

FEBRUARY, 1949

RESEARCH BULLETIN 431

UNIVERSITY OF MISSOURI COLLEGE OF AGRICULTURE
AGRICULTURAL EXPERIMENT STATION

J. H. LONGWELL, *Director*

Forecasting the Price of Corn on the Basis of Current Crop Reports

Erwin T. Hadorn

(Publication authorized February 10, 1949)



COLUMBIA, MISSOURI

TABLE OF CONTENTS

	PAGE
I. INTRODUCTION	3
II. SCOPE OF THE STUDY	4
III. EFFECT OF CHANGES IN PRODUCTION AND DEMAND UPON PRICE	6
a. Changes in the Size of the Crop	6
b. Changes in Demand	9
IV. RELATION OF CURRENT CROP FORECASTS TO PRICE	13
a. Relation of the July 1 Crop Forecast to the December Price	17
b. Relation of the August 1 Crop Forecast to the December Price	17
c. Relation of the September 1 Crop Forecast to the December Price	18
d. Relation of the October 1 Crop Forecast to the December Price	18
e. Relation of the November 1 Crop Forecast to the December Price	19
V. FORECASTING THE DECEMBER PRICE OF CORN FOUR MONTHS IN ADVANCE	19
VI. EVALUATION OF THE FORECAST OF THE DECEMBER PRICE OF CORN	24
VII. SHIFTS IN THE PRICE-QUANTITY SCHEDULE	26
VIII. SUMMARY AND CONCLUSIONS	28
BIBLIOGRAPHY	30

Forecasting the Price of Corn on the Basis of Current Crop Reports

Erwin T. Hadorn

I. INTRODUCTION

This bulletin deals with the problem of price forecasting. Many economists assert that it is humanly impossible to forecast prices. The findings presented in this study show that prices are not accidents--but the results of specific conditions and relationships. An analysis of these basic conditions will not merely give concrete, definite expression to the various factors affecting price trends, but will supply the groundwork upon which sound price forecasts may be developed.

In view of the increasing tendency of the government to participate in the determination of prices, it is necessary to view the conclusions presented here in the light of governmental pricing policies. Clearly, whether market prices will be permitted to reflect the interplay of free market forces will depend in large part on whether legislation will be adapted to fit competitive conditions. At the present time, the objective of government pricing methods consists mainly of supporting prices of agricultural commodities through loans, purchases, payments, and other operations, if prices decline to the specified support levels. The conclusion seems reasonable that in the face of government intervention in the field of pricing, the effects of such policies are not likely to affect unduly the operation of normal market forces.

Now, as before, the success of commodity trading depends largely upon the ability to forecast changes in price trends; and this, in turn, necessitates to a considerable extent a proper evaluation of the immediate and prospective demand and supply situation. The present study is intended to serve as an illustration of an approach to successful price forecasting and to indicate some of the limitations arising from the instability of our economy.

Acknowledgments are due to Professor O. R. Johnson, Chairman of the Department of Agricultural Economics of the University of Missouri, who has made this study possible, and to Professor B. H. Frame and Mr. W. E. Chryst for their helpful suggestions and criticisms.

II. SCOPE OF THE STUDY

It is the objective of this study to establish mathematically the relationship between the size of the United States corn crop and the December price of corn at Chicago, and to determine the accuracy of price estimates made on the basis of the corn crop forecasts released periodically by the United States Department of Agriculture.

In this bulletin, the period from 1920 onward is studied, although the statistical analysis is restricted to the years 1930 through 1940. This is mainly for the reason that in 1930 a statistically more reliable method was adopted by the U. S. Department of Agriculture in making crop forecasts during the growing season. This method uses graphic correlation technique in interpreting the reported condition of the crop. "The development, about 1927, of simple graphic solutions for correlation problems provided the first practical means of forecasting yield from condition or other currently available data on a really satisfactory basis."^{1/}

Data for the war years 1941-1945 are not included in the analysis because conditions during that period were so abnormal that they would contribute little to an understanding of price determination under more normal conditions. A brief analysis of the data for the period 1946-1948 is made; this period is so short, however, that the conclusions must be regarded as tentative.

In this study of corn prices principal attention is given to the Chicago market. This is for the reason that Chicago is by far the most important and largest terminal market. In addition, more than ninety per cent of the futures trading in corn is normally done on the Chicago Board of Trade. It is felt that a study of corn prices at a leading market is more useful than a study of average farm prices. Corn is bought and sold in the Chicago market, for one, but there is no "United States average farm market." Contract market prices are, therefore, more concrete and tangible than farm prices; also they are more quickly and readily available in current reports and relate to one specific grade.^{2/}

The common delivery and trading months upon which commodity exchanges base their futures contracts are December, May, July, and September. Of these, May and December are the most active delivery months. While the May corn price may be considered an "old-crop price", the December price is universally regarded as a "new-crop price", i.e., fluctuations in May corn prices are to a

¹The Crop and Livestock Reporting Service of the United States, USDA, Misc. Pub. 171, 1933, p. 24.

²Generally speaking, the price of corn at Chicago fluctuates with the United States farm price of corn, although normally at a slightly higher level.

great extent accounted for by variations in supplies of corn remaining from the old crop, whereas corn prices in December are influenced largely by the size of the new crop. Since we are primarily concerned with the relationship of corn prices to current forecasts of the production of corn--i.e., expected size of the new crop--the present analysis is restricted to a study of December prices.

The December price of Contract corn (spot, contract grade or better) is selected for analysis.³ An average of the high and the low quotations is used which appears to correspond as closely, on the whole, to the average of all quotations as does any other readily available type of quotation (Table 1).

TABLE 1. - High, Low, and Average Price of Contract Corn (Spot)* at Chicago, during December, 1930 - 1940.

Year	High	Low	Average#
	(cents)	(cents)	(cents)
1930	85 1/2	64 1/4	74 7/8
1931	42	36	39
1932	26 1/2	22	24 1/4
1933	52	42 1/2	47 1/4
1934	111	89	100
1935	65	57	61
1936	114	107 1/4	110 5/8
1937	62 3/4	54 1/2	58 5/8
1938	56 1/2	48 1/2	52 1/2
1939	65 3/4	54 1/4	60
1940	69 1/2	55 1/2	62 1/2

*Contract grade or better.

#Average of the high and low prices.

Source: "Statistics", Chicago Board of Trade.

Although December corn prices tend to be fairly closely in line with crop production, changes in the size of the corn crop do not account for all of the fluctuations in price. Normally, the price of corn shows a strong tendency to follow the trend in the price-level of other raw materials. Apparently part of the variation in the price of corn is caused by the same forces that bring about changes in the general commodity price level. These two factors appear to be the chief determinants of price. Among factors having some influence on the price of corn are the number and values of livestock (particularly hogs), the corn-hog ratio, the quality and distribution of the corn crop, and the production of other feeds. No consideration is given to these minor factors in this study.

³This description of the commodity is chosen, rather than the conventional No. 3 Yellow, to represent the quality to which futures quotations apply.

The technique employed in deriving the price forecasts is the graphic correlation method. It must be recognized that forecasting on this basis alone has serious limitations. In particular, it does not take into consideration the various irregular or unmeasurable factors which tend to modify normal relationships existing between the price and its determinants. A statistical analysis, however, will give concrete, definite expression to such relationships and will thus serve as a fundamental basis on which to develop price estimates. Price forecasting must always be a matter of common sense judgment, which is very materially aided by the knowledge of price-making forces resulting from the quantitative analysis of the factors involved.

III. EFFECT OF CHANGES IN PRODUCTION AND DEMAND UPON PRICE

In this section a brief analysis of the fundamental factors governing annual changes in the price of corn shall be made.

As a cause of year-to-year price changes, the supply factor ranks most important. In a broad sense, the "supply" of corn consists of the production of new corn plus the stocks of old corn on farms and in the channels of trade (including government holdings). In the present study, changes in existing stocks are neglected since we are concerned with the relationship of price to current forecasts of crop production rather than with the relationship of price to supply in its broad sense.

The demand for corn is a result of two forces: (1) the demand for agricultural and industrial products in general (general demand), as from changes in national income; and (2) the demand for corn itself (specific demand) due, for instance, to changes in livestock numbers. In its effect upon the yearly variations in corn prices, the influence of changes in general demand is of importance primarily through its effect upon the general price level. Changes in the specific demand for corn as feed appear to be of secondary importance when considered with other factors such as quality and distribution of the corn crop.^{4/}

A. Changes in the Size of the Crop. - Figure 1 shows the trend in acreage, yield, and production of corn in the United States from 1930 - 1940 (Table 2). The top section of the figure shows that corn acreage does not change greatly from year to year. The greatest change from one year to the next occurred in 1934 when, as a result of extreme drought and the AAA program, the acreage

⁴See Cox, R. W., Factors Influencing Corn Prices, Minnesota Agr. Exp. Sta. Tech. Bul. 81, Sept., 1931.

Shepherd, G., Annual Fluctuations in the Price of Corn, Iowa Agr. Exp. Sta. Res. Bul. 164, June, 1933.

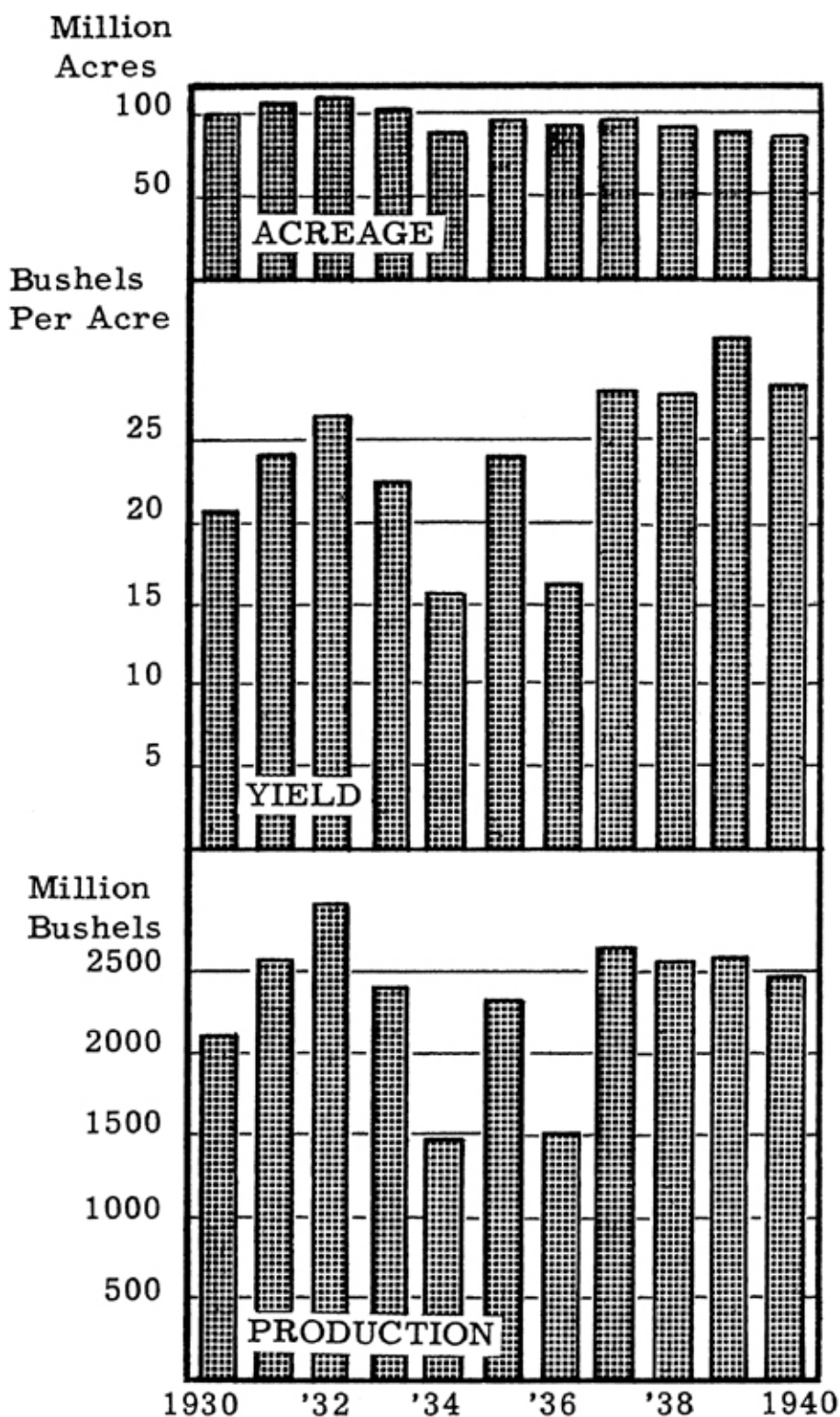


Fig. 1—United States Acreage (harvested), Yield, Production (all grain) of Corn, 1930-1940.

of corn harvested declined 13 per cent below the previous year. Ordinarily, corn acreage remains fairly constant.

TABLE 2. - United States Acreage, Yield, Production of Corn, 1930 - 1940.

Year	Acreage		Yield Per Acre Harvested (bu.)	Production	
	Planted (1,000 acres)	Harvested (1,000 acres)		Harvested As Grain (1,000 bushels)	All Corn (1,000 bushels)
1930	103,915	101,465	20.5	1,757,297	2,080,130
1931	109,364	106,866	24.1	2,229,903	2,575,927
1932	113,024	110,577	26.5	2,578,685	2,930,352
1933	109,830	105,918	22.6	2,104,725	2,397,593
1934	100,563	92,193	15.7	1,146,734	1,448,920
1935	99,974	95,974	24.0	2,001,367	2,299,363
1936	101,959	93,154	16.2	1,258,673	1,505,689
1937	97,174	93,930	28.1	2,349,425	2,642,978
1938	94,473	92,160	27.7	2,300,095	2,548,753
1939	91,639	88,279	29.2	2,341,602	2,580,985
1940	88,692	86,429	28.4	2,206,882	2,457,146

Source: "Agricultural Statistics", 1947, USDA.

The figure shows that the chief reason for fluctuations in the size of the corn crop is yield per acre. The lower part of the graph shows the effect of the rather violent changes in yield--primarily due to changes in weather--and of the moderate changes in acreage upon the total production of corn. A calculation shows that fluctuations in yields explain about 85 per cent of the annual changes in crop production, while changes in acreage account for about 15 per cent.

The production of corn varies widely causing, in turn, wide variations in price. Figure 2 shows the production-price relationship for corn from 1930 through 1940 (see Table 3).^{5/}

It will be observed that in years in which production was comparatively low, prices were relatively high, and vice versa; that is, an inverse relationship or correlation existed between production and price. The droughts of 1934 and 1936 stand out clearly with relatively high corn prices; also the very large production of 1932 is reflected by extremely low prices for that year. The correlation coefficient is a significant $-.918$ indicating about 85 per cent of variation between the two series of data (coefficient of determination

^{5/}It will be noted that the December estimate of the corn crop is used here and not the revised figure. Obviously, the production factor can be no more accurate in its price effect than the accuracy of opinion regarding it.

or the percentage of covariation taken as equal to the square of the correlation coefficient).

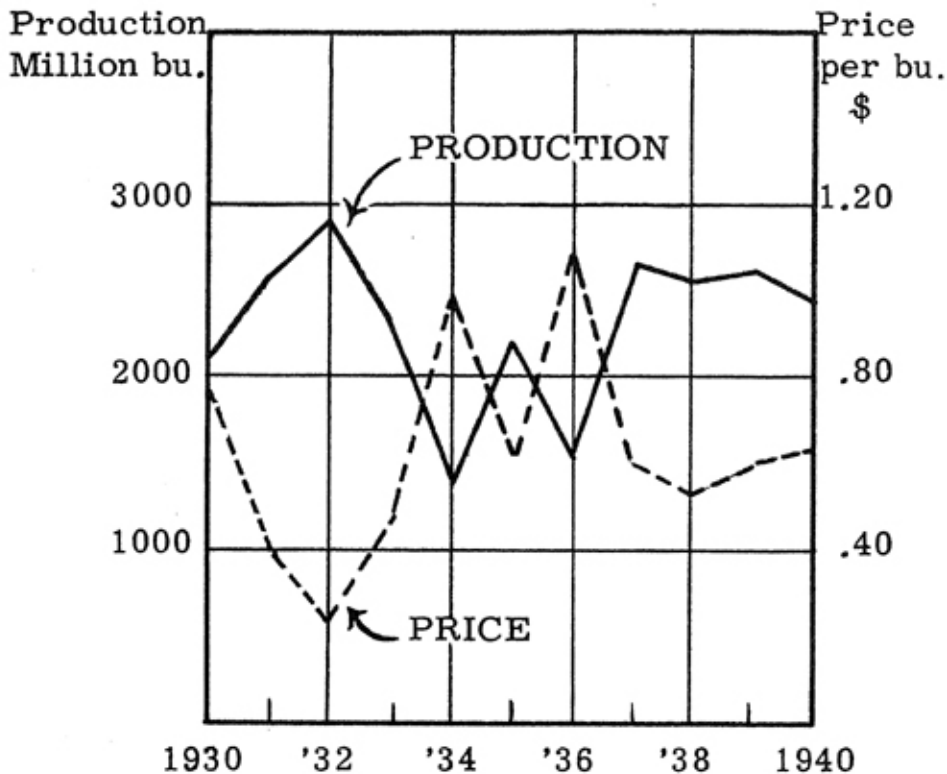


Fig. 2—December Estimate of United States Corn Crop and December Price of Contract Corn (spot) at Chicago, 1930-1940.

Over the years 1930 - 1940 the average production was 2295 million bushels, and the average price 63 cents. On the average, when the United States production of corn was 10 per cent above this figure, the price of corn at Chicago was 17.7 per cent below the average. Conversely, when production was 10 per cent below normal, the price was 17.7 per cent above normal.

In summary, changes in the price of corn from year to year are fundamentally attributable to variations in corn production. A change in corn supplies causes a more than proportionate change in the opposite direction of corn prices. Yearly changes in production, in turn, are traceable primarily to changes in yield per acre, due to fluctuations in weather.

B. Changes in Demand. - Table 4 shows the degree to which changes in the price of corn are associated with changes in the all-commodity price level ($r = +.731$). Evidently, the price of corn fluctuates much more violently than the price level, due partly to the sensitivity of corn prices to the forces making for price level changes and in part to the wide variations in crop production. During the period 1930 through 1940, the annual fluctuations in the in-

dex of the price of corn averaged 45.1 points compared to an average annual change of 6.4 points in the price level.

TABLE 3. - December Estimate of the United States Corn Crop and Average Price of Contract Corn (Spot) at Chicago, in December, 1920 - 1948.

Year	December Estimate of Corn Crop (1,000 bu.)	Average December Price of Corn (cents)
1920	3,232,367	78.1
1921	3,080,372	49.1
1922	2,890,712	73.5
1923	3,054,395	78.4
1924	2,436,513	124.3
1925	2,900,581	81.0
1926	2,645,031	74.5
1927	2,786,288	88.5
1928	2,839,959	86.0
1929	2,622,189	92.3
1930	2,081,048	74.9
1931	2,556,863	39.0
1932	2,908,045	24.3
1933	2,330,237	47.3
1934	1,380,718	100.0
1935	2,202,852	61.0
1936	1,524,317	110.6
1937	2,644,995	58.6
1938	2,542,238	52.5
1939	2,619,137	60.0
1940	2,449,200	62.5
1946	3,287,927	137.8
1947	2,400,952	262.9
1948	3,650,548	146.0

Source: "Crops and Markets", USDA.
"Statistics", Chicago Board of Trade.

In the following, the net and gross influence of production and general demand upon price shall be determined by means of graphic correlation. For this purpose, two diagrams are made, one to show the influence of demand on price, and the other to show the influence of demand on price after the effect of production has been discounted. Finally, a third diagram is prepared to compare the actual price with the "calculated" price taking into account the combined effect of production and demand.

Figure 3 gives the result (Table 5). Section A exhibits the influence of the size of the crop upon price, with corn prices plotted on the vertical axis and corn production on the horizontal. In the

absence of any reason for using a curved line, a straight line is drawn in, computed by the method of least squares, showing the

TABLE 4. - Year-to-Year Changes in the Price of Corn and the All-Commodity Price Level, December. Index, 1930 - 1940 = 100.

Year	Price of Corn		Price Level	
	December Index	Year-to-year Change	December Index	Year-to-year Change
1930	119.3		104.1	
1931	62.1	-57.2	89.7	-14.4
1932	38.7	-23.4	81.8	- 7.9
1933	75.3	+36.6	92.5	+10.7
1934	159.3	+84.0	100.5	+ 8.0
1935	97.1	-62.2	105.8	+ 5.3
1936	176.1	+79.0	110.1	+ 4.3
1937	93.3	-82.8	106.8	- 3.3
1938	83.6	- 9.7	100.7	- 6.1
1939	95.6	+12.0	103.5	+ 2.8
1940	99.5	+ 3.9	104.6	+ 1.1
1930-40 Av.	100.0	+45.1	100.0	+ 6.4

average relation between production and price. The degree of the relationship is indicated by the closeness with which the dots lie

TABLE 5. - United States Production of Corn.
Bureau of Labor Statistics Index of All-Commodity Prices, Actual and Calculated December Prices of Corn at Chicago, 1930 - 1940.

Year	December Estimate United States Corn Crop (million bu.)	B. L. S. Index All-Commodity Prices, Dec. 1926 = 100 (Index)	Dec. Price Of Corn At Chicago	
			Actual (cents)	Calculated (cents)
1930	2,081	79.6	74.9	76.4
1931	2,557	68.6	39.0	42.0
1932	2,908	62.6	24.3	18.8
1933	2,330	70.8	47.3	55.2
1934	1,381	76.9	100.0	107.5
1935	2,203	80.9	61.0	71.8
1936	1,524	84.2	110.6	108.1
1937	2,645	81.7	58.6	51.2
1938	2,542	77.0	52.5	51.4
1939	2,619	79.2	60.0	49.9
1940	2,449	80.0	62.5	58.9

Source: "Crops and Markets", USDA.
"Statistics", Chicago Board of Trade.
U.S. Dept. of Labor, Bureau of Labor Statistics.

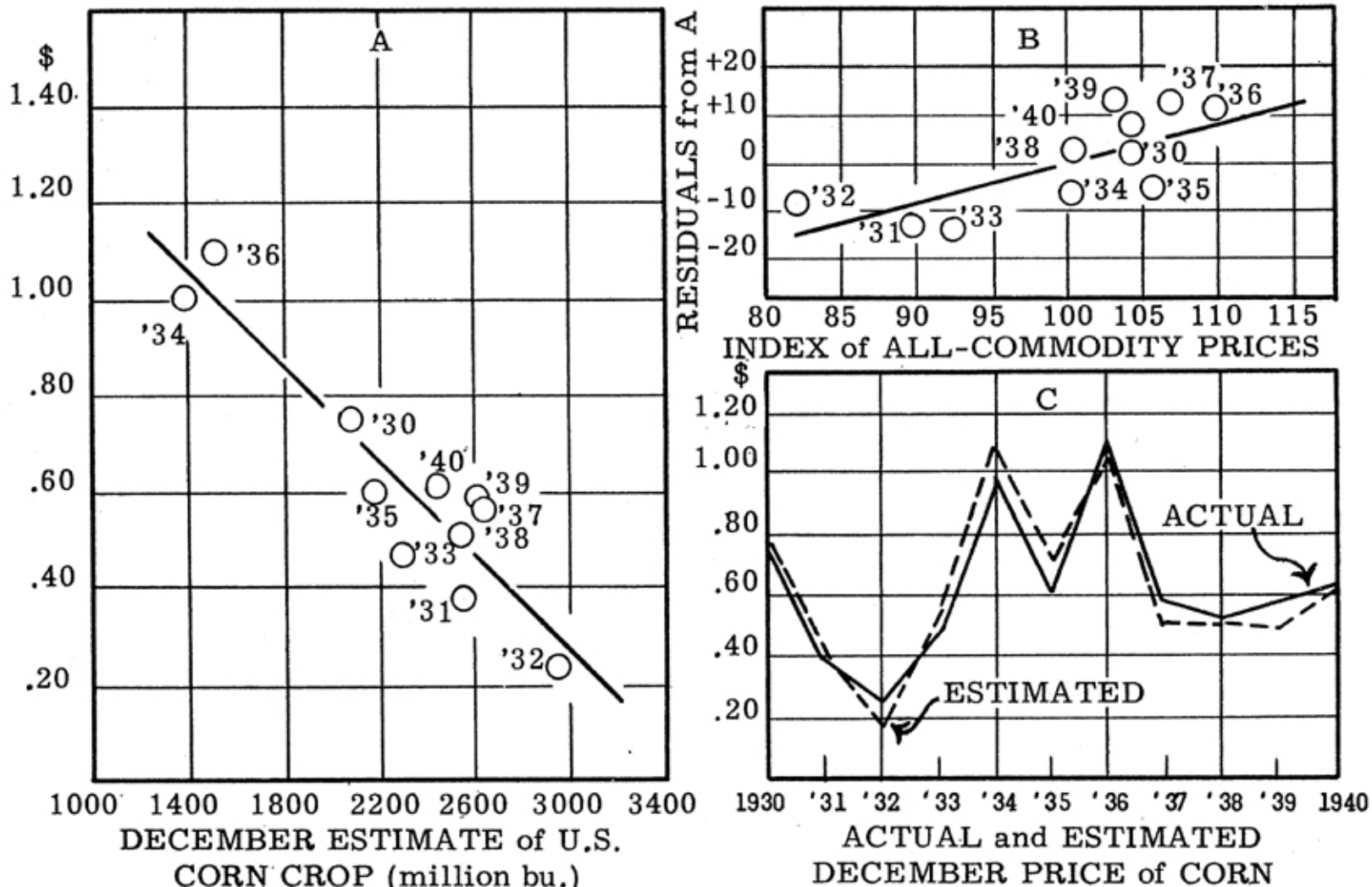


Fig. 3—Influence of the Size of the United States Corn Crop and the All-Commodity Price Level Upon the Price of Corn at Chicago, 1930-1940.

along this regression line. The rather narrow grouping of the dots around the line indicates that changes in the size of the crop predominantly explain changes in price ($r = -.918$). The explanation is not complete, however, for the dots do not exactly fall on the regression line. Evidently, after the influence of changes in crop size has been taken into account, a certain amount of residual fluctuation in corn prices still has to be explained. Having eliminated most of the influence of production, the residual fluctuations can be expected to be largely the result of the influence of demand.

In order to determine the influence of general demand upon the price fluctuations not accounted for by changes in production, the residuals of Section A (equal to the vertical deviations of the dots from the regression line in Section A) are plotted against the Bureau of Labor Statistics index of all-commodity prices in December (1930 - 40 = 100).^{6/} This is shown in Section B. The scatter-diagram reveals a definite relation of the residuals from the regression in Section A to the level of all-commodity prices. The positive relationship between the two variables indicates the tendency of the level of corn prices to follow the trend in all-commodity prices.

To determine the degree to which changes in production and general demand explain annual price variations, the price for each year is calculated from the regression lines in Section A and B and the values of the independent factors (production and general demand) for the respective years. The result is shown in Section C of Figure 3. It will be noted that the estimated and actual prices correspond very closely which is an evidence of the completeness with which changes in corn prices were explained by these influences. The correlation coefficient for estimated and actual prices is $+0.973$ indicating about 95 per cent of covariation.

To summarize, the price of corn in December is determined chiefly by the size of the corn crop and the general demand as reflected by the level of all prices. For the years 1930 through 1940, these two factors combined accounted for 95 per cent of the annual price changes, r being $+0.973$. As a cause of annual price changes, the price level influence definitely ranks second to that of production.

IV. RELATION OF CURRENT CROP FORECASTS TO PRICE

In the following, the relationship between current crop forecasts and the December price of corn shall be determined.

Official forecasts of corn crop production (during the growing season) are issued each month from July until November by the Crop

⁶The use of other measures reflecting changes in general demand is suggested, e.g., index of industrial production, prices of all farm commodities, non-agricultural income.

TABLE 6. - Comparison of Forecasts and Estimates, United States Production of all
Corn, 1930 - 1940.

Year	July 1 Forecast (Thous. bu.)	August 1 Forecast (Thous. bu.)	September 1 Forecast (Thous. bu.)	October 1 Forecast (Thous. bu.)	November 1 Forecast (Thous. bu.)	December Estimate (Thous. bu.)	Revision After Census (Thous. bu.)
1930	2,802,442	2,211,823	1,982,765	2,046,716	2,094,481	2,081,048	2,080,130
1931	2,967,953	2,775,301	2,715,357	2,702,752	2,674,369	2,556,863	2,575,927
1932	2,995,850	2,819,794	2,854,307	2,884,682	2,920,689	2,908,045	2,930,352
1933	2,384,032	2,273,019	2,284,799	2,291,398	2,289,544	2,330,237	2,397,593
1934	2,113,137	1,607,108	1,484,602	1,416,772	1,371,527	1,380,718	1,448,920
1935	2,044,601	2,272,147	2,183,755	2,213,319	2,211,268	2,202,852	2,299,363
1936	2,244,834	1,439,135	1,458,295	1,509,362	1,526,627	1,524,317	1,505,689
1937	2,571,851	2,658,748	2,549,281	2,561,936	2,651,393	2,644,995	2,642,978
1938	2,482,102	2,566,221	2,454,526	2,459,316	2,480,958	2,542,238	2,548,753
1939	2,570,795	2,459,888	2,523,092	2,532,417	2,591,063	2,619,137	2,580,985
1940	2,415,998	2,248,246	2,297,186	2,352,185	2,433,523	2,449,200	2,457,146

Source: "Crops and Markets", USDA.
(Current data in: "Crop Production", USDA.)

Reporting Service of the United States Department of Agriculture.^{7/} These reports are made as of the first and released on or about the tenth of each month. In December an end-of-the-season survey is made based on harvesting returns. Generally, these December estimates are later revised on the basis of subsequent information and Census reports.

Table 6 shows a comparison of the official forecasts and estimates of the United States production of corn. Obviously, the crop forecast for a certain month may be above or below the preceding estimate, depending on the progress made during the month just past. The extent to which crop production can be predicted is definitely limited, but the reported condition of the crop serves as a fairly adequate basis for such a forecast. Naturally, the late-season forecasts are usually more accurate than are early-season forecasts. The accuracy of crop forecasts made early in the season must therefore necessarily be judged by the crop prospects at that time rather than by the harvest 3 or 4 months later--the main part of the corn in the United States being planted in May and June and harvested in October and November. Losses during the growing season may result from a severe drought such as occurred in July, 1934, and 1936. On the other hand, presence of unusually favorable growing conditions may add several hundred thousand bushels to the corn crop. Such influences on crop production cannot be foreseen. However, the nearest approach to accuracy attainable is the goal of the Crop Reporting Service and improved methods of forecasting are employed as they are developed. During the last few years, studies of the relation of weather to yields and other objective methods have served to supplement the condition reports as a basis for making forecasts of crop production. These studies have increased the accuracy of the forecasts materially.

The relationships of the forecasts and estimates of the United States corn crop, July through December, to the December price of corn at Chicago is shown in the form of scatter-diagram in Figure 4. Quantities are plotted against corresponding prices and their average relationships represented by a straight line (line of estimate) computed by the method of least squares.

The purpose of this demonstration is the following: Since the price in the delivery month (in this study the December price) is

⁷Estimates of the probable production of a crop made prior to harvest are called "forecasts" of crop production as distinguished from "estimates" made at harvest time or later. The problem of forecasting the December price of corn considered in this bulletin may be divided into two phases--forecasting the production of corn and estimating the price of corn on the basis of these crop forecasts. The second phase is discussed here.

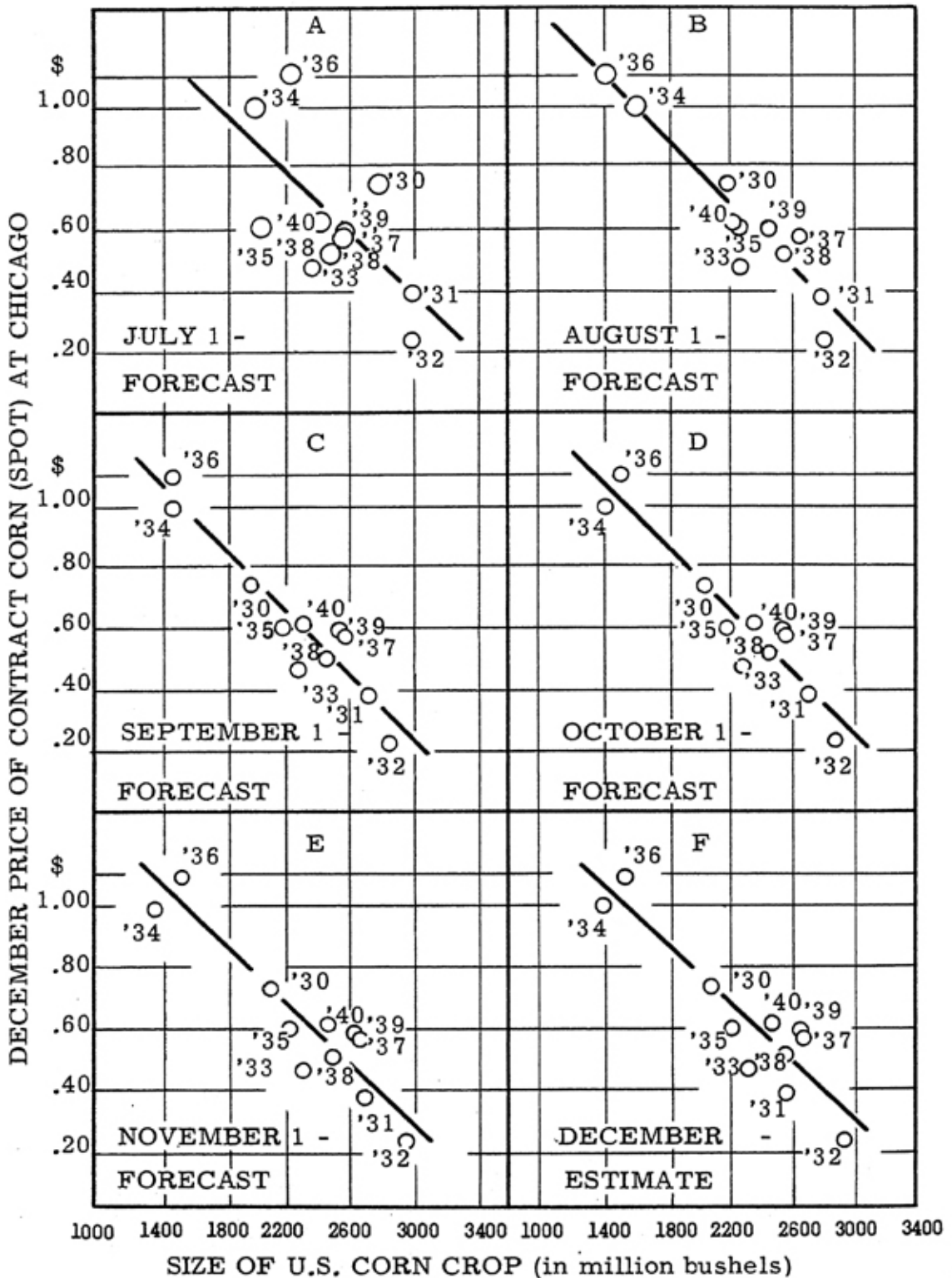


Fig. 4—Regression of the December Price of Corn at Chicago Upon the Forecasts and Estimates of the United States Corn Crop, 1930-1940.

the mark at which the traders are aiming, it is of importance (1) to determine the specific relationships between the forecasts of the production of corn and the actual December price and thereby (2) to ascertain how early in the season it is feasible to make forecasts of the December price on the basis of these crop forecasts. Generally, the relation between crop forecast and December price can be expected to improve as the delivery month is approached. On the other hand, it is desirable to make the price forecast as early in the season as possible.

A. Relation of the July 1 Forecast to the December Price. - Figure 4A shows the relationship between the December price of corn at Chicago and the July 1 forecast of the United States corn crop, the first official forecast of production during the growing season. There is a considerable amount of scatter about the line of average relationship. Unusual weather conditions in a number of years, particularly the drought years of 1934 and 1936, are chiefly responsible for this wide variation.

Since the size of the corn crop has far more to do with corn prices than any other factor,^{8/} it is important to consider the weather in its relation to the size of the crop.^{9/} In the typical season, the outstanding features of the weather influencing the size of the new crop and the price of corn are the weather conditions (particularly rainfall and temperature) in July and early August.

The July 1 forecast, therefore, is based on the condition of the corn crop prior to the "critical period" in the growing season. This results in a relatively poor relationship between the July 1 crop forecast and the December crop estimate, on the one hand, and between the July 1 crop report and the December price ($r = -.642$), on the other. Consequently, the July 1 forecast of the United States corn crop appears to be of little value as a basis of forecasting the December price of corn at Chicago.

B. Relation of the August 1 Forecast to the December Price. - Favorable weather conditions are more important in the production of a good corn crop during July than in any other month. As a result, the August 1 forecast of the corn crop normally is much more reliable than the July 1 report. It is reasonable to expect, therefore, that the average relationship between the August 1 crop fore-

⁸ See Wallace, H. A., "Weather and Corn Prices," Corn and Corn Growing, John Wiley, New York, 1947, pp. 336-337, 372-379.

⁹ See e.g., David, F. E., and Harrell, G. D., Relation of Weather and Its Distribution to Corn Yields, USDA, Tech. Bul. 806, February, 1941.

Jenkins, M. T., Influence of Climate and Weather on Growth of Corn, Climate and Man, USDA Yearbook, 1941, pp. 308-320.

cast and the December price will be much closer than the average relationship between the July 1 forecast and the December price.

Figure 4B shows the regression of the December price of corn at Chicago upon the August 1 forecast of the United States corn crop.

During the years from 1930 to 1940, inclusive, the August 1 forecast more nearly indicated the true size of the corn crop at harvest in eight out of the eleven years than the July 1 forecast and the average deviation between crop forecast and the December estimate declined materially from 282 million bushels in the July forecast to 116 million bushels in the August forecast. Due to the considerably improved accuracy of the August 1 forecast, compared with the July 1 forecast, the coefficient of correlation between the August 1 crop forecast and the December price is a significant $-.937$, against $-.642$ in July.

C. Relation of the September 1 Forecast to the December Price. - After August 20, the weather usually has very little significance. For this reason the September 1 forecast of the corn crop generally comes rather close to the final estimate. In fact, in no year was the margin of error between the September 1 figure and the December estimate in excess of 8 per cent, or about 170 million bushels.

A comparison of the August 1 and the September 1 forecast of the corn crop shows that the September 1 forecast more nearly indicated the size of the crop in 9 out of 11 years than the August 1 forecast and the average deviation declined from 116 to 89 million bushels.

Figure 4C shows the relation of the September forecast of the United States corn crop to the December price of corn at Chicago. There is a high degree of correlation, the coefficient being $-.951$.

D. Relation of the October 1 Forecast to the December Price. It is only rarely that frost in October causes any widespread damage to corn. As a rule, most corn is sufficiently matured to withstand frost damage several weeks before killing frost actually comes. Hence the October 1 forecast in the past generally indicated the size of the corn crop rather accurately. Over the period of observation, the deviations of the October 1 forecast from the December estimate exceeded 4 per cent in only one year (1931), the average deviation being 59 million bushels. Figure 4D shows the regression of the December price of corn at Chicago upon the October 1 forecast of the United States corn crop. The correlation coefficient is almost the same as that of September ($r = -.947$, against $-.951$ in September). In other words, there is no significant change from the previous month.

E. Relation of the November 1 Forecast to the December Price. - Figure 4E shows the relation of the November 1 forecast of the United States corn crop to the December price of corn at Chicago. The picture is essentially the same as for the previous month. The correlation coefficient between price and the November 1 crop forecast is $-.925$, compared to $-.947$ in October.

Summary

The above presentation of scatter-diagrams indicates that as the growing season progresses the relation of the forecasts of the corn crop to the December price of corn becomes more clearly defined. The highest correlation is reached in September, the coefficient for this month being $-.951$. In the succeeding months, the correlation coefficients decline gradually, but not significantly.^{10/}

A time chart covering the period 1930 through 1940 could now be constructed in which the December prices estimated from the regression lines for the various months are plotted along with the actual prices. Such a comparison, however, would show nothing about the amount of the difference between the estimated and actual prices that is not already shown in Figure 4. Since the price estimates would be based on the regression lines derived from the crop forecasts and the actual December prices, the same correlation--except for sign--can be expected between the actual and estimated prices, as exists between crop forecasts and actual prices. That is, the accuracy of the estimate of December prices depends upon the degree of relationship between crop forecasts and actual December prices; therefore, the deviation of the estimated prices from the actual December prices will be the same as the scatter of the dots about the regression lines.

TABLE 7. - Coefficients of Correlation Between the Forecasts and Estimates of the United States Corn Crop and the Actual December Price of Corn at Chicago, 1930 - 1940.

July 1 Crop Forecast	r = $-.642$
August 1 Crop Forecast.	r = $-.937$
September 1 Crop Forecast	r = $-.951$
October 1 Crop Forecast.	r = $-.947$
November 1 Crop Forecast	r = $-.925$
December Crop Estimate.	r = $-.918$

Table 7 shows a comparison of the various correlation coefficients. Evidently, with the exception of the July 1 forecast, the re-

¹⁰The decline in the correlation coefficients following September seems to indicate that the price in December is largely established with the September forecast of the corn crop, inasmuch as later revisions of the crop forecast are usually of minor importance.

lation of the several crop reports to the December price is sufficiently high to provide a reasonable basis from which to estimate December prices.

V. FORECASTING THE DECEMBER PRICE OF CORN FOUR MONTHS IN ADVANCE

In the following, the technique of forecasting the December price of corn on the basis of current crop reports shall be investigated. The August 1 crop forecast will serve as an example in this demonstration.

Obviously, the only way to test our forecasting method is to assume that we are back, say, in 1932 and that in August of that and each succeeding year through 1940, forecasts of the December price shall be made on the basis of the information available at the time of the forecast.

The first step is to estimate the influence of general demand. As shown previously (Section III, B), the trend in corn prices tends to follow rather closely the trend of all-commodity prices. A method must, therefore, be devised to allow for changes in the price level. One way of doing this is to base our calculations on corrected values (prices "deflated" by the price level index) and subsequently to adjust ("inflate") estimated prices to compensate for current price levels.

The practice of deflating prices has the shortcoming that it does not make allowance for the disparity in the rates at which corn prices and all-commodity prices rise or fall (compare Table 4).^{11/} However, until the extent to which changes in general demand affect corn prices can be more accurately estimated, this procedure is probably the best.

Due to the lag between the period covered and the release of the data, the July price level index is used in adjusting calculated values. In the absence of reliable forecasts of price level changes,^{12/} the accuracy of the adjustment must rest on the assumption that the price level will not change materially during the next four months.

¹¹See Shepherd, G. S., Agricultural Price Analysis, The Iowa State College Press, Ames, Iowa, 1941, pp. 252-282.

¹²See Graue, Erwin, Forecasts of General Price Level, The American Economic Review, Vol. XXIV, No. 2, June, 1934, pp. 250-265.
Dewey, E. R., and Dakin, E. F., Cycles, The Science of Prediction, Henry Holt and Co., New York, 1947.

Nourse, E. T., The Timing of Price Changes, Chap. X in Price Making in a Democracy, The Brookings Institution, Washington, 1944.

Pettee, E. W., Long-Term Commodity Price Forecasting, 1850-1930, The Journal of Business of the University of Chicago, Vol. IX, Nos. 2, 3, 4, April, July, October, 1936.

This approach is entirely in line with current theory. Thus, discussing the problem of forecasting of price of agricultural commodities (after the crop is harvested), E. C. Bratt¹³ states:

"... Although the principal factors determining price are known at harvest, one that is not known is business-cycle changes. Our forecasts of the business cycle are rather poor, and therefore any effect which changes in business conditions may have on the demand for the product is largely unknown. For most products, the changes in business conditions are adequately shown, for this purpose, by the changes in the general average of wholesale prices. . . . Except in case of the most unusually rapid changes in cyclical conditions, the change in general wholesale prices will be relatively slight in the period of a few months. Therefore, our inability to forecast business-cycle changes does not prevent us from forecasting the price of agricultural commodities satisfactorily at most times. . . ."

The next step is to forecast the influence of supply. As shown previously (Section III, A), price fluctuates widely from year to year in response to new estimates of production. In order to determine the effect of the size of crop upon the price which is likely to prevail in December, the paired price-quantity figures for 1930 and 1931¹⁴ are plotted in a diagram and a line is fitted to the resulting points. The probable December price for 1932, as derived from the August 1 crop forecast of that year, is then indicated by the point on the price axis which the forecast will locate when the regression line is used.

By the same method, the forecast of price for the following year, 1933, is based on the price-supply relation from 1930 to 1932, inclusive. This process is continued, that is, new observations are added as time progresses and each forecast is made according to the average relationship prevailing during the years prior to the time of the forecast. Thus, the price forecast for 1940 is based on the relationship prevailing over the 10-year period from 1930 to 1939, inclusive.

Table 8 shows how the forecast is derived, and Figure 5 demonstrates how closely forecasted prices compare with the actual when this method is applied. It will be seen that for all years except one (1938) the directional movement of estimated and actual prices is the same. The average deviation between actual and forecasted prices over the 9 years from 1932 through 1940 is 6.3 cents and the correlation coefficient between the two series is +.969.

¹³Bratt, E. C., *The Forecasting of Agricultural-Commodity Prices, Business Cycles and Forecasting*, Richard D. Irwin, Inc., Chicago, 1941, pp. 784-788.

¹⁴For reasons explained in Section VII of this bulletin, the years prior to 1930 are not used in the correlation.

TABLE 8. - Forecast of the December Price of Corn at Chicago Four Months in Advance.

Year	August 1 Crop Forecast	December Crop Estimate	December Price At Chicago	December Price Level	"Deflated" December Price (3) ÷ (4)	Price Calculated From (1) (2) (5)	July Price Level	Adjusted Price Forecast (6) x (7)	Error of Forecast
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	mill. bu.	mill. bu.	cents	Index 1926 = 100	cents	cents	Index 1926 = 100	cents	cents
1930	2,212	2,081	74.9	79.6	94.1	----	---	----	----
1931	2,775	2,557	39.0	68.6	56.9	----	---	----	----
1932	2,820	2,908	24.3	62.6	38.8	36.4	64.5	23.5	- 0.8
1933	2,273	2,330	47.3	70.8	66.8	79.6	68.9	54.8	+ 7.5
1934	1,607	1,381	100.0	76.9	130.0	119.4	74.8	89.3	-10.7
1935	2,272	2,203	61.0	80.9	75.4	76.1	79.4	60.4	- 0.6
1936	1,439	1,524	110.6	84.2	131.4	126.4	80.5	101.8	- 8.8
1937	2,659	2,645	58.6	81.7	71.7	51.1	87.9	44.9	-13.7
1938	2,566	2,542	52.5	77.0	68.2	61.2	78.8	48.2	- 4.3
1939	2,460	2,619	60.0	79.2	75.8	68.5	75.4	51.6	- 8.4
1940*	2,248	2,449	62.5	80.0	78.1	82.7	77.7	64.3	+ 1.8

*War years omitted because of abnormal conditions.

Using the same general technique, the December price may be forecasted on the basis of the September 1, October 1, or November 1 crop forecasts and the corresponding price level figures.

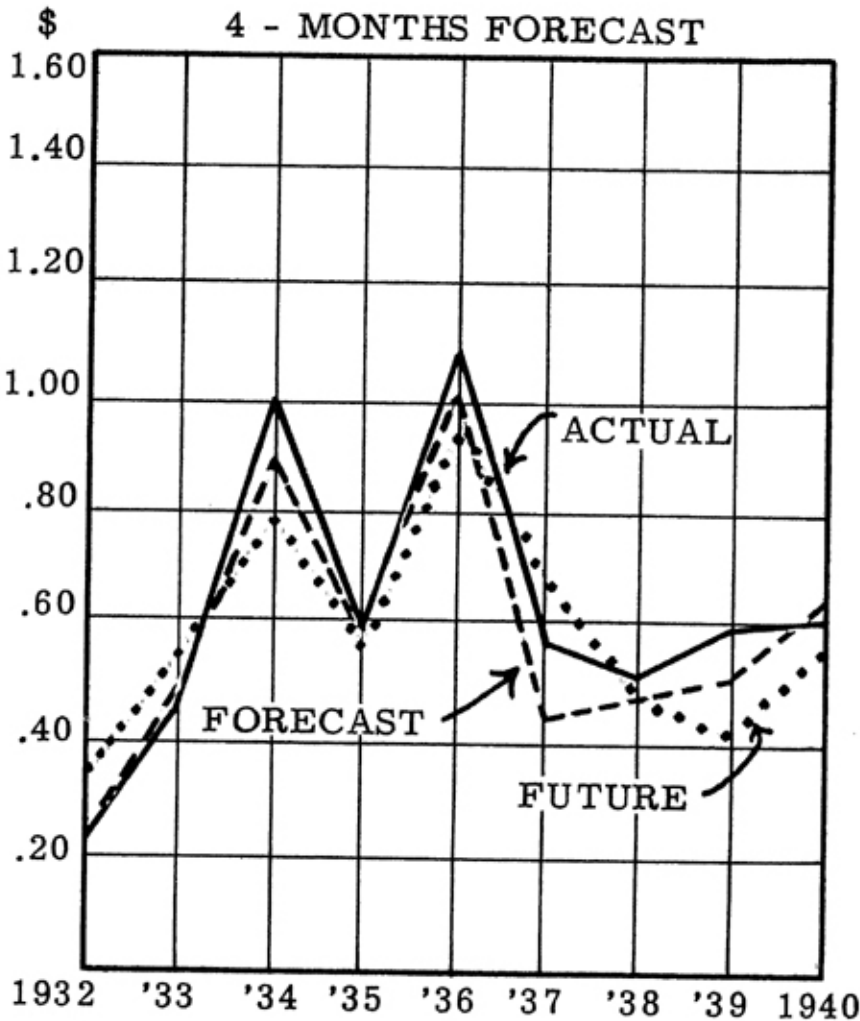


Fig. 5—Comparison of Actual, Forecasted and Futures Prices of Corn at Chicago, 1932-1940.

In spite of the increased accuracy which these later crop reports may provide in estimating price, it is desirable to have forecasts of price as early in the season as possible. This is particularly important in view of the fact that as the delivery date approaches the spread between the price of the commodity in the futures market and the actual December price narrows. Thus, as the season advances, future quotations seem to become better price indicators of actual December prices than the forecasts developed on the basis of crop forecasts and price level. However, since December futures contracts are bought and sold on the basis of the

TABLE 9. - Evaluation of the Forecast of the December Price of Corn at Chicago.

Year	Forecasted December Price of Corn	Price of Corn For December Delivery *	Actual December Price of Corn#	Trading Operation	Gain or Loss Per Bushel In Cents**	
					(5) Gain	Loss
	(1)	(2)	(3)	(4)		
1932	23.5	33.5	24.3	Sell	9.2	----
1933	54.8	55.6	47.3	Sell	8.3	----
1934	89.3	79.6	100.0	Buy	20.4	----
1935	60.4	57.9	61.0	Buy	3.1	----
1936	101.8	94.4	110.6	Buy	16.2	----
1937	44.9	67.1	58.6	Sell	8.5	----
1938	48.2	48.2	52.5	----	---	----
1939	51.6	42.3	60.0	Buy	17.7	----
1940##	64.3	55.9	62.5	Buy	6.6	----
1930-40 Total Net Gain Per Bushel Bought or Sold: 90.0 cents						

*Average of the high and low quotations for the five days following the release of the August 1 forecast.

Average of the high and low prices of Contract corn (spot) at Chicago during December.

**Represents the difference between (2) and (3).

War years omitted because of abnormal conditions.

price quotations of the December future, our forecasts can only be of practical value in deciding whether to buy or to sell, if they forecast actual December prices more accurately than the futures prices.

VI. EVALUATION OF THE FORECAST OF THE DECEMBER PRICE OF CORN

As the price forecasts of this study are quantitative in nature, their effectiveness can be ascertained simply by comparing the relationship between forecasted prices and actual prices to the relationship between futures prices and actual prices.

Figure 5 shows a comparison of actual, forecasted, and futures prices. The Figure shows that forecasted prices are closer to the actual prices in all years except one (1938) in which the forecasted December price and the price of the December future are the same.

In order to determine the practical value of the forecast, the relationship between forecasted prices and price quotations in the futures market is used as a basis for buying and selling futures contracts: futures contracts are bought when futures quotations are below forecasted prices, and contracts are sold when futures prices are above calculated prices.

A tabulation of the success of this price forecasting technique, tested on this basis, is given in Table 9. It will be seen that with an annual trading volume of 100,000 bushels a total net gain of \$90,000 is realized over the nine years from 1932 through 1940, disregarding commission and other charges.

From a practical viewpoint it is fully appreciated that the actual results for a given year are likely to deviate somewhat from the forecast. A more conservative forecast would, therefore, assume a "range of error". Accordingly, if the forecasted price comes very close to the future price in any one year it would not seem advisable to base the future transaction merely on the existence of a slight deviation between forecasted and future price.

In actual practice, of course, many refinements on the technique may be required and allowance made for such factors as carry-over, government purchases, foreign shipments, business conditions, and support prices.

However, the above demonstration may suffice to show that an accurate evaluation of the basic demand-and-supply conditions can be obtained with simple methods which, if properly applied, can furnish an effective standard by which current tendencies can be tested and on which reasoned expectations can be based.

In summary, the technique outlined above furnishes a sound basis for a well-formed judgment regarding prospective price developments. Prices in the grain futures market conform in the long

run closely to fundamental demand-and-supply conditions. However, until changes in basic demand-and-supply conditions are properly discounted in the market, prices may be substantially above or below those justified by the fundamental conditions. Generally, the accuracy of prices of futures contracts as a forecast of prices at date of maturity "varies inversely with the length of the period of maturity, so that prices of futures contracts cannot be relied upon to indicate even fairly accurately the prices that will prevail several weeks in the future."^{15/}

Therefore, a correct and early evaluation of immediate and prospective demand-and-supply conditions offers the trader real opportunities, enabling him to be ahead of the crowd, to turn bearish before the readjustment sets in and to become bullish while markets still afford opportunities for buying at favorable prices.

VII. SHIFTS IN THE PRICE-QUANTITY SCHEDULE

It should be recognized that the price estimates of this study are based on "normal" relationships between the size of the crop and price, with some additional consideration given to changes in general demand. This means that the forecasts are estimations of prices assuming relatively stable levels of economic activity and general prices.

Occasionally, however, the levels of business activity and general prices change suddenly and violently and abnormal conditions arise which may not merely exert an undue influence upon the normal price-quantity relationship but even shift the entire price structure (demand schedule) to new levels.

This fact is seen from an examination of Figure 6 showing corn price-production relationships for the period 1920 through 1948, omitting the war years 1941-45 (Table 3).

Corn prices during the 1930's generally appear on a lower plane relative to production than during the twenty's. The transition year was 1930. From December, 1929, to December, 1930, production and prices simultaneously declined about 20 per cent. Thereafter, the price-production relationship continued on a definitely lower level. It should be noted that this lowering in the level of corn prices is apparent even when corn prices are "corrected" for changes in the price level.^{16/}

¹⁵L. D. Howell, Analysis of Hedging and Other Operations in Grain Futures, USDA, Tech. Bul. 971, August, 1948, p. 58.

See H. Working, Quotations on Commodity Futures as Price Forecasts, Econometrica, Vol. 10, No. 1, January, 1942.

¹⁶See Hoffman, G. W., Grain Prices and the Futures Market, A 15-Year Survey, 1923-1938, USDA Tech. Bul. 747, January, 1941, pp. 18-23. ". . . which suggests that these broader factors (the onset of the depression in 1930 with the lowering of all-commodity prices) should be given greater weight than was accomplished by deflating corn prices," p. 20.

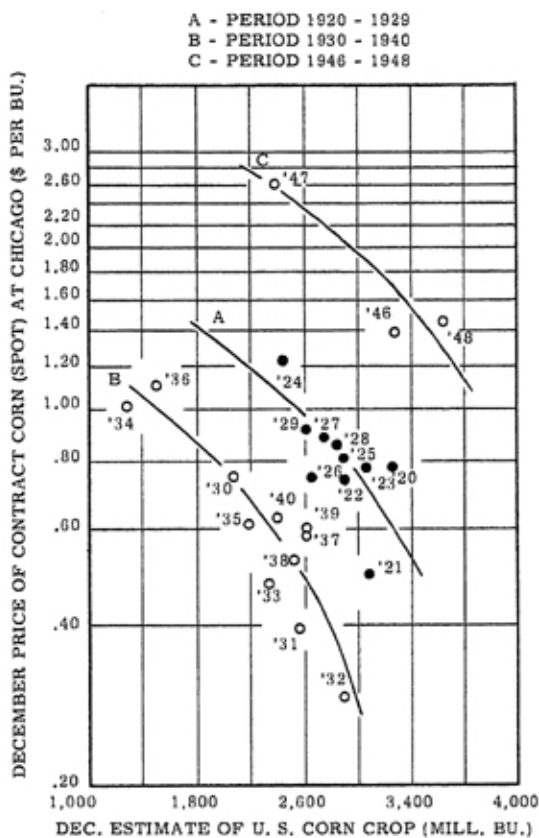


Fig. 6—Regression of the December Price of Corn at Chicago Upon the December Estimate of the United States Corn Crop, 1920-1948.

Regarding the cause of this shift in the level of corn prices, Hoffman (p. 20-23) states:

"It is difficult to evaluate or even enumerate the forces causing this general lowering of corn prices after 1929. Shepherd has shown that for the years 1899-1915 annual corn supplies and prices had a gradual upward trend but that following the war their trend shifted to a definitely lower level.^{17/} This lowering and leveling of the trends in corn production and prices occurred at a time when business activity and the general price level also declined.^{18/} With the onset of the depression in 1930 with lowering all-commodity prices, corn prices again moved to lower levels. . . ."

" . . . The drop in the price of corn suggests a decline in demand for the years beginning 1930. This seems to be borne out

¹⁷Shepherd, G., Annual Fluctuations in the Price of Corn, Iowa Agr. Exp. Sta. Res. Bul. 164, Ames, Iowa, June, 1933.

¹⁸Shepherd, G., Agricultural Price Analysis, p. 242, also noted that "for nearly a decade after World War I--from 1921 to 1929--the general demand for agricultural products was fairly constant. From 1929 on, however, the demand became unstable, shifting down and up with depression and recovery, recession, etc."

by the fact that no larger amounts of the products of grains (mainly meats) were bought in response to lowered prices. . . . Furthermore, wheat fed on farms increased during 1930-33 about 100 million bushels over previous years and to a limited extent this may have contributed to a lower corn-price level. . . . To some extent also foreign tariffs on pork products beginning in 1930 appear to have been a factor. . . ."

During the World War II and the immediate post-war period with rapidly expanding economic activity and sharply rising level of all-commodity prices, corn prices again moved to higher levels. This is shown in Figure 6 by the position of the years from 1946 to 1948, inclusive (Period C).¹⁹ This period is so short, however, that it cannot yet be definitely ascertained whether the new plane of the price-production relationship has been established or whether it is still in a transitional stage. This will be possible as more information becomes available and as the pattern of the post-war economy emerges more clearly.

Shifts in price-supply schedules may arise at any time. It is necessary, therefore, to be alert to those factors which may cause severe or abrupt deviations from the past. Previous experience may be of help in establishing "patterns of reaction". It has been proven that even substantial shifts in trend movements can at times be anticipated in so far as they "cast their shadows before them".

First of all, however, the pattern of past performance must be understood to properly evaluate future trends. Past performance alone is not a sufficient base from which to judge the course of future events. It does, however, represent past experience, and past experience is one of the few factual bases available in forecasting work.

VIII. SUMMARY AND CONCLUSIONS

1. The purpose of this study is to investigate the possibility of forecasting the December price of corn at Chicago on the basis of current forecasts and estimates of the United States corn crop released by the United States Department of Agriculture.

2. Changes in the December price of corn from year to year are fundamentally attributable to variations in corn crop production. A change in crop size causes a more than proportionate change

¹⁹In order to permit a comparison of the slope of the regression lines (demand elasticities), Figure 6 is drawn to a ratio scale. It may be noted that although the level of corn prices has shifted a number of times in the past, the changes in slope have never been significant (Period A, -1.94; Period B, -1.77; Period C, -1.79). It must be realized, however, that the slope of the line of estimate of Period C depends only on one year, 1947, and that more years are needed before a definite conclusion can be drawn.

in the opposite direction of corn prices. Yearly changes in production, in turn, are traceable primarily to variations in yield per acre, due to fluctuations in weather.

3. Changes in the size of the corn crop do not account for all of the fluctuations in price. Normally, the price of corn is influenced by changes in general demand as reflected by changes in the level of all-commodity prices. However, as a cause of annual price changes, the price level influence definitely ranks second to that of production. About four-fifths of the annual price changes can be accounted for by changes in crop production, the correlation coefficient being $-.918$.

4. The size of the crop and the general price level appear to be the primary determinants of price. For the years from 1930 through 1940, the correlation coefficient between actual December prices and prices calculated from these two factors is $+.973$.

5. Official forecasts of corn crop production during the growing season are issued each month from July through November by the Crop Reporting Service of the U. S. Department of Agriculture. The correlation coefficients between these crop forecasts and December prices are the following: July, $-.642$; August, $-.937$; September, $-.951$; October, $-.947$; November, $-.925$. In the light of these figures it appears that, with the exception of the July crop forecast, these crop reports provide adequate bases from which to determine the probable December price.

6. A four-month forecast of the December price of corn at Chicago is made on the basis of the August forecast of the corn crop and the July index of the general level of all-commodity prices. Forecasted and actual prices correspond very closely, and in all years except one their directional movements coincide. The average deviation between forecasted and actual prices is 6.3 cents and the correlation coefficient between the two series is $+.969$.

7. In order to determine the effectiveness of the price forecasts, the relationship between forecasted prices and price quotations in the futures market is used as a basis in buying and selling futures contracts: Contracts are bought when the analysis indicates that future prices are below those justified by the basic demand-and-supply conditions, and contracts are sold when future prices are above indicated prices.

8. A tabulation of the success of market trading on this basis shows that with a trading volume of 100,000 bushels a total net gain of \$90,000 is realized over the nine years from 1932 through 1940, disregarding commission and other charges.

9. It is pointed out that the price forecasts of this study are based on "normal" relationships between the size of the crop and price, with some consideration given to changes in general de-

mand. Occasionally, however, the levels of economic activity and general prices change suddenly and violently and abnormal conditions arise which may not merely exert undue influence upon normal price-quantity relationships but even shift the entire price structure to new levels. Such disruptions constitute the chief limitation to price forecasting.

10. Price forecasting must always be a matter of common-sense judgment, which is materially aided by the knowledge of price-making forces resulting from a quantitative analysis of the factors involved. The present study outlines a method which furnishes concrete, definite expression to such relationships and thus serves as a basis upon which sound and successful price forecasts may be developed.

BIBLIOGRAPHY

- Agricultural Statistics, USDA, Washington, D. C.
- Bean, L. H., The Farmers' Response to Price, Journal of Farm Economics, Vol. XI, No. 3, July, 1929.
- Bratt, Elmer C., Business Cycles and Forecasting, Richard D. Irwin, Inc., Chicago, 1941.
- Climate and Man, 1941 Yearbook of Agriculture, USDA, Washington, D. C.
- Cox, Rex W., Factors Influencing Corn Prices, Minnesota Agr. Exp. Sta. Tech. Bul. 81, September, 1931.
- Davis, Floyd E., and Harrell, George D., Relation of Weather and Its Distribution to Corn Yields, USDA, Tech. Bul. 806, February, 1941.
- Dewey, Edward R., and Dakin, Edwin F., Cycles, The Science of Prediction, Henry Holt, New York, 1947.
- Graue, Erwin, Forecasts of the General Price Level in Retrospect, 1919-1931, The American Economic Review, Vol. XXIV, No. 2, June, 1934.
- Greene, R. M., Batting Averages in Agricultural Forecasting, Journal of Farm Economics, Vol. VIII, No. 2, April, 1926.
- Hartkemeier, Harry P., The Supply Function for Agricultural Commodities, The University of Missouri Studies, Vol. VII, No. 4, October, 1932.
- Hawley, H. L., Corn Prices, M.S.A. Thesis.
- Hoffman, G. Wright, Grain Prices and the Futures Market, A 15-Year Survey, 1923-1938, USDA, Tech. Bul. 747, January, 1941.
- Howell, L. D., Analysis of Hedging and Other Operations in Grain Futures, USDA, Tech. Bul. 971, August, 1948.
- Mills, Frederick C., Statistical Methods, Applied to Economics and Business, Henry Holt and Co., New York.
- Nourse, E. G., The Timing of Price Changes, Price Making in a Democracy, The Brookings Institution, Washington, 1944.
- Pearson, Frank A., and Bennett, Kenneth R., Statistical Methods,

- Applied to Agricultural Economics, John Wiley and Sons, New York, 1942.
- Pettee, E. W., Long-Term Commodity Price Forecasting, 1850 to 1930, The Journal of Business of the University of Chicago, Vol. IX, Nos. 2, 3, 4, April, July, October, 1936.
- Prices of Grain and Grain Futures, Report of the Federal Trade Commission on the Grain Trade, Vol. VI.
- Research on Relationships of Weather to Crop Yields, Papers Relating to Objectives and Progress of Crop-Weather Research, BAE, USDA, 1938.
- Sarle, Charles F., Adequacy and Reliability of Crop-Yield Estimates, USDA, Tech. Bul. 311, June, 1932.
- Schultz, Henry, The Theory and Measurement of Demand, The University of Chicago Press, Chicago, 1938.
- Shepherd, Geoffrey S., Annual Fluctuations in the Price of Corn, Iowa Agr. Exp. Sta. Res. Bul. 164, June, 1933.
- Shepherd, Geoffrey S., Agricultural Price Analysis, Iowa State College, Ames, Iowa, 1941.
- Smith, Bradford B., The Adjustment of Agricultural Production to Demand, Journal of Farm Economics, Vol. VIII, No. 2, April, 1926.
- Statistical Yearbook of the Board of Trade of the City of Chicago, Chicago, Illinois.
- Stine, O. C., Progress in Price Analysis and An Appraisal of Success in Price Forecasting, Journal of Farm Economics, Vol. XI, No. 1, January, 1929.
- The Crop and Livestock Reporting Service of the United States, USDA, Misc. Pub. 171, November, 1933.
- Thomsen, Frederick L., Agricultural Prices, McGraw-Hill Co., New York, 1936.
- USDA, BAE, Bibliography No. 58, Price Studies of the USDA Showing Demand-Price, Supply-Price, and Price-Production Relationships, October, 1935.
- Waite, Warren C., The Effect of a Business Depression on the Demand for Livestock Products and the Outlook for these Products, Journal of Farm Economics, Vol. XIV, No. 2, April, 1932.
- Wallace, Henry A., Forecasting Corn and Hog Prices, Chap. XVII in Persons, Foster, and Hettinger, The Problem of Business Forecasting, 1924.
- Wallace, Henry A., and Bressman, Earl N., Corn and Corn Growing, John Wiley, New York, 1947.
- Warren, G. F., and Pearson, F. A., Interrelationships of Supply and Price, Cornell University, Agr. Exp. Sta. Bul. 466, March, 1928.
- Working, E. J., Indications of Changes in the Demand for Agricultural Products, Journal of Farm Economics, Vol. XIV, No. 2, April, 1932.
- Working, Holbrook, Quotations on Commodity Futures as Price Forecasts, Econometrica, Vol. 10, No. 1, January, 1942.