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PRICE RELATIONS OF LIVERPOOL WHEAT FUTURES

WITH SPECIAL REFERENCE TO THE DECEMBER–MARCH SPREAD

Sidney Hoos and Holbrook Working

The influences that may affect price relations between different wheat futures in a great importing market differ in many respects from those affecting price relations in such a market as Chicago. General similarities which appear despite such differences are especially significant, for they point to characteristics of futures markets that are not dependent on special conditions in a particular market.

At Liverpool, as at Chicago, price influences which might seem significant principally for deferred futures are found in fact to have nearly or quite as much effect on the near future. Expectations of subsequent developments are reflected in prices of all futures about equally. Price differences between futures arise mainly from conditions and expectations that have greater price significance for the near future than for the deferred future.

The price spread between the December and the March futures at Liverpool appears to have depended mainly on conditions that tend to determine the level of European stocks of imported wheat at about the end of December. Among these conditions have been the pressure of export surpluses during the previous crop year, affecting European stocks in early August, and the various factors that determine what proportion of the current crop year's shipments to Europe will be made during August–November. The December–March spread as early as September implies a forecast of shipments during the autumn. As such, it has been reasonably trustworthy, but it has tended to underestimate the force of extreme conditions, with the result that unusually wide spreads have tended to widen as the season progressed. The influences affecting the December–March spread tend in August–October to bear principally on the price of the December future, but to affect the March future in the same direction. In November and December they tend to affect only the price of the December future.

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Econometric studies of price behavior, combining economic analysis and statistical measurement, generally serve two purposes: they afford a quantitative basis for interpreting current price developments and prospects; and they contribute toward a sound understanding of the functioning of prices in the economic system. The analysis of price behavior of Liverpool wheat futures here presented can have no immediate application in interpretation of current price developments, so long as no prices of futures are quoted at Liverpool or in any similar large importing market; but the conclusions deserve present publication for their contribution to understanding of the functions of futures markets. When the possibility arises for resumption of private trading in wheat on open markets in importing Europe, there will arise for practical decision the question whether such trading should be resumed, and whether the facilities afforded should include an organized futures market. In such a decision, the findings of the present study will deserve consideration.

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One of the important characteristics of a futures market is the fact that it affords price quotations on the commodity for delivery at different times in the more or less distant future. The meanings of differences between the prices quoted simultaneously for delivery at different times, however, have been but little understood, and the most commonly accepted general interpretation is indicated by the present study to be mainly erroneous.

Intensive study at the Food Research Institute of price relations of different futures in particular markets was started, some twelve years ago, with investigations into the relations between the July and September wheat futures at Chicago. There was available as a guide to the research neither any previous careful study of such price relations nor any well-formed body of opinion generally held by traders or by writers in the trade press. In these circumstances it was necessary to proceed by trying out a variety of ideas as to the causal relationships involved, testing them by both statistical and historical analyses of available records for past years. In these tests, the ideas which seemed most widely prevalent proved either mistaken or only partly true, and it became necessary to develop new hypotheses on which to work. Eventually the causal relationships involved in determination of price spreads between certain Chicago wheat futures were fairly clearly revealed.

In the research on price relations among Liverpool wheat futures, started next, greater difficulty was encountered than in the initial studies of Chicago prices. It was supposed at the outset that much of what had been learned of price relations at Chicago would prove directly applicable to interpretation of price relations at Liverpool. This proved not to be the case. In a broad sense the findings of the study of Liverpool prices accord with and supplement the findings of the studies of Chicago prices; but in many details the conclusions reached with respect to price relations at Chicago proved misleading rather than helpful as a guide to the study of price relations at Liverpool.

It proved not difficult in the study of price relations among Liverpool wheat futures to find statistical series showing clearly significant correlations with the price spreads under investigation. The difficulty was to ascertain

the meaning of these correlations in terms of causal influences. None of the statistical series which were found to have a close correlation with the price spreads could be regarded as a direct measure of a true causal influence, and publication of the statistically measured relations without interpretation was more likely to be misleading than helpful. To arrive at a justifiable interpretation, it was necessary to form hypotheses consistent with known facts and to attempt to verify the hypotheses by testing their implications in connection with other facts.

In presenting the results of such a study, it is not profitable to trace the successive steps of the work. To do so would require outlining numerous chains of involved reasoning that led only to the conclusion that other data and ideas must be sought. In the end an interpretation was found that brought the whole of a considerable body of accumulated information into logical relationship. The present publication is an exposition of the final conclusions, backed by the principal evidence on which they rest. Some readers may incline toward a different interpretation. We have endeavored to set out the evidence in sufficient detail to permit the critical reader to judge the validity of other interpretations than that here given.

The conclusions here set forth rest on detailed statistical analysis of price relations between two Liverpool wheat futures—the December and the March—supplemented by less intensive studies of price relations among other Liverpool wheat futures, and interpreted in the light of earlier findings with respect to price relations among Chicago futures.[1] The first section of the present study outlines broadly the known facts regarding inter-option price relations, taking into account the results of previously published studies, conclusions reached on subsequent pages, and other evidence; and illustrates the generalizations by a running interpretation of price developments at Liverpool during a three-year period. Subsequent sections deal with phases of the detailed statistical analysis of price relations between the December and the March futures at Liverpool.

I. GENERAL CHARACTERISTICS OF PRICE RELATIONS AMONG FUTURES

The most natural assumption with respect to the price relation between two futures in any market seems to be that the price of the more distant future tends to reflect in anticipation the effect of events expected to transpire in the time interval between expiration of the two futures, while the nearer future tends not to reflect such anticipations or to reflect them less strongly. On this assumption, the price difference between two futures has been widely interpreted as indicating the market's appraisal of expected price change. A principal result of our investigations of price relations in both the Chicago and the Liverpool futures markets has been to show that this assumption is a mistaken one. But while it is mainly false, it contains some elements of truth. In these circumstances it is necessary to define quite precisely what common suppositions are false and what suppositions are supported by the facts.

The common supposition implies, for example, that changes in prospects for the winter-wheat harvest in the United States, which is nearly completed by the end of July, should affect the price of the Chicago July future more than they affect the price of the May. This view has been widely held, but it is almost wholly mistaken.[2] The mere fact that such a differential effect is expected tends fre-

[1] In testing possible interpretations of the statistical evidence with respect to behavior of Liverpool price relations, we assumed that a sound interpretation would necessarily show at least a certain broad similarity between the influences operating at Liverpool and those operating at Chicago. Maintenance of this requirement forced us to carry the Liverpool study much further than would otherwise have seemed necessary, and had a profound effect on the conclusions. The evidence finally assembled on behavior of the Liverpool prices seems to us sufficient in itself to warrant the interpretation here presented, but the grounds for accepting this interpretation instead of others that have been considered appear fully only when the characteristics of Chicago prices are brought under consideration also.

[2] Expressions of this specific expectation may be found in trade journals published in the United States not many years ago. We know of no general statement of influences believed to affect price relations between

quently to cause it to be realized temporarily, but measurable effects of this sort are only temporary. Damage to the growing winter-wheat crop that occurs in April, for example, is likely at first to cause the price of the July future to rise slightly more than that of the May, but such a special effect on the price of the July future soon disappears. It has not been possible to find any measurable persistent relation between the size of the new winter-wheat harvest and the spread between the May and the July futures at Chicago.

Applied to Liverpool prices, the common supposition implies, to take a similar example, that the size of the prospective wheat harvest in the Southern Hemisphere should affect the relation between the prices of the December and March futures at Liverpool, since supplies of new-crop Argentine and Australian wheat are available in Europe in large volume in March, but not in December. On this theory, prospects for a large harvest in the Southern Hemisphere would be expected to be accompanied by a price for the March future considerably lower, relative to the December future, than would accompany prospects for a small harvest. Investigation, however, fails to bear out this expectation.[1]

These two examples illustrate a general tendency. What is true of the effects of expectations regarding coming harvests is true also of the effects of most other expectations that affect prices. In general, expectations regarding future developments affect the price of a near future nearly if not quite as much as they affect the prices of deferred futures.[2] This being the case, it follows that most expectations regarding future developments have no important effect on the relations between the prices of near and distant futures.

The influences that are important in determining the relations between prices of near and distant futures, so far as they have been ascertained, are distinctly limited in kind and number. They are connected with existing or expected *conditions* rather than with expectations of *change in conditions*. The pertinent conditions are chiefly those related to scarcity or abundance of supplies that will be available for use during the interval between the time of expiration of the nearer future and the time of arrival of substantial supplies from a new source. The specific influences affecting price relations between near and distant futures apparently vary according to the market, and vary somewhat according to the pair of futures under consideration.

Influences at Chicago

The price relations between Chicago futures which can be discussed with most confidence are those between old-crop and new-crop futures, since it is these that have lent themselves best to statistical analysis. At Chicago the May is strictly an old-crop future and the July is in the main a new-crop future. The relation between the two has proved an especially profitable subject for study. Nearly as informative has been analysis of relations between the July and the September futures.[3]

successive futures in the same market published prior to our work on the subject.

The view that the more distant future is the more sensitive to influence from anticipated events is taken by the distinguished British economist, R. G. Hawtrey. Writing in *A Century of Bank Rate* (London, 1938), he holds that the relation of the distant future to the near may be affected not only by crop prospects, but also by expectations of change in the general price level. Hawtrey writes with an understanding of price influences in futures markets that prevents his taking such an extreme view as is stated in the text above. Even so, his view would be clearly in error with reference to Chicago wheat futures prices; and as applied to Liverpool prices, it seems to us to err in the direction of the extreme view.

Hawtrey's view is so expressed that any brief quotation must fail to reflect it adequately, but its main outlines appear in the following sentences: "Now it is quite impossible for the market to foresee a change in the price level even over a period of a few months with any approach to exactitude. But conditions do arise in which the expectation of such a change has a quite definite and even measurable effect on the market.

"In the case of any one commodity an expectation of a change of price may be disclosed by quotations in a forward market. But in the case of a commodity of which a stock is held there is a limit to the divergence between the present or spot price and the forward price." (*Op. cit.*, p. 210.)

[1] It will be shown in a later section that a sensitive statistical test indicates that there may be a very slight tendency in this direction, to which reference will be made shortly in another connection.

[2] Indeed, it may be added, they tend to affect cash wheat prices nearly if not quite as much as they affect the prices of futures.

[3] See Holbrook Working, "Price Relations between July and September Wheat Futures at Chicago since

Although the July is predominantly a new-crop future, its price is under special influence from residual effects of the old-crop supply situation. Differences between prices of the July and the September futures at Chicago are usually in the same direction and about one-third as large as differences prevailing at the same time between the May and the September futures. The price differences between the July and the September futures have proved to be related almost entirely to the old-crop supply situation, much as though the July were definitely an old-crop future.

The dominant influence on relations between prices of the May, July, and September futures at Chicago is exerted by the supply of old-crop wheat, measurable by the carryover of such wheat in the United States on July 1. If the supply is large, the distant futures tend to stand at a premium (or "carrying charge") over the near. If the supply is small, the near future tends to be at a premium, and the amount of the premium tends to be in direct relation to the degree of scarcity. The supply that is chiefly important from this standpoint is not merely that adjacent to Chicago, nor even the total supply in terminal markets, but the whole supply in the country, including stocks on farms. Stocks removed from normal availability for commercial use, such as those held by the Grain Stabilization Corporation in 1930–31 and by farmers under government loans in 1938–39, however, seem to count for little in determining spreads between old-crop and new-crop futures at Chicago.

The only other major influences found to bear often on relations between old-crop and new-crop futures at Chicago are those related to corners and squeezes, or similar speculative manipulations. The size of the positive spread (the so-called carrying charge) that accompanies given large stocks, however, depends partly on commercial storage charges and on the amount of available storage capacity; and the size of negative spreads accompanying given small stocks depends partly on what wheats are eligible for delivery on the futures and on the need that merchants and mills feel for carrying reserves of wheat of special qualities.

One other apparent characteristic of inter-option spreads at Chicago is worthy of notice, though it cannot be supported by clear statistical evidence. Price relations among old-crop futures at Chicago seem at times to be influenced appreciably by differences between price expectations of holders of actual wheat, unhedged, and price expectations of traders in futures. If, for example, many farmers are holding strongly in expectation of higher prices than are generally expected by traders in futures, prices of spot wheat and of futures may tend to pull apart. The markets for spot wheat and for futures are so intimately connected that no such strain can greatly affect their relations, but apparently such divergence of opinion can, for several months at a time, keep cash prices a cent or two per bushel higher than normal in relation to the near future and the near future at a similarly abnormal premium over more distant futures.[1]

Influences at Liverpool

Differences between prices of near and distant futures at Liverpool seem to have been free of important influence from speculative manipulation. The Liverpool Corn Trade Association has been notably successful in preventing the development of corners and squeezes.[2] At Liverpool, as at Chicago, the expected size of new crops that will become available between the dates of expiration of successive futures has no clear effect on the price spread between the futures. These facts point to the conclusion that at Liverpool the supply situation involving only existing stocks of wheat must be the dominant influence determining price relations among futures.

No direct measure has been found of supplies that seem to be dominant in determina-

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1885," Wheat Studies, March 1933, IX, 187–238; and "Price Relations between May and New-Crop Wheat Futures at Chicago since 1885," *ibid.*, February 1934, X, 183–228. Another study by the same author—"Prices of Cash Wheat and Futures at Chicago since 1883," *ibid.*, November 1934, XI, 75–124—throws additional light on price relations between futures, although it is not directed specifically to that subject.

[1] Price relations that developed in September 1935 were thus interpreted in Wheat Studies, January 1936, XII, 198.

[2] Reasons for this success are suggested in Holbrook Working and Sidney Hoos, "Wheat Futures Prices and Trading at Liverpool since 1886," Wheat Studies, November 1938, XV, 137–38.

tion of price relations among Liverpool futures. British port stocks show fairly high statistical correlations with Liverpool inter-option spreads, but they seem to be only a part of a larger total that influences the spreads. General measures of world wheat supplies, at the other extreme of inclusiveness, are even less satisfactory than British port stocks alone as a basis for explaining Liverpool inter-option spreads. Apparently the price difference between a near future and the succeeding one depends mainly on the volume of existing total supplies of imported wheat in Europe in relation to the rate of consumption of imported wheat. The price difference between two futures which both mature in fairly distant months seems to depend mainly on expectations regarding the relative abundance of supplies of imported wheat that will be in Europe at about the end of the nearer of the two delivery months.

The evidence for these conclusions is not direct, since there exists no historical series of comprehensive statistics on supplies of imported wheat in Europe, and of course there is no direct information on the expectations of traders regarding supplies likely to be available in the future. But all the indirect evidence points clearly in this direction. Part of the basis for these conclusions is to be found by study of the systematic character of relations among all the Liverpool futures quoted at any one time. The rest, so far as it can be presented here, consists of information accumulated with respect specifically to the spread between prices of the December and March futures.

There lies in these conclusions an important implication that should be noted before going further. The level of stocks of imported wheat in Europe depends in part on opinions regarding prices. When importers think that current prices are probably low in view of the international wheat situation and exporters regard them as relatively high, importers tend to buy freely and exporters to sell freely, resulting in heavy accumulation of stocks in importing countries. Such was the case in the autumn and winter of 1924–25. On the other hand, when importers think that current prices are unduly high in view of the international wheat situation and exporters regard them as relatively low, importers tend to buy sparingly and exporters to sell reluctantly. This, which has arisen more often than the reverse situation, tends to result in unusually low levels of stocks of imported wheat in Europe. In the perhaps more usual circumstance, intermediate between these extremes, in which the balance of opinion regarding prices is about the same in importing countries as in those exporting countries that hold most of the exportable surplus, the level of European stocks of imported wheat presumably depends largely on the abundance or scarcity of wheat in the world.

It may thus be supposed that when there is no great divergence of opinion between importers and exporters regarding the level of prices warranted by circumstances, price relations among Liverpool wheat futures depend mainly on the degree of ease or tightness in the general international wheat situation. Abundance of exportable surpluses then tends to be accompanied by premiums of deferred futures over the near (carrying charges) and tightness in the international wheat position tends to be accompanied by premiums of near futures over the deferred. But when there is marked difference of opinion between importers and exporters regarding the level of prices warranted, that difference of opinion tends to affect the accumulation of stocks, and the level of stocks in turn affects price relations between Liverpool futures. Thus differences between opinions of importers and exporters on price prospects may have a substantial indirect effect on price relations among Liverpool wheat futures.[1]

A Chronological Review

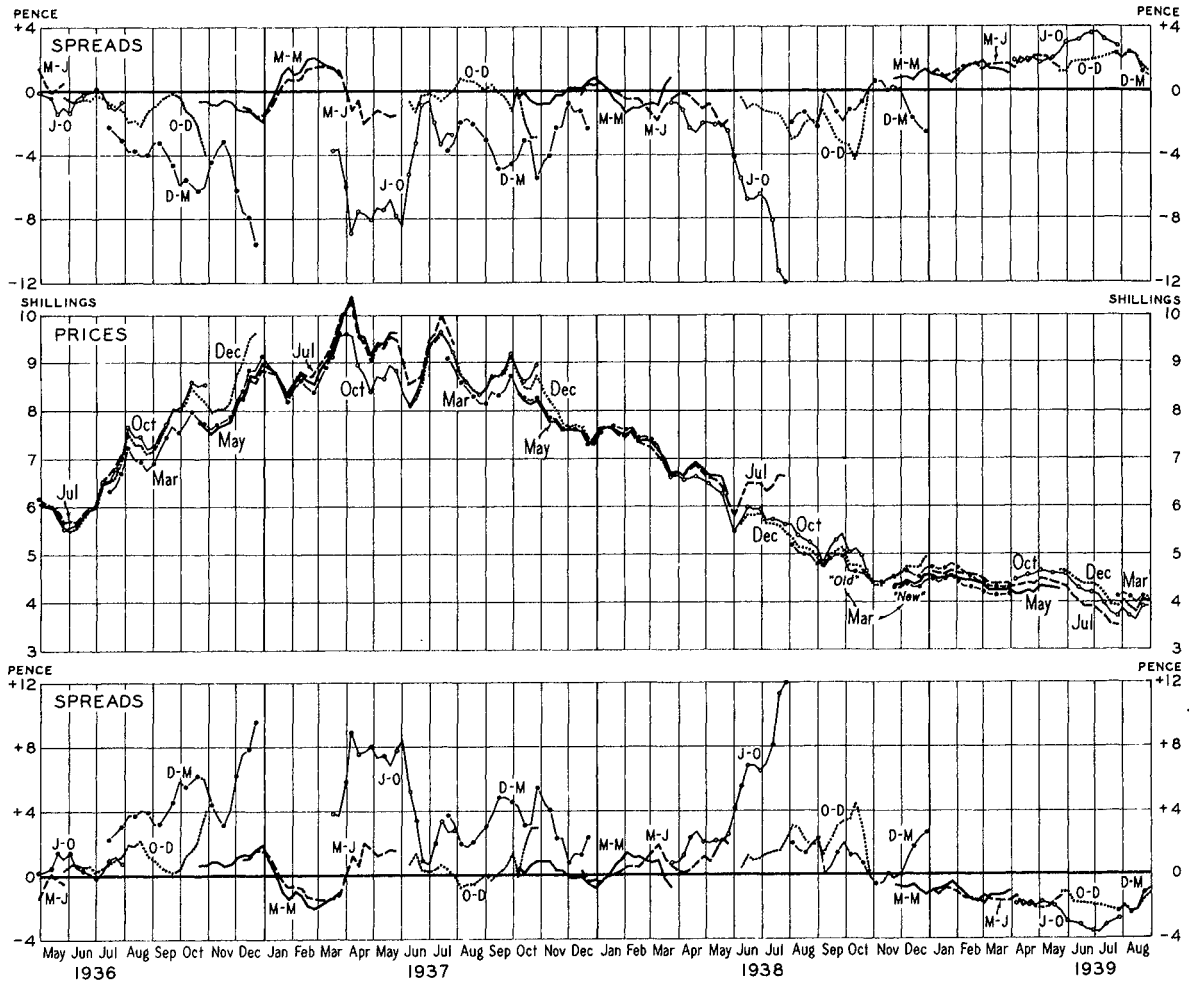
The interpretation of price relations among Liverpool futures outlined above may be clari-

[1] This fact seems to have been a major source of confusion in the evidence with which we have had to deal regarding influences affecting price relations between Liverpool wheat futures. Circumstances that affect price relations by leading to difference of opinion between importers and exporters are often circumstances that may seem to have their effect merely through creating expectations of price change. More critical examination of the evidence indicates that such effects spring not from existence of a *general* expectation of price change but from divergence between expectations, as indicated above.

fied and certain systematic tendencies specifically indicated by applying the interpretation to price relations in a specific recent period,[1] such as that covered by Chart 1.

CHART 1.—PRICES OF LIVERPOOL WHEAT FUTURES AND INTER-OPTION SPREADS, WEEKLY, MAY 1936 TO AUGUST 1939*

(Shillings per cental; pence per cental)



* Data from Table IX, and from WHEAT STUDIES, November 1938, XV, 179–80.

When differences between prices of different futures are large, the relations appear fairly clearly in the price curves shown in the middle section of the chart; but it is often not possible to get an accurate impression of the timing of changes in price relations merely by visual comparison of the price curves. When two curves turn sharply up or down after following a roughly horizontal course, they seem to draw together even though the vertical distance between them remains unchanged. An accurate visual impression of change in the difference between two price series is obtainable only from a chart of the differences themselves, such as are shown in the top and bottom sections of Chart 1. Charts of price differences shown directly have also

[1] The period is chosen for discussion primarily because it is recent. Its length is determined partly by the choice of scale and the space conveniently available. One consideration influencing the choice of period is the fact that it includes a considerable variety of situations meriting discussion. The choice does not imply that the period reflects especially well the normal behavior of price relations among Liverpool wheat futures.

the advantage of permitting use of a larger vertical scale than can be used in charting the prices.

In Chart 1 the spreads are designated by the initials of the delivery months, as follows: J–O, July–October; O–D, October–December; D–M, December–March; M–M, March–May; M–J, May–July.[1]

The top section of the chart shows these spreads plotted with the price of the nearer future in each pair taken as the base. The October–December spread as shown in this section thus represents the premium of the December future over the October or its discount under the October; the December–March spread represents the premium of the March future over the December or its discount under the December. The bottom section of Chart 1 shows the spreads plotted with the price of the more distant future in each pair taken as the base, and the curves show graphically premiums or discounts of the nearer future over or under the more distant of the two futures.

In our earlier publications dealing with inter-option spreads and in Chart 15, following page 138 below, all spreads have been shown as premiums or discounts of the more distant over or under the nearer future. Discussion of the influences bearing on inter-option price spreads, however, calls often for reasoning in the opposite terms. The reader unaccustomed to analysis of price spreads may find it helpful while following the exposition in subsequent paragraphs to refer to both of the sets of spread curves in Chart 1.

About two years prior to the date with which Chart 1 begins, the "world" wheat carryover as of about August 1 had reached the record high of 1,188 million bushels (Chart 2, p. 113). As a result primarily of two successive short world crops, the carryover about August 1, 1936 was at the moderate level of 752 million bushels. Another short crop in 1936 led to reduction of the carryover to the distinctly low level of 512 million bushels about August 1, 1937. Good crops in 1937–38 made the supply situation for that year slightly easier than for 1936–37, and bumper harvests in 1938–39 created a new world wheat surplus. "World" wheat carryovers, as estimated by the Food Research Institute, and stocks in each of the four major exporting countries about August 1 of each year were as follows, in million bushels:

August 1	World	U.S. (July 1)	Canada	Argentina	Australia
1936....	752	142	127	60	43
1937....	512	83	37	45	41
1938....	593	153	25	72	50
1939....	1,157	253	103	230	50

May 1936—July 1937.—From May to early July 1936, prices of all the quoted Liverpool futures held close together, as is usual when supplies are ample but not burdensome. Crop deterioration after the first of July induced a rapid price advance, and deferred futures tended to fall to substantial discounts under nearer futures.

This development of substantial negative spreads (inverse carrying charges) between successive futures obviously cannot be explained as a direct effect of appearance of a prospect of comparative world wheat shortage, for currently available supplies in the world remained abundant until near the close of the crop year 1936–37. On the basis of the record for this price movement alone, one might be tempted to infer that there is a general tendency in a broad price advance for the deferred futures to lag. Examination of the record for other periods, however, would fail to support this hypothesis. The pertinent facts seem to be that the crop damage led to divergence of opinion between exporters and importers on price prospects. Importers considered that the price advance was excessive and bought sparingly; supplies of wheat in the hands of importers fell to inconveniently low levels; and prices of spot wheat and the nearer futures were held at considerable premiums over the deferred, these premiums tending irregularly to increase from July until the end of December 1936.[2]

[1] The short dash connecting the initials or the names of the months is not a minus sign but merely a typographical connective to be neglected in oral reading.

[2] The course of price relations during the summer and autumn of 1924 may profitably be studied in this connection. Crop damage in the summer of 1924 led to a price advance similar to that of 1936, but importers then were impressed with the danger of shortage and bought freely, with the result that price relations among Liverpool futures followed a course quite different from that of July–December 1936.

The disposition of importers to permit wheat stocks to fall to low levels during the autumn of 1936 was encouraged by the relatively low level at which Argentine wheat was being offered for shipment from the new crop, to be harvested near the end of the calendar year. Forward purchases of Argentine wheat reached an unusual volume and led to unexpectedly and unprecedentedly heavy shipments of Argentine wheat during January–March.[1] The resulting accumulation in the hands of importers reversed the price relations among Liverpool wheat futures during January, the May future going to a premium over the March and the July to a premium over the May. By about the end of March, however, it became apparent that Argentine shipments must soon drop off sharply[2] and that importers' supplies were likely soon to be depleted. Recognition of this prospect caused the May future to go to a premium over the July in early April and to remain at a substantial premium for the rest of the life of the May future.

The tightness of the international supply position for 1936–37 was strongly reflected in the spread between the 1937 July and October futures. Throughout April and May 1937 the spread between these two futures was generally close to 8*d.* per cental (equivalent to about 10 cents per bushel). During June, however, the July future lost most of its premium over the October, in consequence of arrival in Europe of large supplies of foreign wheat shipped under the incentive of the previous high prices.[3] On the assumption that the United States would soon commence shipping freely from the large export surplus which it had in prospect, importers were unwilling to accumulate large stocks except at prices close to parity with the October future. It soon appeared, however, that a large export movement from the United States would be slow in getting under way, owing to the persistence with which prices of United States wheats were held out of line with importers' ideas. In the light of this situation, importers took the available supplies more eagerly, and the July futures at Liverpool soon recovered to a premium of about 3*d.* per cental over the October.

The crop year 1937–38.—The international supply position for 1937–38 proved nearly as tight as that for 1936–37, as is indicated by the estimates of year-end carryovers given above (p. 107). The large exportable surplus of the United States continued to be firmly held, but Southern Hemisphere sellers offered wheat for shipment from their new crops at prices substantially below the basis at which Northern Hemisphere wheats and the small remaining supplies of old-crop wheat in the Southern Hemisphere were being held. Close buying by importers in this situation led in October to an unexpected temporary shortage of supplies immediately available in Europe, which finally carried the price of the October future to about 3*d.* per cental over the December; but otherwise prices of the October and December futures were generally close together. The March future meanwhile sold generally at a substantial discount under the December, apparently reflecting the willingness of traders in the Southern Hemisphere to sell for new-crop shipment at prices lower than those asked for corresponding qualities of Northern Hemisphere wheat.[4]

Expectation that wheat from the Southern Hemisphere would be pressed on the market after harvest caused the May future to go to a small premium over the March in late December 1937. But Australia—holder of the principal surplus in the Southern Hemisphere—sold for some time with considerable reserve, supplies of wheat immediately available in Europe remained comparatively small, and in consequence the March future advanced to a premium over the May and the May to a premium over the July.[5] The nearer futures declined relative to the more distant after early March when for a week or two Australian holders pressed sales heavily,[6] but again

[1] WHEAT STUDIES, May 1937, XIII, 383–84.

[2] There was discussion in March of prospective exhaustion of the Argentine surplus and of the possibility that the Argentine government might restrict exports (see *ibid.*, p. 389).

[3] WHEAT STUDIES, September 1937, XIV, 13–14. The July future actually fell to a discount under the October during part of one week at the end of June.

[4] See WHEAT STUDIES, January 1938, XIV, 204, Chart 9.

[5] WHEAT STUDIES, May 1938, XIV, 334.

[6] *Ibid.*, pp. 329, 334.

the anticipated surplus failed to accumulate and prices of the nearer futures went to substantial premiums over the more distant.

Emergence of burdensome wheat surplus. The extraordinary widening of the price spread between the July and the October futures after mid-May 1938 seems mainly attributable in its earlier part to development of a sharp difference of opinion on the price outlook. The price of the July future was dominated by the ideas of holders of wheat in the United States and Australia, from which countries Europe required a continuous flow of wheat, whereas the developing opinion of traders in Liverpool wheat futures that current spot prices could not be maintained in the face of anticipated world surplus found reflection in lower prices on the deferred futures. Further widening in July of the price spread between the July and the October futures seems mainly a consequence of appearance of an unexpected degree of shortage in supplies immediately available in Europe. The reduction of stocks which importers naturally permitted in anticipation that exporters would soon sell more cheaply was inadvertently allowed to go too far.[1]

The disparity between price opinions of importers and exporters and the consequent maintenance of stocks in Europe at a low level kept the nearer futures at premiums over the more distant through most of August–October also, despite the great size of exportable surpluses. Initiation of the export subsidy program of the United States at the end of August 1938 led temporarily to expectation that export sales from the United States would be so stimulated as to cause accumulation of some surplus stocks in Europe by December at least, and the December future consequently fell to the level of the March for about a week in early September. Expectations of such an accumulation of stocks revived during October and persisted through November, but in December the available supplies of wheat proved still so short that the December future again went to a substantial premium over the March.

The great world wheat surplus that had emerged in consequence of the abundant harvests of 1938–39 was finally reflected in accumulation of surplus stocks in Europe soon after the end of December 1938. The rate and amount of accumulation of total stocks in Europe was influenced by governmental building of war reserves, which presumably had little influence on price spreads, but from early 1939 there appeared to be also a surplus in commercial hands. During 1939 all futures at Liverpool maintained the price relations characteristic of a condition of surplus, with prices of all deferred futures showing carrying charges over nearer futures.

Summary

The foregoing review of the course of price relations among Liverpool wheat futures during May 1936—August 1939 and the developments to which they were related brings to light two general characteristics of price relations that do not appear so clearly from the type of analysis presented in subsequent sections. It appears that the conditions which affect relations between prices of futures for any two successive delivery months commonly have a similar effect on the relations between prices of futures for other delivery months; and it appears that large disparities between prices of successive futures usually develop gradually. Both of these characteristics arise from the facts that the wheat market is continuous, that it always reflects the efforts of traders to anticipate the future, and that changes in conditions and in expectations generally develop gradually. The conditions that determine the relation between prices of a near future and the next one usually may be expected to continue until the more distant future has become the nearest one. Thus they tend logically to be reflected similarly in price relations between more than one pair of successive delivery months. And because extreme conditions cannot often be foreseen with confidence many months in advance, the large price differences which accompany such extreme conditions usually develop more or less gradually.

[1] Importers perhaps underestimated the extent to which supplies had been absorbed (or were being absorbed) into the emergency reserve that was being accumulated by the British government. On this and other points discussed in this paragraph, see also Wheat Studies, September 1938, XV, 18–19.

The different classes of conditions noted in the foregoing account of inter-option price relations during an illustrative period of slightly over three years may well be reviewed by way of summary.

1. Unexpected shortage that became apparent in the delivery month caused the near future to advance sharply relative to deferred futures on several occasions: October and December 1936, October 1937, and July and December 1938.

2. Shortage of supplies at the end of a crop year in which the international wheat position was relatively tight was a dominant influence holding the July and earlier futures at a premium over the October in 1937, and accounted in part for qualitatively similar price relations in 1938.

3. Disparity between price expectations of importers and of exporters led to hand-to-mouth buying and maintained premiums on the near futures during July–December 1936, July–December 1937, and June–October 1938. During the first two of these periods, importers were encouraged in their anticipation of lower prices by willingness of exporters in the Southern Hemisphere to sell for shipment from their new crops at prices below those at which Northern Hemisphere supplies were being held. (Disparity of price expectations assumed a quite unusual relative prominence during the three years reviewed above.)

4. Expectation of a temporary accumulation of surplus stocks led to carrying charges between the March, May, and July futures for a few weeks in December–January 1937–38; and a similar expectation that was realized maintained such price relations during most of January–March 1937.

5. Pressure of export surpluses from a burdensome world supply maintained carrying-charge relations among all futures from January 1939 until trading terminated with the declaration of war by Great Britain.

It deserves to be noted that the interpretations of specific developments given above rest in large part on the statistical analyses presented below. Rarely is the connection between cause and effect in a particular price movement entirely clear and obvious. Usually a price movement is associated with more than one circumstance which, on one ground or another, may be considered to have been its primary cause. Choice among alternative explanations must be guided by judgment of their reasonableness. The explanations offered above have in large part been judged reasonable on the ground that they are consistent with the results of the statistical analyses discussed elsewhere in this study.

II. RELATIONS OF WHEAT SUPPLIES TO THE SPREAD

Investigation of the relations between wheat supplies and the December–March spread at Liverpool requires statistical analysis of the relations of the spread to a considerable number of statistical series. The relations first examined led to inconclusive or negative results, but contributed information that was helpful as a guide to further studies. No one of the statistical analyses indicates the full basis for the conclusions finally reached. To give the full basis for the conclusions it is necessary to present several different analyses, some of which are worth recording chiefly because their results provide the logical basis for examining other relationships.

The connections among the several statistical analyses summarized in this section, and the pertinence of each to the final conclusions, will appear more clearly if the analyses to be discussed and the principal conclusions drawn from each are summarized briefly at the outset.

Summary of Analyses

Price relations between the May and the July and between the July and September futures at Chicago had previously been found to depend on total stocks of wheat in the United States, rather than on stocks in any particular position (p. 104). In view of this, it appeared reasonable to suppose that price relations among Liverpool futures, so far as they are dependent upon the level of stocks, might be related to fairly comprehensive statistics of wheat on hand in the world. Statistical tests, however, failed to bear out this sup-

position. The only supply series which were found to show a fairly close correlation with the December–March spread at Liverpool were British port stocks and, quite surprisingly, estimates of wheat stocks in the Southern Hemisphere on August 1 preceding.

The facts having failed to support this initial hypothesis, attention was turned to the question whether the December–March spread might depend largely on the expected size of the new crop in the Southern Hemisphere. Inasmuch as Europe depends mainly on the Northern Hemisphere for its supplies of imported wheat during the autumn and early winter but by March is usually drawing the larger proportion of its imports from the Southern Hemisphere, it appeared possible that the size of the prospective surplus available from the Southern Hemisphere might be a major factor determining whether the March future would sell at a premium over the December future or at a discount under it.

Some slight indication was found that perhaps a marked change in Southern Hemisphere crop prospects during September–November may tend to be reflected in a change in the spread between the December and March futures at Liverpool. The evidence in this direction, however, is questionable, and no indication was found that the large differences in price relations between the December and March futures at Liverpool in different years can be explained in any significant degree by differences in prospects for the Southern Hemisphere crops.

These preliminary studies indicated that further analysis might well be directed toward exploring the connection between the December–March spread and the level of British port stocks. Such further study developed two definite conclusions: (1) that if the spread is determined more or less directly by the level of British port stocks, the determining influence at any time is not primarily the actual current level of stocks, but expectations regarding the level at a date more or less distant; and (2) that not even expectations regarding the level of British port stocks can be regarded as more than a partial explanation of the spread.

There emerged also the idea that perhaps the direction and size of the spread tends to be determined by the expected level of total stocks of imported wheat in Europe or of some more or less inclusive aggregate. Variations in such a total from year to year would presumably correspond roughly with variations in the level of British port stocks. Since the correspondence would be imperfect, variations in the level of British port stocks could not be expected, on this supposition, to afford more than a rather imperfect explanation of variations in the December–March spread at Liverpool.

There are in existence no reasonably comprehensive statistics of stocks of imported wheat in Europe, but inferences regarding the probable level of such stocks may be drawn from statistics of shipments of wheat to Europe. When shipments to Europe during August–November are large relative to the total for the crop year, it may be assumed that stocks of imported wheat in Europe tended to increase during the period of arrival of such shipments, and when shipments during August–November were small relative to the total for the crop year, it may be assumed that stocks of imported wheat in Europe decreased (or perhaps merely increased less than usual) during the period over which Europe was dependent on those arrivals for its supplies of imported wheat. For the purpose of statistical analysis, it was sufficient to study directly the relation between shipments to Europe and the December–March spread without making specific estimates of stocks of imported wheat in Europe.

In the course of the ensuing statistical analysis of relations between the December–March spread and wheat shipments to Europe, consideration was given to December–February shipments as well as to August–November shipments, both expressed as percentages of the total for the crop year. This revealed some surprising facts which were difficult to explain. December–February shipments showed fairly high statistical correlations with the December–March spread, which could not be accounted for on the basis of the original hypothesis or of any other interpretation that involved supposing that the spread tends to be affected directly by ex-

pectations regarding probable shipments during December–February.

Search for an explanation in terms of indirect causation led to a re-examination of the fact, already noted, that there is a rather close correspondence for postwar years between the December–March spread at Liverpool and stocks of wheat in the Southern Hemisphere about the first of the previous August. This observation, when first made, was given little weight, since it did not appear reasonable to believe that a relatively small proportion of total wheat supplies, located in the Southern Hemisphere on August 1, could have a major influence on price relations between Liverpool futures in the subsequent December, and it seemed possible that the observed relation occurred by chance. On further consideration, however, it appeared not unreasonable to suppose that the level of Southern Hemisphere stocks might reflect the effects of forces more potent than the stocks themselves. The level of Southern Hemisphere stocks on August 1 might indeed be a generally serviceable index of the pressure of export surpluses at the beginning of the crop year. If so, they should serve also as a rough index of the level of European stocks of imported wheat at the beginning of the crop year.

Carrying this reasoning one step further afforded a basis for a statistical test of its validity: if the level of stocks in the Southern Hemisphere on August 1 tends to reflect the level of stocks of imported wheat in Europe at the same time, the Southern Hemisphere stocks series should prove a particularly useful one for use in conjunction with the statistics of shipments to Europe during August–November. Heavy shipments to Europe during August–November tend to result in accumulation of stocks in Europe; but whether the result is to bring European stocks to a very high level or to only a moderate level will depend partly on the volume of stocks at the beginning of the period of accumulation, and partly on the rate of utilization of imported wheat. On analysis, the facts proved fully in accord with this line of reasoning and the supposition that the level of Southern Hemisphere stocks on August 1 tends to reflect the level of European stocks of imported wheat at the beginning of the European crop year.

Since agreement of facts with an hypothesis does not prove the hypothesis sound but merely fails to disprove it, another test was made. If Southern Hemisphere stocks on August 1 are useful in giving statistical explanation of the December–March spread in December primarily because they reflect the volume of imported wheat with which Europe started the crop year, it seems reasonable to suppose that relations between the October and the December futures early in the crop year would serve the same purpose as well or better. An appropriate test gave striking fulfillment of this supposition.

The successive steps outlined above, involving alternately the framing of possible explanations of observed facts and the testing of the explanations by reference to other facts, point strongly to the conclusion that the price spread between the December and the March futures is determined largely by expectations regarding the probable level of stocks of imported wheat in Europe near the end of the calendar year. But it would be a mistake to accept this conclusion without qualification. The price relation between the October and the December futures at Liverpool, here interpreted as reflecting merely the level of European stocks of imported wheat at the beginning of the crop year, may in fact reflect also the disposition of importers toward the accumulation of stocks. From the statistical results it seems clear that the absolute level of stocks is the main fact of importance; but the evidence does not necessarily contradict the suggestion that fairly large stocks, for example, sometimes result in a large premium of the March future over the December and sometimes in only a small premium, depending on whether handlers of imported wheat in Europe are reluctant or eager to carry large supplies.

The foregoing conclusions rest chiefly upon the analyses discussed in the remainder of this section of the study. Before proceeding to the detailed exposition, however, it is necessary to describe the data used in the investigation.

The basic data on prices and spreads

through October 15, 1938 have been published in our previous study on Liverpool futures.[1] Averages based on subsequent quotations appear in Table IX. The weekly and monthly prices are simple arithmetic averages of daily closing prices, each of the five different futures having its individual series. The weekly average prices and spreads are dated as of the Saturday on which the week ends. The inter-option spreads were uniformly constructed from the successive futures by using the near future as the base; for example, the December–March spread series on a weekly basis was derived by subtracting the weekly prices of the December future from corresponding prices of the March future.

In this and subsequent sections we consider only the December–March spread, and when "the spread" is used without specific reference to particular futures, reference is made to the price spread between the December and March futures.

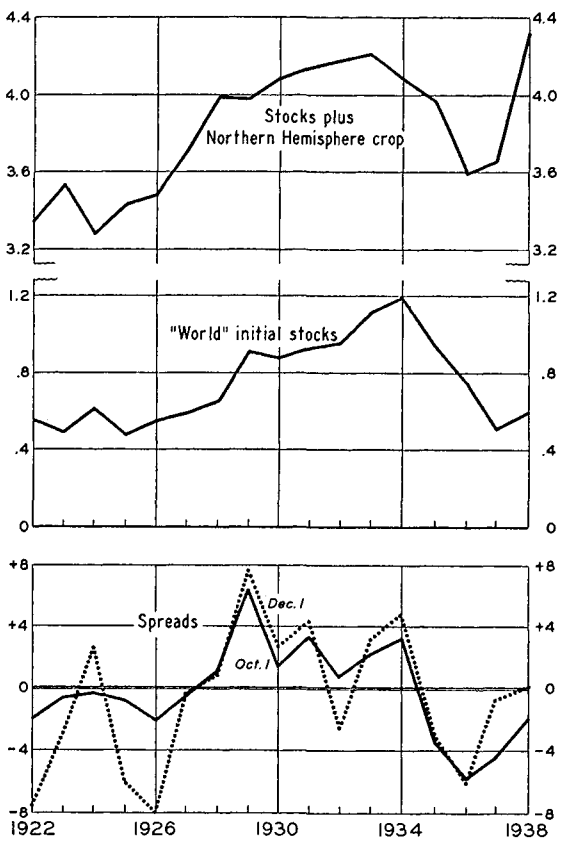
Preliminary Investigations

In order to provide some background of the development of the subsequent analysis, it is advisable to discuss briefly some preliminary investigations that yielded results of a negative character but which, nevertheless, substantially aided in the formulation and interpretation of other hypotheses. As suggested earlier, a significant causal connection between the spread and world supplies of wheat might be expected because certain inter-option spreads at Chicago appear to be determined primarily by the level of total wheat stocks in the United States. Furthermore, since the United Kingdom imports from all the major wheat exporting countries, and since the Liverpool wheat futures market is widely viewed as the point of convergence of the dominant international price-making influences, it might be logical to expect that Liverpool inter-option spreads are chiefly influenced by the level of world wheat supplies.

Close study of statistics on world wheat supplies and the December–March spread failed to reveal a significant relation between the two. In Chart 2 are shown the spreads near the first of October and December and two series of data on wheat supplies, world stocks on August 1, and these stocks combined with Northern Hemisphere crops, from

Chart 2.—"World" Wheat Supplies and Liverpool December–March Spread near October 1 and December 1, Annually from 1922*

(Million bushels; pence per cental)



* Data from Tables I and II.

1922. Examination of the chart clearly indicates that neither the premium or discount of one future in relation to the other, nor the amount of premium or discount, can be substantially accounted for by the two series of world wheat supplies. It is fairly clear that neither series of supplies is closely related to the spread at Liverpool as are United States total stocks of wheat to the May–July and July–September spreads at Chicago.

Another preliminary step that yielded largely negative results was investigation of

[1] Holbrook Working and Sidney Hoos, "Wheat Futures Prices and Trading at Liverpool since 1886," Wheat Studies, November 1938, XV, 121–80.

the relation of Southern Hemisphere crop prospects to the spread. Since the wheats of the Northern and Southern Hemispheres are harvested in different periods of the calendar year, the principal supplies from those two sources enter the European import markets at different times. The Liverpool December future matures when Northern Hemisphere supplies are relatively abundant in Europe, whereas the March future matures when Southern Hemisphere wheats are plentiful. In September Northern Hemisphere harvests are completed or well under way, and the size of the crop is fairly well established. But during September–December the estimates of Southern Hemisphere prospective supplies and exportable surplus are still heavily dependent upon growing conditions, weather developments and other uncertain elements, and crop estimates are subject to marked change. On these grounds one might expect Southern Hemisphere crop developments during September–December to be reflected in the spread, especially through influence on the March futures price.

Examination of Broomhall's "provisional estimates of exportable surplus" of Argentina and Australia failed to support the hypothesis that the size of the prospective surplus of those two countries was an important influence determining whether the March future was at a premium or discount in relation to the December. *Changes in the estimates* of exportable surplus gave some evidence of being associated with corresponding changes in the spread between the December and March futures.[1] When changes in the spreads and in the corresponding estimates of exportable surplus were studied year by year, however, it appeared unlikely that they are significantly connected by a causal relationship. Varying premiums or discounts of the March future in relation to the December within the same year or in different years could not be largely accounted for either by the size of estimates of Southern Hemisphere exportable surplus or by changes in those estimates. Hence, to the extent that such estimates affect futures prices, they seem to influence the December and March futures equally or nearly so, and the price spread between the two futures appears to be almost independent of Southern Hemisphere crop prospects.

[1] The linear correlation between percentage changes in estimates of exportable surplus and absolute changes in the spread was $-.72$ ($P < .01$) for the period 1922 to 1936. For the same period, but omitting 1926 when the English coal strike resulted in excessively high ocean freight rates and near futures at Liverpool were at a premium over distant, the linear correlation dropped to $-.55$ ($P < .05$). The corresponding changes in surplus estimate and spread were between the earliest and latest dates when both the exportable surplus estimate and the spread were available. Such dates varied from year to year.

[2] In a preliminary investigation, the widely used and much more inclusive statistics of stocks afloat to Europe and in British ports were employed. The level of stocks afloat to Europe proved not significantly related to the December–March spread at Liverpool.

United Kingdom Port Stocks and the Spread

United Kingdom port stocks, as the dominant element of supplies on hand, hold a position of importance all out of proportion to their volume at a particular time. Since the United Kingdom imports about 75 per cent or sometimes more of the wheat annually utilized there, these large volumes of supplies originating in other countries ultimately pass through the ports of the United Kingdom. But not all of these imported wheats need be included in the records of port stocks, since supplies on hand may be divided into several categories: mill stocks, private elevator stocks, and port stocks. Unfortunately, statistical data on mill stocks and private elevator stocks are not available, except as they may be included in the supplies designated as port stocks. As a series to measure British stocks we have used port stocks, for which the statistical data extend back through the last decade of the nineteenth century (Chart 3, p. 116).[2]

We do not know the importance of port stocks in relation to total stocks in the United Kingdom, but it is altogether likely that the proportion varies from month to month. The subject of port stocks and their importance as a source of immediate supplies was considered by a Royal Commission appointed in 1903. The opinion was then expressed that ". . . . it may legitimately be assumed that, in a normal year, the amount held conjointly in first [port stocks] and second hand stocks is unlikely to fall below six weeks supply—

two weeks in first hand stocks and four weeks in second hands."[1]

Storage facilities and trade practices have drastically changed since 1903. During the ten years 1893–94 to 1902–03, there was a tendency for the volume of port stocks to decrease. The subsequent developments were so well anticipated in testimony by George J. S. Broomhall before the Royal Commission in 1903 that the following statement merits quotation.

> Now merchants are letting down their reserves as trade becomes more organised. They have no need, they think, to hold large reserves, and they are content to buy from hand to mouth. The steamers supply with such regularity that they can depend upon the hour at which they will receive their supplies. I look upon it as probable that within ten years' time, if there are no political disturbances, we shall do without stocks altogether in the ports, beyond perhaps one week's stock, and that we shall depend upon a regular supply coming in by regular steamers.[2]

Port stocks were generally lower in the five-year period before the outbreak of the World War in 1914 than they were in the preceding five years.

In the years 1921–22 to 1927–28, port stocks were generally at a lower level than in the prewar years. During the years from 1929–30 to 1934–35, however, stocks rose to a level as high as in the period immediately preceding the World War. In more recent years, until 1939, port stocks were at about the same level as during the period just after 1920. Considering the prewar and postwar years as two separate periods, one finds that port stocks were smaller in the latter period. This change in level appears more significant when it is noted that during the postwar period utilization requirements were greater than in prewar years.[3] In 1936–37, United Kingdom port stocks during each of the three months October–December were sufficient for about nine days of total utilization requirements. The narrowness of the margin between stocks on hand and immediate requirements raises the question whether the price relations between the December and March futures can be much influenced by the level of port stocks.

Examination of Chart 3, which shows the December–March spread near the first of October, November, and December,[4] and the corresponding port stocks, indicates that the volume of stocks and the spread move together fairly closely. With few exceptions, changes in the spread are accompanied by changes of the same direction in the volume of stocks. But visual study of the graphical presentations is inadequate to reveal which of the three months shows the closest relation between the spread and stocks.

In order to obtain quantitative measurements of the relations between movements of the spread and volume of stocks it is convenient to consider the spread of the three different months with the stocks of various months. Correlation of the volume of port stocks for each month with the spread of each of several months yields measures of the degrees of relationship between the spread and stocks, and evidence emerges on the question whether and how the relationship varies from month to month. The results of such a correlation analysis are summarized in the following tabulation.[5]

Date for stocks	Coefficient of correlation with spread for the first week ending in:		
	October	November	December
October 1	+.47	+.64	+.60
November 1 ..	+.55	+.72	+.65
December 1 ..	+.59	+.78	+.71
January 1 ...	+.52	+.67	+.71

Coefficients of correlation such as these measure the closeness of linear relationship between the two variables involved. The high-

[1] Great Britain Parliamentary Papers, *Report of the Royal Commission on Supply of Food and Raw Material in Time of War. I—The Report*, 1905, XXXIX, 15.

[2] *Ibid., II—Minutes of Evidence*, p. 97.

[3] M. K. Bennett, "Per Capita Wheat Consumption in Western Europe: I. Measurement, from 1885–86," WHEAT STUDIES, March 1935, XI, 303.

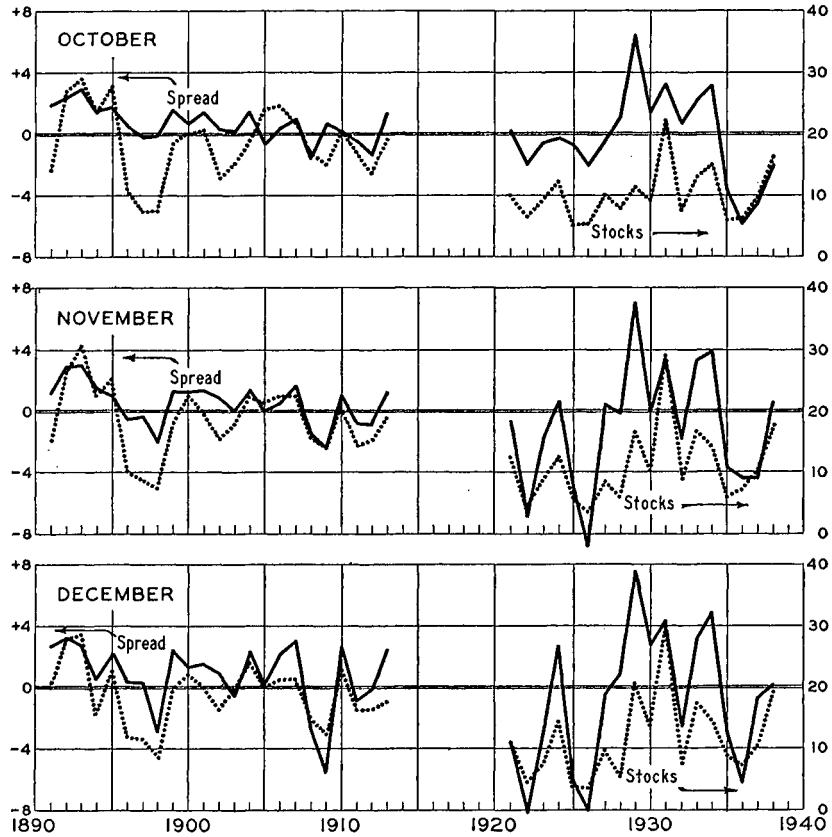
[4] The spreads shown are averages for the first week ending in the month indicated.

[5] Based on data in Table I. All of the correlation coefficients are statistically significant: the chances are less than 1 in 100 that such values would occur in a random sample drawn from a population in which the two variables are not correlated. However, conventional tests of statistical significance are of doubtful validity when applied to time series data, since the necessary sampling conditions are rarely fulfilled by such data. This qualification is pertinent to all the tests of statistical significance used in this study, and their interpretation must be viewed accordingly.

est correlation in the above tabulation, +.78 for the spread at about November 1 and port stocks about December 1, indicates only a moderate degree of relationship. All of the coefficients are high enough to leave no doubt of the existence of a real connection between highly correlated with stocks one month later, likewise the first of December. And the spread at about December 1 is quite as closely related to the level of port stocks one month later, about January 1, as to the current level of stocks.

CHART 3.—UNITED KINGDOM PORT STOCKS AND DECEMBER–MARCH SPREAD, OCTOBER, NOVEMBER, AND DECEMBER, ANNUALLY FROM 1891*

(Million bushels; pence per cental)



* Data from Table I.

port stocks and the December–March spread. They afford also some clues as to the nature of the relationship.

It is clear from these coefficients that the spread is not merely a reflection of the scarcity or abundance of existing port stocks. If that were the case, the spread at about the first of each month should be most highly correlated with the stocks of that month. Instead, the spread at about October 1 is most highly correlated with stocks two months later, about the first of December. The spread at about November 1 is most

It is not clear, however, what positive conclusion should be drawn from these observations. They seem consistent with the supposition that the direction and size of the spread between the December and March futures tend to determine whether port stocks will be accumulated in large volume or kept low. They are at least equally consistent with the supposition that there is no direct causal connection between port stocks and the spread, but that each tends to be determined independently by some common influences. Whichever of these views be taken, the fact

that none of the coefficients is very high favors, although it does not compel, the supposition that the statistics of port stocks are significant primarily as a more or less imperfect index of the level of some larger category of stocks. Thus, it may be reasoned either that the spread itself tends to determine the level of total stocks of imported wheat in western Europe, and that British port stocks serve as a rough index of the relative level of such stocks; or that certain facts and expectations which determine the spread also determine the level of total stocks of imported wheat.

Still another interpretation which deserves consideration is that it is only in the month of December that the December–March spread is determined by existing objective facts such as the level of port stocks, and that in earlier months the spread represents a market forecast of what the spread will be in December. This interpretation implies that the spread in any month should be more highly correlated with December 1 stocks than with stocks in earlier months. The observed correlations are in accord with this implication. If the spread is determined in December by existing circumstances, of which the level of port stocks is a good index, and in earlier months represents merely a forecast of what those circumstances will be, it seems reasonable to suppose further that in October, when the prospect for accumulation of stocks may not be clear, the December–March spread might often be at a level inappropriate to the level which port stocks actually attain in December. Therefore the correspondence between the spread and actual December 1 stocks should steadily improve as the month of December is approached. The statistics are in accord with this supposition in showing a marked improvement between October and November in the correlation with December 1 stocks, the coefficient rising from +.59 to +.78. But the decline of the coefficient to +.71 for about the first of December tends to cast doubt on the validity, or at least the adequacy, of this interpretation.

The fact that the spread shows a lower correlation of December 1 stocks with the spread about December 1 than with the spread about November 1, however, need not be interpreted as implying (illogically) that expectations regarding British port stocks have less absolute influence on the spread after early November than they did previously. It may indicate merely that this *relative* influence declines because other circumstances which could not earlier be anticipated with confidence assume increasing importance after early November. The fact that the correlation of the December–March spread with January 1 stocks increases between the first of November and the first of December gives an indication of what influences may assume increasing importance after early November, and suggests a revision of the interpretation with which the previous paragraph was started. The hypothesis may be advanced that the December–March spread in December is determined mainly by the level of existing port stocks, but partly by expectations of changes in stocks during the next month or more; and that in earlier months the spread represents a market forecast of what the spread will be in December.

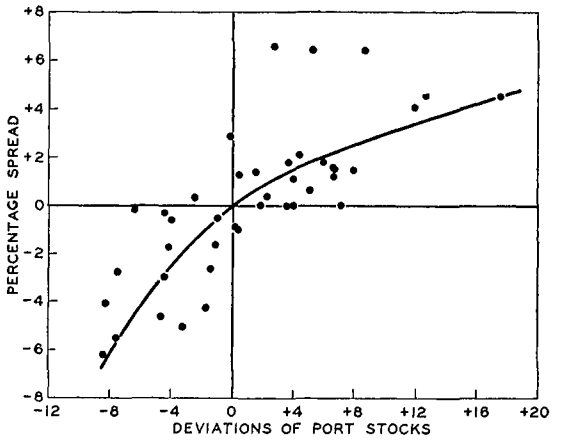
Before turning to consideration of other relationships involving the December–March spread, a more detailed examination may be made of that relation to British port stocks for which the correlation is highest: the relation between port stocks about December 1 and the spread about November 1. The data have been shown graphically as time series in Chart 3. In Chart 4 (p. 118) they are shown in the form of a scatter diagram. Port stocks are here shown as deviations from "normal," since the tendency after the 1914–18 war has been to carry smaller port stocks than were held in prewar years. "Normal" port stocks are defined as 16 million bushels for the prewar period and 12 million bushels for the postwar period. The spread is expressed as a percentage of the corresponding price of the December future.

Each dot on Chart 4 represents the spread and the corresponding port stocks for a single year. The smooth curve drawn through the dots expresses the apparent average relationship. On the basis of the smooth curve, the average relation may be tabulated in terms of

deviations of port stocks from normal, in million bushels, and the accompanying *percentage* spreads, measured in terms of elevation

CHART 4.—RELATION BETWEEN DECEMBER–MARCH SPREAD ABOUT NOVEMBER 1, AND UNITED KINGDOM PORT STOCKS, DECEMBER 1, ANNUALLY FROM 1891*

(Percentages; million bushels)



* Based on data in Table I. The chart shows relations between absolute deviations of stocks from "normal" (16 million bushels prior to 1914, and 12 million bushels after 1920), and the spread expressed as a percentage of the December future price.

or depression of the March future relative to the December, as follows:

Stocks	Spread	Stocks	Spread	Stocks	Spread
+12	+3.5	+4	+1.5	−4	−2.5
+10	+3.0	+2	+ .8	−6	−4.2
+ 8	+2.5	0	0	−8	−6.3
+ 6	+2.0	−2	−1.0		

The above tabulation roughly measures corresponding changes in the spread and stocks which may be expressed otherwise as follows: As port stocks increase, the price of the December future tends to decline relative to the March; a positive spread widens or a negative spread narrows. Conversely, as stocks decrease, the price of December wheat tends to advance relative to the March future; a positive spread narrows, or a negative spread widens. Changes in stocks below "normal" are associated with a larger corresponding change in the spread than when they are above "normal." These relations between the stocks and the spread are not only characteristic of a tendency over many years, but also are evident within a single crop year.

Although the December–March spread tends to vary with the level of British port stocks, one would hardly expect British stocks to be as significant for the Liverpool spreads as United States stocks are for Chicago spreads. British port stocks, at any one time, are only a minute part of import requirements. Hence our conclusions that expectations regarding the level of port stocks at some later date, rather than the actual current level, partially determine the spread should be supplemented by ideas of what types of market conditions chiefly influence those expectations. In the succeeding subsections, we shall examine the roles of other supplies, especially wheat shipments and carryover stocks, in the determination of the December–March spread.

SHIPMENTS AND THE SPREAD

Data on shipments are among the most familiar statistical series of wheat supplies, since they are widely published and carefully watched by practically all traders and students of wheat prices. Shipments are an index of the flow of wheat from the exporting to the importing regions, and often indicate the current propensities to export and import wheat supplies. In a broad sense, shipment statistics reflect the course of international trade. They may be segregated into the two categories of shipments from the Northern Hemisphere and the Southern Hemisphere. Shipments from the Northern Hemisphere usually reach their peak in October or November, and those from the Southern Hemisphere usually attain a maximum in February. World total shipments thus rise to one peak in October or November, and around February rise to another peak, usually higher than the first. Shipments from the Northern Hemisphere are at their maximum when Southern Hemisphere shipments are at about their low point; and the northern shipments are near their low when the southern shipments are at their highest level.[1] Wheats from the Northern Hemisphere are reaching Europe in greatest volume when the Liverpool December future is approaching expiration; Southern Hemi-

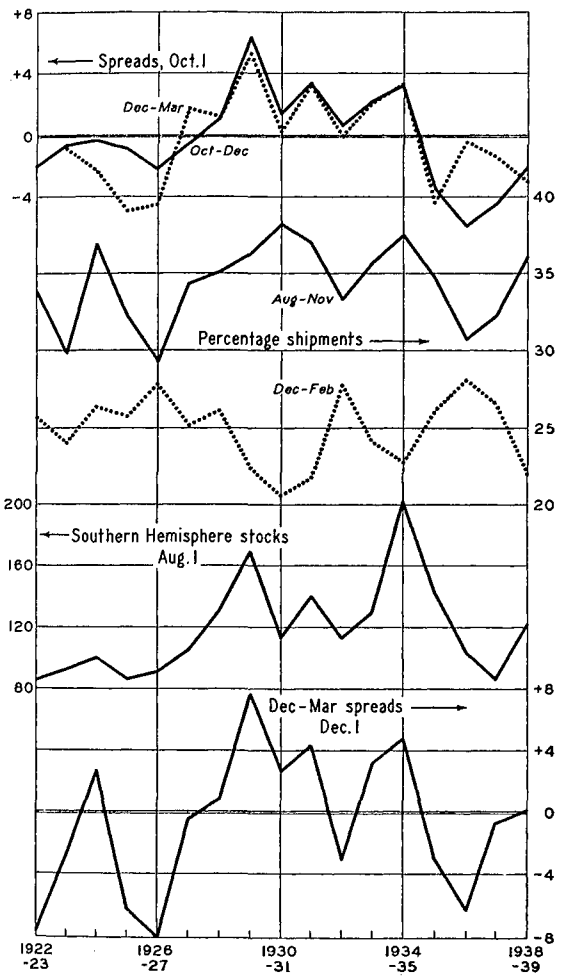
[1] See M. K. Bennett, "Seasonal Aspects of the European Wheat Trade," WHEAT STUDIES, March 1939, XV, 300.

sphere supplies are arriving most plentifully when the March future is about to expire.

Chart 5 shows the December–March spreads in October and December, shipments to Europe during August–November and December–February (in percentages of crop-year totals), Southern Hemisphere wheat stocks about August 1, and the October–December spread near the first of October. Examination of the shipment series shows that August–November and December–February shipments generally vary inversely. The larger autumn shipments are relative to those during the entire crop year, the smaller are the winter shipments relative to the crop-year total, and conversely. Although this inverse relation between shipments in the autumn and winter is evident from the chart, it is not a necessary relation since spring and summer shipments also enter into the crop-year totals. Examination of the various series in Chart 5 suggests that the December–March spread is correlated to some extent with all of the other series. First, we shall consider relations with shipments.

CHART 5.—DECEMBER–MARCH AND OCTOBER–DECEMBER SPREADS, PERCENTAGE SHIPMENTS TO EUROPE IN AUGUST–NOVEMBER AND DECEMBER–FEBRUARY, AND SOUTHERN HEMISPHERE INITIAL STOCKS, ANNUALLY FROM 1922*

(Pence per cental; percentages; million bushels)



* Data from Tables I, II, III, IX, and from WHEAT STUDIES, November 1938, XV, 172–80.

The following tabulation contains statistical measures of the degree of association between three shipment ratios and the December–March spread in various months, based on data for 1922–23 to 1937–38.[1]

Date of spread	Coefficients of correlation between designated shipment ratios and December–March spread		
	Aug.–Nov. to Aug.–July	Dec.–Feb. to Aug.–July	Dec.–Feb. to Aug.–Nov.
Oct. 1...	+.652	−.717	−.753
Nov. 1...	+.738	−.683	−.786
Dec. 1...	+.804	−.704	−.824

These statistical measures support the supposition that the direction and size of the spread are related to the level of shipments. As shown in Chart 6, when August–November shipments are a large percentage of the crop-year total, the spread tends to be positive and large (that is, the price of the December future is low relative to March wheat, or the March future is high relative to the December). But if August–November shipments are low, the December futures price tends to be at a premium above the March.

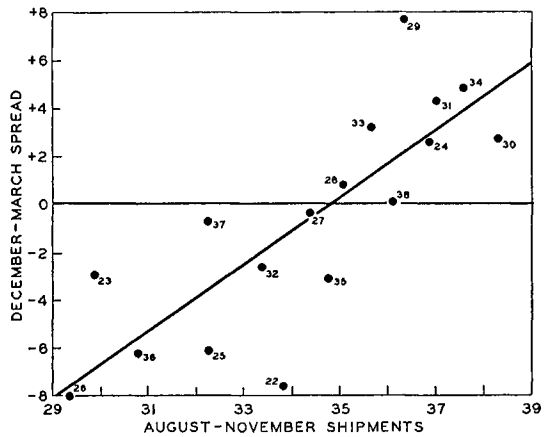
Tendencies opposite to these appear when December–February shipments are related to the spread. Relatively large winter shipments usually are associated with market situations

[1] According to tests of statistical significance appropriate for small samples, the correlation coefficients are sufficiently high so that the chances are less than 1 in 100 that they could result from a chance distribution. The relationships between the shipment ratios and the spread may be slightly curvilinear, but the degree of linear relationship measured by the correlation coefficients may be assumed to be an adequate approximation of the degree of association between shipments and the spread.

in which March wheat is at a discount under December; small winter shipments are related to situations where March wheat is at a premium over December.

CHART 6.—RELATION BETWEEN DECEMBER–MARCH SPREAD ABOUT DECEMBER 1 AND AUGUST–NOVEMBER PERCENTAGE SHIPMENTS TO EUROPE*

(Pence per cental; percentages)



* Data from Tables I and III.

The coefficients of correlation with autumn shipments are such as might be expected on the supposition that the shipments largely determine the level of European stocks of imported wheat about the end of December, and that the spread depends on the expected level of these stocks. As the crop year advances and the actual level of autumn shipments becomes more certain, the relation between the spread and autumn shipments improves. In the above data, the correlation between autumn shipments and the spread near the first of October is +.65; by the first of December the correlation between the current spread and autumn shipments has risen to +.80.

The coefficients of correlation between the spread and winter (December–February) shipments appear superficially to support the view that prospect of large shipments during the winter should tend to affect the spread by depressing the price of the March future relative to the December, and that prospect of small shipments during the winter should tend to elevate the price of the March future relative to the December. But on this theory, the correlation between the spread and subsequent winter shipments should improve as the season progresses and expectations concerning winter shipments may become more definite. The coefficients given above fail to show such improvement. Indeed, if separate allowance be made for the relation of autumn shipments to the spread, the residual ("partial") relation of winter shipments to the spread is found actually to decrease between October and December.[1] The trend of the coefficients is such as to suggest that perhaps the correlations between the spread and December–February shipments arise not from any important direct effect of expectation regarding those shipments, but from the fact that other circumstances affect both the spread and the December–February shipment ratio.

AUGUST 1 STOCKS AND THE SPREAD

Since the spread in October, November, and December appears to be related to the autumn accumulation of imported wheat in Europe, measured in terms of August–November shipments, and since shipments are a connecting link between exports and imports, attention was directed towards export pressure during the existence of the December–March spread. A rough index of such pressure is the volume of Northern Hemisphere

[1] Owing to the fairly high correlation between autumn and winter shipments ($r = -.679$), a partial correlation analysis affords a more trustworthy basis for interpretation than the gross correlation coefficients given above. Such an analysis, taking

S = December–March spread near the first of October, November, and December, respectively (pence per cental)

A = August–November shipments to Europe as percentages of August–July shipments

B = December–February shipments to Europe as percentages of August–July shipments

yields coefficients for 1922–23 to 1937–38 as follows:

	r_{sa}	r_{sb}	$\beta_{sa.b}$	$\beta_{sb.a}$	$b_{sa.b}$	$b_{sb.a}$	$R_{s.ab}$
Oct. ...	+.65	−.72	+.31	−.51	+.35	−.69	.75
Nov. ...	+.74	−.68	+.51	−.34	+.79	−.63	.78
Dec. ...	+.80	−.70	+.61	−.29	+1.05	−.61	.83

Most noteworthy among the above coefficients are the β's, which measure the degree to which variation in the spread may be explained by variations in autumn and winter shipments, respectively, when they are considered simultaneously. Of interest also are the facts that $b_{sb.a}$ declines much less from October to December than does $\beta_{sb.a}$, and that the R's are very close to the r's of the last column of the text tabulation on p. 119, which also take account of both autumn and winter shipments, but in a different way.

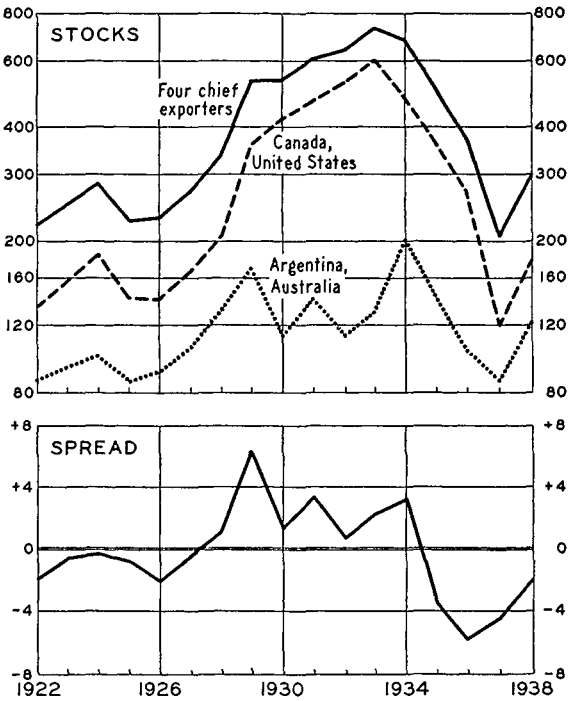
new-crop wheat supplemented by old-crop carryovers. As shown above (Chart 2, p. 113), year-to-year changes in the December–March spread do not closely follow corresponding changes in the level of either "world" wheat stocks on about August 1 or of those plus Northern Hemisphere crops. However, close examination of the relations between the spread and August 1 stocks in the four chief exporting countries revealed the surprising fact that year-to-year changes in the spread are closely related to changes in the level of August 1 stocks in the Southern Hemisphere (Australia and Argentina).

August 1 stocks have a dual significance. First, they represent the residual or difference between total supply and utilization during the past crop year. Second, they may be an important segment of the current year's supply, especially of exports during the autumn. The year-end stocks generally regarded as most important are those of the four chief exporters—United States, Canada, Australia, and Argentina—since it is from these countries that Europe receives the bulk of its imports. In addition, the stocks of these dominant exporters primarily determine the volume of world stocks at the beginning of the international crop year.[1]

The trend of carryover stocks over a period of years reflects the growth and disappearance of physical surpluses which are associated with repercussions on the structure of wheat prices. As shown in Chart 7, stocks of the four chief exporters on August 1, 1922, totaled 221 million bushels. During the next two years they increased about 30 million bushels annually, but at the beginning of 1925–26 receded to 228 million bushels. The following year had a slight increase of only 4 million bushels, whereas the next three years showed considerable increases. By August 1, 1930–31, the year-end carryover stocks reached a level of 534 million bushels. The redundant supply of wheat continued to increase until the peak was reached at the beginning of 1933–34 when the combined stocks of the four chief exporters were 730 million bushels, an amount more than three times as large as that at the beginning of 1922–23. The next four crop years each showed successively smaller stocks, with those of 1937–38 approximating 200 million bushels. Within a period of 16 years, the volume of combined year-end stocks passed through a composite cycle composed of a four-year minor cycle from 1922–23 to 1925–26, which was followed by a twelve-year major cycle from 1926–27 to 1937–38.

CHART 7.—AUGUST 1 STOCKS OF WHEAT, AND DECEMBER–MARCH SPREAD ABOUT OCTOBER 1, ANNUALLY FROM 1922*

(Million bushels; pence per cental)



* Data from Tables I and II.

Year-end stocks of the United States and Canada combined followed a course almost parallel to that of the four chief exporters because the stocks of those two countries bulk so large in the total. The greater part of these redundant carryovers in North America was held in the United States.

The fluctuations in the combined stocks of Australia and Argentina followed a pat-

[1] The statistics of stocks here used are in considerable part estimates by the Food Research Institute. For detailed description, see Helen C. Farnsworth, "World Wheat Stocks, 1890–1914 and 1922–39," WHEAT STUDIES, October 1939, XVI, 39–66.

tern unlike that of either the two Northern Hemisphere exporters or the four chief exporters. Whereas from 1922–23 to 1929–30 variations in Australian and Argentine stocks followed changes in the level of total stocks, beginning with 1930–31 the two series diverged. From 1930–31 to 1933–34 Southern Hemisphere stocks alternately increased and decreased, and at the beginning of 1934–35 reached the peak of the postwar years with stocks of 202 million bushels. After 1934–35, August 1 stocks in the chief exporting countries of the Northern and Southern Hemispheres again moved in the same directions and in roughly proportional amounts.

The correspondence in the movement of the December–March spread and year-end stocks is evident from Chart 7. From the chart it is clearly evident that the spread more closely followed Southern Hemisphere stocks than it followed either those of the Northern Hemisphere or total stocks. Since the price relations between the December and March futures apparently are closely related to the physical supplies of wheat in the Southern Hemisphere about August 1, the question arises why such a relationship should exist. A possible explanation centers about the role of Southern Hemisphere stocks in reflecting other price-influencing factors more important than the stocks themselves which, after all, are only a minute part of total supplies.

The level of Southern Hemisphere stocks about August 1 may be viewed as an index of the pressure of total export surpluses at the beginning of the international crop year. When stocks of wheat in the Southern Hemisphere are large, there is prospect that supplies will flow to Europe freely during the autumn. In such circumstances, the Southern Hemisphere at least can usually be counted on to ship freely, since both Australia and Argentina are reluctant to carry substantial stocks beyond late November in Australia and late December in Argentina. Moreover, the existence of large stocks in these countries as late as August 1 is an indication of previous pressure of export surplus which would have tended toward accumulation of surplus stocks of imported wheat in Europe. For both reasons large supplies in the Southern Hemisphere on August 1 indicate the probability of continuing abundance of supplies in Europe such as should keep the price of the Liverpool December future under the March. On the other hand, if supplies in the Southern Hemisphere are small on August 1, reasoning similar to that above suggests the possibility that supplies of imported wheat in Europe during the autumn may be quite moderate in relation to the demand and that spot wheat in December may command a premium over wheat for later delivery. Thus it appears quite logical, once the fact is noted, that in September and October current expectations regarding the relative abundance of European supplies of imported wheat in December, as reflected in the December–March spread, should be closely related to the volume of supplies in the Southern Hemisphere on August 1.

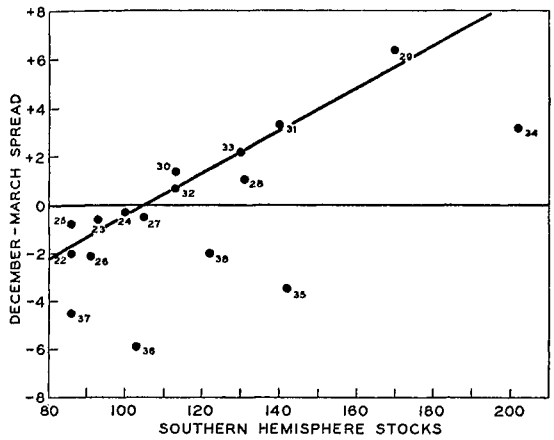
Market opinion as of early September may subsequently be proved more or less mistaken. Under some circumstances, which will be noted below in connection with seasonal variations in the spread, there are certain general tendencies for the December–March spread to change between September and December. In addition, more or less abnormal events such as unusual crop developments or shipping conditions may cause abnormal changes. For example, the December–March spread was about the same in September 1930 and in September 1932, corresponding to the similarity of Southern Hemisphere stocks in those two years; but by December the spreads were quite different. Unexpectedly heavy shipments from Russia during the autumn of 1930 created in importing Europe a plethora of wheat supplies that depressed the price of the Liverpool December future relative to the March.

Chart 8 shows the relation between the December–March spread in October and Southern Hemisphere stocks of wheat about August 1. From 1922–23 to 1933–34 a marked linear relationship existed between the spread and stocks; large Southern Hemisphere stocks were associated with March wheat being at a premium over December, and small stocks were associated with March wheat at a dis-

count under December. After 1933 the relationship altered so that substantially larger August 1 stocks than formerly were accompanied by the same price spread.

CHART 8.—RELATION BETWEEN DECEMBER–MARCH SPREAD ABOUT OCTOBER 1 AND SOUTHERN HEMISPHERE INITIAL STOCKS, ANNUALLY FROM 1922*

(Pence per cental; million bushels)



* Data from Tables I and II. The line of average relationship shown is based on data for the years 1922–33 only.

Since the level of Southern Hemisphere August 1 stocks may be interpreted as an index of the pressure of export surpluses and of the level of European supplies of imported wheat at the beginning of the crop year, it is pertinent to note the degree of association between the August 1 stocks and the spread about the first of successive months. The following correlation coefficients serve as such measures.[1]

Date for spread	Correlation coefficients	
	1922–1937	1922–1933
September 1	+.64	+.95
October 1	+.64	+.96
November 1	+.74	+.87
December 1	+.71	+.85

Two sets of coefficients are given since it is evident from Chart 8 that the usual relationship between the spread and stocks did not hold during 1934–36. Apparently an unusually strong holding disposition existed in the Southern Hemisphere prior to August in each of those three years. Presumably, therefore, the level of stocks in the Southern Hemisphere in those years did not have its usual significance as an index either of pressure of export surpluses or of supplies of imported wheat in Europe at the beginning of the crop year, and the coefficients for 1922–1933 are of most significance for the present analysis.[2]

The decrease in the correlation between the spread and stocks, 1922–1933, from about +.95 in September and October to about +.85 in November and December seems explicable in terms of the interpretation that Southern Hemisphere stocks on August 1 reflect the pressure of export surpluses and the level of European imported supplies at the beginning of the crop year. Exporters, especially those in the Southern Hemisphere, have a tendency to ship freely when August 1 stocks are heavy. Such relatively large autumn shipments, comprising Northern Hemisphere new-crop wheat as well as old-crop stocks in both hemispheres, tends to depress the price of spot wheat and the near futures relative to the distant. Excepting unusual developments, the accumulation of the export pressure reaches its peak near the

[1] The coefficients for September are for years from 1923 since the spread was not in existence as early as September 1922. All of the correlation coefficients are statistically significant; the chances are less than 1 in 100 that such high correlations would result from random distributions.

[2] It is clear that the influences affecting the level of Argentine stocks and the relation of those stocks to other features of the world wheat situation tended to be substantially altered by establishment of the Argentine Grain Board in November 1933, with power to control the flow of Argentine wheat into export. The policy of the grain board was especially influential in keeping August 1 stocks in Argentina at a high level in 1934 and 1935. In 1933–34 also there developed in Australia an unusual tendency toward holding by growers, which "tended . . . . to weaken the general rule . . . . that Australia can be counted upon to export more freely than the United States and Canada" (M. K. Bennett and H. C. Farnsworth, WHEAT STUDIES, December 1934, XI, 172). In 1936 the stocks remaining in Argentina on August 1 were small, reflecting extreme shortage of the previous crop, but Australia was a rather firm holder under circumstances discussed above (pp. 107–08).

Southern Hemisphere stocks on August 1 of 1937 and 1938, at the ends of crop years during which prices ruled fairly high, were not strikingly out of line with the Liverpool December–March spread, as judged by the average relationship in years prior to 1934; but it may be doubted whether this reflected a tendency toward re-establishment of the conditions responsible for the relationship that held so uniformly in earlier years.

middle of October. By November and early December pressure from August 1 stocks has eased off, but it is still reflected in the spread owing to the accumulation of imported supplies in Europe.

Since both autumn shipments and Southern Hemisphere August 1 stocks appear to be closely related to the December–March spread, it is pertinent to consider how those two supply elements interact in the determination of the spread.

Determination of the Spread

The two suppositions suggested above, that (1) August–November shipments reflect the accumulation of imported wheat in Europe during the arrival of such shipments, and (2) Southern Hemisphere stocks on August 1 serve as an index of the level of imported wheat in Europe at the beginning of the international crop year, may be merged into a single hypothesis regarding the determination of the December–March spread. The evidence suggests that the December–March spread reflects the accumulation of imported wheat in Europe during the autumn. In addition the spread also appears to be connected with the level of European stocks at the beginning of the crop year, August 1. Hence those two hypotheses may be combined into one by connecting the accumulation of stocks to the level from which the accumulation begins. It is clear that relatively large autumn (August–November) shipments to Europe result in accumulation of imported wheat in Europe, but whether total imported stocks are at a high level near the end of the calendar year also depends on the level of imported stocks previous to the accumulation. Heavy autumn shipments that supplement a low initial level of imported stocks might not result in greater stocks in December than light autumn shipments supplementing a high initial level of imported stocks. It is a combination of the level of European stocks of imported wheat at the beginning of the crop year and the rate of accumulation in the following months, rather than each separately, that determines the level of supplies of imported wheat in Europe near the end of the calendar year.[1]

Reasoning along the above lines suggests the hypothesis, which may be tested, that the December–March spread is determined primarily by market expectations concerning the probable level of European stocks of imported wheat near the end of the calendar year. Southern Hemisphere stocks on August 1 and August–November shipments to Europe may be simultaneously correlated with the spread; and if the hypothesis is supported, variations in the spread should be substantially accounted for by variations in the two supply series. Such a statistical analysis gives some grounds for accepting the validity of the hypothesis, although it does not unequivocally prove it.[2] In accordance with this

[1] The interpretation here given seems competent also to explain the peculiar relation of winter (December–February) shipments to the spread, noted above (p. 120). In general, winter shipments tend to be large in relation to total shipments during the crop year when autumn shipments have been relatively small, and to be small when autumn shipments have been large. But in a correlation of the December–March spread with both autumn and winter shipments, the coefficient of partial regression of the spread on winter shipments reflects the apparent effect on the spread of *deviations* of winter shipments from the percentage normally accompanying the given percentage level of autumn shipments. It seems reasonable to suppose that the level of European stocks of imported wheat on August 1 tends to affect the relation between the autumn and winter shipment percentages: that if August 1 stocks are small, shipments during the autumn may be large, for example, and yet shipments during the winter may not be particularly small. Thus, it may be that the strange partial correlations noted above between the spread and winter shipments, autumn shipments being "held constant," may arise merely from the fact that both the spread and winter shipments are affected by the level of stocks of imported wheat in Europe about August 1.

[2] Statistical relations of the spread to shipments and year-end carryover stocks, taking

S = December–March spread near the first of October, November, and December, respectively (pence per cental)

A = August–November shipments to Europe as percentages of August–July shipments

C = Australian and Argentine stocks, August 1 (million bushels)

are as follows:

	r_{sa}	r_{sc}	$\beta_{sa.c}$	$\beta_{sc.a}$	$b_{sa.c}$	$b_{sc.a}$	$R_{s.ac}$
a) Crop years 1922–23 to 1937–38, inclusive							
Oct.	+.65	+.64	+.42	+.38	+.47	+.036	.66
Nov.	+.74	+.74	+.45	+.47	+.70	+.062	.80
Dec.	+.80	+.71	+.59	+.35	+1.02	+.051	.82
b) Crop years 1922–23 to 1933–34, inclusive							
Oct.	+.61	+.96	+.09	+.92	+.079	+.086	.97
Nov.	+.70	+.87	+.31	+.69	+.501	+.121	.90
Dec.	+.79	+.85	+.45	+.60	+.803	+.117	.93

reasoning, large August 1 stocks in the Southern Hemisphere in conjunction with heavy August–November shipments should be reflected in Liverpool by extreme depression of the December future relative to the March during October–December. A low level of stocks in the Southern Hemisphere on August 1 in combination with relatively light shipments during August–November should result in the March futures price being at an extreme discount in relation to the December future.

Since in the above hypothesis and analyses Southern Hemisphere stocks on August 1 are viewed as an index of supplies more significant than the stocks themselves, namely, the level of European stocks of imported wheat at the beginning of the crop year, some other measure of the initial level of European imported stocks should serve equally well in a statistical explanation of the spread. One such measure is the price relation between the October and December futures early in the crop year. The October–December spread near the first of October tends to reflect the current relative abundance or stringency of European stocks of wheat.[1] Thus in the above statistical analysis the substitution of the October–December spread for Southern Hemisphere stocks on August 1 should yield similar results if the hypothesis is to be supported.

In fact such a statistical explanation[2] is found, on trial, to be somewhat better than the one involving Southern Hemisphere stocks, which suggests that the October–December spread in October serves better than Southern Hemisphere stocks on August 1 as an index of the level of European imported stocks of wheat at the beginning of the crop year. However, both statistical analyses lead to the same explanation of the determination of the December–March spread. The evidence strongly points to the conclusion that the spread between the prices of the December and March futures is determined chiefly by expectations regarding the level of stocks of imported wheat in Europe near the end of the calendar year.

Such an interpretation of the determination of the December–March spread at Liverpool bears some analogy to previous conclusions on the determination of certain inter-option spreads at Chicago. The studies on Chicago futures prices showed that the domestic supplies of all wheat in the United States, measured in terms of July 1 carryover, primarily determine the price spreads between consecutive futures, May–July and July–September, at Chicago. The dominant influence affecting the price relations between the Chicago futures is the wheat supply situation for the old crop; the inter-option spreads are not a reflection of expected ease of supplies after harvest but of existing ease or stringency of supplies available for a period prior to the expiration of the distant future. The December–March spread at Liverpool is determined largely by expectations regarding the probable level of imported wheat in Europe near the end of the calendar year. At both Chicago and Liverpool relative abundance of current physical supplies available for a period prior to the delivery month of the distant future, rather than expectations of changes in supply conditions, is the dominant influence affecting the price relations between futures. This analogy between the findings for Chicago and Liverpool must not be overemphasized. The supplies which seem most closely related to the Liverpool spread are by no means so inclusive, in relation to the scope of the market, as those which are most closely related to the Chicago spread. But in both markets the inter-option spreads appear to be

[1] The October–December spread may also partly reflect importers' propensity towards the accumulation of stocks. To that extent the October–December spread might not serve as a satisfactory index of the level of imported stocks of wheat near the beginning of the crop year.

[2] The statistical relations, taking

S = December–March spread near the first of October, November, and December, respectively (pence per cental)

A = August–November shipments to Europe as percentages of August–July shipments

Z = October–December spread near first of October (pence per cental)

are as follows:

	r_{sa}	r_{sz}	$\beta_{sa.z}$	$\beta_{sz.a}$	$b_{sa.z}$	$b_{sz.a}$	$R_{s.az}$
a) Crop years 1922–23 to 1937–38, inclusive							
Oct. ...	+.65	+.70	+.40	+.50	+.45	+.45	.78
Nov. ..	+.74	+.89	+.39	+.70	+.60	+.87	.95
Dec. ..	+.80	+.84	+.50	+.59	+.88	+.82	.95
b) Crop years 1922–23 to 1933–34, inclusive							
Oct. ...	+.61	+.86	+.22	+.75	+.18	+.50	.88
Nov. ...	+.70	+.92	+.30	+.76	+.49	+.93	.95
Dec. ..	+.79	+.88	+.45	+.64	+.80	+.88	.96

determined chiefly by conditions related to the relative scarcity or abundance of actual physical supplies available or expected to be available during the period between the expiration of the near future and the time of arrival of substantial supplies from a new source.

III. SEASONAL VARIATIONS IN THE SPREAD AND PRICES

In the preceding section the analyses and interpretations of certain observed relations pointed to the conclusion that the December–March spread is determined chiefly by market expectations regarding the probable level of stocks of imported wheat in Europe near the end of the calendar year. Hence, changes in such market expectations should be reflected by changes in the spread. Actually the spread varies from month to month, and even from week to week and from day to day. Since the spread exhibits movements such as do the actual prices themselves, it may be viewed as a price series. Here we are interested in two questions concerning the December and March futures prices and their inter-option spread: (1) Do the movements of weekly spreads and prices tend to follow seasonal patterns; and (2) do the patterns of seasonal variation recur regularly, or do they prevail only under certain circumstances?

The phrase "seasonal variation" implies measurable changes that systematically and regularly recur at about the same time each year. Such seasonal price tendencies result from influences that act upon prices in roughly the same manner and at about the same time year after year. A familiar example of a seasonal tendency in wheat prices is the depression of spot wheat prices after harvest. The rapid rate of farm marketing during and immediately following harvest usually results in large supplies of wheat in country and terminal elevators. These abundant supplies ease the market and tend to depress cash wheat prices. Such a price movement has been sufficiently regular and pronounced to lead some traders to believe that a tendency exists towards post-harvest depression of wheat prices. But investigation has shown that the post-harvest depression of wheat prices is a tendency not similar from year to year, but highly variable.[1]

An associated seasonal variation in wheat prices is related to carrying costs. The wheat crop is harvested only once during the crop year, but is consumed relatively uniformly throughout the year. Some of the influences that affect cash prices are expenses of storage, interest, insurance and handling borne in carrying forward the supplies from time of harvest until needed. Because of the accumulation of each successive month's cost of carrying the wheat, cash prices tend in general to rise from shortly after harvest until near the time of the next harvest.

In regard to seasonal variations in wheat futures prices, until relatively recently the situation has been less clear. Since futures prices do not involve the seasonal trend due to carrying costs, one might suppose that futures prices do not tend to follow a seasonal pattern. However, fairly recent studies of Chicago wheat futures present evidence that under certain market conditions futures prices do exhibit seasonal tendencies, which differ according to circumstances.[2]

Seasonal tendencies are not evident in the weekly prices of the December and March futures at Liverpool, or in their inter-option spread, when all years are taken together. Classification of crop years into certain groups, however, reveals conditioned seasonal variations, or seasonal movements whose existence is largely dependent upon special market situations.[3] It is observed that: (1) when March wheat has been at a large premium over December wheat in September,

[1] Holbrook Working, "The Post-Harvest Depression of Wheat Prices," WHEAT STUDIES, November 1929, VI, 1–40.

[2] Holbrook Working, "Price Relations between July and September Wheat Futures at Chicago since 1885," WHEAT STUDIES, March 1933, IX, 218; and "Price Relations between May and New-Crop Wheat Futures at Chicago since 1885," *ibid.*, February 1934, X, 205.

[3] Although eight different classifications were studied, the results of only one are discussed in the text, since that classification was the most satisfactory from the viewpoint of grouping years that were uniform in seasonal movement of both the prices and spread.

prices of both futures have tended to decline during August–December, with the March future declining slightly less than the December and consequently going to an increasing premium; (2) when March wheat has been at a moderate premium over December wheat, the prices of both futures have tended to decline moderately, but consistently, with the price spread tending to narrow until the middle of October and thereafter to widen; and (3) when March wheat has been at a large discount under December wheat in September, the prices of both futures have tended to advance during August–December, with the March future advancing less than the December, and consequently going to an increasing discount.

Seasonal Variations in the Spread

Considering the December–March spread as a separate price series, we shall note the behavior of the spread under certain market conditions which are expressed by its direction and width in September. By the first of September, Northern Hemisphere crops have been fairly well appraised and something is known of prospects for the Southern Hemisphere crops; yet the December and March futures will be quoted simultaneously for about four additional months. Therefore, for purposes of analyses, we consider the relations between the futures prices in September as the criteria for classifying the crop years into groups as follows:

I. Years of moderate or large negative spreads: the price of the March future more than 1 per cent under that of the December.

II. Years of small spreads: the price of the March future 1 per cent under to 1 per cent over that of the December.

III. Years of moderate positive spreads: the price of the March future more than 1 per cent but less than 2 per cent over that of the December.

IV. Years of large positive spreads: the price of the March future 2 per cent or more over that of the December.

On the basis of the above criteria, the crop years were grouped as follows:[1]

I	II	III	IV
1908–09	1905–06	1906–07	1929–30
1925–26	1909–10	1907–08	1931–32
1926–27	1910–11	1912–13	1933–34
1935–36	1911–12	1913–14	1934–35
1936–37	1923–24	1928–29	
	1924–25	1930–31	
	1927–28	1932–33	

The weekly averages of the December–March spread for the four groups of years are shown in Chart 9 and Table VI.

The only seasonal tendency in the spread common to the four groups is a decline during the month of December (Chart 9). During the final month of trading in December wheat, the price of the December future has tended to advance relative to the March future. A positive spread has tended to narrow, whereas a negative spread has tended to widen. The economic significance of the decline in December is not yet wholly clear. It may be connected with the closing out of trades in December wheat. A somewhat similar relative rise in the price of the near future during its delivery month is common at Chicago.[2]

The spread curves of the individual years, including the two latest years not represented in the averages, are shown in Chart 10. Examination of the separate curves indicates that in each of the years in Groups I and IV the spread had a net decline during December. In Group II, four years out of the seven show a decline during December; and in Group III, three of the four years in which December wheat was quoted most of the month also show a net decline in the spread during December. It appears, therefore, that

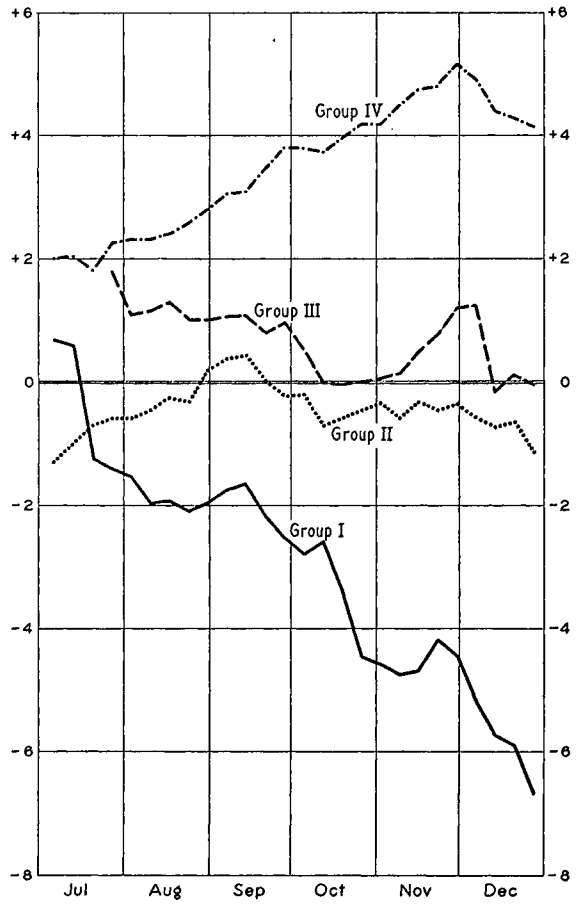
[1] Crop years prior to 1903–04 were omitted since Argentine wheat was not tenderable at Liverpool prior to 1903, when the Graded Wheat Futures Contract was introduced. See Holbrook Working and Sidney Hoos, "Wheat Futures Prices and Trading at Liverpool since 1886," Wheat Studies, November 1938, XV, 145. The crop years 1903–04, 1904–05, 1914–15, 1921–22, and 1922–23 could not be classified because trading in the March future did not begin as early as September of those years. The two years 1937–38 and 1938–39 fall in Group I, but were not used in computing the weekly averages for that group, since the data for those two years were not available when the computations were made.

[2] See Holbrook Working, Wheat Studies, IX, 219, and X, 206, 210.

the tendency for the spread to decline during December is general in the sense that such a decline occurred in most of the individual years as well as in the sense that it was a dominant tendency in each of the four classes of years.

CHART 9.—AVERAGES, BY WEEKS, OF DECEMBER–MARCH SPREAD, BY GROUPS OF YEARS*

(*Pence per cental*)



* Data from Table VI.

Noting other characteristics of seasonal variation in the four groups of years, we first consider Group I. The weekly averages plotted for Group I in Chart 9 indicate that when the spread is negative and large in September there is a strong tendency for the spread to become wider as the crop year advances. March wheat tends to go to an increasing discount relative to December. The weekly averages suggest that during November the decline is arrested, only to be continued in December; but over the August–December interval there is a strong tendency for the spread to fall. Reference to the spread curves for the individual years of Group I, in Chart 10, indicates the extent to which the individual years behave uniformly. Five of the seven years show a net decline in the spread during September–December.[1] Prior to 1937–38, however, all but one of the years in Group I follow roughly the average seasonal variation shown by the corresponding curve in Chart 9. On the basis of the average seasonal pattern and curves of the individual years, there is evidence that wide negative spreads in September have generally tended to increase in width during the remainder of the calendar year.

The weekly averages for Group II in Chart 9 (years of small spreads in September) suggest only a slight seasonal pattern. The weekly averages indicate a tendency for the spread to rise slightly through August, reach a peak in about the middle of September, and then decline to a level which is maintained through most of October–December; during December there is some tendency to decline, but it is not so marked as in the other groups of years. However, the significance of the pattern of seasonal variation in years of Group II is highly doubtful, since the indi-

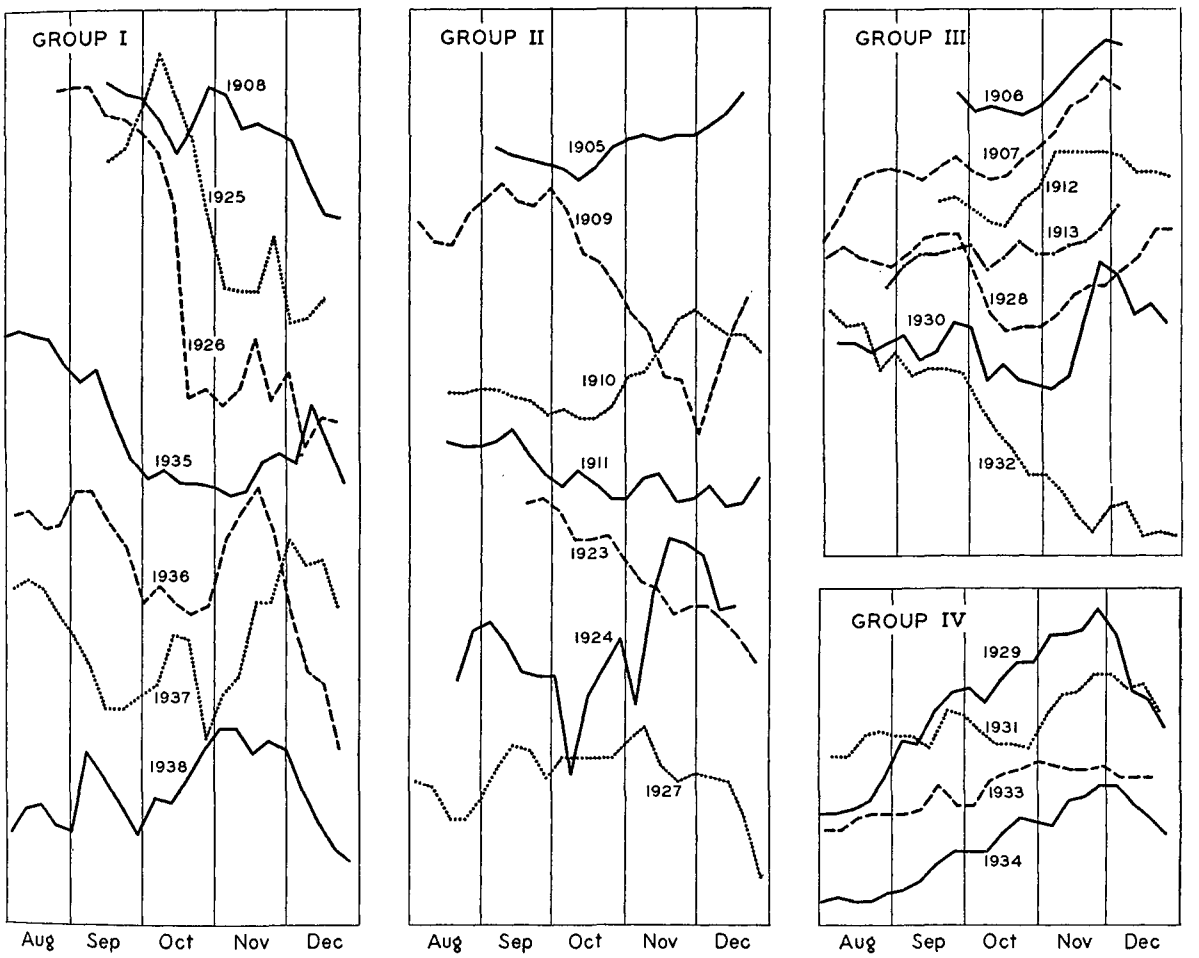
[1] The course of the December–March spread during 1926 merits special attention since it was strongly influenced by a situation in ocean shipping. The English coal strike that began May 1, 1926 necessitated large imports of coal. Since available ocean tonnage was utilized largely for coal imports and bottoms were scarce, ocean freight rates rose to abnormally high levels. The reluctance to import wheat over the barrier of high freight rates caused a stringency in English wheat stocks on hand, and the tightness of the supply position of near wheat was reflected by negative carrying charges in Liverpool wheat futures prices. From October 2 to November 6, the premium of December wheat over March more than quadrupled, from 2.1*d.* per cental to 8.8*d.* per cental. This sharp increase in negative carrying charges, shown by the 1926 curve in Chart 10, was due more to the strike and its repercussions than to fundamental factors such as the international statistical position of supplies. For a detailed account of the situation in 1926 see: M. K. Bennett and J. S. Davis, "Survey of the Wheat Situation, August to November, 1926," WHEAT STUDIES, January 1927, III, 152; V. D. Wickizer, "Shipping and Freight Rates in the Overseas Grain Trade," *ibid.*, October 1938, XV, 71–72; and D. H. Robertson, "A Narrative of the General Strike of 1926," *Economic Journal*, September 1926, XXXVI, 375–93.

vidual years, shown in Chart 10, are quite dissimilar in their seasonal movement. This lack of uniformity in the seasonal movement of the spread when it is small in September suggests that the slight seasonal pattern of weekly averages for Group II is probably spurious.

During November the spread rises and March wheat regains its premium over December wheat, only to fall again in December when the usual decline occurs. But these seasonal tendencies are not typical of all of the individual years in Group III. Study of the curves of the years in Group III, shown in

CHART 10.—CURVES OF DECEMBER–MARCH SPREAD, WEEKLY, GROUPED ACCORDING TO SPREAD IN SEPTEMBER*

(Pence per cental)



* Data from Table IX and WHEAT STUDIES, November 1938, XV, 166–80; grouping as described in accompanying text. The horizontal and vertical scales are in the same proportion as the scales in Chart 15; the curves are enlarged (2.5 times) reproductions of the corresponding curves in that chart.

The weekly spread averages for the years in Group III indicate that in this class of years (moderate positive spreads in September) the spread tends to narrow from the beginning of August to about the middle of October, when March wheat in an average year is no longer at a premium over December wheat. Chart 10, indicates there is a slight tendency for the spread to rise after the middle of October, but the timing of the rise is not uniform. Furthermore, the indicated tendency for the spread to decline from August to the middle of October rests on data which are complete for only four years. Therefore it

is doubtful whether there is sufficient uniformity in the seasonal movement of the years in Group III to conclude that the corresponding curve in Chart 9 is typical of the seasonal movement of the December–March spread when it is positive and moderately wide in September.

According to weekly averages for Group IV, wide positive spreads in September consistently increase in width until the end of November, but during December the spread follows the common tendency to decline. Wide positive spreads may therefore be considered to have two prominent seasonal tendencies: (1) a major seasonal movement during the August–November period, when the spread widens further; and (2) the typical decline in December. The August–November movement is a conditioned seasonal tendency since it is dependent upon the price relation between the futures in September; and the December decline appears to be a general seasonal tendency common to the four groups of years. The seasonal movement of the curve for Group IV in Chart 9 well represents the seasonal movement of the individual years in that group. The spread curves for the years in Group IV, shown in Chart 10, show that in each of the years the spread tended to rise during August–November, and decline in December.

In summary, the evidence suggests that when the spread is large early in the crop year, whether it is positive or negative, it tends to become larger as the crop year advances. However, years with small spreads in September do not tend to follow a uniform pattern of seasonal variation.

Why do wide spreads, whether positive or negative, increase in width as the crop year advances? A tentative answer may be given in the following terms. We earlier suggested the conclusion that the December–March spread is chiefly determined by market expectations regarding the probable level of stocks of imported wheat in Europe near the end of the calendar year. Hence, when March wheat is at a large premium over December wheat early in the crop year, the market expects a high level of imported stocks at the end of the calendar year. These expectations may be well founded, but a considerable degree of uncertainty might exist in the market as to actual level of stocks that will prevail in December. However, as the crop year advances and expectations gradually become more certain as to the probable level of stocks in December, the spread continuously reflects the improved expectations. By the end of November, when the probable level of imported stocks near the end of the calendar year is well appraised, the price of December wheat is at a discount sufficiently under March to reflect fairly accurately the level of imported stocks of wheat.

Reasoning along similar lines, one may say that when March wheat is at a large discount under December wheat early in the crop year, the market expects a relatively low level of imported stocks near the end of the calendar year. As grounds for such expectations become more certain, the price of December wheat advances relative to March wheat. By the end of November, when the low level of imported stocks becomes fairly definite, relative tightness in supplies on hand is reflected by negative carrying charges. Thus expectations early in the crop year are continuously modified in line with the accumulation of additional information. Another plausible explanation, which bears some similarity to the first, is that the seasonal tendencies in large spreads (Groups I and IV) reflect the market's conservative attitude towards the reliability or fulfillment of current expectations. The market as a whole might have a tendency to discount or fail to give adequate weight to current indications, especially those prevalent early in the crop year when traders are uncertain concerning later prospects.

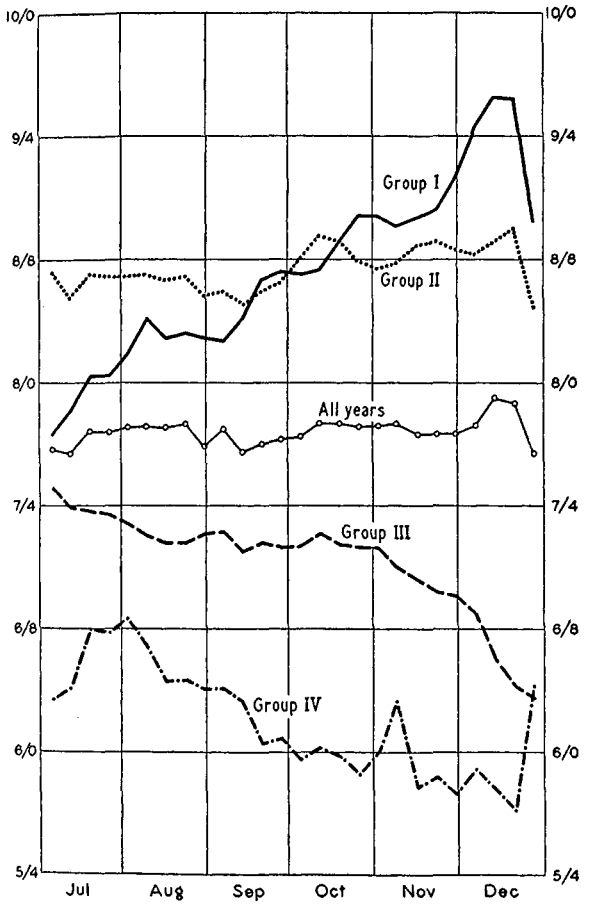
Seasonal Variations in the December Future

In conjunction with the seasonal variation of the spread, it is pertinent to investigate the seasonal tendencies of the December futures price at Liverpool. In our analysis of the seasonal movement of December wheat futures prices, we have used the classification of years just employed in analysis of seasonal movement of the December–March spread. Therefore the weekly averages showing the

seasonal variation in the spread in Chart 9 may be compared with the corresponding group averages of seasonal variation in December futures prices shown in Chart 11. Comparison of seasonal tendencies in the spread and prices is helpful in discerning the seasonal relationships between the December and March futures and their price spread.

CHART 11.—AVERAGES, BY WEEKS, OF PRICE OF LIVERPOOL DECEMBER FUTURE, BY GROUPS OF YEARS*

(Shillings and pence per cental)



* Data from Table VI.

Chart 11 shows clearly that when all years are considered together, as is usual in determining averages of seasonal variation, there is very little evidence that seasonal tendencies exist in the December futures price. The weekly averages for the composite group, "all years," fluctuate within the relatively narrow range of 7.5*s.* and 8.0*s.* per cental. But when consideration is given to different market situations by classifying the years into comparable groups, certain seasonal tendencies become evident. Some evidence emerges that the December futures price tends to follow seasonal patterns which vary according to the price relations between the futures in September.

Chart 11 shows the pattern of seasonal variation for years in Group I. The weekly averages for those years indicate that as the crop year advances the price of the December future tends to rise. The March future also advances in price but to a lesser degree, as indicated by the seasonal movement of the spread which shows that the December future rises relative to the March. Comparison of the price curves of the years in Group I, shown in Chart 12, indicates how typical is the average seasonal tendency. In all but two of the years, the December futures price shows a net rise from August to December. In 1937 and 1938, however, the December future fell in price. It is of some interest that the spread movement of those years also was opposite to that of the other years in Group I. From the seasonal movement of the individual years in Group I and the average for the group, there is some basis for generalizing that when the spread is negative and large in September, the price of the December future tends to advance as the season progresses.

The weekly averages for Group II do not indicate that the December futures price follows a marked seasonal pattern. There is a very slight tendency for the price to be somewhat higher during October–November than in the preceding two months, but the difference in level is too small to be important. In fact, examination of the price curves for the years in Group II substantiates the view that those years do not behave uniformly in seasonal movement, and the average pattern in Chart 11 is not typical of the movement of most of the individual years.

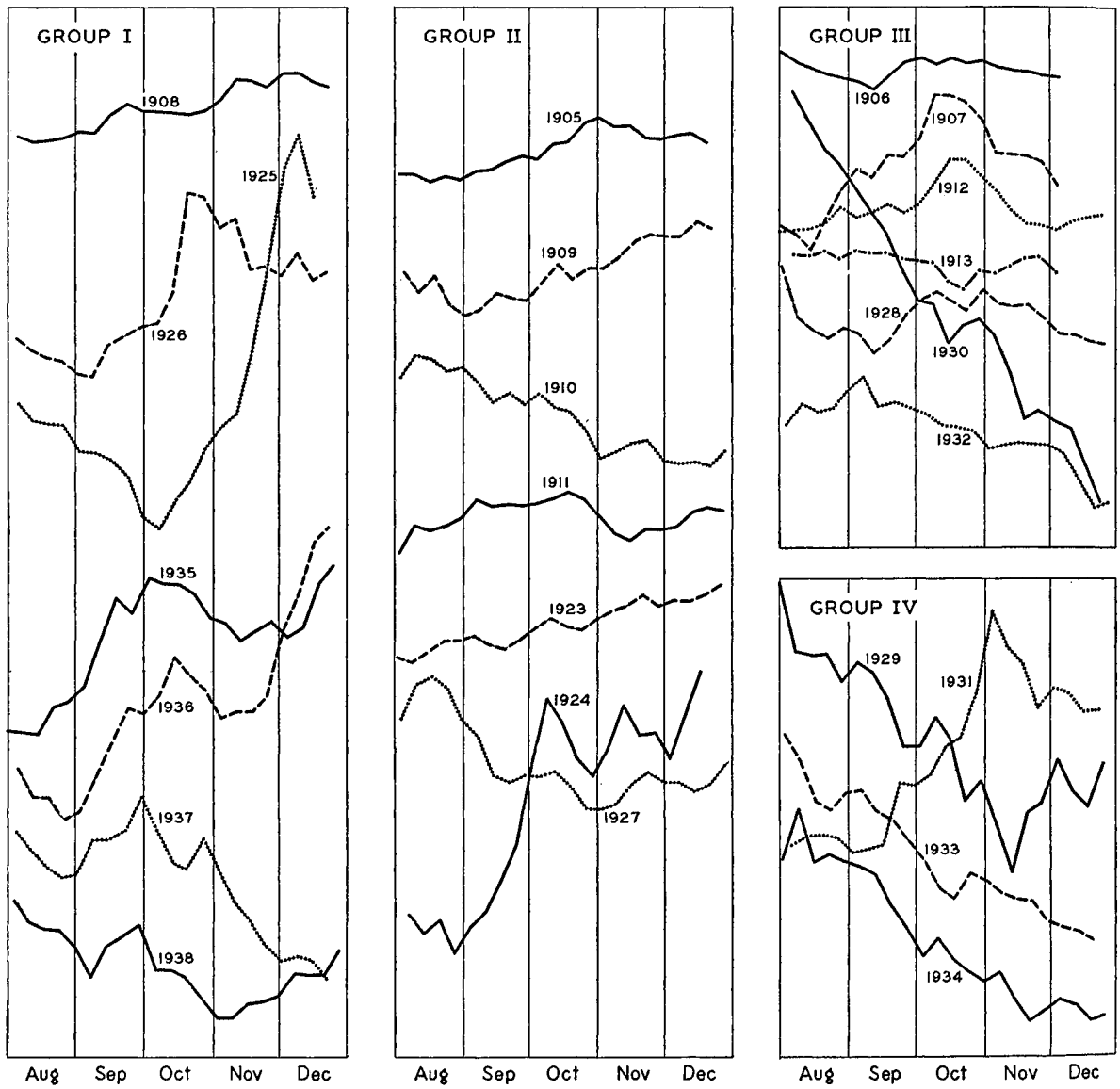
In the years classified in Group III, the price of the December future apparently tends to decline slightly during August–October, while during November and December the tendency toward price decline seems

strong. Examination of the price movement of the several years in Group III, shown in Chart 12, indicates that a price decline previous to November is not typical of the separate years. During November–December, however, price declines occurred in all years in the group. Thus there is evidence that when the spread is positive and moderately wide in September, the price of the December future tends to decline near the end of the calendar year.

When the spread is positive and large in September (years in Group IV, Chart 11), the December futures price tends to decline during August–December. The March future also tends to decline, but less strongly since

CHART 12.—CURVES OF PRICE OF LIVERPOOL DECEMBER FUTURE, WEEKLY, GROUPED ACCORDING TO SPREAD IN SEPTEMBER*

(Shillings and pence per cental)



* Data from Table IX and WHEAT STUDIES, November 1938, XV, 166–80; grouping as described in accompanying text. The vertical scale is one-fourth that used for Chart 10; the curves are enlarged (2.5 times) reproductions of corresponding curves in the center section of Chart 1 or in Charts 3 or 4 of WHEAT STUDIES, November 1938, XV.

the seasonal movement of the spread for Group IV indicates that March wheat advances in price relative to December wheat. The course of prices in three of the four years in Group IV, as shown in Chart 12, broadly followed the seasonal tendency to decline during August–December. In 1931, however, prices rose sharply from early in September to early November, and thereafter fell to a lower level. Although only four years were classified in Group IV, the price movement of those years suggests that when the spread in September is positive and large, there is some tendency for the December futures price to decline as the season advances.

In summary, the December and March futures prices generally appear to have strong seasonal tendencies only when the spread is large, whether positive or negative, in September. If the spread is positive and large, both futures tend to decline, with the March future falling less than the December. If the spread is negative and large in September, both futures tend to rise, but with the March futures price advancing less than the December.

IV. RELATIONS OF PRICE CHANGES TO SPREAD CHANGES

Influences which affect both futures in precisely the same manner do not affect the spread between the prices of the two futures. Influences which do affect the spread must bear on only one of the futures prices, or upon both futures differently. In other words, a change in the December–March spread requires that both futures prices change in the same direction but in different amounts, or that both futures prices change in opposite directions. Price effects similar in both the December and March futures are not reflected by their inter-option spread; whereas a price effect different in one future from that in the other future must be accompanied by a change in the December–March spread. These necessary interrelationships are used in this final section of the study as a basis for revealing further characteristics of the price influences which act specifically on the December–March spread.

For this purpose, attention is concentrated on weekly changes in prices and in the spread. Statistical measures are computed separately for each month and for each of three classifications based on sign and size of the spread. This procedure serves as a means of determining whether the average price effects differ either according to the time of the year or according to circumstances related to the size of the spread. The main conclusions that emerge are:

1. Influences affecting the spread tend to be stronger in the last two or three months of the life of the December future than in earlier months, and to be strongest when the March future is at a large discount under the December.

2. Changes in the spread tend to arise from influences which affect the price of the December future but which have either no effect or a much smaller effect on the price of the March future. More specifically, the average tendency has been for these spread-determining influences to have no effect on the price of the March future during November and December, and during earlier months to affect the price of the March future about one-third to one-half as much as they affect the December.

Classification of the Data

An early step in examining the manner in which changes in the futures prices are related to changes in the spread is the classification of paired changes in the prices and spread. In order to determine whether the relations between price changes and spread changes vary systematically according to the sign and size of the spread, or whether the relations are largely independent of such circumstances, weekly changes are classified into three groups: large negative spreads; small spreads, positive or negative; and large positive spreads. This classification is broadly similar in principle to that used in connection with seasonal variations discussed above (p. 127). The important difference is that the earlier criteria of grouping were the sign and size of the spread in September, and

each year was classified according to its spread in September. Here we consider each weekly change separately, and classify the changes on the basis of the position of the price for March wheat relative to December wheat at the end of each weekly change. Therefore, within the same year a weekly change might fall in one class and the next weekly change might fall in either the same or some other class. The classes, defined in terms of price relations at the end of the weekly change, are as follows:

Class A: March wheat at least 1*d.* under December

Class B: March wheat less than 1*d.* under or over December

Class C: March wheat at least 1*d.* over December

Variability of Prices and the Spread

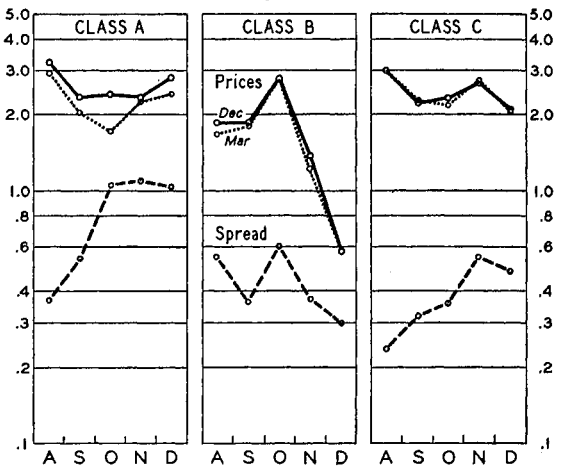
Averages of weekly changes in prices of the December and the March futures and averages of weekly changes in the December–March spread, classified as described above, are shown graphically in Chart 13. The average weekly change[1] of the prices in most of the categories is between 1.8*d.* and 2.8*d.* per cental. The price of the March future appears slightly less variable than that of the December, especially when there is a large negative spread (Class A). With two exceptions, these averages suggest that the variability of prices tends to be about the same in all the months from August to December and to be about the same whatever the price relation between the December and the March futures. In November and December of weeks in Class B, however, the variability of prices has been exceptionally low.[2]

This observation regarding the variability of prices raises a rather interesting minor problem. Why should wheat prices be exceptionally stable in the months of November and December, but not similarly stable in August, September, or October, when the December–March spread is narrow? The clue to the answer may lie in the further observation that narrow spreads occur much less frequently in November and December than in previous months. In September and October, 39 and 41 per cent of the weeks, respectively, ended with the December–March spread narrow (falling in Class B); but in November only 27 per cent of the weeks, and in December only 16 per cent ended with the December–March spread narrow.[3] Perhaps the December–March spread tends to remain narrow in November and December only when conditions are such as to favor stability of prices.

The variability of the December–March spread depends to a considerable extent on both the size of the spread and the time of year. Weekly changes in the spread have averaged much larger when the price of the March future has been 1*d.* per cental or more

Chart 13.—Average Weekly Changes in Prices of Liverpool December and March Futures and December–March Spread, by Months and Spread Classes*

(Pence per cental; logarithmic vertical scale)



* The averages are "standard deviations," from Table V.

[1] The averages are "standard deviations," which tend to be about one-fourth larger than simple arithmetic means of changes taken without regard to sign. The fact that the averages are measures of variability gives some ground for preferring the standard deviation as the particular form of average for use in this instance. A further consideration is the availability of standard deviations as by-products of calculations to be discussed below.

[2] By the *z* test, the probability that variability in these months should have fallen so far below the general average merely by chance is very much less than 1 per cent. None of the other departures have a probability as small as 5 per cent.

[3] The number of weekly changes in each category is given in Table IV.

under that of the December (Class A) than when the spread has been narrower or of the opposite sign. During October–December, for Class A, the average weekly change in the spread has been about 40 per cent of the average weekly change in the price of the December future. When the March future has been at least 1*d.* per cental *over* that of the December, the average weekly change in the spread, even in November and December, has been only about 20 per cent of the average weekly change in the price.

The greater variability of the December–March spread during the two or three months before expiration of the December future is most marked in Class A. For weeks in this class, the average weekly change in the spread has been over twice as great during October–December as during August and September. When the March future has been at a premium of 1*d.* or more per cental (Class C), the variability of the spread has been about twice as great in November and December as in August, but the greatest increase in variability has come between October and November rather than between September and October.

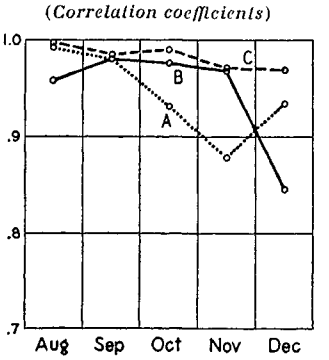
For weeks in which the spread has been narrow (Class B), weekly changes in the spread have averaged smaller in November and December than during earlier months. This is perhaps mainly a consequence of the apparent tendency for the December–March spread to remain narrow in November and December only when market conditions favor stability of prices. Average weekly changes in the spreads in November and December of weeks in Class B have actually been larger, relative to average weekly changes in prices, than they have been in September and October.

Changes in the Two Futures

Before examining the relations between weekly changes in the spread and changes in one of the prices, it is advantageous to consider changes in the prices of the two futures. From market observation and charts of futures prices, it is evident that near and distant futures broadly parallel each other in price movement.[1] The degree of correspondence in movement tends to vary somewhat according to circumstances, as appears from the coefficients of correlation shown in Chart 14.

The differences among the coefficients of correlation shown in Chart 14 bear a considerable similarity in pattern to the differences among the measures of variability shown in Chart 13. In general, the correlation between price changes in the December and the March futures is high when changes in the spread average small relative to the changes in price; and the correlation between price changes

Chart 14.—Average Degree of Relationship between Weekly Changes in Price of Liverpool December and March Futures, by Months and Spread Classes*



* Data from Table IV.

tends to be comparatively low when changes in the spread average large relative to the changes in price. Thus, the correspondence between price movements has been closest when the price of the March future has been considerably above that of the December (Class C); and has tended to be poorest when the price of the March future has been considerably below that of the December (Class A).[2] Also, the correlation has been less in the

[1] See Chart 1, p. 106, also Holbrook Working and Sidney Hoos, "Wheat Futures Prices and Trading at Liverpool since 1886," Wheat Studies, November 1938, XV, where Charts 3 and 4, facing page 150, show average weekly prices of five futures at Liverpool from May 1886.

[2] The coefficients of correlation by themselves give only slender ground for asserting that the correspondence tends to be poorer in Class A than in Class B, since in one month (September) the coefficients are the same for both classes, and for two of the other four months the coefficients for Class B were below those for Class A, and about as far below as they were above in the other two months. Of the differences between corresponding correlation coefficients

last month or two before expiration of the December future than in earlier months. These relations are broadly in agreement with those found at Chicago.[1] There, also, the correspondence between weekly changes in the prices of two futures tends to decrease as the distant future goes to increasing discount under the near, and as the season advances.

Changes in the Spread and Prices

We have defined the December–March spread as the difference between the prices of the December and the March futures, with the December taken as the base. In the consideration of the relations of price changes to spread changes it is well to fix in mind the necessary relations between changes in the spread and changes in the prices. Since the near future is taken as the base or level of reference, and the distant future is expressed as a premium over or discount under the near future, it follows that a decline in the spread is equivalent to the narrowing of a positive spread or the widening of a negative spread. Conversely, a rise in the spread is equivalent to a widening of a positive spread or a narrowing of a negative spread. A rise of the December–March spread thus indicates that the price of March wheat has advanced relative to December wheat, or that December wheat has decreased relative to March. Likewise, a decline of the December–March spread indicates that March wheat has fallen in price relative to December wheat, or that the December has increased in relation to the March.

In order to determine statistically the average relations between changes in the spread and changes in the futures prices we have used regression coefficients which measure the average change in futures prices for a 1*d.* change in the December–March spread.[2] Such regression coefficients, computed for the five months from August to December, are as follows:

	December future	March future	Standard error
August	−2.16	−1.16	±.93
September ...	−1.68	− .68	±.55
October	−1.70	− .70	±.29
November ...	− .70	+ .30	±.25
December	−1.36	− .36	±.28

These statistical measures suggest that a change in the December–March spread tends to be accompanied, on the average, by opposite changes in prices of the futures, with the December future changing more than the March. The amount of change in the prices cannot be precisely determined from the regression coefficients, since they must be interpreted in conjunction with their standard errors. Examination of the price effects in the separate months, as indicated by the regression coefficients supplemented by their respective standard errors, strongly suggests that the price effects generally are different during August–October from those during November–December. This seems reasonable, since in the previous section it was shown that under certain circumstances the futures prices and the spread tend to follow a pattern of seasonal variation.

Pooling the weekly changes during August–

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for Class A and Class B, however, those for October and November, when Class A shows the lower correlations, are clearly significant, whereas the other differences might rather readily have occurred by chance (see the "confidence limits" accompanying the coefficients in Table IV).

[1] Holbrook Working, "Price Relations between May and New-Crop Wheat Futures at Chicago since 1885," Wheat Studies, February 1934, X, 193.

[2] Of course, regression coefficients may be computed so that they measure the average change in the spread for a 1*d.* change in the December futures price. Such regression coefficients, among other statistical measures, are given in Table VII in the appendix. The measures discussed in the text proved most useful in determining the relations between spread changes and price changes. Since the spread is equal to the distant futures price (March) minus the near futures price (December), the sums needed for calculation of a coefficient of correlation between the spread and the price of the December future suffice also for calculation of coefficients of correlation between the spread and the price of the March future and between the two futures, and for calculation of the associated regression coefficients.

Let X = change in spread
Y = change in December future
Z = change in March future

and let x, y, z be deviations of the corresponding changes from their respective means, so that $\Sigma x = \Sigma y = \Sigma z = 0$. Then it may be shown that

$$r^2_{xz} = \frac{(\Sigma x^2 + \Sigma xy)^2}{\Sigma x^2(\Sigma x^2+2\Sigma xy+\Sigma y^2)} \; ; \; r^2_{yz} = \frac{(\Sigma y^2 + \Sigma xy)^2}{\Sigma y^2(\Sigma x^2+2\Sigma xy+\Sigma y^2)}$$

$$b_{xz} = \frac{\Sigma x^2 + \Sigma xy}{\Sigma x^2+2\Sigma xy+\Sigma y^2} \; ; \; b_{yz} = \frac{\Sigma y^2 + \Sigma xy}{\Sigma x^2+2\Sigma xy+\Sigma y^2}$$

$$b_{zx} = b_{yx} + 1 \; ; \; b_{zy} = b_{xy} + 1$$

October into one group, and the changes during November–December into another group, is one means of ascertaining whether the relation of price changes to spread changes differs significantly between the two groups of months. The statistical results, indicating the average change in the futures prices for a 1*d.* change in the spread, are as follows:

	December future	March future	Standard error
August–October	−1.7	−.7	±.24
November–December .	−1.0	.0	±.18

The above measures indicate that during August–October an increase (or decrease) of 1*d.* in the spread is associated with an average decrease (or increase) of about 1.7*d.* in the December futures price and an average decease (or increase) of about .7*d.* in the March future. During November–December, however, a change of 1*d.* in the spread is accompanied by a change equal, but of opposite direction, in the December future with no change in the March.[1] The transition from the relation of price changes to spread changes during August–October to the relation prevalent during November–December probably is not sharp or sudden. Presumably such a transition is gradual and continuous, with the rate of transition varying somewhat according to market situations.

In order to answer the question whether the relation of price changes to spread changes is dependent upon the sign and size of the spread, appropriate regression coefficients and their standard errors have been computed, with the data further segregated according to direction and size of the spread, using the spread classification already described (p. 134).[2] The results indicate that for each spread class there is one tendency common to the months of August, September, and October and another tendency common to the months of November and December. For the months August–October, the statistical data suggest that the price changes accompanying given changes in the spread tend to be smaller in weeks of small spread (Class B) than in weeks of large negative spread (Class A).[3] But for November–December the data give an opposite

the number of weekly changes on which each coefficient is based are shown below.

Pool	Number of changes	Class	b_{yx}	σ_b
		August–December		
1	142	A	−1.317	±.182
2	140	B	−1.002	±.357
3	171	C	− .527	±.418
4	453	$A + B + C$	−1.267	±.151
		August–October		
5	57	A	−1.972	±.205
6	93	B	− .912	±.467
7	90	C	−1.477	±.838
8	240	$A + B + C$	−1.677	±.240
		November–December		
9	85	A	−1.002	±.240
10	47	B	−1.365	±.456
11	81	C	− .198	±.472
12	213	$A + B + C$	− .980	±.189

Differences between some of the above regression coefficients, together with standard errors of the differences, are:

Between 8 and 12, .697 ± .305
Between 1 and 5, .655 ± .274
Between 5 and 9, .970 ± .316

The statistical data suggest that the difference between pools 8 and 12 is unlikely to have arisen solely by chance. A similar conclusion holds for the difference between 1 and 5, and the difference between 5 and 9. Thus, taking all weeks together, it is fairly clear that there has been a real tendency for equal changes in the December–March spread to be accompanied by larger changes in price of the December future during August–October than during November–December; and taking only weeks of large negative spread (Class A) this tendency is even clearer.

[1] The difference between the regression coefficients for August–October and November–December appears to be statistically significant. The difference of .7*d.* (1.7 minus 1.0) is about 2.3 times as large as its standard error of .3*d.*

[2] The regression coefficients and other statistical measures for the three classes, respectively, of large negative spreads, of small spreads, positive or negative, and of large positive spreads for the different months are given in Table VII. In the study of the statistical measures, various charts were used. These charts are not reproduced here because the measures were interpreted in conjunction with their standard errors and graphical presentation of numerous regression coefficients with their standard errors might be more confusing than revealing unless the reader is familiar with statistical theory. For such a reader the numerical measures are adequate to check our conclusions. In the analysis, the data given by months in Table VII were supplemented by regressions of the December futures price on the spread, based on data for the groups of months used above and the three spread classes, A, B, and C, explained on page 134. These regression coefficients, their standard errors, and

[3] The comparison is between the regression coefficients of pools 5 and 6 of the previous footnote, for which the difference is 1.060 ± .510. Such a difference, having a probability $P = .05$, is conventionally regarded as barely large enough to be considered significant. It is not large enough to carry much weight in the face of contrary evidence.

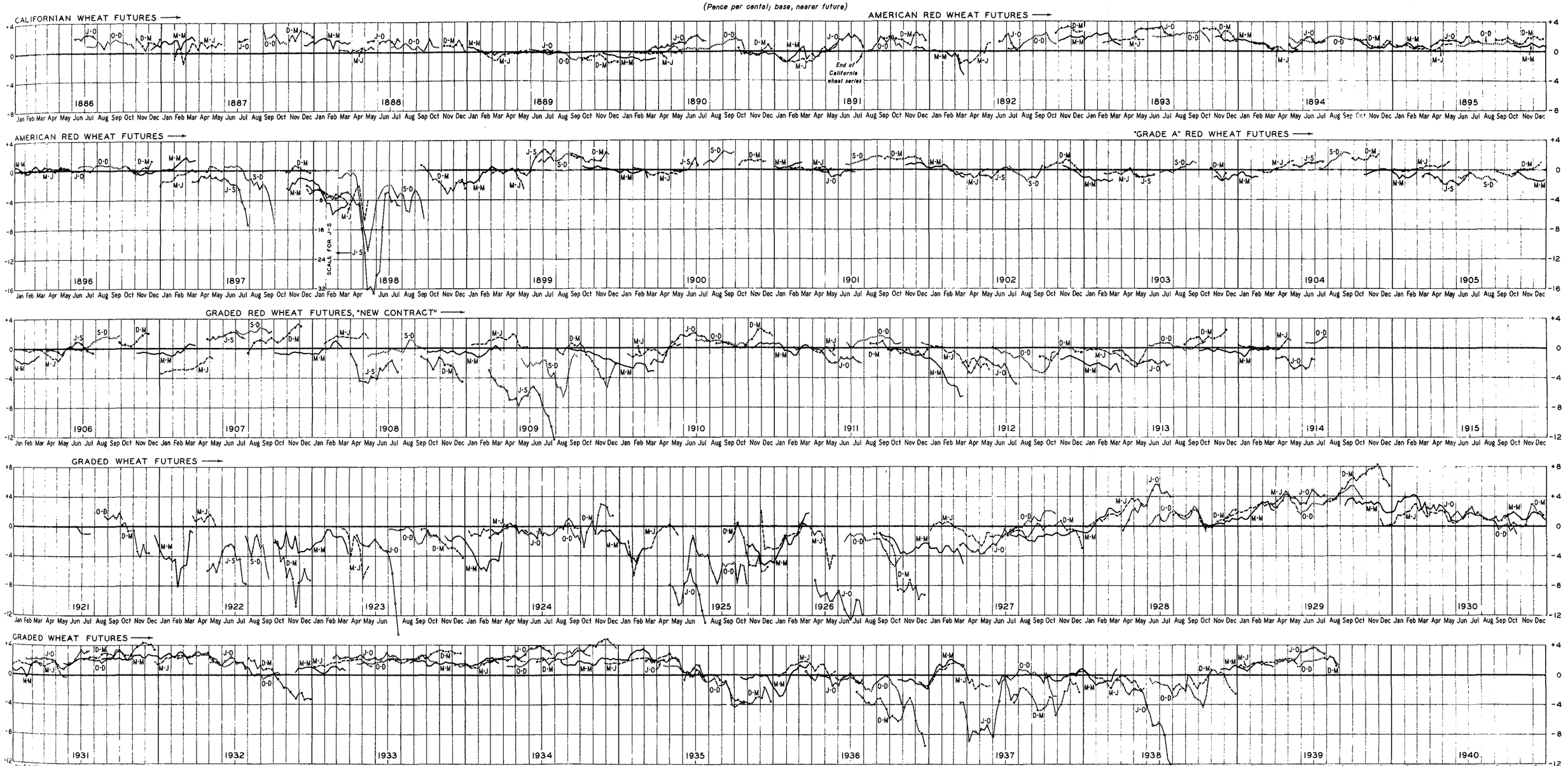
indication. Since it appears reasonable to suppose that any real difference in tendency during August–October attributable to size and direction of the spread, should appear to some extent in November–December also, the evidence is conflicting. Therefore, it appears reasonable to conclude that during the last five months of the calendar year the price changes associated with changes in the December–March spread do not vary according to the sign or size of the spread.

The positive conclusions concerning the relations of price changes to spread changes may be briefly restated as follows. Influences affecting the spread seem to result in price effects different in August–October from November–December. A change of 1*d.* in the December–March spread during August–October has been accompanied on the average by changes of about 1.7*d.* in the December future and .7*d.* in the March future. During the last two months of the calendar year, weekly changes in the spread tend to be accompanied by equal, but necessarily opposite, changes in the price of December wheat and no change in the price of March wheat. It appears, therefore, that factors bearing on the spread tend to induce differential price effects; that the magnitude of the differential effects has a seasonal fluctuation; and that the differential is not much affected by the direction or size of the spread.

The statistical analyses underlying this study and their presentation in Sections II–IV are primarily the work of Sidney Hoos, now of the Giannini Foundation of Agricultural Economics, University of California. The work was done with the co-operation of Holbrook Working, who wrote the introductory pages and Section I. The authors are indebted to P. Stanley King for most of the charts and to Jean Hoover Ballou for the tables and for other assistance in preparation of the manuscript.

CHART 15.– PRICE SPREADS BETWEEN LIVERPOOL WHEAT FUTURES, WEEKLY, JUNE 1886 – AUGUST 1939

(Pence per cental; base, nearer future)



Based on weekly averages of daily closing prices; data from Table IX and WHEAT STUDIES, November 1938, XV, 157-80.

APPENDIX TABLES

TABLE I.—UNITED KINGDOM PORT STOCKS AND DECEMBER–MARCH SPREADS AT LIVERPOOL, 1891–1914 AND 1921–39*

Crop year	Port stocks (*thousand bushels*)				Spread[a] (*pence per cental*)			Percentage spread, Nov. 1[b]
	Oct. 1	Nov. 1	Dec. 1	Jan. 1	Oct. 1	Nov. 1	Dec. 1	
1891-92.....	14,000	15,200	20,000	22,700	+1.9	+1.2	+2.6	+1.17
1892-93.....	27,000	26,300	27,900	28,300	+2.4	+2.9	+3.2	+4.10
1893-94.....	29,200	30,800	28,600	29,000	+3.0	+3.0	+2.7	+4.59
1894-95.....	23,600	22,400	15,900	16,300	+1.5	+1.5	+ .5	+2.84
1895-96.....	28,000	25,200	22,640	19,880	+1.8	+1.0	+2.1	+1.54
1896-97.....	11,200	10,100	12,000	14,400	+ .5	− .5	+ .3	− .62
1897-98.....	7,300	8,680	11,520	11,120	− .2	− .3	+ .3	− .33
1898-99.....	7,330	7,280	8,560	8,040	− .1	−2.0	−2.9	−2.74
1899-1900...	18,520	17,920	19,680	19,440	+1.6	+1.3	+2.4	+1.84
1900-01.....	20,070	22,400	22,000	20,320	+ .7	+1.3	+1.3	+1.81
1901-02.....	20,810	20,000	20,420	17,490	+1.5	+1.4	+1.5	+2.05
1902-03.....	12,960	15,600	16,480	14,840	+ .3	+ .9	+ .9	+1.28
1903-04.....	15,340	17,920	19,560	20,150	+ .2	.0	− .5	.00
1904-05.....	18,820	22,400	24,000	24,310	+1.5	+1.3	+2.2	+1.48
1905-06.....	23,950	21,440	20,000	19,340	− .7	.0	+ .1	.00
1906-07.....	24,640	22,400	21,120	20,510	+ .4	+ .5	+2.1	+ .65
1907-08.....	21,760	22,520	21,160	20,750	+1.0	+1.6	+3.0	+1.60
1908-09.....	16,400	15,720	14,960	14,440	−1.6	−1.5	−2.6	−1.60
1909-10.....	14,990	14,040	12,600	13,790	+ .6	−2.5	−5.4	−2.66
1910-11.....	20,550	20,720	22,720	22,680	+ .1	+1.0	+2.6	+1.22
1911-12.....	16,810	14,360	16,200	17,630	− .5	− .8	− .8	− .91
1912-13.....	13,560	15,320	16,400	16,640	−1.4	− .9	− .1	− .98
1913-14.....	18,960	19,040	17,520	15,700	+1.4	+1.2	+2.4	+1.43
1921-22.....	9,870	12,450	11,050	8,840	+ .2	− .6	−3.6	− .50
1922-23.....	6,320	4,160	4,480	5,880	−2.0	−6.9	−7.6	−5.56
1923-24.....	9,280	8,880	7,760	8,480	− .6	−1.8	−2.9	−1.71
1924-25.....	12,320	12,500	14,360	17,280	− .3	+ .6	+2.6	+ .41
1925-26.....	5,120	5,720	3,760	6,160	− .8	−5.2	−6.1	−4.07
1926-27.....	5,340	3,760	3,600	4,760	−2.1	−8.8	−8.0	−6.28
1927-28.....	9,960	8,640	9,600	8,000	− .5	+ .4	− .4	+ .33
1928-29.....	7,800	5,920	5,680	6,200	+1.1	− .2	+ .8	− .18
1929-30.....	11,440	16,760	20,560	16,840	+6.4	+7.0	+7.7	+6.39
1930-31.....	9,040	9,960	13,920	19,720	+1.4	.0	+2.7	.00
1931-32.....	22,080	28,960	29,520	23,880	+3.3	+3.3	+4.3	+4.59
1932-33.....	7,600	8,840	7,600	7,520	+ .7	−1.8	−2.6	−2.93
1933-34.....	13,200	16,760	17,240	19,120	+2.2	+3.3	+3.2	+5.99
1934-35.....	15,120	13,960	14,760	16,120	+3.2	+3.9	+4.8	+6.52
1935-36.....	5,920	6,240	8,800	10,760	−3.5	−3.7	−3.1	−5.00
1936-37.....	6,120	7,200	7,400	9,000	−5.9	−4.4	−6.2	−4.61
1937-38.....	9,760	10,160	10,340	13,000	−4.5	−4.4	− .7	−4.35
1938-39.....	16,440	17,640	19,080	19,120	−2.0	+ .6	+ .1	+ .01

* Stocks, 1891–1924, compiled from Broomhall's *Corn Trade News* and Chicago *Daily Trade Bulletin;* based on a joint compilation of Broomhall's, *The Daily Market Record* (Minneapolis), and the *Daily Trade Bulletin* (Chicago). Stocks, 1925–36, compiled from *Corn Trade News.* Stocks include wheat and flour. Weekly price spreads from WHEAT STUDIES, November 1938, XV, 157–80. Monthly prices and spread computed from *ibid.*, pp. 153–56.

[a] Average for first week ending in the month indicated.

[b] Spread as percentage of average price of December future during first week ending in November.

TABLE II.—STATISTICS OF "WORLD" WHEAT SUPPLIES, FROM 1922*

(*Million bushels*)

Crop year	Initial stocks (about August 1)								Production			Aug.–Dec. supplies[d]
	United States grain[a]	Canadian grain[b]	Total North America[a]	Australia	Argentina	Total Australia and Argentina	Four chief exporters	"World"	Northern Hemisphere[c]	Australia and Argentina	"World"[c]	
1922-23..	107	28	135	24	62	86	221	547	2,794	305	3,145	3,341
1923-24..	134	23	157	33	60	93	250	491	3,034	373	3,458	3,525
1924-25..	137	48	185	34	66	100	285	609	2,668	356	3,071	3,277
1925-26..	111	31	142	28	58	86	228	475	2,958	306	3,315	3,433
1926-27..	101	40	141	24	67	91	232	546	2,929	391	3,369	3,475
1927-28..	111	56	167	35	70	105	272	590	3,126	400	3,587	3,716
1928-29..	115	91	206	36	95	131	337	651	3,338	509	3,905	3,989
1929-30..	232	127	359	40	130	170	529	911	3,072	289	3,426	3,983
1930-31..	294	127	421	48	65	113	534	874	3,213	446	3,704	4,087
1931-32..	329	139	468	60	80	140	608	925	3,218	410	3,681	4,143
1932-33..	391	136	527	48	65	113	640	951	3,234	455	3,744	4,185
1933-34..	382	218	600	55	75	130	730	1,118	3,101	463	3,635	4,219
1934-35..	274	203	477	84	118	202	679	1,188	2,900	374	3,337	4,088
1935-36..	147	214	361	57	85	142	503	939	3,029	286	3,394	3,968
1936-37..	142	127	269	43	60	103	372	752	2,841	401	3,303	3,593
1937-38..	83	37	120	41	45	86	206	512	3,146	395	3,605	3,658
1938-39..	153	25	178	50	72	122	300	593	3,727	523	4,323	4,320
1939-40..	253	103	356	50	230	280	636	1,157	3,563	330	3,958	4,720

* Data on stocks from WHEAT STUDIES, October 1939, XVI, 66. Data on production as in WHEAT STUDIES, December 1939, XVI, 183.

[a] United States data as of July 1; including United States grain in Canada.

[b] Including Canadian grain in the United States.

[c] Northern Hemisphere excludes China, USSR, Turkey, Manchukuo, Syria and Lebanon, Palestine, and Cyprus. "World" excludes also Brazil and Peru.

[d] "World" initial stocks plus Northern Hemisphere production.

TABLE III.—SHIPMENTS OF WHEAT AND FLOUR TO EUROPE, FROM 1922*

Crop year	Million bushels			Percentage of August-July	
	Aug.–Nov.	Dec.–Feb.	Aug.–July	Aug.–Nov.	Dec.–Feb.
1922-23	197.60	149.92	584.4	33.81	25.65
1923-24	189.34	152.21	633.9	29.87	24.01
1924-25	232.60	166.40	630.2	36.91	26.40
1925-26	170.81	136.11	530.2	32.22	25.67
1926-27	200.63	190.51	683.5	29.35	27.87
1927-28	228.61	167.32	664.9	34.38	25.16
1928-29	243.22	181.10	693.9	35.05	26.10
1929-30	175.67	108.24	483.5	36.33	22.39
1930-31	233.39	125.27	609.6	38.29	20.55
1931-32	216.03	126.67	583.6	37.02	21.70
1932-33	150.36	125.46	450.5	33.38	27.85
1933-34	143.51	97.10	402.9	35.62	24.10
1934-35	141.17	85.68	375.6	37.59	22.81
1935-36	124.85	93.65	359.3	34.75	26.06
1936-37	147.13	134.38	477.9	30.79	28.12
1937-38	132.13	109.31	410.2	32.21	26.65
1938-39	163.65	99.72	453.5	36.09	21.99

* Compiled from Broomhall's weekly statistics of shipments, adjusted to calendar months, as in WHEAT STUDIES, March 1939, XV, 330.

TABLE IV.—COEFFICIENTS OF CORRELATION BETWEEN WEEKLY CHANGES IN PRICES OF DECEMBER AND MARCH FUTURES, AND RELATED DATA*

Month	Coefficient			Number of weekly changes		
	Class A	Class B	Class C	Class A	Class B	Class C
Aug. ..	+.993	+.959	+.997	6	17	29
Sept...	+.981	+.981	+.985	15	31	33
Oct....	+.931	+.977	+.990	36	45	28
Nov. ..	+.879	+.969	+.971	42	31	42
Dec....	+.935	+.845	+.970	43	16	39

Month	95 per cent confidence limits, lower and upper[a]					
	Class A		Class B		Class C	
Aug. ..	+.935	+.999	+.887	+.985	+.934	+.999
Sept...	+.942	+.994	+.961	+.991	+.970	+.993
Oct....	+.868	+.965	+.958	+.987	+.978	+.995
Nov. ..	+.785	+.934	+.936	+.985	+.946	+.984
Dec....	+.883	+.965	+.601	+.945	+.943	+.984

* Classification of prices and spreads as in Table V.

[a] Correlation coefficients corresponding to $z \pm 2\sigma_z$, z being the transformed correlation coefficient (see R. A. Fisher, *Statistical Methods for Research Workers*, 7th ed., London, 1938, p. 203).

TABLE V.—STANDARD DEVIATIONS OF WEEKLY CHANGES IN PRICES OF DECEMBER AND MARCH FUTURES AND OF DECEMBER–MARCH SPREAD AT LIVERPOOL, BY MONTHS AND SPREAD CLASSES*

(Pence per cental)

Month	December future price				March future price				December–March spread			
	Class A	Class B	Class C	All classes	Class A	Class B	Class C	All classes	Class A	Class B	Class C	All classes
Aug.....	3.217	1.869	2.999	2.725	2.932	1.676	2.982	2.628	0.370	0.548	0.237	0.396
Sept. ...	2.351	1.866	2.239	2.165	2.037	1.803	2.259	2.066	0.544	0.361	0.318	0.422
Oct.	2.416	2.800	2.330	2.673	1.720	2.787	2.172	2.381	1.052	0.605	0.356	0.783
Nov.....	2.316	1.358	2.655	2.318	2.256	1.228	2.744	2.260	1.098	0.373	0.543	0.831
Dec.	2.804	0.573	2.098	2.357	2.413	0.571	2.062	2.129	1.039	0.298	0.478	0.771

* Weeks were classified according to the following criteria: A: Weeks of large negative spread; March wheat at least 1*d.* under December. B: Weeks of small spread; March wheat less than 1*d.* under or over December. C: Weeks of large positive spread; March wheat at least 1*d.* over December. Data for 1903–13 and 1921–36.

TABLE VI.—AVERAGES, BY WEEKS, OF DECEMBER FUTURE PRICE AND DECEMBER–MARCH SPREAD AT LIVERPOOL, BY GROUPS OF YEARS*

Average date[a]	Price (*shillings and pence per cental*)					Spread (*pence per cental*)			
	Group I	Group II	Group III	Group IV	All years	Group I	Group II	Group III	Group IV
July 6.....	7 8.6	8 7.2	7 5.1	6 3.4	7 7.7	+0.70	−1.30	....	+2.00
13.....	7 10.2	8 5.5	7 3.9	6 4.1	7 7.4	+0.60	−1.00	....	+2.03
20.....	8 0.4	8 7.0	7 3.6	6 8.0	7 8.9	−1.25	−0.70	....	+1.80
27.....	8 0.5	8 6.9	7 3.4	6 7.8	7 8.8	−1.40	−0.60	+1.80	+2.22
Aug. 3.....	8 1.9	8 6.9	7 2.8	6 8.7	7 9.1	−1.55	−0.60	+1.10	+2.32
10.....	8 4.2	8 7.0	7 2.1	6 6.9	7 9.1	−1.95	−0.45	+1.15	+2.32
17.....	8 2.9	8 6.6	7 1.6	6 4.6	7 9.1	−1.85	−0.25	+1.30	+2.40
24.....	8 3.2	8 6.9	7 1.6	6 4.7	7 9.3	−2.10	−0.32	+1.00	+2.60
31.....	8 2.9	8 5.6	7 2.2	6 4.1	7 7.9	−1.93	+0.20	+1.00	+2.82
Sept. 7.....	8 2.7	8 5.9	7 2.3	6 4.1	7 9.0	−1.76	+0.37	+1.06	+3.05
14.....	8 4.2	8 5.1	7 1.0	6 3.3	7 7.5	−1.66	+0.42	+1.08	+3.10
21.....	8 6.7	8 5.9	7 1.6	6 0.6	7 8.0	−2.18	+0.01	+0.80	+3.47
28.....	8 7.2	8 6.5	7 1.3	6 0.9	7 8.3	−2.54	−0.23	+0.96	+3.78
Oct. 5.....	8 7.0	8 8.0	7 1.4	5 11.5	7 8.5	−2.78	−0.19	+0.54	+3.78
12.....	8 7.3	8 9.5	7 2.2	6 0.3	7 9.4	−2.60	−0.71	−0.01	+3.72
19.....	8 9.1	8 9.2	7 1.5	5 11.8	7 9.4	−3.38	−0.60	−0.04	+3.95
26.....	8 10.8	8 7.9	7 1.3	5 10.6	7 9.1	−4.44	−0.46	0.00	+4.18
Nov. 2.....	8 10.8	8 7.4	7 1.3	6 0.0	7 9.2	−4.60	−0.34	+0.06	+4.18
9.....	8 10.1	8 7.7	7 0.0	6 3.3	7 9.3	−4.76	−0.60	+0.13	+4.50
16.....	8 10.7	8 8.9	6 11.2	5 9.7	7 8.6	−4.70	−0.34	+0.49	+4.75
23.....	8 11.2	8 9.1	6 10.4	5 10.3	7 8.6	−4.18	−0.44	+0.76	+4.82
30.....	9 1.3	8 8.6	6 10.2	5 9.2	7 8.6	−4.44	−0.37	+1.20	+5.15
Dec. 7.....	9 4.5	8 8.3	6 9.0	5 10.9	7 9.2	−5.20	−0.59	+1.24	+4.92
14.....	9 6.5	8 9.1	6 6.1	5 9.6	7 11.0	−5.74	−0.74	−0.15	+4.38
21.....	9 6.4	8 10.0	6 4.3	5 8.2	7 10.6	−5.90	−0.66	+0.12	+4.28
28.....	8 10.4	8 4.9	6 3.5	6 4.3	7 7.3	−6.70	−1.14	−0.05	+4.13

* Years grouped according to spread in September; see above, p. 127.

[a] The average date was selected as the date around which the weeks centered. For example, all weeks ending between October 2 and October 8 were dated as of October 5.

TABLE VII.—COEFFICIENTS OF CORRELATION AND REGRESSION BETWEEN WEEKLY CHANGES IN PRICES AND IN THE DECEMBER–MARCH SPREAD*

Month	Class A	Class B	Class C	All classes	Class A	Class B	Class C	All classes
	CORRELATION OF SPREAD AND DECEMBER FUTURE (r_{SD})				CORRELATION OF SPREAD AND MARCH FUTURE (r_{SM})			
Aug.	−.794 ±.304	−.481 ±.226	−.111 ±.191	−.313 ±.134	−.575 ±.409	−.218 ±.252	−.070 ±.192	−.177 ±.139
Sept.	−.654 ±.210	−.267 ±.179	−.007 ±.180	−.327 ±.108	−.550 ±.232	−.081 ±.185	+.103 ±.179	−.132 ±.113
Oct.	−.784 ±.107	−.129 ±.151	−.507 ±.169	−.498 ±.084	−.565 ±.142	+.107 ±.152	−.388 ±.181	−.211 ±.094
Nov.	−.291 ±.151	−.471 ±.164	+.064 ±.158	−.249 ±.091	+.133 ±.157	−.270 ±.179	+.190 ±.155	+.111 ±.093
Dec.	−.535 ±.132	−.266 ±.259	−.190 ±.161	−.445 ±.091	−.146 ±.155	+.245 ±.259	+.089 ±.164	−.136 ±.101
	REGRESSION OF DECEMBER FUTURE ON SPREAD (b_{DS})				REGRESSION OF SPREAD ON DECEMRER FUTURE (b_{SD})			
Aug.	−6.90 ±2.64	−1.64 ±.77	−1.41 ±2.42	−2.16 ±.93	−.091 ±.035	−.141 ±.066	−.009 ±.015	−.046 ±.020
Sept.	−2.82 ± .91	−1.38 ±.92	− .05 ±1.26	−1.68 ±.55	−.151 ±.049	−.052 ±.035	−.001 ±.026	−.064 ±.021
Oct.	−1.80 ± .24	− .60 ±.70	−3.32 ±1.11	−1.70 ±.29	−.341 ±.046	−.028 ±.033	−.077 ±.026	−.146 ±.024
Nov.	− .61 ± .32	−1.71 ±.60	+ .31 ± .77	− .70 ±.25	−.138 ±.072	−.129 ±.045	+.013 ±.032	−.090 ±.033
Dec.	−1.44 ± .35	− .51 ±.49	− .83 ± .71	−1.36 ±.28	−.198 ±.049	−.139 ±.134	−.043 ±.037	−.146 ±.030

* Classification of prices and spread as noted in Table V. Two other sets of regression coefficients are readily obtainable from those here tabulated, since $b_{MS} = b_{DS} + 1$, and $b_{MD} = b_{SD} + 1$.

TABLE VIII.—PRICES OF LIVERPOOL WHEAT FUTURES, MONTHLY, SEPTEMBER 1938 TO AUGUST 1939*

(*Shillings and pence per cental*)

Month	Old contract[a]					New contract				
	Mar.	May	July	Oct.	Dec.	Mar.	May	July	Oct.	Dec.
Sept.	4 10.4	.....	.....	5 1.8	4 11.4	.....	.....	.....	.....	.....
Oct.	4 7.3	.....	.....	4 10.8	4 8.0	.....	.....	.....	.....	.....
Nov.	4 5.4	4 5.9	.....	.....	4 5.0	.....	.....	.....	.....	.....
Dec.	4 7.0	4 7.7	.....	.....	4 8.6	4 4.1	4 5.0	.....	.....	.....
Jan.	4 8.6	4 8.7	.....	.....	.....	4 5.5	4 6.2	4 7.3	.....	.....
Feb.	4 6.7	4 7.7	.....	.....	.....	4 3.8	4 5.3	4 6.8	.....	.....
Mar.	4 3.8	4 5.0	.....	.....	.....	4 1.9	4 3.2	4 4.8	.....	.....
Apr.	.....	4 4.7	.....	.....	.....	.....	4 2.4	4 4.2	4 6.1	.....
May	.....	4 6.9	.....	.....	.....	.....	4 3.3	4 5.1	4 7.2	.....
June	.....	.....	.....	.....	.....	.....	.....	4 .3	4 3.6	4 5.3
July	.....	.....	.....	.....	.....	.....	.....	3 7.9	3 11.1	4 1.2
Aug.	.....	.....	.....	.....	.....	4 1.1	.....	.....	3 9.4	3 11.3

* Averages of daily prices from *London Grain, Seed and Oil Reporter*. For similar data, May 1886 to August 1938, see WHEAT STUDIES, November 1938, XV, 153–56.

[a] Removal of the duty on non-Empire wheats, announced Nov. 17, 1938, to take effect Jan. 1, 1939, had the effect of permitting buyers taking delivery on old March and May contracts to deduct 5*d*. per cental from the purchase price if non-Empire wheat was delivered. These two futures became in a sense contracts for delivery of Australian wheat, while on new contracts delivery of Argentine wheat was expected.

Week ending	Prices, old contract[a]					Spreads, old contract[a]					Week ending	Prices, new contract					Spreads, new contract				
	Mar.	May	July	Oct.	Dec.	Mar.–May	May–July	July–Oct.	Oct.–Dec.	Dec.–Mar.		Mar.	May	July	Oct.	Dec.	Mar.–May	May–July	July–Oct.	Oct.–Dec.	Dec.–Mar.
Sept. 3	4 9.5	.....	.....	5 1.6	4 11.4	.....	.....	.....	—2.2	—1.9	Sept. 3	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
10	4 8.3	.....	.....	4 9.6	4 8.3	.....	.....	.....	—1.3	.0	10	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
17	4 10.9	.....	.....	5 1.4	4 11.4	.....	.....	.....	—2.0	— .5	17	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
24	4 11.2	.....	.....	5 3.5	5 .5	.....	.....	.....	—3.0	—1.3	24	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Oct. 1	4 11.6	.....	.....	5 4.9	5 1.6	.....	.....	.....	—3.3	—2.0	Oct. 1	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
8	4 7.8	.....	.....	5 .4	4 8.9	.....	.....	.....	—3.5	—1.1	8	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
15	4 7.7	.....	.....	5 1.4	4 8.9	.....	.....	.....	—4.5	—1.2	15	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
22	4 7.6	4 7.8	.....	4 11.2	4 8.3	+ .2	.....	.....	—2.9	— .7	22	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
29	4 6.4	4 6.5	.....	4 6.5	4 6.3	+ .1	.....	.....	— .2	+ .1	29	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Nov. 5	4 4.7	4 4.8	.....	.....	4 4.1	+ .1	.....	.....	.....	+ .6	Nov. 5	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
12	4 4.7	4 5.0	.....	.....	4 4.1	+ .3	.....	.....	.....	+ .6	12	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
19	4 5.6	4 6.3	.....	.....	4 5.6	+ .7	.....	.....	.....	.0	19	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
26	4 6.1	4 6.6	.....	.....	4 5.8	+ .5	.....	.....	.....	+ .3	26	4 3.5	4 4.2	.....	.....	.....	+ .7	.....	.....	.....	.....
Dec. 3	4 6.5	4 7.3	.....	.....	4 6.4	+ .8	.....	.....	.....	+ .1	Dec. 3	4 3.4	4 4.2	.....	.....	.....	+ .8	.....	.....	.....	.....
10	4 7.7	4 8.2	.....	.....	4 8.6	+ .5	.....	.....	.....	— .9	10	4 4.3	4 5.1	.....	.....	.....	+ .8	.....	.....	.....	.....
17	4 6.7	4 7.1	.....	.....	4 8.4	+ .4	.....	.....	.....	—1.7	17	4 3.8	4 4.4	.....	.....	.....	+ .6	.....	.....	.....	.....
24	4 6.1	4 6.9	.....	.....	4 8.4	+ .8	.....	.....	.....	—2.3	24	4 3.8	4 4.8	.....	.....	.....	+1.0	.....	.....	.....	.....
31	4 8.4	4 9.2	.....	.....	4 11.0	+ .8	.....	.....	.....	—2.6	31	4 5.5	4 6.8	.....	.....	.....	+1.3	.....	.....	.....	.....
Jan. 7	4 8.9	4 8.9	.....	.....	.....	.0	.....	.....	.....	.....	Jan. 7	4 5.6	4 6.6	4 7.6	.....	.....	+1.0	+1.0	.....	.....	.....
14	4 8.0	4 7.9	.....	.....	.....	— .1	.....	.....	.....	.....	14	4 4.7	4 5.6	4 6.9	.....	.....	+ .9	+1.3	.....	.....	.....
21	4 8.2	4 8.2	.....	.....	.....	.0	.....	.....	.....	.....	21	4 5.3	4 6.0	4 6.9	.....	.....	+ .7	+ .9	.....	.....	.....
28	4 9.4	4 9.6	.....	.....	.....	+ .2	.....	.....	.....	.....	28	4 6.3	4 6.8	4 7.8	.....	.....	+ .5	+1.0	.....	.....	.....
Feb. 4	4 8.8	4 9.0	.....	.....	.....	+ .2	.....	.....	.....	.....	Feb. 4	4 5.2	4 6.0	4 7.2	.....	.....	+ .8	+1.2	.....	.....	.....
11	4 7.4	4 7.9	.....	.....	.....	+ .5	.....	.....	.....	.....	11	4 4.0	4 5.2	4 6.7	.....	.....	+1.2	+1.5	.....	.....	.....
18	4 6.8	4 7.8	.....	.....	.....	+1.0	.....	.....	.....	.....	18	4 3.8	4 5.4	4 6.9	.....	.....	+1.6	+1.5	.....	.....	.....
25	4 5.3	4 6.9	.....	.....	.....	+1.6	.....	.....	.....	.....	25	4 3.4	4 5.0	4 6.7	.....	.....	+1.6	+1.7	.....	.....	.....
Mar. 4	4 4.5	4 6.2	.....	.....	.....	+1.7	.....	.....	.....	.....	Mar. 4	4 2.8	4 4.6	4 5.9	.....	.....	+1.8	+1.3	.....	.....	.....
11	4 3.7	4 5.1	.....	.....	.....	+1.4	.....	.....	.....	.....	11	4 1.8	4 3.1	4 4.7	.....	.....	+1.3	+1.6	.....	.....	.....
18	4 3.6	4 4.9	.....	.....	.....	+1.3	.....	.....	.....	.....	18	4 1.6	4 2.9	4 4.6	.....	.....	+1.3	+1.7	.....	.....	.....
25	4 3.6	4 4.8	.....	.....	.....	+1.2	.....	.....	.....	.....	25	4 1.7	4 2.9	4 4.6	.....	.....	+1.2	+1.7	.....	.....	.....
Apr. 1	.....	4 4.6	.....	.....	.....	.....	.....	.....	.....	.....	Apr. 1	.....	4 2.9	4 4.6	.....	.....	.....	+1.7	.....	.....	.....
8	.....	4 3.9	.....	.....	.....	.....	.....	.....	.....	.....	8	.....	4 2.0	4 3.4	4 5.3	.....	.....	+1.4	+1.9	.....	.....
15	.....	4 4.3	.....	.....	.....	.....	.....	.....	.....	.....	15	.....	4 2.1	4 4.1	4 5.8	.....	.....	+2.0	+1.7	.....	.....
22	.....	4 5.4	.....	.....	.....	.....	.....	.....	.....	.....	22	.....	4 2.8	4 4.6	4 6.6	.....	.....	+1.8	+2.0	.....	.....
29	.....	4 4.8	.....	.....	.....	.....	.....	.....	.....	.....	29	.....	4 2.2	4 4.3	4 6.4	.....	.....	+2.1	+2.1	.....	.....
May 6	.....	4 6.5	.....	.....	.....	.....	.....	.....	.....	.....	May 6	.....	4 3.8	4 5.9	4 7.7	.....	.....	+2.1	+1.8	.....	.....
13	.....	4 7.0	.....	.....	.....	.....	.....	.....	.....	.....	13	.....	4 3.4	4 5.5	4 7.4	.....	.....	+2.1	+1.9	.....	.....
20	.....	4 7.2	.....	.....	.....	.....	.....	.....	.....	.....	20	.....	4 3.3	4 5.0	4 7.0	.....	.....	+1.7	+2.0	.....	.....
27	.....	4 6.9	.....	.....	.....	.....	.....	.....	.....	.....	27	.....	4 3.0	4 4.4	4 6.8	4 7.9	.....	+1.4	+2.4	+1.1	.....
June 3	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	June 3	.....	.....	4 3.8	4 6.8	4 7.9	.....	.....	+3.0	+1.1	.....
10	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	10	.....	.....	4 1.5	4 4.6	4 6.3	.....	.....	+3.1	+1.7	.....
17	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	17	.....	.....	4 .2	4 3.4	4 5.2	.....	.....	+3.2	+1.8	.....
24	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	24	.....	.....	3 10.9	4 2.4	4 4.2	.....	.....	+3.5	+1.8	.....
July 1	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	July 1	.....	.....	3 10.8	4 2.4	4 4.3	.....	.....	+3.6	+1.9	.....
8	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	8	.....	.....	3 10.1	4 1.8	4 3.8	.....	.....	+3.7	+2.0	.....
15	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	15	.....	.....	3 8.6	3 11.8	4 1.9	.....	.....	+3.2	+2.1	.....
22	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	22	.....	.....	3 6.4	3 9.4	3 11.6	.....	.....	+3.0	+2.2	.....
29	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	29	4 1.4	.....	3 6.0	3 8.8	3 11.1	.....	.....	+2.8	+2.3	+2.3
Aug. 5	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	Aug. 5	4 2.2	.....	.....	3 10.2	4 .2	.....	.....	.....	+2.0	+2.0
12	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	12	4 1.2	.....	.....	3 8.5	3 10.8	.....	.....	.....	+2.3	+2.4
19	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	19	3 11.9	.....	.....	3 7.5	3 9.7	.....	.....	.....	+2.2	+2.2
26	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	26	4 1.4	.....	.....	3 10.6	4 .1	.....	.....	.....	+1.5	+1.3

* Weekly averages in shillings and pence per cental, from *London Grain, Seed and Oil Reporter*. For similar data, May 1886 to August 1938, see WHEAT STUDIES, November 1938, XV, 157–80 (for September 1938, some of the previously published averages were incorrect).

[a] See Table VIII, footnote *a*.

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