by farmers for livestock and livestock products—explained 83 percent of the variation in quantity of the four major feed grains fed to livestock. On the average, a 1-percent change in prices of feed grains was associated with a change of 0.5 percent in consumption of feed grains in the opposite direction; a 1-percent change in number of animals fed was associated with a change in consumption of 1.5 percent in the same direction; and a 1-percent change in livestock prices was associated with a change in consumption of 0.5 percent in the same direction. Similar factors explained 81 percent of the variation in the quantity of corn fed to livestock. These analyses can be used to indicate the demand for feed for livestock in any given year. In some years, because of an inadequate supply, the actual quantity fed may be less than that indicated by the analysis, although in time prices of feed and of livestock would be expected to adjust in such a way as to equate supply and demand.

The two variables—production of corn plus nonloan stocks on October 1 and number of grain-consuming animal units fed on farms—explained 87 percent of the variation in sales of corn by farmers. On the average, a 1-percent change in production was associated with a 2.0-percent change in the same direction in sales and a 1-percent change in animal units fed was associated with a 0.6 percent change in the opposite direction in sales.

Each of these relationships is subject to certain types of statistical errors and limitations. The nature and magnitude of these are indicated in the text and in the tables that accompany each analysis.

PRINCIPAL ECONOMIC FORCES IN THE FEED-LIVESTOCK ECONOMY

The general bearing that supplies of feed, number of animal units fed, production of livestock, consumer income, and prices of feed and livestock products have on the feed-livestock economy are shown in figure 1. These relationships are discussed in detail by Foote, Klein, and Clough (*6*).[2] Only a brief summary of these relationships is included here.

In any given year, supplies of feed are determined mainly by the acreage used for feed crops and the yield per acre. Acreage used for feed crops normally does not vary greatly from year to year, and changes in yields depend mainly upon weather and the general level of cultural practices. Within the usual framework of price relationships, year-to-year changes in supplies of feed are determined chiefly by nonprice factors.

Factors that affect the number of animal units fed also affect the quantity of feed fed per animal unit. For this reason, these factors are grouped together in the diagram. Within the range of standard feeding practices, returns per unit of feed fed diminish when increasing quantities of feed are fed to a given number of animals. Because of these diminishing returns, changes in the number of animal units cause changes in prices of feed and result from them as well. When the number of animal units on farms at any given time is relatively small, higher livestock-feed price ratios (and, therefore, relatively lower feed prices) are required to move a given supply of feed into consumption than when the number of animal units is large.

Production of livestock and livestock products might be expected to depend mainly upon the number of animal units fed, the rate of feeding per head, and certain technological factors, such as changes in breeding and methods of feeding. Statistical analyses of these relationships are presented in this publication.

Prices of meat animals and livestock products are determined mainly by the marketings of these products during the period under consideration, and by the level of consumer income. Consumer income is considered to be determined mainly by factors outside the feed-livestock economy.

Prices of feedstuffs adjust to prices of livestock products in such a way that in any crop year the feed fed will very nearly equal the feed produced. Breimyer said, "The price of feed grains may be considered to be that price which is equivalent to the value of the livestock products obtained from the last unit of feed input fed at a level of intensity at which the total units of feed required

[2] Italic numbers in parentheses refer to Literature Cited, p. 36.

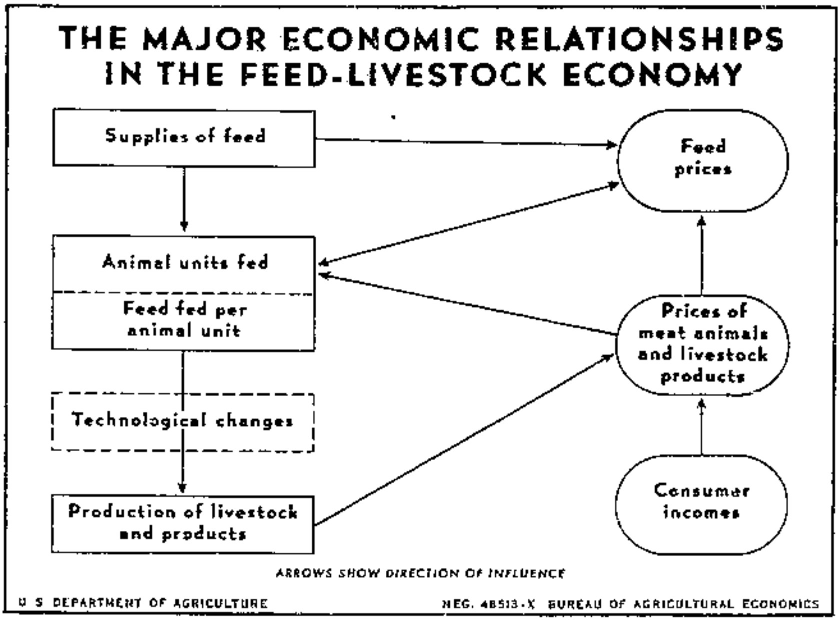

FIGURE 1.—This diagram shows the principal economic forces that affect the feed-livestock economy. The rectangles represent forces that are essentially physical; the circles, those that are mainly economic.

are the same as the number available" (*1*, p. 609). Because of diminishing returns, the number of animal units on farms will largely determine the quantity of livestock products obtained from "the last unit of feed input fed". Thus, prices of feed result in large part from the supply of feed, the number of animal units to be fed, and the level of livestock prices. Prices of corn are closely related to prices of total feed concentrates. Thus, these same factors largely determine the price of corn.

FACTORS THAT AFFECT PRICES OF CORN FROM NOVEMBER TO MAY

By November prices of corn have generally adjusted to a new-crop basis, but by June or July they begin to reflect the outlook for the coming crop. Thus, the effect of factors that affect prices of corn in any given crop year can best be ascertained by confining the analysis to the November to May period. In years when crops are large in relation to available storage, and particularly in years in which the moisture content of corn is high, prices may be depressed below normal from October through December or January. However, such years are fairly rare, so that they probably do not greatly affect average relationships during a number of years. In any given year, supplemental allowance would need to be made for such factors if they were believed to be important.

The variables used in the analysis of factors that affect prices of corn were as follows:

X_0 = price per bushel received by farmers for corn, average for November to May, in cents.

X_1 = Total supply of feed concentrates, including total stocks of corn on October 1, and of oats and barley on July 1, production of the four feed grains, imported grain and wheat and rye fed, and byproduct feeds used for feed, in million tons (unweighted).

X_2 = Number of grain-consuming animal units fed on farms during the October to September year, in millions.

X_3 = Index numbers of prices received by farmers for livestock and livestock products (1910–14 = 100), average for November to May.

Data for these are shown in table 1.

TABLE 1.—*Price received by farmers for corn, November to May: Actual and computed price per bushel and related variables, 1921–51*

Period beginning	X_0 Price of corn: Actual	X_0 Price of corn: Computed from an analysis based on Deviations from average [1]	X_0 Price of corn: Computed from an analysis based on Year-to-year change [2]	X_1 Supply of feed concentrates [3]	X_2 Grain-consuming animal units fed annually [3]	X_3 Price received by farmers for livestock and products (Nov.–May) [4]
	Cents	*Cents*	*Cents*	*Million tons*	*Millions*	
1921	51	54	----------	136	152	123
1922	73	77	75	126	163	132
1923	76	70	66	129	162	128
1924	108	91	104	114	151	144
1925	69	76	83	129	149	151
1926	66	85	80	123	152	150
1927	83	87	68	123	153	151
1928	83	89	84	126	153	160
1929	78	86	85	122	154	148
1930	60	65	65	113	152	110
1931	33	36	35	122	156	78
1932	24	25	22	138	159	67
1933	45	37	38	115	154	74
1934	83	84	112	82	131	106
1935	56	59	49	114	138	118
1936	106	97	104	90	138	123
1937	51	49	46	123	138	114
1938	44	47	49	130	148	108
1939	55	46	44	136	156	107
1940	58	52	60	140	156	122
1941	74	75	77	151	167	159
1942	90	97	89	172	192	194
1943	112	108	105	164	193	196
1944	107	104	108	158	173	206
1945	115	108	111	155	168	215
1946	138	137	136	158	160	278
1947	220	199	214	133	154	305
1948	120	127	129	167	160	285
1949	118	107	102	176	166	258
1950	155	154	163	178	172	327
1951	167	167	176	170	175	318

[1] From an analysis based on logarithms for 1921–42 and 1946–50.
[2] From an analysis based on first differences of logarithms for 1922–42.
[3] Year beginning October.
[4] Index numbers, 1910–14 = 100.

These appear to be logical variables based on the diagram shown in figure 1. Some question might be raised as to whether the high-protein feeds are complementary or supplementary to corn. Such feeds represented 7 percent of the total supply of feed concentrates in 1948–50. This is a valid question. As the evidence on this point is not clear, it was decided to include them with the other feeds, at least as a first approximation. The number of grain-consuming animal units fed during the entire crop year would be expected to be partly a result and partly a cause of corn prices. The size of the spring pig crop and the number of chicks hatched in the spring, for example, are affected by prices of corn during the heavy marketing period. After allowing for time lags in the effect of prices of corn on numbers of livestock, it appears that when used in an analysis of factors that affect prices of corn during the November to May period this variable would be mainly an independent factor. This view is partly borne out by the extremely low simple correlation between prices of corn in November to May and the number of animal units fed. No sound statistical method, other than the multiple equation method, exists for adequately separating the simultaneous cause and effect aspects of a variable of this type.

As the several independent variables are believed to affect the dependent variables jointly, rather than additively, and the relationships are believed to be more stable in percentage than in absolute terms, all data were converted to logarithms before running the analyses. Two analyses were run: One based on deviations from average and the other in terms of year-to-year change.[3] Originally each of the analyses was based on data for 1921–42, but calculated values were obtained for the post-World War II period. Examination of a chart similar to that shown in figure 2 indicated that the analysis based on deviations from average would yield better forecasts in current years if the postwar years were included in the analysis. Hence the analysis was rerun, based on 1921–42 and 1946–50. As indicated by figure 3, inclusion of the postwar years was not required for the analysis based on year-to-year change.

For purposes of comparison, table 2 shows the principal statistical coefficients obtained from these analyses. The correlation coefficients were left in the squared form, as these are easier to interpret in terms of the percentage of variation in the dependent variable explained by the respective independent variables. All of these coefficients are statistically significant.

Results obtained from the three analyses are remarkably close. The respective regression coefficients should be and, within sampling limits, are nearly the same. The standard errors of estimate are approximately equivalent to an error of 12 percent of the computed value. The partial correlation between price and supply is higher for the first-difference analysis than for those based on deviations from average, because year-to-year variations in supply are large in relation to the longer-time changes in level. As year-

[3] For a discussion of the circumstances under which the use of logarithms is desirable and of the statistical aspects and alternative interpretations of analyses based on deviations from average versus those based on year-to-year change, see Thomsen and Foote (*10*, pp. 284–286).

TABLE 2.—*Principal statistical coefficients obtained from analyses relating November to May prices of corn to supply of feed concentrates, animal units fed, and prices of livestock and livestock products* [1]

Coefficient	Based on deviations from average		Based on year-to-year change excluding postwar years
	Excluding postwar years	Including postwar years	
$R^2_{0.123}$	0.916	0.954	0.912.
$s_{0.123}$	0.0500	0.0472	0.0548.
$b_{01.23} \pm s_{b_{01.23}}$	-2.05 ± 0.30	-1.82 ± 0.24	-2.36 ± 0.24.
$b_{02.13} \pm s_{b_{02.13}}$	1.85 ± 0.57	1.71 ± 0.50	1.94 ± 0.57.
$b_{03.12} \pm s_{b_{03.12}}$	1.25 ± 0.10	1.36 ± 0.06	1.13 ± 0.18.
$r^2_{01.23}$	0.715	0.720	0.850.
$r^2_{02.13}$	0.373	0.334	0.406
$r^2_{03.12}$	0.896	0.952	0.707.
$a_{0.123}$	−0.559	−0.949	0.00373.

[1] These values relate to the regression equations when all variables are expressed in logarithms.

to-year variations in prices of livestock are smaller than the longer-time changes in level, the partial correlation between price and this variable is higher when based on deviations from average. Changes in supply, on the average, account for a larger percentage of the year-to-year changes in prices of corn than do changes in prices of livestock, after allowing for the effects of the other independent variables. In terms of deviations from average, however, changes in prices of livestock account for a larger percentage of the variation. In each case, changes in numbers of animal units account for a smaller percentage of the variation in prices, on the average, than do changes in supply or in prices of livestock, after allowing for the effects of the other independent variables. All of these relationships are consistent with those that would have been expected from *a priori* considerations.

Three additional points should be mentioned:

(1) In the past, many analyses have been run based on supplies of feed or supplies of corn *per animal unit.* In a logarithmic analysis, such a procedure implies that $b_{01.23}$ and $b_{02.13}$ are equal in absolute value. The ratios of these coefficients for the analyses discussed here range between 1.06 and 1.22. This indicates that this procedure is reasonably sound, particularly if only a rough approximation is desired.

(2) When the price of a particular group of products is used as a demand shifter, as in this analysis, the question may be raised as to whether the implied correlation reflects merely changes in general demand conditions which affect the two commodity groups similarly. If this were true, it would be preferable to use the general factor as a demand shifter in the analysis in place of the more limited factor. One way to determine the relevance of this criticism is to compare the relative size of the simple correlation between prices of corn and prices of livestock, and between prices of corn and disposable income, respectively, and to compute the

partial correlation coefficient between prices of corn and livestock when disposable income is held constant. If X_0 represents the price of corn, X_1 the price of livestock products, and X_2 disposable income, then for the criticism to be valid, r_{01} should be smaller than r_{02}, and $r_{01.2}$ should not differ significantly from zero. For the calendar years 1922–43, these coefficients are as follows: $r_{01} = 0.80$, $r_{02} = 0.57$, $r_{01.2} = 0.73$. Therefore, this criticism does not appear valid.

(3) A further criticism of an analysis of this type that is occasionally made is that the degree of association between the independent variables is so high as to give indeterminate results. In these analyses, the highest simple correlations between the various independent variables were those between the number of animal units and the supply of concentrates. These were nearly 0.85 for the analyses based on deviations from average and 0.55 for the analysis based on first differences. These are not sufficiently high to cause indeterminancy in an analysis based on mathematical computations, although the correlation based on deviation from average might slow up the speed of convergence materially in a graphic analysis.[4] All of the other simple intercorrelations were quite low.

Figures 2 and 3 show prices of corn, adjusted for the remaining variables, against each of the independent variables in turn, for two of these analyses. Actual data, rather than logarithms, have been used in constructing these charts. In each section, the relevant partial regression curve, based on the mathematical analysis, has been drawn. In the last section of each chart, the unexplained residuals have been plotted against time. Data for the years used in the analyses are shown as dots; data for the excluded years are shown as X's.

In the analysis based on first differences, the war and postwar years give a closer fit than do the prewar years used in the analysis. As supply relative to demand at ceiling prices was extremely short in the November to May periods beginning 1943, 1944, and 1945, the actual values ordinarily would have been below the regression curves for those years. Several reasons can be given for the failure of this to show up in this particular analysis. One explanation for the closeness of fit is as follows: Had larger supplies of corn been available, farmers would have expanded the number of animal units fed more than they did. The desire on their part to increase the number of animals fed created intense competition for supplies of corn. However, price ceilings for corn may have been consistent with existing feed supplies, *animal units*, and prices of livestock. In other words, animal units were apparently held down to a point at which supplies of feed were just used up at ceiling prices. This hypothesis is borne out by an analysis of the factors that affect the number of animal units fed to be discussed in the next section. Animal units for the marketing years beginning 1944, 1945, and 1946 are a good deal farther below the calculated curves than are those for any of the years included in the analysis.

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[4] See Thomsen and Foote (*10*, pp. 288–290) for a discussion of the effects of intercorrelation among the independent variables.

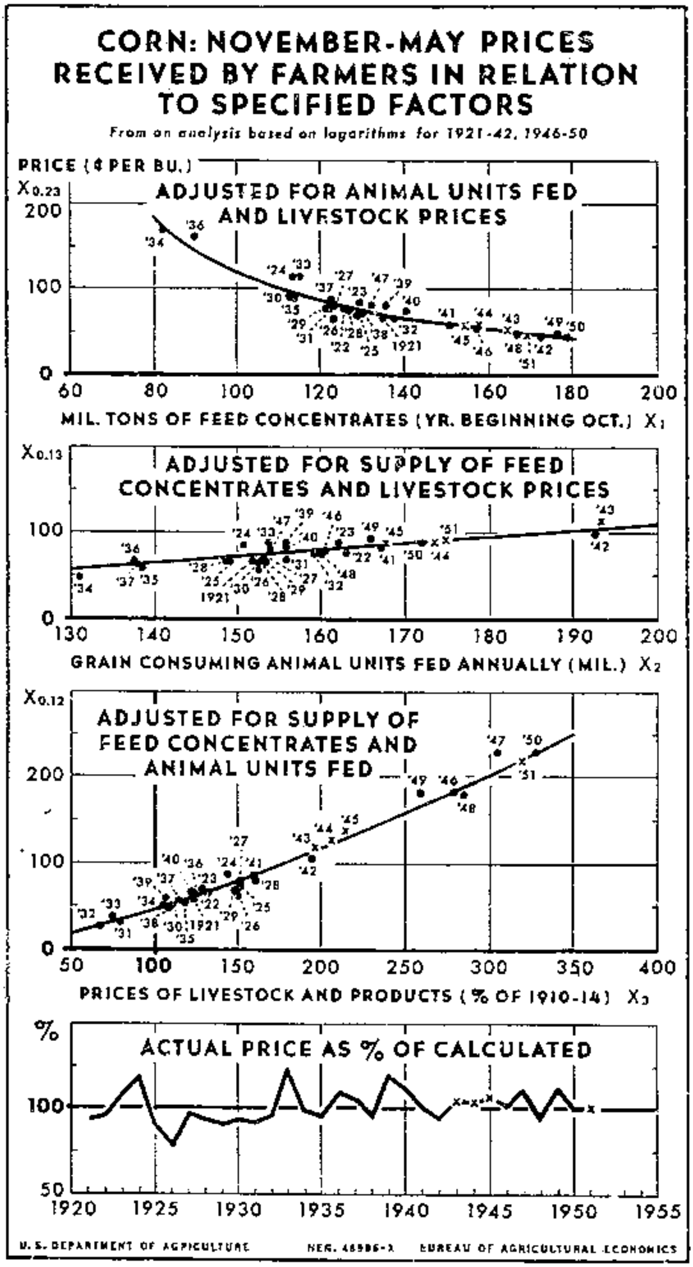

FIGURE 2.—The three factors—supply of feed concentrates, number of animal units fed, and prices of livestock and livestock products—explained 95 percent of the variations of prices of corn around their average for 1921–42 and 1946–50.

An additional factor which may have been of importance is as follows: Some of the wartime desire on the part of farmers to expand livestock numbers grew out of the fact that most of the

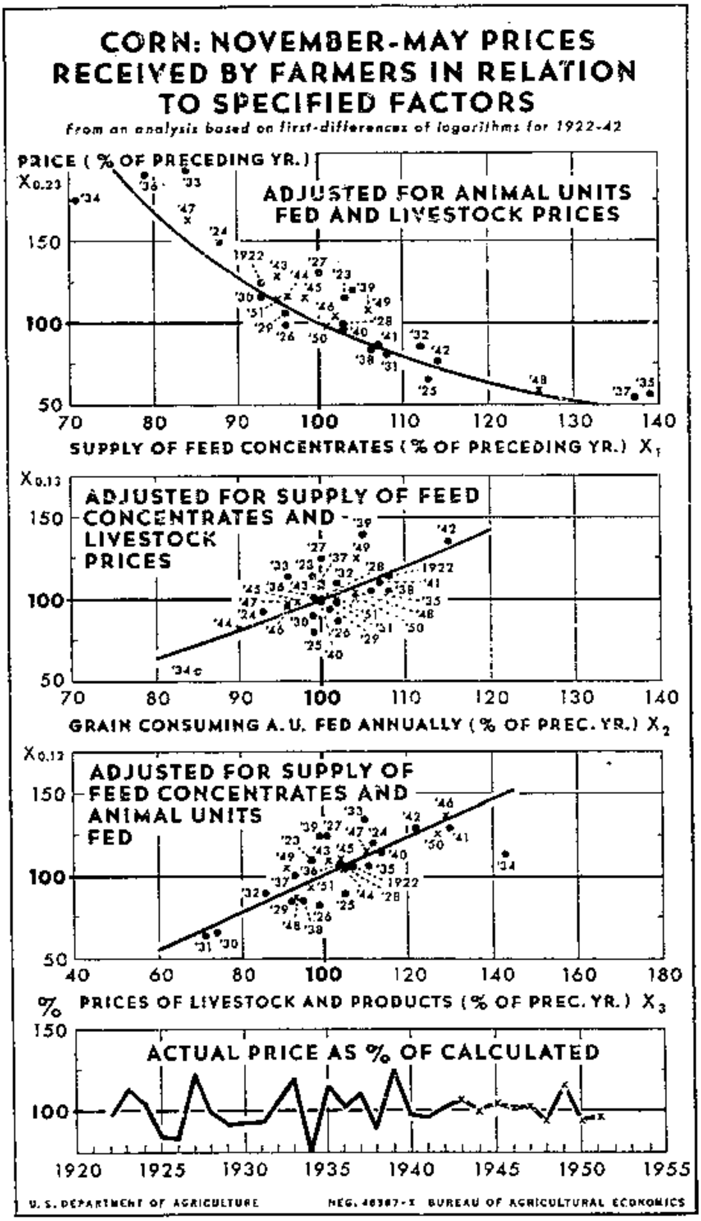

FIGURE 3.—The three factors—supply of feed concentrates, number of animal units fed, and prices of livestock and livestock products—explained 91 percent of the year-to-year variation in prices of corn in 1922–42. These relationships appear to have remained unchanged in the post-World War II period.

price uncertainty was removed by price ceilings for corn and price supports for livestock products. But the analysis assumes normal uncertainty. Thus it would be expected to fail to reflect any stimulation in demand owing to this factor. It also would fail to reflect the abnormal demand for corn for food use and for alcohol, as these factors are not included in the analysis. It probably can be concluded that the demand for corn during the war years was higher than that indicated by the analysis but very likely not as high as was assumed by many people on a judgment basis. The extent to which the actual value for certain years, such as 1933, 1939, and 1949, is above the calculated value probably reflects, at least partly, the effect of the support program in those years.

With slight modification, this analysis can be used to give an early season estimate of the probable level of the season-average price received by farmers for corn. Prices from November to May normally average about 6 percent below the average price for the year. However, larger quantities of corn are sold during the months in which prices tend to be lowest. Thus the weighted season average price tends to be about 4.5 percent higher than the average from November to May.

FACTORS THAT AFFECT NUMBER OF ANIMAL UNITS FED DURING THE YEAR

As indicated by the diagram in figure 1, changes in the number of animal units fed from one year to the next are determined mainly by changes in the total supply of feed concentrates and by the relative levels of feed and livestock prices. Effective price levels are those that prevail when farmers are making decisions regarding the number of animal units to be fed during the crop year. Breeding for the fall pig crop takes place in the preceding spring, and that for the spring pig crop in the preceding fall and winter. Hens fed during the crop year come mainly from chicks hatched the preceding spring. Thus, the number of animal units fed in the crop year beginning in October of any year would be determined mainly by the price levels prevailing during the corresponding calendar year. It was thought that farmers would be influenced more by the relative levels of feed and livestock prices during this period than by the change in these prices from the preceding calendar year.

The exact nature of the function used is indicated below. The following symbols may prove helpful:

A_t = animal units fed in year t.
S_t = supply of feed concentrates in year t.
C_t = price of corn in year t.
L_t = price of livestock in year t.
a = constant value in the regression equation.
b_i = specified partial regression coefficients.

The equation used was as follows:

$$\frac{A_t}{A_{t-1}} = a \left(\frac{S_t}{S_{t-1}} \right)^{b_1} C_{t-\frac{3}{4}}^{b_2} \; L_{t-\frac{3}{4}}^{b_3}.$$

A multiplicative equation was used because the two price series, at least, would affect the dependent variable jointly.

When translated into logarithms, the equation takes the following form:

$$\text{Log } A_t - \log A_{t-1} = \log a + b_1 (\log S_t - \log S_{t-1}) + b_2 \log C_{t-\frac{3}{4}} + b_3 \log L_{t-\frac{3}{4}}.$$

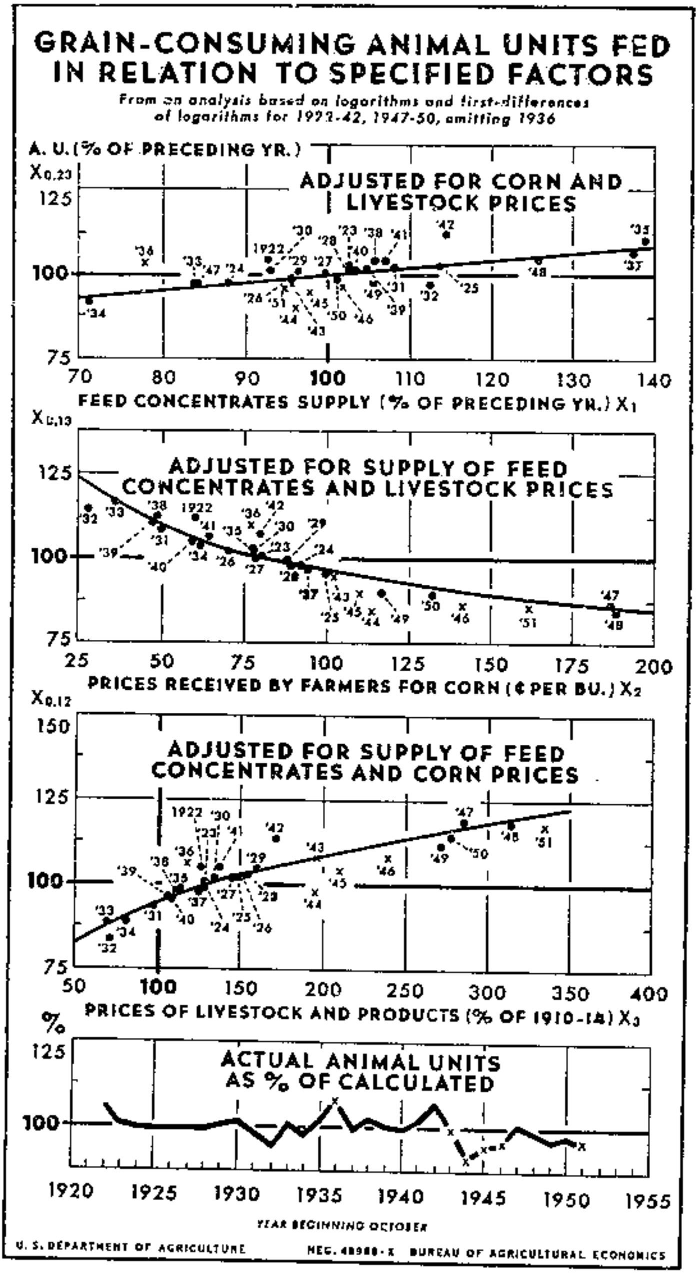

FIGURE 4.—The three factors—supply of feed concentrates, prices received by farmers for corn, and prices received by farmers for livestock and livestock products—explained 78 percent of the year-to-year variation in number of animal units fed on farms. During World War II farmers would have liked to feed more animals at ceiling prices for corn and livestock products than available supplies of feed permitted. This accounts for the large negative deviations in the years 1944–46.

A second decision is needed with respect to factors that motivate farmers in planning their livestock operations. Presumably, if a support program is completely effective, stocks under loan or owned by the Government will not affect the market price or other parts of the feed-livestock economy except during those periods when prices are sufficiently high so that farmers would redeem the loans or the Commodity Credit Corporation could sell its corn. So far as supplies of feed affect the number of animal units fed, after allowance for the effects of the level of feed and livestock prices, it is believed that in actual practice farmers would be affected more by total supplies than by supplies not under loan, at least if market prices were fairly close to the loan level.

The variables used were as follows:

X_0—Grain-consuming animal units fed on farms during the October to September feeding year, ratio to preceding year.
X_1—Total supply of feed concentrates, ratio to preceding year.
X_2—Average prices received by farmers for corn in the calendar year during which the crop year begins, cents per bushel.
X_3—Index numbers of prices received by farmers for livestock and livestock products in the calendar year during which the crop year begins (1910–14 = 100).

All variables were converted to logarithms before running the analyses.

Originally the analysis was based on data for 1922–42, omitting 1936. The latter year was omitted because the drought in 1936, following closely as it did the severe drought in 1934, caused little change in the number of animal units fed. Farmers apparently used straw and other low-grade roughages to carry their animals through, despite the severe shortage of feed. At no other time since production records began have two such severe droughts followed each other so closely. Examination of a chart similar to that shown in figure 4 indicated that the analysis would yield

TABLE 3.—*Principal statistical coefficients obtained from analyses relating animal units fed during the year to the total supply of feed concentrates and to prices of corn and livestock during specified years* [1]

Coefficient	Based on years beginning October	
	1922–42, excluding 1936	1922–42 and 1947–50, excluding 1936
$R^2_{0.123}$	0.861	0.780.
$s_{0.123}$	0.0108	0.0125.
$b_{01.23} \pm s_{b_{01.23}}$	0.204 ± 0.039	0.214 ± 0.040.
$b_{02.13} \pm s_{b_{02.13}}$	−0.212 ± 0.030	−0.185 ± 0.032.
$b_{03.12} \pm s_{b_{03.12}}$	0.288 ± 0.040	0.207 ± 0.036.
$r^2_{01.23}$	0.633	0.585.
$r^2_{02.13}$	0.758	0.625.
$r^2_{03.12}$	0.764	0.626.
$a_{0.123}$	−0.211	−0.092.

[1] These values relate to the regression equations when all variables are expressed in logarithms.

TABLE 4.—*Animal units fed during the year: Actual and computed, and related variables, 1921–51*

Year beginning October	X_0 Grain-consuming animal units fed annually		X_1 Total supply of feed concentrates	X_2 Price received by farmers for corn [2]	X_3 Price received by farmers for livestock and products [2 3]
	Actual	Computed [1]			
	Millions	*Millions*	*Million tons*	*Cents*	
1921	152		136		
1922	163	154	126	60	126
1923	162	161	129	80	128
1924	151	151	114	91	128
1925	149	150	129	100	149
1926	152	154	123	70	151
1927	153	154	123	79	146
1928	153	154	126	89	155
1929	154	153	122	88	159
1930	152	150	113	78	134
1931	156	157	122	50	98
1932	159	169	138	28	72
1933	154	154	115	36	70
1934	131	134	82	61	81
1935	138	136	114	77	114
1936	138	128	90	77	118
1937	138	139	123	95	125
1938	148	146	130	49	111
1939	156	156	136	48	106
1940	156	157	140	59	108
1941	167	164	151	64	137
1942	192	180	172	79	171
1943	193	195	164	103	198
1944	173	192	158	113	195
1945	168	177	155	110	210
1946	160	170	158	141	241
1947	154	153	133	187	287
1948	160	164	167	188	314
1949	166	174	176	117	272
1950	172	174	178	133	278
1951	175	183	170	162	335

[1] From an analysis based on logarithms, with an equation of the form shown on page 12, for 1922–42 and 1947–50, excluding 1936.
[2] Calendar year during which the crop year begins.
[3] Index numbers, 1910–14 = 100.

better forecasts in current years if the postwar years were included.[5] Hence the analysis was rerun based on 1922–42 and 1947–50, excluding 1936. Residuals for many of the interwar years were reduced, although the total sum of squares of the residuals for 1922–42 was increased. Residuals for the postwar years were reduced materially.

Figure 4 shows the charts indicating the respective degrees of partial correlation and the final residuals plotted against time for the second analysis. As noted in connection with the Novem-

[5] This chart is given in Thomsen and Foote (*10*, p. 296).

ber to May analysis of corn prices, there is reason to believe that the limited supplies of feed during World War II prevented farmers from expanding numbers of animal units as much as they would have liked to do under existing ceiling prices for feed and livestock. This accounts for the sizable negative deviations during the years beginning October 1944, 1945, and 1946. The 14 to 22 percent of the variation in X_0 unexplained by these analyses during the years included in the analysis probably reflects, at least partly, the fact that full allowance was not made for all of the time lags.

This analysis is mainly of value in making forecasts for more than a year ahead or for appraising probable effects of alternative agricultural policies. Better estimates than those provided by the analysis could be obtained immediately preceding or during the early part of any given marketing year by taking into account available information on livestock numbers, including farmers' intentions and recent trends.

Table 3 shows the principal statistical coefficients obtained from these analyses. Data on which the analyses were based and the calculated values for the dependent variable from the analysis that includes the postwar years are given in table 4.

FACTORS THAT AFFECT PRODUCTION OF LIVESTOCK AND LIVESTOCK PRODUCTS

Lorie (*8*) discusses in considerable detail the type of equation that should be used in an analysis of this type. He concludes that all variables (except time) should be expressed in logarithms. As the analyses discussed here are based on first differences rather than deviations from average, the effect of the time trend is included in the constant value in the regression equation. The dependent variable is the index of production of livestock and livestock products for sale and for home consumption. This was used because it is included as an independent variable in the analysis of the factors that affect prices of livestock and livestock products.

The variables used were as follows:

X_0—Index of production of livestock and livestock products for sale and home consumption, 1935-39 = 100.
X_1—Total concentrates fed to livestock, in million tons.
X_2—Grain-consuming animal units fed on farms during the year, in millions.

Two analyses were run. For each of these the independent variables were based on the usual October to September corn-marketing year. For one, the index of livestock production applied to the following calendar year, and for the other to the period October to June. The latter was used as an independent variable in the analysis of factors that affect November to May prices of livestock. The former might be expected to give improved results, assuming that there is an average lag of about 10 weeks between the time grain is consumed and the time the livestock is ready for market. As each of these analyses gave results that are somewhat inconsistent with *a priori* expectations, both are discussed.

Table 5 gives the principal statistical coefficients from these analyses. Data on which the analyses are based are given in table 6.

The surprising thing about these analyses is the low value obtained for $r^2_{01.2}$, which indicates the percentage of year-to-year variation in production of livestock and livestock products for sale and for home consumption that is associated with year-to-year variation in concentrates fed, after allowing for the effects of number of animal units fed. Apparently, even on a year-to-year basis, changes in the total number of animal units fed affect this over-all production series a good deal more than do changes in the total quantity of concentrates fed, although the reverse may well be true for certain livestock products such as production of milk. This variable had a statistically significant effect on total *live-weight production* of livestock and livestock products, as measured by the series published by Jennings (*7*). The small negative value obtained for $b_{01.2}$ in the analysis for October to June is of no significance, as this coefficient does not differ significantly from zero. As r_{02} is almost as large as $R_{0.12}$ for each of these analyses, the simple relationship probably can be used for most analytical purposes.

When the antilogarithms of the constant values in the two simple regression equations are obtained, values of 1.013 and 1.009 are given. Similar values from the multiple regression equations fall within this range. These indicate that, on the average, a given number of animal units will yield 1.3 and 0.9 percent, respectively, more livestock products in each year than in the preceding year, when the analysis is based on 1922–42 or 1925–42. For 1910–44, Lorie (*8*) found a value of only 0.2 percent. Research in breeding and feeding has steadily expanded since 1910, so that use of a later period could be expected to give a higher figure. Other differences in the two sets of analyses probably account for a substantial part of the discrepancy.

TABLE 5.—*Principal statistical coefficients obtained from analyses made to relate production of livestock and livestock products for sale and home consumption to total concentrates fed and grain-consuming animal units fed during the year* [1]

Coefficient	Based on years beginning October	
	1922–42—X_0 applies to following calendar year	1925–42—X_0 applies to period October to June
$R^2_{0.12}$	0.808	0.775.
$s_{0.12}$	0.010	0.009.
$b_{01.2} \pm s_{b_{01.2}}$	0.095 ± 0.048 [2]	—0.091 ± 0.043.[2]
$b_{02.1} \pm s_{b_{02.1}}$	0.596 ± 0.112	0.702 ± 0.106.
$r^2_{01.2}$	0.179 [2]	0.225.[2]
$r^2_{02.1}$	0.613	0.746.
$a_{0.12}$	0.00530	0.00453.
$b_{02} \pm s_{b_{02}}$	0.735 ± 0.093	0.562 ± 0.090.
r^2_{02}	0.766	0.710.
$a^2_{0.2}$	0.00584	0.00369.

[1] When all data are expressed as first differences of logarithms.

[2] Coefficients of this magnitude would be expected to appear between 5 and 10 percent of the time due to chance if the true correlation and regression coefficients were zero.

TABLE 6.—*Production of livestock and livestock products for sale and home consumption: Actual and computed, and related variables, 1921–51*

Year beginning October	X_0 Index of production of livestock and products, 1935–39 = 100				X_1 Total concentrates fed to livestock	X_2 Grain-consuming animal units fed annually
	Following calendar year		October–June [2]			
	Actual	Computed [1]	Actual	Computed [3]		
					Million tons	*Millions*
1921	91				108	152
1922	97	96			106	163
1923	99	98			111	162
1924	96	95	98		97	151
1925	97	97	98	97	107	149
1926	98	99	100	101	103	152
1927	100	100	100	101	108	153
1928	99	101	100	101	107	153
1929	99	100	101	102	105	154
1930	100	99	102	102	96	152
1931	99	104	104	105	104	156
1932	103	102	104	106	111	159
1933	106	100	106	104	92	154
1934	93	96	96	98	71	131
1935	101	100	98	98	94	138
1936	98	100	101	100	75	138
1937	102	101	101	100	97	138
1938	107	108	105	107	99	148
1939	112	112	112	110	102	156
1940	115	114	116	112	108	156
1941	127	122	127	122	119	167
1942	139	142	135	139	142	192
1943	143	141	147	138	139	193
1944	141	135	140	139	129	173
1945	138	140	140	138	133	168
1946	135	135	138	138	123	160
1947	128	132	128	137	110	154
1948	134	134	121	131	120	160
1949	136	139		125	127	166
1950	141	141			129	172
1951	145	144			132	175

[1] From an analysis based on first differences of logarithms for 1922–42.
[2] This series is not available after 1948.
[3] From a simple regression analysis based on first differences of logarithms for 1925–42, the independent variable being animal units fed on farms. The regression coefficient for the multiple correlation analysis comparable to that referred to in footnote 1 gave the wrong sign for total concentrates fed to livestock and did not differ significantly from zero.

FACTORS THAT AFFECT PRICES OF LIVESTOCK AND LIVESTOCK PRODUCTS

As prices of livestock and livestock products from November to May are used as one of the independent variables in the analysis of factors that affect prices of corn during these months, the average price for these months is used as the dependent variable in the analysis discussed here.

The diagram shown in figure 1 indicates that prices of livestock are determined mainly by production (or sales) of livestock products and disposable income. The supply variable used in this analysis is the same as that used as the dependent variable in one of the preceding analyses, that is, an index representing production for sale and home consumption from October to June.

The November to May level of consumer income was estimated as follows: A simple scatter on a calendar-year basis was made between personal disposable income and personal income from 1929 to date, and regression lines were fitted which allowed for the shifting level of taxes. The November to May average for personal income was then obtained and used to estimate the November to May average for personal disposable income. Before 1929, a similar method was used to derive estimates of disposable

TABLE 7.—*Prices received by farmers for livestock and livestock products: Actual and computed, and related variables, 1924–51*

Period beginning	X_0 Price of livestock (November–May)[1] Actual	X_0 Price of livestock (November–May)[1] Computed[2]	X_1 Production of livestock and products for sale and home consumption (October–June)[3]	X_2 Estimated personal disposable income (November–May)
				Billion dollars
1924	144	......	98	76
1925	151	151	98	78
1926	150	148	100	78
1927	151	146	100	76
1928	160	160	100	78
1929	148	158	101	78
1930	110	117	102	67
1931	78	79	104	54
1932	67	59	104	44
1933	74	79	106	50
1934	106	108	96	56
1935	118	120	98	62
1936	123	135	101	70
1937	114	116	101	66
1938	108	109	105	68
1939	107	108	112	74
1940	122	119	116	83
1941	159	145	127	105
1942	194	182	135	126
1943	196	198	147	142
1944	206	249	140	154
1945	215	207	140	152
1946	278	252	138	166
1947	305	383	128	183
1948	285	371	121	193
1949	258	......	......	196
1950	327	......	......	216
1951	318	......	......	230

[1] Index numbers, 1910–14 = 100.
[2] From an analysis based on first differences of logarithms for 1925–42.
[3] Index numbers, 1935–39 = 100. This series is not available after 1948.

income from the income of industrial workers. This gave a consistent income series for the entire period on which the analysis was based.

On an *a priori* basis it was difficult to decide whether the relationships should be joint or additive. A first-difference logarithmic analysis was used mainly to be consistent with the other analyses. The production series begins in 1924, and the first-difference analysis covers the years 1925 to 1942.

The variables used were as follows:

X_0—Index numbers of prices received by farmers for livestock and livestock products (1910–14 = 100), November to May average.

X_1—Index numbers of production of livestock and livestock products for sale and for home consumption (1935–39 = 100), October to June.

X_2—Estimated personal disposable income, November to May average, billion dollars.

Data for this analysis are given in table 7.

This analysis provides further evidence of the inadvisability of using consumer income as a demand shifter for prices of corn in place of prices of livestock. The partial correlation coefficients indicate that livestock production and disposable income are of nearly equal importance in effecting changes in livestock prices. This is brought out also by the fact that disposable income alone explained only about three-fourths of the variation in prices of livestock, whereas consumer income plus livestock production explained more than 95 percent of the variation.

The positive constant in the equation implies an upward shift in the demand for livestock products, after allowing for the independent variables used in the analysis. The indicated increase, assuming no change in the independent variables, is 1.3 percent per year.

Principal statistical coefficients obtained from the analysis relating prices of livestock and livestock products to production of livestock and livestock products and personal disposable income, 1925–42, are as follows:

Coefficient	*Value* [1]
$R^2_{0.12}$	0.959
$s_{0.12}$	0.0164
$b_{01.2} \pm s_{b_{01.2}}$	−2.08 ± 0.25
$b_{02.1} \pm s_{b_{02.1}}$	1.45 ± 0.08
$r^2_{01.2}$	0.825
$r^2_{02.1}$	0.959
$a_{0.12}$	0.00578

[1] When all data are expressed as first differences of logarithms.

As one of the independent variables for this analysis is no longer available, it cannot be used for purposes of forecasting. However, the analysis was developed primarily to determine certain statistical coefficients for use in the four-equation model of the feed-livestock economy discussed in the next section. A similar analysis using currently available data could be run on a calendar-year basis.

A FOUR-EQUATION MODEL OF THE FEED-LIVESTOCK ECONOMY AND ITS CYCLIC STRUCTURE

The demand and supply functions for some agricultural commodities imply an inner mechanism or structure which, in the absence of other factors such as weather, would generate an endless series of observations as to price and production for successive years, on the basis of specified initial conditions. A simple system of this sort that is familiar to agricultural economists is the "cobweb" model described by Ezekiel (*2*). For any given commodity group, there is some interest in knowing whether this inner mechanism is essentially a stabilizing factor, or whether it tends to perpetuate cycles of considerable and possibly of ever-increasing magnitude.

The four sets of equations that have been discussed can be used in such a study. They can also be used in sequence to follow through the effects of changes in supplies of feed or in consumer income on production of livestock and on prices of feed and livestock or to study the effects over time of specified support programs for corn. In the next few paragraphs a summary is given of the analyses developed in the preceding sections to show how they can be fitted into a simultaneous system of equations for the entire feed-livestock economy.

Because of the complexity of this approach, the author has found it helpful to use symbols which imply the particular variables involved. The following symbols are used:

C—Price received by farmers for corn, which is assumed to be representative of the general price level for all feeds, in cents per bushel.
S—Supply of all feed concentrates, in million tons.
A—Number of grain-consuming animal units fed on farms annually, in millions.
L—Price received by farmers for livestock and livestock products, index numbers (1910–14 = 100).
Q—Production of livestock and livestock products for sale and home consumption, index numbers (1935–39 = 100).
I—Personal disposable income, in billion dollars.
Δ—Change in the particular item from the preceding year.

When all variables are expressed in logarithms, the following equations are given by the analyses discussed previously.

$$\Delta C = 0.00373 - 2.36\ \Delta S + 1.94\ \Delta A + 1.13\ \Delta L.$$
$$\Delta A = -0.092 + 0.214\ \Delta S - 0.185\ C^{6} - 0.207\ L.^{6}$$
$$\Delta Q = 0.00369 + 0.562\ \Delta A.$$
$$\Delta L = 0.00578 - 2.08\ \Delta Q + 1.45\ \Delta I.$$

As ΔQ is assumed to be a direct function of Δ A, as feed fed per animal did not have a statistically significant effect on the series used to represent sales of livestock products (see page 17), the last equation can be rewritten as:

$$\Delta L = -0.00190 - 1.17\ \Delta A + 1.45\ \Delta I.$$

If this is done, the third equation can be omitted.

These relationships are *not* assumed to take place simultaneously, but instead to occur in sequence within the year. The following sequence was assumed in analyzing year-to-year changes in the several variables involved: (1) Prices of livestock from November to May are determined by the level of animal units in the preceding year and the current disposable income from November to May. (2) Prices of corn from November to May are determined by the level of animal units in the preceding year,

[6] These prices apply to the calendar year in which the crop year begins.

new-crop supplies of feed, and prices of livestock from step 1. (3) Animal units fed are determined by new-crop supplies of feed and prices of corn and livestock for the calendar year beginning in the same year that the October to September corn-marketing year begins. Prices for the calendar year were determined by weighting prices for November to May and June to October by the proportion of the sales for the calendar year obtained from each period. (4) Prices of livestock from June to October are determined by the level of animal units from step 3 and current disposable income for June to October. (5) Prices of corn from June to October are determined by the level of animal units from step 3, the level of prices of livestock from step 4, and the supplies of feed used in step 2.

In using this system of equations, three types of deviations from reality were made:

(1) Aggregates for the livestock industry were used, whereas it is realized that the nature of the time sequences for beef cattle, for example, would differ from those for production of eggs.

(2) It was assumed that the new crop of corn did not affect prices of corn until November, and that the relationships between prices of corn and supplies of feed, animal units fed, and prices of livestock and livestock products that were found to prevail from November to May were equally applicable from June to October. Actually, both the old supply of corn and the estimate of the new supplies of feed affect prices in the latter part of the marketing year.

(3) Prices of feed and of livestock and livestock products were assumed to have no effect on production of feed grains, within the framework of usual price relationships. This appears to be nearly true in terms of year-to-year relationships, but it would be less true during a number of years.

The first simplification would be unsatisfactory in the study of specified support programs for livestock, but in a study of support programs for corn it probably does no great damage. The second would be undesirable in analyzing short-term relationships. The study for which this system was developed was concerned mainly with aggregates during a 25-year period.

All of the analyses were based on first differences of logarithms, so that the results are given in the form of percentage changes from the preceding year. Actual levels for any given year are obtained by applying these changes to the computed level in the preceding year. By this method, the study can be continued year after year for as long as desired.

In an analysis of the effects of specified loan programs for corn on the feed-livestock economy, the following general approach was used: (1) Certain assumptions were made regarding year-to-year changes in production of feed and disposable income; (2) the effects of these on prices of corn and livestock, on production of livestock, and on total returns to farmers, within the assumed loan-program framework, were measured on a year-to-year basis; (3) results for the specified loan programs and those arising without a loan program were compared, both by years and in total for a number of years.

This method appears preferable to one in which results for

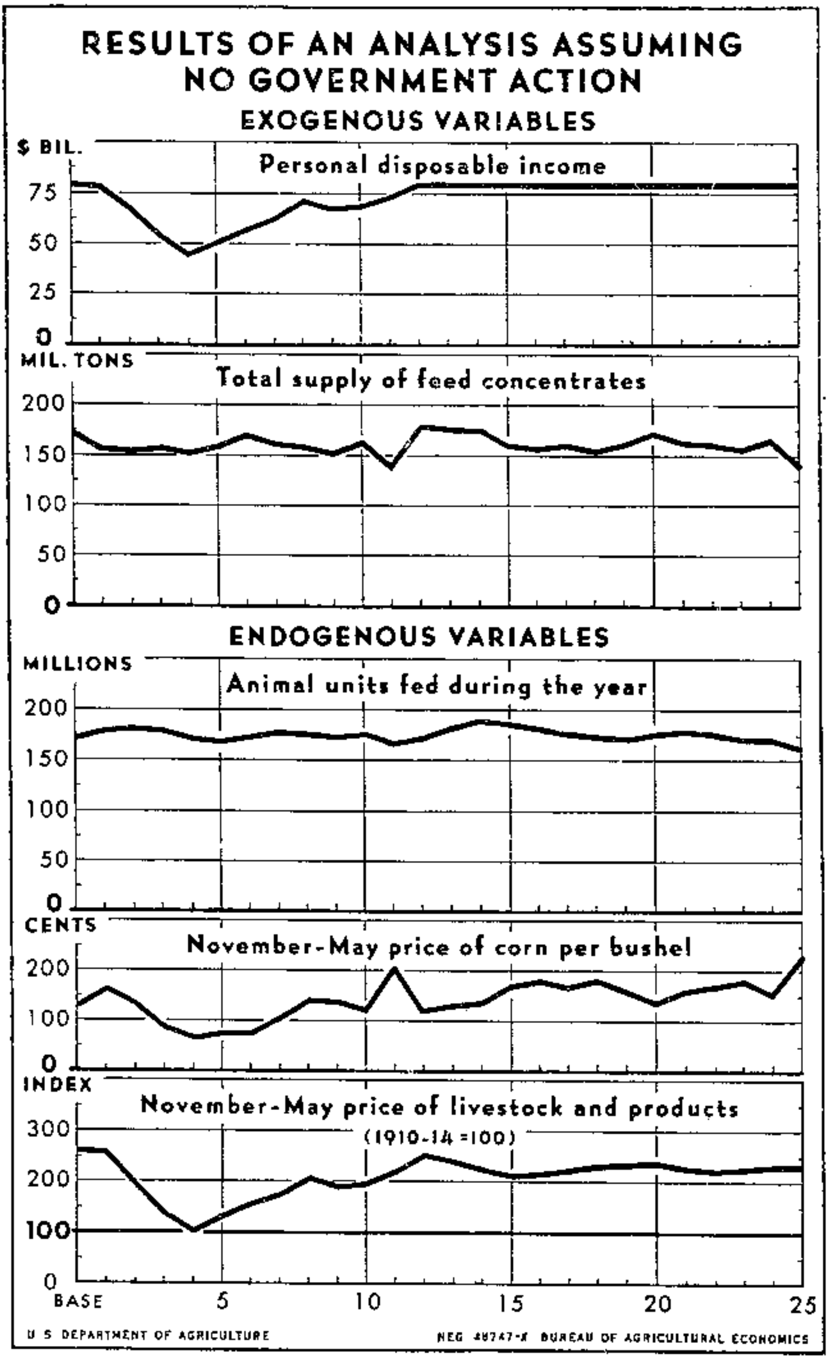

FIGURE 5.—When supplies of feed concentrates and disposable income vary as shown, the system of equations discussed here indicates that animal units fed during the year and prices of corn and of livestock and livestock products vary in the way shown above.

specified loan programs are compared with actual prices for a given period. Many factors other than those allowed for in the system of equations affect actual prices, so that the differences between results under a given loan program and actual prices reflect not only those resulting from the loan program as such, but also the effects of all factors not allowed for in the equations. Under the system described above, the differences that are found result mainly from the type of loan program assumed. However, results will depend to some extent upon the particular pattern chosen for the factors outside the system, the starting levels for the various items, the particular equations used, and the length of time for which results are computed. All of these must be chosen as logically and as realistically as possible.

Some of the results obtained from a sequential use of these equations are shown in figure 5. This chart shows the levels assumed for supplies of feed concentrates and disposable income in one set of computations and the resulting prices of corn and livestock products and the number of animal units fed during the year for 25 years, assuming no action on the part of the Government.

The changes implied by such a system of equations can be ascertained for a limited number of years by a direct solution of the equations. An algebraic solution can be obtained which will indicate (in the absence of changes in major outside factors) the nature of the changes which would be likely to occur over as long a period as the equations were applicable. Such a solution is given in Foote (*4*). It indicates that, for this set of equations, the system probably would involve cyclical changes in the variables and that the changes would tend to increase in size. These conclusions are consistent with the results of direct analyses similar to that shown in figure 5.

FACTORS THAT AFFECT CONSUMPTION OF CORN AND TOTAL FEED CONCENTRATES

Two analyses were run to determine whether the elasticity of demand for corn for livestock feeding could be measured separately from that for the total of the four major feed grains (corn, oats, barley, and sorghum grains). In each analysis, the quantity of the respective grains fed to livestock during the October to September feeding year was used as the dependent variable, and the price received by farmers during the same period was used as an independent variable. The number of animal units fed during the year and the index of prices received by farmers for livestock and livestock products were used as additional independent variables in each analysis. Consumption of feed grains other than corn was included as an additional variable in the analysis for corn. The regression coefficient for this variable was about a sixth as large as that for corn but it did not differ significantly from zero. The indicated coefficients of elasticity of demand for each analysis were almost identical.

It was concluded that the high degree of correlation between consumption of corn and consumption of the four feed grains and between their prices prevented the separation of these two elasticities. The elasticity of demand for corn from this analysis was

TABLE 8.—*Corn and total feed concentrates: Actual and computed amount fed to livestock, and related variables, 1921–51*

Year beginning October	X_0 Consumption of corn		X'_0 Consumption of 4 feed grains		X_1 Price received by farmers for	X'_3	X_4 and X'_4	X_2 Feed grains, excluding corn, fed to livestock	X_3 and X'_2 Grain consuming animal units fed annually
	Actual	Computed [1]	Actual	Computed [1]	Corn, per bushel	Feed grains [2]	Livestock and products [2]		
	Million tons	*Million tons*	*Million tons*	*Million tons*	*Cents*			*Million tons*	*Millions*
1921	75	....	95	....	52	84	123	20	152
1922	72	73	92	95	73	111	129	20	163
1923	74	66	96	85	81	123	126	22	162
1924	58	61	82	83	106	149	145	24	151
1925	68	70	92	96	70	105	151	24	149
1926	67	68	88	89	74	114	146	21	152
1927	70	64	93	84	85	132	153	22	153
1928	66	70	91	97	84	123	160	25	153
1929	65	64	87	88	80	115	142	23	154
1930	52	63	76	86	60	82	106	24	152
1931	64	62	86	84	32	50	77	22	156
1932	74	63	95	84	32	49	69	21	159
1933	63	60	76	74	52	82	77	13	154
1934	44	46	55	58	82	122	107	11	131
1935	56	53	76	69	66	96	118	21	138
1936	42	46	59	62	104	150	124	17	138
1937	56	54	78	76	52	77	114	22	138
1938	59	63	80	88	49	69	107	21	148
1939	62	59	83	78	57	84	107	20	156
1940	63	63	89	87	62	90	128	26	156
1941	70	72	96	100	75	113	163	26	167
1942	82	86	111	116	92	143	194	30	192
1943	80	75	106	101	112	177	195	26	193

1944	76	69	101	94	109	166	206	25	173
1945	77	68	107	91	127	201	223	30	168
1946	75	73	99	101	156	245	282	24	160
1947	63	63	86	88	216	308	314	22	154
1948	71	79	97	109	130	182	284	26	160
1949	79	74	103	98	125	188	268	24	166
1950	78	82	105	109	153	228	327	27	172
1951	80	75	107	101	168	246	317	27	175

[1] From an analysis based on first differences of logarithms for the years 1922–42.
[2] Index numbers, 1910–14 = 100.

nearly equal to the reciprocal of the coefficient of price flexibility for the analysis of factors that affect prices of corn from November to May. For this reason, it was assumed that the elasticity probably represented essentially the elasticity of demand for total feed grains and perhaps for total feed concentrates. If the elasticity of demand for corn could be separately determined, the demand for corn would probably be somewhat more elastic because of the possibility of substituting corn for other feed grains. Were it not for the fact that corn is the dominant feed grain (in the 1949–50 feeding season, corn constituted 77 percent of the total grains fed to livestock), the demand for corn for livestock feeding would be expected to be highly elastic because of the availability of close substitutes.

The variables used in these two analyses are shown below. Each refers to the total or average for the marketing year beginning October.

Analysis dealing with consumption of corn:

X_0—Quantity of corn fed to livestock, in million tons.
X_1—Price received by farmers for corn, in cents per bushel.
X_2—Quantity of feed grains, excluding corn, fed to livestock, in million tons.
X_3—Grain-consuming animal units fed on farms during the year, in millions.
X_4—Price received by farmers for livestock and livestock products, index numbers, 1910–14 = 100.

Analysis dealing with consumption of all feed grains:

X'_0—Quantity of feed grains fed to livestock, in million tons.
X'_1—Price received by farmers for feed grains, index numbers, 1910–14 = 100
X'_2—Same as X_3 above.
X'_3—Same as X_4 above.

Each analysis was based on first differences of logarithms for 1922–42. Data for the analyses are shown in table 8.

These analyses primarily measure the demand for feed concentrates by livestock. In years of short supply or unusually strong demand, the supply of feed may be the limiting factor in determining the actual consumption. Thus, in using these studies for forecasting purposes, the effect of supply on consumption must be allowed for on a judgment basis before using the results from the statistical formulas. It is realized that some farmers base their feeding operations primarily on the quantity of feed available on their own farms, with little regard to the economic factors included in these analyses. The effects of such operations would enter into the formulas given here only through the animal-units-fed factor. Feeding operations of this type probably account, at least in part, for the fact that the factors included in the analyses explain only about 80 percent of the year-to-year variation in the quantity of feed actually fed to livestock.

Principal statistical coefficients obtained from the analysis made to determine the relation between quantity of corn fed to livestock and price received by farmers for corn, quantity of feed grains, excluding corn, fed to livestock, grain-consuming animal units fed during the year, and price received by farmers for livestock and livestock products, years beginning October 1922–42, are as follows:

Coefficient	Value [1]
$R^2_{0.1234}$	0.810
$s_{0.1234}$	0.0367
$b_{01.234} \pm s_{b_{01.234}}$	-0.473 ± 0.100
$b_{02.134} \pm s_{b_{02.134}}$	-0.075 ± 0.124 [2]
$b_{03.124} \pm s_{b_{03.124}}$	1.700 ± 0.343
$b_{04.123} \pm s_{b_{04.123}}$	0.484 ± 0.192
$r^2_{01.234}$	0.585
$r^2_{02.134}$	0.022 [2]
$r^2_{03.124}$	0.606
$r^2_{04.123}$	0.285
$a_{0.1234}$	-0.0050

[1] When all variables are expressed as first differences of logarithms.
[2] These coefficients do not differ significantly from zero.

Principal statistical coefficients obtained from the analysis relating quantity of four major feed grains fed to livestock to price received by farmers for these items, grain-consuming animal units fed during the year, and price received by farmers for livestock and livestock products, years beginning October 1922–42, are as follows:

Coefficient	Value [1]
$R^2_{0.123}$	0.825
$s_{0.123}$	0.0316
$b_{01.23} \pm s_{b_{01.23}}$	-0.460 ± 0.069
$b_{02.13} \pm s_{b_{02.13}}$	1.547 ± 0.277
$b_{03.12} \pm s_{b_{03.12}}$	0.498 ± 0.137
$r^2_{01.23}$	0.723
$r^2_{02.13}$	0.647
$r^2_{03.12}$	0.438
$a_{0.123}$	-0.0040

[1] When all data are expressed as first differences of logarithms.

FACTORS THAT AFFECT SALES OF CORN BY FARMERS

Phillips (*9*) published an analysis of factors that affect sales of corn by farmers in the North Central region. About 85 percent of the total quantity of corn sold by farmers in the United States comes from these States. He showed that 88 percent of the variation in sales for 1926–45 was associated with variations in production of corn per head of livestock.

A similar analysis was run for the United States, except that the factors used and the form of the equation were changed slightly from the ones used by Phillips to make them conform with other studies discussed in this bulletin. A logarithmic equation for the years beginning October 1921–42 was used, based on these factors:

X_0—Sales of corn by farmers, in million bushels.
X_1—Production of corn, plus October 1 nonloan stocks, in million bushels.
X_2—Grain-consuming animal units fed on farms during the year, millions.

The study indicates that sales are about twice as variable as supply. That is, a 10-percent increase in supply would be expected to result in about a 20-percent increase in sales, provided the number of animal units fed did not change. As the number of animal units would normally increase with an increase in feed supply, this would have an offsetting effect on sales, as indicated by the regression equation.

The partial regression coefficient for animal units does not differ significantly from zero. However, as the sign of the coefficient is in line with expectations and this variable would be expected to have a small but genuine effect on sales of corn, it was retained in the analysis.

Data for this analysis are shown in table 9. Since 1946, actual values in all years have been above the computed values. This is believed to reflect, at least in part, effects of the support program for corn. The analysis was rerun including the post-World War II years, but computed values based on this analysis for 1946 to 1951 were only slightly higher than those obtained from the analysis based on the years 1921 to 1942.

TABLE 9.—*Corn: Actual and computed sales by farmers, and related variables, 1921–51*

Year beginning October	Sales: Actual	Sales: Computed [1]	Production of corn, plus October 1 nonloan stocks	Grain-consuming animal units fed annually
	Million bushels	*Million bushels*	*Million bushels*	*Millions*
1921	602	693	3,290	152
1922	499	537	2,960	163
1923	590	553	3,000	162
1924	418	366	2,390	151
1925	584	543	2,900	149
1926	462	509	2,827	152
1927	521	510	2,833	153
1928	498	485	2,760	153
1929	441	450	2,663	154
1930	337	313	2,219	152
1931	458	473	2,744	156
1932	567	637	3,201	159
1933	445	493	2,784	154
1934	153	222	1,705	131
1935	395	361	2,364	138
1936	216	191	1,681	138
1937	[2] 566	498	2,709	138
1938	[2] 575	532	2,865	148
1939	[2] 582	531	2,907	156
1940	[2] 487	450	2,674	156
1941	[2] 541	505	2,893	167
1942	579	630	3,363	192
1943	552	620	3,342	193
1944	713	649	3,313	173
1945	603	609	3,175	168
1946	807	712	3,389	160
1947	489	438	2,629	154
1948	[2] 1,034	862	3,728	160
1949	[2] 907	768	3,559	166
1950	742	628	3,253	172
1951	697	599	3,193	175

[1] From an analysis based on logarithms for 1921–42.

[2] Includes an allowance for unredeemed loans and purchase agreement deliveries to CCC.

Principal statistical coefficients obtained from the analysis relating sales of corn by farmers to production of corn, plus

October 1 nonloan stocks, and grain-consuming animal units fed during the year for the years beginning October, 1921–42, are as follows:

Coefficient	Value [1]
$R^2_{0.12}$	0.874
$s_{0.12}$	0.055
$b_{01.2} \pm s_{b_{01.2}}$	2.01 ± 0.23
$b_{02.1} \pm s_{b_{02.1}}$	−0.60 ± 0.50 [2]
$r^2_{01.2}$	0.805
$r^2_{02.1}$	0.069 [2]
$a_{0.12}$	−2.91

[1] When all variables are expressed as logarithms.

[2] These coefficients do not differ significantly from zero.

AN ITERATIVE ANALYSIS OF FACTORS THAT AFFECT PRICES OF CORN FROM JUNE TO SEPTEMBER

Analyses previously discussed indicate the principal factors that are believed to affect prices of corn from November to May. In this section, an analysis is discussed which indicates the principal factors that affect prices of corn during the remainder of the marketing season. The general form of the equation and the general types of factors used are the same as for the other analyses. Certain modifications are required, however. In this instance, only an analysis based on first differences is discussed.

Variables Used

From June to September, new-crop oats and barley can be fed and the prospective size of the new corn crop begins to affect prices. The supply of old-crop corn, which can be represented approximately by stocks on July 1, also is important. From a statistical standpoint, the problem is how to weight the various factors. A method developed for use in this study was used to determine the appropriate weights. The exact components of the supply variable were as follows:

1. Stocks of corn on July 1, excluding stocks under loan or owned by the Commodity Credit Corporation on October 1. This gives an estimate of the variation in the "free" supplies of corn that are available for feeding or for other use during the last few months of the marketing year, assuming that year-to-year variations for June 1 stocks are about the same as for July 1 stocks.

2. An average of the July 1, August 1, and September 1 Crop Reporting Board estimates of the size of the new corn crop. It was felt that the Board estimates would have more effect pricewise than would the actual size of the crop, as the latter would not be known until later in the year.

3. July 1 stocks of oats and barley, excluding stocks under loan or owned by CCC on October 1, plus new-crop production of these two grains. These would be available for feeding during the late summer months.

4. The quantity of concentrates other than corn, oats, and barley fed from July to October.

As a first approximation, these were converted to millions of tons and added together. The final results indicate that, when the data are expressed in million tons, stocks of corn should be multiplied by about 3, new-crop corn production by about 0.8, and the new-crop supply of oats and barley by about 0.5. The results added together form the supply variable. The quantity of other concentrates fed can be omitted, as year-to-year changes are of negligible importance.

The main demand shifter for June to September prices of corn, as for November to May prices, is the level of prices for livestock and livestock products. An average of the index numbers for June to September was used in the analysis of prices of corn for that period.

A second demand factor is the number of animal units to be fed. It was felt that numbers in both the July to September and the October to December quarter would be important, but it was not known how these should be weighted. As the animal-units-fed series is not available on a quarterly basis, the series given in Jennings (7) on livestock production, weighted by the amount of feed required per production unit, was used instead. The iterative method was used to determine appropriate weights in this instance, too, but the results were less satisfactory than for the supply variable, reflecting in part the low degree of partial correlation between prices of corn and production of livestock, after adjusting for the effects of the other variables. Data for the two quarters were weighted on an equal basis for the final analysis. Details regarding the use of the iterative method are given in the Appendix.

These variables were converted into first differences of logarithms and used in an analysis covering the years 1922–42. The data are presented in table 10.

Results of the Final Analysis

This analysis was run in two parts: (1) A linear analysis for the separate components of supply, the partial regression coefficients from which were used as weights in obtaining the supply variable for the second analysis; and (2) an analysis based on first differences of logarithms using as the dependent variable prices received by farmers for corn from June to September (X_0) and as the independent variables the supply series derived from the first analysis (X_1), production of livestock during July to December (X_2), and prices of livestock and livestock products during June to September (X_3). The second analysis is similar to that previously discussed based on first differences of logarithms from November to May. Final results from the second analysis are presented in this section. The first analysis was used in obtaining the second. Final results from it are shown under the fourth approximation in table 12 in the Appendix.

Principal statistical coefficients obtained from the final analysis in which the relationship of June-to-September prices of corn to supply of feed concentrates, units of livestock production, and

TABLE 10.—*Price received by farmers for corn, June-September: Actual and computed price per bushel, and related variables, 1921–52*

Year [1]	X_0 Price of corn		X_1 Components of the supply variable				X_2 Units of livestock production (July–December)	X_3 Prices received by farmers for livestock and products (June–September) [7]
	Actual	Computed [2]	July 1 stocks of corn [3]	New-crop corn production [4]	New-crop supply of oats and barley [5]	Weighted total [6]		
	Cents	*Cents*	*Million tons*	*Million tons*	*Million tons*	*Million tons*	*Millions*	
1921	59			87		142		118
1922	63	76		82		124		122
1923	86	75		83		111		123
1924	99	88		71		107		123
1925	105	108		83		111	79	148
1926	74	90	15	74	34	124	79	149
1927	94	84	14	66	31	111	80	137
1928	100	105	9	81	20	110	84	158
1929	93	97	11	73	26	111	82	159
1930	84	88	10	65	26	102	82	128
1931	50	61	9	79	19	108	85	94
1932	29	29	15	81	34	131	84	71
1933	48	31	20	65	21	126	84	73
1934	66	73	15	49	14	94	70	82
1935	81	105	6	61	28	83	70	113
1936	88	82	11	48	22	87	75	117
1937	108	91	4	73	26	87	74	128
1938	51	54	17	70	28	127	78	110
1939	50	51	17	70	26	127	86	102
1940	63	60	14	65	31	113	84	106
1941	70	71	16	72	32	125	90	143

1942	83	74	18	78	36	142	103	172
1943	108	84	23	80	33	157	114	196
1944	116	116	16	84	30	137	97	191
1945	112	108	21	80	37	152	100	210
1946	173	131	15	95	36	144	95	241
1947	211	206	20	72	31	139	92	286
1948	197	241	13	97	34	137	91	331
1949	120	127	22	99	32	167	96	272
1950	142	141	20	89	34	155	98	286
1951	164	160	22	90	33	159	102	335
1952	172	162	19	90	32	151	98	311

[1] Data relate to the calendar year, not the crop year as in other analyses.

[2] From an analysis based on first differences of logarithms for 1922–42.

[3] Excluding stocks under loan or owned by the Commodity Credit Corporation on October 1.

[4] An average of the July 1, August 1, and September 1 Crop Reporting Board estimates.

[5] July 1 stocks of oats and barley, excluding stocks under loan or owned by the Commodity Credit Corporation on October 1, plus new-crop production of these two grains.

[6] July 1 stocks of corn times 3.19 plus new-crop corn production times 0.81 plus new-crop supply of oats and barley times 0.54. Partly estimated before 1934.

[7] Index numbers, 1910–14 = 100.

prices of livestock and livestock products, 1922–42, were studied are as follows:

Coefficient	*Value* [1]
$R^2_{0.123}$	0.758
$s_{0.123}$	0.0729
$b_{01.23} \pm s_{b_{01.23}}$	-1.59 ± 0.34
$b_{02.13} \pm s_{b_{02.13}}$	0.70 ± 0.70 [2]
$b_{03.12} \pm s_{b_{03.12}}$	0.84 ± 0.23
$r^2_{01.23}$	0.570
$r^2_{02.13}$	0.056 [2]
$r^2_{03.12}$	0.429
$a_{0.123}$	-0.00328

[1] When all variables are expressed as first differences of logarithms.
[2] These coefficients do not differ significantly from zero.

Figure 6 shows prices of corn, adjusted for the remaining variables, against each of the independent variables. Relationships indicated by these charts are less refined than those for the November to May first-difference analysis, reflecting the lower degrees of partial correlation. The three variables used in this analysis together explained 76 percent of the variation in June-to-September prices of corn from 1922–42, whereas similar factors explained 91 percent of the variation in November-to-May prices. The lower percentage explained by this analysis may reflect: (1) The fact that changing prospects for the oncoming crop have a less stable effect on prices than do crops already harvested; (2) in years of short supply, the prospect of a large crop for the following year does not influence price to the same extent that it does when year-end stocks are large; and (3) changes in nonfeed demands for corn, such as for export or for use by the wet- or dry-processing industries, in some years affect prices of corn significantly during the last quarter of the marketing year. This is likely to be particularly true in years of short supplies at the close of the marketing year. No allowance for these demand factors has been made in the analysis.

Results from the Method as Applied to Certain Related Problems

Meinken ran similar analyses for oats and barley for July to October when marketings are heaviest for these crops.[7] In each case, the price received by farmers was the dependent variable and a first-difference logarithmic analysis was used covering the years 1922 to 1941. In these analyses, as for corn, the three variables—a composite of supplies of old- and new-crop corn and new-crop oats and barley, production of livestock from July to December, and prices received by farmers for livestock and livestock products for the months included in the analysis—were used as independent factors. Weights for the components of supply were determined by a linear first-difference analysis through the method discussed in this section.

Table 11 compares the weights obtained from the analyses for oats and barley with those obtained for corn. In each case, the current supply of the commodity as such carries the largest

[7] These studies are given in an unpublished manuscript entitled The Demand and Price Structure for Oats, Barley, and Sorghum Grains, by Kenneth W. Meinken.

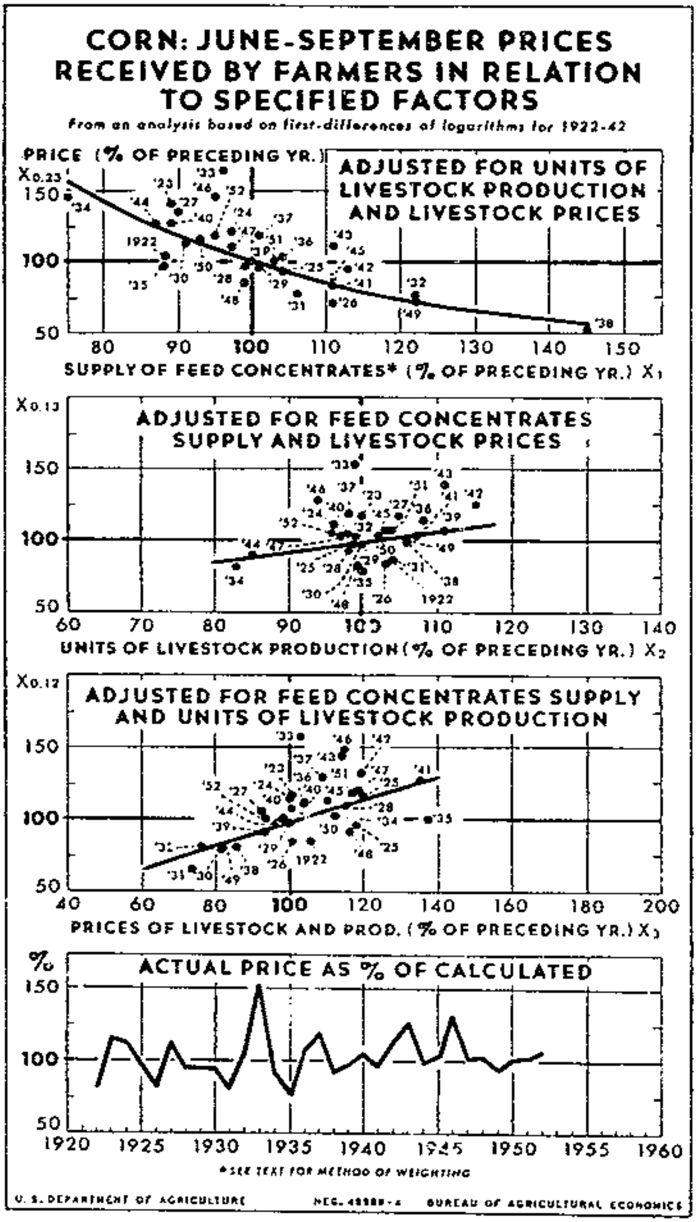

FIGURE 6.—The three variables—supply of feed concentrates, including an allowance for stocks of corn on July 1 and new-crop supplies of corn, oats, and barley, livestock production from July to December, and prices of livestock and livestock products from June to September—explained 76 percent of the year-to-year variation in prices received by farmers for corn from June to September. The charts indicate that relationships that prevailed during the interwar period continued into the post-World War II years.

weight, and the weights for other components are consistent with *a priori* expectations. The regression coefficient for barley in the analysis for oats had the wrong sign but, as it did not differ significantly from zero, its value was assumed to be zero in these computations. Results for the analyses for oats and barley confirm those obtained for corn in that they indicate that this general approach is useful in analyzing problems of this type.

TABLE 11.—*Corn, Oats, and Barley: Relative weights by which specified components of the supply of feed grains should be multiplied 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				
		Stocks of corn, July 1	Prospective new crop of corn	New-crop supply of Oats	New-crop supply of Barley	Total
Corn [2]	June to September	0.64	0.16	[3] 0.10	[3] 0.10	1.00
Oats [4]	July to October	.19	.24	.57	0	1.00
Barley [4]	do	.11	.14	.20	.55	1.00

[1] When all components are expressed in tons.
[2] Based on relative size of the regression coefficients given by the fourth approximation for the second analysis shown in table 12.
[3] These components were combined in the analysis for corn.
[4] Based on relative size of the regression coefficients from analyses similar to those used for corn. From an unpublished manuscript by Kenneth W. Meinken.

LITERATURE CITED

(1) BREIMYER, H. F.
1943. THE EFFICIENCY OF FEEDING LIVESTOCK. Jour. Farm Econ. 25: 599–621, illus.

(2) EZEKIEL, MORDECAI.
1938. THE COBWEB THEOREM. Quart. Jour. Econ. 52: 255–280, illus.

(3) ———
1941. METHODS OF CORRELATION ANALYSIS. Ed. 2, 531 pp., illus. New York and London.

(4) FOOTE, RICHARD J.
1953. A FOUR-EQUATION MODEL OF THE FEED-LIVESTOCK ECONOMY AND ITS ENDOGENOUS MECHANISM. Jour. Farm Econ. 35: 44–61, illus.

(5) ———, and IVES, J. RUSSELL.
1941. RELATIONSHIP OF THE METHOD OF GRAPHIC CORRELATION TO LEAST SQUARES. U. S. Bur. Agr. Econ. Statis. and Agr. Ser. 1, 33 pp., illus. (Processed.)

(6) ———, KLEIN, JOHN W., and CLOUGH, MALCOLM.
1952. THE DEMAND AND PRICE STRUCTURE FOR CORN AND TOTAL FEED CONCENTRATES. U. S. Dept. Agr. Tech. Bul. 1061, 79 pp., illus.

(7) JENNINGS, R. D.
1948. UNITS OF LIVESTOCK PRODUCTION. A MEASURE OF GRAIN CONSUMPTION AT THE NATIONAL LEVEL. U. S. Bur. Agr. Econ. FM 63, 19 pp. Washington, D. C. (Processed.)

(8) LORIE, JAMES H.
1947. CAUSES OF ANNUAL FLUCTUATIONS IN THE PRODUCTION OF LIVESTOCK AND LIVESTOCK PRODUCTS. 105 pp., illus. Chicago.

(9) PHILLIPS, REED A.
1946. FACTORS ASSOCIATED WITH FARM SALES OF CORN. U. S. Bur. Agr. Econ. Feed Situation, Aug. 1946, pp. 14–18, illus. (Processed.)

(10) THOMSEN, FREDERICK LUNDY, and FOOTE, RICHARD J.
1952. AGRICULTURAL PRICES. Ed. 2, 510 pp., illus. New York.

APPENDIX

STEPS INVOLVED IN THE ITERATIVE ANALYSIS

The following method can be used whenever additive weights are desired for the components of one or more variables to be used in a logarithmic analysis. It has been applied mainly to problems that involve the determination of proper weights for several components of a supply variable. Two research papers have contributed to the statistical problem considered here. Foote and Ives (*5*) demonstrated that a successive approximation method similar to the one outlined here will converge to the least-squares value. Ezekiel (*3*, pp. 390–403) proposed methods along these lines for studying joint relationships while holding other variables constant.

The following steps are used when weights for components of a supply variable are desired and price is used as the dependent variable:

1. The components of the supply factor are combined in some simple way. (As a first step, they were converted to tons and added together.) The composite is used as one independent variable in a logarithmic analysis.

2. Values of the dependent variable from this analysis are adjusted for the effects of the independent variables other than supply and the antilogarithms obtained. (In the case of first-difference analyses, some additional calculations are involved. The calculated value plus 2 has for its antilogarithm a figure in terms of percentage of the preceding year. This should be applied to the actual price in the preceding year to get an estimated price. The difference between this estimate and the actual price in the preceding year is the adjusted dependent variable that should be used as the dependent variable in the linear first-difference analysis discussed in step 3.)

3. The adjusted dependent variable is used as the dependent variable in a linear analysis in which the separate components of the supply factor are used as independent variables. The partial regression coefficients from this analysis are proportionate to the weights that should be applied to the individual supply components.

4. The following method may be used to test whether these partial regression coefficients differ significantly from each other: (*a*) Compute the simple linear correlation between the dependent variable used in step 3 and the supply factor based on constant weights for the components. (In the case considered here, the latter is the same as the supply variable used in step 1.) Compute the unexplained sum of squares for this analysis. If X_0 is the

dependent variable, this will equal $\Sigma(X_0-\overline{X}_0)^2(1-r^2_{01})$. (*b*) Compute the unexplained sum of squares for the linear multiple correlation analysis in step 3. This will equal $\Sigma(X_0-\overline{X}_0)^2(1-R^2_{0.1\ldots p})$. (*c*) Take the difference between these two sums of squares and divide it by P–1. This represents the variance owing to the differences between the regression coefficients in the linear analysis. (*d*) Divide the sum of squares obtained in step b by N–P–1. This represents the error or remainder variance. (*e*) Compute the ratio between the variance in step c and the variance in step d, and compare this with the tabular values in an F table, using P–1 and N–P–1 degrees of freedom. If the ratio obtained is larger than the tabular value at the 5-percent point, the differences between the regression coefficients are statistically significant. If this is approximately true, the weights determined in step 3 should be used, provided they appear logical.

A method of successive approximation to refine the various coefficients is next considered. This is used only if the F-ratio obtained in step 4e is equal to or larger than that at, say, a 10-percent probability level. If the regression coefficients do not differ significantly, the simple weighting procedure originally used in step 1 is satisfactory, and that analysis becomes the final one.

5. Obtain a new supply composite by multiplying each component by its partial regression coefficient from the linear analysis or by weights that are proportionate to these coefficients. (In the case of first-difference analyses, the actual values are multiplied by the weights, the total obtained, and the first-difference logarithms are derived from this total.)

6. Use this composite with the other variables originally used in step 1 to obtain a second approximation for the logarithmic analysis.

7. If the second approximations for the partial regression coefficients for the variables other than supply differ from the first approximations obtained in step 1, get a new series for the dependent variable adjusted for the effects of these nonsupply factors and obtain the antilogarithms of these.

8. Use the variable obtained in step 7 as the dependent variable in a linear analysis, using the same components of supply as independent variables as were used in step 3.

9. If the regression coefficients obtained in step 8 differ from those obtained in step 3, repeat step 5, 6, 7, and 8 until the results converge to stable values. The final result will yield a set of weights to be applied to the components of supply to give a composite factor of supply that will maximize the multiple correlation in the logarithmic analysis, for which price is the dependent variable and supply is one of several independent variables.

For the series of analyses discussed here, the basic analysis is a logarithmic one, using first differences, for which the dependent variable is the June-to-September average price received by farmers for corn. The independent variables are: (1) The composite feed-concentrate-supply variable, for which the weights are determined from a separate linear analysis; (2) the composite units of livestock production variable, for which the weights were partially determined from a separate linear analysis; and (3) average June-to-September index numbers of prices received by farmers for livestock and livestock products.

The dependent variable for the linear analysis involving the separate components of the supply factor was determined by adjusting year-to-year changes in the price of corn for the effects of year-to-year changes in units of livestock production and prices of livestock, using the highest-order partial regression coefficients from the logarithmic analysis. Likewise, the dependent variable for the linear analysis involving the separate components of the units-of-livestock-production variable was determined by adjusting year-to-year changes in the price of corn for the effects of year-to-year changes in supply of feed and prices of livestock, using the highest-order partial regression coefficients from the logarithmic analysis. Results for each succeeding approximation were used to improve the results for the following analysis.

Results of the Successive Iterations for the Analysis of Factors That Affect June-to-September Prices of Corn

In an iterative analysis of this type, values for certain coefficients may be assumed to start with, as the results of successive iterations will converge toward the statistically most likely or "true" values. During the process of analysis, certain coefficients may be obtained which are inconsistent with *a priori* expectations. Particularly if the standard errors of these coefficients are large, consistent coefficients may be assumed or the variable may be omitted from the analysis, in which case a regression coefficient of zero is assumed. Table 12 lists the coefficients obtained or assumed for succeeding approximations for each of the three analyses involved in the over-all analysis of factors that affect the price of corn from June to September. (The third analysis dealing with components of the units-of-livestock-production factor was omitted from the discussion in certain earlier sections, partly to simplify the discussion and partly because the results were none too satisfactory.)

Results obtained from the second approximation for the analysis dealing with the components of the supply of feed concentrates were tested to determine whether the regression coefficients differed significantly from each other. An F value of 3.30 was obtained, compared with the 5-percent point value of 3.24. As the individual coefficients in general seemed reasonable, it was decided to use them. As the coefficient for concentrates other than corn, oats, and barley fed ($b_{04.123}$) was positive and had such a high standard error, this factor was omitted. Year-to-year changes in this item were extremely small.

In the first analysis, data on livestock production units for the July-to-September quarter only were used. In the second approximation, data for the July to September quarter were weighted by 2 and for the October-to-December quarter by 1. The series on prices of corn was then adjusted for the effects of supplies of feed concentrates and prices of livestock. The adjusted price was used as the dependent variable in a linear analysis in which the two livestock production series were used as separate independent variables. These two variables explained only 7 percent of the residual variation in prices of corn. This is consistent with the

TABLE 12.—*Successive approximations for the three sets of multiple correlation analyses used in connection with the basic analysis of factors that affect June to September prices of corn* [1]

Analysis dealing with factors that affect the price of corn, June to September

Coefficient	Approximation			
	1st	2d	3d	4th
$R^2_{0.123}$	0.634	0.738	0.770	0.758.
$b_{01.23} \pm s_{b_{01.23}}$	-0.82 ± 0.36	-1.65 ± 0.39	-1.70 ± 0.34	-1.59 ± 0.34.
$b_{02.13} \pm s_{b_{02.13}}$	-1.06 ± 0.54	0.23 ± 0.69	0.76 ± 0.69	0.70 ± 0.70
$b_{03.12} \pm s_{b_{03.12}}$	1.21 ± 0.29	1.10 ± 0.24	0.87 ± 0.23	0.84 ± 0.23.
	Analysis dealing with components of the supply of feed concentrates			
$R^2_{0.1234}$		0.530	0.587	0.656.
$b_{01.234} \pm s_{b_{01.234}}$	1 [2]	-2.69 ± 0.69	-2.88	-3.19.
$b_{02.134} \pm s_{b_{02.134}}$	1 [2]	-0.68 ± 0.40	-0.78	-0.81.
$b_{03.124} \pm s_{b_{03.124}}$	1 [2]	-0.85 ± 0.87	-0.61	-0.54.
$b_{04.123} \pm s_{b_{04.123}}$	1 [2]	1.93 ± 3.80	0 [2]	0. [2]
	Analysis dealing with components of production of livestock			
$R^2_{0.12}$			0.071	
$b_{01.2}$	1 [2]	2 [2]	1 [2, 3]	1. [2]
$b_{02.1}$	0 [2]	1 [2]	1 [2, 3]	1. [2]

[1] See text for exact variables used. Many of the coefficients shown here would not be statistically significant, based on the usual tests.

[2] Assumed values.

[3] Calculated values for this analysis were as follows:

$b_{01.2} \pm s_{b_{01.2}}$, -1.82 ± 1.62; $b_{02.1} \pm s_{b_{02.1}}$, 0.96 ± 1.05.

highest-order partial coefficient of determination between prices of corn and production of livestock from the logarithmic analysis which was only 0.05 for this approximation. The analysis indicated, however, that, if anything, October-to-December livestock production units (for which the sign of the regression coefficient was consistent with *a priori* expectations) were more important than July to September livestock production units (for which the regression coefficient had the "wrong" sign). In subsequent logarithmic analyses, these two series were given equal weights.

In the basic analysis of the factors that affect June-to-September prices of corn, the regression coefficient for the units-of-livestock-production factor ($b_{02.13}$) had the wrong sign on the first approximation. This occasionally occurs in analyses of this type and may merely indicate the need for additional approximations. In this instance, the dependent variable, in terms of first-difference logarithms, for the second approximation for the linear analysis involving the components of the supply of feed concentrates was obtained by use of the formula $X_{0.3} = X_0 - b_{03.1}\ (X_3 - \overline{X}_3)$. In other words, the computations for this approximation were based on results that would have been obtained had the X_2 factor been omitted from the analysis.

In general, the multiple correlation coefficient for the basic analysis should be the same or higher for each succeeding approximation, and the regression coefficients should change in an orderly way. In the analyses discussed here, this takes place through the third approximation but does not hold for the fourth. This is believed to be because of rounding errors. The weights for the components of the feed-concentrate-supply factor were carried to two decimals only, which is equivalent to two significant figures for the smaller coefficients. Thus, there is no sound way of choosing between the third and the fourth approximations. The fourth was chosen mainly because the weights for the supply factor continue to change in an orderly way through that approximation.

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