EFFECTS OF CCC STOCKS ON THE CASH-FUTURE PRICE SPREADS FOR CORN

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Robert N. Wisner

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EFFECTS OF CCC STOCKS ON THE

CASH-FUTURE PRICE SPREADS

FOR CORN

By

Robert N. Wisner

A THESIS

Submitted to
Michigan State University
in partial fulfillment of the requirements
for the degree of

MASTER OF SCIENCE

Department of Agricultural Economics

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Approved Lester V. Manderscheid

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ABSTRACT

EFFECTS OF PRICE-SUPPORT PROGRAMS ON
THE CASH-FUTURE PRICE SPREADS FOR CORN

by Robert N. Wisner

The objectives of this study were (1) to determine whether CCC price-support activities have affected cash-future price spreads for corn through their effects on the commercial supply of corn storage and (2) to obtain predictions of the cash-future spreads with CCC corn stocks as a variable. In the economic framework, cash-future spreads were considered as being determined by the commercial supply and demand for corn storage. Price-support programs might affect the commercial supply of storage through changes in the quantity of unoccupied grain storage space. Effects on the commercial demand for storage were assumed to be through changes in the current and future-supply and demand for corn.

The main variables determining cash-future spreads were believed to be corn consumption, commercial (non-CCC) corn stocks, stocks of other grains, interest cost, the general price level and time. This relationship was studied at four separate dates during the year: January 1, April 1, July 1, and October 1. Regression equations were computed in pairs containing the same variables; one equation was based on the 1927-1962 period and one was based on the 1934-1962 period. The longer period provided seven observations prior to the beginning of

CCC activities; more would have been desirable, but data for earlier years were not available. If CCC activities have affected the commercial supply of corn storage it was believed that the relationships between spreads and the independent variables might be changed for the 1934-1962 period as compared with the longer period. Consequently, significant differences in the corresponding regression coefficients for the two time periods and significant coefficients for CCC stocks might be expected.

Within the limitations of the approach and the data, no evidence was found that CCC activities have affected spreads through their effects on the commercial supply of storage on January 1, April 1, or July 1. However, the October 1 equations provided some evidence that CCC activities may have affected the commercial supply of storage at the beginning of the marketing year. In each of three pairs of equations which were computed for that date, the equation based on the shorter period provided a considerably better fit in terms of R^2, $\bar{R}$ and $S_{y.x}$ than the equation based on the longer period. In addition, for the shorter period, only the coefficients of the variable for CCC stocks were significant at the 10 percent level. Direct statistical tests, however, revealed no significant differences in the corresponding coefficients of October 1 equations for the two periods. This appeared due to the small number of coefficients which were significantly different from zero. Effects of CCC activities on the commercial supply of storage would appear to be through their effects on congestion in marketing firms at harvest time rather than through a tightening up of the supply of unoccupied grain storage space in total.

Predictions of cash-future spreads can be obtained from the equations provided estimates of the independent variables are available. However, the equations appear to be more useful as a framework for determining the effects of changes in the independent variables on the spreads. For January 1, significant relationships were found between spreads and commercial corn stocks, corn consumption, and time. Corn consumption and time were also important variables for April 1 and July 1 equations. An additional variable, stocks of other grains, was important for July 1. In the October 1 equations, the most important variable determining spreads appeared to be CCC corn stocks, although corn consumption was also of some importance.

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TABLE OF CONTENTS

Chapter | Page

I. DEFINING THE PROBLEM 1

The General Approach and Objectives 1
The Characteristics of Corn 3
Price Support Operations for Corn Since 1933 14

II. REVIEW OF LITERATURE RELATED TO THE EFFECTS OF GOVERNMENT PROGRAMS ON THE CASH-FUTURES PRICE SPREAD 25

Descriptive Studies 25
Factors Affecting the Quantity Placed Under Price Support 32
Government Programs and the Cash-Future Price Spreads 34
Summary 36

III. THEORY OF THE CASH-FUTURE PRICE SPREADS 37

Hedging Purposes and Functions 37
The Supply and Demand for Storage 42
The Introduction of a Government Supply and Demand for Storage 49
Hypothesis to be Tested 55

IV. THE METHOD OF ANALYSIS 57

The Approach 57
The Data 60

V. RESULTS OF THE ANALYSIS 71

January 1 Equations 72
April 1 Equations 91
July 1 Equations 103
October 1 Equations 113

VI. SUMMARY AND CONCLUSIONS 126

BIBLIOGRAPHY 136

APPENDIX 140

LIST OF TABLES

Table Page

1. Acreage Harvested and Production of Corn for Grain in U.S., 1927-1962 6

2. Percentage of the Total Corn Crop Acreage Planted With Hybrid Seed 7

3. Percentages of the Total Corn Supply Accounted for by Feed and Other Uses, 1958-1959 9

4. Price Support Program for Corn--1933 Through 1963 16

5. Simple Correlations Between the Variables, Standard Errors, and t Values of the Coefficients of Equation 1-1 73

6. Simple Correlations Between the Variables, Standard Errors, and t Values of the Coefficients of Equation 1-2 76

7. Actual Adjusted December Spreads and Spreads Estimated With Equations 1-1 and 1-2 78

8. Simple Correlations Between the Variables, Standard Errors, and t Values of the Coefficients of Equation 1-3 80

9. Simple Correlations Between the Variables, Standard Errors, and t Values of the Coefficients of Equation 1-4 82

10. Actual Adjusted December Spreads and Spreads Estimated With Equations 1-3 and 1-4 83

11. Standard Errors and t Values of the Coefficients of Equation 1-5 84

12. Standard Errors and t Values of the Coefficients of Equation 1-6 85

13. Actual Adjusted December Spreads and Spreads Estimated With Equations 1-5 and 1-6 86

Table		Page

14. Simple Correlations Between the Variables, Standard Errors, and t Values of the Coefficients of Equation 2-1 92

15. Simple Correlations Between the Variables, Standard Errors, and t Values of the Coefficients of Equation 2-2 93

16. Actual Adjusted March Spreads and Spreads Estimated With Equations 2-1 and 2-2 94

17. Standard Errors and t Values of the Coefficients of Equation 2-3 95

18. Standard Errors and t Values of the Coefficients of Equation 2-4 96

19. Actual Adjusted March Spreads and Spreads Estimated With Equations 2-3 and 2-4 97

20. Simple Correlations Between the Variables, Standard Errors, and t Values of the Coefficients of Equation 2-5 99

21. Simple Correlations Between the Variables, Standard Errors, and t Values of the Coefficients of Equation 2-6 100

22. Actual Adjusted March Spreads and Spreads Estimated With Equations 2-5 and 2-6 101

23. Simple Correlations Between the Variables, Standard Errors, and t Values of the Coefficients of Equation 3-1 104

24. Simple Correlations Between the Variables, Standard Errors, and t Values of the Coefficients of Equation 3-2 105

25. Actual Adjusted June Spreads and Spreads Estimated With Equations 3-1 and 3-2 106

26. Simple Correlations Between the Variables, Standard Errors, and t Values of the Coefficients of Equation 3-3 107

27. Simple Correlations Between the Variables, Standard Errors, and t Values of the Coefficients of Equation 3-4 108

28. Actual Adjusted June Spreads and Spreads Estimated With Equations 3-3 and 3-4 110

Table | Page

29. Simple Correlations Between the Variables, Standard Errors, and t Values of the Coefficients of Equation 4-1 114

30. Simple Correlations Between the Variables, Standard Errors, and t Values of the Coefficients of Equation 4-2 115

31. Actual Adjusted September Spreads and Spreads Estimated With Equations 4-1 and 4-2 116

32. Standard Errors and t Values of the Coefficients of Equation 4-3 117

33. Standard Errors and t Values of the Coefficients of Equation 4-4 118

34. Actual Adjusted September Spreads and Spreads Estimated With Equation 4-3 and 4-4 119

35. Simple Correlations Between the Variables, Standard Errors, and t Values of the Coefficients of Equation 4-5 120

36. Simple Correlations Between the Variables, Standard Errors, and t Values of the Coefficients of Equation 4-6 121

37. Actual Adjusted September Spreads and Spreads Estimated With Equations 4-5 and 4-6 122

LIST OF FIGURES

Figure Page

1. The Supply of Storage 48
2. Equilibrium of the Supply and Demand for Corn in Current and Future Time Periods 49
3. Equilibrium of the Supply and Demand for Storage 49
4. The Government Supply and Demand for Storage 52
5. The Commercial Supply and Demand for Storage 52
6. Variables Determining the Quantity of Commercial Corn Stocks Carried From Period t to Period t+1 56

CHAPTER I

Defining the Problem

During the past 30 years, American agriculture has been characterized by high production and government price-support programs. Government programs to stabilize farm prices evolved from a desire to overcome an inherent weakness of the agricultural economy: the inflexibility of production processes in the short-run. The "Ever Normal Granary" was set up to achieve that objective by storing grain from large crops as a reserve for years of small crops and unforeseen national emergencies. This system was reasonably successful during the 1930's and 1940's. However, from 1953 to 1961 the nature of government price-support programs resulted in a steady increase in government controlled stocks of grain. Doubts were raised as to whether the Commodity Credit Corporation (hereafter referred to as the CCC) would continue grain storage operations of the magnitude obtained in recent years. Then, with the passage of the 1961 Feed Grain Program these doubts were strengthened. In view of possible reductions in government grain storage programs, questions arise as to what would be the impact of such changes on firms in the grain trade.

The General Approach and Objectives

The logical approach to determining the effects of changes in CCC grain storage programs on the grain trade appears to be an examination

of the effects of government storage programs in the past. Such an examination should provide a basis for generalizations about the effects of future changes in government programs. The purpose of this thesis is to examine the effects of government price-support activities since the introduction of the CCC on one aspect of the grain trade: the cash-futures price spreads. The study will be limited to an examination of the cash-futures price spreads for one commodity, corn, at a particular market. The market used, for reasons indicated in Chapter IV, is the Chicago Board of Trade.

The approach used will be to expand upon a concept introduced by Holbrook Working, that the cash-future price spread may be regarded as a return for the creation of time utility, in other words a price of storage.[1] The link between cash and futures prices is stocks. This provides a mechanism by which firms adjust current and future consumption to levels at which the difference between expected future price and current price is equal to the net marginal cost of holding inventories of grain over time. Hence, cash and futures prices are intimately related at all times. Using this theoretical construct, it should be possible to postulate certain effects of government programs on the supply and demand for corn storage, and to obtain quantitative estimates of the magnitude of these effects by statistical analysis.

During the operation of the CCC, vast changes have been taking place in corn production and utilization; consequently the study will begin with an examination of the characteristics of corn and changes

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[1] Holbrook Working, "The Theory of the Price of Storage," <u>American Economic Review</u>, Vol. XXXIX, December, 1949, pp. 1954-62.

which have occurred in the supply and demand for corn in the United States during the period studied. This will be followed by a review of CCC corn price-support operations since 1933. After a brief summary of studies related to the effects of government programs on the cash-future price spreads for corn, the theoretical relationship between cash and futures prices will be presented in detail. This will provide a connection between the supply and demand functions for corn and the supply and demand functions for corn storage. The theory will then be expanded to include a governmental supply and demand sector for storage and the interrelationships between the governmental and non-governmental storage sectors. A statistical analysis will be attempted for the purpose of separating the effects of various factors influencing the cash-futures price spreads for corn.

Specifically, the objectives of the study are:

1. To determine whether or not CCC activities have affected the relationship of cash-future price spreads for corn with commercial corn stocks, corn consumption, and stocks of other grains.

2. To determine the effects of changes in CCC corn stocks on the cash-future price spreads.

The Characteristics of Corn[2]

Corn is the most important single crop grown in the United States. Its value is closely related to the supply and demand for livestock. The 1959 corn crop was worth 4.5 billion dollars, whereas the next most

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[2]Unless otherwise indicated, this section is based on Richard J. Foote, John W. Klein, and Malcolm Clough, The Demand and Price Structure for Corn and Total Feed Concentrates, U.S.D.A. Technical Bulletin No. 1061, October 1952.

valuable crop, wheat, was worth 2 billion dollars.[3] In this section, factors determining the supply and demand for corn, and hence its value, will be described.

Factors Affecting the Supply of Corn.--In the United States, most of the corn is planted during April and May and matures in September and October. It is harvested during late fall and early winter and either moves directly into marketing channels or into storage. Production is largely concentrated in the "Corn Belt States" of Iowa, Illinois, Indiana, and parts of Ohio, Wisconsin, Missouri, Kansas, Nebraska, South Dakota, and Minnesota. This group produces around two-thirds of the total United States output.

Corn production in 1950 accounted for about 48 percent of the total supply of feed concentrates, oats accounted for 13 percent, barley and sorghum grains about 8 percent, by-product feeds fed 12 percent, domestic wheat, rye, and imported grains fed 2 percent, and stocks 1 percent. In 1960, corn production made up 42 percent of the total supply of feed concentrates.[4] During 1926-1945, stocks of the four feed grains, in percentage terms, were about twice as variable as production and exports were about three times as variable. On a tonnage basis, changes in stocks accounted for more than 80 percent of the difference between changes in production and consumption, and net exports accounted for about 20 percent. Imports are relatively unimportant;

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[3]Figures are from U.S.D.A., Agricultural Statistics, 1960, pp. 1, 29. They are obtained by multiplying total production of the crop by the season average price per bushel.

[4]U.S.D.A., E.R.S., Grain and Feed Statistics through 1961, Supplement for 1961 to Statistical Bulletin No. 159, p. 5.

they normally represent less than 1 percent of the domestic production. A notable exception was the drought year of 1936 when imports equaled 7 percent of domestic production.

From 1909 to 1933, harvested acreage of corn was relatively constant. However, since the near-record of more than 97 million acres was harvested for grain in 1932, acreage has declined. It has not exceeded 90 million acres since 1933, and since 1945 it has been below 79 million acres. During the post-war period, acreage of corn harvested for grain reached a low of 57 million acres in 1962.[5]

The long-term downward trend in corn acreage has been more than offset by a marked upward trend in yield per acre. The opposite trends in acreage and production are shown in Table 1. A major factor contributing to the increased yield per acre since the early 1930's has been the marked increase in the use of hybrid seed. By 1950 practically all corn in the corn belt was planted with hybrid seed. As shown in Table 2, 95.7 percent of the total corn crop acreage in United States in 1960 was planted with hybrid seed. Other elements have contributed greatly to higher yields and the expanded production of corn. Fertilizer and the use of power machinery in corn production have expanded markedly. The declining acreage also has been accompanied by a general withdrawal of lower producing land from corn production. In addition, weather conditions have been more favorable for corn production in recent years than during the 1930's.

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[5]U.S.D.A., E.R.S., Grain and Feed Statistics Through 1961, Supplement for 1961 to Statistical Bulletin No. 159, p. 7, and U.S.D.A., A.M.S., Feed Situation, August 1963, p. 42.

TABLE 1.--Acreage Harvested and Production of Corn for Grain in U. S., 1927 - 1962*

Year	Million Acres	Production, 1000 Bushels	Year	Million Acres	Production, 1000 Bushels	Year	Million Acres	Production, 1000 Bushels
1927	98	2,218,189	1939	78	2,341,602	1951	71	2,628,937
1928	100	2,260,990	1940	76	2,206,882	1952	71	2,980,793
1929	83	2,135,038	1941	77	2,414,445	1953	71	2,881,801
1930	86	1,757,297	1942	79	2,801,819	1954	69	2,707,913
1931	91	2,229,903	1943	82	2,688,490	1955	68	2,872,959
1932	97	2,578,685	1944	85	2,801,612	1956	65	3,075,336
1933	92	2,104,725	1945	78	2,577,449	1957	63	3,045,355
1934	61	1,146,734	1946	78	2,916,089	1958	64	3,356,205
1935	83	2,001,367	1947	74	2,108,320	1959	72	3,824,598
1936	68	1,258,673	1948	77	3,307,038	1960	72	3,908,070
1937	81	2,349,425	1949	77	2,946,206	1961	58	3,625,530
1938	83	2,300,095	1950	72	2,764,071	1962	57	3,643,615

*U.S.D.A. Grain and Feed Statistics through 1961, Supplement for 1961 to Statistical Bulletin No. 157, pp. 7, 9 and U.S.D.A., A.M.S., Feed Situation, August 1963, p. 42.

TABLE 2.--Percentage of the Total Corn Crop Acreage Planted With Hybrid Seed*

Year	Percent	Year	Percent
1950	78.0	1956	91.1
1951	81.5	1957	92.5
1952	84.6	1958	93.9
1953	86.5	1959	94.9
1954	87.3	1960	95.7
1955	89.4		

*U.S.D.A., Agricultural Statistics, 1960 and 1961.

An indication of the trend in the use of fertilizer for corn production is suggested by fertilizer use in Ohio, Illinois, Minnesota, and Missouri. Four times as much fertilizer was used in these states during 1948 to 1950 as in the late 1930's. In these states plus Indiana, Illinois, and Nebraska, the consumption of the three primary plant nutrients rose an average of 8 percent per year from 1956 to 1960 and 5 percent from 1960 to 1961. Consumption of nitrogen rose 17 percent per year from 1956 to 1960 and 21 percent from 1960 to 1961. Analysis of the 1959 census data shows that 69 percent of the three primary nutrients and 79 percent of the nitrogen fertilizer used in these three states were applied to corn. Total primary plant nutrients applied to corn rose from an estimated 63 pounds per acre in 1960 to 81 pounds in 1961. This was an increase of 18 pounds per acre compared with annual increases averaging less than 2 pounds per acre from 1956 to 1960.[6]

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[6] James Vermeer, An Economic Appraisal of the 1961 Feed Grain Program, Agricultural Economic Report No. 38, U.S.D.A., E.R.S., June 1963, p. 21.

The increase in the number of tractors used in the corn belt has been accompanied by an increased use of larger units of equipment for seedbed preparation, planting, cultivating, and harvesting corn. This mechanization has permitted an increased portion of the supply of feed grains to go into the production of livestock and livestock products for food and a relatively smaller part to go into the maintainance of horses and mules for farm power. Mechanization has also made possible more rapid and timely seedbed preparation and planting, particularly in wet years. It has reduced the time required for harvesting corn, with the result that corn is placed on the market earlier than in the past.

In short, acreage planted to corn has been reduced but increased yields per acre have created an upward trend in corn production. Mechanization, hybrid seed, and higher levels of fertilizer application have been the major factors contributing to the increased production. In addition, they have reduced the time required for harvesting and have tended to place corn on the market earlier than in previous periods.

Factors Affecting the Demand for Corn.--Almost 80 percent of the corn produced in the United States is fed to livestock on or near farms where it is grown. Most of the remainder enters the so-called commercial supply. Of the commercially sold corn, more than half is sold directly as grain for feed or is used in mixed feeds. Thus, in total, about 90 percent of the corn produced is used for livestock feed. The remainder of the commercial supply is used for wet milling (cornstarch, sirup, sugar, and oil), for dry milling (corn meal, grits, hominy, and breakfast foods), for alcohol and distilled spirits, and for exports. These corn processing industries provide the major sources of by-product feeds fed to livestock, including gluten feed and meal, and distillers dried grains. The percentages of the corn supply accounted for by various uses in 1958-1959 are shown in Table 3. Of the non-feed uses, exports have been most variable, ranging from less than 1 percent of the total in many years to as much as 4 or 5 percent in a few years.

TABLE 3.--Percentages of the Total Corn Supply Accounted for by Feed and Other Uses, 1958-1959*.

Use	Percentage	Use	Percentage
Seed	.4	Export	5.7
Alcohol	.9	Livestock feed	86.2
Food	2.7	Wet milling	4.1

*Geoffrey S. Shepherd, Marketing Farm Products, 4th Edition, The Iowa State University Press; Ames, Iowa, 1962, p. 435. Based on U.S.D.A., Agricultural Statistics, 1960, p. 35.

The dry processing of corn for food is currently only about half as large as at the turn of the century, reflecting a marked drop in percapita consumption of corn meal and other dry-process products. In contrast, the use of corn for producing starch, sugar, sirup, and other wet-process products has more than doubled since 1909. In recent years it has been a major non-feed use of corn. However, as Alfred Marshall has pointed out, the derived demand for a factor of production will be more inelastic the smaller the fraction of total cost accounted for by the factor in question.[7] For this reason, the demand for corn for non-feed purposes is highly inelastic; there is practically no relationship of corn for non-feed uses with its price. Factors connected with the feed-livestock economy are the principal ones that affect the price

[7]Alfred Marshall, Principles of Economics, Eighth Edition, Macmillan and Co.; London, 1920, pp. 385-386.

of corn.

Economic theory tells us that the profit-maximizing farmer will feed corn up to the point at which the marginal value product of an additional unit of corn is equal to the price of the additional unit. Accordingly, it seems useful to briefly examine the factors determining the marginal value product of corn fed to livestock. These include livestock prices, the supply of other feed grains, the supply of protein supplements, and technological relationships in livestock production.

A shift to the right in the supply of other feed grains, assuming all other things remain constant, will reduce their prices. Producers will then substitute larger amounts of other grains for corn; as a result the demand for corn will shift to the left. Year to year changes in the production of other feed grains, however, tend to be associated with changes in corn production. This should be expected since the heavy-producing areas for corn and other feed grains coincide to a considerable extent, thus making weather a common factor. In other words, the supply of corn and the supply of other feed grains tend to move together.

Livestock prices, which are directly related to the marginal value product of corn, are determined by the supply and demand for livestock. Looking first at the supply side, it is obvious that the supply of livestock products is determined by the number of animals fed and the level of feeding. The number of animals fed is in turn related to the demand for livestock. If the demand for livestock products suddenly increases, livestock production and the demand for feed are usually expanded in the short run by increasing the quantity of feed fed per animal. However, changes in livestock numbers are more important than increases in the quantity fed per animal in increasing livestock production and the demand for corn over a period of a year or more. A second factor affecting the number of animal units fed is the availability of feed. Profit-maximizing farmers will feed up to the point at which the cost of producing an extra unit of livestock is equal to the marginal revenue. The supply of feed enters since it affects the cost of producing the additional output.

From these relationships we can see that feed prices and livestock numbers are interrelated. If the number of animal units on farms at any given time is small, higher livestock-feed price ratios (and therefore lower feed prices) are required to move a given supply of feed into consumption than if the number of animal units is large.

Let us turn now to changes in the demand for corn over the years. The increased consumption of livestock products as consumers moved up the income scale has far overshadowed the decrease in consumption of processed corn products. Technological factors would also be of some importance except that they tend to be offsetting. Better breeding and improved feeding practices would improve the efficiency of production and in this way would increase the returns from a given volume of corn fed. However, they would also reduce the quantity of feed required to produce a given output of livestock and hence, would reduce the demand for corn.

Benedict and Stine point out that the demand for corn has been modified over the years by an increase in the production and use of other feed grains such as grain sorghum, oats, and barley, along with the increased use of by-product protein feeds such as cottonseed and soybean meals. These changes also would appear to have been more than offset by the increased demand for livestock products.[8]

In recent years, the demand for prepared animal feeds has been increasing rapidly. Over three times as much grain was processed and manufactured into prepared animal feeds in 1959 as in 1939.[9] The total amount of corn utilized in prepared animal feeds in 1959 was 12.6 million tons.[10] This would indicate that farmers are selling a larger portion of their corn crop than in the past and buying back the increased portion in the form of prepared feed. Although it should not affect the total demand for corn, this trend would tend to increase the total off-farm commercial grain storage requirements.

In addition to the changes in the demand for corn already noted, there has been a pronounced increase in corn consumption during the second half of the marketing year.[11] In the late 1920's, around 70 percent of the corn consumed as grain was consumed during October to March and only about 30 percent was consumed during April to September. The later percentage has gradually increased until in 1956 it was about 40 percent of the total. From 1946 to 1956 much of the increase occurred in the July-September quarter. The decrease in the first half of the marketing year has been principally in the October-December

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[8]Murray R. Benedict and Oscar C. Stine, The Agricultural Commodity Programs - Two Decades of Experience, The Twentieth Century Fund; New York, 1956, p. 186.

[9]Walter G. Heid, Fr., Changing Grain Market Channels, U.S.D.A., E.R.S., Marketing Economics Division, ERS-39, November, 1961, p. ii.

[10]*Ibid*., p. 19.

[11]Malcolm Clough, "Changing Pattern of Corn Disappearance," U.S.D.A., A.M.S., Feed Situation, May 21, 1956, p. 24-27.

quarter. At the present annual rate of domestic consumption, this would mean that, as compared with the late 1920's, about 250 to 275 million bushels of United States corn consumption has been shifted from the first half to the second half of the marketing year.

There are several reasons for this change. A U.S.D.A. publication on seasonal patterns in marketing meat animals reveals that there has been a marked increase in hog marketings in September, October, and November since the 1920's, while marketings during January and February have declined.[12] This has increased corn consumption in the July-September quarter and reduced the quantity fed from the new crop in the October-December quarter. The trend toward year-round fattening of beef cattle also has increased consumption in April to September relative to October through March. In addition, the relatively heavy feeding of dairy cows during the summer has tended to increase corn use during that period.

A pronounced increase in broiler production during the past 20 years also has added to corn consumption during April through September. Commercial broiler production, which was practically nonexistent prior to 1930 has expanded to the present level of over a billion head annually. It is estimated that in recent years broilers are fed about 10 to 15 percent more feed during April through September than during October through March.[13] The declining number of farm chickens would offset a small part of the influence of sharply expanding broiler

[12] Harold F. Breimyer and Charlotte A. Kause, Charting the Seasonal Market for Meat Animals, U.S.D.A., A.M.S., Agricultural Handbook No. 83, June 1955, p. 28-30.

[13] Malcolm Clough, "Changing Pattern of Corn Disappearance," Op. Cit., p. 27.

production.

Summary of Factors Determining Corn Prices.--The purpose of this section has been to present a general picture of the economic forces determining corn prices and changes that have occurred in these forces. Large changes have taken place in corn production and utilization concurrently with CCC operations. In production, technological changes in the form of hybrid seed, mechanization, and higher levels of fertilization have occurred, thus shifting the supply of corn to the right. On the demand side, there has been a shift to the right in the demand for livestock, thus increasing the demand for corn. This effect has been offset to a small extent by changes in the supply of other feed grains. There has also been a technological change in livestock production which would tend to both increase and decrease the demand for corn. The two effects have tended to cancel each other. Finally the demand for prepared livestock feeds has increased and the seasonal consumption of corn has shifted toward a more uniform pattern throughout the year.

The following section will review price support operations for corn since 1933. Chapter III will present the theory of the cash-futures price spreads. This will provide a means of connecting the current and future supply and demand for corn with the cash-future spreads.

Price Support Operations for Corn Since 1933[14]

In 1933 the newly created CCC was given power to make non-recourse loans on corn stored under seal on farms where grown. Under the program,

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[14]This section is based on Benedict and Stine, Op. Cit., unless otherwise indicated.

farmers in the "commercial" corn areas, could, if they chose, have their corn appraised, measured, and put under seal, and could receive a loan on it at a specific rate per bushel. The loans could be repaid later with interest if they wished to reclaim the corn. If the market price remained below the loan level and farmers did not choose to reclaim it, they could turn it over to the CCC and be absolved from any obligation to make up the loss. The "commercial" corn area is established each year to include counties with a 10-year average production per farm, exclusive of corn for silage, of 450 bushels or more and an average of four or more bushels per acre of cropland.[15] An additional requirement for corn placed under price-support loans, since the loans are based on shelled corn, is that the moisture content must be below 13.5% to insure safe storage. If it is above this level, corn is likely to get out of condition, to become sour, musty, or heat damaged, thus adversely affecting its feed value.[16]

The purposes of the price-support loan program were:

1. To relieve pressure on the corn market and encourage orderly marketing of the crop.

2. To put money into the hands of farmers immediately without forcing them to sell corn and hogs quickly in a glutted market in order to get funds for meeting current obligations.

Price-support operations for corn are summarized in Table 4. This summary will be supplemented by information in the following paragraphs. The resealing provision is an extension of the loan for another

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[15] U.S.D.A., A.M.S., Feed Situation, March 1958, p. 19.

[16] U.S.D.A. Miscellaneous Publication No. 692, Grain Production and Marketing, p. 24.

TABLE 4.--Price Support Program For Corn - 1933 Through 1963*

Year	Support Price: Cents per Bushel	Support Price: Percent of Parity	Seasonal Average Price Received by Farmers, Cents per Bushel	Eligibility Conditions	Resealing Offered
1933	45	60	52.0	Compliance with 1934 Corn-hog Contracts	yes
1934	55	68	81.5	Compliance with Corn-hog Contracts	no
1935	45	55	65.5	Compliance with Corn-hog Contracts	no
1936	55	66	104.4	None	no
1937	50	59	51.8	Participation in 1937 Conservation Program	yes
1938	57	70	48.6	Acreage allotment and 1937 requirement	yes
1939	57	69	56.8	Comply with total soil-depleting acreage allotment	yes
1940	61	75	61.8	Acreage allotment	a
1941	75	85	75.1	Acreage allotment	a
1942	83	85	91.7	Acreage allotment	no
1943	90	85	112.0	Acreage greater than 90% of goals	no
1944	98	90	109.0	None	no
1945	101	90	127.0	None	no
1946	115	90	156.0	None	no
1947	137	90	216.0	None	no
1948	144	90	130.0	None	yes

1949	140	90	125.0	None	yes
1950	147	90	152.0	Acreage allotment	yes
1951	157	90	166.0	None	no
1952	160	90	152.0	None	yes
1953	158	90	148.0	None	yes
1954	162	90	143.0	Acreage allotment	yes
1955	158	87	135.0	Acreage allotment	yes
1956	150	84	129.0	Acreage allotment or Acreage Reserve Program	yes
1957	140	77	111.0	Acreage allotment or Acreage Reserve Program	yes
1958	136	77	112.0	Acreage allotment or Acreage Reserve Program	yes
1959	112	66	104.0	None	yes
1960	106	65	99.7	None	yes
1961	120	74	108.0	Reduction of 1959-60 base acreage by 20% or more	yes
1962	120	74	111.0	Reduction of 1959-60 base acreage by 20% or more	yes
1963	125[e]	78	[d]	Reduction of 1959-60 base acreage by 20% or more	yes

TABLE 4.--Continued

Year	Support Price to Non-compliers, Cents per Bushel	Quantity Placed Under Support			Quantity Delivered to CCC, 1000 Bushels
		Loan, 1000 Bushels	Purchase Agreements, 1000 Bushels	Percent of Production	
1933	0	267,762	-	11.2	0
1934	0	20,075	-	1.4	0
1935	0	30,966	-	1.3	0
1936	0	158	-	0.01	0
1937	0	61,117	-	2.8	47,521
1938	0	229,839	-	9.0	132,983
1939	0	301,729	-	11.7	187,339
1940	0	103,125	-	4.2	12,299
1941	0	110,871	-	4.2	29,799
1942	0	56,401	-	1.8	[b]
1943	0	7,895	-	0.3	0
1944	0	20,647	-	0.7	0
1945	0	2,996	-	0.1	0
1946	0	25,982	-	0.8	0
1947	0	1,134	-[b]	0.08	0
1948	0	354,759	195,848	16.7	346,854
1949	0	328,935	57,707	13.1	89,800[c]
1950	0	51,554	2,505	2.0	500[c]

1951	0	25,199	970	1.0	700[c]
1952	0	309,127	107,986	14.0	303,000[c]
1953	0	568,900[c]	102,300[c]	16.3	359,000[c]
1954	0	199,508	59,522	9.6	208,000[c]
1955	0	365,138	65,074	14.7	364,000[c]
1956	125	401,342	75,988	15.5	395,000[c]
1957	110	319,695	49,323	12.1	227,000[c]
1958	106	343,253	37,567	11.3	197,000[c]
1959	112	481,620	47,847	13.8	338,000[c]
1960	106	562,828	74,963	16.3	288,000[c]
1961	0	581,294	77,282	18.2	478,300[f]
1962	0	535,806	55,384	16.2	d
1963	0	d	d	d	d

*Compiled by the author. Sources were:

Benedict and Stine, The Agricultural Commodity Programs--Two Decades of Experience.

U.S.D.A., Agricultural Prices, December 15, 1962.

U.S.D.A., Agricultural Statistics, 1951 and 1961.

U.S.D.A., Feed Situation, various issues.

B. F. Jones, Quantities of Commodities Involved in CCC Price Support Programs 1948-1960, Department of Agricultural Economics, Michigan State University, Agricultural Economics 890.

L. V. Manderscheid, Influence of Price Support Program on Seasonal Corn Prices, unpublished Ph.D. dissertation, Food Research Institute of Stanford University: Stanford, California, 1960.

Year refers to crop harvested in that year.

- Indicates that the provision was not operative in that year.

[a]Original loans were for a period of more than one year.

[b] Negligible.

[c] Rounded to the nearest 100,000 bushels.

[d] Data were not available when the table was compiled.

[e] Includes a loan rate of $1.07 per bushel and a price support payment of 18¢ per bushel.

[f] Preliminary.

year or longer. Instead of delivering or redeeming the corn, the farmer can renew his loan provided the corn is still of good quality.

Some additional government activities occurred during World War II which are not brought out in Table 4. The United States Department of Agriculture encouraged the expansion of pork and lard production by selling government corn at prices below market value. Also 100 million bushels of wheat were sold at feed prices (about the price of corn). The program for feeding wheat to livestock was later expanded at the direction of Congress, and the quantity of wheat fed during the war period reached a total of nearly 1.5 billion bushels. Normal feed use would have been about 500 million bushels for the five year period. In January 1943 ceilings were imposed on corn prices at 100 percent of parity. That tended to discourage speculative holding of corn for further price advances. In addition, the demand for livestock products, and consequently the demand for corn, was partially held in check by rationing and prices were held down by price controls and consumer subsidies.

In 1947 the CCC initiated a second form of price support: purchase agreements. Under purchase agreements, the CCC purchases a specified quantity, or any fraction thereof, of corn if it meets certain quality specifications and if delivered by the grower during a certain period. The price set in the purchase agreement is the same as the price at which loans are extended. The purchase agreement is an option, issued without cost to the grower, which he can exercise or not as he chooses.[17]

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[17]Lester V. Manderscheid, Influence of Price-Support Program on Seasonal Corn Prices, Unpublished Ph.D. dissertation, Food Research Institute, Stanford University Library; Stanford, California, 1960, pp. 18-19.

Until 1949 the CCC was not permitted to acquire any real property except office space and that already leased when the CCC charter was granted. In the fall of 1948 large crops caused a severe shortage of storage facilities; consequently, on June 7, 1949 restrictions on the ownership of storage facilities were relaxed. However, before the CCC could construct new storage facilities, it was required to determine that privately owned storage in the area concerned was not adequate. In addition to its own purchase and lease program the CCC was directed to make loans to grain growers in need of storage facilities.[18]

In the Agricultural Act of 1949, the following provisions were made concerning CCC sales in the domestic market:

1. CCC sales policies should be worked out so as not to discourage the private trade from acquiring and carrying normal inventories.

2. CCC was not permitted to sell stored commodities at less than 5 percent above the current support price plus reasonable carrying charges. This restriction did not apply to sales for new or by-product uses, to sales made because of deterioration in quality, or to sales for export.

The Agricultural Act of 1956 provided for an Acreage Reserve Program under which soil bank certificates were issued for reducing acreages of basic crops. These certificates could be redeemed for cash or exchange for CCC grain. The act also initiated a Conservation Reserve Program with contracts ranging from 3 to 15 years for land taken out of production on which a cover crop was or was to be established.

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[18] Murray R. Benedict, Can We Solve The Farm Problem?, The Twentieth Century Fund; New York, 1955, p. 402.

The program provided payments for establishing conservation practices and annual cash payments based on the value of the land for crop production.[19]

The 1961 Feed Grain Program, approved on March 22, 1961, provided payments to corn producers who reduced their acreage by at least 20 percent of their base acreage for 1959 and 1960. The payments ranged from 50 percent to 60 percent of the value of the production of the diverted acres, figured at the county support price. Half of the payment would be available immediately to the producer in cash upon his declaration of intention to comply. Payment certificates were redeemable either in cash or commodity. If the producer elected to receive the cash equivalent of the grain, the Secretary of Agriculture was authorized as the producer's agent to market from existing CCC stocks the quantity of grain covered by the certificates.[20] Thus, an important aspect of the program was that it permitted CCC to sell existing stocks of corn at market prices, above or below the support level. This provision was continued until 1963. Under the 1963 program the CCC is not allowed to redeem certificates at less than $1.07 per bushel plus an allowance for seasonal variation.

In summary, price support programs during the early years of operation attempted mainly to even out fluctuations from year to year and within year in the supply of corn. The war years were characterized by price ceilings, rationing, and attempts to expand production. Following a post-war readjustment period, CCC stocks began to accumulate.

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[19] U.S.D.A., A.M.S., Feed Situation, op. cit., September 21, 1956, p. 19.

[20] Commodity Exchange Authority, The Corn Futures Market 1961-62, U.S.D.A.; Washington, D. C., p. 7.

From 1953 to 1961, with high levels of corn production, large CCC stocks were built up. Then in 1961 there was an abrupt shift in policy. CCC was permitted to sell corn in the domestic market at the market price even if the loan price was above the market price. In 1963, CCC was again prevented from selling corn, other than that deteriorating in quality, in the domestic market at less than a specific price.

The following chapter will review previous studies of the effects of CCC price support programs on the demand for storage facilities, marketing firms, and the cash-future price spreads.

CHAPTER II

Review of Literature Related to the Effects of Government Programs on the Cash-Futures Price Spread

The purpose of this chapter is to review and summarize previous studies of the effects of government price-support programs on the supply and demand for corn storage and on the cash-future price spreads for corn. This information will complete the problem setting and will provide a background for selecting the analytical approach.

Descriptive Studies

Several descriptive studies have attempted to determine the impact of government programs on grain production and marketing. These studies provide some idea of the nature and magnitude of the construction of grain storage facilities that has taken place in recent years and problems in grain marketing that have arisen under government price-support programs.

Schumaier, in a study of grain production and marketing in Illinois, indicates that between 1955 and 1958, total off-farm grain storage space in Illinois increased about 45 percent from 202 million bushels to about 293 million bushels.[21] During this period processor storage space remained virtually unchanged. All of the space added was located in country, subterminal, and terminal elevators. Total

[21] C. P. Schumaier, Illinois Grain Production and Trade, Illinois Agricultural Experiment Station Bulletin No. 637, Urbana, Illinois, February 1959, p. 103.

storage space in country elevators increased by about 84 percent, while subterminal and terminal space increased by around 58 percent. During the same period, CCC binsite storage increased by about 36 percent. Information which was obtained on recent and planned additions at the time of the 1955 survey indicated that much of the country elevator space added since 1955 has been flat, steel, warehouse-type construction with aerating equipment designed to store corn for the CCC.

In a 1954 survey Schumaier attempted to determine whether a shortage of storage facilities existed in Illinois. The survey revealed that the average occupancy of storage space at terminal, subterminal, and processing plants was about 62 percent. For elevators the occupancy level was 70 percent; for processors it was around 56 percent. Processors, terminal and subterminal elevators reported 19 percent of their average volume was stored for CCC and another 5 percent for farmers largely on loan agreements that pass to the CCC upon their expiration. Country elevators, in rough terms, carried stored-grain inventories consisting of one-third for farmers, one-third for the CCC, and one-third for themselves.[22] The data upon which these estimates were based was obtained from responsible executives in the firms interviewed and was for one year only. Hence, Schumaier warns, it should be interpreted with caution. However there did not appear to be any shortage of storage space at the processor and terminal level in 1954.[23] It is also interesting to note that CCC storage was most often reported as long-term storage of a year or more. Processors, as would be

[22] Ibid., p. 59.

[23] Ibid., p. 49.

expected, stored predominately for their own accounts although some space was rented to the CCC.[24]

CCC-owned facilities were found to be entirely flat storage that requires filling, turning, and emptying with portable handling equipment. Consequently, its use is economically limited to long-term storage, of which CCC is almost the only user.

It should be recognized that storage space requirements are not uniform throughout the year, particularly for elevators located in the grain producing areas. For this reason, an average level of occupancy may be misleading in attempting to ascertain whether adequate storage facilities exist. At harvest time facilities are required for storing large volumes of grain until they can be shipped to other links in the marketing chain. Country elevators, river, and terminal elevators frequently become temporarily filled when transportation is not immediately available during favorable harvesting weather.

Schumaier reported that in Illinois, there were ample handling facilities at the country elevator level, although handling problems do arise in years when the bulk of the harvest arrives in a single week and rail cars are short in supply. This results from the fact that country elevators had a little over half enough space to store the peak load as computed by Schumaier from 1949-53 average sales and 1955 storage space.[25] For Illinois in total the available grain storage space was slightly over twice as much as would be needed for the computed peak load and about 3.5 times as much as would be needed for the

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[24] Ibid., p. 50.

[25] Ibid., p. 56-57.

computed average load. The amount of storage space available, however, varied greatly from region to region.[26] It should be noted that a lack of storage space at the local level at harvest time may limit the quantity of corn going under loan.

Schumaier concluded, at the time the bulletin was published, that grain storage space in Illinois was adequate to handle peak requirements with space left over at the terminals for imported grain. Between 1951 and 1954 a large amount of storage was also constructed for the United States in total. In February 1955 the U.S.D.A. indicated that from 1951 to 1954 a national increase of almost 645 million bushels of capacity of commercial grain storage facilities took place. This does not include government owned or farm storage facilities.[27] For the period 1951 to 1962, total off-farm commercial grain storage capacity increased from 2,176 million bushels to 5,489 million bushels; in other words, total commercial storage capacity has more than doubled since 1951. From January 1, 1961 until January 1, 1962 it has increased by about 10 percent, nearly a half billion bushels.[28] These figures would tend to indicate that for the United States in total there has been a definite lack of grain storage space.

A Great Plains Agricultural Council publication indicates that there has been a lack of grain storage facilities in other states, at least at harvest time. "Congestion at the local elevator at harvest

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[26] Ibid., p. 57-58.

[27] U.S.D.A. Press Release 491-55, February 28, 1955.

[28] From U.S.D.A., S.R.S., Stocks of Grains in All Positions, Washington, D. C., January 24, 1962, p. 11. Cited in Geoffrey S. Shepherd, Marketing Farm Products, 4th Ed., The Iowa State University Press; Ames, Iowa, 1962, pp. 437-38.

time is a common thing throughout the Plains States. This problem is aggrevated if the local elevator finds itself filled with 'dead storage' of grain which is owned by CCC or by farmers with loans who have not yet decided whether to sell or whether to forfeit the grain."[29] When grain does not flow into use, the country or terminal elevator often finds itself cramped for space to carry on its merchandising and processing operations. Another factor which has contributed to congestion at harvest time is the technological change in corn harvesting. This along with improved roads and truck transportation have reduced the main harvest period to three or four weeks.

A recent North Central Regional Research Publication was directed toward finding the reasons for the large amount of storage construction, whether excess storage capacity would exist if CCC acquisitions were reduced or a series of poor crop years occurred, and what has been the effect of government storage programs on marketing firm operations. In the North Central region, construction of grain storage capacity in selected terminal markets had increased while the volume of shipments and receipts had decreased. "It is evident that this additional storage space was not constructed in response to an increase in merchandising activity. Rather, it was the result of an increase in the demand for space to store CCC grain."[30]

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[29] Norris Anderson, Clarence Miller, Leonard Schrubben, Obed Wyum, and Layton Thompson, Economic Aspects of Grain Storage in the Northern Great Plains, Great Plains Agricultural Council Publication No. 14, Montana Agricultural Experiment Station Bulletin 523; Bozeman, Montana, August 1956, p. 32.

[30] Geoffrey S. Shepherd, Allen Richards, and John T. Wilkin, Some Effects of Federal Grain Storage Programs on Grain Storage Capacity, Grain Stocks, and Country Elevator Operations, Indiana Agricultural Experiment Station Research Bulletin 697, June 1960, (North Central Regional Publication No. 114), p. 9.

An important reason for the large response to increased CCC demands for storage was that several incentives have been provided to encourage the expansion of storage facilities. The first of these were occupancy contracts, which began as informal agreements between CCC and warehousemen that CCC would not use its own storage facilities in a local area if privately owned storage space was available. In August and September 1953 and from May through August 1954, formal occupancy programs were in effect. The crucial point of these programs was guaranteed occupancy.[31]

A second incentive for storage construction was accelerated amortization. The internal revenue code of 1954 provided for depreciation of new and remodeled storage facilities over a five year period.[32]

Storage and handling agreements have provided an additional incentive for storage space expansion. These agreements are contracts between CCC and individual warehousemen to handle and store CCC grain. Stored CCC grain has provided revenue from receiving, storing, conditioning, and loading out. In 1959 this amounted to a total of 21¢ per bushel for one year's storage plus handling.[33]

Cooperative elevators were allowed financial aid from cooperative banks for building grain storage facilities. Such loans required that the cooperative have a commitment from CCC guaranteeing utilization of not less than 75 percent of the storage space constructed for at least

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[31] *Ibid.*, p. 4.

[32] *Ibid.*, p. 5.

[33] *Ibid.*, pp. 5-6.

three years if the structure was not an addition to the existing structure or for at least two years if it was. These loans could be made for up to 80 percent of the cost of the storage facility.[34]

The study indicated that CCC tended to store most of its corn stocks in CCC-owned facilities and the lowest proportion in terminal storage, excluding processors. However, from 1956 to 1958 CCC corn stocks rose considerably but only a small part of the increase was stored in CCC-owned facilities; most of it was stored in commercial subterminal and country elevators. In 1958, 33 percent of the total CCC off-farm corn stocks was stored in subterminal and country elevator facilities, 56 percent in CCC-owned or controlled facilities, and 11 percent in terminals. In contrast with corn, 54 percent of the CCC-owned wheat was stored in subterminal and country elevators, 33 percent in terminals, and 13 percent in CCC-owned or controlled storage.[35] This latter information as we shall see in Chapter III, has relevance for the quantity of corn storage which will be supplied since as stocks of other grains increase, less storage space is available for corn storage. From this information, it appears that a tightening of available storage in subterminals, country elevators, and terminals may have been occurring due to CCC wheat storage.

Apparently, CCC influence has been stronger in country areas than in terminals, since construction of country elevator space between 1946 and 1954 increased at a greater rate than storage construction in

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[34] *Ibid.*, p. 6. From Allen E. Korpela, *Federal Farm Law Manual*; Oxford, N. H., Equity Publishing Corp., 1956, p. 51.

[35] Geoffrey S. Shepherd, Allen Richards and John T. Wilkin, "The Grain-Storage Picture," *Iowa Farm Science*, 14, June 1960, p. 8-520.

selected terminal markets. In the terminal markets, any sharp reduction in the wheat storage program could leave the elevators with excess capacity not readily convertible to other uses.[36]

Grain storage construction has been of two general types: flat storage (quonset type, for example) which can be converted readily to alternative uses such as for storage of fertilizer, feed, and other farm supplies, and permanent storage which has no important alternative uses. In Iowa, on the average, almost as much flat capacity as upright capacity exists. In addition, capital structures of Iowa cooperative elevators indicated that managers expected adequate grain for merchandising and storing to utilize the additional storage space in event CCC storage operations were reduced.[37]

Factors Affecting the Quantity Placed under Price Support

We have seen that CCC has encouraged a rapid expansion of grain storage facilities. Government price support operations raise another question: What determines the level of the CCC demand for these new facilities? Allen Richards found that the main factors affecting the quantity of corn placed under price support loan were:[38]

1. The demand for corn as evidenced by the number of livestock on feed.

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[36] Indiana Research Bulletin 697, Op. cit., p. 9, from John Wilkin, Impact of U.S.D.A. Support Program on Commercial Grain Storage, Unpublished M.S. thesis, Iowa State University Library; Ames, Iowa, 1958, p. 74.

[37] Indiana Research Bulletin 697, Ibid., p. 10.

[38] Allen B. Richards, "Factors affecting the Quantity of Corn Placed under Loan," The Ninth Annual Symposium, Commodity Markets and the Public Interest, Proceedings, The Chicago Board of Trade, September 5, 6, 7, 1956, p. 147.

2. Corn supply conditions arising out of production each year.

3. The relationship between the market price and the loan price.

Richards found that the larger the corn crop in relation to the demand for corn, the larger the quantity of corn sealed. For a given supply of corn, an increase in the number of animal units on feed would decrease the amount of corn available for sealing under the government price support program. However, the most important factor affecting the quantity of corn sealed is the difference between the market price for corn and the loan price. The amount of corn sealed increases at an increasing rate as the market price falls below the loan rate. The reason for this is that if the loan rate is above the market price, the marginal returns from feeding will be equated to the loan rate and any corn not fed will be placed under support if it is eligible. The further the loan rate is above a given market price the sooner the marginal returns from feeding will be equated to the loan rate and the greater will be the amount of corn resealed. If, on the other hand, the loan rate is below the market price, there will be very little incentive to put any corn under loan.[39]

In addition, Gerald Gold points out that loan prices must be above market prices before farmers will feel the difference is worth the time and trouble of taking out a loan. Also, the amount of grain eligible for loan may be limited due to high moisture content or for other reasons.[40]

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[39] Ibid., pp. 149-154.

[40] Gerald Gold, Modern Commodity Futures Trading, The Commodity Research Bureau, Inc.; New York, 1959, pp. 96-97.

Government Programs and the
Cash-Future Price Spreads

For the commodities wheat and cotton, Telser studied the supply of storage during the operation of CCC.[41] For cotton the period studied was 1934-1954; for wheat it was 1927-1954. The empirical supply curves were constructed by regression analysis of interoption spreads, commercial stocks, and consumption. An additional variable, stocks of other grains, was included for wheat.

The effects of changes in the fraction of stocks held by CCC seem to vary during the year. For cotton, at each date studied an increase in the fraction of total stocks held by the government decreased the spread. However, in most cases the coefficient of government stocks was not statistically significant.

The wheat storage supply curve was studied for the dates July 31, September 30, December 31, and May 31. On September 30 and December 31 an increase in government stocks relative to commercial stocks increased the spreads. For the other two dates, an increase in government stocks relative to commercial stocks decreased the spread. Perhaps the reason for this, Telser suggests, is that during the middle part of the crop year a considerable part of government stocks is held as loan collateral. It is possible that the convenience yield of such stocks is quite high.[42]

One other study has dealt directly with the effects of government programs on the cash-futures spreads. Manderscheid, in an analysis of

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[41]Lester G. Telser, "Futures Trading and the Storage of Cotton and Wheat," Journal of Political Economy, Vol. 66, June 1958, pp. 233-255.

[42]*Ibid.*, p. 252.

the effects of government programs on the seasonality of corn prices, used the cash-future price spreads to isolate the seasonal element of corn prices. Consequently, one phase of his work involved an examination of the effects of government price-support programs on the seasonal pattern of the cash-future price spreads. The time period studied was 1901 to 1954.

Manderscheid concluded that there has been an increase during the price-support period in the level of the spread and also an increase in the spread prior to harvest time. It should be mentioned here that these spreads are cash price minus future price, while spreads in Chapter III will be discussed as future price minus cash price. Hence there has been an increase in the cash price relative to the future price during the support period or a decrease in the level of spreads when considered as future price minus cash price. The larger spread prior to harvest during the support period apparently has resulted from a shortage of available corn supplies prior to harvest. This, in turn, has resulted in a greater change in cash-futures price spreads at harvest time. Technological developments which have allowed more rapid harvesting and marketing have contributed to an earlier timing of the seasonal low for the September spread during the support period.[43]

Following harvest there is less advantage in holding corn relative to the September future than there was in the pre-support period. This is due to (1) the smaller average increase in the spread during the year, and (2) the greater variability of the spread in the support period years. This variability is partially related to uncertainties

[43] L. V. Manderscheid, op. cit., pp. 97-98.

about the effects of the program and changes in it.[44]

Summary

We have seen that much descriptive work has been done on the effects of government programs on the availability of storage facilities and on marketing firms. In addition, one study examined the changes in the seasonality of cash-future price spreads which have been associated with government price support operations. In the case of wheat and cotton, quantitative estimates have been made of the effects of government programs on the total supply of storage. However in the case of corn, no quantitative estimates have been made of the relationship of government storage to cash-future price spreads. As a prelude to estimating this relationship, the economic relationships determining the cash-future spreads will be specified in the following chapter.

[44] Ibid., p. 98.

CHAPTER III

Theory of the Cash-Future Price Spreads

In previous sections we have reviewed the major factors determining the supply and demand for corn. We have looked at CCC operations since 1933 and their effects on the supply of corn. In Chapter II, some major effects of government programs on grain storage capacity and on marketing firms were examined. In addition, some effects of government programs on the seasonality of cash-futures spreads for corn were presented. The purpose of this chapter is to assemble these factors into an economic framework that will indicate the interrelationships between various variables and the price spread.

Since futures trading exists mainly for hedging purposes, this chapter will begin with the purposes and functions of hedging. In the first section the forces which cause cash and futures prices to move together will be delineated. The following section will demonstrate how these forces can be considered as a supply and demand for storage. A final section will introduce government storage programs into the economic framework.

Hedging Purposes and Functions

According to the traditional concept, hedging consists of matching one risk with an opposing risk. For example, millers or other grain processors who sell their products at a fixed price for future delivery before they can obtain needed grain, usually buy grain

futures contracts at the time of the forward delivery sales. Later, when the grain is purchased, the futures contracts are sold. In such transactions any loss caused by an advance in grain prices is expected to be offset by gains made in the sale of futures contracts.[45]

At this point a definition of futures trading is in order. Futures trading involves a contract in which a seller agrees to deliver a certain class, quantity, and grade of grain, with provisions for delivery of other classes or grades at differentials, at a stated place at a designated future date, and a buyer agrees to accept and pay for such grain at the time of delivery. These contracts are between members of an organized exchange and are subject to the rules and regulations of the exchange upon which the trade is made. Persons who are not members of the exchange may carry on futures transactions through members of the exchange.[46] Normally less than 1 percent of all futures contracts are actually held for delivery.

From the above example, it is apparent that the usefulness of hedging in the traditional sense depends upon a reasonably stable relationship between cash prices and the prices of futures contracts. However, Holbrook Working has pointed out that hedging is done for a variety of reasons other than simple risk-avoidance. He suggests that there are five main types of hedging.[47]

Carrying-Charge hedging is done in connection with the holding

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[45]U.S.D.A., Miscellaneous Publication No. 692, Op. Cit. p. 60-61.

[46]Ibid., p. 59.

[47]Holbrook Working, "New Concepts Concerning Futures Markets and Prices," American Economic Review, Vol. LII, No. 3, June 1962, p. 438.

of commodity stocks for direct profit from storage. In contrast to the traditional concept that such hedging is done only to reduce the risk of stock-holding, the main effect of carrying-charge hedging is to transform the operation to one that seeks profit from anticipating changes in cash-futures price relationships. The decision the carrying-charge hedger makes is not primarily whether to hedge or not, but whether to store or not.[48]

Operational hedging normally entails the placing and "lifting" of hedges in such quick succession that changes in the cash-future price relationship over the interval can be largely ignored; this is the main fact which distinguishes operational hedging from carrying-change hedging. Because of the short intervals over which operational hedges are carried, the amount of risk reduction accomplished tends to be insufficient to explain the observed frequency of such hedging. In view of this the main use of operational hedging is apparently to simplify business decisions and allow operations to proceed more steadily than otherwise. For example, in the flour milling industry, buying and selling decisions are made easier by judging prices on particular lots of wheat in terms of their relation to wheat futures prices rather than in terms of absolute level.[49]

Selective hedging involves hedging or not hedging stocks according to price expectations. Because the stocks are hedged when a price decline is expected, the purpose of such hedging is not risk avoidance, in the strict sense, but avoidance of loss. Personal inquiry by Holbrook

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[48] *Ibid.*, p. 38.

[49] *Ibid.*, p. 439.

Working among large and well-managed firms in the grain trade has revealed that, though hedging is their standard practice in most parts of the country, they sometimes hedge incompletely.[50] To the extent that they allow circumstances in individual instances to influence the decision whether to hedge unsold stocks or not, they hedge selectively. From an economic standpoint, selective hedging deserves appraisal as a means of allowing handlers of a commodity to increase the efficiency of their participation in the price-forming process instead of largely withdrawing from such participation, as in the case of routine carrying-charge or operational hedging.

Anticipatory hedging is carried out when the futures contract is not offset by either an equivalent stock of goods or a formal merchandising contract. It takes either of two forms: (a) purchase contracts in futures acquired by processors or manufacturers to cover raw material "requirements," or (b) sales contracts in futures by producers, made in advance of the completion of production. In either form, the anticipatory hedge serves as a temporary substitute for a merchandising contract that will be made later. The purpose of such hedging may be said to be to take advantage of the current price.[51]

Pure risk-avoidance hedging, which involves avoiding the risk of both price increases and price decreases, is unimportant or virtually non-existent in modern business practice.[52]

From these categories of hedging, an overall definition of hedging

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[50] Ibid., p. 439.

[51] Ibid., p. 441.

[52] Ibid., p. 442.

evolves. Hedging in futures can be defined as the process of "making a contract to buy or sell on standard terms, established and supervised by a commodity exchange, as a temporary substitute for an intended later contract to buy or sell on other terms."[53] Speculation, in the ordinary usage of the term, refers to buying and selling (or more accurately, holding) purely for the sake of gain from price change, and not merely as an incident to the normal conduct of a processing or merchandising business. The importance of this definition can be seen in the objection of business purchasing agents to being said to speculate when they seek to time their buying, within reasonable limits, in accordance with their judgment of price prospects.[54]

According to the traditional concept of hedging, futures traders are sharply divided into two classes, speculators and hedgers. Risk is transferred from hedgers to speculators. The question arises, do speculators require a fee for their risk bearing services. This question will be discussed in the following section. The significance of the newer concepts is that hedging is not done solely for the reduction of risk. Hedgers take part in many of the roles traditionally assigned to speculators. They also take more active roles in the price formation process than was previously supposed. This is not to imply that speculators are not important in futures markets. However they are not as important as the traditional concept of hedging implies.

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[53] Holbrook Working, "Hedging Reconsidered," Journal of Farm Economics, Vol. XXXV, No. 4, November 1953, p. 560.

[54] Holbrook Working, "New Concepts Concerning Futures Markets and Prices," Op. Cit., p. 442.

The Supply and Demand for Storage

Holbrook Working has pointed out that continuous arbitrage between cash and futures prices results from the fact that if it appears at any time that cash prices in the delivery month would be higher than the present price of the future, more buyers than sellers of that future would appear and the price of the future would be bid up to equality with the expected price in the delivery month (except for variations in the quality and location of the deliverable grain represented by the futures contract as compared with the quality represented by cash prices).[55] This continuous arbitrage between cash and futures prices makes it necessary in most considerations of price influences, to regard the two sets of prices as determined in a single market.[56] "At the cash-grain tables buyers and sellers ordinarily do not discuss prices; they bargain in terms of cents 'over' and cents 'under.' When agreement is reached in these terms, the premium or discount settled on is applied to the latest quotation for the 'basic' future to arrive at a formal price."[57]

Futures trading, due to constant arbitrage between cash and futures prices, provides a means of allowing cash prices to reflect expectations regarding future events. Expectations influencing futures prices should always affect both cash and futures prices, unless a period intervenes when stocks from past and future production are expected to be non-existent. The reason for this is related to the fact

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[55]Holbrook Working, "Theory of the Inverse Carrying Change in Futures Markets," Journal of Farm Economics, Vol. XXX, No. 1, February 1948, p. 5.

[56]Ibid., p. 5.

[57]Ibid., p. 7.

that futures prices equal or are closely related to cash prices expected at the time the future matures. The difference between cash and futures prices, then, provides a good approximate index of the return which can be expected for providing storage of the commodity.[58] When the expected returns for storing are large, firms will store larger quantities of the commodity than when the returns for storage are small. Since storage is essentially a means of transferring part of the current supply to the future supply of the commodity, it is apparent that if current and future demands are given and all other factors determining current and future supply are given, an increase in stocks will affect cash prices and futures prices in opposite directions. For example, suppose expectations of a short crop in the future period result in an initial increase in the future price relative to the current price. This will provide an incentive for larger stockholding, thus shifting current supply to the left and raising the current price. At the same time the future price will be reduced by a shift to the right in the future supply.

Using this framework, we can think of the cash-future price spread as a price of storage. The question arises, however, what is the explanation for a large amount of storage space being supplied even when the price of storage is zero or negative? One condition which makes that possible is the fact that grain storage is an enterprise in which most of the costs are fixed, from the short-run standpoint. Owners of large storage facilities are generally engaged either in merchandising or processing and maintain storage facilities as a necessary adjunct to

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[58] Holbrook Working, "Theory of the Price of Storage," American Economic Review, Vol. XXXIX, No. 6, December 1949, p. 1254.

their merchandising or processing business. Consequently, the costs of storage may be charged against the rest of the business, which remains profitable.[59] As Nicholas Kaldor has pointed out:[60]

> In normal circumstances, stocks, of all goods possess a yield, measured in terms of themselves, and this yield which is a compensation to the holder of stocks, must be deducted from carrying costs proper in calculating net carrying cost. The latter can, therefore, be negative or positive.

Kaldor also tells us that the marginal yield of such stocks falls sharply with an increase in stocks above "requirements" and may rise very sharply with a reduction of stocks below "requirements." There is some level of stocks at which the marginal yield is zero. The yield of stocks which are used up in production comes from the opportunity to lay hands on them the moment they are needed, as well as from a reduction of the cost of frequent orders, deliveries, and delay.

With the introduction of a convenience yield, the net marginal cost of storage can be considered as the marginal outlay minus the marginal yield. For clarity, the yield will be referred to as the marginal convenience yield. This explains why inventories are carried when the apparent return is zero or negative.

There is one limitation which was hinted at in the first section of this chapter that should be pointed out. The futures prices may be discounted expected futures prices or may be reduced by a "risk premium" which is necessary to persuade speculators to perform the risk-bearing function. That problem cannot be dealt with here. The assumption will

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[59] Ibid., p. 1260.

[60] Nicholas Kaldor, "Speculation and Economic Stability," Review of Economics Studies, Vol. VII, 1939-40, p. 3.

be made that if such a "risk premium" exists, it should remain relatively constant; hence the prices of futures contracts should be very closely related to expected future prices. This does not appear to be a serious limitation in view of an observation made by Roger W. Gray in a study of corn futures prices at Chicago for 1921-1940 and 1947-1959 that "No 'downward' bias was evident in corn futures in either of these two periods."[61]

Since it has been shown that cash and futures prices are intimately related at all times through stocks, the next step in developing a theory of the cash-future price spreads is to specify the forms of the supply and demand for storage.

The demanders of storage are an economic group who desire to have stocks carried from one period in which they do not intend to consume the commodity into another period in which they do intend to consume it. Brennan suggests that, consequently, the demand for storage of a commodity can be derived from the demand for its consumption. Under the assumption that all variables affecting consumption except price are exogenous, the demand function for consumption in period t can be written as:

$P_t = f_t\ (C_t \mid Z_{it})$; $\frac{\partial P_t}{\partial C_t} < 0$, where P_t is price in period t, C_t is consumption in period t, and Z_{it} are I other "exogenous" variables in period t. The subscripts indicate that the variables may shift

[61] Roger W. Gray, "The Search for a Risk Premium," Journal of Political Economy, Volume LXIX, No. 1, June 1961, p. 255. For a discussion of the issues involved see: P. H. Cootner, "Returns to Speculators: Telser vs Keynes," Journal of Political Economy, Volume LXVIII, August 1960, pp. 396-404 followed by L. G. Telser, "Reply," P. H. Cootner, "Rejoinder," pp. 408-18. J. M. Keynes, A Treatise on Money, II, Macmillan and Co., London, 1930, pp. 142-47.

periodically.[62] For convenience, the notation Z_{it} will be dropped from the other equations in this section. Given a fixed demand function for period t, the price in period t is determined by the intersection of the supply and demand for the commodity. This can be written as:

$P_t = f_t\ (S_{t-1} + X_t - S_t)$ where S_{t-1} represents stocks at the end of period t-1, X_t is production t, and S_t is stocks at the end of t. For convenience, it is assumed that current production and subsequent levels of production and stocks are known.

Similarly, the price of the commodity in period t+1 can be written as:

$P_{t+1} = f_{t+1}\ (S_t + X_{t+1} - S_{t+1})$. An increase in S_t in period t can be thought of as shifting the supply function for the commodity to the left in period t, thus raising P_t, assuming all other things are constant. At the same time it will shift the supply function for the commodity in period t+1 to the right, thus lowering P_{t+1}, assuming all other things constant. The demand function for storage can now be written as:

$$P_{t+1} - P_t = f_{t+1}\ (C_{t+1}) - f_t\ (C_t) \text{ or}$$

$$P_{t+1} - P_t = f_{t+1}\ (S_t + X_{t+1} - S_{t+1}) - f_t\ (S_{t-1} + X_t - S_t).$$

The partial derivative of the above expression with respect to S_t is assumed negative. Hence the demand for storage is a decreasing function of the cash-future price spread.[63] In general, the demand for storage of a commodity from period t to period t+1 will shift to the right as

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[62] Michael J. Brennan, "The Supply of Storage," American Economic Review, Vol. XLVIII, No. 1, March 1958, pp. 51-52.

[63] Ibid., p. 52.

a result of (1) an increase in production in t, (2) a decrease in production in t+1, or (3) an increase in stocks expected to be carried out of t+1. Opposite movements of these variables will produce a shift to the left.

Now let us examine the supply function for storage. This refers not to the supply of storage space, but to the supply of commodities as inventories. In a competitive industry in an uncertain world, a firm seeking to maximize net revenue will provide storage of that quantity of stocks at which the net marginal cost of storage per unit of time just equals the expected change in price per unit of time. As we have already seen, the net marginal cost of storage is marginal outlay minus marginal convenience yield. Brennan indicates that in addition, there may be a marginal risk aversion factor for holding stocks over time. If such a factor exists it can be deducted from the marginal convenience yield to obtain a net marginal convenience yield. The only change from treating the risk aversion factor in this way would be that net marginal convenience yield would eventually become negative rather than reaching a zero minimum, since the marginal risk aversion factor, according to Brennan, should be an increasing function of stocks.[64]

The total outlay on physical storage is made up of rent, handling costs, interest, depreciation, insurance, taxes, etc. For an individual firm, total outlay may increase either at a constant or an increasing rate. However, in the aggregate, it seems reasonable to assume that the marginal outlay for storage is approximately constant until total warehouse capacity is almost fully utilized. Beyond this level, marginal

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[64] _Ibid_., p. 53.

outlay will rise at an increasing rate.

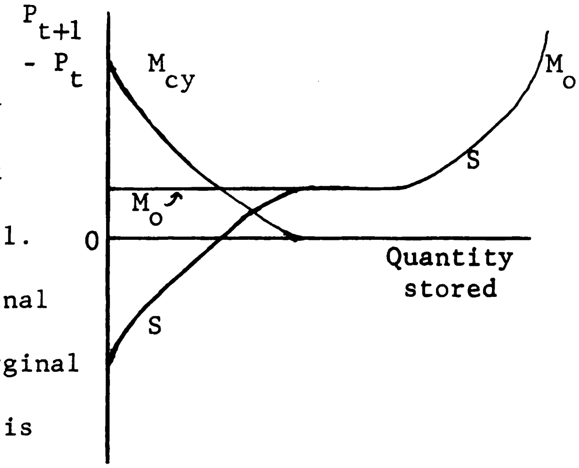

Figure 1.
The Supply of Storage

The supply of storage, along with its components, marginal outlay and marginal yield, assuming no risk aversion factor, is shown in Figure 1. The curve, M_{cy}, represents the marginal convenience yield; M_o represents marginal outlay. When stocks are small, M_{cy} is greater than M_o and storage will be supplied even at a negative price. The supply of storage, SS, thus intersects M_o at the quantity at which $M_{cy} = 0$, and for stocks larger than this quantity SS and M_o are identical. The introduction of a risk aversion factor would cause SS to lie above M_o beyond the point at which M_{cy} is zero; however for simplicity it will be assumed that marginal risk aversion equals zero. Under the assumption of a competitive industry, SS in Figure 1 will necessarily be the storage supply function since expected change in price per unit of time is the difference between present price and the future price and SS is the net marginal cost of storage.

The intersection of the supply and demand for storage can now be considered as determining the cash-future price spread. The equilibrium of the commodity supply and demand functions in the two periods is shown in Figure 2. The difference between P_t and P_{t+1} must just equal net marginal storage cost between the two periods. At this point the demand for storage intersects the supply of storage and determines the cash-future price spread, W, as shown in Figure 3.

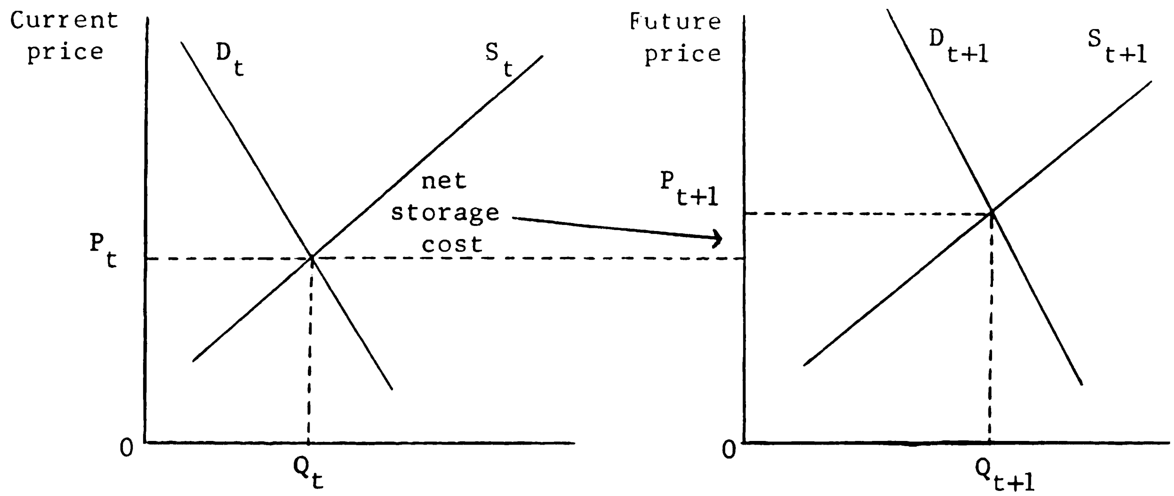

Figure 2. Equilibrium of the Supply and Demand for Corn in Current and Future Time Periods

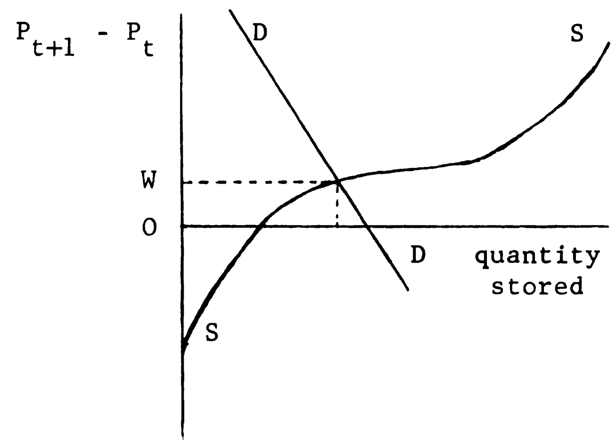

Figure 3 Equilibrium of the Supply and Demand for Storage

<u>The Introduction of a Government Supply and Demand for Storage</u>

Consider the introduction of a government storage sector into the theory of cash-future price spreads In particular, consider the components of the storage supply function facing the government The marginal convenience yield of commercial stocks, we have seen, arises from lower costs and reduced delay from holding stocks for normal merchandising and processing activities. Firms providing storage for CCC corn, however, do not have the privilege of using these stocks any time the need for them arises. A partial exception to this is stocks under price support loans. As we have seen, until a specific deadline, July 31, of the marketing year, producers have the opportunity to repay the loan with interest and use the corn. This amounts to selling and later rebuying the corn, except that producers are given the opportunity to repay the loan even if the market price rises above the loan price. In view of these facts, it appears that (1) corn owned by CCC and stored either in commercial or CCC-owned facilities provides virtually no convenience yield for the supplier of storage and (2) corn under price-support loan may provide some convenience yield for producers since it assures them of a maximum price they will have to pay in the future for the quantity of corn stored and a minimum price they will receive for their corn if they do not choose to repay the loan. We can expect the marginal convenience yield of stocks under loan to vary considerably from year to year and within years, due to variations in the cash price relative to the support price.

Also in the case of CCC corn, the government bears all risks of price changes so that there should be no marginal risk aversion factor for such stocks. The remaining component of the government supply of storage, marginal outlay, is assumed to be the same as for the commercial sector.

In view of the above considerations, the supply of storage facing the government should be expected to have a different shape than that of the commercial sector. It should be pointed out here that the commercial sector is intended to include all non-government supply and demand for corn storage. An additional distinction between these two sectors is that the intersection of the government supply and demand for storage only determines the price which the government has to pay for storage and not the cash-future price spreads. These considerations make it desirable to separate commercial and government storage into two sectors.

Now consider the demand for government storage. This is determined by the size of CCC inventories and the quantity of corn under loan and purchase agreements. In general, we can say that it is not closely related to the cash-future price spreads or the cost of storage to the government. Hence it is shown in Figure 4 as being perfectly inelastic (D'D'). In Figure 4, P_{sg} is the government price of storage, M'_{cy} the government marginal convenience yield, M'_o the total marginal outlay function and S'S' is the government supply of storage. The corresponding functions in Figure 5 represent the commercial demand for storage, the commercial supply of storage, and its components. The commercial marginal outlay function has been drawn as a residual; it is the segment of the total marginal outlay function M'_o in Figure 4 which lies to the right of D'D'. This was done in view of the fact, as we have seen in Chapter II, that CCC has maintained large inventories even at the end of the marketing year. When the new crop moves into marketing channels, a considerable portion of the total storage supply is already accounted for by CCC stocks. Due to occupancy contracts, storage and handling agreements, etc., CCC stocks cannot be removed from storage by the individual firm even if the return for commercial storage were greater than for CCC storage.

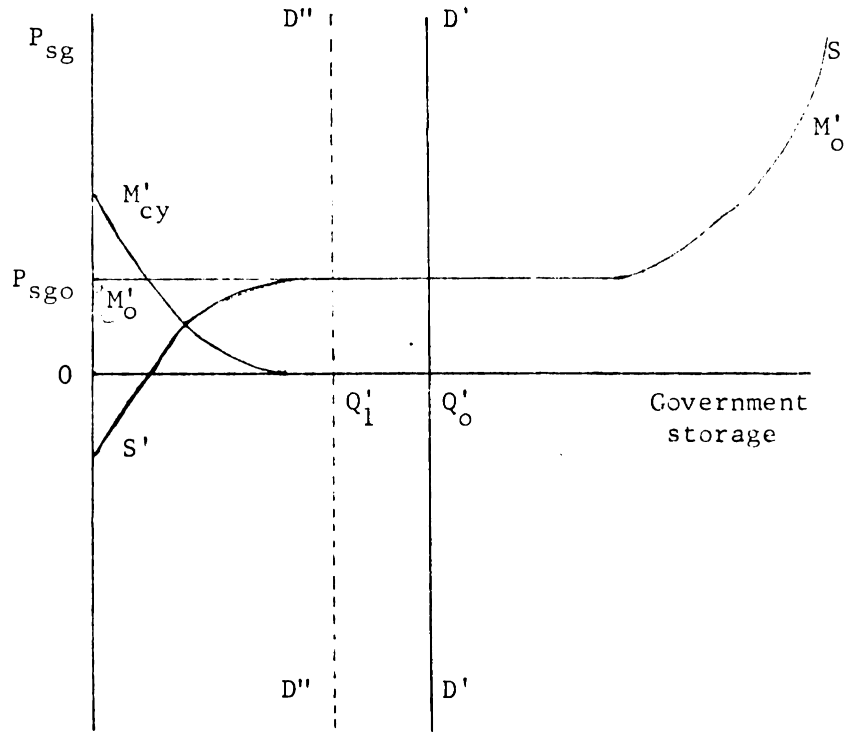

Figure 4. The Government Supply and Demand for Storage

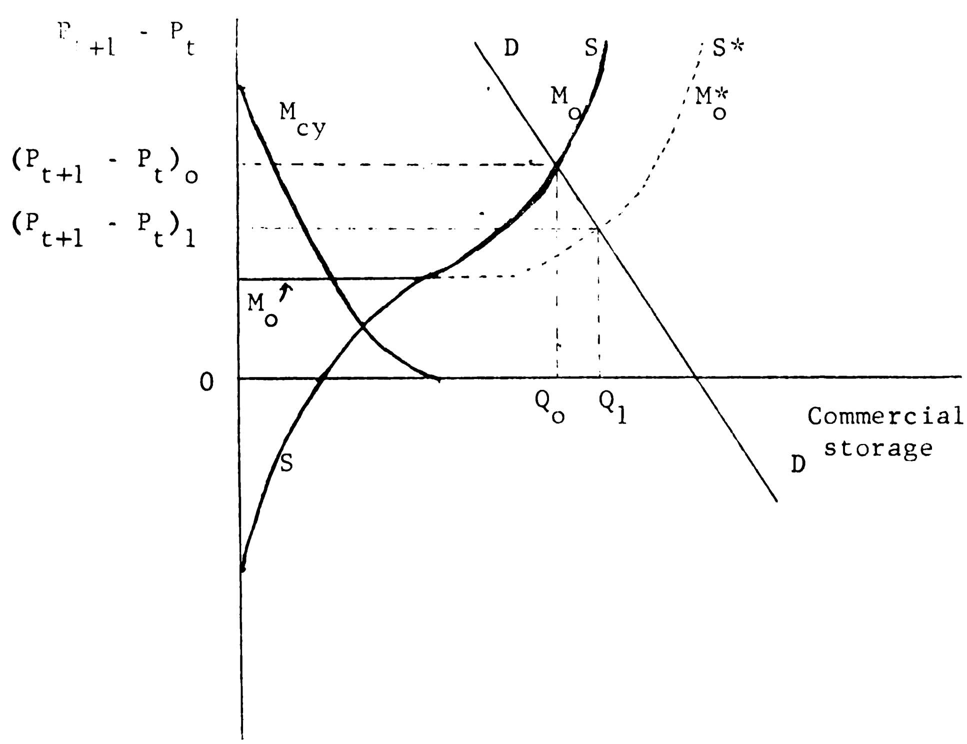

Figure 5 The Commerical Supply and Demand for Storage

Using this theoretical framework, a reduction in government demand to $D''D''$ shifts the marginal outlay function for commercial storage to the right to M_o^*, thus changing the form of the commercial supply function from SS to SS* and lowering the price spread from $(P_{t+1} - P_t)_o$ to $(P_{t+1} - P_t)_1$, provided the demand for commercial storage remains unchanged. This will increase the commercial quantity stored from Q_o to Q_1. An additional possibility is that CCC stocks under loan may affect the marginal convenience yield of commercial stocks. In some years, a considerable amount of corn placed under loan early in the marketing year later is removed and moves into commercial channels. In effect the government supplies free storage when this happens and the result may be to reduce the quantity of stocks which firms will carry when marginal returns for carrying stocks are zero.

Now let us examine the possible impact of changes in the government demand for storage on the commercial demand for storage. As we have seen previously the demand for commercial storage is:

$$P_{t+1} - P_t = f_{t+1} (S_t + X_{t+1} - S_{t+1}) - f_t (S_{t-1} + X_t - S_t).$$

It should be remembered that this demand function is based on the assumption of given demands for the commodity in period t and period t+1. A shift to the right of the demand in t+1, all other things held constant, will increase future price and quantity, thus increasing the demand for corn. A shift to the right of the current demand for corn will decrease the demand for storage, all other things held constant. Opposite shifts will have opposite effects on the demand for storage. A shift to the right in the demand for corn would be brought about by an increase in the price of substitutes, a decrease in the price of complements, an increase in livestock numbers, or an increase in livestock prices, all other things held constant. Opposite changes in these variables will produce a shift to the left of the demand for corn.

It can be seen then, that changes in government programs which are expected to change the present or future supplies of other feed grains will affect the commercial demand for corn storage.

Under the assumption of given present and future demands for corn, recognizing the limitations of such an assumption, the commercial demand for storage when government storage exists is:

$$P_{t+1} - P_t = f_{t+1}\,[S_t + (X_{t+1} - S_{gt+1}) - S_{t+1}] - f_t\,[S_{t-1} + (X_t - S_{gt}) - S_t],$$

where S_t, S_{t+1}, and S_{t-1} are commercial stocks and S_{gt+1} and S_{gt} are additions to government stocks. From this function, it can be seen that an increase in S_{gt+1}, all other things constant, will shift the demand for corn storage to the right. A decrease in S_{gt} will have a similar effect. A decrease in S_{gt+1} or an increase in S_{gt}, all other things constant, will shift the demand for corn storage to the left. It is apparent also, that in anticipating the impact of changes in government programs on the commercial demand for corn storage, consideration must be given to changes in acreage allotments, Conservation Reserve Programs, and other policies designed to reduce corn production, both in current and future periods.

In short, there are several possible effects of changes in CCC corn storage on the commercial demand for corn storage. Some of these effects should tend to cancel each other. In general, when no changes are expected in future price support programs, including CCC storage, acreage allotments, and conservation programs, the main effect of a decrease in CCC corn stocks, assuming normal production, is probably

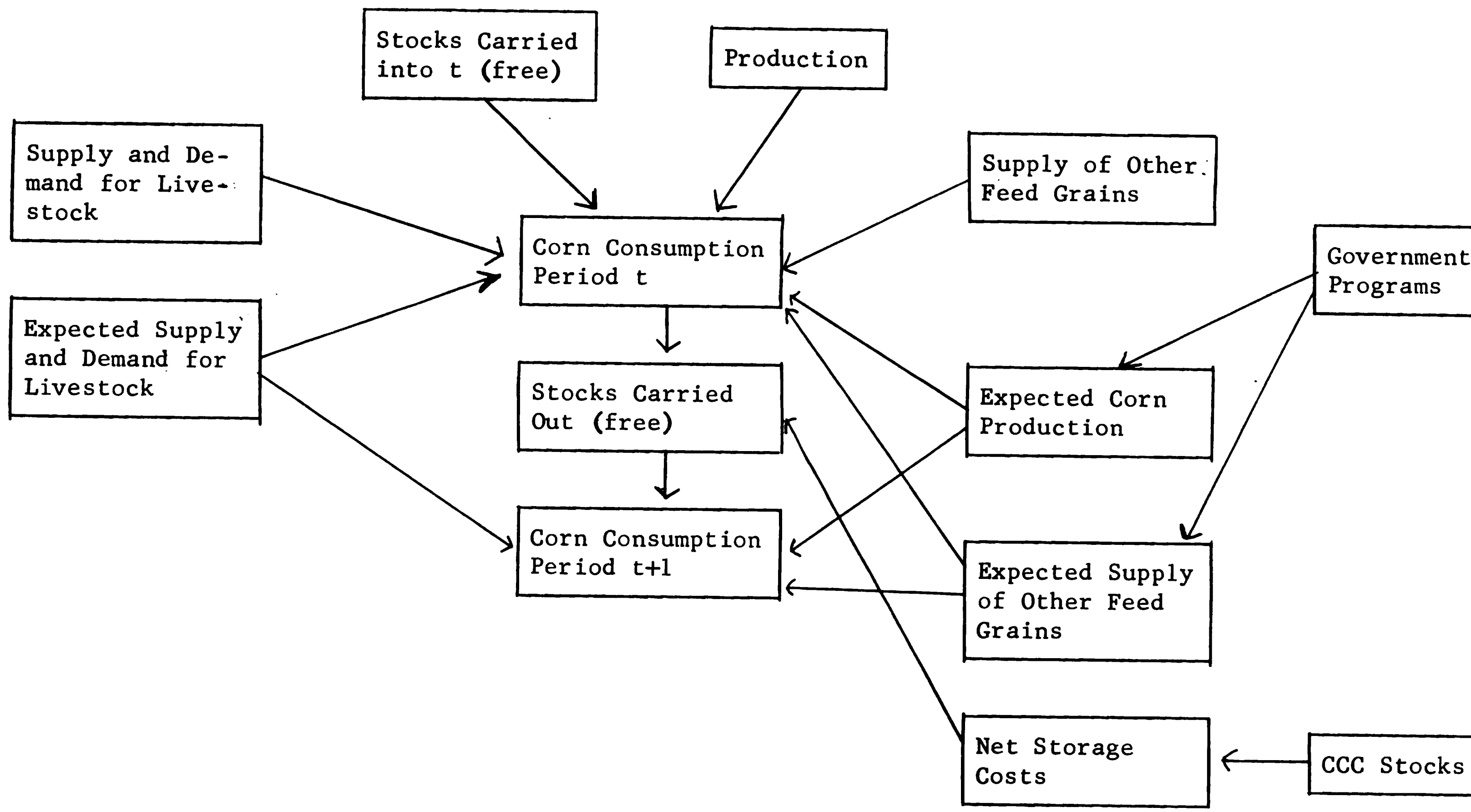

Figure 6. Variables Determining the Quantity of Commerical Corn Stocks Carried From Period t to Period t+1.

CHAPTER IV

The Method of Analysis

The first section of this chapter discusses the method of utilizing the theoretical relationships outlined in the previous chapter to obtain a test of the hypothesis and to obtain the objectives stated in the introductory chapter. The second section will consider what data are appropriate for the analysis and the adjustments required in the data in order to make them conform to the requirements of the theory.

The Approach

It is apparent from the economic relationships presented in Chapter III that annual observations of price spread and commercial corn stocks will not necessarily trace out a storage supply function. It appears reasonable to assume that such intersection points represent varying levels of both the supply of storage and the demand for storage. Furthermore, it does not seem reasonable to assume that the conditions required for the just-identified case are met. The conditions are, in general, that the number of predetermined variables in the model but not in the equation are equal to the number of endogenous variables in the equation minus one.[65] In view of these considerations,

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[65] Richard J. Foote, Analytical Tools for Studying Demand and Price Structures, Agricultural Handbook No. 146, U.S.D.A.; Washington, D. C., August 1958, p. 62.

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the following comments by Elmer Working in his classic article may have direct bearing on the problem.[66]

> It does not follow, that when conditions are such that shifts of supply and demand are correlated, an attempt to construct a demand curve will give a result that will be useless. Even tho shifts of supply and demand are correlated, a curve which is fitted to the points of intersection may be useful for purposes of price forecasting, provided no new factors are introduced which did not affect the price during the period of study. So long as the shifts of supply and demand remain correlated in the same way, and so long as they shift through approximately the same range, the curve of regression of price upon quantity can be used as a means of estimating price from quantity.

With these statements in mind, consider a curve fitted to the intersection points of the commercial supply and demand functions for storage from 1927 to date and a comparison of this curve with one fitted to the intersection points from 1934 to date. The first curve contains seven observations prior to the introduction of CCC price support operations. We have seen that when government price support operations are introduced, their effects on the commercial demand for corn storage are through shifts in the current and future supply and demand functions for corn. Given the current and future levels of the supply and demand for corn, the commercial demand for corn storage should be unaffected by government programs. Now let us assume that current supply and demand for corn and expected future supply and demand conditions are reflected by current consumption and consumption in period t + 1. This assumption seems reasonable, since, as we have seen in Chapter III, current and future consumption are factors that the demanders of storage adjust in response to changes in current and expected future supply and demand conditions. With this approach,

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[66]Elmer Working, "What Do Statistical Demand Curves Show?" Quarterly Journal of Economics, Vol. XLI, No. 1, February 1927, p. 227.

using the major variables determining the supply and demand for storage, a regression analysis for each period should yield coefficients for the various variables, with a very similar magnitude for both periods provided no new variables affecting the supply have been introduced during the latter period. If the hypothesis is false, however, we might expect a difference in the size of the corresponding regression coefficients for the two time periods and a significant coefficient for CCC corn stocks.

This is the approach which will be used. It will also provide a basis for predicting the cash-future price spreads. Since the approach will treat both (C_t) and C_{t+1}) as exogenous, such predictions will require an estimate of C_{t+1} in order to be useful. Thus for predictive purposes, the best available estimate of C_{t+1} at the time of the prediction should be used. The justification here for treating it as exogenous is that C_{t+1} affects the price spread directly but is not "significantly" affected by the price spread. In using this approach for predictions, care should be exercised, since as we have seen in Chapters I and II, some rather irreversible processes have been going on during the operation of the CCC. One of the more important of these is the construction of new storage facilities. If CCC stocks were reduced considerably, the marginal outlay function for commercial storage would shift to the right to a position which had not been previously attained, provided alternative uses for the new storage space are not important. Fixed asset theory tells us that an asset will be used in production as long as its marginal value product is less than its acquisition cost but greater than its salvage value. Here the important question is how much of the new storage space has an important salvage value (alternative use)? This question cannot be answered, but it should be pointed out that predictions based on the approach to be used here are not valid for large decreases in CCC stocks.

The Data

From Chapter III, the variables required for a least-squares regression of the intersection points of the commercial demand functions for storage are:

1. The cash-future price spreads.
2. Commercial stocks of corn.
3. Total stocks of corn under CCC control.
4. Total consumption of corn, domestic and export.
5. Stocks of other grains.
6. All available components of the marginal outlay for storage.

In addition to these it may be desirable to provide either a variable which will account for the effects of variations in the general price level or in some manner remove the effects of the general price level from the cash-future price spreads.

In considering the appropriate time period to use, it is desirable to obtain the longest reasonably homogenious period available, but at the same time considerable variation is required in the studied variables. In order to determine whether CCC price support activities have altered the direction or magnitude of the relationships between other variables and the spread, several observations are required prior to the introduction of CCC price support programs. With these considerations in mind, the time period 1927 to date was chosen. The approach will be to compare the effects of the relevant variables on the spread for the complete period and for 1934 to date. A longer time period would have been desirable; however some of the data needed were not available prior to the fourth quarter of 1926. The war years, 1943-45, and the immediate post-war years, 1946-48, were excluded from the analysis. During World War II, as was pointed out in the introductory chapter, government controls and other unusual conditions prevented the operation of "normal" supply and demand relationships. The immediate post-war period represented a readjustment toward peace-time conditions. During this period the demand for corn was unusually high and exports were large.

Since CCC activities may have different effects on the cash-future spreads at different times during the year, the cash-futures spread was studied at four different dates: January 1, April 1, July 1, and October 1. These dates were selected because they coincide with the dates for which quarterly grain stocks are published.

In computing the cash-future price spreads, cash prices for No. 2 corn at Chicago were used. The Chicago market provides prices for a specific grade, daily, from actual transactions, at a particular location. Some measurement error exists in these prices due to quality variations within grades, but this limitation is not serious and is unavoidable in any cash corn price series. The Chicago market also has the advantage of providing opportunity to use futures prices determined at the same location as the cash prices.

It is well to recognize that the cash-future spreads at other markets may differ from the spreads at the Chicago market due to differences in regional supply and demand conditions and availability of storage space. However, it is beyond the scope of this thesis to consider regional variations in the cash-future price spreads for corn.

The cash-future price spreads from 1927 to 1954 were obtained from L. V. Manderscheid, Influence of Price-Support Program on Seasonal Corn Prices.[67] Consequently this section is based on Manderscheid's work and explains the procedures used by him in collecting and adjusting cash and future prices to obtain the cash-future spreads.

Cash and futures prices were obtained by Manderscheid from the Annual Report of the Chicago Board of Trade, supplemented by information from the Chicago edition of the Wall Street Journal and the Chicago Journal of Commerce. Cash and futures prices were compiled for each Friday (except for war years) unless the market was closed on Friday for a holiday or any other reason. In that case Thursday was used. No particular significance was attached to Friday; any other day might be equally justified. The low price for No. 2 mixed or better cash corn was recorded along with the low for a widely traded futures contract.

In choosing the futures contracts used in deriving the spread for a particular month, futures were selected which would always be traded in the month for which they were chosen. The December future is traded in volume in June and subsequent months; hence it was selected for June. The May future was selected since it has a large trading volume and is used every year. The September future was used to provide an old crop future for the end of the marketing year.

Thus, from June through October, Manderscheid recorded the price of the December future; from November through March the May future was

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[67] Manderscheid, op. cit., pp. 55-62.

recorded, and from April through September, the September future was recorded. In addition on the first Friday of November, both the December and May futures were recorded. Similarly, on the first Friday of April, both the May and the September futures prices were recorded.

Manderscheid then adjusted the futures prices to yield a synthetic "September" future for a 16-month period extending from the June prior to harvest to the September following harvest. The method used was employed by Holbrook Working in a study of wheat prices.[68] This method assumes that a fairly constant inter-option spread has prevailed between two particular future prices and that measuring the inter-option spread at one properly chosen point allows us to adequately adjust a future price so as to make it comparable to the price which might have prevailed if the other future had been traded or had been recorded. This assumption is probably not inconsistent with fact since traders tend to keep inter-option spreads within a narrow range.

The procedure for adjusting the May future to yield a "September" future involved adding to the price of the May future the premium of the September future over the May future on the first Friday of April. Similarly, the December future was adjusted by adding to it the premium of May over December on the first Friday of November plus the premium of September over May on the first Friday of April. In event the premium was negative, it merely involved subtraction rather than addition. It should be noted that the transfer from one future to the next was made one month prior to the beginning of the delivery month. The switch was made at this point in order to remove possible effects of

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[68]Holbrook Working, "Cycles in Wheat Prices," Wheat Studies, Vol. VIII, No. 1, November, 1931.

any corners or squeezes.

A problem occurred in recording cash prices when the low quality of the corn crop resulted in no trading of No. 2 mixed or better corn on the Chicago market. Under these circumstances, Manderscheid obtained market differentials between the No. 2 corn and the highest grade that was traded by taking the difference between the low prices of these two grades on the last day that both were traded. This differential was then used to adjust the price of the lower grade corn to the level of No. 2 corn. This adjustment should lead to as small an error as any possible method which might be suggested.

The cash-future price spreads were obtained by subtracting the "September" price from cash price. Both spreads and futures prices were averaged to provide a series of average monthly prices. This tended to smooth out small price changes while leaving larger, more meaningful changes.

The price spreads used in this thesis were monthly averages for December, March, the second June and the first September of each 16 month period. The September future in the second September of each 16-month period is an old crop future, at the delivery month for that contract. The spread in the second September, consequently represents a quality and location differential, rather than a price of storage. For this reason the spread for the first September of each period was used. This spread represents the difference between cash price and the expected future price of new crop in the following September. The spread for the second June of each period was used since it is based on an old-crop future, and hence represents the difference between the current price and the expected price in September of the same marketing

year.

These spreads were then compiled for 1955 through June 1963 by the author, using the procedures discussed above. The prices were obtained from the Annual Report of the Chicago Board of Trade and from the Drovers' Journal.

The cash-future spreads were adjusted to remove the effects of two additional variables. The first of these was the general price level. The monthly average spreads were deflated by dividing them by the Bureau of Labor Statistics Monthly Index of Wholesale Prices for all commodities (1957-59 = 100). These indexes were obtained from monthly Federal Reserve Bulletins. The procedure for adjusting the Wholesale Price Index for the base periods 1926 and 1947-49 to obtain a 1957-59 base was based on five years for which both 1947-49 and 1926 bases were published and on five years for which both 1947-49 and 1957-59 bases were both published. For these overlapping years, the monthly index with the later base was divided by the monthly index with the earlier base. These adjustment factors were then averaged for the five-year period. The 1947-49 base index, when multiplied by .841 yields a 1957-59 base index. The adjustment factor to convert the 1926 base index to a 1947-49 base is .633.

The cash-future spreads were also adjusted to remove the effects of variations in the interest rate. Interest cost, as previously noted, is one of the components of the marginal outlay for storage. On the aggregate level this is the only component of the marginal outlay which is available. Published interest rates charged by banks to customers for business loans do not take into account variations in conditions under which loans are made; hence they do not provide an accurate indication of the interest cost of holding stocks of corn. In addition, the series of bank rates on short term business loans published by the Federal Reserve Board of Governors in the Federal Reserve Bulletin was revised in 1948. The revised series was extended back only to 1939.[69] In view of these considerations, the short-term interest rate on four to six-month prime commercial paper in the New York money market was selected as the basis for computing interest cost. This choice was made on the assumption that the cost of a loan is highly correlated with the interest rate in the New York money market.

The monthly interest rates were obtained from the Federal Reserve Bulletin. Since the published rates are in percent per year, they were converted to rates per month. These were then multiplied by monthly deflated cash prices to obtain the interest cost per month. The interest cost per month was multiplied by the number of months until September, the date when the "September" future reached maturity, to obtain the interest cost for each date studied. The interest cost was then added to the cash-future spreads, since these spreads are cash price minus future price rather than the future price minus cash price called for by the theoretical framework of Chapter III. For the statistical analysis, the signs of the deflated net spreads were reversed to convert them to future price minus cash price. Cash prices for the years 1927 to 1954 were not directly available from Manderscheid's dissertation. Hence, monthly average cash prices were obtained by reinflating average monthly future prices and adding these to the corresponding average monthly spreads. The cash prices thus obtained were

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[69] Federal Reserve Board of Governors, The Federal Reserve Bulletin, March 1949, pp. 228-37.

then deflated by the Wholesale Price Index before computing interest costs. It should be recognized that the deduction of interest cost from the cash-future spreads, in practice, takes account of variations in interest cost without using up an additional degree of freedom.

Total corn stocks for the United States in all positions quarterly from 1927 to date were obtained from U.S.D.A., Grain and Feed Statistics through 1961[70] and from various issues of the Feed Situation.[71] Published corn stocks for United States in total are not available prior to 1926. Since stocks of corn in interior mills, elevators, and warehouses are not available prior to 1943, the years before 1943 were adjusted to include an approximation of stocks in these positions. Adjustment was made by computing interior mill, elevator and warehouse stocks as a percentage of farm and terminal stocks for the first five years that interior mill, elevator, and warehouse stocks were published. These percentages were averaged for each quarter, and stocks for the earlier years were increased by the corresponding percentages. The adjustments are based on the assumption that the percentage of the total corn supply stored in various positions remained reasonably constant for the period 1927-43. Farm and terminal stocks multiplied by .021 provided an approximation for interior mill, elevator, and warehouse stocks for January 1. For April 1 the adjustment factor was .034; for July 1 it was .043, and for October 1 it was .085.

Stocks of corn under loan and purchase agreements and in CCC inventories quarterly from 1933 to date were obtained directly from the

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[70] Op. cit.

[71] Op. cit.

Agricultural Stabilization and Conservation Service. Commercial stocks of corn were then computed by subtracting total corn stocks under CCC control from total corn stocks in all positions. Commercial stocks thus include stocks of corn on farms. Although farmers probably do not base their stockholding activities on the size of cash-future spreads, it can be seen from the economic relationships presented in the previous chapter that farm storage of corn should be expected to influence present and future supply and demand conditions which in turn influence the cash-future spreads.

The major stocks of other grains are wheat, oats, and barley. These stocks were included in the analysis because they provide an indication of the level of occupation of total available storage facilities. Stocks of rye, sorghum, and other grains were not included since they comprise only a small percentage of the total supply of grains and should be expected to have a very small effect on the supply of storage space available for corn. Stocks of oats and wheat were obtained from the same sources as total corn stocks. Since stocks are not available for interior mills, elevators and warehouses prior to 1943 for oats and prior to 1935 for wheat, only CCC stocks, farm, and terminal stocks were used for these grains. It was assumed in so doing, that stocks of wheat and oats in these positions would be highly correlated with stocks in other positions. Beginning in 1960, all off-farm stocks of both grains except CCC-owned stocks are combined into a single group. Consequently an adjustment was required to obtain the approximate size of stocks held in terminal markets. For each quarter of the last five years that terminal stocks were published, terminal stocks were computed as a percentage of all non-farm and non-CCC stocks. These percentages were averaged by quarter to obtain an approximation of terminal stocks for 1960 to 1963.

In the case of barley stocks, the only published figures available for the years 1927-34 are visible supplies. For this reason, visible supplies of barley were used. They consist of stocks in regularly authorized warehouses at prominent grain centers of the United States east of the Rocky Mountains, including quantities afloat on the Great Lakes and the Barge canal. Here, the assumption was made that visible supplies would be closely correlated with total stocks of barley. Visible supplies were obtained from the Annual Report of the Chicago Board of Trade from 1927 to date. CCC stocks of barley were obtained from the same sources as corn stocks and were added to visible supplies to obtain total stocks of barley. Total supplies of oats, barley, and wheat were then combined into a single variable.

Quarterly domestic and export consumption of corn for grain only was obtained from the same sources as total corn stocks; it is not available prior to 1926. For the analysis, domestic and export consumption were combined into a single variable. It would have been desirable to subtract imports from total consumption; however quarterly imports of corn into United States are not available. This is not a serious limitation since annual imports normally amount to less than 1 per cent of corn production.

Two additional variables were believed to be useful in the analysis. The first of these was production of corn for grain. The second was the number of grain consuming animal units fed annually. Both of these variables were obtained from the same sources as total corn stocks; neither is available quarterly. The number of grain consuming animal units provides an additional measure of the demand for corn, while production provides an additional measure of the total supply.

CHAPTER V

Results of the Analysis

In this chapter the equations used to estimate the cash-future price spreads will be presented for each of the four dates studied. The dates will be referred to as January 1, April 1, July 1, and October 1 since these correspond to the times of the year for which U.S.D.A. stocks data are published. The procedure followed will be to present the equation, the regression coefficients, standard errors of the coefficients, the standard error of estimate, R^2, $\bar{R}$, the degress of freedom, and the simple correlations between the variables.[72] In addition, comparisons will be made of estimated and actual spreads, and the coefficients will be tested for statistical significance with the t test. The reader who is mainly interested in the results of the analysis should turn directly to summaries of the equations for each date. These are presented on pages 89, 102, 112 and 124.

For the first date to be studied, January 1, the variables will be defined and discussed in terms of the reasons for inclusion where these are not apparent from previous chapters. Since the same variables will be used for each of the four dates studied, discussion of the

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[72]The coefficient of multiple determination adjusted for degrees of freedom is $\bar{R}^2$. Its formula is:

$$\bar{R}^2 = 1 - \frac{N - 1}{D.F.} (1 - R^2)$$

where D.F. is the number of observations minus the number of independent variables minus one. The statistic, $\bar{R}$ is the square root of $\bar{R}^2$.

variables will not be repeated for April 1, July 1, or October 1 equations. Equations for January 1 will be identified by the first number, 1. A second number identifies the number of the equation for the date studied. For example, equation 1 - 3 is the third equation for January 1. Even numbered equations are based on the time period 1934 through 1963; odd numbered equations are for the period 1927 through 1963. Equations for April 1 will be identified by the number 2; for July 1 by the number 3; for October 1 by the number 4. Similar notation will be used for the variables. For example, X_{31} refers to the first variable for July 1 equations.

Economic theory and previous work have provided no indications of the appropriate functional forms for the variables. Consequently, functional forms for all variables were selected on the basis of preliminary graphic analysis.

January 1 Equations

Three regression equations were computed for each of the two time periods for January 1. Each set of variables was included in one equation covering the period 1927 through 1963 and in one equation for 1934 through 1963.

Equation 1 - 1. Time period: 1927 - 1963.

$$\hat{Y}_{11} = +34.91 - 106.28 \frac{1}{X_{11}} + 71.56 X_{12} - 61.72 X_{12}^2 + 20.133 X_{12}^3 + 10.07 X_{13} - 0.28 X_{13}^2 + 0.47 X_{14} - 3.92 X_{15}.$$

$R^2 = .72 \quad \bar{R} = +.79 \quad S_{y \,.\, x} = 9.76 \quad D.F. = 22$

Other important statistics of equation 1 - 1 are presented in Table 5.

TABLE 5.--Simple Correlations Between the Variables, Standard Errors and t Values of the Coefficients of Equation 1-1

Variable	Simple Correlation With X_{12}	X_{13}	X_{14}	X_{15}	Y	Standard Error of Coefficients[a]	t Value of Coefficients
X_{11}	-.68	-.68	-.81	-.77	-.26	38.83	-2.74
X_{12}		+.83	+.82	+.91	+.01	15.49	+1.94
X_{13}			+.78	+.80	+.22	62.20	+0.16
X_{14}				+.82	+.22	1.31	+0.36
X_{15}					-.15	0.91	-4.29

[a]The formula for the variance of the coefficients of X_{12} taken as a group was obtained from Dr. L. V. Manderscheid, Department of Agricultural Economics, Michigan State University. Where $S^2_{y.x}$ is the squared standard error of estimate and $C_{i\,j}$ is the i j th element of the inverse sum of squares and cross products matrix,

$$V\ (b_{12} + b_{13} + b_{14}) = S^2_{y.x}\ (C_{22} + C_{33} + C_{44} + 2C_{23} + 2C_{24} + 2C_{34}).$$

The combined standard error of the coefficients is the square root of this formula. The variance of the coefficients of X_{13} taken as a group is:

$$V\ (b_{15} + b_{16}) = S^2_{y.x}\ (C_{55} + C_{66} + 2C_{56}).$$

$\hat{Y}_{11}$ = estimated adjusted December spread. The adjusted spread refers to average monthly spreads (future price minus cash price), deflated, minus interest cost, in cents per bushel.

X_{11} = million bushels of commercial stocks of corn on January 1 divided by million bushels of total corn consumption for the preceding quarter.

X_{12} = million bushels of corn in CCC inventories and under loan and purchase agreements, divided by million bushels of total corn consumption for the preceding quarter.

X_{13} = hundred million bushels of total corn consumption for the quarter following January 1.

X_{14} = hundred million bushels of wheat, oats, and barley stocks.

X_{15} = time in years.

The reasons for dividing commercial and CCC corn stocks by consumption during the previous quarter are twofold. First, current consumption can be considered an indicator of the current supply and demand for corn and is one of the variables affecting the demand for corn storage. In the analysis, consumption in the quarter preceding January 1 was used as current consumption. Stocks were divided by consumption to account for both variables simultaneously. The second reason has been suggested by Telser.[73] He argues that it is not the absolute size of stocks, but their size relative to consumption that determines the marginal convenience yield.

Consumption in the quarter immediately following January 1 was included in the analysis as an indication of future consumption. This provides a measure of expected future corn supply and demand conditions, which, as we have seen previously, also affect the demand for corn storage. Quarterly consumption was selected since expectations regarding future conditions may change considerably within the year. Consumption during the three months immediately following the month in which spreads were observed should provide a more accurate picture of expectations at that time than would be provided by a longer unit of time.

The last variable, X_{15}, was included to capture the effects of changes through time in variables, such as technology, that were not directly measurable. The level of X_{15} was one for 1927, two for 1928, etc. This trend variable was not continued during the years omitted from the analysis.

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[73]Lester G. Telser, "Futures Trading and the Storage of Cotton and Wheat," Op. Cit., p. 250.

From previous chapters it is apparent that the only variables for which we can predict, a priori, the sign of the coefficients are X_{14} and X_{15}. An increase in the stocks of other grains, all other things remaining constant, should decrease the supply of unoccupied storage space, thus increasing the cash-future spread. From previous work by Manderscheid, discussed in the review of literature, we should expect the coefficient of X_{15} to be negative.

Values of t for 22 and 15 degrees of freedom, from a standard table for two-sided tests are as follows:

level of significance	22 degrees of freedom	15 degrees of freedom
10%	1.72	1.75
5%	2.07	2.13
2%	2.51	2.60
1%	2.82	2.95

From Table 5 it can be seen that the coefficient of X_{11} is significantly different from zero at the 2 percent level and the coefficients of X_{12} are significant at the 10 percent level. Since the sign of the coefficient of X_{15} has been predicted in advance, a one-sided test is appropriate for that coefficient. For a one-sided test, the coefficient of X_{15} is significant at the 1 percent level. Coefficients of the other two variables are not significantly different from zero at the 10 percent level. Also, Table 5 indicates that the independent variables are highly intercorrelated. This would tend to increase the standard deviations of the coefficients and consequently would reduce their statistical significance.

Before comparing actual and estimated spreads from equation 1-1, let us examine equation 1-2, which contains the same variables as equation 1-1, but covers a shorter time period.

Equation 1-2. Time Period: 1934 - 1963

$$\hat{Y}_{11} = -52.39 - 77.74 \frac{1}{X_{11}} + 65.52 X_{12} - 47.88 X_{12}^2 + 14.947 X_{12}^3$$

$$+ 23.46 X_{13} - 0.99 X_{13}^2 - 0.29 X_{14} - 4.09 X_{18}.$$

$R^2 = .70$ $\bar{R} = +.74$ $S_{y.x} = 10.57$ D.F. = 15

TABLE 6.--Simple Correlations Between the Variables, Standard Errors, and t Values of the Coefficients of Equation 1-2

Variable	Simple Correlation With X_{12}	X_{13}	X_{14}	X_{18}	Y	Standard Error of Coefficients	t Value of Coefficients
X_{11}	-.60	-.66	-.80	-.68	-.62	46.69	-1.67
X_{12}		+.83	+.81	+.94	+.30	18.68	+1.74
X_{13}			+.78	+.89	+.44	95.45	+0.24
X_{14}				+.89	+.46	2.02	-0.14
X_{18}					+.29	1.68	-2.44

The variable X_{18} is a trend variable beginning in 1934. All other variables in equation 1-2 are the same as those in equation 1-1.

The simple correlations between the independent variables have not been greatly affected by reducing the time period studied from 1927 - 1963 to 1934 - 1963. However, the simple correlations of the independent variables with adjusted cash-futures spreads have been increased considerably. The coefficient of X_{18} is significant at the 2.5 percent level; however none of the other regression coefficients are significantly different from zero at the 10 percent level. This is partly due to a loss of degrees of freedom as compared with equation 1-1. The loss of degrees of freedom also contributed to the reduction of $\bar{R}$ from +.79 in equation 1-1 to +.74 in equation 1-2.

Actual adjusted spreads and spreads estimated with equations 1-1 and 1-2 are compared in Table 7. The range of adjusted December spreads for the period 1927 - 1963 was 71.33 cents; for the 1934 - 1963 period it was 68.27 cents. For 22 out of the 31 years studied, equation 1-1 was in error by 7.51 cents or less. The largest errors were in 1934 and 1949. Errors were also large for the years 1936, 1935, 1928, and 1962. Errors from equation 1-2 were 7.91 cents or less for 13 out of 24 years. The three largest errors were for the years 1934, 1935, and 1936. Large errors were also obtained for 1949, 1950, 1953, 1956, 1959 and 1962.

At least five of the above years were somewhat unusual. The year 1934 was characterized by the beginning of CCC activities, the depression and with it a falling demand for corn, and a large corn crop in 1933. The December 1934 spreads reflected the very short corn crop of 1934 which was caused by the severe drought of that year. In 1949 some readjustment to peacetime conditions was probably still going on. The December 1958 spreads were probably influenced by the removal of acreage allotments on corn in November, 1958. In addition, the year 1962 was somewhat unusual, since an abrupt change in policy permitted CCC to dispose of corn in the domestic market at or below the market price even if the support price was above the market price.

TABLE 7.--Actual Adjusted December Spreads and Spreads Estimated With Equations 1-1 and 1-2

Years	$\hat{Y}_{11}$	$\hat{Y}_{12}$	Y	$Y-\hat{Y}_{11}$	$Y-\hat{Y}_{12}$
1927	+20.33	--	+24.71	+ 4.38	--
1928	+17.62	--	+ 7.25	-10.37	--
1929	+15.05	--	+ 8.77	- 6.28	--
1930	+10.41	--	+ 7.23	- 3.18	--
1931	- 2.63	--	+ 3.86	+ 6.49	--
1932	+15.29	--	+18.72	+ 3.43	--
1933	+16.07	--	+23.58	+ 7.51	--
1934	- 3.32	+ 2.78	+21.65	+24.97	+18.87
1935	-33.20	-34.84	-46.62	-13.42	-11.78
1936	+ 2.46	+ 1.57	-11.03	-13.49	-12.60
1937	-46.00	-46.68	-43.68	+ 2.32	+ 3.00
1938	+ 0.27	- 2.28	+ 2.74	+ 2.47	+ 5.02
1939	+ 1.04	- 1.47	+ 7.05	+ 6.01	+ 8.52
1940	+ 2.60	+ 3.87	+ 5.05	+ 2.45	+ 1.18
1941	- 2.08	- 3.32	- 6.15	- 4.07	- 2.83
1942	+11.31	+12.56	+18.26	+ 6.95	+ 5.70
--	--	--	--	--	--
1949	+ 6.24	+ 3.39	- 8.14	-14.38	-11.53
1950	- 0.23	+ 1.76	- 9.25	- 9.02	-11.01
1951	+ 0.33	+ 2.11	- 5.80	- 6.13	- 7.91
1952	- 5.74	- 1.78	- 9.62	- 3.88	- 7.84
1953	- 3.63	- 5.03	+ 4.97	+ 8.60	+10.00
1954	-11.51	-13.68	- 5.51	+ 6.00	+ 8.17
1955	- 0.19	- 4.21	+ 0.77	+ 0.96	+ 4.98
1956	+ 0.37	- 1.41	+ 7.56	+ 7.19	+ 8.97
1957	+ 3.25	+ 5.54	+ 1.85	- 1.40	- 3.69
1958	- 0.62	+ 0.83	+ 1.00	+ 1.62	+ 0.17
1959	+ 1.21	+ 1.63	- 7.32	- 8.53	- 8.95
1960	+ 4.45	+ 5.98	- 1.50	- 5.95	- 7.48
1961	+13.60	+11.85	+12.46	- 1.14	+ 0.61
1962	- 3.42	- 2.52	+ 5.86	+ 9.28	+ 8.38
1963	- 5.46	- 6.92	- 4.87	+ 0.59	+ 2.05

In view of one of the objectives of the study, let us compare the coefficients of equations 1-1 and 1-2. They are as follows:

	equation 1-1	equation 1-2
b_{11}	-106.28*	-77.74
b_{12}	+ 71.56*	+65.52
b_{13}	- 61.72*	-47.88
b_{14}	+ 20.133*	+14.947
b_{15}	+ 10.07	+23.46
b_{16}	- 0.28	- 0.99
b_{17}	+ 0.47	- 0.29
b_{18}	- 3.92*	- 4.09*

The asterisk indicates that coefficients are significantly different from zero at the 10 percent level of probability. Due to the lack of significance of all the coefficients of equation 1-2 except b_{18} and of three coefficients of equation 1-1, it does not appear worthwhile to test for significant differences between the coefficients of the two equations.

The coefficient of X_{14} in equation 1-1 is positive, as would be expected, while the coefficient of X_{14} in equation 1-2 is negative. In view of the lack of significance of both coefficients, however, this cannot be considered as a contradiction of the theoretical framework of Chapter III.

The independent variables of equations 1-1 and 1-2 are highly intercorrelated. This would tend to increase the standard errors and reduce the significance of the regression coefficients. With this problem in mind, two new variables were used in equations 1-3 and 1-4.

Equation 1-3. Time Period: 1927 - 1963.

$$\hat{Y}_{13} = -426.81 - 113.57 \frac{1}{X_{11}} + 62.93 X_{12} - 72.44 X_{12}^2 + 27.880 X_{12}^3$$

$$+ 347.73 X_{16} - 59.28 X_{16}^2 + 10.21 X_{17} - 2.60 X_{15}. \quad R^2 = .72 \quad \bar{R} = + .79$$

$$S_{y.x} = 9.74 \quad D.F. = 22$$

Other important statistics of equation 1-3 are presented in Table 8.

TABLE 8.--Simple Correlations Between the Variables, Standard Errors, and t Values of the Coefficients of Equation 1-3

Variable	Simple Correlation With X_{12}	X_{16}	X_{17}	X_{15}	Y	Standard Error of Coefficients	t Value of Coefficients
X_{11}	-.68	+.61	-.80	-.77	-.26	39.84	-2.85
X_{12}		-.16	+.79	+.91	+.10	14.46	+1.27
X_{16}			-.49	-.21	-.40	98.33	+2.93
X_{17}				+.78	+.22	22.25	+0.46
X_{15}					-.15	0.92	-2.82

X_{16} = million bushels of corn consumption in the quarter following January 1 divided by ten millions of bushels corn production in the corresponding marketing year.

X_{17} = ten millions of bushels oats, barley, and wheat stocks divided by millions of grain consuming animal units fed annually.

The variable, X_{16} was included to provide a measure of the demand for corn relative to the supply and also as an attempt to reduce the simple correlations with other variables by reducing the correlation of the demand variable with time. The variable, X_{17}, was included in view of the lack of significance of X_{14}, as a measure of the supply of substitutes for corn relative to the demand for feed grains.

Equation 1-3 produced a slight decrease in the standard error of estimate from 9.76 to 9.74 as compared with equation 1-1. The R^2 and $\bar{R}$

were unchanged. The main reductions in intercorrelations were as follows:

equation 1-1	equation 1-3
X_{11} and X_{13} = -.68	X_{11} and X_{16} = +.61
X_{12} and X_{13} = +.83	X_{12} and X_{16} = -.16
X_{13} and X_{14} = +.78	X_{16} and X_{17} = -.49
X_{14} and X_{15} = +.82	X_{17} and X_{15} = +.78
X_{13} and X_{15} = +.80	X_{16} and X_{15} = -.21

From Table 8 it can be seen that the coefficients of X_{11}, X_{16}, and X_{15} in equation 1-3 are significant at the 1 percent level. Coefficients of the other two variables are not significantly different from zero at the 10 percent level.

Now let us turn to equation 1-4, which contains the same variables as equation 1-3, but is based on the shorter time period.

Equation 1-4. Time Period: 1934 - 1963.

$$\hat{Y}_{14} = -476.53 - 108.87 \frac{1}{X_{11}} + 56.35 X_{12} - 76.50 X_{12}^2 + 29.077 X_{12}^3$$

$$+ 369.70 X_{16} - 63.07 X_{16}^2 - 6.38 X_{17} - 1.13 X_{18}.$$

$R^2 = .71 \quad \bar{R} = +.74 \quad S_{y.x} = 10.41 \quad D.F. = 15$

Other important statistics of equation 1-4 are presented in Table 9.

TABLE 9.--Simple Correlations Between the Variables, Standard Errors, and t Values of the Coefficients of Equation 1-4

Variable	Simple Correlation With					Standard Error of Coefficients	t Value of Coefficients
	X_{12}	X_{16}	X_{17}	X_{18}	Y		
X_{11}	-.60	+.67	-.80	-.68	-.62	46.28	-2.35
X_{12}		-.15	+.78	+.94	+.30	17.54	+0.51
X_{16}			-.49	-.23	-.47	93.46	+3.28
X_{17}				+.84	+.44	28.40	-0.23
X_{18}					+.29	1.35	-0.84

From Table 9 it can be seen that the coefficient of X_{11} is significant at the 5 percent level and the coefficients of X_{16} are significant at the 1 percent level. The remaining regression coefficients are not significantly different from zero at the 10 percent level.

Equation 1-4 produced a reduction in the standard error of estimate from 10.57 to 10.41 as compared with equation 1-2. The R^2 and $\bar{R}$ were practically unchanged. The following reductions in intercorrelations were obtained:

equation 1-2	equation 1-4
X_{12} and X_{13} = +.83	X_{12} and X_{16} = -.15
X_{12} and X_{14} = +.81	X_{12} and X_{17} = +.78
X_{13} and X_{14} = +.78	X_{16} and X_{17} = -.49
X_{13} and X_{18} = +.89	X_{16} and X_{18} = -.23
X_{14} and X_{18} = +.89	X_{17} and X_{18} = +.84

Spreads estimated with equations 1-3 and 1-4 are compared with actual adjusted spreads in Table 10. In 20 out of 31 years studied, equation 1-3 was in error by 6.61 cents or less. For the post-war period the largest errors were in the years 1954, 1959, 1962, and 1963. Equation 1-4 was in error by 7.37 cents or less in 19 out of 24 years. The largest error in the post-war period was 8.51 cents in 1951.

TABLE 10.--Actual Adjusted December Spreads and Spreads Estimated With Equations 1-3 and 1-4

Years	$\hat{Y}_{13}$	$\hat{Y}_{14}$	Y	$Y-\hat{Y}_{13}$	$Y-\hat{Y}_{14}$
1927	+15.40	--	+24.71	+ 9.31	--
1928	+ 5.82	--	+ 7.25	+ 1.43	--
1929	+11.41	--	+ 8.77	- 2.64	--
1930	+ 9.56	--	+ 7.23	- 2.33	--
1931	+ 6.01	--	+ 3.86	- 2.15	--
1932	+16.57	--	+18.72	+ 2.15	--
1933	+12.35	--	+23.58	+11.23	--
1934	+ 2.07	- 4.08	+21.65	+19.58	+25.73
1935	-41.73	-44.71	-46.62	- 4.89	- 1.91
1936	+13.21	+ 7.05	-11.03	-24.24	-18.08
1937	-37.07	-37.09	-43.68	- 6.61	- 6.59
1938	+ 4.21	+ 1.52	+ 2.74	- 1.47	+ 1.22
1939	+ 8.31	+ 6.37	+ 7.05	- 1.26	+ 0.68
1940	+ 8.99	+ 8.89	+ 5.05	- 3.94	- 3.84
1941	+ 3.17	+ 0.41	- 6.15	- 9.32	- 6.56
1942	+ 6.07	+ 5.16	+18.26	+12.19	+13.10
--	--	--	--	--	--
1949	- 8.45	- 9.07	- 8.14	+ 0.31	+ 0.93
1950	- 4.93	- 4.10	- 9.25	- 4.32	- 5.15
1951	+ 2.48	+ 2.71	- 5.80	- 8.28	- 8.51
1952	- 8.17	- 4.95	- 9.62	- 1.45	- 4.67
1953	- 1.58	+ 1.96	+ 4.97	+ 6.55	+ 3.01
1954	-15.71	-13.51	- 5.51	+10.20	+ 8.00
1955	+ 2.86	+ 1.28	+ 0.77	- 2.09	- 0.51
1956	+ 3.67	+ 0.19	+ 7.56	+ 3.89	+ 7.37
1957	+ 5.02	+ 2.69	+ 1.85	- 3.17	- 0.84
1958	+ 2.26	+ 1.59	+ 1.00	- 1.26	- 0.59
1959	+ 2.78	- 0.26	- 7.32	-10.10	- 7.06
1960	+ 0.24	+ 1.83	- 1.50	- 1.74	- 3.33
1961	+16.41	+13.67	+12.46	- 3.95	- 1.21
1962	- 3.52	- 0.45	+ 5.86	+ 9.38	+ 6.31
1963	-13.88	- 7.37	- 4.87	+ 9.01	+ 2.50

In view of the lack of significance of the coefficients for X_{17} and the high simple correlations of this variable with other variables, equations 1-5 and 1-6 were computed excluding X_{17}. In omitting X_{17} from the analysis, it should be pointed out that variables in the equation which are highly correlated with X_{17} may carry part of the effect of that variable. This would be reflected by changes in the regression coefficients of the remaining variables.

Equation 1-5. Time Period: 1927 - 1963.

$$\hat{Y}_{15} = -432.79 - 117.16 \frac{1}{X_{11}} + 63.38 X_{12} - 70.47 X_{12}^2 + 26.880 X_{12}^3 + 359.36 X_{16} - 61.51 X_{16}^2 - 2.55 X_{15}.$$

$$R^2 = .72 \quad \bar{R} = +.80 \quad S_{y.x} = 9.57 \quad D.F. = 23$$

Other important statistics of equation 1-5 are presented in Table 11.

TABLE 11.--Standard Errors and t Values of the Coefficients of Equation 1-5

Variable	Standard Error of Coefficients	t Value of Coefficients
X_{11}	38.39	-3.05
X_{12}	13.87	+1.43
X_{16}	94.50	+3.15
X_{15}	0.90	-2.84

Equation 1-5 produced a reduction in the standard error of estimate from 9.74 to 9.57 as compared with equation 1-3. The R^2 remained unchanged; however $\bar{R}$ increased very slightly from +.79 to +.80. From Table 11 it can be seen that the coefficients of X_{11} and X_{16} are significant at the 1 percent level. The coefficient of X_{15} is significant at the 2 percent level, but the coefficients of X_{12} are not significantly different from zero at the 10 percent level. High simple correlations of X_{12} with other variables could, in part, account for the lack of significance of the coefficients of X_{12}.

Equation 1-6. Time Period: 1934 - 1963.

$$\hat{Y}_{16} = -477.01 - 105.96 \frac{1}{X_{11}} + 55.82\, X_{12} - 76.66\, X_{12}^{2} + 29.343\, X_{12}^{3}$$

$$+ 365.71\, X_{16} - 62.29\, X_{16}^{2} - 1.23\, X_{18}.$$

$$R^2 = .71 \quad \bar{R} = +.76 \quad S_{y.x} = 10.10 \quad D.F. = 16.$$

Other important statistics of equation 1-6 are presented in Table 12.

TABLE 12.--Standard Errors and t Values of the Coefficients of Equation 1-6

Variable	Standard Error of Coefficients	t Value to Coefficients
X_{11}	43.09	-2.46
X_{12}	16.92	+0.50
X_{16}	103.87	+2.92
X_{18}	1.24	-0.99

Equation 1-6 produced a reduction in the standard error of estimate from 10.41 to 10.10 as compared with equation 1-4. The coefficient of multiple determination remained unchanged, while the $\bar{R}$ increased from +.74 to +.76. The coefficient of X_{11} in equation 1-6 is significant at the 5 percent level, while the coefficients of X_{16} are significant at the 2 percent level. The coefficients of X_{12} and X_{18} are not significantly different from zero at the 10 percent level. Again the high simple correlation of X_{12} with other variables, especially X_{18}, might account for part of the lack of significance of its coefficients.

Cash-future spreads estimated with equations 1-5 and 1-6 are compared in Table 13. For 20 out of 31 years, equation 1-5 was in error by 6.97 cents or less. For 18 out of 24 years studied, errors from equation 1-6 were 6.70 cents or less. Equation 1-6 provided slightly smaller errors for the post-war years than equation 1-5. The average post-war error from equation 1-6 was 4.00 cents; for equation 1-5, it was 5.19 cents.

TABLE 13.--Actual Adjusted December Spreads and Spread Estimated With Equations 1-5 and 1-6

Years	$\hat{Y}_{15}$	$\hat{Y}_{16}$	Y	$Y-\hat{Y}_{15}$	$Y-\hat{Y}_{16}$
1927	+15.75	--	+24.71	+ 8.96	--
1928	+ 5.78	--	+ 7.25	+ 1.47	--
1929	+10.59	--	+ 8.77	- 1.82	--
1930	+ 9.28	--	+ 7.23	- 2.05	--
1931	+ 5.01	--	+ 3.86	- 1.15	--
1932	+16.22	--	+18.72	+ 2.50	--
1933	+11.80	--	+23.58	+11.78	--
1934	+ 2.77	- 3.86	+21.65	+18.88	+25.51
1935	-41.45	-44.75	-46.62	- 5.17	- 1.87
1936	+12.96	+ 7.62	-11.03	-23.99	-18.65
1937	-36.82	-36.98	-43.68	- 6.86	- 6.70
1938	+ 5.30	+ 1.13	+ 2.74	- 2.56	+ 1.61
1939	+ 9.20	+ 6.05	+ 7.05	- 2.15	+ 1.00
1940	+10.84	+ 7.97	+ 5.05	- 5.79	- 2.92
1941	+ 4.12	+ 0.14	- 6.15	-10.27	- 6.29
1942	+ 5.92	+ 5.18	+18.26	+12.34	+13.08
--	--	--	--	--	--
1949	- 9.12	- 8.83	- 8.14	+ 0.98	+ 0.69
1950	- 4.41	- 4.39	- 9.25	- 4.84	- 4.86
1951	+ 2.42	+ 2.79	- 5.80	- 8.22	- 8.59
1952	- 9.33	- 4.52	- 9.62	- 0.29	- 5.10
1953	- 2.00	+ 1.97	+ 4.97	+ 6.97	+ 3.00
1954	-16.29	-13.35	- 5.51	+10.78	+ 7.84
1955	+ 2.36	+ 1.57	+ 0.77	- 1.59	- 0.80
1956	+ 2.16	+ 1.19	+ 7.56	+ 5.40	+ 6.37
1957	+ 5.76	+ 2.42	+ 1.85	- 3.91	- 0.57
1958	+ 3.31	+ 1.07	+ 1.00	- 2.31	- 0.07
1959	+ 1.46	+ 0.66	- 7.32	- 8.78	- 7.98
1960	+ 1.35	+ 1.15	- 1.50	- 2.85	- 2.65
1961	+15.68	+14.19	+12.46	- 3.22	- 1.73
1962	- 3.45	- 0.60	+ 5.86	+ 9.31	+ 6.46
1963	-13.31	- 8.08	- 4.87	+ 8.44	+ 3.21

The Durbin-Watson test for serial correlation of the residuals was applied to equations 1-5 and 1-6. The statistic,

$$d' = \frac{\sum_{t=2}^{N} (d_t - d_{t-1})^2}{\sum_{t=1}^{N} d_t^2},$$ for equation 1-5 was 1.29; for equation 1-6 it was 1.31. In the formula for d', d_t is the unexplained residual of observation t. For both equations, the results were inconclusive.

Now let us examine the regression coefficients of equations 1-3, 1-4, 1-5, and 1-6. They are as follows:

	equation 1-3	equation 1-4	equation 1-5	equation 1-6
b_{11}	-113.57*	-108.87*	-117.16*	-105.96*
b_{12}	+ 62.93	+ 56.35	+ 63.38	+ 55.82
b_{13}	- 72.44	- 76.50	- 70.47	- 76.66
b_{14}	+27.88	+ 29.08	+ 26.88	+ 29.34
b_{15}	+347.73*	+369.70*	+359.36*	+365.71*
b_{16}	- 59.28*	- 63.07*	- 61.51*	- 62.29*
b_{17}	+ 10.21	- 6.38	not included	not included
b_{18}	- 2.60*	- 1.13	- 2.55*	- 1.23

The asterisk indicates that coefficients are significantly different from zero at the 10 percent level of probability. The variable, X_{17}, has a positive coefficient in equation 1-3 and a negative coefficient in equation 1-5. However, neither coefficient is significantly different from zero, even at the 20 percent level. Consequently this cannot be considered a contradiction of economic theory.

In Chapter III the null hypothesis was advanced that government programs have affected cash-future spreads only through their effects on the demand for corn storage. In Chapter IV it was suggested that if the hypothesis is false, we might expect (1) a significant coefficient for CCC stocks and (2) a significant difference in the corresponding regression coefficients of equations for the two time periods studied. A t test was employed as a partial check on the latter condition. Since X_{11} and X_{16} are the only variables that are significant in the equations for both periods the test was applied only to those two variables.

The formula for the t statistic is:

$$t = \frac{b_1 - b'_1}{S_{b_1 - b'_1}}$$

The denominator of the formula is:

$$S_{b_1 - b'_1} = \sqrt{S^2_{b_1} + S^2_{b'_1} - 2\, S_{b_1 \, b'_1}}$$

In applying the t test, $S_{b_1 \, b'_1}$ was assumed equal to zero. However, since each set of regression equations is based on similar time periods, the covariance of b_1 and b'_1 will tend to be positive. Consequently the t test applied in this manner will give a conservative test of the hypothesis. An approximate formula for the degrees of freedom of the test is given by Walker and Lev.[74]

The t values of differences between the coefficients are as follows:

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[74]Helen M. Walker and Joseph Lev, Statistical Inference, Holt, Rinehart, and Winston; New York, 1953, pp. 157-158.

equations 1-3 and 1-4

coefficients	t values	degrees of freedom
$b_{11} - b'_{11}$	-0.077	51
$b_{15} - b'_{15}$	-0.124	52
$b_{16} - b'_{16}$	+0.124	52
	equations 1-5 and 1-6	
$b_{11} - b'_{11}$	-0.194	52
$b_{15} - b'_{15}$	-0.037	52
$b_{16} - b'_{16}$	+0.027	52

It is apparent that none of the t values are significant even at the very low level of 50 percent, for which t = .68. With this test the hypothesis cannot be rejected; however, it should be recognized that a complete test of the hypothesis was not obtained. In view of the very small t values obtained, the additional computing cost of obtaining a more precise test does not appear to be justified.

Summary of January 1 Equations.--Six equations were computed for January 1. Three of these were based on the observations from 1927 - 1963 and three were based on observations from 1934 - 1963. The coefficients of multiple determination and adjusted multiple correlation coefficients for the equations based on the longer time period in every case were slightly larger than those for the corresponding equations based on the shorter period. Similarly, standard errors of estimate were smaller for equations based on the 1927 - 1963 period than on the 1934 - 1963 period. Simple correlations between independent variables were relatively large for all equations. This could account for the lack of significance of several regression coefficients.

Equation 1-5 had a standard error of estimate of 9.57 cents;

this was the smallest standard error of estimate of the six equations. For 20 out of 31 years studied, estimated spreads from equation 1-5 were in error by 6.97 cents per bushel or less. This should be compared with a range of actual adjusted December spreads of 71.33 cents in the period studied. For the shorter period, the range of actual adjusted December spreads was 68.27 cents. Equation 1-6 was in error by 6.70 cents or less for 18 out of 24 years studied; however, its standard error of estimate was 10.10 cents per bushel.

A t test for significant differences between the coefficients of X_{11} and X_{16} in equations 1-5 and 1-6, assuming $S_{b_1 b_1'}$ equals zero, indicated that differences were not significant even at the 50 percent level. Consequently, the author decided that the extra computational cost of obtaining a more powerful test was not justified. Equation 1-5 would appear to give the best results for predictive purposes, since it has the smallest standard error of estimate of the six equations and its coefficients apparently are not significantly different from those of equation 1-6.

In short, the hypothesis that CCC activities have influenced cash-future price spreads only through their effects on the commercial demand for corn storage was not rejected. Differences between regression coefficients for the two periods were not significant and coefficients of the variable for CCC stocks were not significantly different from zero at the 10 percent level except in equation 1-1. It should be pointed out that significant coefficients for CCC stocks might be obtained even if the only effects of such stocks were on the commercial demand for storage. In addition, an important reason for not obtaining significant differences in regression coefficients for the two periods may be the small number of observations which was available prior to 1934.

In the remainder of this chapter, the results of equations for the other three dates studied will be presented. Assumptions underlying these regression equations will be discussed in a section of the following chapter.

April 1 Equations

Variables used in the April 1 equations are defined in the same way as those for January 1 equations. However, the first subscript, 2, indicates that variables are based on observations for April 1. The cash-future spreads used are March spreads. Corn consumption in the quarter preceding March 1 is used in computing the variable, X_{21} and X_{22}. The variable, X_{23}, is corn consumption in the quarter following April 1; the variable, X_{26}, is corn consumption in the quarter following April 1 divided by corn production in the previous year. Stocks used in X_{21}, X_{22}, X_{24}, and X_{27} are April 1 stocks. The units for all variables are the same as those used in January 1 equations.

Equation 2-1. Time Period: 1927 - 1963.

$$\hat{Y}_{21} = -236.03 - 14.98 \frac{1}{X_{21}} + 29.39 X_{22} - 33.77 X_{22}^2 + 13.964 X_{22}^3$$

$$+ 127.52 X_{23} - 22.55 X_{23}^2 + 1.251 X_{23}^3 + 5.38 X_{24} + 0.03 X_{24}^2$$

$$- 0.011 X_{24}^2 - 1.93 X_{25}.$$

$R^2 = .71 \quad \bar{R} = +.74 \quad S_{y.x} = 10.01 \quad D.F. = 19$

Other important statistics of equation 2-1 are presented in Table 14.

TABLE 14.--Simple Correlations Between the Variables, Standard Errors, and t Values of the Coefficients of Equation 2-1

Variable	Simple Correlation With X_{22}	X_{23}	X_{24}	X_{25}	Y	Standard Error of Coefficients	t Value of Coefficients
X_{21}	-.24	-.18	-.39	-.21	-.41	22.92	-0.66
X_{22}		+.85	+.87	+.89	-.01	11.66	+0.82
X_{23}			+.86	+.85	+.13	63.96	+1.66
X_{24}				+.86	+.16	89.38	+0.06
X_{25}					-.15	0.87	-2.21

Simple correlations of X_{21} with the other independent variables have been reduced considerably as compared with the January 1 equations. However simple correlations between the other independent variables remain high. The coefficient of X_{25} is significant at the 5 percent level; none of the other coefficients are significantly different from zero at the 10 percent level.

Now let us examine equation 2-2 which is based on the 1934-1963 period.

<u>Equation 2-2</u>. Time Period: 1934 - 1963.

$$\hat{Y}_{22} + -285.09 + 0.84 \frac{1}{X_{21}} + 38.50 X_{22} - 43.96 X_{22}^2 + 17.29 X_{22}^3$$

$$+182.15 X_{23} - 29.81 X_{23}^2 + 1.563 X_{23}^3 - 24.14 X_{24} + 2.65 X_{24}^2$$

$$- 0.087 X_{24}^3 - 1.97 X_{28}.$$

$$R^2 = .73 \quad \bar{R} = +.69 \quad S_{y.x} = 10.49 \quad D.F. = 12$$

Other important statistics of equation 2-2 are presented in Table 15.

TABLE 15.--Simple Correlations Between the Variables, Standard Errors, and t Values of the Coefficients of Equation 2-2

Variable	Simple Correlation With X_{22}	X_{23}	X_{24}	X_{28}	Y	Standard Error of Coefficients	t Value of Coefficients
X_{21}	-.23	-.14	-.37	-.16	-.48	30.10	+0.03
X_{22}		+.84	+.88	+.91	+.32	12.96	+0.89
X_{23}			+.86	+.93	+.37	83.46	+1.84
X_{24}				+.92	+.39	110.16	-0.20
X_{28}					+.25	1.72	-1.14

From Table 15 it can be seen that simple correlations between the variables are approximately the same as for equation 2-1. The R^2 is essentially unchanged, while $\bar{R}$ has been decreased and $S_{y.x}$ has been increased as compared with the 1927-1963 period. At the 10 percent level only the coefficients of X_{23} are significant.

Actual adjusted March spreads and spreads estimated with equations 2-1 and 2-2 are compared in Table 16. For the 1927-1963 period the range of actual adjusted March spreads was 73.26 cents. For the shorter period the range was 65.77 cents. Spreads estimated with equation 2-1 were in error by 10.16 cents or less for 24 out of 31 years studied. For 18 out of 24 years, estimate from equation 2-2 were in error by 7.37 cents or less.

TABLE 16.--Actual Adjusted March Spreads and Spreads Estimated With Equations 2-1 and 2-2

Years	$\hat{Y}_{21}$	$\hat{Y}_{22}$	Y	$Y-\hat{Y}_{21}$	$Y-\hat{Y}_{22}$
1927	+14.50	--	+21.12	+ 6.62	--
1928	+ 4.46	--	- 0.78	- 5.24	--
1929	+12.91	--	+ 2.75	-10.16	--
1930	+ 8.92	--	+ 4.18	- 4.74	--
1931	+ 1.02	--	+ 2.48	+ 1.46	--
1932	+ 8.40	--	+22.82	+14.42	--
1933	+12.35	--	+12.71	+ 0.36	--
1934	+ 0.77	+ 7.84	+15.09	+14.32	+ 7.25
1935	-43.49	-44.78	-39.78	+ 3.71	+ 5.00
1936	+ 0.32	- 2.63	- 6.41	- 6.73	- 3.78
1937	-38.70	-37.89	-50.44	-11.74	-12.55
1938	- 1.71	- 2.67	+ 3.18	+ 4.89	+ 5.85
1939	+ 1.02	- 7.54	+ 4.70	+ 3.68	+12.24
1940	- 1.31	+ 1.55	+ 1.49	+ 2.80	- 0.06
1941	+ 5.73	+ 3.38	- 6.86	-12.59	-10.24
1942	+ 1.62	+ 2.92	+15.33	+13.71	+12.41
--	--	--	--	--	--
1949	+ 2.47	+ 0.34	-17.19	-19.66	-17.53
1950	- 2.53	- 1.73	-13.63	-11.10	-11.90
1951	- 3.95	- 3.42	- 2.74	+ 1.21	+ 0.68
1952	-10.12	- 6.56	- 6.54	+ 3.58	+ 0.02
1953	- 4.35	- 5.28	- 0.52	+ 3.83	+ 4.76
1954	- 4.89	- 5.19	- 5.44	- 0.55	- 0.25
1955	- 0.69	- 1.83	- 5.42	- 4.73	- 3.59
1956	- 1.07	- 0.05	+ 2.85	+ 3.92	+ 2.90
1957	- 4.36	- 3.43	+ 2.61	+ 6.97	+ 6.04
1958	- 4.70	- 4.97	- 3.95	+ 0.75	+ 1.02
1959	-10.47	-10.68	- 8.10	+ 2.37	+ 2.58
1960	- 8.49	- 9.61	- 3.68	+ 4.81	+ 5.93
1961	+13.02	+13.43	+ 6.06	- 6.96	- 7.37
1962	+ 1.01	+ 0.13	+ 1.20	+ 0.19	+ 1.07
1963	- 6.40	- 5.32	- 5.79	+ 0.61	- 0.47

In view of the lack of significance of the coefficients of X_{24} and the high simple correlations of this variable with other independent variable, equation 2-3 and 2-4 were computed excluding X_{24}.

<u>Equation 2-3</u>. Time Period: 1927 - 1963.

$$\hat{Y}_{23} = -235.41 - 30.70 \frac{1}{X_{21}} + 15.61 X_{22} - 17.89 X_{22}^2 + 9.142 X_{22}^3$$
$$+ 144.82 X_{23} - 24.63 X_{23}^2 + 1.334 X_{23}^3 - 1.44 X_{25}.$$

$R^2 = .66$ $\bar{R} = +.73$ $S_{y.x} = 10.04$ D.F. = 22

Other important statistics of equation 2-3 are presented in Table 17.

TABLE 17.--Standard Errors and t Values of the Coefficients of Equation 2-3

Variable	Standard Error of Coefficients	t Value of Coefficients
X_{21}	20.81	-1.48
X_{22}	11.56	+0.59
X_{23}	88.89	+3.13
X_{25}	0.77	-1.86

As compared with equation 2-1, the R^2 was reduced slightly, but both $\bar{R}$ and $S_{y.x}$ were essentially unchanged. The standard errors of all coefficients have been reduced. The coefficients of X_{23} are significant at the 1 percent level; those of X_{25} are significant at the 5 percent level. None of the other coefficients are significant at the 10 percent level.

Now let us turn to equation 2-4 which is based on the 1934-1963 period.

<u>Equation 2-4</u>. Time Period: 1934 - 1963.

$$\hat{Y}_{24} = -298.29 + 0.62 \frac{1}{X_{21}} + 32.22 X_{22} - 35.16 X_{22}^2 + 14.143 X_{22}^3$$
$$+ 153.81 X_{23} - 25.26 X_{23}^2 + 1.328 X_{23}^3 - 1.43 X_{28}.$$

$R^2 = .71$ $\bar{R} = +.75$ $S_{y.x} = 9.62$ D.F. = 15

Other important statistics of equation 2-4 are presented in Table 18.

TABLE 18.--Standard Errors and t Values of the Coefficients of Equation 2-4

Variable	Standard Errors of Coefficients	t value of Coefficients
X_{21}	24.90	+0.02
X_{22}	11.83	+0.95
X_{23}	39.07	+3.33
X_{28}	1.15	-1.25

As compared with equation 2-2, the R^2 is essentially unchanged, while the $\bar{R}$ has been increased and $S_{y.x}$ has been reduced. The standard errors of all coefficients have been reduced by omitting X_{24}. The coefficients of X_{23} are significant at the 1 percent level; none of the other coefficients are significant at the 10 percent level.

Spreads estimated with equations 2-3 and 2-4 are compared in Table 19. Spreads estimated with equation 2-3 were in error by 9.20 cents or less for 23 out of 31 years studied. Equation 2-4 was in error by 9.60 cents or less for 18 out of 24 years.

TABLE 19.--Actual Adjusted March Spreads and Spreads Estimated With Equation 2-3 and 2-4

Years	$\hat{Y}_{23}$	$\hat{Y}_{24}$	Y	$Y-\hat{Y}_{23}$	$Y-\hat{Y}_{24}$
1927	+18.18	--	+21.12	+ 2.94	--
1928	+ 8.42	--	- 0.78	- 9.20	--
1929	+ 8.63	--	+ 2.75	- 5.88	--
1930	+ 6.47	--	+ 4.18	- 2.29	--
1931	- 8.83	--	+ 2.48	+11.31	--
1932	+ 4.44	--	+22.82	+18.38	--
1933	+12.39	--	+12.71	+ 0.32	--
1934	+ 3.93	+ 4.74	+15.09	+11.16	+10.35
1935	-40.89	-46.02	-39.78	+ 1.11	+ 6.24
1936	+ 1.26	- 1.76	- 6.41	- 7.67	- 4.65
1937	-35.88	-37.42	-50.44	-14.56	-13.02
1938	+ 6.21	- 1.65	+ 3.18	- 3.03	+ 4.83
1939	+ 0.68	- 4.90	+ 4.70	+ 4.02	+ 9.60
1940	+ 2.75	+ 3.19	+ 1.49	- 1.26	- 1.70
1941	+ 5.74	+ 4.51	- 6.86	-12.60	-11.37
1942	- 2.58	+ 0.77	+15.33	+17.91	+14.56
--	--	--	--	--	--
1949	+ 2.14	- 1.23	-17.19	-19.33	-15.96
1950	- 1.19	+ 0.33	-13.63	-12.44	-13.96
1951	- 5.00	- 4.12	- 2.74	+ 2.26	+ 1.38
1952	-11.52	- 4.54	- 6.54	+ 4.98	- 2.00
1953	- 4.79	- 4.63	- 0.52	+ 4.27	+ 4.11
1954	- 5.43	- 6.06	- 5.44	- 0.01	+ 0.62
1955	- 2.50	- 5.14	- 5.42	- 2.92	- 0.28
1956	- 3.80	- 2.98	+ 2.85	+ 6.65	+ 5.83
1957	- 3.63	- 1.83	+ 2.61	+ 6.24	+ 4.44
1958	- 2.99	- 3.79	- 3.95	- 0.96	- 0.16
1959	-10.06	-10.00	- 8.10	+ 1.96	+ 1.90
1960	- 7.10	- 8.13	- 3.68	+ 3.42	+ 4.46
1961	+11.48	+12.29	+ 6.06	- 5.42	- 6.23
1962	+ 1.76	- 0.51	+ 1.20	- 0.56	+ 1.71
1963	- 6.98	- 5.13	- 5.79	+ 1.19	- 0.66

In view of the null hypothesis to be tested, let us examine the coefficients of equations 2-1, 2-2, 2-3, and 2-4. They are as follows:

	equation 2-1	equation 2-2	equation 2-3	equation 2-4
b_{21}	- 14.98	+ 0.84	- 30.70	+ 0.62
b_{22}	+ 29.39	+ 38.50	+ 15.61	+ 32.22
b_{23}	- 33.77	- 43.96	- 17.89	- 35.16
b_{24}	+ 13.964	+ 17.029	+ 9.142	+ 14.143
b_{25}	+127.52	+182.15*	+144.82*	+153.81*
b_{26}	- 22.55	- 29.81*	- 24.63*	- 25.26*
b_{27}	+ 1.251	+ 1.563*	+ 1.334*	+ 1.328*
b_{28}	+ 5.38	- 24.14	not included	not included
b_{29}	+ 0.03	+ 2.65	not included	not included
b_{210}	- 0.011	- 0.087	not included	not included
b_{211}	- 1.93*	- 1.97	- 1.44*	- 1.43

The asterisk indicates that coefficients are significant at the 10 percent level. The t test was used as a partial check for significant differences in the coefficients, b_{25}, b_{26}, and b_{27}, in equations 2-3 and 2-4. Differences were not significant even at the 50 percent level of probability.

Two additional equations were computed for April 1, using the variables X_{26} and X_{27} in place of X_{23} and X_{24} in an attempt to reduce simple correlations between the independent variables. The variable, X_{26}, is corn consumption in the quarter following April 1 divided by corn production in the preceding year; the variable, X_{27}, is stocks of other grains divided by the number of grain consuming animal units fed annually.

Equation 2-5. Time Period: 1927 - 1963.

$$\hat{Y}_{25} = +35.42 - 13.45 \frac{1}{X_{21}} + 58.12 X_{22} - 55.22 X_{22}^2 + 18.670 X_{22}^3$$
$$- 125.32 X_{26} + 33.54 X_{26}^2 + 357.34 X_{27} - 243.99 X_{27}^2 - 2.95 X_{25}.$$

$R^2 = .56 \quad \bar{R} = +.60 \quad S_{y.x} = 11.77 \quad D.F. = 21$

Other important statistics of equation 2-3 are presented in Table 20.

TABLE 20.--Simple Correlations Between the Variables, Standard Errors, and t Values of the Coefficients of Equation 2-5

Variable	Simple Correlation With X_{22}	X_{26}	X_{27}	X_{25}	Y	Standard Error of Coefficients	t Value of Coefficients
X_{21}	-.24	+.42	-.40	-.21	-.41	27.36	-1.69
X_{22}		+.44	+.86	+.92	-.01	13.24	+1.63
X_{26}			+.26	+.50	-.33	124.96	-0.73
X_{27}				+.84	+.16	37.63	+3.01
X_{25}					-.15	0.95	-3.10

As compared with equation 2-1, simple correlations between the independent variable have been reduced considerably. At the same time the R^2 has been reduced from .71 to .56 and $\bar{R}$ has been reduced from +.74 to +.60. The $S_{y.x}$ has been increased from 10.01 to 11.77.

In general, we might expect an increase in X_{27}, stocks of other grains divided by the number of grain consuming animal units, would increase spreads. The reasoning behind this is that an increase in the supply of substitutes for corn relative to the demand would shift the demand for corn to the left, thus lowering the cash price relative to the future price. Consequently, a one-sided t test could be used for the coefficients of X_{27}. However, in view of the functional form used for X_{27}, a two-sided test was applied. With a two-sided test, the coefficients of X_{27} are significant at the 1 percent level. The coefficient of X_{25} is significant at the 1 percent level; none of the other coefficients are significant at the 10 percent level.

Now let us turn to equation 2-6 which is based on the 1934-1963 period.

Equation 2-6. Time Period: 1934 - 1963.

$$\hat{Y}_{26} = -49.39 + 5.33 \frac{1}{X_{21}} + 67.28 X_{22} - 67.92 X_{22}^2 + 22.267 X_{22}^3$$
$$- 83.43 X_{26} + 22.22 X_{26}^2 + 383.99 X_{27} - 264.75 X_{27}^2 - 2.47 X_{28}.$$

$R^2 = .55 \quad \bar{R} = +.52 \quad S_{y.x} = 12.44 \quad D.F. = 14$

Other important statistics of equation 2-6 are presented in Table 21.

TABLE 21.--Simple Correlations Between the Variables, Standard Errors, and t Values of the Coefficients of Equation 2-6

Variable	Simple Correlation With X_{22}	X_{26}	X_{27}	X_{28}	Y	Standard Errors of Coefficients	t Values of Coefficients
X_{21}	-.23	+.56	-.37	-.16	-.48	38.83	+0.14
X_{22}		+.32	+.87	+.91	+.32	15.06	+1.44
X_{26}			+.19	+.41	-.21	153.71	-0.40
X_{27}				+.89	+.38	61.23	+1.95
X_{28}					+.25	1.61	-1.53

As compared with equation 2-2, simple correlations between the variables have been reduced considerably. At the same time the R^2 has been reduced from .73 to .55 and $\bar{R}$ has been reduced from +.69 to +.52. The $S_{y.x}$ has been increased from 10.49 to 12.44. Only the coefficients of X_{27} in equation 2-6 are significant at the 10 percent level.

Actual adjusted March spreads and spreads estimated with equations 2-5 and 2-6 are compared in Table 22. Spreads estimated with equation 2-5 are in error by 9.22 cents or less for 21 out of 31 years studied. Equation 2-6 was in error by 9.60 cents or less for 17 out of 24 years.

TABLE 22.--Actual Adjusted March Spreads and Spreads Estimated With Equations 2-5 and 2-6

Years	$\hat{Y}_{25}$	$\hat{Y}_{26}$	Y	$Y-\hat{Y}_{25}$	$Y-\hat{Y}_{26}$
1927	+ 9.80	--	+21.12	+11.32	--
1928	- 7.12	--	- 0.78	+ 6.34	--
1929	+13.71	--	+ 2.75	-10.96	--
1930	+ 6.80	--	+ 4.18	- 2.62	--
1931	+11.54	--	+ 2.48	- 9.06	--
1932	+ 7.50	--	+22.82	+15.30	--
1933	+11.49	--	+12.71	+ 1.22	--
1934	+ 2.46	+ 1.09	+15.09	+12.63	+14.00
1935	-32.11	-35.88	-39.78	- 7.67	- 3.90
1936	+ 1.25	- 1.30	- 6.41	- 7.66	- 5.11
1937	-33.72	-35.10	-50.44	-16.72	-15.34
1938	-12.05	-16.91	+ 3.18	+15.23	+20.09
1939	+ 1.22	- 1.23	+ 4.70	+ 3.48	+ 5.93
1940	- 7.38	- 8.11	+ 1.49	+ 8.87	+ 9.60
1941	+ 6.48	+ 3.76	- 6.86	-13.34	-10.62
1942	+ 0.52	+ 0.85	+15.33	+14.81	+14.48
--	--	--	--	--	--
1949	+ 4.03	+ 2.78	-17.19	-21.22	-19.97
1950	- 1.87	- 1.89	-13.63	-11.76	-11.74
1951	+ 3.32	+ 3.56	- 2.74	- 6.06	- 6.30
1952	-10.77	- 4.82	- 6.54	+ 4.23	- 1.72
1953	- 4.30	- 1.78	- 0.52	+ 3.78	+ 1.26
1954	- 0.94	- 0.99	- 5.44	- 4.50	- 4.45
1955	- 2.31	- 3.20	- 5.42	- 3.11	- 2.22
1956	- 6.04	- 5.69	+ 2.85	+ 8.89	+ 8.54
1957	- 2.32	- 1.53	+ 2.61	+ 4.93	+ 4.14
1958	+ 5.12	+ 2.63	- 3.95	- 9.07	- 6.58
1959	- 4.78	- 6.33	- 8.10	- 3.32	- 1.77
1960	- 6.31	- 5.45	- 3.68	+ 2.63	+ 1.77
1961	+ 7.99	+ 9.13	+ 6.06	- 1.93	- 3.07
1962	- 4.91	- 5.76	+ 1.20	+ 6.11	+ 6.96
1963	-15.01	-11.79	- 5.79	+ 9.22	+ 6.00

The Durbin-Watson test for serial correlation of the residuals was applied to equations 2-3 and 2-4. For both equations the results were inconclusive.

Now let us examine the coefficients of equations 2-3 and 2-4. They are as follows:

	equation 2-5	equation 2-6
b_{21}	- 13.45	+ 5.33
b_{22}	+ 58.12	+ 67.28
b_{23}	- 55.22	- 67.92
b_{24}	+ 18.670	+ 22.267
b_{25}	-125.32	- 83.43
b_{26}	+ 33.54	+ 22.22
b_{27}	+357.34*	+383.99*
b_{28}	-243.99*	-264.75*
b_{29}	- 2.95*	- 2.47

The asterisk indicates that coefficients are significant at the 10 percent level. The t test was used as a partial test for significant differences in the coefficients, b_{27} and b_{28}, for the two equations. Differences were not significant even at the 50 percent level.

Summary of April 1 Equations.--Three pairs of equations were computed for April 1. In two of the three pairs, the equation for the longer period provided a larger $\bar{R}$, essentially the same R^2 and a smaller $S_{y.x}$ than the equation for the 1934-1963 period. In the remaining pair, the equation for the 1934-1963 period provided a larger R^2, essentially the same $\bar{R}$, and a slightly smaller $S_{y.x}$ than the equation for the 1927-1963 period. Simple correlations between the independent variables were relatively large and could account for the lack of significance of several coefficients.

For predictive purposes, equation 2-1, based on the 1927-1963 period would appear to give the best results of the April 1 equations.

Coefficients of the variable for CCC corn stocks were not significant at the 10 percent level in any of the six equations. In addition, differences in the corresponding regression coefficients of equations for the two periods were apparently not significant at the 50 percent level. In short, the equations provided no evidence that CCC activities have affected the commercial supply of corn storage for April 1; consequently the null hypothesis was not rejected.

July 1 Equations

Four regression equations were computed for July 1. Variables in these equations are defined in the same manner as those for January 1 equations. However, the first subscript of the variables, 3, indicates that they are based on observations for July 1. The cash-future spreads used for July 1 are June spreads. The variable, X_{33}, represents corn consumption in the quarter following July 1; consumption used in computing variables X_{31} and X_{32} is consumption in the quarter preceding July 1. The variable, X_{36}, is corn consumption in the quarter following July 1 divided by production for the preceding year. Stocks used in computing the variables X_{31}, X_{32}, X_{34}, and X_{37} are July 1 stocks. The units used for all variables are the same as those used in January 1 equations.

Equation 3-1. Time Period: 1927 - 1962.

$$\hat{Y}_{31} = -67.60 - 5.11 \frac{1}{X_{31}} + 22.99 X_{32} - 30.95 X_{32}^2 + 9.503 X_{32}^3$$

$$+ 48.10 X_{33} - 9.98 X_{33}^2 + 0.646 X_{33}^3 + 3.05 X_{34} - 1.22 X_{35}.$$

$R^2 = .83 \quad \bar{R} = +.87 \quad S_{y.x} = 5.20 \quad D.F. = 20$

Other important statistics of equation 3-1 are presented in Table 23.

TABLE 23.--Simple Correlations Between the Variables, Standard Errors, and t Values of the Coefficients of Equation 3-1

Variable	Simple Correlation With X_{32}	X_{33}	X_{34}	X_{35}	Y	Standard Error of Coefficients	t Value of Coefficients
X_{31}	+.05	-.08	-.09	-.02	-.61	6.86	-0.75
X_{32}		+.89	+.88	+.92	+.03	4.71	+0.33
X_{33}			+.91	+.92	+.19	10.95	+3.54
X_{34}				+.87	+.23	1.12	+2.73
X_{35}					-.04	0.42	-2.91

Simple correlations between the variables X_{32}, X_{33}, X_{34}, and X_{35} are high. In spite of this, the coefficients of X_{33} are significantly different from zero at the 1 percent level. With a one-sided test, the coefficients of X_{34} and X_{35} are also significant at the 1 percent level; however, coefficients of the other two variables are not significant at the 10 percent level.

Before comparing actual and estimated spreads from equation 3-1, let us turn to equation 3-2, based on the shorter time period.

Equation 3-2. Time Period: 1934 - 1962

$$\hat{Y}_{32} = -102.21 + 3.75 \frac{1}{X_{31}} + 20.89 X_{32} - 28.39 X_{32} + 8.929 X_{32}$$

$$+ 61.26 X_{33} - 12.22 X_{33} + 0.775 X_{33} + 2.75 X_{34} - 1.69 X_{38}.$$

$R^2 = .83 \quad \bar{R} = +.84 \quad S_{y.x} = 5.63 \quad D.F. = 13$

Other important statistics of equation 3-2 are presented in Table 24.

TABLE 24.--Simple Correlations Between the Variables, Standard Errors, and t Values of the Coefficients of Equation 3-2

Variable	Simple Correlation With X_{32}	X_{33}	X_{34}	X_{38}	Y	Standard Error of Coefficients	t Value of Coefficients
X_{31}	-.02	-.13	-.09	-.05	-.56	11.05	+0.34
X_{32}		+.87	+.90	+.90	+.30	5.81	+0.25
X_{33}			+.91	+.97	+.38	18.49	+2.69
X_{34}				+.94	+.41	1.53	+1.80
X_{38}					+.28	0.97	-1.73

When compared with equation 3-1, the R^2 of equation 3-2 is unchanged, while $\bar{R}$ has been reduced slightly, from +.87 to +.84, and $S_{y.x}$ has been increased from 5.20 to 5.63. Simple correlations of X_{32}, X_{33}, X_{34}, and X_{35} with Y have been increased considerably; however, simple correlations between these variables remain high. The coefficients of X_{33} are significant at the 5 percent level, while those of X_{34} and X_{38} are significant at the 10 percent level.

Cash-future spreads estimated with equations 3-1 and 3-2 are compared in Table 25. The range of actual adjusted June spreads for the 1927 through 1962 period was 55.56 cents; for 1934 through 1962 it was 49.81 cents. For 25 out of 30 years studied, equation 3-1 was in error by 4.97 cents or less. Equation 3-2 was in error by 3.30 cents or less for 16 out of 23 years.

TABLE 25.--Actual Adjusted June Spreads and Spreads Estimated With Equations 3-1 and 3-2

Years	$\hat{Y}_{31}$	$\hat{Y}_{32}$	Y	$Y-\hat{Y}_{31}$	$Y-\hat{Y}_{32}$
1927	+ 3.22	--	+ 5.37	+ 2.15	--
1928	- 8.53	--	-10.21	- 1.68	--
1929	+ 2.73	--	- 3.60	- 6.33	--
1930	- 3.68	--	- 5.34	- 1.66	--
1931	-11.88	--	-10.74	+ 1.14	--
1932	+ 4.46	--	+ 3.78	- 0.68	--
1933	+ 6.61	--	+13.54	+ 6.93	--
1934	-11.22	- 8.85	- 3.08	+ 8.14	+ 5.77
1935	-24.66	-25.28	-26.29	- 1.63	- 1.01
1936	- 8.11	- 7.14	-10.01	- 1.90	- 2.87
1937	-39.41	-39.01	-42.02	- 2.61	- 3.01
1938	- 2.86	- 3.39	+ 1.44	+ 4.30	+ 4.83
1939	+ 0.12	- 2.46	- 1.57	- 1.69	+ 0.89
1940	-10.56	-10.41	-13.71	- 3.15	- 3.30
1941	- 2.52	- 2.20	+ 2.45	+ 4.97	+ 4.65
1942	+ 5.13	+ 4.97	+ 7.79	+ 2.66	+ 2.82
--	--	--	--	--	--
1949	- 3.15	- 3.09	-16.86	-13.71	-13.77
1950	-12.86	-10.34	- 8.01	+ 4.85	+ 2.33
1951	- 5.47	- 5.68	- 6.55	- 1.08	- 0.87
1952	- 6.77	- 7.13	- 4.65	+ 2.12	+ 2.48
1953	- 8.59	- 9.48	- 9.76	- 1.17	- 0.28
1954	- 8.69	- 7.72	-12.47	- 3.78	- 4.75
1955	- 8.37	-10.29	- 9.59	- 1.22	+ 0.70
1956	- 6.65	- 6.63	- 7.66	- 1.01	- 1.03
1957	- 7.09	- 7.12	- 4.92	+ 2.17	+ 2.20
1958	-14.01	-13.62	-11.69	+ 2.32	+ 1.93
1959	-11.24	-12.18	-10.27	+ 0.97	+ 1.91
1960	- 9.22	- 9.51	- 4.79	+ 4.43	+ 4.72
1961	+ 9.91	+10.32	+ 4.50	- 5.41	- 5.82
1962	- 4.60	- 4.50	- 3.02	+ 1.58	+ 1.48

In equations 3-3 and 3-4, the variables X_{36} and X_{37} were included in place of X_{33} and X_{34} in an attempt to reduce the simple correlations between the independent variables. The variable, X_{36}, is corn consumption in the quarter following July 1 divided by corn production in the preceding year; the variable, X_{27}, is stocks of other grains divided by the number of grain consuming animal units fed annually.

Equation 3-3. Time Period: 1927 - 1962.

$$\hat{Y}_{33} = +9.77 - 19.54 \frac{1}{X_{31}} + 44.19 X_{32} - 51.94 X_{32}^2 + 15.082 X_{32}^3$$

$$- 6.66 X_{36} + 6.37 X_{36}^2 + 6.00 X_{37} - 1.64 X_{35}.$$

$R^2 = .68$ $\bar{R} = +.75$ $S_{y.x} = 6.92$ D.F. = 21

Other important statistics of equation 3-3 are presented in Table 26.

TABLE 26.--Simple Correlations Between the Variables, Standard Errors, and t Values of the Coefficients of Equation 3-3

Variable	Simple Correlation With X_{32}	X_{36}	X_{37}	X_{35}	Y	Standard Error of Coefficients	t Value of Coefficients
X_{31}	+.05	-.10	-.08	+.02	-.61	7.97	-2.45
X_{32}		+.84	+.88	+.92	+.03	5.71	+1.28
X_{36}			+.82	+.91	+.09	26.02	-0.01
X_{37}				+.86	+.22	2.60	+2.31
X_{35}					-.04	0.60	-2.74

Simple correlations between the independent variables have been changed very little as compared with equation 3-1. However, the R^2 has been reduced from .83 to .68; $\bar{R}$ has been reduced from +.87 to +.75; $S_{y.x}$ has been increased from 5.20 to 6.92. The coefficient of X_{37} is significant at the 2.5 percent level; the coefficient of X_{35} is significant at the 1 percent level; the coefficient of X_{31} is significant at the 5 percent level. Coefficients of the other two variables are not significantly different from zero at the 10 percent level. The increased t value of the coefficient of X_{31} is due mainly to an increase in the absolute size of the coefficient from 5.11 in equation 3-1 to 19.54 in equation 3-3. This increase may indicate that part of the effect attributed to X_{33}^3 and other variables in equation 3-1 is now being associated with X_{31}.

Now let us examine equation 3-4, which contains the same variables as equation 3-3 but is based on the shorter time period.

Equation 3-4. Time Period: 1934 - 1962.

$$\hat{Y}_{34} = +15.69 - 19.43 \frac{1}{X_{31}} + 47.53\ X_{32} - 55.58\ X_{32}^2 + 15.762\ X_{32}^3$$

$$- 29.94\ X_{36} + 11.33\ X_{36} + 5.47\ X_{37} - 0.89\ X_{38}.$$

$R^2 = .69 \quad \bar{R} = +.72 \quad S_{y.x} = 7.22 \quad$ D.F. = 14

Other important statistics of equation 3-4 are presented in Table 27.

TABLE 27.--Simple Correlations Between the Variables, Standard Errors, and t Values of the Coefficients of Equation 3-4

	Simple Correlation With					Standard	t Value
Variable	X_{32}	X_{36}	X_{37}	X_{38}	Y	Error of Coefficients	of Coefficients
X_{31}	-.02	-.16	-.07	-.05	-.56	9.48	-2.05
X_{32}		+.77	+.90	+.90	+.30	6.71	+1.15
X_{36}			+.82	+.91	+.29	31.36	-0.60
X_{37}				+.92	+.39	3.08	+1.78
X_{38}					+.28	0.95	-0.93

Simple correlations between the variables have not been greatly changed as compared with equation 3-2. The R^2, however, has been reduced from .83 to .69; the $\bar{R}$ has been reduced from +.84 to +.72; the $S_{y.x}$ has been increased from 5.63 to 7.22. As in equation 3-3, the absolute size of the coefficient of X_{31} has been increased. In addition, its sign has been changed from positive in equation 3-2 to negative in equation 3-4, and its standard error has been decreased from 11.05 to 9.48. Here again, the change in the size of the coefficient may indicate that X_{31} is carrying part of the effect associated with other variables in equation 3-2. In equation 3-4, only the coefficients of X_{31} and X_{37} are significantly different from zero at the 10 percent level.

Cash-future spreads estimated with equations 3-3 and 3-4 are compared in Table 28. For 20 out of 30 years studied, errors from equation 3-3 were 5.95 cents or less. Equation 3-4 was in error by 5.26 cents or less for 15 out of 23 years.

The Durbin-Watson statistic, d', for equation 3-1 was 2.74; for equation 3-2, it was 3.29. Tables for interpreting d' for several sample sizes and for k' ranging from one to five, where k' is the number of independent variables in the equation, are given by Friedman and Foote.[75] However, neither Friedman and Foote nor the original article by Durbin and Watson provide tables for k' = 9.[76] Consequently, the author used a linear extrapolation of the tabled values to k' = 9 testing the d of equation 3-2. The approximate rejection regions for testing the hypothesis of no serial correlation in the residuals were $4\text{-}d' < 0.48$ and $d' < 0.48$. Since the observed values of 4-d' and d' were not near the rejection region, it appears correct to assume d' falls in the inconclusive range. For equation 3-1, the d' was in the inconclusive range for k' = 5; hence it would also be in the inconclusive range for k' = 9.

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[75] Joan Friedman and Richard J. Foote, Computational Methods for Handling Systems of Simultaneous Equations, U.S.D.A. Agriculture Handbook 94; Washington, D.C., 1955, pp. 77-78.

[76] J. Durbin and G. S. Watson, "Testing for Serial Correlation in Least Squares Regression," Biometrika, 1951, Vol. 38, p. 174.

TABLE 28.--Actual Adjusted June Spreads and Spreads Estimated With Equations 3-3 and 3-4

Years	$\hat{Y}_{33}$	$\hat{Y}_{34}$	Y	$Y-\hat{Y}_{33}$	$Y-\hat{Y}_{34}$
1927	+ 1.60	--	+ 5.37	+ 3.77	--
1928	-14.48	--	-10.21	+ 4.27	--
1929	- 0.37	--	- 3.60	- 3.23	--
1930	- 5.49	--	- 5.34	+ 0.15	--
1931	- 1.71	--	-10.74	- 9.03	--
1932	+ 3.73	--	+ 3.78	+ 0.05	--
1933	+ 3.89	--	+13.54	+ 9.65	--
1934	- 7.40	- 6.53	- 3.08	+ 4.32	+ 3.45
1935	-17.67	-22.40	-26.29	- 8.62	- 3.89
1936	-10.24	-11.99	-10.01	+ 0.23	+ 1.98
1937	-36.70	-35.15	-42.02	- 5.32	- 6.87
1938	- 5.77	- 7.06	+ 1.44	+ 7.21	+ 8.50
1939	+ 3.17	+ 3.05	- 1.57	- 4.74	- 4.62
1940	-14.63	-13.58	-13.71	+ 0.92	- 0.13
1941	- 5.82	- 6.79	+ 2.45	+ 8.27	+ 9.24
1942	- 0.22	- 0.57	+ 7.79	+ 8.01	+ 8.36
--	--	--	--	--	--
1949	- 5.48	- 4.34	-16.86	-11.38	-12.52
1950	-12.64	-14.95	- 8.01	+ 4.63	+ 6.94
1951	- 0.39	- 1.29	- 6.55	- 6.16	- 5.26
1952	- 3.69	- 3.16	- 4.65	- 0.96	- 1.49
1953	- 8.25	- 7.23	- 0.76	- 1.51	- 2.53
1954	-13.42	-13.12	-12.47	+ 0.95	+ 0.65
1955	- 0.18	- 1.94	- 9.59	- 9.41	- 7.65
1956	- 1.71	- 3.78	- 7.66	- 5.95	- 3.88
1957	- 7.14	- 7.50	- 4.92	+ 2.22	+ 2.58
1958	-11.55	-11.78	-11.69	- 0.14	+ 0.09
1959	- 9.44	- 8.88	-10.27	- 0.83	- 1.39
1960	-10.64	- 9.49	- 4.79	+ 5.85	+ 4.70
1961	+ 7.38	+ 7.61	+ 4.50	- 2.88	- 3.11
1962	-12.69	- 9.87	- 3.02	+ 9.67	+ 6.85

Now let us examine the regression coefficients of the four equations. They are as follows:

	equation 3-1	equation 3-2
b_{31}	- 5.11	+ 3.75
b_{32}	+22.99	+20.89
b_{33}	-30.95	-28.39
b_{34}	+ 9.503	+ 8.929
b_{35}	+48.10*	+61.26*
b_{36}	- 9.98*	-12.22*
b_{37}	+ 0.646*	+ 0.775*
b_{38}	+ 3.05*	+ 2.75*
b_{39}	- 1.22*	- 1.69*

	equation 3-3	equation 3-4
b_{31}	-19.54*	-19.43*
b_{32}	+44.19	+47.53
b_{33}	-51.94	-55.58
b_{34}	+15.082	+15.762
b_{35}	- 6.66	-29.94
b_{36}	+ 6.37	+11.33
b_{37}	+ 6.00*	+ 5.47*
b_{38}	- 1.64*	- 0.89

The asterisk indicates that coefficients are significantly different from zero at the 10 percent level. It should be noted that in equations 3-1 and 3-2 the coefficients, b_{35}, b_{36}, and b_{37} are for the variable, X_{33}, while b_{38} is for the variable, X_{34}. In equations 3-3 and 3-4, coefficients b_{35} and b_{36} are for variable X_{36}; b_{37} is the coefficient of X_{37}. The coefficient, b_{38}, is for the trend variable.

The variable, X_{31}, has a negative coefficient in equation 3-1 and a positive coefficient in equation 3-2. However neither coefficient is significantly different from zero, even at the 40 percent level; consequently this cannot be interpreted as a change in the relationship of X_{31} with the cash-future spreads during the 1934-1962 period as compared with the longer period.

The t test was again used to test for significant differences in the corresponding regression coefficients of equations for the two time periods. None of the differences in coefficients were significant even at the very low level of 50 percent. In view of this and the fact that the coefficients of X_{32}, the variable for CCC stocks, were not significant at the 10 percent level in any of the four equations, the hypothesis was not rejected for July 1.

<u>Summary of July 1 Equations</u>.--Two pairs of equations were computed for July 1. One equation of each pair was based on the 1927-1962 period and one was based on the 1934-1962 period. In each pair of equations, the largest $\bar{R}$ was obtained from the equation for the longer period. The R^2's were approximately the same for both periods, while the equation for the longer period in each case produced the smaller $S_{y.x}$. Simple correlations between the independent variables were relatively large for both periods and could account for the lack of significance of several regression coefficients.

Equation 3-1 had the smallest $S_{y.x}$ of the four equations. For 25 out of 30 years studied, spreads estimated with it were in error by 4.97 cents or less. For predictive purposes this equation would appear to give the best results of the July 1 equations.

A t test for significant differences in the corresponding regression coefficients of each pair of equations indicated that differences were not significant, even at the 50 percent level. In addition, coefficients of the variable for CCC stocks were not significant at the 10 percent level in any of the equations. Consequently the hypothesis that CCC activities have influenced cash-future price spreads only through their effects on the commercial demand for corn storage was not rejected.

In the following section the results of equations based on the fourth date studied, October 1, will be presented.

October 1 Equations

Variables used in the October 1 equations are defined in the same manner as those for January 1 equations. However, the first subscript, 4, indicates that variables are based on observations for October 1. The cash-future spreads used are September spreads. Corn consumption in the quarter preceding October 1 is used in computing the variables X_{41} and X_{42}. The variable, X_{43}, is corn consumption in the quarter following October 1; variable, X_{46}, is consumption in the quarter following October 1 divided by corn production for the same year. Stocks used in X_{41}, X_{42}, X_{44}, and X_{47} are October 1 stocks. The units for all variables are the same as those used in January 1 equations.

Pairs of equations were again computed; one equation of each pair was based on the 1927-1962 period and one equation was based on the 1934-1962 period. This was done so that comparisons could be made of corresponding regression coefficients for the two time periods. If the hypothesis is false, significant differences in the coefficients might be expected.

Equation 4-1. Time Period: 1927 - 1962.

$$\hat{Y}_{41} = -540.18 - 0.27 \frac{1}{X_{41}} + 15.18 X_{42} - 0.50 X_{42}^2 + 117.81 X_{43}$$

$$- 6.04 X_{43}^2 - 1.59 X_{44} - 1.01 X_{45}.$$

$R^2 = .49$ $\bar{R} = +.57$ $S_{y.x} = 24.94$ D.F. = 21

Other important statistics of equation 4-1 are presented in Table 29.

TABLE 29.--Simple Correlations Between the Variables, Standard Errors, and t Values of the Coefficients of Equation 4-1

Variable	Simple Correlation With					Standard Error of Coefficients	t Values of Coefficients
	X_{42}	X_{43}	X_{44}	X_{45}	Y		
X_{41}	+.72	+.43	+.61	+.74	+.07	3.03	-0.09
X_{42}		+.47	+.77	+.91	+.23	20.55	+0.71
X_{43}			+.54	+.44	+.54	47.60	+2.35
X_{44}				+.78	+.27	2.41	-0.66
X_{45}					+.11	1.77	-0.57

Simple correlations between several of the independent variables of equation 4-1 are considerably lower than for the other dates studied. However, the R^2 is also considerably smaller than for other dates. The coefficients of X_{43} are significant at the 5 percent level; none of the other coefficients are significant at the 10 percent level. The coefficient of X_{44} is negative; however it is not significant at the 10 percent level. The negative sign may indicate that an increase in the supply of other grains reduces the expected future demand for corn, rather than affecting the supply of storage. Increases in stocks of other grains would then depress the future price relative to the cash price.

Before comparing September spreads with spreads estimated from equation 4-1, let us turn to equation 4-2, which is based on the shorter period.

Equation 4-2. Time Period: 1934 - 1962.

$$\hat{Y}_{42} = -349.61 - 0.24 \frac{1}{X_{41}} + 52.83\ X_{42} - 14.54\ X_{42}^2 + 70.03\ X_{43}$$

$$- 3.63\ X_{43}^2 - 1.55\ X_{44} + 0.07\ X_{48}.$$

$R^2 = .62$ $\bar{R} = +.65$ $S_{y.x} = 23.03$ D.F. = 14

Other important statistics of equation 4-2 are presented in Table 30.

TABLE 30.--Simple Correlations Between the Variables, Standard Errors, and t Values of the Coefficients of Equation 4-2

Variable	Simple Correlation With					Standard Error of Coefficients	t Value of Coefficients
	X_{42}	X_{43}	X_{44}	X_{48}	Y		
X_{41}	+.69	+.50	+.57	+.80	+.25	3.27	-0.07
X_{42}		+.64	+.77	+.88	+.60	21.10	+1.81
X_{43}			+.68	+.73	+.58	52.93	+1.25
X_{44}				+.86	+.54	2.96	-0.52
X_{48}					+.52	2.93	+0.02

As compared with equation 4-1, the R^2 has been increased from .49 to .62 and $\bar{R}$ has been increased from +.57 to +.65. In addition, the $S_{y.x}$ has been reduced slightly. Table 30 indicates that simple correlations of X_{43} and the trend variable with other independent variables have been increased. This would tend to increase the standard errors of the coefficients for these two variables, and consequently could account for part of the reduction in their respective t values. Again, the coefficient of X_{44} has the wrong sign, but is not significant at the 20 percent level. In equation 4-2, only the coefficients of X_{42} are significant at the 10 percent level.

Adjusted September spreads and spreads estimated with equations 4-1 and 4-2 are presented in Table 31. The range of September spreads for the 1927-1962 period was 125.77 cents; for the 1934-1962 period it was 123.82 cents. For 16 out of 29 years studied, estimated spreads from equation 4-1 were in error by 20.38 cents or less. Equation 4-2 was in error by 13.91 cents or less for 15 out of 22 years.

TABLE 31.--Actual Adjusted September Spreads and Spreads Estimated With Equations 4-1 and 4-2

Years	$\hat{Y}_{41}$	$\hat{Y}_{42}$	Y	$Y-\hat{Y}_{41}$	$Y-\hat{Y}_{42}$
1927	+12.16	--	+11.40	- 0.76	--
1928	+ 4.54	--	-41.02	-45.56	--
1929	+ 3.11	--	+ 3.62	+ 0.51	--
1930	-28.33	--	-10.13	+18.20	--
1931	-10.41	--	+ 9.97	+20.38	--
1932	+ 0.30	--	+28.77	+26.47	--
1933	+ 8.48	--	+36.13	+27.65	--
1934	-59.92	-49.92	-36.01	+23.91	+13.91
1935	-55.30	-66.26	-61.65	- 6.35	+ 4.61
1936	-66.07	-69.55	-89.64	-23.57	-20.09
1937	-42.86	-57.96	-89.54	-46.68	-31.58
1938	-18.66	-37.22	+ 6.77	+25.43	+43.99
1939	+ 8.47	+ 1.27	+ 5.09	- 3.38	+ 3.82
1940	+12.18	+ 7.78	-14.88	-27.06	-22.66
1941	+ 3.71	+ 2.10	+34.18	+30.47	+32.08
--	--	--	--	--	--
1949	- 6.70	-12.93	-21.30	-14.60	- 8.37
1950	+ 3.62	+ 0.96	- 7.08	-10.70	- 8.04
1951	- 0.55	- 4.16	-12.18	-11.63	- 8.02
1952	- 8.63	-14.21	- 2.27	+ 6.36	+11.94
1953	- 1.87	- 2.20	-27.19	-25.32	-24.99
1954	-23.81	-11.13	- 1.71	+22.10	+ 9.42
1955	-15.14	- 6.40	+ 6.52	+21.66	+12.92
1956	- 8.70	- 3.14	-16.71	- 8.01	-13.57
1957	+ 2.89	- 0.63	- 1.10	- 3.99	- 0.47
1958	- 1.09	- 4.10	-12.64	-11.55	- 8.54
1959	+ 3.92	+ 3.03	-10.70	-14.62	-13.73
1960	+ 0.41	- 4.08	+ 4.12	+ 3.71	+ 8.20
1961	-13.00	-13.29	+10.44	+23.44	+23.73
1962	- 6.77	+ 1.26	- 3.29	+ 3.48	- 4.55

In view of the wrong signs obtained for the coefficients of X_{44} in equations 4-1 and 4-2 and the lack of significance of these coefficients, equations 4-3 and 4-4 were computed, excluding X_{44} from the analysis.

Equation 4-3. Time Period: 1927 - 1963.

$$\hat{Y}_{43} = -482.46 - 0.42 \frac{1}{X_{41}} + 16.43\ X_{42} - 1.22\ X_{42}^2 + 100.51\ X_{43} - 5.09\ X_{43}^2 - 1.49\ X_{45}.$$

$R^2 = .48 \quad \bar{R} = +.58 \quad S_{y.x} = 24.61 \quad D.F. = 22$

Other important statistics of equation 4-3 are presented in Table 32.

TABLE 32.--Standard Errors and t Values of the Coefficients of Equation 4-3

Variables	Standard Error of Coefficients	t Value of Coefficients
X_{41}	2.98	-0.14
X_{42}	20.26	+0.75
X_{43}	40.08	+2.38
X_{45}	1.60	-0.93

As compared with equation 4-1, standard errors of all coefficients were reduced slightly. The R^2 and $\bar{R}$ are essentially unchanged, while $S_{y.x}$ has been reduced from 24.94 to 24.61. Again the only coefficients which are significant at the 10 percent level are those for X_{43}; they are also significant at the 5 percent level.

Now let us examine equation 4-4, which is based on the 1934-1962 time period.

Equation 4-4. Time Period: 1934 - 1962.

$$\hat{Y}_{44} = -317.59 + 0.06 \frac{1}{X_{41}} + 53.69\ X_{42} - 14.70\ X_{42}^2 + 58.42\ X_{43}$$

$$- 2.99\ X_{43}^2 - 0.83\ X_{48}.$$

$R^2 = .61 \quad \bar{R} = +.67 \quad S_{y.x} = 22.47 \quad$ D.F. = 15

Other important statistics of equation 4-4 are presented in Table 33.

TABLE 33.--Standard Errors and t Values of the Coefficients of Equation 4-4

Variable	Standard Error of Coefficients	t Value of Coefficients
X_{41}	3.13	-0.02
X_{42}	20.54	+1.90
X_{43}	47.38	+1.17
X_{48}	2.31	-0.36

Again, the R^2 and $\bar{R}$ were essentially unaffected by omitting X_{44} from the equation, but $S_{y.x}$ was reduced from 24.04 to 22.57. The standard errors of all coefficients were reduced slightly as compared with equation 4-2; however only the coefficients of X_{42}, CCC stocks divided by consumption, are significant at the 10 percent level.

Cash-future spreads estimated with equations 4-3 and 4-4 are presented in Table 34. Spreads estimated from equation 4-3 were in error by 18.65 cents or less for 18 out of 29 years studied. Equation 4-4 was in error by 18.45 cents or less for 16 out of 22 years.

TABLE 34.--Actual Adjusted September Spreads and Spreads Estimated With Equations 4-3 and 4-4

Years	$\hat{Y}_{43}$	$\hat{Y}_{44}$	Y	$Y-\hat{Y}_{43}$	$Y-\hat{Y}_{44}$
1927	+11.41	--	+11.40	- 0.01	--
1928	+ 6.76	--	-41.02	-47.78	--
1929	+ 2.86	--	+ 3.62	+ 0.76	--
1930	-23.17	--	-10.13	+13.04	--
1931	- 7.41	--	+ 9.97	+17.38	--
1932	+ 3.86	--	+28.77	+24.91	--
1933	+ 1.54	--	+36.13	+34.59	--
1934	-62.77	-52.24	-36.01	+26.76	+16.23
1935	-53.38	-62.67	-61.65	- 8.27	+ 1.02
1936	-67.86	-71.19	-89.64	-21.78	-18.45
1937	-43.01	-56.93	-89.54	-46.53	-32.61
1938	-21.31	-38.67	+ 6.77	+28.08	+45.44
1939	+ 2.06	- 3.69	+ 5.09	+ 3.03	+ 8.78
1940	+ 9.68	+ 7.17	-14.88	-24.56	-22.05
1941	+ 3.34	+ 2.57	+34.18	+30.84	+31.61
--	--	--	--	--	--
1949	- 2.65	- 9.46	-21.30	-18.65	-11.84
1950	+ 5.04	+ 2.98	- 7.08	-12.12	-10.06
1951	- 0.02	- 4.01	-12.18	-12.16	- 8.17
1952	- 9.45	-15.56	- 2.27	+ 7.18	+13.29
1953	- 1.67	- 3.12	-27.19	-25.52	-24.07
1954	-19.30	- 8.30	- 1.71	+17.59	+ 6.59
1955	-10.51	- 3.07	+ 6.52	+17.03	+ 9.59
1956	- 9.93	- 2.27	-16.71	- 6.78	-14.44
1957	+ 0.63	- 3.51	- 1.10	- 1.73	+ 2.41
1958	+ 3.51	+ 0.19	-12.64	-16.15	-12.83
1959	+ 1.53	- 0.18	-10.70	-12.23	-10.52
1960	+ 0.75	- 3.12	+ 4.12	+ 3.37	+ 7.24
1961	-12.23	-12.68	+10.44	+22.67	+23.12
1962	-10.33	- 3.03	- 3.29	+ 7.04	- 0.26

Two additional equations were computed for October 1, using the variables X_{46} and X_{47} in place of X_{43} and X_{44}. The variable, X_{46}, is corn consumption in the quarter following October 1 divided by corn production in the same year; the variable, X_{47}, is stocks of other grains divided by the number of grain consuming animal units fed annually.

Equation 4-5. Time Period: 1927 - 1962.

$$\hat{Y}_{45} = -228.31 + 0.25 \frac{1}{X_{41}} + 38.39 X_{42} - 3.11 X_{42}^2 + 141.37 X_{46}$$

$$- 19.27 X_{46}^2 - 19.27 X_{46}^2 - 30.09 X_{47} - 2.08 X_{45}.$$

$R^2 = .25$ $\bar{R} = +.07$ $S_{y.x} = 30.25$ D.F. = 21

Other important statistics of equation 4-5 are presented in Table 35.

TABLE 35.--Simple Correlations Between the Variables, Standard Errors, and t Values of the Coefficients of Equation 4-5

Variable	Simple Correlation With					Standard Error of Coefficients	t Value of Coefficients
	X_{42}	X_{46}	X_{47}	X_{45}	Y		
X_{41}	+.72	-.60	+.57	+.74	+.07	3.54	+0.07
X_{42}		-.66	+.72	+.91	+.23	25.26	+1.40
X_{46}			-.87	-.75	-.13	95.59	+1.28
X_{47}				+.74	+.14	63.31	-0.48
X_{45}					+.11	2.28	-0.91

The R^2 has been reduced from .49 to .25 as compared with equation 4-1. In addition, $\bar{R}$ has been reduced from +.57 to +.07 and the standard error of estimate has been increased from 24.94 to 30.25. None of the regression coefficients in equation 4-5 are significantly different from zero at the 10 percent level.

Now let us compare equation 4-5 with equation 4-6, which is based on the shorter time period.

Equation 4-6. Time Period: 1934 - 1962.

$$\hat{Y}_{46} = -55.07 - 1.97 \frac{1}{X_{41}} + 73.65 X_{42} - 20.85 X_{42}^2 + 47.48 X_{46}$$

$$- 8.07 X_{46}^2 - 70.86 X_{47} + 1.37 X_{48}.$$

$R^2 = .63 \quad \bar{R} = +.66 \quad S_{y.x} = 22.77 \quad D.F. = 14$

Other important statistics of equation 4-6 are presented in Table 36.

TABLE 36.--Simple Correlations Between the Variables, Standard Errors, and t Values of the Coefficients of Equation 4-6

Variable	Simple Correlation With X_{42}	X_{46}	X_{47}	X_{48}	Y	Standard Error of Coefficients	t Value of Coefficients
X_{41}	+.69	-.55	+.52	+.80	+.25	3.17	-0.62
X_{42}		-.57	+.69	+.88	+.60	20.04	+2.64
X_{46}			-.86	-.71	-.37	67.56	+0.58
X_{47}				+.80	+.41	62.28	-1.14
X_{48}					+.52	2.58	+0.53

Equation 4-6 produced a considerably larger R^2 and $\bar{R}$ than equation 4-5. In addition the $S_{y.x}$ was reduced from 30.25 to 22.77. The coefficients of X_{42} and X_{47} were increased considerably, in absolute terms, while the coefficients of X_{46} and X_{48} were reduced. Also, standard errors of the coefficients of all variables except the trend were reduced. However, only the coefficients of X_{42}, the variable for CCC stocks, are significant at the 10 percent level; they are also significant at the 5 percent level.

September spreads estimated with equations 4-5 and 4-6 are compared in Table 37. Spreads estimated from equation 4-5 were in error by 19.26 cents or less for 17 out of 29 years studied. Equation 4-6 was in error by 18.63 cents or less for 17 out of 22 years.

TABLE 37.--Actual Adjusted September Spreads and Spreads Estimated With Equations 4-5 and 4-6

Years	$\hat{Y}_{45}$	$\hat{Y}_{46}$	Y	$Y-\hat{Y}_{45}$	$Y-\hat{Y}_{46}$
1927	- 7.86	--	+11.40	+19.26	--
1928	- 5.98	--	-41.02	-35.04	--
1929	- 7.01	--	+ 3.62	+10.63	--
1930	-15.23	--	-10.13	+ 5.10	--
1931	-10.86	--	+ 9.97	+20.83	--
1932	-11.76	--	+28.77	+40.53	--
1933	-17.48	--	+36.13	+53.61	--
1934	-43.81	-50.48	-36.01	+ 7.80	+14.47
1935	-19.52	-59.42	-61.65	-42.13	- 2.23
1936	-45.49	-71.01	-89.64	-44.15	-18.63
1937	-30.80	-56.93	-89.54	-58.74	-32.61
1938	-18.34	-40.88	+ 6.77	+25.11	+47.65
1939	+10.54	+ 5.77	+ 5.09	- 5.45	- 0.68
1940	+27.84	+ 6.73	-14.88	-42.72	-21.61
1941	+12.29	+ 5.57	+34.18	+21.89	+28.61
--	--	--	--	--	--
1949	- 8.61	-16.04	-21.30	-12.69	- 5.26
1950	+ 4.31	- 1.85	- 7.08	-11.39	- 5.23
1951	- 6.29	- 8.07	-12.18	- 5.89	- 4.11
1952	-27.62	-18.74	- 2.27	+25.35	+16.47
1953	-12.45	- 5.56	-27.19	-14.74	-21.63
1954	-14.50	- 1.99	- 1.71	+12.79	+ 0.28
1955	-15.65	- 4.68	+ 6.52	+22.17	+11.20
1956	- 7.51	- 8.16	-16.71	- 9.20	- 8.55
1957	+ 3.02	+ 3.37	- 1.10	- 4.12	- 4.47
1958	- 7.84	-13.70	-12.64	- 4.80	+ 1.06
1959	-11.88	+ 6.14	-10.70	+ 1.18	-16.84
1960	-14.34	-13.06	+ 4.12	+18.46	+17.18
1961	+ 6.61	- 7.11	+10.44	+ 3.83	+17.55
1962	- 5.82	+ 9.32	- 3.29	+ 2.53	-12.61

The Durbin-Watson statistic, d', was computed as a test for serial correlation of the residuals of equations 4-5 and 4-6. For both equations the results were inconclusive.

In connection with the null hypothesis, it should be noted that in each pair of October 1 equations, the equation based on the 1934-1962 period produced a considerably better fit in terms of R^2, $\bar{R}$, and $S_{y.x}$ than the equation based on the longer period. The largest difference in fit for the two periods was produced by equations 4-5 and 4-6. For equation 4-5, the R^2 was .25, $\bar{R}$ was +.07, and $S_{y.x}$ was 30.25; for equation 4-6, the R^2 was .63, $\bar{R}$ was +.66, and $S_{y.x}$ was 22.77. Equation 4-6 had the highest R^2 of the six equations and its $S_{y.x}$ was only slightly larger than the $S_{y.x}$ of equation 4-6, the smallest of the October 1 equations.

A significance test for R^2, given by Walker and Lev, indicates that the R^2 of equation 4-6 is significantly different from zero at the 2.5 percent level, while the R^2 of equation 4-5 is not significant at the low level of 25 percent.[77] For the other two pairs of equations, however, R^2's for both periods were significant at the same level. A smaller number of observations and consequently fewer degrees of freedom apparently prevented the R^2's for the 1934-1962 period from being more significant than those for the longer period.

The better fit for the shorter period might indicate that a change has occurred in the relationships between the independent variables and cash-future spreads for the 1934-1962 period as compared with the 1927-1962 period. This could be an indication that the null hypothesis is false for October 1, even though direct statistical tests are inconclusive. In addition, for the shorter time the only regression coefficients that are significant at the 10 percent level are those of the variable for CCC stocks.

Over the observed range for October 1, an increase in the ratio of CCC stocks to corn consumption increased cash-future spreads. From the theoretical framework of Chapter III, this could be explained in

[77]Walker and Lev, <u>Op</u>. <u>Cit</u>., p. 324.

two ways: (1) an increase in October 1 CCC stocks shifts the expected future supply of corn to the left, thus increasing future price relative to the cash price, or (2) an increase in CCC stocks reduces the supply of unoccupied storage space, thus changing the commercial supply function for storage. In reality, a combination of these two effects may have occurred.

Summary of October 1 Equations.--Three pairs of equations were computed for October 1. In each pair, the equation based on the shorter period provided a considerably better fit in terms of R^2, $\bar{R}$, and $S_{y.x}$ than the equation based on the 1927-1962 period. Simple correlations between the independent variables, except for X_{41}, with all other independent variables were somewhat lower than for the other three dates studied. However they were still relatively large and could account for the lack of significance of several regression coefficients.

Equation 4-4 had the smallest $S_{y.x}$ of the six equations. For predictive purposes, it would appear to provide the best results of the October 1 equations.

Although direct statistical tests of the hypothesis were not conclusive, the better fit obtained for the 1934-1962 period as compared with the longer period provided some evidence that it may be false. In addition, the only coefficients which were significant at the 10 percent level in equations for the shorter period were those of the variable for CCC stocks. In every equation, an increase in CCC corn stocks relative to consumption increased cash-future spreads. This could be due either to reductions in the expected future supply of corn or reductions in the supply of unoccupied storage space. In reality, a combination of these effects may have occurred.

In short, though a precise test of the hypothesis was not possible, there is evidence that at the beginning of the marketing year CCC activities may affect both the commercial supply and demand for corn storage.

CHAPTER VI

Summary and Conclusions

The objectives of this thesis were (1) to determine whether CCC price-support activities have affected the cash-future price spreads for corn through their effects of both the commercial supply and the commercial demand for corn storage, and (2) to obtain predictions of the cash-future spreads with CCC corn stocks as a variable. In the analysis, cash-future spreads were treated as a price of storage that is determined by the intersection of the commercial supply and demand for corn storage. The supply of storage is determined by the marginal cost of holding inventories through time minus the marginal convenience yield of those inventories in terms of reduced cost and delay to the stockholder. The prices of futures contracts were considered to be expected future prices of the commodity. Commercial stocks, then, provide a mechanism by which the grain trade, given the current and expected future demand for corn, can adjust current and future corn supplies to a level at which the cash-future spread is equal to the net marginal cost of storing corn from one period to the next.

The main variables determining the cash-future spreads were believed to be corn consumption in the quarter preceding the date at which spreads were observed, corn consumption in the quarter following the date at which spreads were observed, CCC controlled corn stocks, commercial (non-CCC) corn stocks, stocks of other grains, interest cost, the general price level, and time. Corn consumption preceding the date at which spreads were observed was considered to reflect current supply and demand conditions, while corn consumption following the date at which spreads were observed was considered to reflect expected future supply and demand conditions.

The first objective of the thesis was restated in the form of a null hypothesis that CCC activities have affected cash-future spreads only through their effects on the commercial demand for corn storage. The analytical approach consisted of least-squares regression equations of the intersection points of the commercial supply and demand for corn storage. The variables were studied at four separate dates during the year: January 1, April 1, July 1, and October 1. The equations were computed in pairs containing the same variables; one equation was based on the 1927-1962 period and one was based on the 1934-1962 period. For both periods, war and immediate post-war years were omitted from the analysis. If the null hypothesis is false, it was believed that significant differences in the coefficients of variables for the two periods might be obtained.

With the use of a t test described in the preceding chapter, no evidence of significant differences between coefficients for the two periods was found in any of the equations. It should be emphasized, however, that a complete test of the hypothesis was not obtained, and also that the limited number of observations prior to the beginning of CCC activities might prevent detection of significant differences in the relationships even if the hypothesis is false.

With these limitations in mind, we should note that a significant, positive relationship was found between July 1 stocks of other grains and June cash-future spreads. Originally, stocks of other grains were included in the analysis to provide a measure of the quantity of unoccupied grain storage space. It was believed that a positive relationship between stocks of other grains and spreads would indicate a shortage of unoccupied storage space. However, in view of the lack of significance of the variable for CCC corn stocks in the July 1 equations, it appears more reasonable to assume that stocks of other grains represent supplies of substitutes for corn. An increase in these stocks would shift the current demand for corn to the left, thus lowering the cash price relative to the future price, and increasing spreads. In short, CCC stocks do not appear to have created a shortage of unoccupied grain storage space on July 1.

The October 1 equations provided some evidence that CCC stocks may have affected the commercial supply of corn storage at the beginning of the marketing year. In each pair, the equation based on the 1934-1962 period provided a considerably better fit than the equation based on the longer period. This might indicate that a change has occurred in the relationships between variables specifying the commercial supply of storage and the cash future price spreads for the 1934-1962 period as compared with the 1927-1962 period. In addition, for the 1934-1962 period, only the coefficients of the variable for CCC stocks are significant at the 10 percent level. An increase in the ratio of CCC stocks to corn corn consumption, over the observed range, was associated with an increase in spreads. This could reflect expectations that increases in CCC stocks would shift the future supply of corn to the left, thus increasing the future price relative to the cash price, or it could indicate that increases in CCC corn stocks caused a tighting up of the supply of unoccupied storage space. In effect, a combination of these two conditions may have occurred.

It should be noted that the coefficient for stocks of other grains was not significant at the 10 percent level in any of the October 1 equations. This would seem to indicate that CCC corn stocks have not resulted in a shortage of unoccupied storage space in total at the beginning of the marketing year. However, in the review of literature it was noted that CCC stocks have contributed to congestion in country, subterminal, and terminal elevators at harvest time. Consequently, an increase in October 1 CCC stocks might increase congestion at these points in the marketing chain, thus depressing cash price relative to the future price and increasing the spreads. It was also noted in the review of literature that technological changes in production and marketing have tended to place corn on the market earlier and in a shorter time period than in the past. This would tend to magnify the effects of CCC stocks on congestion in marketing firms at harvest.

In short, though direct statistical tests were not conclusive, there is some evidence that CCC corn stocks may have affected the cash-future spreads through the commercial supply of storage at the beginning of the marketing year. Their effects would appear to be through increases in the congestion of country, subterminal, and terminal elevators rather than through a tightening up of the total supply of unoccupied storage space. For the other three dates studied, January 1, April 1, and July 1, within the limitations of the data and the approach, no evidence was found that CCC activities have affected the commercial supply of corn storage. For these dates, the main effects of CCC stocks on the cash-future spreads are probably through their effects on the available supply of corn.

Given the current and expected future demand for corn, an increase in CCC corn stocks, all other things remaining constant, should produce a shift to the left of the available supply of corn. This, in turn, would increase the cash price relative to the future price, and consequently would decrease cash-future spreads. However, if an increase in current CCC stocks is associated with an expected increase in future CCC stocks, the future price will also be affected. The change in spreads will depend upon the size of the increase in current CCC stocks relative to expected increases in future CCC stocks.

In connection with the second objective of the thesis, it would be well to take a brief look at the assumptions underlying least-squares regression. The main assumptions are as follows:[78]

1. Error terms are independent and randomly distributed with constant variances. For tests of significance they are assumed normally distributed.

2. The independent variables are a set of fixed numbers with no measurement error.

3. The number of observations exceeds the number of parameters to be estimated and there are no exact linear relationships between any of the independent variables.

The Durbin-Watson test provided a partial check on assumption 1. However, in connection with assumption 2, several adjustments which were made on the stocks data were pointed out in Chapter IV. These adjustments obviously will introduce errors into the data. In addition, there will always be errors in any statistical series of stocks and consumption. These errors will bias least-squares regression coefficients toward zero. Under such conditions the regression coefficients

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[78]J. Johnston, Econometric Methods, McGraw-Hill Book Company, Inc., New York, San Francisco, Toronto, London, 1963, pp. 107-108.

are inconsistent; even as the sample size becomes infinitely large the expected value of the estimated coefficients will not converge to the true population value. However, provided the errors are random, least-squares regression is still appropriate for prediction.[79]

In connection with assumption 3, the high simple correlations between independent variables create problems in attempting to obtain reasonably precise estimates of their relative effects. However, Johnston suggests that these problems may not be too serious for forecasting purposes, provided the high intercorrelations of the independent variables can reasonably be expected to continue in the future.

There are two additional requirements for least-squares predictions to be valid: (1) the variables must be within the range upon which the equation is based, and (2) there must be no new variables affecting the spread during the period for which the prediction is made. As was pointed out in Chapter IV, estimated spreads from the equations also would not be valid for large reductions in CCC stocks because certain irreversible process may have been occurring during the period studied.

Within the restrictions imposed by the above assumptions, the equations may be used to predict cash-future spreads provided estimates of stocks and consumption are available at the time predictions are to be made. The equations will then provide a range within which the expected value of the spread should fall for given values of the independent variables. However, the equations appear to be more useful as a frame of reference for explaining the direction and approximate size

[79] Ibid., pp. 163-164.

of the effects of changes in the independent variables on the cash-future spreads. With this purpose in mind, the discussion now turns to the best equations which were obtained for each of the dates studied.

The best predicting equations for the four dates studied appear to be equation 1-5, equation 2-1, equation 3-1, and equations 4-4 and 4-6. The $\bar{R}$ for these equations were respectively, +.80, +.73, +.87, +.67, and +.66; the $S_{y.x}$'s were 9.57, 10.49, 5.20, 22.77, and 22.47. These should be compared with a range of actual adjusted December spreads of 71.33 cents, March spreads; 73.26 cents, June spreads; 55.56 cents, and September spreads; 123.82 cents.

In the above equations, the ratio of commercial corn stocks to corn consumption in the preceding quarter was a significant variable only in equation 1-5. Its coefficient was negative; thus an increase in commercial stocks relative to consumption would appear to be caused mainly by a shift of the commercial supply of storage to the right along the demand curve. For the rest of the above equations, except for equation 4-4, the coefficient was also negative. In equation 4-4, the coefficient was +0.06 and was not significantly different from zero at the 10 percent level.

The ratio of CCC corn stocks to consumption in the preceding quarter had significant coefficients only in equations 4-4 and 4-6. In these equations, an increase in CCC stocks was associated with an increase in cash-future spreads. For the other three dates studied, the results for this variable indicated that an increase in CCC stocks was associated with an increase in spreads and that the size of the relationship between spreads and CCC stocks divided by corn consumption varied with the level of CCC stocks relative to consumption. There are several possible explanations for this result. Initially, an increase in CCC stocks might influence expectations regarding future corn supply and demand conditions more than it does current supply and demand conditions. Then, over some range, current supply and demand conditions may become more important relative to expected future supply and demand conditions. Still larger increases in CCC stocks might again focus attention on expected future conditions. An alternative explanation is that due to steady increases in CCC stocks through time, the variable for CCC stocks is highly correlated with time. Consequently, the effects of other variables changing concurrently with CCC stocks, such as the level of the commercial demand for corn storage, may be partly reflected in the coefficients for CCC stocks relative to consumption in the preceding quarter.

In equations 2-1 and 3-1, there was a significant relationship between corn consumption in the following quarter and spreads. The coefficients for this variable indicated that an increase in corn consumption in the following quarter was associated with an increase in cash-future spreads and that the size of the relationship depended upon the level of corn consumption. Again, the result could be due partly to intercorrelations of consumption with other variables which have been changing over time. An alternative explanation might be that increases in corn consumption during the following quarter represent shifts of the commercial demand for storage to the right along the commercial supply of storage.

In equation 1-5, a significant relationship was found between corn consumption in the quarter following January 1 divided by corn production during the preceding year and cash-future spreads. Over the observed range, an increase in this variable was associated with an increase in spreads.

Two other variables were useful in the above equations. As was noted earlier, a significant relationship was found between stocks of other grains and spreads in equation 3-1. In addition, time was a significant variable in equations 1-5, 2-1, and 3-1. Time was included in the analysis to capture the effects of variables changing over time, such as technology, which were not directly measurable. As previous work suggested, the coefficient of the time variable was negative in almost every case.

In examining the residuals from the above equations, it should be noted that errors tend to be large for the years 1942, 1949, 1959, 1961, and 1962. One explanation for this is that cash-future spreads tend to be very sensitive to expectations concerning future supply and demand conditions. Consequently, in making predictions of the spreads it is important to take into consideration unusual expected future supply and demand conditions as reflected by drought, war, and other factors which might affect both the foreign and domestic supply and demand for corn. It should be emphasized also that cash-future spreads are likely to be affected by expectations concerning the effects of changes in acreage allotments, conservation programs, and other policies which will affect corn production and the production of other feed grains. In general, programs designed to reduce corn production will shift the expected future supply of corn to the left thus increasing the future price relative to the cash price and increasing spreads. Programs designed to reduce the production of other feed grains will tend to increase the expected future demand for corn, thus increasing cash-future spreads.

Finally, it should be emphasized that the regression coefficients obtained are not structural coefficients; however, they will provide estimates of the cash-future spreads for given values of the independent variables taken as a group.

Future work might utilize a method of estimating regression coefficients suggested by Arnold Zellner.[80] At the time this study was done, computational facilities for the method were not available. By using the Zellner approach, the efficiency of estimators in separate equations may be improved considerably when the disturbance terms of equations for the different dates are highly correlated. Disturbance terms in the equations studied are probably highly correlated since they reflect some of the same unstudied fluctuations. However, the effects of high correlations between the independent variables of the different equations on the gain in efficiency are not clear.

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[80] Arnold Zellner, "An Efficient Method of Estimating Seemingly Unrelated Regressions and Tests for Aggregation Bias," Journal of the American Statistical Association, Vol. 57, No. 298, June 1962, pp. 348-368.

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APPENDIX

APPENDIX TABLE 1

FUTURE PRICE MINUS CASH PRICE, DEFLATED AND REDUCED BY INTEREST COST, 1926 THROUGH 1963, EXCLUDING WAR AND IMMEDIATE POST-WAR YEARS*

Years	December	March	June	September
		(Cents Per Bushel)		
1962-63	- 4.87	- 5.79	a	a
1961-62	+ 5.86	+ 1.20	- 3.20	- 3.29[b]
1960-61	+12.46	+ 6.06	+ 4.50	+10.44[b]
1959-60	- 1.50	- 3.68	- 4.79	+ 4.12[b]
1958-59	- 7.32	- 8.10	-10.27	-10.70[b]
1957-58	+ 1.00	- 3.95	-11.69	-12.64[b]
1956-57	+ 1.85	+ 2.61	- 4.92	- 1.10[b]
1955-56	+ 7.56	+ 2.85	- 7.66	-16.71[b]
1954-55	+ 0.77	- 5.42	- 9.59	+ 6.52[b]
1953-54	- 5.51	- 5.44	-12.47	- 1.71[b]
1952-53	+ 4.97	- 0.52	- 9.76	-27.19[b]
1951-52	- 9.62	- 6.54	- 4.65	- 2.27[b]
1950-51	- 5.80	- 2.74	- 6.55	-12.18[b]
1949-50	- 9.25	-13.63	- 8.01	- 7.08[b]
1948-49	- 8.14	-17.19	-16.86	-21.30[b]
1941-42	+18.26	+15.33	+ 7.79	--
1940-41	- 6.15	- 6.86	+ 2.45	+34.18[b]
1939-40	+ 5.05	+ 1.49	-13.71	-14.88[b]
1938-39	+ 7.05	+ 4.70	- 1.57	+ 5.09[b]
1937-38	+ 2.74	+ 3.18	+ 1.44	+ 6.77[b]
1936-37	-43.68	-50.44	-42.02	-89.54
1935-36	-11.03	- 6.41	-10.01	-89.64
1934-35	-46.62	-39.78	-26.29	-61.65
1933-34	+21.65	+15.09	- 3.08	-36.01
1932-33	+23.58	+12.71	+13.54	+36.13

1931-32	+18.74	+22.82	+ 3.78	+28.77
1930-31	+ 3.86	+ 2.48	-10.74	+ 9.97
1929-30	+ 7.23	+ 4.18	- 5.34	-10.13
1928-29	+ 8.77	+ 2.75	- 3.60	+ 3.62
1927-28	+ 7.25	- 0.78	-10.21	-41.02
1926-27	+24.71	+21.12	+ 5.37	+11.40

*Computed by the methods described in Chapter IV. Data were obtained from Lester V. Manderscheid, Influence of Price-Support Program on Seasonal Corn Prices, unpublished Ph.D. dissertation, Food Research Institute, Stanford University Library; Stanford, California, October 1960, Chicago Board of Trade Annual Reports, The Drovers Journal, and various issues of the Federal Reserve Board of Governors, Federal Reserve Bulletin.

[a]Data were not available when the table was compiled.

[b]Based on prices quoted before trading in September future was closed for the month.

APPENDIX TABLE 2

COMMERCIAL CORN STOCKS BY QUARTERS FOR UNITED STATES, 1927 THROUGH 1963, EXCLUDING WAR YEARS*

	(1000 Bushels)			
Years	January 1	April 1	July 1	October 1
1963	2,618,338[a]	1,373,573[a]	b	b
1962	2,620,669	1,536,027	811,915	83,446
1961	2,841,997	1,508,524	738,256	81,057
1960	2,841,741	1,542,548	737,271	84,766
1959	2,449,647	1,377,745	695,058	123,531
1958	2,344,907	1,340,378	622,352	116,694
1957	2,216,213	1,192,933	596,866	177,755
1956	2,140,210	1,146,923	552,136	56,295
1955	2,089,771	1,273,485	661,074	177,223
1954	2,086,533	1,168,651	529,379	203,281
1953	2,189,814	1,264,736	629,378	255,337
1952	1,932,596	1,029,390	619,304	180,921
1951	2,013,842	1,261,294	711,427	252,018
1950	2,167,203	1,125,551	575,966	194,666
1949	2,474,837	1,504,091	712,087	453,684
1948	1,535,442	870,665	448,541	123,373
1947	2,180,264	1,310,610	690,892	273,918
1946	1,890,589	1,081,854	518,673	166,120
1942	1,871,663	1,096,343	604,404	352,796
1941	1,594,784	969,623	514,708	294,175
1940	1,814,756	929,880	463,125	264,671
1939	1,815,099	1,053,516	652,003	372,558
1938	1,734,108	1,111,392	648,864	346,960
1937	842,981	436,622	167,653	71,236
1936	1,423,119	817,485	387,592	190,436

1935	869,156	464,600	216,569	70,295
1934	1,551,360	790,278	293,964	284,741
1933	1,921,754	1,230,326	726,458	419,419
1932	1,603,804	962,981	567,894	293,386
1931	1,178,096	675,039	341,312	182,457
1930	1,427,454	799,877	372,561	151,095
1929	1,472,836	840,447	422,787	159,269
1928	1,483,468	778,059	319,395	102,127
1927	1,528,795	950,564	504,856	235,840

*Computed by the methods described in Chapter IV. Data were obtained from U.S.D.A., E.R.S., Grain and Feed Statistics Through 1956, Statistical Bulletin No. 159, Revised May 1956. Grain and Feed Statistics Through 1961, Statistical Bulletin No. 159, Revised June 1961, and various issues of U.S.D.A., A.M.S., Feed Situation.

[a]Preliminary.

[b]Data were not available when the table was compiled.

APPENDIX TABLE 3

TOTAL STOCKS OF CORN IN CCC INVENTORIES, UNDER LOAN, AND UNDER PURCHASE AGREEMENTS, 1934 THROUGH 1963, EXCLUDING WAR YEARS*

Years	January 1	April 1	July 1	October 1
	(1000 Bushels)			
1963	1,605,400	1,666,600	[b]	[b]
1962	1,873,900	1,849,000	1,661,400	1,556,100
1961	1,845,300	2,156,400	2,077,800	1,927,300
1960	1,501,800	1,792,800	1,784,800	1,702,200
1959	1,418,700	1,578,900	1,492,800	1,400,600
1958	1,266,300	1,457,500	1,473,800	1,353,800
1957	1,201,600	1,400,500	1,370,800	1,241,900
1956	941,800	1,161,700	1,189,700	1,109,200
1955	759,000	876,000	940,200	857,600
1954	599,200	825,700	877,500	716,400
1953	372,000	534,900	635,000	513,800
1952	433,100	413,700	352,700	306,200
1951	599,200	590,700	545,600	487,500
1950	516,600	814,400	803,800	649,800
1949	98,200	308,100	555,000	359,328
1948	[a]	700	700	100
1947	3,500	33,700	19,400	9,300
1946	1,700	2,400	10,700	5,700
1942	356,400	350,900	286,100	197,600
1941	477,800	522,100	491,400	405,300
1940	268,600	515,700	539,600	481,400
1939	91,700	250,200	262,800	260,800
1938	9,100	38,400	43,400	45,200
1937	100	100	[a]	[a]
1936	14,600	28,700	11,800	400

1935	21,300	15,000	4,800	0
1934	32,400	178,600	258,600	81,700

*U.S.D.A. Agricultural Stabilization and Conservation Service, Fiscal Division.

[a]Less than 50,000 bushels.

[b]Data were not available when the table was compiled.

APPENDIX TABLE 4

MILLION BUSHELS OF DOMESTIC AND EXPORT DISAPPEARANCE OF CORN, COMBINED, BY QUARTERS FOR UNITED STATES, 1926 THROUGH 1962, EXCLUDING WAR YEARS*

Marketing Year Beginning	October through December	January through March	April through June	July through September
1962	1,060[a]	1,184[a]	924[a]	c
1961	1,140[a]	1,110	912	834
1960	1,008	1,023	849	808
1959	1,005	1,009	813	736
1958	958	912	769	663
1957	871	805	699	622
1956	833	820	623	546
1955	834	771	564	575
1954	779	699	549	567
1953	966	692	588	487
1952	906	763	535	495
1951	1,003	850	545	485
1950	996	761	595	518
1949	1,075	744	561	535
1948	857	761	546	454
1947	856	665	422	326
1946	904	840	634	427
1945	1,001	808	555	357
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1941	877	783	546	363
1940	865	587	479	320
1939	885	643	437	274
1938	794	607	384	294
1937	709	596	449	302
1936	627[b]	427	290[b]	128

1935	666	594	421	230
1934	614	415	262[b]	165
1933	940	614	408	192
1932	967	692	493	310
1931	827	640	387	274
1930	744	501	326	159
1929	884	625	416	219
1928	913	629	407	259
1927	985	700	447	212
1926	924	578	435	269

*U.S.D.A., E.R.S., Grain and Feed Statistics through 1961, Statistical Bulletin No. 159, Revised June 1962, P. 26, and U.S.D.A., A.M.S., Feed Situation, various issues. Figures are corn harvested for grain only.

[a]Preliminary.

[b]Exports were less than 500,000 bushels.

[c]Data were not available when the table was compiled.

APPENDIX TABLE 5

COMBINED STOCKS OF OATS, BARLEY, AND WHEAT BY QUARTERS FOR UNITED STATES, 1927 THROUGH 1963, EXCLUDING WAR YEARS*

	(1000 Bushels)			
Years	January 1	April 1	July 1	October 1
1963	1,634,167[a]	1,195,109[a]	b	b
1962	1,725,161	1,263,379	890,419	1,968,716
1961	1,877,453	1,381,129	1,011,948	2,092,275
1960	1,625,106	1,192,659	835,415	2,265,706
1959	1,968,419	1,413,242	952,488	2,010,369
1958	1,611,758	1,147,530	742,333	2,465,674
1957	1,574,189	1,084,914	791,861	1,994,336
1956	1,897,992	1,319,743	855,931	2,028,739
1955	1,755,256	1,239,382	836,200	2,272,641
1954	1,562,368	1,090,944	731,816	2,153,855
1953	1,471,319	955,000	573,799	1,925,810
1952	1,411,694	862,622	426,628	1,855,841
1951	1,494,255	983,871	526,926	1,855,414
1950	1,365,740	871,521	450,943	1,900,222
1949	1,490,617	951,720	480,154	1,900,219
1948	1,317,345	747,621	306,565	1,968,879
1947	1,338,670	1,011,158	314,659	1,775,428
1946	1,512,526	841,055	359,346	1,829,533
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1942	1,503,111	951,384	589,008	2,093,151
1941	1,260,360	815,406	457,807	1,745,448
1940	994,106	625,091	318,419	1,603,308
1939	1,137,389	706,040	351,814	1,297,920
1938	1,046,936	637,770	292,697	1,448,544
1937	734,647	424,410	125,514	1,430,962
1936	1,076,911	687,920	357,938	1,051,129

1935	622,385	383,711	150,071	1,391,254
1934	837,801	536,486	280,243	848,750
1933	1,246,536	822,415	452,423	1,119,507
1932	1,226,594	764,526	416,506	1,614,252
1931	1,234,422	784,747	421,935	1,646,396
1930	1,083,226	681,334	336,011	1,630,585
1929	1,189,288	724,881	330,042	1,428,595
1928	945,054	508,937	177,207	1,563,603
1927	1,013,312	593,859	220,419	1,307,177

*Computed by the methods described in Chapter IV. Data were obtained from U.S.D.A., E.R.S., Grain and Feed Statistics Through 1956, Statistical Bulletin No. 159, Revised May 1956, Grain and Feed Statistics Through 1961, Statistical Bulletin No. 159, Revised June 1961, various issues of U.S.D.A., A.M.S., Feed Situation, and The Chicago Board of Trade Annual Report.

[a]Preliminary.

[b]Data were not available when the table was compiled.

APPENDIX TABLE 6

BUREAU OF LABOR STATISTICS WHOLESALE PRICE INDEX FOR ALL COMMODITIES, 1927 THROUGH 1963, EXCLUDING WAR YEARS, ADJUSTED TO 1957 THROUGH 1959 BASE*

Years	March	June	September	December
1963	99.90	a	a	a
1962	100.70	100.00	101.20	100.40
1961	101.00	99.50	100.00	100.40
1960	100.92	100.50	100.25	100.50
1959	100.58	100.67	100.67	99.99
1958	100.67	100.25	100.16	100.25
1957	98.31	98.73	99.24	99.66
1956	94.86	96.04	97.14	97.81
1955	92.51	92.76	93.94	93.60
1954	92.93	92.51	92.51	92.09
1953	92.51	92.09	93.35	92.59
1952	94.44	93.52	94.02	92.17
1951	97.95	96.73	94.55	95.45
1950	81.29	83.74	90.23	93.32
1949	84.32	82.25	81.82	80.49
1948	85.92	88.48	89.70	86.45
1947	79.64	78.57	83.79	86.88
1946	57.97	60.10	66.01	75.01
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1942	51.96	52.49	53.02	53.77
1941	43.39	46.37	48.87	49.83
1940	41.74	41.26	41.52	42.59
1939	40.83	40.25	42.11	42.16
1938	42.43	41.68	41.68	40.99
1937	46.74	46.42	46.53	43.49
1936	42.38	42.16	43.44	44.82
1935	42.27	42.48	42.96	43.07

1934	39.23	39.71	41.31	40.94
1933	32.05	34.60	37.69	37.69
1932	35.14	34.02	34.76	33.33
1931	39.66	37.26	36.79	36.52
1930	48.44	46.31	44.82	41.74
1929	51.90	51.32	51.90	50.05
1928	51.11	51.96	53.29	51.48
1927	50.31	49.93	51.37	51.53
1926	--	--	--	52.12

*Computed by the methods described in Chapter IV. Data were obtained from various issues of the Federal Reserve Board of Governors, Federal Reserve Bulletin.

[a]Data were not available when the table was compiled.

APPENDIX TABLE 7

SHORT TERM INTEREST RATES ON FOUR- TO SIX-MONTH PRIME COMMERCIAL PAPER IN THE NEW YORK MONEY MARKET, 1927 THROUGH 1963, EXCLUDING WAR YEARS*

	(Per Cent Per Annum)			
Years	March	June	September	December
1963	3.34	3.38	a	a
1962	3.25	3.25	3.34	3.29
1961	3.03	2 91	3.05	3.19
1960	4.49	3.81	3.39	3.23
1959	3.35	3.83	4.63	4.88
1958	2.33	1.54	2.93	3.33
1957	3.63	3.79	4.00	3.81
1956	3.00	3.38	3.50	3.63
1955	1.69	2.00	2.54	2.99
1954	2.00	1.56	1.31	1.31
1953	2.36	2.75	2.74	2.25
1952	2.38	2.31	2.31	2.31
1951	2.06	2.31	2.19	2.31
1950	1.31	1.31	1.66	1.72
1949	1.56	1.56	1.38	1.33
1948	1.38	1.38	1.56	1.56
1947	1.00	1.00	1.06	1.19
1946	0.75	0.75	0.81	1.00
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1942	0.63	0.69	0.69	0.69
1941	0.56	0.56	0.50	0.56
1940	0.56	0.56	0.56	0.56
1939	0.50	0.50	0.63	0.56
1938	0.75	0.75	0.63	0.63
1937	0.75	1.00	1.00	1.00
1936	0.75	0.75	0.75	0.75

1942	0.63	0.69	0.69	0.69
1941	0.56	0.56	0.50	0.56
1935	0 75	0.75	0 75	0.75
1934	1.00	0.75	0.75	0.75
1933	1 50	1.50	1.25	1.25
1932	3.50	2.50	2.00	1.25
1931	2.50	2.00	2.00	3.75
1930	3.75	3.25	3.00	2.75
1929	5.75	6.00	6.25	5.00
1928	4.00	4.75	5.50	5.25
1927	4.00	4.25	4.00	4.00
1926	--	--	--	4.50

*Obtained from various issues of the Federal Reserve Board of Governors, <u>Federal Reserve Bulletin</u>. Figures are monthly averages.

[a]Data were not available when the table was compiled.

APPENDIX TABLE 8

CORN PRODUCTION AND GRAIN-CONSUMING ANIMAL UNITS FED ANNUALLY FOR UNITED STATES, 1926 THROUGH 1963, EXCLUDING WAR YEARS*

Years	Production (1000 bushels)[a]	Grain-Consuming Animal Units (Millions)
1963	3,861,640[b]	176.0[b]
1962	3,643,615[c]	173.2[c]
1961	3,625,530	168.9
1960	3,908,070	167.6
1959	3,824,598	165.7
1958	3,365,205	167.7
1957	3,045,355	160.0
1956	3,075,336	161.0
1955	2,872,959	165.3
1954	2,707,813	161.6
1953	2,881,801	156.9
1952	2,980,793	158.8
1951	2,628,937	167.3
1950	2,765,071	168.1
1949	2,946,206	163.8
1948	3,307,038	158.6
1947	2,108,321	153.1
1946	2,916,089	159.6
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1942	2,801,819	192.2
1941	2,414,445	167.1
1940	2,206,882	155.8
1939	2,341,602	156.1
1938	2,300,095	148.3
1937	2,349,425	137.8
1936	1,258,673	137.8
1935	2,001,367	138.7
1934	1,146,734	131.2
1933	2,104,725	153.9
1932	2,578,685	159.7
1931	2,229,903	156.4
1930	1,757,297	152.8
1929	2,135,038	154.1
1928	2,260,990	153.2
1927	2,218,189	153.7
1926	2,140,207	153.1

*Sources: U.S.D.A., E.R.S., Grain and Feed Statistics Through 1961, Statistical Bulletin No. 159, Revised June 1962, pp. 3-5, 9, and U.S.D.A., A.M.S., Feed Situation, August 1963, pp. 10, 43.

[a] Production for grain only.

[b] August 1, 1963 indications.

[c] Preliminary.