THE DISTRIBUTION OF PRICE CHANGES FOR TWO DAY TRENDS OCCURRING IN THE DECEMBER WHEAT FUTURES MARKET, 1921-1957

by

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INTRODUCTION

Wheat is one of the most important food grains in the world, and, therefore, has received a great deal of attention from the economist. Yet, in all the economic studies of wheat, this author could find none which has been made pertaining to the distribution of daily price changes of wheat. Until relatively recently, such a study would have been inconceivable due to the amount of labor involved and the great mass of data which must be used to acquire an accurate picture of daily price changes. However, at the present, with the use of high speed digital computers it is now feasible to investigate the distribution of daily price changes.

A study of the distribution of price changes for wheat was made primarily to help further the understanding of the phenomenon of the pricing of wheat. This study is designed to yield some knowledge as to what can be expected in the way of price changes for wheat on the basis of what has happened in the past.

The prices occurring in the wheat futures market were chosen to represent the pricing of wheat. This choice was made under the assumption that the wheat futures market is a market where pure competition exists and that the market is governed by the fundamental forces of supply and demand at work in the wheat economy.

To facilitate the description of the price changes occurring in the wheat futures market it was felt that it was best to compare the distribution of the observed price changes with a com-

parable theoretical distribution which possessed definable and consistent qualities. The normal distribution concept found in the area of mathematical statistics affords these properties. The theoretical normal distribution describes a family of distributions, any one of which may be chosen by specifying, N, the number of observations and, σ, the standard deviation of the distribution. Further the theoretical normal distribution may be adjusted so that its mean will coincide with the mean of an observed distribution. Therefore, because of the flexibility of this theoretical concept, it was used as a benchmark in this study.

The comparison of an observed distribution with its corresponding normal distribution will show one of three things: (1) The observed distribution is not significantly different from a normal distribution as in Figure 1.

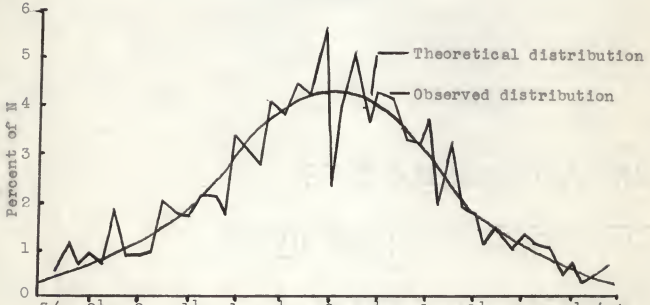

Figure 1.

(2) the observed distribution is different from a normal distribution but not greatly different as in Figure 2.

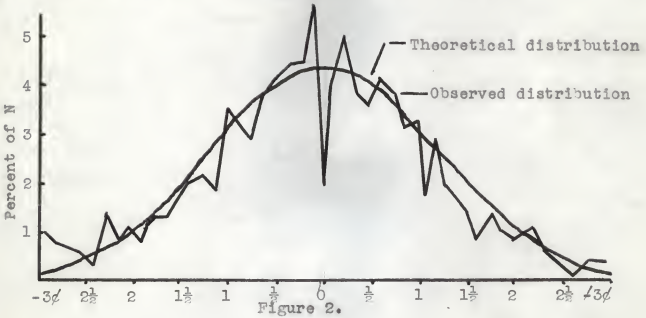

Figure 2.

(3) the observed distribution is considerably different from a normal distribution as in Figure 3.

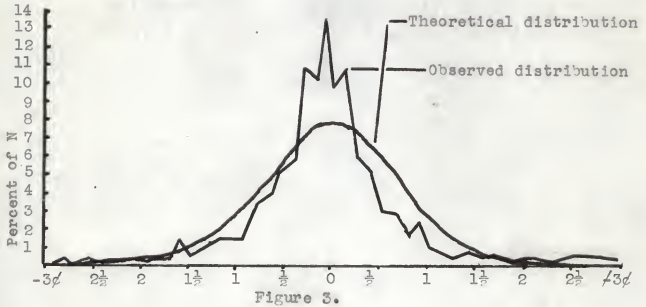

Figure 3.

On the basis of the above information it will be possible to specify the observed distributions which require more study in order to specify the exact nature of the distribution.

POSITION OF THE DECEMBER WHEAT FUTURES MARKET

It is advantageous to define the position occupied by the Chicago December wheat futures market in the economy. To do this, it is necessary to start with economic theory and its explanation of the functioning of the free enterprise economy.

The economic system is classified as a pricing system. The type of enterprise is primarily free enterprise. The functions of the economy are: (1) The fixing of values, (2) allocation of resources, (3) distribution of the product, (4) change, and (5) growth. These functions are performed through the market place.

The concept of the market place represents the place or area where the forces of supply and demand interact to specify the prices, quantities, and allocation of the economic goods within that area. It is not the purpose here to state how this is performed, butto observe that it is performed.

In theory, the pricing system is characterized by the owners of productive resources selling their resources to entrepreneurs in exchange for monetary units, and then using the income thus derived to buy the products of the entrepreneurs. Two basic sectors exist in the economy: The owners of resources or consumers, and the business enterprise or entrepreneurs sector. The two sectors meet in two different markets. The entrepreneurs acquire resources and productive services from the consumers in exchange for wages, interest, and rents in the productive services market. The second market is the consumers goods market

where entrepreneurs yield goods and services in return for monetary units from the consumers.[1]

The price used in this study was derived from a market which is analogous to the productive services market in theory. Although it could not be conceived to be a true theoretical productive services market, it is closer to this than the theoretical consumer goods market.

The commodity futures market is located in the business enterprise sector of the economy. The business enterprise side of the economy is composed of all firms which are engaged in the manufacturing and distribution of economic goods and services. The firms in this area provide the raw materials with economic value. These firms are owned by the entrepreneur who acts according to the tendencies of the enterprise system, as outlined above.

The number of firms reported in the United States in the first half of 1957 was 6,651,229.[2] The number of farms reported in 1957 was 4,856,000.[3] Assuming that each farm can be listed as a firm, this would bring the total number of firms in the United States to around 11,500,000.

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[1]An explanation of the mechanics involved in the functioning of these markets is beyond the scope of this study. However, if the reader is interested in this, he will find a good discussion of it in E. H. Phelps Brown's, The Framework of the Pricing System.

[2]This excludes agriculture, forestry, and fishing groups. United States Department of Commerce, Statistical Abstract of the United States, 1958, p. 488.

[3]Ibid., p. 611.

An industrial classification of the business enterprise segment of the U. S. economy contains the following primary classification of industries: (1) Agriculture, (2) mining, (3) contract construction, (4) manufacturing, (5) wholesale and retail trade, (6) finance, insurance, and real estate, (7) transportation, (8) communications and public utilities, (9) services, (10) government and government enterprises.[1] This classification pertains to the production and/or source of goods and service. It is evident that almost any agricultural product one might choose would enter many or most of these areas of the economy during its movement from the raw material stage to the finished product.

The agricultural sector of the economy produces many different products which are identified under two headings--livestock and crops. The division under crops is then broken down and includes feed grains, food grains, cotton, tobacco, oil crops, vegetables, fruits and nuts, sugar crops, and seeds.[2] Wheat constitutes the major portion of the food grains produced and marketed in the United States.

Prices for wheat exist in many places and stages in the wheat marketing channel. Wheat futures prices were felt to best reflect the supply and demand conditions existing in the over-all wheat economy. To further justify the importance of futures prices some further word should be given on the purpose and functioning of the futures market.

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[1]This classification is used by the United States Department of Commerce; United States Department of Commerce, op. cit., p. 493.

[2]This classification is used by the United States Department of Commerce; United States Department of Commerce, op. cit., p. 644.

The trading of futures involves the buying and selling of a contract. This contract is a promise to accept delivery, or deliver a specified amount of the commodity at a specified time and place. Mr. Holbrook Working has offered a broad definition of the general concept of futures trading. He states, "trading conducted under special regulations and conventions, more restrictive than those applied to any other class of commodity transactions, which serve primarily to facilitate hedging and speculation of promoting exceptional convenience and economy of the transactions."[1]

A commodity possesses certain characteristics which facilitate its being traded in the futures market. These characteristics are: (1) Units must be homogeneous, (2) the commodity must be susceptible to standardization of grades, (3) supply and demand must be large, (4) the supply must flow naturally to market, (5) supply and demand must be uncertain, and (6) the commodity must not be perishable.[2]

One of the major reasons for a futures market for any commodity revolves around the existence of the uncertainty of supply and demand. The existence of this cuases an uncertainty with respect to the price of the commodity--giving rise to risk in the handling of the commodity as it progresses through the marketing

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[1]Working, Holbrook, "Futures Trading and Hedging," The American Economic Review, June 1953, Vol. XLIII, No. 3., p. 315.

[2]A detailed discussion of each of these characteristics with respect to futures trading may be found in Julis B. Baer's and Olin G. Saxon's Commodity Exchanges and Futures Trading, p. 110-125.

channel. The futures market exists largely to provide a means for shifting the risk of price changes. It is organized to provide the mechanism wherein the shifting of this risk can be done swiftly and economically. The market also serves other functions. These may be briefly classified as facilitating: (1) Efficient financing, (2) accumulation, interpretation and the market's evaluation of information on the known influences acting on the market, and (3) the orderly conduct of the market.[1]

The futures market probably represents one of the best approximations available in our economy of the classical concept of the perfect market. Although the futures market does not conform entirely to the perfect market concept, it is sufficiently close to be referred to as a market where pure competition exists. The perfect market refers to a market where there is found: (1) A large number of buyers and sellers, (2) perfect mobility, (3) complete knowledge, (4) homogeneous products and services, and (5) only pecuniary consideration. "Pure competition assumes the existence of large numbers of buyers and sellers, a homogeneous product and considerable, though not complete information."[2]

The futures market conforms to this concept of pure competition. It affords a high degree of mobility and the considerations are primarily pecuniary. Thus the market affords the best

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[1]If the reader is interested in the economic functions of the futures market, a very good discussion of this may be found in Julis B. Baer's and Olin G. Saxon's Commodity Exchanges and Futures Trading, p. 27-50. The author feels that a comprehensive discussion of this area is beyond the scope of this study.

[2]Waite, Warren C., and Harry C. Trelogan, Agricultural Market Prices, Second edition, p. 115.

reflection of the known supply and demand conditions throughout the economy, as they exist at any given time.

A relation exists between the futures price and the cash price. This relation is provided for by allowing the delivery or accepting delivery on the futures contract during the contract's delivery month. This generally allows the cash price and the futures price to move together. The prices in each market may deviate, and do at times, but as the delivery month approaches, these differences lessen in frequency, magnitude, and length of duration. Theoretically, assuming that the futures price is an estimate of the price that will prevail during the delivery period, the difference between the futures price and the cash price should be just equal to the cost of holding the commodity until the delivery period.

The Chicago wheat futures prices were used in this study because the Chicago market is the largest of the three major commodity exchanges in reference to wheat futures trading. In the Chicago wheat futures market, trading is going on in various delivery month contracts at most all times. Futures trading is offered in five delivery month contracts in the course of the year; these delivery months being March, May, July, September, and December. The December contract was used in this study. The daily prices were available on IBM cards and some previous work had been done using the Chicago December wheat futures prices.

PURPOSE AND PROBLEM

The wheat economy represents a market in pure competition wherein the resource wheat is allocated by the price of the resource. Within this market the forces of supply and demand are at work to establish the price, given the conditions which exist in the economy. This price in turn determines the allocation of wheat throughout the economy.

To many people, the producer, the consumer, the handler, and the processor of wheat, price is important. When conditions which affect the supply and demand change the price of wheat in the futures market changes and the allocation is adjusted in response. Therefore, price changes in the wheat futures market are of interest to many people.

Although considerable is known as to what brings about price changes and how these have occurred in the past, very little was known as to the distribution of these price changes. The pattern of daily price changes, over a considerable period, had not previously been tabulated.

It was the purpose of this study to investigate the distribution of price changes in the Chicago December wheat futures market for the period 1921-1957, and to classify these distributions as occurring in the pattern: Category A, not significantly different from a normal distribution; category B, significantly but not very different from a normal distribution; and category C, significantly and considerably different from a normal distribution.

PROCEDURE AND ASSUMPTIONS

The price quotations used in this study were taken from the Kansas City Grain Market Review, 1921-1957, and placed on IBM cards. With the data in this form, it was possible to summarize the daily price changes for the entire period by direction of movement, magnitude of change, and length of movement in the same direction. With the data in this form it was possible to choose the appropriate distributions for further investigation.

The available IBM facilities were used to summarize the price changes. The principal machines used for this purpose were the 402 accounting machine and the IBM 650 digital computer. Other supporting IBM machines were also used where appropriate.

The prices for each day were assumed to reflect the supply and demand conditions which existed in the market at the time the prices were recorded. Thus a change in price is taken to reflect a change in the known conditions existing in the market. The changes in the market conditions which brought about the price changes were assumed to be: (1) Independent on one another, (2) numerous and of approximately equal weight, and (3) such that their deviations about the mean are balanced with respect to magnitude and number.

Given these assumptions, the null hypothesis was made that the observed distribution in each case did not differ significantly, at the 5 percent level of probability, from a normal distribution which possessed the same number of observations and standard deviation as that calculated for the observed distribu-

tion. The alternative hypothesis being that the observed distribution in each case did differ significantly, at the 5 percent level of probability, from a normal distribution curve which possesses the same number of observations and standard deviation as that calculated for the observed distribution. First, the above null hypothesis was tested for each observed distribution. The result of this first test determined whether the observed distribution fell into category A or not. At the completion of the first test the null hypothesis was tested using the one percent level of probability. This second test determined whether the observed distribution fitted into category B or C.

The distributions for two day trend price comparisons were used in this study because they contained more observations per distribution than did the longer trends. Day-to-day price changes were not used in that they did not constitute a trend. The term trend as it is used in this study refers to the movement of daily price changes in which the close price has moved in the same direction for more than one day. The direction and length of the trend was determined by subtracting the close price for a given day from the close price for the day following. A terminated two-day trend, therefore, is a trend in which the close price moved in the same direction for two days and changed direction on the third day. A two-day non-terminated trend is constituted by the price moving in the same direction for three or more days.

The price comparisons used in this study are basically three. The first type of comparison involves only the close price. Using the close price two comparisons are made:

(1) $\frac{C_2 - C_0}{2}$

where C_2 is the close the second day of a trend,

C_0 is the reference day of the same trend.

This gave the average daily difference in the close price for the two day trend.

(2) $C_2 - C_1$ was the other comparison made using only the close prices.

Where C_2 is the same as above,

C_1 is the close price the first day of the two day trend.

Using the open price and close price two comparisons were made. They were:

(1) $C_2 - O_2$

where C_2 is the same as above,

O_2 is the open price the second day of the trend.

This gave the distribution of the price change which occurred during the trading day the second day of the trend.

(2) $O_3 - C_2$

where C_2 is the same as above

O_3 is the open price the day following the close price the second day of the trend.

This price comparison gave the distribution of price changes which had occurred over night, between the second day close and the following day's opening.

The distributions were accumulated in the above classification of price comparisons for all two day trends. Next all two

day trends were divided into two categories, terminated and non-terminated, and the distributions of each price comparison was accumulated under each of these categories. This classification was made to see if there existed any distinguishable difference between the distributions based on whether the trend was terminated or non-terminated.

Limitation of drum space on the 650 prevented the investigation of the entire distribution for each type of the selected price changes. Therefore, the distribution analysis for the two day trends was limited to the area of ±2.875 cents. Any change equal to or greater than ±3.000 cents was grouped into one category. In all cases this resulted in a truncated distribution. Thus in every case, the distribution being investigated is that distribution which lies between ±2.875 cents inclusive.

The mean and standard deviation were calculated using the number of observations occurring in each class interval between the ±2.875 cents range. The observations beyond this were ignored. The assumption was made that the observed distribution conformed to the theoretical distribution beyond these limits given the number of observations and standard deviation for the individual observed distribution. This assumption was conformed to in every case, although in some cases it was of more significance than in others. The percent of observations which would theoretically fall beyond the ±2.875 area, in each case, was multiplied by the number of observations falling within this area. The number thus calculated was then used to derive the actual

percent of observations which fell in each category between ± 2.875. This allowed the comparison of the observed distribution within the ± 2.875 range with the theoretical normal distribution for the same area. The maximum percentage of observations added in this manner was 1.25, which was not felt to be a significant percentage.

The Kolmogorov-Smirnov one-sample test was used in each case to test the null hypothesis and classify the observed distributions.[1] This test is concerned with the degree of similarity between the observed distribution and the corresponding theoretical normal distribution. It determines whether the observed values can reasonably be considered as coming from a population that has the characteristics of a normal distribution. Essentially, the test involves comparing the cumulative percentages of the observed distribution with the corresponding cumulative proportions which would fall into that interval given a normal distribution with the same number of observations and standard deviation. The difference between the observed and theoretical are then compared with the maximum tolerable difference.

The formula for the Kolmogorov-Smirnov one-sample test is $D = \text{maximum } \left|F_o(x) - S_n(x)\right|$. Where D is the maximum deviation $F_o(x)$ is the completely specified cumulative normal frequency distribution which possesses the same mean, number of observations and standard deviation as that possessed by $S_n(x)$, $S_n(x)$

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[1] Siegel, Sidney, Non Parametric Statistics for the Behavioral Sciences, pp. 47-51.

is the observed cumulative distribution with N observations.[1] The D thus derived is compared with the maximum tolerable difference allowed under the null hypothesis. The maximum tolerable difference is for the 5 percent level $\frac{1.36}{\sqrt{N}}$ and at the 1 percent level $\frac{1.63}{\sqrt{N}}$.[2] If D is greater than or equal to these values the null hypothesis is rejected at that particular level of probability.

The Kolmogorov-Smirnov one-sample test was used to classify the distributions into the three categories A, B, and C. If the observed distribution was not rejected at the 5 percent level of probability, it was classified in the category A. If the observed distribution was rejected at the 5 percent level but was not significantly different from a normal distribution at the 1 percent level, the observed distribution was classified in category B. If the observed distribution was significantly different from a normal distribution at both the 5 and 1 percent level, it was classified in category C.

The normal distribution curve was chosen as the standard for comparison in this study for the following reasons: (A) Little was known as to the nature of the specific daily price changes, but it appeared that there would be a tendency toward a concentration of small differences and that large daily price changes would appear with progressively less frequency as one moved farther from zero. (B) The basic assumptions behind the theory

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[1] Ibid., p. 48.

[2] Siegel, Sidney, op. cit., p. 251.

of the normal distribution curve were acceptable in their application to the price changes investigated in this study. These basic assumptions as enumerated by Fredrick C. Mills are: "(1) The casual forces affecting individual events are numerous and of approximately equal weight, (2) the casual forces affecting individual events are independent of one another, (3) the operation of the casual forces is such that deviations above the mean of the combined results are balanced as to magnitude and number of deviations below the mean."[1] (C) The normal distribution equation defines a family of curves in which any member may be chosen by the specification of the number of observations and standard deviation.[2] Therefore, it was possible to choose the proper normal curve with which the observed distribution should be compared. (D) The normal distribution of prices is often implicitly

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[1] Mills, Fredrick Cecil, Statistical Methods Applied to Economics and Business, p. 436.

[2] "The equation of the normal curve is:

$$y = \frac{N}{\sigma\sqrt{2\pi}} e^{-\frac{x^2}{2\sigma^2}}$$

Where x is any abscissa
y is the corresponding ordinate
σ is the standard deviation of the distribution
π is the mathematical constant which gives the ratio of any circle to its diameter, and whose approximate value is 3.1416
e is another mathematical constant whose approximate value is 2.71828
N is the number of cases in the distribution and therefore also the number of units under the curve when it is drawn."

Walker, Helen, Elementary Statistical Methods, p. 172.

assumed in economic studies when the phenomena of prices are studied. This is evidenced by the construction of the index of irregularity and the statement that this area includes 68.3 percent of the prices. These are the reasons the observed frequency distributions found in this study were compared with the corresponding theoretical normal distribution. It was felt that this constituted the first logical step in a comprehensive study of the distribution of price changes.

AVERAGE DAILY DIFFERENCE OF THE CLOSE PRICE FOR TWO DAY TRENDS, 1921-1957

The average daily difference of the close price for two day trends more specifically is the comparison $\frac{C_2 - C_0}{2}$.

The observed distribution for this difference is given in Table 1. The observed distribution is significantly different from the corresponding normal distribution at the 5 percent level of probability; therefore, the null hypothesis was rejected. The observed distribution is also significantly different at the 1 percent level, thus, the observed distribution was classified as a type C distribution.

Table 1. Wheat: Frequency distribution of the average change in close price for two day trends in the Chicago December futures, 1921-1957.

Price Change	Number of Days	
	Up	Down
(cents)		
.000	35	--
.125	19	26
.250	49	42
.375	70	80
.500	80	90
.625	101	96
.750	65	75
.875	69	82
1.000	51	69
1.125	47	57
1.250	62	41
1.375	30	43
1.500	39	33
1.625	32	41
1.750	25	25
1.875	32	25
2.000	26	19
2.125	16	16
2.250	14	11
2.375	9	8
2.500	8	12
2.625	5	12
2.750	5	3
2.875	6	7
3.000	60	39

The mean value is -0.005, which is very close to zero, indicating a degree of balance in the deviation from no change with respect to magnitude and frequency of deviation. The standard deviation for the observed distribution is $\pm$1.185.

The two day trends in Table 1 have been separated according to whether the trend was terminated or non-terminated following the second day of the trend. The distributions for each is given in Table 2.

Table 2. Wheat: Frequency distribution of the average change in close price for terminated and non-terminated two day trends occurring in the Chicago December Futures, 1921-1957.

Terminated Trends			Non-terminated Trends		
Price Change	Number of Days Up	Down	Price Change	Number of Days Up	Down
(cents)			(cents)		
.000	22	--	.000	13	--
.125	17	12	.125	2	14
.250	31	22	.250	18	20
.375	36	39	.375	34	41
.500	47	46	.500	33	44
.625	51	51	.625	50	45
.750	30	36	.750	35	39
.875	46	47	.875	22	35
1.000	26	43	1.000	25	26
1.125	29	36	1.125	18	21
1.250	36	22	1.250	26	19
1.375	15	23	1.375	15	20
1.500	20	24	1.500	19	9
1.625	21	21	1.625	11	20
1.750	12	15	1.750	13	10
1.875	13	9	1.875	19	6
2.000	16	16	2.000	10	3
2.125	10	11	2.125	6	5
2.250	9	7	2.250	5	4
2.375	5	5	2.375	4	3
2.500	3	9	2.500	5	3
2.625	4	9	2.625	1	3
2.750	3	2	2.750	2	1
2.875	5	4	2.875	1	3
3.000	34	26	3.000	26	13

Both distributions were found to be significantly different from their corresponding normal distribution at the 5 percent and 1 percent level of probability. Thus, the null hypothesis was rejected in both cases, and both distributions were classified as a C type distributions.

The mean for the two day terminated trends is -0.021. The mean for the two day non-terminated trend is $\not$0.031. This indi-

cates that differences may exist which could prove significant if the distribution for the two day up terminated were compared with the two day down terminated. An investigation of the distributions of the two day down trends terminated and non-terminated might also show some significant differences from one another.

The standard deviations were ∠1.217 for the two day terminated and ∠1.139 for the two day non-terminated. The dispersion of the terminated trends was slightly more than for the non-terminated trends.

PRICE CHANGES BETWEEN THE CLOSE PRICE THE SECOND DAY OF TREND AND CLOSE PRICE THE FIRST DAY OF TREND FOR THE TWO DAY TRENDS, 1921-1957

The observed distribution given in Table 3 for the price change between $C_2 - C_1$ was found to differ significantly from the corresponding normal distribution at the 5 percent level of probability. Therefore, the null hypothesis was rejected. However, the observed distribution was not significantly different from the corresponding normal distribution at the 1 percent level of probability. This indicates a greater degree of conformity to the normal distribution than was found in the case of the average price change, therefore, this distribution was classified as a B type distribution. The mean value is -0.029. The standard deviation is ∠1.173.

Table 3. Wheat: Frequency distribution of the price change between the close the second day and the close the first day for two day trends occurring in the Chicago December Futures, 1921-1957.

Price Change	Number of Days	
	Up	Down
(cents)		
.000	35	--
.125	70	102
.250	87	78
.375	66	78
.500	62	71
.625	72	65
.750	67	51
.875	54	60
1.000	56	64
1.125	30	31
1.250	51	39
1.375	33	36
1.500	26	27
1.625	16	25
1.750	25	25
1.875	18	15
2.000	17	19
2.125	19	15
2.250	17	25
2.375	9	8
2.500	7	11
2.625	3	12
2.750	12	13
2.875	10	8
3.000	93	64

The observed distributions for terminated and non-terminated trends using the same comparison as above is given in Table 4. The two observed distributions were tested against their corresponding normal distributions with a variation of results. The observed distribution for the terminated trends were found not to differ significantly from its corresponding distribution at the 5 percent level of probability; therefore, the null hypothesis

with reference to this distribution was accepted and the distribution was classified as an A type distribution.

Table 4. Wheat: Frequency distribution of the price change between the close the second day and the close the first day for terminated and non-terminated two day trends occurring in the Chicago December Futures, 1921-1957.

Terminated Trends			Non-terminated Trends		
Price Change	Number of Days		Price Change	Number of Days	
	Up	Down		Up	Down
(cents)			(cents)		
.000	22	--	.000	13	--
.125	38	55	.125	32	47
.250	50	40	.250	37	38
.375	36	43	.375	30	35
.500	41	37	.500	21	34
.625	40	39	.625	32	26
.750	32	27	.750	35	24
.875	31	30	.875	23	30
1.000	35	33	1.000	21	31
1.125	18	16	1.125	12	15
1.250	31	21	1.250	20	18
1.375	18	21	1.375	15	15
1.500	16	16	1.500	10	11
1.625	10	16	1.625	6	9
1.750	14	19	1.750	11	6
1.875	8	9	1.875	10	6
2.000	12	8	2.000	5	11
2.125	10	8	2.125	9	7
2.250	9	18	2.250	8	7
2.375	4	6	2.375	5	2
2.500	6	8	2.500	1	3
2.625	3	6	2.625	0	6
2.750	4	10	2.750	8	3
2.875	6	5	2.875	4	3
3.000	47	44	3.000	46	20

The observed distribution for the non-terminated differences was found to differ significantly from the corresponding normal distribution at the 5 percent level of probability. The null hypothesis was, therefore, rejected. The observed distribution

did not differ significantly from the corresponding normal distribution at the 1 percent level of probability, therefore, falling into the category of a B type distribution.

The means for the two distributions were -0.039 for the terminated two day trends and -0.011 for the non-terminated two day trends. Both are close to zero change. The standard deviations are $\pm$1.151 for the terminated trends and $\pm$1.140 for the non-terminated trends.

The results of the distribution for the terminated and non-terminated trends do not display a great deal of difference. However, on the basis of the results of the Kolmogorov-Smirnov one-sample test, further investigation of these distributions to detect further differences may be warranted.

PRICE CHANGES BETWEEN THE OPEN PRICE THE SECOND DAY OF A TWO DAY TREND AND THE CLOSE PRICE THE SECOND DAY OF A TWO DAY TREND, 1921-1957

The observed distribution of the $C_2 - O_2$ difference is given in Table 5. The observed distribution differs significantly from the corresponding normal distribution at the 5 percent and 1 percent level of probability. Therefore, the null hypothesis was rejected and the distribution was classified as a C type distribution. The mean value for the observed distribution was -0.018 and the standard deviation was found to be $\pm$1.091.

Table 5. Wheat: Frequency distribution of the price change between the open price and close price the second day of the two day trends occurring in the Chicago December Futures, 1921-1957.

Price Change	Number of Days	
	Up	Down
(cents)		
.000	104	--
.125	93	89
.250	75	96
.375	67	86
.500	94	72
.625	57	67
.750	57	51
.875	54	53
1.000	53	61
1.125	22	34
1.250	40	43
1.375	19	32
1.500	36	29
1.625	22	30
1.750	16	20
1.875	15	21
2.000	17	9
2.125	12	11
2.250	15	13
2.375	7	6
2.500	17	10
2.625	6	5
2.750	7	13
2.875	6	4
3.000	42	54

The observed distributions for the $C_2 - O_2$ two day terminated and $C_2 - O_2$ two day non-terminated differences were found to be quite different. The observed distribution for the terminated trends was not significantly different from its corresponding normal distribution at the 5 percent level of probability. Thus, the null hypothesis was accepted, and the distribution was classified as an A type distribution. The observed distribution for

the non-terminated trends was significantly different from its corresponding normal distribution at the 5 percent level of probability, as well as at the 1 percent level. The null hypothesis was, therefore, rejected and the distribution classified as type C distribution.

Table 6. Wheat: Frequency distribution of the price change between the open price and close price the second day of terminated and non-terminated two day trends occurring in the Chicago December Futures, 1921-1957.

Terminated Trends			Non-Terminated Trends		
Price Change	Number of Days Up	Down	Price Change	Number of Days Up	Down
(cents)			(cents)		
.000	57	--	.000	47	--
.125	52	41	.125	41	48
.250	41	50	.250	34	46
.375	45	39	.375	22	47
.500	52	45	.500	42	27
.625	30	35	.625	27	32
.750	39	29	.750	18	22
.875	31	26	.875	23	27
1.000	31	27	1.000	22	34
1.125	11	23	1.125	11	11
1.250	20	29	1.250	20	14
1.375	13	21	1.375	6	11
1.500	24	15	1.500	12	14
1.625	16	17	1.625	6	13
1.750	8	12	1.750	8	8
1.875	8	15	1.875	7	6
2.000	7	6	2.000	10	3
2.125	4	7	2.125	8	4
2.250	9	6	2.250	6	7
2.375	3	4	2.375	4	2
2.500	12	6	2.500	5	4
2.625	2	2	2.625	4	3
2.750	5	9	2.750	2	4
2.875	4	3	2.875	2	1
3.000	22	41	3.000	29	13

The means for the two day terminated and non-terminated trends are respectively -0.016 and -0.010. The respective standard devia-

tions were ⁄1.114 for the terminated and ⁄1.059 for the non-terminated trends.

The distributions of the terminated and non-terminated trends for this difference are very similar with respect to the location of the respective means and the dispersions. The difference between the two distributions as indicated by the Kolmogorov-Smirnov one-sample test is that a greater proportion of the observations in the non-terminated distribution lie between -0.125 and ⁄0.625 than is true of the terminated distribution.

PRICE CHANGES BETWEEN THE CLOSE PRICE THE SECOND DAY OF A TWO DAY TREND AND THE OPEN PRICE THE FOLLOWING DAY, 1921-1957

The distribution of the $O_3 - C_2$ difference is given in Table 7. The observed distribution was tested and found to differ significantly from its corresponding normal distribution at the 5 percent level and 1 percent level of probability. The null hypothesis was rejected at both the levels of probability and the observed distribution was classified as a type C distribution. The observed distribution differed from its corresponding distribution by containing a higher proportion of its observations within the range ⁄.250 than would be expected in a normal distribution with the same number of observations and the same standard deviation. The mean was -0.007 and the standard deviation ⁄0.655.

Table 7. Wheat: Frequency distribution of the price change between the close price the second day and the open price the following day for two day trends occurring in the Chicago December Futures, 1921-1957.

Price Change	Number of Days	
	Up	Down
(cents)		
.000	238	--
.125	157	171
.250	167	202
.375	108	104
.500	94	87
.625	47	62
.750	49	51
.875	32	27
1.000	31	23
1.125	13	23
1.250	14	15
1.375	5	4
1.500	7	18
1.625	6	0
1.750	5	8
1.875	5	2
2.000	5	3
2.125	0	0
2.250	2	2
2.375	2	3
2.500	4	4
2.625	5	1
2.750	2	2
2.875	2	0
3.000	25	22

The observed distribution for the difference $O_3 - C_2$ for terminated and non-terminated trends was also significantly different from their corresponding normal distributions at the 5 percent and 1 percent level of probability. Thus, the null hypothesis was rejected for both of the observed distributions and both were classified as type C distributions.

Table 8. Wheat: Frequency distribution of the price changes between the close price the second day and the open the following day for the terminated and non-terminated two day trends occurring in the Chicago December Futures, 1921-1957.

Terminated Trends			Non-terminated Trends		
Price Change	Number of Days		Price Change	Number of Days	
	Up	Down		Up	Down
(cents)			(cents)		
.000	135	--	.000	103	--
.125	96	101	.125	61	70
.250	106	109	.250	61	93
.375	58	56	.375	50	48
.500	50	51	.500	44	36
.625	25	36	.625	22	26
.750	23	31	.750	26	20
.875	13	12	.875	19	15
1.000	21	12	1.000	10	11
1.125	8	13	1.125	6	10
1.250	7	10	1.250	8	5
1.375	1	4	1.375	4	0
1.500	3	12	1.500	3	6
1.625	3	3	1.625	2	3
1.750	3	4	1.750	2	4
1.875	1	0	1.875	4	2
2.000	2	3	2.000	3	0
2.125	0	0	2.125	0	0
2.250	1	1	2.250	1	1
2.375	0	1	2.375	2	0
2.500	3	3	2.500	1	1
2.625	4	0	2.625	1	1
2.750	0	1	2.750	2	1
2.875	2	0	2.875	0	0
3.000	12	14	3.000	13	8

The mean value for the terminated trends was -0.021 and for the non-terminated trends, it was $\not$0.030. Although both of these are close to zero, it is only the second case studied in which the means for the terminated and non-terminated trends differed in sign.

The standard deviation in both cases was relatively small. The standard deviation for the terminated trends was $\not$0.641 and

for the non-terminated trends was ∠0.655, reflecting the relative high concentration of differences close to zero.

SUMMARY AND CONCLUSIONS

This study constitutes only one phase of an exhaustive study of price changes occurring during trends in the future markets. As a part of this larger study the function of this investigation was to determine what type, or types, of distributions which could be expected from these price changes. To accomplish this purpose, this study has concentrated on the distribution of price changes for two day trends occurring in the Chicago December wheat futures market. This investigation of twelve distributions for two day trends has shown that these distributions vary considerably and do not fit into any single category.

In all twelve of the observed distributions the mean was found to be very close to zero. The mean ranged from -0.039 to ∠0.031. This indicates that the deviations of the price changes from zero, or no change, are approximately balanced with respect to magnitude and number. It should be kept in mind that this is stated with regard to the distribution of price changes between ∠2.875 cents.

The standard deviation for the observed distributions gave a picture of greater variation than that given by the mean. The standard deviation varied from a low figure of ∠0.641 to a high of ∠1.815. This illustrates that there exists considerable variation in the dispersion about the mean.

In two cases all three of the observed distributions for the given price comparisons were classified into the same category. All three observed distributions for the price comparisons were $\frac{C_2 - C_0}{2}$ and $O_3 - C_2$; were classified as category C distributions. The observed distributions for the price comparisons $C_2 - C_1$ and $C_2 - O_2$ were classified in different categories. The observed distribution for the terminated two day trends were in both these cases classified as category A distributions. The classification of the observed distributions illustrated that it is not safe to assume that all three of the distributions for a given price comparison will fall into the same category.

The two observed distributions in category A did not differ significantly from their corresponding normal distributions. In these cases it can be assumed that the changes in the market conditions which were reflected in the price of wheat futures can be assumed to be (1) independent on one another, (2) numerous and of approximately equal weight, and (3) their deviations about the mean are balanced with respect to magnitude and number.

Some distributions were found to differ considerably from a normal distribution and some did not differ significantly from a normal distribution. Classifying the observed distributions according to the defined categories, A, B, and C, it was found that two distributions fit into category A, two in category B, and eight in category C. It is not to be presumed on the basis of the findings of this investigation that this indicates the ratio which would be found in the investigation of price changes

for other lengths of trend, delivery month contracts, and commodities. It can be stated on the basis of the findings presented in this study that distributions fitting into all three categories can be expected to be found in the further investigation of price changes and that each distribution needs to be investigated before any inferences are drawn from it based on the assumption that it conforms to one of the categories defined in this study.

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THE DISTRIBUTION OF PRICE CHANGES FOR TWO DAY TRENDS OCCURRING IN THE DECEMBER WHEAT FUTURES MARKET, 1921-1957

by

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Wheat is one of the most important food grains in the world, and, therefore, has received a great deal of attention from the economist. Yet, in all the economic studies of wheat, this author could find none which has been made pertaining to the distribution of daily price changes of wheat. Until relatively recently, such a study would have been inconceivable due to the amount of labor involved and the great mass of data which must be used to acquire an accurate picture of daily price changes. However, at the present, with the use of high speed digital computers, it is now feasible to investigate the distribution of daily price changes.

A study of the distribution of price changes for wheat was made primarily to help further the understanding of the phenomenon of the pricing of wheat. This study is designed to yield some knowledge as to what can be expected in the way of price changes for wheat on the basis of what has happened in the past.

The prices occurring in the wheat futures market were chosen to represent the pricing of wheat. This choice was made under the assumption that the wheat futures market is a market where pure competition exist and that the market is governed by the fundamental forces of supply and demand at work in the wheat economy.

To facilitate the description of the price changes occurring in the wheat futures market, it was felt that it was best to compare the distribution of the observed price changes with a comparable theoretical distribution which possessed definable and consistent qualities. The normal distribution concept found in

the area of mathematical statistics affords these properties. The theoretical normal distribution describes a family of distributions, any one of which may be chosen by specifying, N, the number of observations and, σ, the standard deviation of the distribution. Further, the theoretical normal distribution may be adjusted so that its mean will coincide with the mean of an observed distribution. Therefore, because of the flexibility of this theoretical concept it was used as a benchmark in this study.

The distributions for two day trend price comparisons were used in this study because they contained more observations per distribution than did the longer trends. Day-to-day price changes were not used in that they did not constitute a trend. A trend as defined in this study is constituted when the close price moves in the same direction for at least two consecutive days.

It was the purpose of this study to investigate the distribution of price changes in the Chicago December wheat futures market for the period 1921-1957, and to classify these distributions as fitting into one of the three categories: (A) not significantly different from a normal distribution, (B) significantly but not very different from a normal distribution, and (C) significantly and considerably different from a normal distribution.

The Kolmogorov-Smirnov one-sample test was used to classify the distributions into the three categories, A, B, and C. If the observed distribution was not rejected at the 5 percent level of probability, it was classified in the category A. If the ob-

served distribution was rejected at the 5 percent level but was not significantly different from a normal distribution at the 1 percent level, the observed distribution was classified in category B. If the observed distribution was significantly different from a normal distribution at both the 5 and 1 percent level, it was classified in category C.

Limitation of drum space on the 650 prevented the investigation of the entire distribution for each type of the price changes. Therefore, the distribution analysis for the two day trends was limited to the area of ±2.875 cents.

Twelve distributions for the two day trends occurring in the Chicago December wheat futures market were investigated. The means for the distributions in all cases were found to be very close to zero. The mean ranged from -0.039 to +0.031, indicating that the deviations of the price changes from zero are approximately balanced with respect to magnitude and number. The standard deviation varied from ±0.641 to ±1.815 showing considerable variation in the dispersion about the mean. The classification of the observed distributions illustrated that it is not safe to assume that all of the distributions for a given price comparison will fall into the same category.

This study constitutes only one phase of an exhaustive study of price changes occurring during trends in the future markets. As a part of this larger study the function of this investigation was to determine what type, or types, of distributions could be expected from these price changes. To accomplish this purpose

this study has concentrated on the distribution of price changes for two day trends occurring in the Chicago December wheat futures market. This investigation of twelve distributions for two day trends has shown that these distributions vary considerably and do not fit into any single category.

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