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THE SUPPLY OF SPECULATIVE SERVICES IN WHEAT, CORN, AND SOYBEANS†

I. INTRODUCTION

Despite much empirical investigation, students of organized futures markets are still far from agreement on which of several rival theories of speculation and hedging more adequately explains the "facts" of futures trading. C. O. Hardy and J. M. Keynes were the first to state clearly the relevant issues. Their theories view the hedgers, who deal in the physical commodity, as the purchasers of price insurance from the speculators. The hedgers, who own inventories, bear the risk of a price decline that they transfer to the speculators by the sale of futures contracts not greater in quantity than the physical amount of their inventories. If speculators are averse to bearing risk, then they must be induced to purchase the futures contracts from the hedgers by the expectation of a positive return. Therefore, since the speculators are net long, it is necessary for the futures prices to rise to maturity on average if the speculators are to receive a positive compensation for their risk bearing.[1]

Hardy pointed out that although hedgers may be willing to pay for the transfer of risk to the speculators, it may be unnecessary for them to do so if speculators are sufficiently eager to assume risk. H. Working's empirical findings showed speculators' trading to have resulted in net losses rather than gains on average. Keynes apparently believed that speculators succeeded in obtaining a positive return.[2]

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[1] The first correct economic analysis of hedging is by C. O. Hardy (*7*). Keynes' earliest analysis of related problems referred to forward exchange markets. Subsequently, Keynes introduced the concept of normal backwardation and argued that the futures price is normally below the expected spot price, which he identified with the current spot price, by an amount necessary to remunerate the long speculators for their risk bearing. (See *15*, Chapters 28 and 29.)

[2] Hardy's view on this matter deserves to be quoted in full (*7*, p. 225):

> The theory generally accepted among economists is that speculators who buy and sell hedges to grain dealers, millers, and other tradesmen are experts in the art of discounting the future, and that hedgers as a class, therefore, pay something to speculators as a class. No statistics bearing on this question are available, but it does not seem probable that, as a matter of fact, speculators as a class receive any compensation for their services. The pro-

It is implicit in Hardy's writing that speculation is a complicated phenomenon. It is first necessary to distinguish between amateur and professional speculators. The former value the opportunity of assuming risk and are willing, if necessary, to pay for risk bearing for the same reasons as motivate gamblers to play unfair games in return for their pleasure from gambling. To these amateurs speculation represents a "good" for which they are willing to pay and not a "bad" for which they must be paid to undertake. The losses on speculation, if any, are made up by other sources of income. Amateurs who cannot sustain the losses and who leave the market are replaced by others; a rapid turnover of amateurs is compatible with the maintenance of a large stock of them. Thus to the amateurs speculation in commodities is comparable to the purchase of a lottery ticket which has a small probability of a large gain. The cost of the speculation is the return foregone on the margin and the brokerage fees. There is also the chance of losing some of the margin which the speculator controls by placing a stop-loss order with his broker.[3]

In the Keynesian theory there is postulated a class of professional speculators who make their living by maintaining long positions in futures contracts. They receive a positive return for so doing because they assume the risk of price declines from the hedgers. One of the moot empirical points in the study of futures trading is whether there exists such a class of professional speculators. Such a group would have to receive most of their income from their speculative activities. Even if such a class exists, the presence of amateurs or part-time speculators complicates the analysis of futures trading in two ways. First, the hedgers can profit from their futures transactions by selling the speculators the opportunity of bearing risk. Second, the professional speculators can obtain a positive profit by skillful trading with the amateurs. It no longer follows that professional speculators must earn their living from the maintenance of a long position in futures.[4]

Second, there are forces affecting speculation in commodity futures that originate outside the market in the particular commodity. This speculation is motivated by changes in the general price level. Thus to protect the real value of his assets a risk averter can purchase or sell futures. During periods of generally rising prices, the gain on the futures offsets the losses on nominal assets while during periods of falling prices the reverse occurs. Such net positions in commodity futures, though classified as speculative, are more accurately described as hedges against changes in the price level because they tend to reduce and not to increase the risk of those who engage in them. In addition, the desire to spec-

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fessional large-scale operators, who do succeed in staying in business year after year, and presumably are making satisfactory profits, are the survivors of a large number whose financial strength is exhausted, or whose taste for speculation is satisfied before they attain the dignity of professionals.

According to Working, "speculators in wheat futures as a group have in the past carried the risks of price changes on hedged wheat and have received no reward for the service, but paid heavily for the privilege" (*25*, p. 534). See also *28*. Keynes' estimate of a 10 per cent normal backwardation is stated in *15*, p. 143. Blair Stewart analyzed the actual outcome of speculation using records obtained from a brokerage firm. He found that speculators lost heavily in the aggregate in his sample (*19*).

[3] Related issues are discussed by Milton Friedman (*4*). The text elaborates my *21*.

[4] Some estimates of speculators' profits are given by H. S. Houthakker (*10*). The relevant evidence for my purpose is that the large speculators seem to do better than the others. In Houthakker's study the large speculators are those whose commitments in excess of a certain quantity subject them to reporting their position to the Commodity Exchange Authority.

ulate on the general price level inspires some futures transactions. If futures prices are not perfectly correlated with the general price level, then there is a possibility of speculative profits from buying or selling a combination of futures contracts in different commodities. These speculative transactions together with the futures trading that results from a desire to protect the real value of investors' portfolios inject forces into commodity futures markets that disturb the simple relations which might otherwise exist between the hedgers and the speculators of the given commodity[5]

A reexamination of the traditional view of hedging is also necessary. Short hedging is the purchase of the spot commodity accompanied by the sale of an equal quantity of futures. It is normally undertaken by the owners of inventories of which there are two kinds. The first is a manufacturer who holds a stock of the raw material in order to reduce costs. For example, there are two sources of such cost savings made possible by the holding of inventories. First, it is possible to engage in fewer transactions and thereby reduce transactions costs. Second, the inventory holding makes possible a steadier output rate and that is generally less expensive than a policy that requires a more fluctuating output rate. The firm lifts its hedge by buying back its futures contract at the prevailing futures price when it sells the processed goods. Notice that such a firm may hedge a stock of the processed commodity by the sale of futures contracts of the raw material. The expense of the hedging, if any, is included in the price of the finished good. This kind of hedging is implicit in the theories of Keynes and Hicks. (See, for example, *9*, Chapter X; *15*.)

Besides the manufacturers who are short hedgers, there are inventory firms who specialize in the storage of the physical commodity without engaging in any production. Such firms lift their short hedges at the same time that they sell, at the prevailing spot price, the physical goods which they have held in inventory. The customers of these specialized inventory firms are usually the processors of the raw material. To an inventory firm the return on its hedged stock is the change in the spot price less the change in the futures price and the storage costs.

Not all of the stocks held by both kinds of firms, the processors and the firms who specialize in inventory holding, are hedged nor is short hedging done automatically. Even if it is true that short hedging is motivated by the desire to protect oneself against the risk of price declines so that short hedging is analogous to the purchase of price insurance, it does not follow that all inventories will be hedged. The amount of short hedging varies inversely with its expected cost just as, in general, the amount of insurance that a firm will buy varies inversely with the size of the insurance premium relative to the actuarial value of the loss.

[5] The relation between movements of futures prices and the general price level is shown by the fact that futures prices tend to rise when prices are generally rising and to fall when prices are generally falling. This phenomenon indicates that changes in the general price level are not fully anticipated. To see why, consider the following example. Suppose the price level rises at the rate of 2 per cent per year. Then the September futures price in successive years should reflect this so that the average price of each contract is 2 per cent above the preceding one. Actually, prices of a *given* contract tend to rise under these conditions which implies that the market does not fully anticipate actual changes. In this respect futures prices resemble expectations that tend to understate changes. For additional information, see H. Theil (*23*, Chapters 4 and 5). For evidence on the relation between futures prices and the general price level see *20*, pp. 243–46.

However, unlike ordinary insurance, the "premium" of short hedging is a random variable. This is because the premium is the change in the spot price less the change in the futures price and neither of these can be known for sure at the time the hedge is initiated. The return on holding unhedged stocks is also a random variable which may be more variable than the return on hedged stocks. Nevertheless if the expected return on unhedged stocks is high enough relative to the expected return on hedged stocks, the firm will increase its holding of unhedged stocks relative to hedged stocks.[6]

Both kinds of hedging firms find it advantageous to hold inventories. The processing firm holds stocks to facilitate its production, and the inventory firm holds stocks to satisfy the varied demands of its customers for particular grades. Even in the absence of price uncertainty, it would be *convenient* for inventory firms to hold stocks because they cannot be certain of the exact demands by their customers for particular quantities and qualities of the good. The fact that the quantity demanded at a given price cannot be exactly predicted is important both in explaining why stocks are held and why stocks are hedged by the sale of futures instead of forward contracts, as we shall see below.

Periodic production, characteristic of agricultural goods, is neither necessary nor sufficient to explain stockholding. There are large inventories of many non-agricultural goods and some of these are also traded on organized futures exchanges.[7] There is, however, a more important question of whether the predominance of short over long hedging, typical of markets for which we have data, depends on periodic production. To answer this question, let us consider another kind of hedge—the long hedge.

Typical long hedgers are firms who have committed themselves to deliver a given quantity of the finished product on a later date at a price presently agreed upon, a transaction called a *forward* sale, and who do not now have the raw material necessary to fulfill their forward contract in the finished good. The forward contract is a commitment comparable in its terms and detail with a spot contract except that the goods are to be delivered later.[8] To avoid the risk of a price rise of the raw material between the time of making the forward contract in the finished good and the time of actually buying the raw material, the firm can buy futures contracts equal in quantity to what is needed to satisfy the forward commitment. Since presumably there is always the alternative of immediately buying the raw material, the long hedger must prefer the purchase of the futures instead. This preference is understandable if the spot price happens to be high because supplies are scarce. This explains why there tends to be more long hedging toward the end of the crop year when there is a peak of the seasonal spot price, a trough in raw material supplies, and none of the new crop yet available for consumption.

A futures contract differs from a forward contract because, unlike the latter, a buyer of futures cannot be certain of the actual quality, location, or even the exact

[6] See the important article by H. Working (*26*, and my *22*).

[7] Examples are copper, silver, and tin.

[8] The distinction between a forward and a futures contract is crucial for the understanding of futures trading. A forward contract is one arranged between two parties who specify the terms in considerable detail. A futures contract leaves many of these details subject to a wider range of choice often at the seller's discretion. For a thorough analysis, see *11*.

date at which he would receive the physical goods if he held the futures contract until maturity. Moreover, what might be delivered on a futures contract may be unsuitable for meeting the terms of the forward sale of the processed good. The potential long hedger would have to sell the goods delivered on the futures contract and purchase the exact physical stocks he needed for the forward commitment. Since the price of the required raw material may change relative to the price of the good delivered on the futures contract, the long hedger increases his risk by buying futures instead of immediately buying the raw material. This difference between long hedging, which is risk increasing, and short hedging, which is risk decreasing, is of crucial importance.

Some readers may object that short hedging is risk increasing in precisely the same way as long hedging because the short hedger has the alternative of selling *forward* contracts instead of *futures* contracts and that the latter is risk increasing compared to the former. This objection relies on the symmetry of the alternatives open to short and long hedgers, which can be represented as follows:

Short hedger (Positive inventory)	Long hedger (Negative inventory)
1. Sell spot	1. Buy spot
2. Sell futures	2. Buy futures
3. Sell forward	3. Buy forward

The long hedger can be said to hold a *negative* inventory because of his having a commitment to deliver either the raw or the processed goods to a specific buyer on a later date at a price determined in the present. In other words, a long hedger has a backlog of orders. The alternatives of short and long hedgers are symmetric in the sense that for every action open to a positive inventory holder there is a corresponding action open to a negative inventory holder. Hence there is *accounting* symmetry. But there is no *economic* symmetry between the corresponding alternatives.

Before analyzing the economic asymmetry which derives from the economic function of inventory holding, we consider one risk-avoiding alternative open to both. Given that a firm has a positive inventory, to sell spot means that it closes out its position and bears no further price risk. Similarly, given a negative inventory holding, to buy forward means that it closes out its forward sales commitment and correspondingly incurs no further price risk. Hence to a positive inventory holder a spot sale is economically equivalent to a forward sale by a negative inventory holder. There remain two alternatives for the positive inventory holder—sell futures or sell forward—to compare with the two alternatives for the negative inventory holder—a spot purchase or a purchase of futures contracts.

Assume that a firm has a positive inventory and consider the consequences of its "hedging" by the *forward* sale of this inventory. If, for the sake of the argument, we suppose its entire inventory to be sold forward then this means its total stock is committed to particular buyers. It would have no stocks to satisfy unforeseen (random) variations of demand. Even if the price is known for certain, a firm cannot know exactly the precise amounts of the various qualities that it will sell at the given price. An inventory firm provides part of its merchandising service by holding stocks to satisfy the exigencies of its customers' demands. If such a firm were to commit its total inventory by forward sale then it would have to satisfy its customers' unforeseen demands by its own spot purchases at the time of these demands. Because such unplanned purchases are more costly to the inventory firm, they yield it a lower return than the purchases that they have planned. Similarly, a processing firm does not fully commit its inventory in order to satisfy the unforeseen demands of its customers. One may say that stocks sold forward provide no convenience yield to the inventory firm while stocks that are hedged by a futures sale do have a convenience yield.

There is another way of putting the argument. A firm which commits its stocks by forward sale can satisfy unforeseen demands by delivering its committed stocks to the buyer of the moment and filling its forward commitment by a subsequent spot purchase. This pair of transactions implies that the firm which sells its stock *forward* incurs a forward basis risk due to unforeseen changes between the spot and the forward price. In addition the transactions costs involved in forward transactions generally exceed futures transactions costs. Hence a firm attempting to hedge its stocks by forward instead of futures sales incurs the same basis risk and larger transaction costs.

The unforeseen exigencies of demand require a firm to hold free stocks. By selling futures the firm does not impair the convenience yield of its stocks while it simultaneously reduces its price risk as compared to the alternative of holding unhedged stocks. Therefore, the pertinent risk-reducing alternative to the holding of unhedged stocks is the sale of futures and not forward contracts.

For a firm with a negative inventory the safest course is clearly an immediate acquisition of the raw material to offset its forward sale. Hence, compared with buying spot, a futures purchase is a risk-increasing way to hedge a negative inventory commitment.

Nevertheless the existence of long hedging raises the possibility of a futures market in equilibrium without any speculative transactions. I call an equilibrium involving only hedgers a pure hedging equilibrium. For a pure hedging equilibrium the sales of the short hedgers must equal the purchases of the long hedgers at a mutually acceptable futures price. Such an equilibrium enables a specialization of the storage and processing activities among different firms. In the next section we shall see that a necessary condition for a pure hedging equilibrium is that the futures price exceeds the spot price by the marginal cost of storage. However, a pure hedging equilibrium is unlikely in practice because an inherent characteristic of futures contracts encourages a predominance of short over long hedging for reasons that we now consider.

An organized futures exchange must operate above a given scale to be viable. To attract the necessary volume of trading the futures contract must appeal to many firms dealing in the physical commodity. This explains why the futures contract is standardized and provides for alternative grades, delivery locations, etc. In addition the broad appeal of the futures contract reduces the opportunity for manipulation by those who would attempt to engross the supplies of deliverable grades. At the same time the broad appeal of the futures contract helps explain why long hedging is risk increasing and short hedging risk reducing to negative and positive inventory holders, respectively. Futures contracts provide for a number of alternative grades and delivery points to be determined at the seller's discretion. Hence even by standing for delivery a long hedger cannot be certain of receiving the precise good required for his forward commitment. In contrast, the short hedger with a deliverable grade can satisfy his futures contract by delivery. Thus by delivery a short hedger can avoid a basis risk while a long hedger cannot.

Given that the unpredictability of demand makes stockholding necessary and prevents hedging by the sale of forward contract, the desire to secure a convenience yield from stocks together with the desire to reduce the price risk of stock holding explains the predominance of short over long hedging in organized futures markets. Periodic production of the commodity is neither necessary nor sufficient for this phenomenon.

The issues raised in this brief summary of hedging and speculation require an empirical analysis. To see whether long speculation yields a positive return, we should examine the seasonal pattern of futures prices. To determine whether an increase of short hedging depresses futures prices, we should relate the seasonal pattern of hedging commitments to the seasonal of futures prices. Finally, to study whether short hedging is risk reducing and long hedging risk increasing, we have to examine the relation between stocks, short and long hedging commitments, and the ratio of the spot to the futures price. The latter relation is complicated by the effects of the government price support program.

I examine evidence for three agricultural commodities, wheat, corn, and soybeans which are actively traded on the Chicago Board of Trade, the major organized futures exchange. My sample includes data for the years 1952 to 1962 or 1964 depending on the particular relation under study.

A summary of the empirical findings appears at the end of this article.

II. THE SEASONAL PATTERN OF SPOT AND FUTURES PRICES

Let

p_t = spot price at time t
$f_{i,t}$ = price of a futures contract maturing at time i as quoted at time t, $t \leqq i$.

A specialized inventory firm buys a unit of the commodity at time t and pays the spot price p_t. It simultaneously sells one unit of futures at a price $f_{i,t}$. Hence at the time of acquiring the stock, its liability in money terms is

$$f_{i,t} - p_t,$$

an expression known as the *basis*. The firm stores the goods for n periods. At time $t+n$ it sells the commodity at a price p_{t+n} and buys back its futures contract at a price $f_{i,t+n}$ thus lifting its hedge. Denote the marginal storage cost per unit, including interest charges, of holding a stock for n periods by c_n. The firm's net return from holding one unit of hedged stocks for n periods is

$$(1) \qquad (f_{i,t} - p_t) - (f_{i,t+n} - p_{t+n}) - c_n .$$

This expression is the change in the basis less marginal storage cost from t to $t+n$. It is also the change in the spot price less the change in the futures price minus the marginal storage cost; that is, rearranging (1) we obtain

$$(2) \qquad (p_{t+n}-p_t) - (f_{i,t+n}-f_{i,t}) - c_n .$$

For there to be a positive net return on average from the holding of *hedged* stocks, it is necessary that the expression in (2) be positive on average. Therefore,

$$(3) \qquad (p_{t+n}-p_t) \geqq (f_{i,t+n}-f_{i,t}) + c_n .$$

This simple relation shows that if there is an upward seasonal of the futures price, then there must be a *larger* seasonal increase of the spot price for there to be a positive net return on average from the holding of hedged stock. However, if there is a downward or no seasonal of the futures price on average and a positive return to the holding of hedged stocks, then there is a smaller upward seasonal of the spot price. Hence a study of the seasonal movement of the spot and futures prices shows whether a specialized inventory firm can obtain a positive return on hedged stocks.

To calculate the return to a processing firm of holding short hedged stocks of the raw material used in its manufacturing, we must introduce the spot price of the finished product. Accordingly, let

m_t = the spot price at time t of that quantity of the manufactured good that can be made from one unit of the raw material.

The net return to a processing firm of holding one unit of short hedged raw materials for n periods is given by

$$(4) \qquad (m_{t+n}-f_{i,t+n}) - (p_t-f_{i,t}) - c_n .$$

In this case the cost of short hedging is included in the price of the manufactured good. If no firms specialize in inventory holding so that all stock holders of raw materials are also processors, then there would not necessarily be a seasonal rise in the spot price. In the absence of firms that specialize in inventory holding, expression (4) would be positive on average by a sufficiently large amount to include the cost of manufacture, storage and hedging while expression (2), which gives the return to specialized inventory firms for holding hedged stocks, would be negative, so that

$$(p_{t+n}-p_t) < (f_{i,t+n}-f_{i,t}) + c_n .$$

For the continued existence of firms that specialize in inventory holding and hold hedged stocks, relation (3) must be satisfied so that the return from holding short hedged stocks is positive on average.

The return on unhedged stocks to a specialized inventory firm is

$$(5) \qquad p_{t+n} - p_t - c_n' ,$$

where c_n' is the marginal storage cost of holding unhedged stocks for n periods. The latter, c_n', may exceed the marginal storage cost of holding an equal quantity of hedged stocks, c_n, if banks are willing to lend a given amount to finance the holding of the latter at a lower interest rate than they would require on unhedged stocks.[9] Thus under these conditions

$$c_n' > c_n .$$

If on average it is not more costly to hold hedged than unhedged stocks, this implies that on average the following inequality is satisfied:

$$f_{i,t+n} - f_{i,t} \leqq c_n' - c_n . \quad (6)$$

This inequality sets an upper limit to the size of a possible upward seasonal movement of the futures price.

To analyze long hedging we introduce the forward price of the manufactured good. Thus let

$m_{n,t}$ = the forward price at time t for delivery at time $t+n$ of that quantity of the manufactured good that can be made from one unit of the raw material.

The long hedger sells the processed good forward at time t for delivery at time $t+n$ and concurrently buys futures maturing at time $t+i$. Sometime before he has to honor his forward contract, he buys the raw material at the then prevailing spot price, p_{t+n}, and simultaneously lifts the long hedge by selling the appropriate quantity of the futures contract at a price of $f_{i,t+n}$. The return from the pair of transactions, neglecting manufacture expense, is

$$(m_{n,t} - f_{i,t}) - (p_{t+n} - f_{i,t+n}) .$$

The alternative to a long hedge is the immediate purchase of the raw material at the time of the forward sale of the finished good. This yields a return of

$$m_{n,t} - p_t - c_n .$$

A necessary condition for the regular occurrence of long hedging is that it be at least as remunerative as the immediate purchase of the raw material at the time of the forward sale of the finished good. This implies

$$(m_{n,t} - f_{i,t}) - (p_{t+n} - f_{i,t+n}) \geqq m_{n,t} - p_t - c_n ,$$

which simplifies to

$$f_{i,t+n} - f_{i,t} \geqq p_{t+n} - p_t - c_n . \quad (7)$$

Notice that the long hedger avoids the direct payment of storage costs by deferring acquisition of the raw material to a time that he expects will be more advantageous. Condition (7), necessary for the regular use of long hedging, and condition (3), necessary for the regular use of short hedging, can both be satisfied if

$$p_{t+n} - p_t = f_{i,t+n} - f_{i,t} + c_n . \quad (8)$$

This equation means that parallel movement of the spot and futures prices is necessary for a pure hedging equilibrium in the futures market.

[9] This point is made by Houthakker in *11*. See also *18*, p. 145.

We now examine some empirical evidence on the seasonal movement of futures prices. To the most casual inspection it is clear that futures prices vary irregularly from quotation to quotation. Moreover, the average price changes from year to year. A seasonal index of futures prices ought to account for changes of the annual average price and ought not be too much obscured by the irregular quote-to-quote price changes. To handle the first complication, one may divide each of the futures prices in a sequence over the life of a given contract by the average price of the sequence. This makes more nearly homogenous the sample of deflated prices by quote in different years. The effects of the irregular forces on the deflated futures prices are reduced by averaging the deflated prices by quote over the years in the sample.

With apologies for a slight albeit convenient change of notation, let

f_{ijt} = the price of futures contract i maturing in year t as quoted at quote j.
$i = 1, \ldots, I$ numbers the futures contracts
$t = 1, \ldots, T$ denotes the years and T equals the number of years in the sample
$j = 1, \ldots, J_i$, where J_i equals the number of quotations over the life of futures contract i used in the sample.[10]

Thus for the December wheat contract maturing in 1966, the closing price on August 31, 1966, is denoted by

$$f_{\text{December wheat, 1966, August 31, 1966}} \,.$$

I use the closing prices as reported by the Commodity Exchange Authority for the 15th and the last trading date of (virtually) every month that a futures contract was traded in all of the years in the sample. Prices on the 15th of the expiring month of the contract are never used, and, in some calculations as noted below, the last price quotation used in the analysis is on the 15th of the next to the last month of trading. This gives from 17 to 21 quotations at biweekly intervals for each futures contract. The average price over the life of a given contract i maturing in year t is

$$\bar{f}_{i.t} = (1/J_i) \sum_{j=1}^{J_i} f_{ijt} \,.^{11} \tag{9}$$

The deflated price, r_{ijt}, is defined by

$$r_{ijt} = f_{ijt}/\bar{f}_{i.t} \,. \tag{10}$$

The seasonal index for quote j is the average of the deflated quotes over the years in the sample as follows:

$$\bar{r}_{ij.} = (1/T) \sum_{t} r_{ijt} \,. \tag{11}$$

[10] I shall refer to a quote as that date in the life of a given futures contract for which its price appears in my sample. Prices are taken from annual issues of U.S. Dept. of Agr., Commodity Exchange Authority, *Commodity Futures Statistics,* which publishes some of the data collected by the Commodity Exchange Authority.

[11] I use the dot convention common in statistics whereby the replacement of a subscript by a dot means summation over that subscript, e.g.,

$$x_{i.} = \sum_j x_{ij} \,.$$

TABLE 1.—REGRESSIONS OF SEASONAL FUTURES PRICE INDEX, 1952–62, BY FUTURE, WHEAT, CORN, AND SOYBEANS

$$\bar{r}_{tj.} = \alpha_{0t} + \alpha_{1t}j, \quad j = 1, \ldots, J_t$$

Commodity and future	α_{0t}	t-ratio	$\alpha_{1t} \times 10^3$	t-ratio	Date of first quote[a]	Number of quotes $= J_t$, sample size	R	$S.E.$ of estimate $\times 10^2$
WHEAT								
July	1.015	181.8	-1.237	-3.049	31 Aug.	20	.584	1.046
September	1.032	206.2	-2.379	-6.876	30 Nov.	18	.864	.762
December	1.013	177.3	-1.063	-2.560	31 Jan.	20	.517	1.071
March	.977	249.3	1.688	6.229	31 May	18	.841	.597
May	.985	318.0	1.100	5.343	15 July	19	.792	.492
CORN								
September	1.021	262.9	-1.473	-5.704	15 Nov.	19	.810	.616
December	1.041	253.6	-2.929	-10.73	15 Feb.	19	.933	.652
March	1.053	325.7	-3.930	-17.58	31 May	18	.975	.492
May	1.043	250.3	-3.160	-10.97	31 July	18	.939	.634
July	1.023	209.3	-1.738	-5.141	30 Sept.	18	.789	.744
SOYBEANS								
September	.983	218.6	1.273	4.096	30 Nov.	18	.715	.684
November	.991	281.2	.655	2.686	31 Jan.	18	.557	.536
January	.979	168.1	1.504	3.829	15 April	17	.703	.793
March	.970	209.2	2.200	6.860	31 May	18	.864	.706
May	.948	132.5	3.820	7.719	31 July	18	.888	1.089
July	.949	111.7	3.749	6.380	30 Sept.	18	.847	1.293

[a] The quote number, $j = 1, \ldots, J_t$, are at biweekly intervals beginning with the indicated date. The last quote used in these regressions is on the 15th of the month before the future matures. Regressions using the quotation on the last trading day of the month were also calculated and in some cases give noticeably different coefficients. The explanation is in the well-known phenomenon of greater variability of futures prices during the expiring month.

The seasonal indexes of the futures prices for the 6 soybean, and 5 corn and wheat contracts, respectively, averaged over the 11 contracts per future maturing in the years 1952 to 1963 are shown in Charts 1–4. All of the soybean futures display an upward seasonal while all of the corn futures display a downward seasonal. Two of the wheat futures, March and May, display an upward seasonal while the other three contracts, July, September, and December display a downward seasonal. Charts 1–4 also show a straight line graph fitted by least squares to the price relatives of the following form:

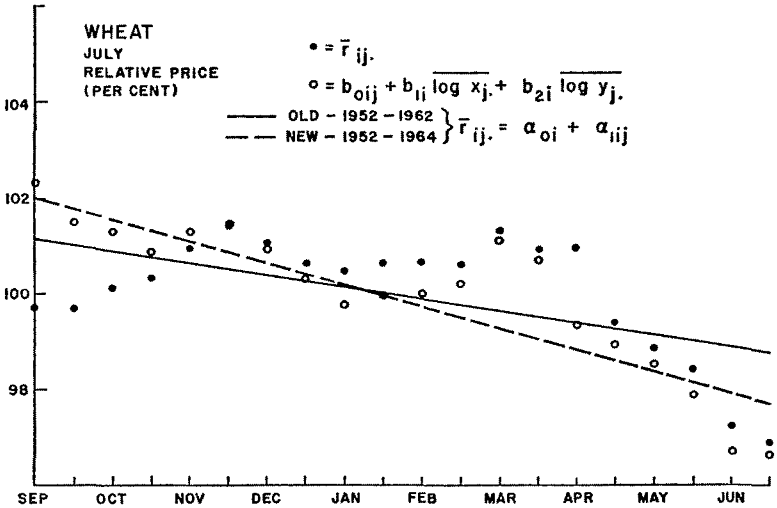
$$\bar{r}_{tj.} = \alpha_{0t} + \alpha_{1t}j + \text{residual}, \; j = 1, \ldots, J_t. \tag{12}$$

The fit is tolerably good as is evident to the eye; the regressions themselves are given in Table 1.[12]

What do these results mean? First, the sample period has been chosen to minimize the effects of changes in the general price level, since 1952 to 1962 was

[12] The results in Table 1 add new evidence to my earlier work on seasonals in futures given in *21*. This new evidence supports my hypothesis that futures prices are the market expectation of the subsequent spot price. For the contrary view to my original work see *2*.

CHART 1



a period of remarkably stable general prices in U.S. history. There was perhaps a slight upward trend of the general price level at the rate of about 2 per cent per year. This would impart a slight upward trend to the futures seasonal if the movement of general prices were unanticipated (see footnote 5).

The downward trend of the corn futures seasonal can be attributed to the declining trend of corn prices during this period. Spot corn prices fell about 2.75 per cent per annum over this 11-year period and corn futures prices moved down on average from quote to quote. Be that as it may, it leaves with losses the long speculator who anticipated a positive return from the sale of "price insurance" to short hedgers. More to the point, the secular trend of corn prices does not destroy the typical upward seasonal movement of *spot* corn prices. Despite the annual downward drifting corn prices, spot corn prices display the J-shaped pattern that is conducive to a positive return from storage.

CHART 2

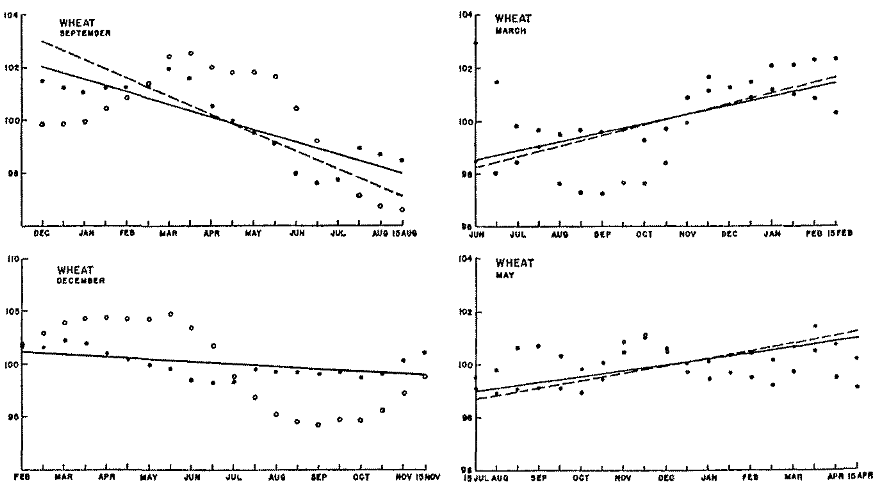
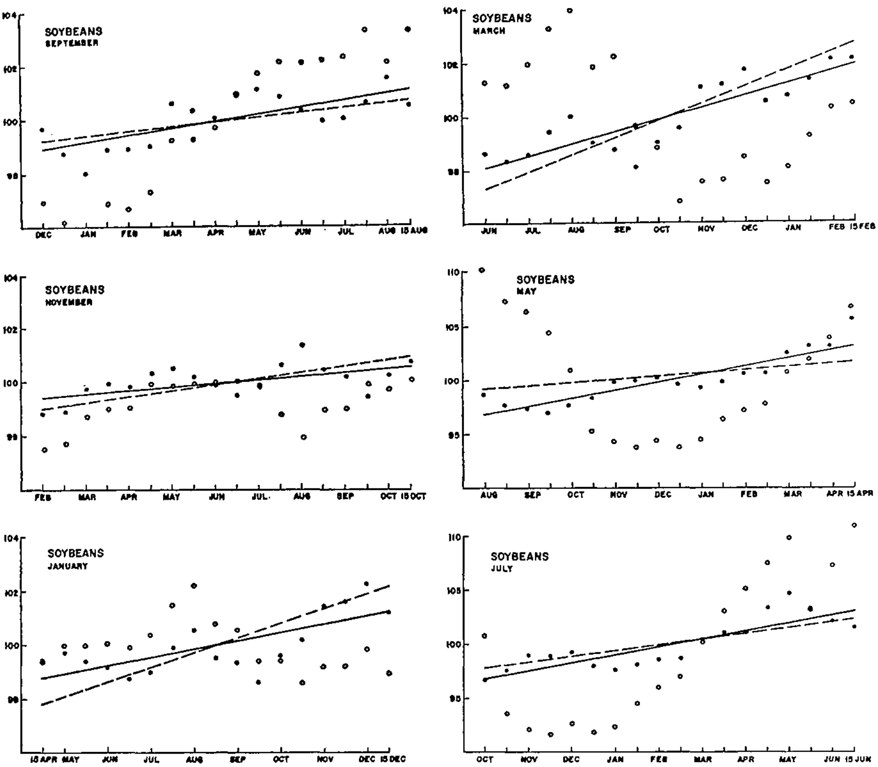


CHART 3



What of wheat and soybeans? The latter shows an upward seasonal and yet there is no particular upward price trend from 1952 to 1962. Soybeans rose from \$2.89 in crop year 1952 to \$3.34 in 1953, then fell \$1.20 per bushel from 1953 to 1959, finally rising 70 cents per bushel to end at \$2.90 in 1963. Despite the absence of trend, the wide price movements "explain" the seasonal pattern. The largest seasonal rise is for the May and July contracts. However, the May 1954 and May 1961 contracts rose 50 per cent during their trading period and the July contracts changed correspondingly. To illustrate the extreme effect of these two years on the sample, I calculated the seasonal index excluding them. The graphs of the seasonals for the 11-year and the 9-year average are shown in Chart 5 with striking results indeed. Virtually *all* of the rise in the 11-year index is attributable to just two contracts. In fact the index based on the nine other years shows no seasonal trend whatever! Such extreme price movements are characteristic of the May and July soybean contracts which mature at the end of the crop year.[13] Wheat prices show the same U-shape over the 11-year sample period as soybeans but the year-to-year variation is much less than for soybeans. The seasonal pattern for wheat is mixed.

Another way of measuring the large annual variation around the "seasonal"

[13] These large deviations seem consistent with the distribution of price changes proposed by B. Mandelbrot. He postulates a distribution which has an infinite variance and would produce outliers or large changes more frequently than, say, a lognormal distribution of price changes (*16*; *17*).

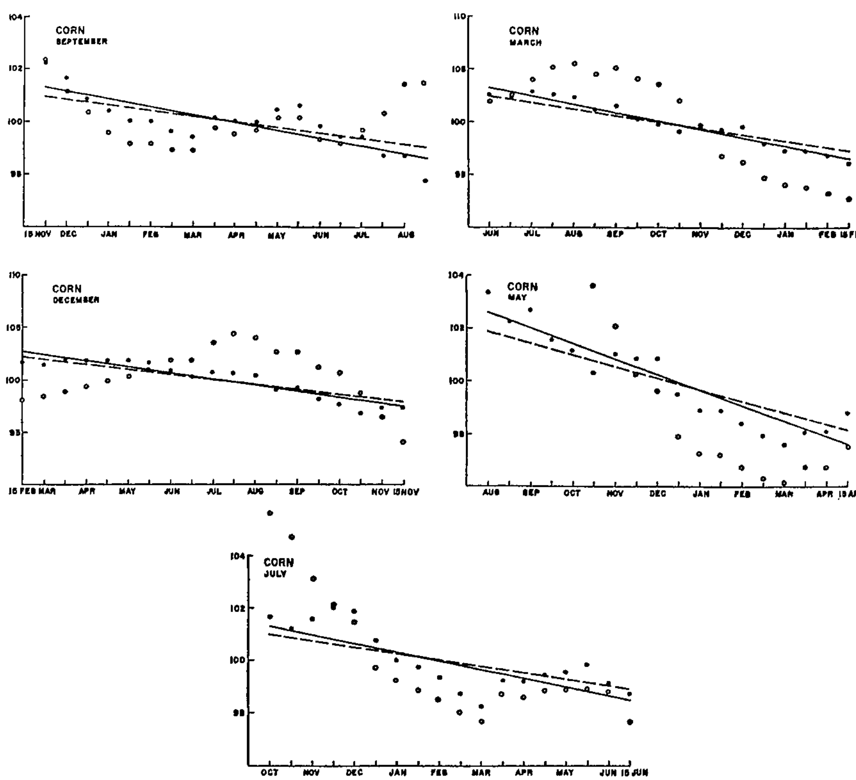
is to compare the trend lines fitted to the data for 1952 to 1963 with the trend lines fitted to a sample of two more years, 1964 and 1965. The more variable the annual seasonal pattern, the greater the difference between the two trend lines. In fact there are sizable changes for the July and September wheat contracts, the May corn contract, and the January, March, and May soybean contracts.[14] It is clear that a speculative strategy attempting to exploit a "normal" seasonal pattern would encounter considerable risk because of the highly variable nature of the "seasonal" from year to year.

To get a better picture of the variability of the seasonal, I chose another measure that explicitly uses all of the price data instead of just the average by quote over all the years. The new regression estimates the seasonal from the following:

$$f_{ijt} - \bar{f}_{i.t} = a_{0i} + a_{1i}j + a_{2i}j^2 + \text{residual}. \tag{13}$$

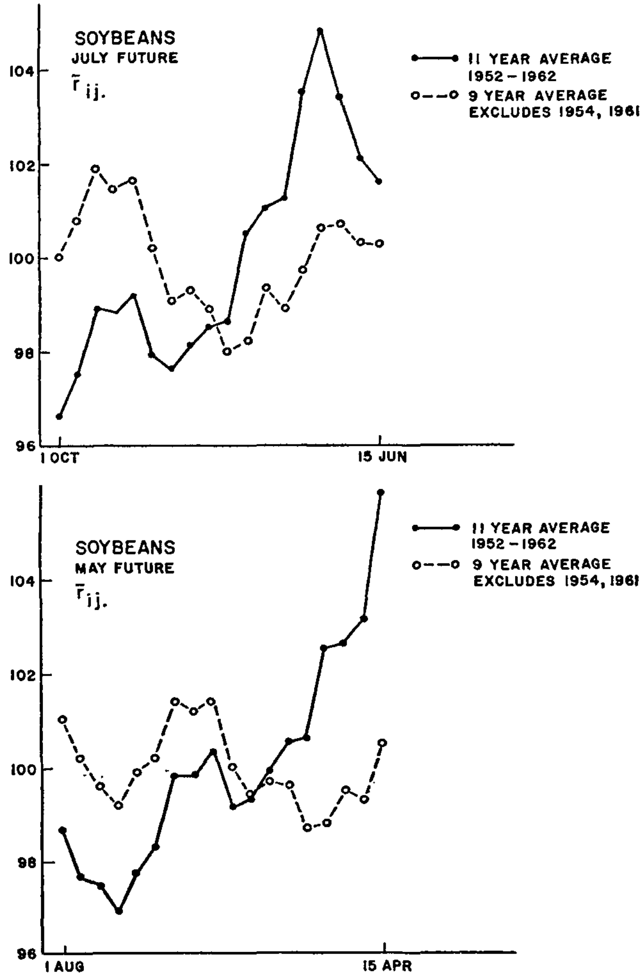
It differs from the previous one (12) in three ways. First, it uses the arithmetic difference between the quoted price and the average price over the life of the contract. Actually, this gives about the same result as would $f_{ijt}/\bar{f}_{i.t}$. Second, (13) explicitly uses all of the price data thereby providing a measure of the year-to-year variability of the seasonal. Third, it allows for a nonlinear seasonal by including the term j^2.

CHART 4



[14] The actual regression equations are available on request.

CHART 5



Graphs of the estimated regressions are shown in Charts 6–8 and the pertinent information about the regressions is in Table 2. In only a few cases does the regression "explain" as much as 22 per cent of the variation of prices around the contract averages. Most of the regression coefficients have low *t*-ratios except for wheat. This is an interesting finding because the corn and soybean futures, which show the clearer seasonal pattern based on the average seasonal $\bar{r}_{ij.}$ and regressions in Table 1 now show larger year-to-year variability of the seasonal.[15] These

[15] The residuals of the regressions (13) have marked serial correlation. It would be difficult to reject the hypothesis that first differences of the residuals are successively independent. First differencing of (13) gives

(13′) $$f_{i,j,t} - f_{i,j-1,t} = (a_{1i} + a_{2i}) + 2a_{2i}j$$
$$+ \text{first difference of residual.}$$

I actually estimated a closely related regression as follows:

(13″) $$\log f_{i,j,t} - \log f_{i,j-1,t} = \sum_t a_{0t}\delta_t + a_{1i} \ (\log f_{i,j-1,t} - \log f_{i,j-2,t})$$

where $\delta_t = 1$ in year t and 0 otherwise. I found that a_1 is very close to zero and that the serial correlation of the residuals in (13″) is virtually zero. These results are consistent with the ones reported in the text.

TABLE 2.—INTER-YEAR SEASONAL REGRESSIONS OF FUTURES PRICES, 1952–64, BY FUTURE, WHEAT, CORN, SOYBEANS[a]

$$f_{ijt} - \bar{f}_{i.t} = a_{0i} + a_{1i}j + a_{2i}j^2, \quad j = 1, \ldots, J_i; \; t = 1, \ldots, T$$

Commodity and future	a_{0i}	t-ratio	a_{1i}	t-ratio	a_{2i}	t-ratio	Date of first quote	Sample size $= TJ_i$	R	S.E. of estimate in cents per bushel
WHEAT										
July	.140	.093	1.0005	2.892	–.07804	–4.643	30 Sept.[b]	247	.467	7.058
September	6.347	3.897	–.5393	–1.438	–.0073	–.403	30 Nov.	247	.444	7.651
December	8.294	5.308	–1.974	–5.761	.0867	5.468	15 Feb.[b]	260	.339	7.573
March	–6.113	–4.393	1.0090	3.149	–.03059	–1.966	31 May	247	.337	6.535
May	–5.813	–4.010	1.2064	3.795	–.04776	–3.248	15 July	260	.254	7.024
CORN										
September	1.785	1.665	–.1296	–.551	–.0030	–.272	15 Nov.	260	.210	5.195
December	2.517	3.083	–.1557	–.870	–.0061	–.742	15 Feb.	260	.387	3.956
March	2.747	2.950	–.05579	–.260	–.01684	–1.617	31 May	247	.451	4.373
May	3.709	3.774	–.5320	–2.351	.0124	1.127	31 July	247	.328	4.617
July	2.728	2.705	–.4467	–1.923	.01337	1.185	30 Sept.	247	.217	4.738
SOYBEANS										
September	–3.537	–1.522	.5733	1.072	–.01689	–.650	30 Nov.	247	.125	10.91
November	–1.341	–.732	–.3308	–.784	.03577	1.744	31 Jan.	247	.261	8.61
January	–4.264	–1.994	–.0938	–.181	.0440	1.660	15 April	234	.382	9.716
March	–8.428	–3.139	.7729	1.250	.00538	.179	31 May	247	.359	12.610
May	–9.575	–2.431	.5724	.631	.02962	.672	31 July	247	.330	18.496
July	–8.905	–2.147	1.2272	1.285	–.02590	–.558	30 Sept.	247	.200	19.478

[a] In contrast with Table 1, these regressions use the price as quoted on the last trading day of the month before the future matures. Table 1 uses as its last quote the one on the 15th of the month before maturity. In addition there are 11 years of data for Table 1 and 13 years for Table 2.

[b] Notice that both of these contracts have their first quote somewhat later than in Table 1.

results incline me to accept the hypothesis that futures prices represent unbiased market expectations of subsequent spot prices.[16]

Table 3 contains estimates of (13) for spot prices. Regression (13) accounts for 64 per cent of the spot price deviations from the annual averages for wheat, nearly 30 per cent for corn, and nearly 20 per cent for soybeans. There are correspondingly higher *t*-ratios of the coefficients of the spot price regressions than for futures price regressions and the typical spot price seasonal pattern is easily discernible. However, the regressions for the spot prices are not fully comparable to the futures regressions because the spot prices are monthly weighted averages of daily closing prices and thus rely on 12 observations per crop year. The futures regressions use biweekly closing prices instead of average prices over biweekly periods. Nevertheless, despite the averaging, the spot prices vary more from month to month than the futures prices and, although the multiple correlations are higher, the standard errors of estimate for the spot regressions are not less than the corresponding statistic for the futures regressions.[17]

Comparisons of future and spot prices raise the interesting question of how accurately futures prices predict spot prices. Does the pattern of futures prices at one time predict the subsequent seasonal movement of spot prices? For example, if the May future on average is above the March, is it also true that the average spot price in May is above the average spot price in March by the same amount? Table 4 gives the pertinent figures. Thus the average March wheat future is a bit more than 4 cents above the grand mean, \$2.08, while the average spot price in March is 6.3 cents above the spot price grand mean of \$2.19. The absolute errors as a percentage of the mean prices are, respectively, 1.5 per cent for wheat, 1.6 per cent for corn, and 1.8 per cent for soybeans. Moreover, this comparison makes no allowance for the inherent difficulties of predicting prices for these different commodities. For instance, soybean prices fluctuate more during the sample period than wheat and corn prices and are probably harder to predict. To give another example, the last old crop futures price is usually harder to forecast

[16] Roger Gray found a change in the seasonal pattern of spot wheat prices, which he attributes to the effect of the price support program. The seasonal rise in the price of spot wheat is larger for the period 1949–61 than for 1921 to 1943. (See 6.) These findings led me to calculate the spot seasonal for wheat and corn in the pre-support era (soybeans were a minor crop at that time and are not pertinent to this problem). My results are as follows:

Wheat, No. 2 Hard Winter, Kansas City, July, 1925 to 1937 (13 years)

$$p_{jt} - \bar{p}_{.t} = -.18 + .61j - .07j^2 \quad S.E. = 7.99,\ R = .157$$
$$t\text{-ratios} \quad -.08 \quad .76 \quad -1.15$$

Corn, No. 3 Yellow, Chicago, October, 1920–29

$$p_{jt} - \bar{p}_{.t} = 1.00 - 1.89j + .08j^2 \quad S.E. = 8.91,\ R = .377$$
$$t\text{-ratios} \quad .34 \quad -1.84 \quad 2.70$$

Hence there is no statistically significant seasonal for wheat while there is for corn. For corn the minimum price is reached in January and the maximum in September. The "normal" price rise for this period was 11.5 cents per bushel which is about 14 per cent of the average spot price during this sample period, slightly higher than in the period 1952–63. Although it is true that both sample periods ante-date the price support programs, the impact of the Great Depression on the wheat prices probably accounts for the results. Unfortunately, excluding the Great Depression years leaves too small a sample to give reliable results. There are also other factors that could account for the difference between the two periods such as the prevalence of specialized inventory firms. Hence I would be reluctant to attribute the entire effect to the price support program, particularly in view of the corn results which show a larger return from stockholding in the pre-price support period. Hence I must disagree with Gray's conclusions.

[17] The view that futures prices reveal no bias agrees with Roger Gray. See 5.

TABLE 3.—INTER-YEAR SEASONAL REGRESSION OF SPOT PRICES BY MONTHS, WHEAT, CORN, AND SOYBEANS

$$p_{jt} - \bar{p}_{.t} = a_0 + a_1 j + a_2 j^2$$

Commodity and period	a_0	t-ratio	a_1	t-ratio	a_2	t-ratio	Sample size	R	$S.E.$ of estimate in cents per bushel
WHEAT[a]	–17.69	–12.71	4.700	9.550	–.237	–6.441	144	.798	4.66
CORN[b]	–9.293	–5.267	2.091	3.350	–.0791	–1.692	144	.541	5.91
SOYBEANS[c]	–26.98	–5.463	10.78	6.169	–.795	–6.078	156	.447	17.23

[a] No. 2 Hard Winter, Kansas City, June 1952–May 1963.

By choosing June instead of July as the first observation in the spot wheat regression, I depart in effect from the custom of making July the first month of the crop year. For completeness, here is the regression using July as the opening month:

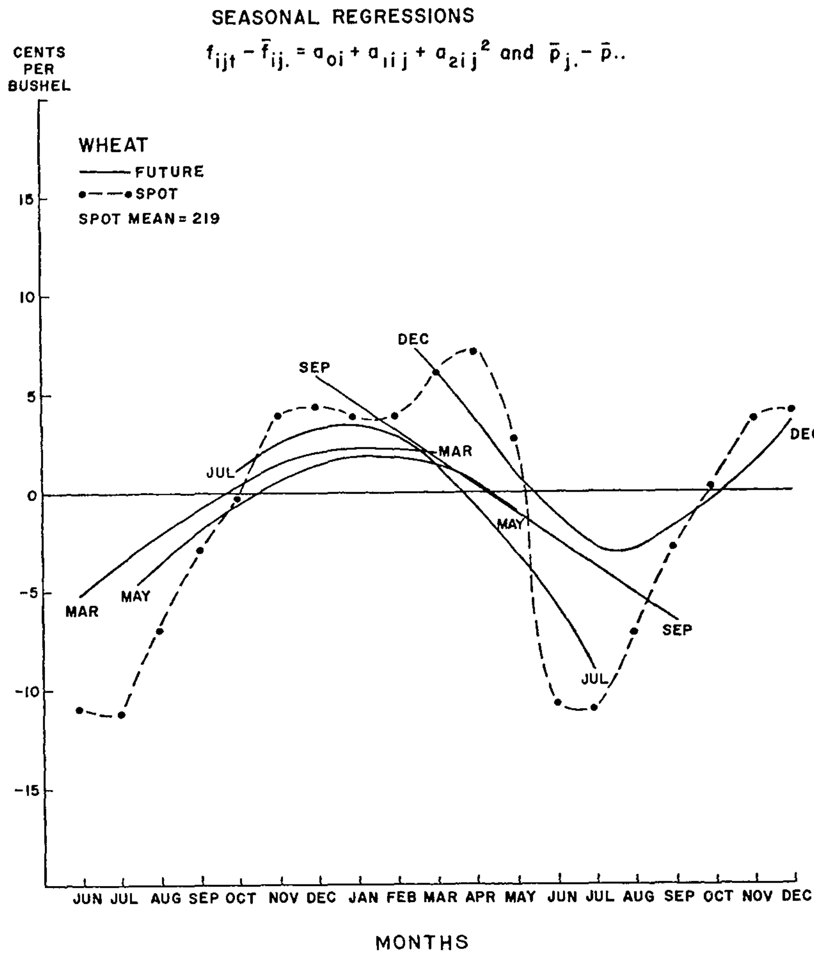
$$p_{jt} - \bar{p}_{.t} = -20.34 + 7.90j - .572j^2, \quad S.E. = 7.21, \quad R = .658$$

t-ratios −9.45 10.38 −10.04

[b] No. 3 Yellow, Chicago, October 1952–September 1963.

[c] No. 1 Yellow, Chicago, October 1952–September 1964.

Chart 6



because it depends both on the carryover into the new crop year and on the size of the forthcoming harvest. The carryover not only depends on the rate of demand in the old crop year but also on the new crop. Thus we should expect larger forecasting errors for the last old crop futures and this is borne out by the July wheat and September soybean contracts. However, it does not seem to be true of the last old crop corn future—September—since the December corn future shows a larger error.

This examination of the seasonal price movement throws some light on the question of whether it is possible for speculators to earn a positive return on average by using a particular systematic speculative policy derived from the Keynesian theory. An upward seasonal implies that adherence to a long position in futures would be profitable on average and the reverse holds for a downward seasonal. Therefore, if hedgers are net short and if they buy price insurance from risk-averse speculators, there ought to be an upward seasonal of futures prices. In fact all corn contracts show downward trends, all soybean contracts

CHART 7

SEASONAL REGRESSIONS

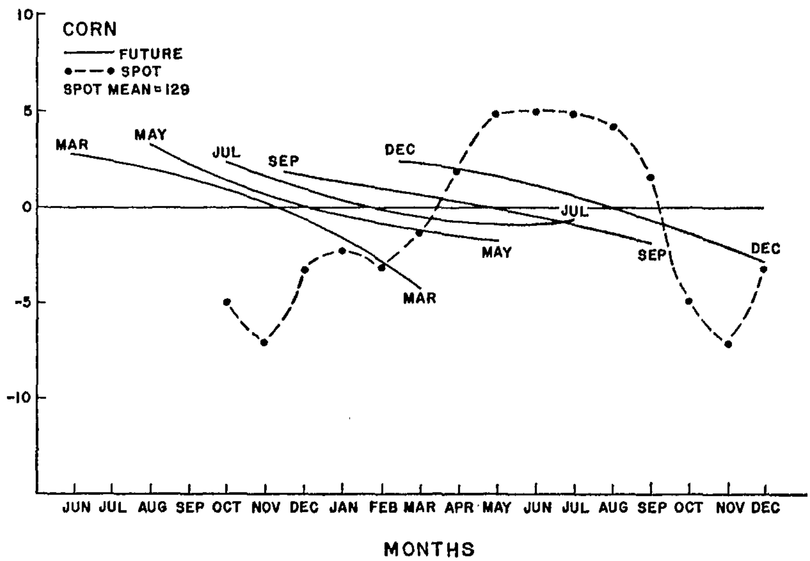


CHART 8

SEASONAL REGRESSIONS

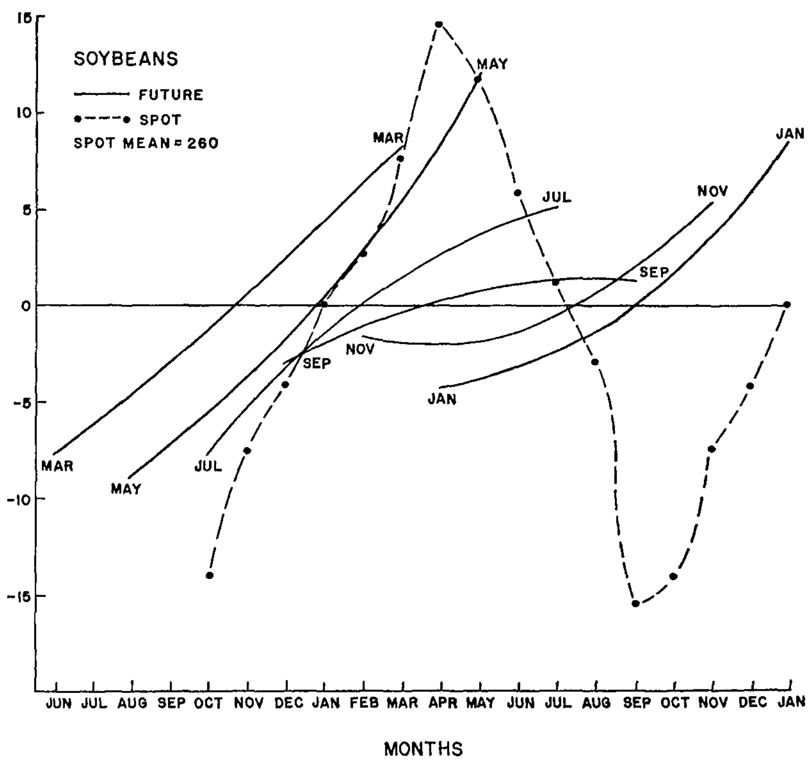


TABLE 4.—ESTIMATES OF THE ACCURACY OF FUTURES PRICES IN PREDICTING THE SEASONAL PATTERN OF SPOT PRICES, WHEAT, CORN, AND SOYBEANS

(Cents per bushel)

Commodity, month and period	Futures[a]		Spot[b]		Error = spot–future deviation
	Mean	Deviation from grand mean	Mean	Deviation from grand mean	
WHEAT					
July 1952–63	203.9	−4.54	207.7	−11.03	−6.49
September 1952–63	204.7	−3.69	216.1	−2.70	0.99
December 1952–63	209.0	0.61	223.2	4.39	3.78
March 1953–64	212.6	4.15	225.1	6.30	2.15
May 1953–64	211.9	3.45	221.8	2.05	−1.40
Grand mean	208.4		218.8		
CORN					
September 1953–64	130.7	−0.2	132.0	1.0	1.2
December 1952–63	129.0	−1.9	126.2	−4.8	−2.9
March 1953–64	130.3	−0.6	128.0	−3.0	−2.4
May 1953–64	131.6	0.7	134.3	3.3	2.6
July 1953–64	132.8	1.9	134.3	3.3	1.4
Grand mean	130.9		131.0		
SOYBEANS					
September 1952–64	246.8	−5.5	248.0	−12.5	−7.0
November 1952–64	242.4	−9.9	252.5	−8.0	1.9
January 1953–65	248.4	−3.9	260.1	−0.4	3.5
March 1953–65	254.0	1.7	267.5	7.0	5.3
May 1953–65	259.7	7.4	271.6	11.1	3.7
July 1952–64	262.6	10.3	264.2	3.7	−6.6
Grand mean	252.3		260.5		

[a] Futures price averages are over the life of the contract and overall contracts denoted by the years.

[b] Spot prices are as follows: Wheat is No. 2 Hard Winter, Kansas City, Corn is No. 3 Yellow at Chicago, Soybeans are No. 1 Yellow at Chicago. All spot prices are weighted monthly averages of daily closing prices in the indicated markets.

upward trends, and 3 wheat contracts trend down while 2 trend up. In contrast, the seasonal pattern of spot prices is clear cut and consistent with theoretical expectations. In every case spot prices rise after the harvest is complete and reach their peak before the new crop enters commercial channels.

Comparison of the spot and futures seasonal price patterns implies that firms specializing in holdings stocks can expect a positive gross return by short hedging their stock for the interim between harvests. The spot price regression in corn gives a rise of 11.8 cents per bushel from October to the following September, which is about 10 per cent of the average spot price. Since there was a downward trend of corn futures, the gross return to short hedged stocks was more than 10 per cent per annum. The seasonal rise in spot wheat from June to the following July is 17.8 cents per bushel which is 12.3 per cent of the average spot price of wheat during the sample period. The upward seasonal in March and May futures implies that the gross return to short hedged stocks in these futures was less than 12 per cent per annum while the downward trend in the other wheat futures implies a larger gross return to short hedged than to unhedged stocks. Soybeans show the smallest return from holding stocks over a 12-month period—only 5 cents per bushel. However, a policy of holding stocks from October to April implies a gross return of 26.5 cents per bushel which is more than 10 per cent of the average spot price. There would have been some losses on the futures account if soybean stocks were short hedged because of the upward seasonal of soybean futures. These results imply that the gross return from the holding of short hedged stocks is about 10 per cent per annum. To measure the net return requires information about storage costs. It is worth noting that the estimates of the seasonal rise in spot prices of corn and wheat derived from regression (13) are close to the rule of thumb estimates of storage costs in the trade—a result that increases our confidence in the validity of the regressions.

Tests of the further implications of the rival views of hedging and speculation lead to a comparison of the seasonal movement of short and long hedging commitments with the seasonal pattern of futures prices. This is the subject of the next section.

III. THE RELATION BETWEEN THE SEASONAL PATTERNS OF HEDGING AND FUTURES PRICES

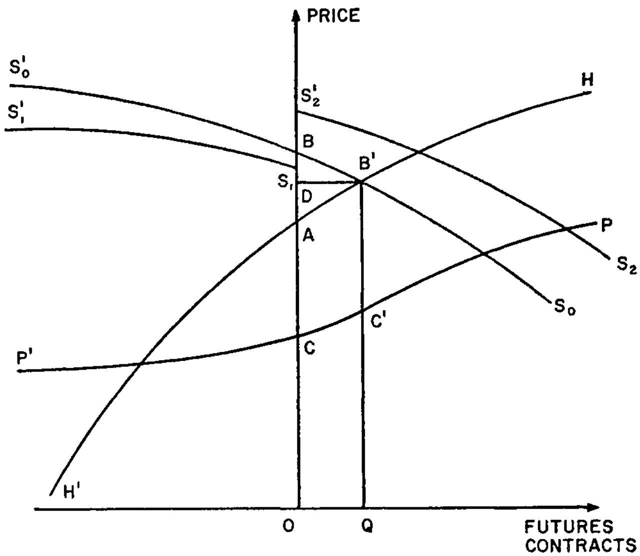
The empirical relations between the seasonal indexes of futures prices and hedging commitments are more easily understood using a diagram to depict the equilibrium in the futures market.

We begin with the conventional view that speculators provide the hedgers with price insurance. Initially, suppose a futures market in which there are no hedgers and only speculators. Speculators who are long believe that the futures price will rise while those who are short believe the opposite. The equilibrium futures price must be such that the purchases which the bullish speculators wish to make just equal the sales of the bearish speculators. The equilibrium price represents the market expectation of the subsequent spot price. This gives one point on the speculators' excess demand schedule, the point *OB* in Chart 9. Can we find the other points on the schedule if no hedgers are in the market?

Suppose all of the speculators think that prices will be higher in the future. Therefore, they will attempt to buy more futures contracts. This drives up the futures price until some speculators become willing to assume a short position. Although the new equilibrium price is above *OB*, net commitments are still zero and all we know is that the speculative schedule has shifted. An increase in bearish sentiment drives futures prices down and net commitments remain zero. The inevitable conclusion is that in a market without hedgers we cannot discover the shape of the speculators' schedule. All we can say, together with J. P. Morgan, is that the futures price will fluctuate.

To obtain other points on the speculators' schedule besides those intersecting the price axis, there must be another group of traders in the market with a motive for their dealings different from the speculators'. This group is the hedgers who enter the futures market in order to obtain price insurance according to one theory. If at the prevailing futures price *OB* the hedgers desire to sell futures contracts, then the speculators can be induced to assume a net long position in futures at a price below *OB* if they expect the subsequent futures price (or, for

CHART 9



simplicity, spot price) at which they will sell their futures contracts to exceed the current futures price by a sufficiently large amount to remunerate them for their risk bearing. Moreover, if each risk-averse speculator limits the size of his futures commitment, it will be necessary to attract more speculators who, presumably, have higher opportunity costs into the futures market. The speculators' excess demand for futures $S_0'S_0$, in Chart 9 is drawn on the assumption of a given *initial* amount of stocks. It is downward sloping not because the speculators have risk aversion but because the expected spot price decreases as we move from the left to the right of the origin. The geometric representation of speculators' risk aversion is discussed below.

A negative slope of $S_0'S_0$ is consistent with speculators being indifferent to risk if the *expected* prices are lower when hedgers are net short because more stocks are held for later consumption and if expected prices are higher when hedgers are net long because less stocks are held for later consumption. To analyze the equilibrium of the futures market it is convenient to begin with a futures market consisting solely of hedgers and without speculators.

We wish to obtain a pure hedging equilibrium. Hence we must derive the hedgers' excess supply of futures contracts. For a given current spot price, the higher is the current futures price, the larger is the return (or the lower is the cost) of holding hedged stocks since, if necessary, the short hedger can be certain of obtaining the difference between the futures and the spot price by actually delivering the physical goods in fulfillment of the futures contract. To the right of the origin in Chart 9 the hedgers are net short in futures. Hence this argument implies that the excess supply of hedging commitments, the schedule *AH*, has a positive slope, to the right of the origin. For the moment we assume a given spot price.

To the left of the origin the hedgers are net long. The lower is the futures price relative to the spot price, the larger is the expected return from long hedging. Although I have argued that long hedging is a risk-increasing activity, the amount of long hedging ought to increase as the expected return increases, provided the risk per unit of long hedging does not increase enough to offset the larger expected return. Assuming the latter, the hedging futures schedule is positively sloped throughout and is thus drawn as *H'H* in Charts 6–8. It is shown as a continuous schedule through the point *A*. This continuity is necessary for the existence of a pure hedging equilibrium! If, however, long hedgers were only willing to buy futures at a lower price than short hedgers were willing to sell futures, then a pure hedging equilibrium would be impossible. Geometrically, this state of affairs would be represented by a jump in the hedging schedule as it crosses the price axis. The jump would go from the long hedgers' maximum buying price up to the short hedgers' minimum selling price.[18]

If we assume that a pure hedging equilibrium is possible despite the asymmetry of short and long hedging, then the hedging schedule *H'H* is continuous throughout. We have seen above that a pure hedging equilibrium implies that equation (8) must hold. Assume in addition that hedges are placed in contracts maturing at time $t + n$ (cf. (8)). Therefore,

$$f_{n,t+n} = p_{t+n}. \tag{14}$$

This means that the spot price prevailing at time $t + n$ and the price of a futures contract maturing at time $t + n$ are the same. Together with (8), (14) implies that in a pure hedging equilibrium,

$$f_{n,t} = p_t + c_n. \tag{15}$$

Equation (15) translated into words says that in a pure hedging equilibrium the futures price is above the current spot price by the marginal storage cost. In Chart 9, *OA* is the futures price corresponding to $f_{n,t}$ that equilibrates long and short hedging. Hence the equilibrium spot price, *OC*, is below *OA* by the marginal storage cost, c_n. In the diagram the marginal storage cost is the vertical line *CA*. (In this analysis we may assume without loss of generality that the marginal storage cost on stocks is *net* of the marginal convenience yield on stocks. See footnote 26.)

So far I have derived two of the schedules shown in Chart 9, the hedgers' futures schedules, *H'H*, and the speculators' schedule, $S_0'S_0$. In addition I have shown the spot price, *OC* to be below the equilibrium futures price, *OA*, in a pure hedging equilibrium, by the marginal cost of storage. It is now necessary to derive the relation between the spot and the futures price as a function of the amount of hedging and to determine the equilibrium in a futures market containing both hedgers and speculators. We accomplish both purposes by analyzing the consequences of the entrance of speculators into a market in which there is a pure hedging equilibrium.

Assume that speculators now enter a futures market that is in a pure hedging equilibrium. If the speculators' excess demand schedule were to intersect the

[18] The origin in Chart 9 is ambiguous because it not only represents a situation in which the sales of the short hedgers equal the purchases of the long hedgers, but it also includes the possibility that both are zero. This would happen if the hedging schedule had a jump on the vertical axis.

hedging schedule at the point OA so that the points OA and OB would coincide, then, in effect there would be an equilibrium among the speculators by themselves and another among the hedgers by themselves. It would be as if there were two separate markets, one of hedgers and one of speculators.

Next assume that OB is above OA, which implies that the speculators anticipate a higher price than the hedgers. Given an initial pure hedging equilibrium at a futures price OA, the entrance of the speculators would drive up the futures price from OA to QB'. This induces the short hedgers to sell more futures contracts to the speculators and to hedge more of their stocks. It also follows that short hedgers must hold a larger *absolute* amount of stocks to the right of the origin. To prove this, suppose that the stocks held by the hedgers were the same at OQ as at O. The equilibrium futures price at net short hedging commitments OQ is QB'. Let OD equal QB'. OD exceeds OA by the amount AD. Hence if stocks and the current spot price were the same at OQ as at O, then the futures price $OD = QB'$ would exceed the current spot price by more than the marginal cost of storage, which is impossible. Therefore, the spot price corresponding to short hedging commitments OQ must exceed the spot price OC pertaining to a pure hedging equilibrium. Hence at OQ the current consumption must be lower and the stocks held by short hedgers must be larger than at O.

A similar argument applies to every quantity of hedging commitments and permits us to determine the locus of the spot prices as a function of the amount of hedging commitments and of the amount of stocks held for subsequent sale. This locus $P'P$ is drawn as an increasing function of the short minus the long hedging commitments. It is instructive to derive $P'P$ in another way. Let

q_t = consumption during period t
S_t = stocks at the beginning of period t
S_{t+1} = stocks at the end of period t = stocks at the beginning of period $t + 1$.

Assume that consumption varies inversely with the spot price. Hence there is a demand relation as follows:

$$p_t = f(q_t)$$

and

$$\frac{\delta f}{\delta q_t} < O .$$

Since current consumption equals the stocks carried into the period less the stocks held for consumption in subsequent periods, or, algebraically,

$$q_t = S_t - S_{t+1} ,$$

it follows that

$$\frac{\delta f}{\delta S_t} < O \text{ and } \frac{\delta f}{\delta S_{t+1}} > O .$$

There is a given amount of stocks S_t at the beginning of period t and there is a given demand schedule for consumption. Short minus long hedging is an increasing function of S_{t+1}, the stocks carried out of period t for use in subsequent periods. The larger is S_{t+1}, the higher is the current spot price p_t for a given S_t and a given demand schedule $f(q_t)$. Therefore, the locus $P'P$ is an increasing function of short minus long hedging commitments.

The vertical distance between $H'H$ and $P'P$ equals the net marginal cost of storage, which is the marginal cost of storage less the marginal convenience yield. Since the marginal cost of storage is a non-decreasing function of the amount of stocks held and the marginal convenience yield is a non-increasing function of the amount of stocks, the net marginal cost of storage is a non-decreasing function of the amount of stocks. Since stocks vary directly with short minus long hedging, it follows that the basis, the futures minus the spot price, is a non-decreasing function of short minus long hedging. Hence the vertical difference between $H'H$ and $P'P$ is drawn to increase as short minus long hedging increases.

To represent the effect of a larger initial stock S_t, one would draw a new spot price locus $P'P$ everywhere below the one shown in the diagram. Since the net marginal cost of storage is a given function of S_{t+1}, a rise in S_t must lower $H'H$ to make the vertical distance between $H'H$ and $P'P$ consistent with the amount of stocks to be carried out of the period, S_{t+1}. Hence a rise in the initial stocks S_t reduces both the spot and the futures prices.

We may also use Chart 9 to illustrate the effect of a change in the marginal cost of storage. A rise in marginal storage costs for all levels of stocks tends to decrease the current spot price and to increase the current futures price. This is because a rise in marginal storage costs tends to reduce the carry-out, S_{t+1}, which increases the rate of current consumption and depresses the current spot price. The reduction in stocks held for subsequent consumption implies that spot prices expected to prevail in the future will be higher. The rise in expected spot prices tends to increase the current futures price. In Chart 9, the decrease in the current spot price would be represented by a downward shift of the $P'P$ schedule and the rise in the expected spot price by an upward shift of the $H'H$ schedule. Hence a rise in marginal storage costs causes an increase in the vertical distance between $H'H$ and $P'P$ via a rise in the former and a fall in the latter schedule. A rise in the marginal convenience yield of stocks is analytically equivalent to a fall in marginal storage costs. It follows that a rise in the marginal convenience yield of stocks moves $P'P$ up and $H'H$ down thereby narrowing the vertical distance between the two schedules.

According to this theory of the determination of equilibrium in the futures market, shifts of the speculators' schedule $S_0'S_0$ trace out the hedging schedule $H'H$ while shifts of $H'H$ trace out $S_0'S_0$. Since $H'H$ has a positive slope and $S_0'S_0$ has a negative slope, a regression of futures prices on hedging commitments will show which of the two schedules, $H'H$ or $S_0'S_0$, is more stable.

The speculators' taste for risk has not yet entered the analysis. If speculators were indifferent to risk then, on average, the return to speculation would be zero. If the speculators are net long and they are indifferent to risk then the futures price at the time they buy futures, which is QB', would equal the futures prices at the time they sell (close out) their futures contracts. Hence the speculative schedule which applies at the time they buy their futures contracts would be the same as the schedule at the time they sell their futures. Thus if speculators are indifferent to risk, the same schedule, $S_0'S_0$, would apply at the time of speculative purchase and sale. If speculators collectively are neither risk lovers nor risk averters, then the current futures price is an unbiased predictor of the subsequent spot price. It follows that the current futures price QB' is also an unbiased predictor of subsequent futures prices for contracts of the same maturity. Hence if speculators are collectively indifferent to risk then the schedule $S_0'S_0$ should remain constant over time.

If speculators are risk averse and net long, then they must collectively expect the later futures price to exceed the current futures price. If they are currently willing to buy OQ futures at a price QB' from the short hedgers, then subsequently they are willing to *sell* OQ futures at a higher price than QB'. To the right of the origin where speculators are net long, their current demand for futures is the schedule BS_0. Their risk aversion implies that they are willing to sell futures subsequently at a higher price than they currently paid. Hence to the right of the origin the speculators' subsequent supply of futures is the schedule $S_2'S_2$ which lies above BS_0. Their current *buying* schedule is BS_0 and their subsequent *selling* schedule is $S_2'S_2$. The latter lies above the former if there is collective speculative risk aversion. Similarly, if speculators are net short (to the left of the origin) then they must anticipate a higher futures price later on. They are willing to sell futures at a given price in the present only if they expect subsequently to buy the same amount of futures at a lower futures price. Hence speculative risk aversion when speculators are net short implies that their subsequent buying schedule $S_1'S_1$ lies below their current selling schedule $S_0'B$.

The negative slope of $S_0'S_0$ has nothing to do with the speculators' risk aversion; this schedule is downward sloping from left to right because the *expected* spot price varies inversely with the quantity of stocks currently held for subsequent consumption, S_{t+1}, and the latter in turn varies directly with the excess of short over long hedging. The risk aversion of the speculators is expressed by a difference between their current and their subsequent schedules. The current schedule is $S_0'S_0$. The subsequent schedule is $S_1'S_1$ if speculators are currently net short and it is $S_2'S_2$ if they are currently net long. The effect of the difference between the current and the subsequent speculative schedules is to make the average futures price when speculators are buying below the average futures price when speculators are selling. The vertical distance between the current and the subsequent schedules is the risk premium. If the supply of speculative services is not perfectly elastic, then the vertical distance between $S_0'S_0$ increases as the amount of short hedging commitments increase (to the right of the origin) and the vertical difference between $S_0'S_0$ and $S_1'S_1$ increases as the amount of long hedging commitments increase (to the left of the origin). The schedules are thus drawn in Chart 9.

One may also assume that the risk premium is independent of the amount of hedging commitments; in this case there would be a constant vertical difference between the current and the subsequent speculative schedules. The assumption of a constant risk premium implies that futures prices have an upward trend when hedgers are net short and a downward trend when hedgers are net long; these trends are independent of the volume of the hedging commitments. A downward trend in the futures prices results when hedgers are net long if long hedging is risk decreasing but not otherwise.

If the supply of speculative services is imperfectly elastic, then the size of the upward trend in futures when hedgers are net short varies directly with the amount of the short hedging commitments. This deduction is a consequence of individual speculator's risk aversion that leads each to limit the size of his commitment and that requires the entry of more speculators at a rising supply price. Hence the more short hedging, the larger the return to speculators per futures contract. Similarly, if long hedging is risk reducing, and there is net long hedging, the current futures price must be higher relative to the subsequent futures price the larger is the amount of the net long hedging. Both of these effects imply particular relations between the seasonal pattern of futures prices and the seasonal pattern of short and long hedging commitments. It is our purpose now to discover whether the empirical evidence supports these implied relations.

In Section II we examined the seasonal pattern of futures prices to determine whether there was evidence of a systematic seasonal of the kind implied by the hypothesis that it is necessary to attract risk-averse speculators into the futures market to assume the price risks from the hedgers. We found no evidence of a consistent seasonal pattern in the three markets for which we examined the pertinent data. We now wish to determine whether the seasonal pattern of futures prices is related to the seasonal pattern of short and long hedging commitments in the manner implied by the hypothesis that the supply of risk-averse speculators is imperfectly elastic.

The hedging pressure theory implies that the price of a given futures contract as quoted on a date before its maturity will be lower relative to the average price of the futures contract over its life, the larger is short hedging commitments on the same date relative to the average level of short hedging commitments. Similarly, if long hedging is risk reducing, then the larger the long hedging commitments relative to its mean the higher ought to be the futures price relative to its mean. Hence a seasonal index of the futures price ought to vary inversely with a seasonal index of short hedging commitments and directly with a seasonal index of long hedging commitments. We now turn to tests of this hypothesis.

Let

X_{jt} = reported outstanding short hedging commitments in year t at quote j

Y_{jt} = reported outstanding long hedging commitments in year t at quote j.[19]

$x_{jt} = X_{jt}/\bar{X}_{.t}$.

$y_{jt} = Y_{jt}/\bar{Y}_{.t}$.

The dependent variable is the deflated futures price defined in (10),

$$r_{ijt} = f_{ijt}/\bar{f}_{i.t} .$$

[19] Reported hedging commitments are given in the annual issues of *Commodity Futures Statistics*. These figures refer to the large hedgers, those holding more than 200,000 bushels in a given futures contract. Small hedgers are not reported separately and are lumped in a residual category. Large speculators are subject to the same reporting requirements as large hedgers. There are relatively more non-reporting traders on the long than on the short side and reported positions vary from 30 to 60 per cent of the total.

Notice that the hedging variables refer to the total hedging commitments summed over the outstanding futures contracts, $i = 1, \ldots, I$. This is unavoidable since hedging commitments by futures contract are not published.[20]

The basic idea in testing the various hedging and speculation theories is to relate r_{ijt} to x_{jt} and y_{jt} and measure the regression coefficients of the latter two variables. A few experiments with alternative regressions indicated that the best results are obtained by taking logarithms of the hedging variables. The empirical analysis can be done in various ways in greater or lesser detail.

First, one may postulate that the coefficients vary by years and are the same for all quotes thereby leading to the following:

$$r_{ijt} = a_{0it} + a_{1it} \log x_{jt} + a_{2it} \log y_{jt} + \text{residual}. \tag{16}$$

To estimate (16) there are J_i observations for every regression and there is a (possibly) different regression for every year t and every contract. Just about as detailed is the hypothesis that the slopes and intercepts, although the same in every year, vary by quote. This implies

$$r_{ijt} = a_{0ij} + a_{1ij} \log x_{jt} + a_{2ij} \log y_{jt} + \text{residual}. \tag{17}$$

For each of the J_i regressions (17) there are T observations. Equations (16) and (17) are in the most atomistic forms that the data can permit.

At the other extreme one can relate the means averaged over the years by quotes as follows:

$$\bar{r}_{ij.} = c_{0i} + c_{1i} \log \bar{x}_{j.} + c_{2i} \log \bar{y}_{j.} + \text{residual}. \tag{18}$$

Regression (18) relies on the assumption that the slopes and intercepts are the same for all years and quotes. It uses the same dependent variables as (12) and thereby tests whether the seasonal pattern of the deflated futures prices is explained better by the seasonal hedging variables than by a simpler linear trend on j.[21]

Finally, a compromise between these extremes postulates that the hedging coefficients are the same by year and by quote but that the intercepts vary by quote. Define the dummy variable δ_j as follows:

$$\delta_j = \begin{matrix} 1 \text{ for quote } j \\ 0 \text{ otherwise.} \end{matrix} \tag{19}$$

The compromise regression is as follows:

$$r_{ijt} = \sum_{j=1}^{J_i} b_{0ij}\delta_j + b_{1i} \log x_{jt} + b_{1i} \log x_{jt} + b_{2i} \log y_{jt}. \tag{20}$$

[20] These hedging figures are preferable to visible supplies, the figures which Cootner used to test the hedging pressure theory (2). Even better than total hedging would be hedging commitments by futures contract, but only a limited amount of such data are available in a special report (24). It is a pity these figures are unavailable for more recent years.

[21] My "Reply" (21), gives regressions comparable to (18) for wheat, corn, and cotton. The present results are more complete and take into account Cootner's criticism that I neglected to use information by year that would exploit a shifting seasonal due to annual variability in the timing of the harvest. As my present work indicates, the refined tests very strongly support my earlier work.

The connection between regressions (18) and (20) is most easily approached by considering the interpretation of the coefficients of the dummy variables. The coefficient of the dummy variable δ_j is b_{0ij} given by the intercept of the following equation:[22]

$$(21) \qquad \overline{r_{ij.}} = b_{0ij} + b_{1i}\overline{\log x_{j.}} + b_{2i}\overline{\log y_{j.}}\,.$$

If the coefficients of the dummy variables in (20) were equal, then (21) would have equal intercepts for all j. Therefore,

$$b_{0ij} \approx c_{0i}\,,$$

and (20) would reduce to (18). Thus for the seasonal hedging pattern to give a complete explanation of the seasonal futures price pattern, it would be necessary for all of the b_{0ij}'s to be the same.

The purpose of deflating futures prices and hedging commitments by their respective averages over the range of quotes $j = 1, \ldots, J_i$ is to remove the influence of year effects. Since the exact timing of the harvest and the seasonal pattern of consumption changes from year to year, it is the intent of these tests to relate the changing seasonal pattern of the hedging variables to the changing seasonal pattern of the futures prices. By making these adjustments a large total amount of hedging ought not to affect the seasonal price pattern because the prices are divided by the averages over the period of quotation. If the deflating has accomplished its purpose, then it is an implication of the procedure that the coefficients of (16), for instance, should be the same by years. Actually the sample sizes for both (16) and (17) are too small to give much reliable information on this score, and one could not reject the hypothesis that the coefficients of (16) *are* the same by years. Moreover, detailed regressions such as (16) and (17) do not compress the amount of information enough to permit comprehension of the overall picture. There are almost as many numbers to study in the complete set of (16) and (17) as are in the raw data.

For these reasons we confine our attention to (18) and (20). Consider (18). According to the hedging pressure theory the short hedging coefficients ought to be *negative* and the long hedging coefficients *positive*. The pertinent estimates are in Table 5. Eight out of 16 short hedging coefficients are positive and the smallest t-ratio is 1.8. Of the 8 negative short hedging coefficients, two have very small t-ratios, $-.4$ and $-.2$. Hence there are only 6 short hedging coefficients out of 16 with the signs predicted by the hedging pressure theory and with t-ratios that are significant at conventional levels. Fourteen out of 16 long hedging coefficients are *negative*! The two positive long hedging coefficients have t-ratios of .9 and 2.5. Hence the results for the long hedging coefficients strongly contradict the hedging pressure theory. The wheat regressions in particular give solid support to the hypothesis that the shifting speculative schedule traces out a positively sloped hedging schedule $H'H$. Moreover, the R^2 of the wheat regressions are at least as high as the R^2 of the simple regressions of $\bar{r}_{ij.}$ on quote number j (cf. (12) and Table 1).

22 The bars denote the average of the log and not the log of the average. This introduces a slight difference between (18) and (21).

TABLE 5.—SELECTED STATISTICS FOR REGRESSIONS OF AVERAGE SEASONAL FUTURES PRICE INDEX ON SHORT AND LONG HEDGING COMMITMENTS BY FUTURES WHEAT, CORN, AND SOYBEANS, 1952–62

$$\bar{r}_{tj.} = c_{0t} + c_{1t} \log \bar{x}_{j.} + c_{2t} \log \bar{y}_{j.}, \quad j = 1, \ldots, J_t$$

Commodity and future	Short hedging coefficient $c_{1t} \times 10^2$	t-ratio	Long hedging coefficient $c_{2t} \times 10^2$	t-ratio	R^2	R^2 for linear quote regression, Table 1	Sample size J_t
WHEAT							
July	6.973	4.290	−10.13	−2.925	.536	.341	20
September	7.580	3.143	−19.46	−3.513	.454	.747	18
December	4.062	1.832	−11.95	−2.511	.296	.267	20
March	7.573	7.175	−11.38	−7.201	.795	.708	18
May	−0.243	−0.193	−4.31	−2.404	.632	.627	19
CORN							
September	4.443	3.331	−0.579	−.279	.501	.657	19
December	5.003	3.825	−7.501	−4.000	.656	.871	19
March	−4.800	−4.687	−9.024	−5.705	.831	.951	18
May	−5.859	−5.316	−4.101	−.985	.691	.883	18
July	−2.655	−1.816	5.978	2.483	.408	.623	18
SOYBEANS							
September	−4.652	−3.195	−3.133	−.949	.555	.512	18
November	−1.294	−1.286	1.121	.939	.239	.311	18
January	3.653	4.842	−1.683	−.969	.669	.494	17
March	3.398	4.859	−4.974	−3.213	.815	.746	18
May	−0.982	−0.423	−14.15	−3.800	.568	.788	18
July	−11.64	−4.292	−9.743	−2.122	.556	.718	18

Regressions based on (18) do not exploit the additional information in the data about the annual variability of the hedging seasonals. To assess this information we turn to estimates of (20) shown in Table 6. Of the 16 short hedging coefficients, 15 are positive, not negative as predicted by the hedging pressure theory, and the one exception, May wheat, has a t-ratio of only −.4! Nine out of 16 long hedging coefficients are negative (although the t-ratio of one is only −.3). Of the 7 positive long hedging coefficients only 2 have t-ratios above 2.5. In contrast, of the 9 negative coefficients, 5 have t-ratios over 2.9. Clearly, these results strongly contradict the hedging pressure theory.

Charts 1–4 show the relation between the hedging seasonal and $\bar{r}_{tj.}$. The solid dot represents $\bar{r}_{tj.}$, and the hollow dot represents the right side of equation (21). The vertical distance between the hollow and the solid dot measures the effect of the hedging seasonal on the deflated futures price. When the seasonal hedging index is net short and greater than one (so that short hedging is above its average level over the season), the solid dot is above the hollow dot. See, for instance, the May soybean contract from the middle of October to the early part of April. When the seasonal hedging index is net short and below its annual mean, the hollow dots are above the solid ones. See the March soybean contract from the beginning of June to the beginning of October. Hence net short hedging tends to raise and net long hedging to lower the seasonal futures index.

Table 6 gives the partial correlation coefficients for the set of all the dummy

TABLE 6.—SELECTED STATISTICS FOR INTRA-YEAR REGRESSION OF SEASONAL FUTURES PRICE INDEXES ON QUOTE DUMMY VARIABLES, AND SHORT AND LONG HEDGING COMMITMENTS BY FUTURE, WHEAT, CORN, AND SOYBEANS, 1952–62

$$r_{tjt} = \sum_{j=1}^{J_t} b_{0tj}\delta_j + b_{1t}\log x_{jt} + b_{2t}\log y_{jt}\,, \quad \begin{matrix} t = 1, \ldots, T \\ j = 1, \ldots, J_t \end{matrix}$$

Commodity and future	Short hedging			Long hedging			Partial r of combined dummy effects	Sample size $T\ J_t$
	$b_{1t} \times 10^2$	t-ratio	partial r	$b_{2t} \times 10^2$	t-ratio	partial r		
WHEAT								
July	1.347	.466	.033	-10.41	-4.303	-.292	.295	220
September	9.050	3.220	.235	-1.739	-.997	-.074	.409	198
December	13.86	6.293	.408	1.795	1.163	.082	.520	220
March	9.409	4.110	.294	1.956	1.351	.101	.423	198
May	-1.400	-.433	-.031	-5.318	-2.926	-.209	.162	209
CORN								
September	9.357	4.428	.307	-6.524	-3.968	-.278	.262	209
December	13.45	8.738	.537	5.511	3.685	.259	.574	209
March	13.23	8.355	.531	-.365	-.302	.023	.666	198
May	9.208	4.985	.350	-6.835	-5.442	-.378	.557	198
July	7.477	3.177	.232	-8.256	-5.968	-.408	.495	198
SOYBEANS								
September	9.085	3.805	.274	-4.549	-2.363	-.174	.369	198
November	3.685	2.339	.173	-2.050	-1.278	-.095	.265	198
January	6.780	4.745	.344	.493	.235	.018	.231	187
March	12.65	7.065	.468	5.125	2.489	.183	.500	198
May	29.65	10.393	.615	4.608	1.546	.115	.579	198
July	36.06	8.240	.525	8.351	2.267	.167	.584	198

variables. This partial correlation coefficient measures the effect of the dummy variables on the seasonal variation of the futures price index. The larger is the partial correlation coefficient, the greater is the contribution of the dummies toward explaining the seasonal variation of the futures prices. Hence the size of the partial correlation is an indication of the failure of the hedging variables to account for all of the seasonal variation of the futures prices. It is a fair summary of these results to say that the dummies are not more important than the hedging variables in explaining the seasonal variation of the futures prices.

There are three theoretical conclusions implied by the findings reported in Tables 5 and 6. These empirical results show that the regression coefficient of the futures price index on the short hedging index is positive and that the regression coefficient of the futures price index on the long hedging index is negative. Hence the first theoretical conclusion is to reject the hypothesis of an imperfectly elastic supply of risk-averse speculation, for short, the hedging pressure theory, because this theory implies empirical results contradicted by the evidence. However, two other hypotheses are compatible with the evidence. First, speculators *prefer* risk. If speculators do prefer risk then they are willing to pay for risk bearing. In terms of Chart 9 this would imply that $S_2'S_2$ lies *below* $S_0'S_0$ to the right of the origin, and that $S_1'S_1$ lies above $S_0'S_0$ to the *left* of the origin.

Such a hypothesis predicts a positive short hedging and a negative long hedging coefficient as observed. Equally consistent with the empirical results is the hypothesis that the speculators' schedule are relatively more volatile than the hedging schedule $H'H$. Hence the regressions identify $H'H$ instead of the speculators' response to risk. That is, an increase in speculation drives up the futures price which induces more short hedging and less long hedging. Conversely, a reduction in long speculation lowers the futures price which induces less short and more long hedging. Although the regressions indicate the hedging response to futures prices, according to the latter interpretation, they do not reveal the nature of the speculators' preferences of risk. On the basis of the empirical results reported in Tables 5 and 6 it does not appear possible to me to decide which of the latter two hypotheses is correct—the speculators *prefer* risk or merely that the speculative schedule is more volatile than the hedging schedule so that the regressions identify $H'H$.

IV. THE INFLUENCE OF STOCKS AND HEDGING ON THE RELATIVE BASIS

So far we have examined the relation between the seasonal pattern of hedging and of futures prices. We now study how year to year changes in stocks, short hedging, and long hedging affect the ratio of the spot to the futures price, a ratio I call the *relative basis*. As shown below, the relative basis is closely related to the Sraffa-Keynes own-interest rate.

The consequences of exogenous shifts in the speculative and hedging schedules, $S_0'S_0$ and $H'H$ in Chart 9 are straightforward. Assume there is an exogenous increase in net speculative purchases of futures. This tends to drive up the futures price relative to the spot price, and by increasing the return to short hedges induces a larger amount. Similarly, an exogenous increase in speculative sales of futures lowers the futures price which increases the return to and therefore the amount of long hedging. Regardless of the speculators' attitudes toward risk, shifts in the speculators' excess demand for futures generates points along the hedging schedule $H'H$. These imply an inverse relation between the relative basis and short hedging and a direct relation between the relative basis and long hedging.

Similarly, an exogenous increase in short hedging lowers and an exogenous increase in long hedging raises the current futures price. Hence exogenous shifts of $H'H$ generate points along the speculators' schedule $S_0'S_0$.

If one wishes to estimate the slopes of the speculators' and hedgers' schedules, it is necessary to isolate the sources of exogenous shifts. Moreover, one requires exogenous factors peculiar to the various groups of traders. Exogenous variables that affect both hedgers and speculators cannot determine the slopes of their respective schedules. In addition, equally frequent and large exogenous shifts of both the speculators' and hedgers' schedules imply the absence of any systematic relation between the relative basis and hedging commitments.

A readily measurable exogenous variable is the initial stock S_t. In the previous section I argue that S_t affects both the hedging and the speculative schedules. Hence a priori it is not an exogenous variable that permits estimation of the slopes of these schedules. The geometry of Chart 9 and the analysis of the consequences of a larger initial stock, for example, do not imply a clear-cut relation between the initial level of stocks and the relative basis. All one can conclude is that if S_t is larger, then both the spot and the futures prices must be lower. If in addition the amount of stocks held for future consumption is larger then the spot price must decrease more than the futures price.

A good candidate for a variable that shifts the hedging and not the speculative schedule would seem to be one which affects the stockholders' risk. Assume we could measure such a variable and that stockholders believe that it is riskier to hold stocks. We wish to determine whether this would permit estimation of the speculative schedule.

If stockholders believe it is riskier to hold stocks, then not only would they sell more futures, thereby covering more of their stocks by short hedging, but also they would reduce their inventories. Hence they sell stocks, depressing the spot price. In the aggregate the attempt of the stockholders to reduce their inventories is successful to the extent that the lower price stimulates more consumption. If consumption is sufficiently price elastic, then stockholders could decrease their inventories by the desired amount without increasing the amount of their hedges. Indeed it may even be possible for the stockholders to *reduce* their outstanding hedges because they have less stocks. Thus for sufficiently price elastic consumption, there would be a decrease in stocks, no change, or possibly a decrease of short hedging, and a fall of the spot price relative to the futures price. If, however, the response of consumption to the lower spot price is too small to reduce stocks to the level desired in the aggregate, then those holding stocks would sell more futures contracts in order to increase their hedge protection. The combined effect of the stockholders' actions changes the speculators' expectations. Thus the rise of current consumption supplied out of existing inventories means less consumption and higher spot prices in the future. Speculators would anticipate this, and at the prevailing futures price they would attempt to buy more futures, which drives up the futures price. Simultaneously, there is a larger supply of short contracts from the inventory-holding short hedgers. The net effect is little if any change in the futures price and an increase of the net long futures commitments. The increase in short hedging is accommodated by a fall in the spot price relative to the futures price. Since the futures price is about the same as before and spot prices are expected to be higher in the future, net long speculators can expect a larger profit. The final result of these forces is a decrease in stocks held for subsequent consumption, a rise in short hedging, and a fall in the ratio of the spot to the futures price. Hence the coefficient of short hedging with respect to the relative basis ought to be negative.

But this is also the prediction of the theory which asserts that the hedging schedule remains constant while the speculators wish to buy more futures contracts at a given futures price. The consequent rise in the return to short hedging induces a larger amount of short hedging and this would imply a negative coefficient of short hedging with respect to the relative basis. Thus whether stockholders perceive more risk or speculators increase their demand for futures exogenously, there is the same inverse relation between short hedging and the relative basis.

Does a similar argument apply to long hedging? Is it true that a belief of greater risk by those who have made forward sales, the holders of *negative* inventories, sets in motion a train of events paralleling the short hedging sequence? If so, then we would obtain the same relation between the relative basis and long hedging whether the speculators' schedule shifts or there is a change in the amount of risk as perceived by forward sellers.

I have argued above that long hedging is risk increasing to negative inventory holders as compared with the alternative of immediate purchase of the goods to satisfy the requirements of the forward sales.

If long hedging does increase risk and if forward sellers believe that risks are greater, then there will be less long hedging and more purchases of stocks to fulfill the forward contract. Hence the spot price rises and the futures price falls thereby increasing the relative basis. Since there is less long hedging, the coefficient of the relative basis on long hedging is negative if long hedging increases risk, assuming a constant speculators' schedule and a given amount of forward sales (a given amount of negative inventories).

We now drop the latter two assumptions, one at a time. Consider first the speculators' reactions to these events. Under normal conditions it is expected that in the future there will be a given quantity of stocks and a rate of consumption compatible with the normal spot price. If the perception of more risk by the forward sellers leads them to buy more stocks immediately than otherwise, and if forward sales are the same, then subsequently more stocks will be available for consumption and the spot price will be correspondingly lower. Hence at the presently quoted futures price, speculators will desire to sell futures because they expect a lower spot price to prevail in the future. The speculators' sales depress the futures price and consequently lower the cost of long hedging. This stimulates some increase in long hedging and reduces the forward sellers' immediate demand for stocks. However, the secondary reaction of long hedgers to the speculators' sales cannot entirely undo the initial effect of the larger demand for immediate stocks to cover the forward sales because of a belief in greater risk. Hence taking the speculative reaction into account does not alter the conclusion that the perception of greater risk by forward sellers increases the relative basis and reduces the amount of long hedging, assuming a constant amount of forward sales.

Finally, let us drop the assumption of a constant amount of forward sales. The belief of greater risk tends to reduce the amount of forward transactions because these are risk increasing to both parties. Forward transactions commit the parties thereto to definite actions regardless of subsequent events. Forward sellers can attempt to avoid the increased risk by immediate acquisition of stocks but this drives up the spot price which raises costs. Forward buyers can attempt to shift risk onto their customers by selling more forward to their customers who will be reluctant to increase their forward purchases save at a lower price. Ultimately, neither the forward buyers nor the sellers can escape the conseqeunces of their belief of increased risk. Their attempts to do so reduce the amount of their forward transactions. Hence there is less long hedging and stocks immediately demanded, less upward pressure on the spot price, less speculative bearishness, and a smaller relative basis. If the reduction in forward transactions is large enough, there may be no net effect on the relative basis and a reduction in long hedging commitments. Hence the coefficient of the relative basis on long hedging can be negative and close to zero after all adjustments occur.

Nevertheless there remains one parallel with short hedging. A fall in the futures price because of an exogenous increase in speculators' bearishness increases the return from long hedging and, therefore, induces an increase in the amount. This would make a positive coefficient of the relative basis on long hedging. We now turn to the empirical findings.

The empirical results are estimates of the function relating the relative basis to four variables as follows: stocks, a measure of government held stocks, short hedging, and long hedging. Let

S_{jt} = amount of stocks in year t at quote j
G_{jt} = fraction of stocks in the government price support program[23]
X_{jt} = short hedging
Y_{jt} = long hedging
β_{ijt} = the relative basis between the futures price for the *ith* contract and the spot price.

The regressions are of the form

(22)
$$\beta_{ijt} = A_{0ij} + A_{1ij} \log S_{jt} + A_{2ij} G_{jt} + A_{3ij} \log X_{jt} + A_{4ij} \log Y_{jt}.$$ [24]

The stock data are available by quarters. There is a separate regression fitted to the annual data by quarters. Hence the number of observations per regression equals the number of years for which I have the data. In every quarter there is a separate regression for every basis and there is one basis for each future.

The relative basis is defined as follows:

(23)
$$\beta_{ijt} = p_{jt}(1 + \rho_{jt})/f_{ijt}$$

where

p_{jt} = spot price for quote j in year t
f_{ijt} = futures price for contract i
ρ_{jt} = 4–6 month Price Commercial Interest Rate.

This choice of definition is guided by the Sraffa-Keynes theory of the own-interest rate.[25] It follows from their theory that a short hedge is equivalent to *borrowing* the physical good for a limited time as determined by the remaining life of the futures contract in which the hedge is placed. Similarly, the sale of

[23] I am grateful to Mr. H. R. Goldstein, of the Agricultural Stabilization and Conservation Service, U. S. Department of Agriculture, for kindly making available to me monthly figures on the quantities of wheat, corn, and soybeans under loan and in inventory.

[24] The use of the fraction of stocks under government support instead of the log of government stocks is partly due to the fact that sometimes the government held very little or no stocks so that the log is either undefined or badly behaved. I rely on the following argument for using the fraction. Let S_1 represent total stocks and S_2 free market stocks. Then government stocks are $S_1 - S_2$.

$$\log (S_1 - S_2) = \log S_1 (1 - S_2/S_1) = \log S_1 + \log (1 - S_2/S_1).$$

The latter is approximately G as follows from the Taylor expansion of $\log (1 - S_2/S_1)$.

[25] For a complete discussion see *14,* Chapters 13 and 17. Keynes attributes the relation to Sraffa on p. 223.

the spot commodity accompanied by the purchase of futures is equivalent to *lending* the physical goods. Consider the following numerical example. Let a bushel of wheat be sold by its owner at a spot price of $2.00 per bushel. Let the proceeds be invested for 12 months at the interest rate of 6 per cent. If the futures price for delivery in 12 months is $1.90, then the seller of the spot wheat can obtain 2.12/1.90 bushels of wheat in 12 months in return for giving up one bushel today. Hence the own-interest rate on a wheat loan in terms of wheat is 11 per cent. If the futures price is above the spot price, then the own-interest rate can be negative. The expression in (23) is 1 plus the own-interest rate.

The regression coefficient of X_{jt} will be negative if more stocks are "borrowed," that is, short hedged, the lower the own-interest rate. Similarly, the coefficient of long hedging, Y_{jt}, will be positive if more stocks are "lent" at higher own-interest rates.

The coefficient of stocks will be negative if more stocks are held for subsequent consumption the larger the amount of stocks initially available. There is an ambiguity about the stock figures, however, because at certain times during the year, consumption and stocks are highly correlated. The higher the rate of consumption for a given amount of stocks, the greater is the convenience yield of the stocks and the larger is the own rate of interest that a firm would be prepared to forego for the sake of keeping stocks. Therefore, depending on the correlation between stocks and consumption, there will be a positive instead of a negative regression coefficient of stocks. This is troublesome because the relevant consumption figure is the expected rate of consumption which can hardly be measured better than by the amount of stocks held.[26]

The government price support program also affects the relative basis. Some government stocks are held as collateral for price support loans to farmers, and the balance is owned by the government. Farmers can redeem their price support collateral by repaying their loans before a given day in the crop year. There is incentive to do so if the market price rises sufficiently above the support price. If this happens, stocks under loan reenter free market supplies. Stocks owned by the government can be sold at the discretion of the authorities but only at a price not less than the government's acquisition price plus storage cost. Therefore, one unit of government stocks is roughly equivalent to a fraction of a unit of free market stocks as measured by its effect on the relative basis. Hence given S_{jt}, the larger is G_{jt}, the smaller is free market supplies. It follows that the sign of the coefficient of G_{jt} should be the opposite of the sign of the stock coefficient.

Owned and loaned stocks have different effects on the relative basis according to the season. If the crop is large, loaned stocks are likely to remain in the government's hands. Hence the relative basis will depend on free market supplies and long and short hedging commitments. However, in years of small crops relative to demand, loan stocks give the farmers an opportunity to speculate on a price rise while the government fixes a minimum price. In such years stocks may

[26] For an exposition of the convenience yield theory see *20*. The concept of convenience yield on stocks seems to have been introduced in a series of important articles on futures trading in the *Review of Economic Studies* in the late 1930's. See *1*; *3*; *8*; *12*; *13*. It was subsequently used by Working (*28*), to explain his earlier empirical results relating the stock of wheat to the spread between the July and September futures contracts. The reader can consult with profit Keynes' analysis of the essential properties of interest and money (*14*).

TABLE 7.—REGRESSIONS OF THE RELATIVE BASIS ON STOCKS, THE FRACTION OF GOVERNMENT HELD STOCKS, SHORT HEDGING AND LONG HEDGING BY QUARTERS AND BY FUTURE, 1952–63, WHEAT, CORN, AND SOYBEANS[a]

$$\beta_{ijt} = A_{0ij} + A_{1ij} \log S_{jt} + A_{2ij} G_{jt} + A_{3ij} \log X_{ijt} + A_{4ij} \log Y_{ijt}$$

Commodity quarter future	A_{0ij} t-ratio	A_{1ij}[b] t-ratio	A_{2ij}[b] t-ratio	A_{3ij}[c] t-ratio	A_{4ij}[c] t-ratio	R^2	S.E.	$\bar{\beta}_{ij.}$
WHEAT[d]								
July quarter		Z–6	Z–7					
July	1.393	.0331	–.0444	–.0978	–.159	.684	.0226	1.081
	11.592	.417	–1.126	–1.234	–2.713			
September	1.392	.0147	–.0434	–.0835	–.160	.657	.0241	1.064
	10.860	.174	–1.032	–.987	–2.568			
December	1.438	–.0161	–.0469	–.0647	–.190	.743	.0228	1.037
	11.835	–.201	–1.176	–.807	–3.208			
March	1.553	–.0838	–.0451	–.0205	–.237	.831	.0215	1.023
	13.545	–1.109	–1.200	–.271	–4.250			
October quarter		Z–2	Z–5					
December	.984	.236	–.134	–.133	–.250	.713	.0353	1.077
	1.245	.759	–.651	–1.077	–3.281			
March	1.146	.191	–.102	–.164	–.248	.705	.0378	1.056
	1.352	.573	–.459	–1.240	–3.032			
May	1.392	.120	–.017	–.196	–.246	.729	.0381	1.061
	1.630	.358	–.079	–1.468	–2.991			
July	1.484	.151	.124	–.275	–.298	.772	.0440	1.113
	1.505	.388	.480	–1.779	–3.136			
January quarter		Z–2	Z–3					
March	1.403	–.100	.015	.099	–.162	.741	.0335	1.068
	2.540	–.539	.141	.914	–3.798			
May	1.705	–.149	.090	–.019	–.138	.744	.0308	1.080
	3.350	–.874	.897	–.191	–3.513			
July	2.122	–.175	.273	–.226	–.150	.767	.0442	1.145
	2.912	–.717	1.907	–1.584	–2.658			
September	2.138	–.185	.265	–.227	–.145	.783	.0412	1.132
	3.147	–.810	1.983	–1.702	–2.762			
April quarter		Z–2	Z–3					
May	2.374	–.433	.219	.0792	–.149	.731	.0331	1.085
	4.531	–2.301	1.974	1.277	–3.694			
July	2.141	–.250	.266	–.162	–.115	.670	.0540	1.160
	2.502	–.812	1.467	–1.605	–1.742			
September	2.167	–.262	.270	–.162	–.118	.676	.0539	1.147
	2.538	–.853	1.492	–1.606	–1.796			
December	2.276	–.311	.285	–.149	–.124	.680	.0533	1.121
	2.695	–1.024	1.594	–1.495	–1.917			

TABLE 7.—(Cont.)

Commodity quarter future	A_{0ij} *t*-ratio	A_{1ij}[b] *t*-ratio	A_{2ij}[b] *t*-ratio	A_{3ij}[c] *t*-ratio	A_{4ij}[c] *t*-ratio	R^2	*S.E.*	$\bar{\beta}_{ij}$.
CORN[e]								
July quarter		*Z–2*	*Z–5*					
July	1.311	–.104	.137	–.0235	.0312	.283	.0226	1.046
	2.522	–.514	.674	–.674	1.163			
September	1.228	–.0354	.103	–.108	.0308	.585	.0274	1.052
	1.945	–.143	.420	–2.550	.946			
December	2.268	–.396	.518	–.159	.0306	.683	.0431	1.094
	2.288	–1.023	1.339	–2.404	.597			
March	2.335	–.427	.509	–.154	.0297	.681	.0441	1.062
	2.303	–1.078	1.287	–2.274	.567			
October quarter		*Z–2*	*Z–5*					
December	2.420	–.583	.459	–.0679	.155	.712	.0517	1.123
	4.726	–2.069	1.152	–.797	2.238			
March	2.420	–.574	.411	–.0767	.148	.738	.0510	1.087
	4.790	–2.068	1.044	–.913	2.166			
May	2.449	–.567	.357	–.0873	.137	.768	.0503	1.066
	4.917	–2.072	.921	–1.053	2.032			
July	2.471	–.547	.285	–.108	.125	.793	.0506	1.052
	4.932	–1.986	.731	–1.291	1.836			
January quarter		*Z–6*	*Z–7*					
March	2.610	–.429	.674	–.138	.0386	.522	.0252	1.016
	2.318	–1.192	1.817	–1.685	.711			
May	2.795	–.479	.838	–.161	.0266	.566	.0267	.994
	2.338	–1.253	2.127	–1.852	.461			
July	2.546	–.382	1.061	–.208	–.0068	.597	.0294	.978
	1.940	–.912	2.455	–2.186	–.108			
September	1.776	–.107	1.195	–.268	–.0727	.656	.0311	.989
	1.279	–.241	2.614	–2.656	–1.085			
April quarter		*Z–6*	*Z–7*					
May	1.201	–.0533	.247	–.0578	.0213	.182	.0332	1.020
	1.083	–.145	.706	–.803	.443			
July	1.236	–.0607	.286	–.0849	.0239	.189	.0376	.999
	.985	–.146	.722	–1.043	.438			
September	.935	.0653	.273	–.136	.0093	.252	.0449	1.006
	.623	.131	.576	–1.396	.143			
December	1.151	.0359	.385	–.202	.0042	.366	.0523	1.039
	.659	.062	.698	–1.786	.056			

TABLE 7.—(Cont.)

Commodity quarter future	A_{0ij} *t*-ratio	A_{1ij}^{b} *t*-ratio	A_{2ij}^{b} *t*-ratio	A_{3ij}^{c} *t*-ratio	A_{4ij}^{c} *t*-ratio	R^2	*S.E.*	$\bar{\beta}_{ij}$.
SOYBEANS[f]								
October quarter		*Z*–2	*Z*–5					
November	1.023	–.0086	.0048	–.0353	.0574	.142	.0419	1.042
	9.207	–.182	.095	–.315	.803			
January	1.034	–.0075	.0058	–.0501	.0505	.149	.0419	1.027
	9.310	–.158	.113	–.448	.706			
March	1.057	–.0022	.0049	–.0753	.0451	.184	.0411	1.015
	9.701	–.047	.099	–.686	.644			
May	1.095	.0023	.0089	–.1024	.0331	.240	.0412	1.009
	10.03	.050	.179	–.931	.472			
July	1.146	.0071	.0126	–.1329	.0206	.323	.0418	1.012
	10.33	.149	.247	–1.189	.288			
January quarter		*Z*–2	*Z*–5					
January	.669	.1815	.0834	–.0697	.0068	.676	.0215	1.036
	4.330	2.093	.519	–1.659	.190			
March	.731	.1565	.1054	–.0756	.0040	.756	.0158	1.024
	6.412	2.447	.889	–2.439	.152			
May	.849	.1015	.1502	–.0721	.0084	.757	.0135	1.018
	8.762	1.868	1.491	–2.736	.378			
July	.971	.0598	.1911	–.0809	.0067	.788	.0124	1.023
	10.87	1.194	2.058	–3.332	.324			
September	1.717	–.3142	.5089	.0306	.0532	.678	.0265	1.084
	9.004	–2.937	2.566	.590	1.212			
April quarter		*Z*–2	*Z*–5					
May	.671	.1909	–.1005	–.0782	.0460	.823	.0152	1.034
	4.875	2.264	–1.049	–3.137	1.400			
July	.600	.2635	–.2019	–.1286	.0374	.824	.0205	1.036
	3.243	2.322	–1.566	–3.834	.846			
September	2.120	–.5450	.1383	.1347	.0708	.573	.0638	1.117
	3.672	–1.540	.344	1.288	.514			
November	2.635	–.7984	.2181	.2058	.0661	.648	.0802	1.146
	3.634	–1.797	.432	1.566	.382			
January	2.632	–.7965	.2138	.1966	.0636	.659	.0784	1.131
	3.712	–1.833	.433	1.530	.376			
July quarter		*Z*–2	*Z*–5					
July	.974	.0556	–.0973	–.0035	–.0063	.164	.0351	1.052
	3.765	.327	–.709	–.052	–.133			
September	2.173	–.6313	.1725	.1056	.0157	.576	.0847	1.117
	3.479	–1.538	.520	.661	.137			
November	2.526	–.8290	.2098	.1384	.0254	.640	.0990	1.142
	3.461	–1.728	.542	.741	.190			
January	2.522	–.8358	.2164	.1403	.0220	.641	.0992	1.124
	3.450	–1.740	.558	.750	.164			
March	2.488	–.8241	.2058	.1310	.0327	.654	.0968	1.111
	3.488	–1.758	.544	.718	.251			

re-enter the free market toward the end of the crop year. The available data, however, do not allow refined estimates of the effects of the price support program on the relative basis; the regressions in Table 7 represent the best results for the given sample.[27]

The empirical results depend on which spot price is used to calculate the relative basis. Spot prices refer to particular grades at given locations while futures prices respond to the effects of transactions in many qualities at many locations. Two kinds of spot prices show this: first, spot prices at specific markets for specific grades and, second, spot prices averaged over several grades and locations. A good example of the latter is the average price received by farmers as calculated by the U. S. Department of Agriculture. It is comparable to the futures prices because both depend on widespread market forces. Spot prices of a given grade at a given market are more closely related to futures prices when a large volume of spot trading and hedging originates in the given spot market. We shall observe examples of these phenomena in some corn regressions.[28]

Table 7 gives the empirical results. First, consider the short hedging coefficients. Fourteen out of 16 wheat coefficients are negative, all 16 corn coefficients are negative, and 12 out of 20 soybean coefficients are negative. Turning to the stock coefficients we find for wheat 10 out of 16 negative, for corn 14 out of 16 negative, and for soybeans 11 out of 20 negative. However, the January and April quarters in soybeans have 6 positive stock coefficients out of 10. As argued above, the positive coefficients in these particular quarters may be due to the relatively higher correlation between stocks and consumption at this time of the soybean crop year especially because in soybeans there were relatively little government stocks.

Since the stock coefficients are generally negative, we expect the coefficients of

[27] I tried a few alternatives depending on whether government owned inventories should be included in total stocks and the regressions in Table 7 represent in most cases the best out of three or four experiments.

[28] The October corn regressions use the spot price at the Chicago Board of Trade while all the other corn regressions use the USDA average price received by farmers. The Board of Trade spot price gave much better fits for the October regressions and was much worse in other quarters. I conjecture that in the early part of the corn crop year, Chicago is a more important spot market and this explains the goodness of fit. I also used USDA average price received by farmers for the soybean regressions and found that the results were hardly affected except for one important feature. The USDA price series led to coefficients of long hedging that were positive and had larger t-ratios.

Notes to Table 7

[a] All stock and hedging figures are in millions of bushels.

[b] Different stock and G concepts are used in different quarters. These are indicated as follows:

Z–2 = total stocks on-farms and off-farms.
The Agriculture Department has discontinued publication of series giving a breakdown of stocks by location making the use of their crude measure a necessity.

Z–6 = total stocks less Commodity Credit Corporation (CCC) owned inventory. Thus Z–6 is free market stocks plus stocks under price-support loans.

Z–5 = CCC owned and loaned stocks as a decimal fraction of Z–2.

Z–3 = CCC owned stocks as a decimal fraction of Z–5.

Z–7 = CCC stocks under price-support loans as a decimal fraction of Z–6.

[c] Reported hedging commitments.

[d] The spot price used to calculate the basis is the USDA average price received by farmers.

[e] The spot price is the USDA average price received by farmers except in October when the price of No. 3 Yellow at the Chicago Board of Trade is used.

[f] The spot price is for No. 1 Yellow at the Chicago Board of Trade.

G to be positive. This is true in 17 out of 20 soybean cases and is true without exception for corn. However, only 9 out of 16 wheat coefficients are positive as anticipated and all of the exceptions occur in the January and April quarters. It should be noted that the July 1 wheat stock figures exclude the new crop wheat available for use on the date while the G figures include price support loans on new crop wheat. Hence, especially in July the G figure is more closely related to the actually available stocks than are the officially reported stock figures. The same argument ought to apply to corn and soybeans in October because on that date the official stock figures also exclude new crop supplies. Nevertheless the signs of the G and S coefficients agree with theoretical prediction. This is probably because the government price support program is relatively more important for wheat than it is for corn and is certainly least important for soybeans.

Now consider the long hedging coefficients. Without exception for wheat all 16 long hedging coefficients are negative and have large t-ratios. In corn, however, 14 out of 16 long hedging coefficients are positive and except for the October quarter all the t-ratios are small. Similarly, all but one of the soybean long hedging coefficients are positive and all of the t-ratios are small.[29]

All of these results fall into a definite pattern except for long hedging. It is argued above that the negative short hedging coefficients are consistent with the hypothesis that the speculators' schedule changes exogenously causing the holders of inventories to respond by varying the amount of short hedging directly with the expected return. The empirical findings in Table 7 thus support one of the major conclusions of the preceding section that short hedgers respond to futures prices so as to increase their returns from hedging (or, equivalently, reduce the cost of hedging).

Perhaps the most important conclusion from the regressions in Table 7 is the strong showing of the short hedging variables in all cases. These results are much better than the relations between stocks and spread heretofore estimated.[30] In the Sraffa-Keynes theory short hedges represent borrowed stocks and the relative basis is the own rate of interest. Hence my empirical results show that the amount of borrowed stocks varies inversely with the own-interest rate and that the supply of loans, the resultant of the speculative activity, traces out the demand for "borrowing."

The long hedging coefficients do not present as uniform a pattern of results for the three commodities because, although the wheat coefficients are significantly negative, both the corn and soybean coefficients are positive albeit not significantly so. Negative long hedging coefficients imply that the long hedging schedule is less stable than the short speculative schedule. Small positive long

[29] See, however, the remarks in the preceding footnote.

[30] Professor Working was the first to estimate relations between the carryover and the difference between the last old crop and the first new crop futures using wheat data. For references to his studies and related material see *20*. My article gives regression estimates of stock spread relations for both cotton and wheat using stocks by quarters for wheat and at selected dates for cotton and spreads between the nearest and the next futures contract (see my Tables 7 and 8). In addition I introduced a measure for consumption to get at the convenience yield. My present results indicate that the empirical relation is clearer between hedging, long and short, and the relative basis, that is, the ratio of the spot to the futures price. Contrary to Professor Working, I believe it is very important to verify and extend empirical relations. For Working's opinion see *27*, p. 456. Houthakker and I also stressed the importance of the relation between hedging and the basis in unpublished Cowles Commission Discussion Papers in 1953.

hedging coefficients imply that the short speculative schedule is more variable than the long hedging schedule. The complete set of results is consistent with the hypothesis that long hedging is risk increasing and partakes of many of the characteristics of speculation itself.

However, there is a variable omitted from these regressions that is of particular relevance to long hedging. This omitted variable is the forward sales (= negative inventories). The effect of leaving this variable out of the regression depends on the relation between the relative basis and forward sales, assuming that forward sales and long hedging are positively correlated. If forward sales increase as the relative basis increases, then the observed long hedging coefficient is algebraically too large. Hence introduction of forward sales would make the long hedging coefficient algebraically smaller. Therefore, the positive long hedging coefficients for corn and soybeans would possibly become negative while the negative wheat long hedging coefficients would remain negative. However, if forward sales and the relative basis vary inversely, then the inclusion of this variable would increase the long hedging coefficients algebraically. It is difficult to say what relation to expect between forward sales and the relative basis. As the relative basis increases, forward sellers become more eager while forward buyers become less eager. The observed coefficient of the relative basis on long hedging would depend on the resultant of these two forces.

Another point about long hedging is of some importance. If long hedging is risk increasing, then the difference between the wheat long hedging coefficients and the corn and soybean coefficients may be due to the fact that long hedging is riskier for wheat than for corn and soybeans, that is, the basis risk in long hedging is larger for wheat than for corn and soybeans. This possibility should be investigated in subsequent research on long hedging.

V. CONCLUSIONS

I have presented the results of tests of the implications of the theory that hedgers are buyers of price insurance from risk-averse speculators who must be coaxed into the futures market by the prospect of a positive expected return. I argue that short and long hedging are asymmetric because while the former is risk reducing to the holders of positive inventories, the latter is risk increasing to the holders of negative inventories. This asymmetry is the result of the economic asymmetry between the alternatives open to holders of positive and negative inventories, respectively. Positive inventory holders cannot sell all of their stocks forward because stocks "hedged" by forward sale have no convenience yield. Some stocks must be uncommitted to meet the unforeseen exigencies of demand. Hence a holder of positive inventories can obtain a convenience yield and reduce price risk by selling futures, short hedging. A holder of negative inventories has the alternatives of buying futures or buying spot to cover his negative inventory commitments. However, buying futures is riskier than buying spot to a negative inventory holder. Hence compared to the relevant alternatives, long hedging is risk increasing while short hedging is risk reducing.

An implication of this theory is that futures prices should tend to rise during the life of a contract. The data show downward trends for corn, upward trends for soybeans, and 3 downward and 2 upward trends for wheat. This pattern of results refutes the theory that hedgers pay for price insurance. The downward trend in corn futures prices seems to be related to the secular decline in corn prices during this period. Nevertheless the seasonal in the corn spot price was unaffected by this secular movement; the corn spot price seasonal displays the J-shape conducive to its storage from the end of one harvest to the beginning of the next. The upward trend in soybeans is fortuitous; it is largely due to only two extreme observations particularly for the May and July futures in 1954 and 1961. Additional tests using all of the price data in the 13 years of the sample period show a highly variable "seasonal." These results are consistent with the hypothesis that by maintaining a long position in futures one cannot expect a systematic positive return except from inflation of the general price level that is unanticipated. Therefore, the futures price can be regarded as the market expectation of subsequent spot prices.

In contrast to the absence of a systematic seasonal in futures prices, there is no doubt of the presence of a seasonal in spot prices. These seasonals measure the gross return from stockholding. The corn futures price pattern and some of the wheat futures price patterns suggest that the return from holding hedged stocks may actually have been larger than the return from holding unhedged stocks.

I also estimate the relation between futures prices and short and long hedging commitments within crop years using data for 11 years at biweekly intervals. The figures for each variable were divided by their respective averages over the period of quotation to remove "year effects." According to the hedging pressure theory the larger the short hedging commitments the larger ought to be the upward seasonal trend of futures prices. Hence the regression coefficient of the seasonal futures price index on the seasonal short hedging index ought to be negative. The results in Table 6 show that the coefficients are actually positive and significantly so. These results are consistent with two hypotheses. The first is that speculators actually prefer risk and are willing to pay for incurring risk. The second hypothesis is that short hedgers increase the amount of short hedging the larger their expected return from short hedging.

It is unnecessary to summarize the results of the regressions relating the relative basis to stocks, a measure of the government participation in the market, and the size of short and long hedging commitments because this would merely repeat the remarks at the end of the preceding section.

In general the evidence confirms the conclusions I reached in my earlier studies of futures trading. The short hedging relation is the stable and the speculative relation the volatile factor in the futures market. Speculators cannot count on receiving a positive return from a simple strategy of maintaining a long position in futures to remunerate them for their bearing the risk of price declines for the holders of inventories. Although short hedging provides price insurance, speculators seem sufficiently eager so that not only are short hedgers able to obtain price insurance cheaply, they also sometimes obtain a larger return on their hedged than on their unhedged stocks. In my opinion the futures price can be considered as an unbiased predictor of the subsequent spot price.

Long hedging has been a relatively neglected area of study. My results are consistent with the hypothesis that long hedging is risk increasing and partakes of many of the characteristics of speculation. The difference between long hedging coefficients in wheat and in corn and soybeans may be due to a relatively greater basis risk in wheat than in the latter two commodities. This possibility deserves investigation. In addition, refined study of long hedging would require data on the magnitude of forward sales.

In addition we need to measure directly the returns to the speculators to help resolve some of the conflicting views about futures trading. Except for Blair Stewart's study, which showed that speculators on average lost money, we have no direct evidence on this topic. For such information it would be necessary to have direct access to the actual financial results of speculation by class of speculators.

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