Expected Returns for Hedged Storage of Wheat in Oklahoma

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Grain elevators assist the grain marketing industry in the assembly, storage, and the distribution of the market supply of wheat. These functions are performed within a price system upon which is superimposed various Government rules and regulations arising from programs designed to implement public policies. The emphasis given to a particular Government program can have dramatic effects upon the revenues of grain elevators.

Grain elevators in Oklahoma derive much of their income from the handling and storage of grain. Some elevators also engage in sideline activities such as fertilizer and gasoline, which are not directly concerned with the grain business. These activities are of varying importance among elevators, ranging from cases in which the elevator is the principal supplier of such items in a particular locality to cases in which the income from these products or services is very small.

THE PROBLEM

The opportunity to earn income from handling wheat during a crop year is dependent upon the size of the crop and the competitive position of the firm. The income is derived primarily from the margin, or the difference between the price paid to the producer and the price which the elevator receives when the wheat is sold. An elevator seeks to maintain a margin which is sufficient to repay the variable costs associated with elevating the wheat, the fixed costs of maintaining the grain handling facilities, and a normal rate of return on the investment. Handling income may also be derived from blending and conditioning wheat.

The opportunity to earn income from storage is dependent upon the size of the elevator, the volume handled, and the storage requirements of the area, state, and nation. Many grain elevators, especially those in the Southern Great Plains, are larger than the sizes which are required solely for grain handling. This excess capacity is partially utilized by local producers who utilize the facilities of grain elevators in lieu of constructing storage of their own, and elevators receive payments for rental of the excess capacity. Other inventory owners, the Commodity Credit Corporation (CCC) in particular, also utilize this excess capacity.

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* Former graduate assistant and professor, respectively.

The individual firm has little or no control over the volume of wheat which it will handle or which it will store for other inventory owners. CCC owned inventories are illustrative of the lack of control which grain elevators have upon the income derived from storage for other inventory owners. At the beginning of the 1961 crop year, CCC owned stocks of wheat amounted to approximately 1.2 billion bushels.[1] Nearly 100 million bushels of this inventory were stored in Oklahoma.[2] At the beginning of the 1968 crop year, CCC owned stocks had declined to slightly more than 100 million bushels, of which approximately six million bushels were stored in Oklahoma.[3] The decline in CCC stocks thus has resulted in reduced opportunities for Oklahoma grain elevators to utilize excess storage capacity.

Grain elevators may utilize their facilities to store wheat which they own and exercise a degree of control over both the volume of wheat stored and the storage income. Some wheat also may be stored to facilitate the operations of the business. Storage on the elevator's account differs from storage for other inventory owners because the returns per bushel are not known in advance and the firm is exposed to considerably more risk than it would face if it engaged solely in a handling operation. This storage may entail longer periods of inventory ownership and greater costs. Given the normal price variability which occurs during the course of a crop year, the return per bushel to individual elevator operators from the storage of owned stocks may be almost random.

The use of futures markets to protect the firm against the risks of adverse price changes has long been advocated. However, several persons in the grain trade in Oklahoma have indicated a belief that futures prices do not provide a good foundation upon which hedging decisions may be based. According to this belief, futures prices are strongly influenced by the domestic demand for wheat, whereas the price of wheat in Oklahoma is strongly influenced by the price of wheat in the Gulf export market. As a consequence of the diverse characteristics of the two markets, an extremely poor relationship between the two prices may exist.

OBJECTIVES AND PROCEDURES

The first objective of this study is to investigate the contention that there is an extremely poor relationship between export prices at Gulf ports and futures contract prices. Specifically, this objective is to determine if the carrying charge, or the change in the spread between cash and futures prices during a specified period, can be predicted from the spread existing at the beginning of that period. Simple linear regression is used to establish whether or not basis changes are correlated with an initial basis and to develop predictive equations which might be utilized to fulfill the second objective.

The second objective is to estimate the average earnings from an annual practice of carrying hedged storage during specified intervals of the crop year. Allied with this objective is an attempt to estimate the average earnings from a practice of carrying hedged storage only when the predicted gross storage earnings are greater than the cost of storage. The expected frequency, or the proportion of years that profits can be expected, is also estimated.

PRICE RISKS INVOLVED IN GRAIN ELEVATOR OPERATIONS

Terminal elevators, by the nature of their functions, generally must expose themselves to price risks. Country elevators generally are able to choose whether or not they wish to place themselves in a situation in which the firm is exposed to price risks. It is theoretically possible for all grain elevators to avoid all price risk by the use of forward sales. However, this may not be an optimal strategy, especially for terminal elevators.

The most common methods utilized by country elevators to merchandise wheat are to ship it "on consignment," "to arrive," or to sell it "track country point." Of the three principal methods, only "on consignment" sales require an elevator operator to maintain inventory ownership for a relatively long period of time. "To arrive" and "track country point" sales can often be made the same day that the wheat is purchased. If "on consignment" sales are uncommon, then a systematic policy of hedging is not likely to provide any benefits to the firm. Frequent market contracts may not be economically feasible for firms which do not buy and sell large quantities of wheat each day.

Some firms (especially terminal elevators) may find that their optimum strategy is to maintain control of inventory over extended periods of time to obtain convenience yields or storage income. The convenience yield of stocks is the benefit which the firm derives from holding stock for merchandizing. This yield is derived in two ways. First, the availability of stocks may allow a firm to maintain a given level of output at a lower cost per unit than would be possible if stocks were not held. These stocks are sometimes called pipeline or working stocks. Second, maintaining stocks may allow a firm to vary the level of output at a lower per unit cost than could be achieved if the stocks were purchased as required. The second source of the convenience yield arises because fewer transactions may be required, thereby lowering purchasing costs. Also, holding stocks in excess of immediate needs allows the firm to seek the best price, possibly achieving a better deal than it could if the need to purchase stocks was urgent.[4]

Both terminal and country elevators have sufficient capacity to include the possibility of storing wheat on their own account to earn storage income. Under this strategy, the firm must assume the risks of price changes or attempt to alleviate the risks by hedging. A firm would derive benefits from hedging if the returns from hedging are, on the average, greater than or equal to the price change minus the net cost of storage. The net cost of storage is not necessarily greater than zero because of convenience yields. However, since convenience yields may be derived only from some minimum level of stocks, the convenience yield would be greater than the costs of storage only for small levels of stocks.[5]

THE ROLE OF FUTURES MARKETS IN GRAIN MARKETING

Much controversy has surrounded futures markets since their origin. Futures markets have been praised as a contributor to more orderly marketing of commodities, and condemned as a cause of excessive variations in price. The contributions of futures markets probably lie between these extreme viewpoints. Much of this controversy possibly has been caused by a lack of understanding of the role of futures markets in the marketing of commodities.

Futures Contract Prices

There are several commodity exchanges which conduct trading in wheat futures contracts. The prices of futures contracts on the various exchanges are rarely, if ever, equal. At times, there is a substantial variance in price among the exchanges. One reason for these variations of price may be found in the differences of the types and grades of wheat deliverable at the contract price on the various exchanges.

A commodity which is traded on a futures exchange should have commercially significant quantities available for delivery. If adequate supplies of a commodity are available, then arbitrage between the cash and futures markets is possible. Such arbitrage, or the threat of it, can prevent imperfections such as "squeezes," which may develop when physical supplies in deliverable positions are small in relation to the open interest.

Futures contract exchanges have attempted to insure that adequate physical supplies of wheat are available at delivery points by designating one or more types and grades of wheat as deliverable at the contract price. The types of wheat chosen by the exchanges for delivery on the contract are those which are marketed in relatively large quantities at the delivery point. The grades designated as acceptable for delivery also should constitute a substantial amount of the trading in that type of wheat. Other types and grades of wheat are also designated as acceptable for delivery, with appropriate premiums or discounts over or under the delivery grade price.

Wheat quality is continuous, but grading standards constitute a discrete scale which cannot completely describe the characteristics of a particular lot of wheat. Relatively substantial variations can exist among lots of wheat given the same rating on a grading scale. These variations are reflected in the price of each separate lot of wheat. A futures contract, however, has only one price at any point in time. If futures markets are to serve as a reliable means of price discovery, then the one price of a futures contract must be related to one set of quality characteristics. Otherwise, the price of a futures contract would be difficult to interpret.

The price of any futures contract should tend to be an evaluation of price prospects during the delivery month for types and grades of wheat deliverable at the contract price. The price usually reflects price prospects for the lowest quality of wheat which may be delivered with no penalty since this is the quality of wheat which is likely to be delivered.

If the above criteria are applied to the various futures markets, then the Kansas City futures contract price should reflect expectations concerning No. 2 hard wheat since this contract designates only hard winter wheats (Dark Hard, Hard Red, and Yellow Hard) as acceptable for delivery, with No. 2 as the grade deliverable at the contract price. The Minneapolis wheat futures contract allows deliveries of spring wheats, with No. 1 Northern Spring desigated as the contract grade. The Chicago wheat futures contract allows delivery of both hard and soft wheats. Deliverable types include winter and spring wheats, with No. 2 Hard Winter, No. 2 Red Winter, No. 2 Yellow Hard Winter and No. 1 Northern Spring designated as deliverable at the contract price.

Cash and Futures Price Relationships

Theoretical Considerations

Keynes (1930) and Hicks (1946) viewed futures contract prices as biased estimates of expected spot prices. This belief was based on the premises that: 1) no forward market can exist without speculation; 2) speculators will be willing to be net buyers of futures contracts only if the futures price is below the expected cash price; and, 3) hedgers use futures markets solely for the purpose of transferring risk. The futures price thus must be sufficiently below the expected cash price so that speculators are assured a satisfactory return. The differences between the current cash price and the current price of a futures contract therefore is a risk premium and ". . . measures the amount which hedgers have to hand over to speculators in order to persuade the speculators to take over the risks of the price fluctuations in question."[6]

The risk premium concept implies that upward secular trends are a normal characteristic of all futures markets. Specifically, since the futures contract price must be less than the expected cash price, futures prices in all markets for all commodities must display an upward trend as the delivery date approaches. The evidence accumulated to date does not support this hypothesis.[7] The trends which have been observed in futures prices have not been consistent with respect to direction, timing, magnitude or duration.

Gray (1960) has advanced the hypothesis that any trends would be due to a lack of balance in the market. "The significant requirement for balance is enough participation by speculators to balance the hedging."[8] This concept of market balance has not been proven, and it will be difficult to do so. The Commodity Exchange Authority (CEA) classifies only the contract holdings of large traders with respect to their position (speculation or hedging). Some method is needed to separate the volume of hedging and the volume of speculation by the small traders before this hypothesis can be tested. Some attempts have been made in this direction (Working, 1960; Larson, 1961). Also, much of the volume of trading classified as speculation by the CEA actually may be anticipatory hedging.[9] If this is the case, then adequate treatment of the market balance hypothesis will depend on a separation of this type of hedging from the published statistics of the CEA.

Analyses of futures contract prices have also failed to explain the frequent changes which these prices exhibit. In particular, futures prices seem to exhibit a different response at different points in time when economic conditions appear to be similar at these points in time. This characteristic of futures contract prices, combined with the failure of the risk premium hypothesis to explain changes in futures prices, lead to an inference that changes in futures prices were largely the result of pure random variation. If this is true, then changes in these prices are unwarranted and cannot be justified by price theory.[10]

The inference that changes in futures prices were largely the result of pure random variation was questioned by some researchers. The statistical tests utilized in prior research had determined that secular and cyclical variation were not essential characteristics of futures prices. However, no one had demonstrated that futures prices exhibited a complete lack of systematic characteristics. Apparent erratic behavior does not constitute such proof, since the reason for such behavior may be extremely complex. Additional research has indicated that futures prices and other prices which are determined largely on the basis of expectations exhibit close approximations to pure random walk.[11] This behavior, in contrast to pure random variation, does have economic significance (Working, 1949).

The economic significance of the discovery that futures prices exhibit random walk is that:[12]

> **Pure random walk in a futures price is the price behavior that would result from perfect functioning of a futures market, the perfect futures market being defined as one in which the market price would constitute at all times the best estimate that could be made, from currently available information, of what the price would be at the delivery date of the futures contracts.**

Random walk provides an explanation for apparently erratic price changes, but fails to provide an explanation of trends in futures prices. However, random walk does not preclude the existence of trends in a price series since this term merely denotes the absence of a *systematic* characteristic.[13]

An Example of Price Relationships—

Given that the price of a futures contract provides a reliable estimate of the expected cash price at the delivery date, the futures market at a given point in time would reflect the profile of expected prices over a future time period. An example may help to illustrate the expected relationships.

Assume that the crop year for Oklahoma wheat begins on June 1 and ends on May 30 the following year. The first futures contract in the crop year would be July. The time period is represented on the horizontal axis and price on the vertical axis of Figure 1.

Assume next that most of the wheat is harvested and available for sale in June but that consumption will occur at a constant rate in each month of the crop year. Storage, therefore, would be required to meet continuous consumption needs from the fixed stocks. Assume further that the price at Gulf ports is $1.44 per bushel in June and the costs of owning and storing the wheat are one cent per bushel per month. The actual Gulf cash price, represented by the solid line, would increase throughout the crop year by one cent per bushel per month from $1.44 in June to $1.55 on May 1. After May 1, the cash price would decline to $1.44 in June if the demand and supply relationships remained unchanged from the previous year. The exact timing of the adjustment would depend upon the amount and time of harvesting of new crop wheat and on the price relationships needed to move old crop wheat into consumption.

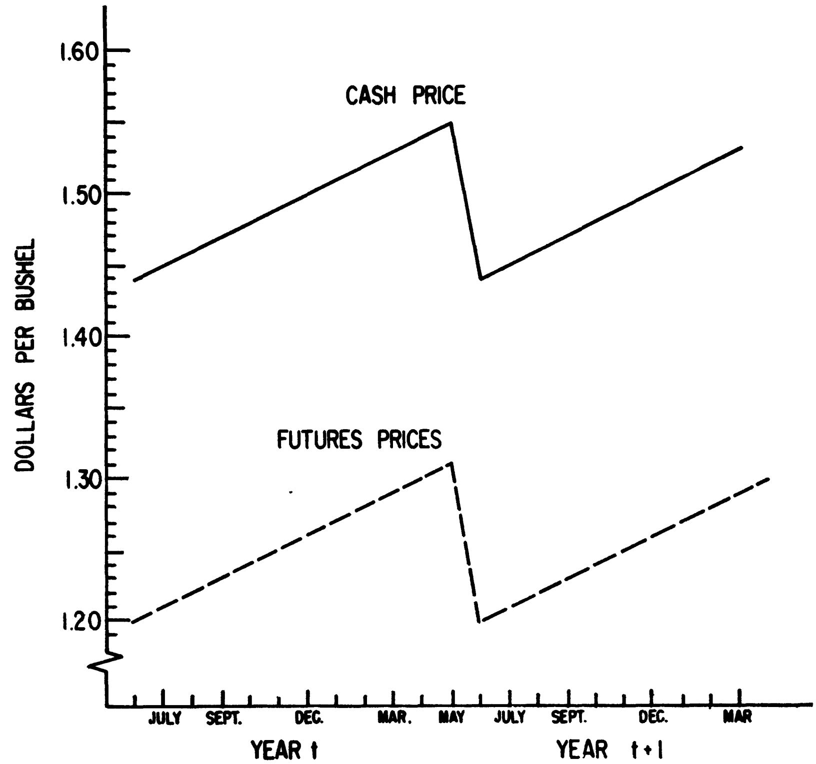

Figure 1. Hypothetical cash and futures prices of winter wheat during crop years for geographically separated markets.

The prices of futures contracts at Kansas City are used to represent the futures prices in the example. If the basic demand and supply conditions for wheat in this market are representative of the demand and supply conditions for the same kind of wheat in the cash market at the Gulf, the futures prices should reflect the storage cost of one cent per bushel per month throughout the crop year. That is, the futures prices for distant months should be higher than the near month by the amounts of storage cost and the slope of the line for futures prices should be the same as for cash prices. In addition, if a significant amount of wheat moves to market through the cash market at the Gulf, then equilibrium would be established when the price difference between the markets is equal to the transfer costs. The transfer cost, in turn, is closely related to the basis.

A basis may be defined as the futures price minus the cash price, or the cash price minus the futures price. The latter definition was selected in order that basis would be expressed in positive numbers for the markets under consideration.

The basis during a delivery month would be 24 cents under the assumptions that the transfer cost is 24 cents per bushel and the same quality of wheat is represented in each market. The December futures price, for example, would be 24 cents under the Gulf cash price in December of the same year.

The data in Figure 1 can be expressed in relative terms. The price scale of interest is not the actual prices but the price relationships. Since July is the first month in the crop year, the July cash price of $1.45 is selected as the base. All cash prices for other months are expressed as cents over July. For example, the September price would be 2 cents computed as the cash price of $1.47 minus the July cash price of $1.45. The price relationships using the new price scale of cents over July are plotted in Section A of Figure 2 for 12 months of beginning with the July price.

The futures prices, plotted in terms of the basis on the vertical axis, are shown in Section B of Figure 2. There is a constant difference of 24 cents between the cash price and the futures price in each delivery month. For example, the cash price in December is 5 cents over July and the initial basis is 19 cents. The difference between the December cash price and the December futures is 24 cents.

At a given point in time, the bases for each delivery month should reflect a profile of expected relative prices. In July, the initial basis is 24 cents for the July futures, 22 cents for the September futures, 19 cents for the December futures, 16 cents for the March futures, and 14 cents for the May futures. At a different reference point, the axes will shift and the profile will reflect prices in two different crop years. With a reference point of December, the basis for July would reflect the new crop in the futures market but the current crop in the cash market. Such a basis would have limited usefulness in the certainty conditions specified in this example because income from storage of wheat between these two time periods could not be earned.

Under the theoretical conditions and assumptions specified, there is an inverse relationship existing between the initial basis of Section B and the change in basis. The vertical scale in Section A, expressed in cents over July, is also the scale for the change in basis during the crop year. The vertical scale in Section B can be transferred to Section C by use of a 45 degree line in the lower left hand quadrant of Figure 2. The line of relationship in Section C has a negative slope and indicates the change in basis associated with the magnitude of the initial basis. For example, an initial basis of 19 cents is associated with a change in basis of 5 cents, and an initial basis of 18 cents is associated with a change in basis of 6

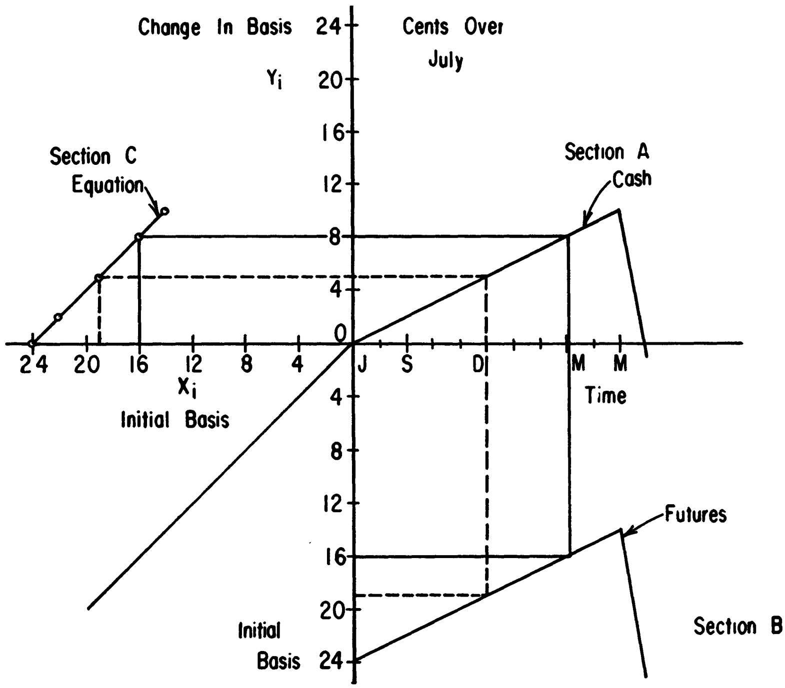

Figure 2. Hypothetical basis, cash and futures price relationships for winter wheat in geographically separated markets.

cents. The slope of this line is —1.0 and reflects the assumed storage and ownership costs.

HEDGING

Many expositions of hedging show separate computations for the price change in each market and then determine the net gain (or loss) on the transaction as the sum of the changes in the separate markets. Although this practice does determine the net gain or loss, the underlying principle of the transaction is hidden. For this reason, firms engaged in the grain trade usually evaluate hedging transactions in terms of basis.

Types of Hedging

Carrying-charge hedging is utilized by firms seeking a profit from storage. The storage operations of a firm utilizing carrying-charge hedging are transformed from that of seeking a profit through changes in price levels to that of seeking a profit through changes in price relationships. The users of carrying-charge hedging are chiefly merchants ". . . whose merchandising business requires close attention to price differences according to grade, quality, and location, who choose to seek storage profits by anticipating changes in price relations . . ."[14] The decision made by carrying-charge hedgers is not whether to hedge or not, but whether to store or not.

Hedging done chiefly to facilitate the operations of the merchandising or processing operation is known as operational hedging. Operational hedging involves rapid turnover of futures and cash transactions so that basis changes may be ignored. A grain broker, for example, may judge that a particular lot of wheat is worth two cents over the price of the near futures. If he is able to purchase the wheat for less than this premium, he will do so and immediately hedge the purchase. A few minutes later the broker may find a buyer willing to pay two cents over the near futures. The broker will sell the wheat and buy in his hedge. The absolute price level in the cash market is not a factor in the transaction. The transaction deals only in premiums with respect to the price of the near future. This practice requires a high degree of short-term correlation between cash premiums (or discounts) and futures prices.

Selective hedging involves price expectations. The decision is whether or not to hedge in order to avoid a loss. Stocks are hedged only if a price decline is expected during the period that the inventory is held.

Anticipatory hedging is also guided by price expectations. However, the futures market commitment is not immediately offset by an equivalent inventory of raw materials, of finished products, or of commitments to deliver (or to accept delivery of) commodities. A businessman who anticipates concluding a deal during the hours the futures exchanges are closed may sell futures contracts at the market close. If the transaction in the cash market materializes, the businessman will then be hedged. This practice is not limited to short-term transactions such as this. Several weeks or months may elapse before the anticipated cash market transaction is concluded.

The last specific purpose of hedging listed is pure risk-aversion hedging. This form of hedging is probably unimportant or virtually nonexistent in current business use of futures markets.[15]

The broader definition of hedging permits practices such as selective and anticipatory hedging to be classified as hedging transactions even though they are closely related to speculation. Any futures transactions which are incident to the normal conduct of a business may be so classified. Speculation may then be distinguished from hedging by defining speculation as the holding of a net long or a net short position (in either market) in hope of a gain from this position, and not as a normal procedure of the business.

Costs of Hedging

An obvious cost involved in hedging transactions is the commission charge. However, this cost is relatively low, even for non-members of the exchange. The current commission charge for wheat futures transactions for non-members is less than one-half cent per bushel for a 5,000 bushel contract. This commission charge is for a "round-turn", i.e., a sale and a purchase of one contract. This cost has been held low in order that trading not be seriously discouraged. Margin requirements are also relatively small, so that the opportunity cost of the capital invested in the margin requirement is also small.

Besides the commission charges, there is another cost of hedging which is not directly charged to hedgers. This cost is the difference between the bid and asked prices, or the "margin," of speculators. The margin of the traders on the futures exchange is synonymous with the margin in the cash market. A cash grain merchant, a typical long-basis hedger, normally buys in the cash market at the bid price and sells at higher asked prices. In the futures market, this situation is reversed. Purchases are made by hedgers at asked prices, and sales are made at bid prices. The merchant is paid for his services in the cash market by receiving the asked price, and he pays for the services of the futures market by buying at asked prices.

The amount of the margin will depend on the activity of the exchange. In a very active exchange, scalpers (who provide much fluidity in the market) can afford to take a smaller margin between their bid and asked prices. They can afford to do so since the greater activity provides an opportunity to make more trades in a given time period, thereby increasing the opportunity to earn a satisfactory return. Also, the greater activity allows the scalper to easily reverse his position if he has judged the market incorrectly. The risk of a large loss is thus smaller. Evidence suggests that on the most active exchanges, the scalper's margins average between 1/10 and 1/5 of one percent of the price.[16]

Returns From Hedging

Hedging effectiveness, if hedging is done solely to transfer risk of price fluctuations can be determined by measuring the extent to which the effects of price changes would be reduced by hedging. A study by Graf (1953) may be used to illustrate the methodology involved in testing this "risk-aversion only" concept of hedging.

Graf defined hedging effectiveness in terms of departures from a no-gain, no-loss situation. The method of analysis employed was to initiate a hedge based on Friday prices. The hedge was maintained for eight weeks. At the end of this time, any change was determined and recorded as a gain or a loss to the hedger. The effectiveness of hedging in reducing the risks associated with price variability was determined by computing the extent to which gains or losses on unhedged grain could have been reduced by hedging. To be 100 percent effective to both long- and short-basis hedgers, there must have been neither a gain nor a loss on the hedge.[17]

Graf thus treated long term prospects solely in terms of current prices. Two months is a substantial period of time in the case of a seasonally produced commodity, but this definition of hedging effectiveness implied that persons engaged in the trading of a commodity would be willing to sell (or buy) the commodity in two months at the same price as the one currently prevailing in the cash market.[18] Grain merchandisers, for example, must be willing to absorb the costs of two months' storage for the protection afforded by a perfect hedge.

Graf's article was followed immediately with an article by Holbrook Working (1953). Working's article was an inquiry into the failure of the conclusions of Graf and others to be reconciled with observable facts. The conclusions were that hedging was relatively ineffective as a means of reducing risk. But it is an observable fact that business interests do hedge, and sometimes in substantial volumes. Working concluded that ". . . the attempted tests of the effectiveness of hedging have gone astray because the prevalent concept of hedging, on which they have been based, is inadequate, and misleading.[19]

Little research has been reported which attempts to evaluate the effectiveness of hedging to earn the storage return under conditions other than at a deliverable location. Analysis of carrying charge hedging at a delivery point is unnecessary since returns are assured to the hedger. If the cash-futures price relationship worsens, the hedger can simply deliver on the futures. This alternative is not open for hedgers in remote locations (relative to the location of the futures market) such as Oklahoma. In these locations, storage returns may be earned only through changes in the cash-futures price relationship.

Heifner (1966) determintd the expected returns from carrying charge hedging for country elevators in Western Michigan. Heifner used linear regression with the initial basis as the independent variable. The dependent variable was the change in the basis, or the return from carrying charge hedging. Net returns for storage were estimated by use of a Monte Carlo technique for several overlapping periods during the crop year. Returns were estimated under two alternatives: 1) storage conducted for the same interval every year and 2) storage conducted only if the basis change is expected to be greater than the variable costs of storage for the interval.

Heifner's study is subject to some limitations and fails to answer several relevant questions. His study covered a period when the CCC was very active in the market, and no attempt was made to determine if the actions of the CCC had any effect on the basis.[20] The prices which Heifner used may be considered as the prices relevant to evaluating a practice of anticipatory hedging. The hypothetical hedgers would have sold futures contracts at the market close in anticipation of overnight purchases of wheat. A question which is of importance relates to the timing of the futures contracts transactions and the effect of this timing on returns. Instead of conducting futures transactions at the market close, these transactions may have been at the market open on the next trading day. Also, Heifner did not determine if the use of a different futures market would have significantly altered the results.

PREDICTIONS OF STORAGE EARNINGS

The Model

The linear model and the Monte Carlo technique used by Heifner were used in this study. The linear model employed in the analysis utilizes the expectations that the cash price should be discounted relative to the futures price prior to the delivery month of the futures contracts. Given a constant interest rate, variable storage costs change in a linear fashion over time. Thus, the cash price should approach the futures price in a linear manner as the delivery month approaches.

Given the hypothesis of a linear relationship, the model can be stated in more formal terms. The model is:

$$y_{it} = \alpha_i + \beta_i x_{it} + u_{it}; \quad i = 1, \ldots, n \text{ intervals}$$
$$t = 1, \ldots, T \text{ years}$$

where y_{it}=the change in the cash-futures price spread during storage interval i of year t;

x_{it}=the cash-futures price spread at the beginning of storage interval i during year t; and,

u_{it}=random disturbances occurring during period i of year t.

The cash-futures price spread, or basis, is defined as the cash price minus the futures price at a given point in time. The coefficients of the equation (α_i and β_i) provide estimates of the characteristics associated with the cash-futures price relationship during a specified storage interval. The intercept coefficient, α_i, is zero under the assumptions that (1) all wheat produced is of single homogeneous type, (2) all transactions occur at a single geographic location, and (3) futures contracts mature on a single day in the delivery month. The coefficient α_i would be positive under the assumptions outlined for the development of Figure 2 in a previous section which involves geographic separation of markets and cash prices higher than futures prices. The slope coefficient, β_i, would be negative for the example in Figure 2.

For the purpose of this study, the change in the basis is defined as the selling basis minus the buying basis.

The hypothesized relationship is not a casual relationship in the sense that the independent variable (the initial basis) causes a change in the basis. However, the initial spread between the cash and the futures price is caused by conditions in the market at that time, and may indicate the direction and magnitude of the change in this relationship during the coming period. The relationship can be used only to determine the average change in basis associated with a given initial basis.

The Data

Price Series

Evaluation of the initial basis as a predictor of average storage earnings for firms in Oklahoma requires that the cash price used for the analysis be an accurate reflection of the price at which transactions occur in Oklahoma. The first choice of an ideal price series to satisfy this condition would be a price series relating to a specific type and quality of wheat at a terminal location such as Enid. Unfortunately, such a price series could not be obtained.

The relationship of export prices for wheat and the price of wheat in Oklahoma suggests that a price series from the Gulf export market may be suitable as a second choice for the analysis. The price of wheat in various export markets has been published weekly since March, 1962 in the *Grain Market News*. The official title of this price series is "Grains: Export prices basis prompt or 30-day shipment." The price of wheat given for Gulf ports is the price of No. 1 Hard Red Winter wheat, f.o.b. vessel, for immediate shipment or shipment within the next 30 days.

The price reported in the *Grain Market News* is the prevailing asked price of exporters at the close of business on Thursday of each week. The price on Wednesday is given if Thursday is a holiday. This price is determined from the registrations with the CCC of wheat sales by exporters. These registrations are required for wheat exports from the United States. This price series is the longest series pertaining to a specific grade of wheat at a specific point which could be readily obtained.

The price which exporters pay for wheat delivered to an export elevator (f.o.b. track price) is assumed to be closely related to the price of wheat loaded on a vessel. The price relevant to elevator operators in Oklahoma is the f.o.b. track price at the Gulf on any given day since this is the price which would be paid for wheat delivered that day. The f.o.b. vessel price provides a reliable measure of price changes in Oklahoma on a given day only if changes in f.o.b. track prices are closely related to changes in f.o.b. vessel prices.

The difference between f.o.b. track and f.o.b. vessel is the handling cost of unloading the wheat from the transport vehicle and loading it on the vessel plus a profit margin. Prices f.o.b. track which were reported from 1965 and 1966 indicate that during this period the difference of these prices, or the "fobbing charge", ranged from two to four cents and averaged about 3.5 cents per bushel. Since the reported track price may have been paid at a time during the day, a small variation between the two price series was expected. Based on this small variation and the fact that a large amount of the wheat produced in Oklahoma is exported, the f.o.b. vessel price should reflect the prices in a large area of Oklahoma on any given day.

Period

An attempt was made to select a period in which no high price support programs for wheat had been in force. However, during the time in which the technology of production and the marketing system were comparable with the present, only data for the crop years 1964 through 1967 were available. The desirability of using no years with high price supports was partially offset by the desirability of having more than four years included in the analysis.

There were two crop years immediately prior to the 1964 crop year in which disappearance exceeded production even though high price support programs were in effect. The data were examined to determine whether or not the relationship of the cash and futures prices was the same in the complete period 1962 through 1967. Use of the "r" test criteria proposed by Dixon (1962) indicated that many of the basis changes which occurred during the 1963 crop year could not reasonably be expected to come from the same structure which generated the remaining observations. This is the year that the transition was made from a high to a low price support level.

The 1963 data posed a dilemna. If inferences were desired about the structure which characterizes the cash-futures market relationship, including any contamination which might arise due to events such as changing price support levels, then all the observations should be used. On the other hand, if inferences were desired about the cash-futures market price relationships which existed under a relatively free market environment, then the 1963 crop year data should be omitted from the analysis.

There was a great deal of uncertainty concerning policies with respect to farm legislation in 1963. The rejection of the wheat referendum by producers was unexpected by many members of the grain trade and by the officials of the United States Department of Agriculture. No alternative programs had been seriously considered prior to the referendum. The final lower price support level therefore caused many last minute adjustments. The circumstances of the 1963 crop year are not likely to be repeated in the future, and another period of transition probably would have a different effect on the cash-futures market price relationships. For these reasons, the data for the 1963 crop year were excluded from the analysis.

Exclusion of the 1963 data leaves only 5 years of observations (the 1962 and 1964 through 1967 crop years). Since the regression equations for the storage intervals are based on observations at two points in a crop year, only five values of the initial basis and the change in basis can be obtained for each of the storage intervals.

Storage Intervals

Ten overlapping storage intervals are considered for each year. These intervals are set up to begin in the first week of a futures contract delivery month and to end in the first week of a later delivery month. Storage intervals are not set up to end late in the delivery month in order to exclude changes in the price of the expiring futures contract which may be caused by the efforts of traders to close out futures market commitments. Storage intervals thus are restricted to periods within a crop year, and are chosen to facilitate comparisons among delivery months.

Regression Estimates of Basis Changes at Gulf Ports With Respect to Kansas City Futures Contract Prices

Anticipatory Hedging

A practice of selling futures contracts in anticipation of purchases of cash wheat during the hours that the futures exchange is closed would have strong appeal as a feasible hedging policy. The elevator operator can determine the size of the basis which exists in the market prior to the close of a trading season. There is little reason to expect a large change in the basis during the remainder of the day that the exchange will be open. There is a greater chance of new information becoming available during the hours (or weekend) that the futures exchange is closed, and the new information may have a significant effect on futures prices. If the overnight purchases were hedged at the open the next morning, then the buying basis of the elevator operator would differ from that prevailing in the market since cash prices probably would change by nearly an equal amount.

The estimated functional relationships using this hedging practice for ten storage intervals are reported in Table 1. These equations are estimated for a period extending from the first Thursday of the month at the beginning of the storage interval to the first Thursday of the month at the end of the interval. The second column (average initial basis) is the mean value of the spread between the price of the Kansas City futures contract in which the hedge was placed and the f.o.b. vessel price at the beginning of each storage interval during the observational period. The standard errors of the average initial bases are enclosed in parentheses immediately under each of the ten values reported. The last four columns give the estimates of the coefficients of each equation and the coefficient of determination. Student's t statistics are in parentheses below the b values, and are for the test of the null hypothesis H_0: $\beta = -1$ against the two-tailed alternative H_a: $\beta \pm -1$.

The definitions of basis and basis changes utilized in this analysis require a positive sign for the intercept term and a negative sign for the slope coefficient. Cash prices at Gulf ports normally exceed the prices of all Kansas City wheat futures contracts within a crop year. The basis, defined as the Gulf cash price minus the futures price, is therefore positive. Since the intercept term reflects the location differential, its sign should also be positive. Similarly, a positive change in the basis (selling basis minus the buying basis) is a profit and a negative change in the basis is a loss. This implies that the slope should be negative. Also, the expected value of the slope (absolute value) for wheat of the quality priced by the futures contract is one.

The coefficients in Table 1 all have the algebraic signs which would be expected from the definitions of basis and basis change. The hypothesis of linearity in the relationship between the variables may be accepted in all cases. Four of the slope coefficients given in the table may be considered as different from minus one. Three of these are for storage intervals ending in May, and the fourth is for a storage ending in December. This indicates that a change in the price spread at the beginning of one of these four intervals tends to be accompanied by a change in the basis which is not proportional to the change in the initial basis. Thus, during certain periods of the crop year, a change of one cent in

Table 1. **Statistical Coefficients for Regression of the Seasonal Basis Change on the Initial Basis for No. 1 Hard Red Winter Wheat Stored at Gulf Ports and Hedged in the Kansas City Futures Market with an Anticipatory Hedging Practice**

Storage Interval	Average Initial Basis (s_x)	a	b (t)	$s^2_{y \cdot x}$	R^2
	(Cents/Bu.)				
July-September	21.7245 (2.314)	26.21752	—1.13890 (—.4677)	1.88394	.83**
July-December	18.0250 (2.561)	15.01150	—1.02144 (—.1078)	1.03765	.90**
July-March	15.7500 (2.993)	25.38613	—1.12293 (—.6806)	1.16945	.93**
July-May	18.7000 (5.281)	15.10883	— .64887 (1.3916)*	11.72387	.57**
September-December	19.9000 (2.841)	29.30830	—1.23785 (—2.3734)*	.32432	.98**
September-March	16.7750 (4.174)	21.38772	— .87706 (1.0270)	.99886	.95**
September-May	19.6000 (5.728)	14.36502	— .62704 (1.3362)*	10.22368	.63**
December-March	24.0745 (2.354)	28.07766	—1.19222 (— .8722)	1.07689	.91**
December-May	26.6750 (4.688)	18.34157	— .87504 (.2943)	15.85065	.59**
March-May	25.4750 (5.108)	10.71496	— .56977 (1.3990)*	9.86972	.53**

*$t_{(3, 0.70)} = 1.250$. Therefore, $H_0:\beta = -1$ may be rejected in favor of $H_a:\beta \pm -1$.
**Hypothesis of no linear relationship between the variables may be rejected with $F[_{0.75, (1, 3)}] = 2.02$.

the basis does not tend to result in a one cent change in earnings.

The coefficients of determination indicate that there is a high degree of correlation (.90 or greater) between the initial basis and the change in basis for all storage intervals except those ending in May. Generally, therefore, the initial basis was a good predictor of gross earnings from hedged storage during the five years used to estimate these equations.

The relatively low degree of correlation exhibited by the storage intervals ending in May can be explained partially as deviations from the normal movements of the basis during a crop year. Comparison of the average initial bases for the storage intervals ending in May show that there is a small average increase (.9 cent) from July to September, a substantial average increase (7.075 cents) from September to December, and an average loss (−1.2 cents) from December to March when the change in the cash price is measured with respect to the price of the May futures contract. These comparisons reflect the fact that large relief shipments of wheat to the Far East during the 1965 crop year caused a smaller decline in the basis during the early spring months of 1966 than the decline normally experienced in these months. Such behavior cannot be considered as an imperfection in the market (as contrasted to the 1963 data), and must be recognized as consistent with possible future events.

The estimates of the intercept terms of these ten equations cannot be evaluated against any fixed standard. However, the price of No. 1 Hard Red Winter wheat at the Gulf generally exceeded the price of the near futures by at least 20 cents during the period of analysis. All of the estimates which are less than 20 occur in the storage intervals ending in May, and include the period of the crop year in which the cash price exhibited an average decrease relative to the price of the May futures contract. The decline in the cash price indicates that negative carrying charges may be experienced during this portion of the crop year for hedges placed in the May futures contract. The coefficients indicate that positive carrying charges can be expected infrequently with the market conditions that prevailed during these five years.

Simultaneous Hedging

Some elevator operators may prefer to follow a different policy from the practice of anticipatory hedging. The second hedging policy utilized for the evaluation of the initial basis as a predictor of earnings from hedged storage is denoted as simultaneous hedging. The practice could also be called delayed hedging since overnight purchases (made at the previous afternoon's cash price) are not hedged until the open of the futures exchange the next morning. The second policy is evaluated to determine whether or not there is a substantial difference between selling futures contracts at the market close or at the open when the same cash price applies to both transactions.

Comparison of the average initial basis for each storage interval under the policies of anticipatory and simultaneous hedging reveals that the futures exchange averaged higher prices at the Friday open for the majority of the storage intervals (Table 2). The average initial basis under the policy of simultaneous hedging is smaller in seven of the storage intervals which indicates that the futures prices were higher at

Table 2. Statistical Coefficients for Regression of the Seasonal Basis Change on the Initial Basis for No. 1 Hard Red Winter Wheat Stored at Gulf Ports and Hedged in the Kansas City Futures Market with a Simultaneous Hedging Practice

Storage Interval	Average Initial Basis (s_x)	a	b (t)	$s^2_{y \cdot x}$	R^2
	(Cents/Bu.)				
July-September	20.9500 (1.972)	23.25385	—1.01808 (—.0571)	1.56080	.77**
July-December	17.5745 (2.612)	27.97633	—1.18784 (—.6962)	1.98724	.87**
July-March	14.7500 (2.915)	22.21346	— .87040 (.6219)	1.47632	.85**
July-May	18.0745 (5.132)	11.68689	— .43911 (1.7319)*	11.05103	.38
September-December	19.8500 (2.452)	33.95758	—1.46764 (—3.0761)*	.55567	.97**
September-March	16.8500 (3.979)	20.76564	— .80063 (1.7439)*	.82766	.94**
September-May	19.2000 (5.754)	14.06997	— .59609 (1.2042)	14.89866	.51**
December-March	24.0745 (2.420)	19.00228	— .78722 (.8987)	1.31314	.79**
December-May	26.5500 (4.669)	19.82799	— .92478 (.1499)	21.93554	.53**
March-May	25.6745 (4.862	10.36985	— .55384 (1.0905)	15.82635	.38

*$t_{(3, 0.70)} = 1.250$. Therefore, $H_0: \beta = -1$ may be rejected in favor of $H_a: \beta \pm -1$.
**Hypothesis of no linear relationship between the variables may be rejected with $F[_{0.75, (1, 3)}] = 2.02$.

the opening of the Kansas City Board of Trade on the next day. The average initial basis is the same in one interval when these two practices are compared, and slightly larger in two of the intervals.

The initial basis would be expected to be less useful as a predictor of basis changes under the policy of simultaneous hedging than under the policy of anticipatory hedging since the hedger is, in effect, establishing a basis somewhat independent from the current market spread between the cash and futures prices. The purchase of the futures contracts at the end of the storage interval also may be made at a price which would result in a selling basis which is not entirely consistent with current market spreads. There is no way of knowing whether the futures price would be higher or lower at the open on the next morning, so that the gross returns from this practice could involve a certain amount of randomness. Basis changes could not be expected to be as highly correlated with the initial basis as they would be under anticipatory hedging. This expectation is confirmed by the generally lower coefficients of determination given in Table 2 as compared with those in Table 1. However, the correlation coefficients do not appear to be sufficiently different to discredit the practice of simultaneous hedging as a feasible hedging practice.

The algebraic signs of the regression coefficients conform with the signs which were expected. The hypothesis of a linear relationship between the variables is not rejected in eight of the ten cases. The two exceptions are for storage intervals ending in May. These results, together with the generally lower coefficients of determination, are indicative of a greater uncertainty of returns when hedges are initiated and terminated at prices which do not completely reflect current market differentials.

Again, some of the slope coefficients may be considered as different from minus one. Two of these coefficients are for the same storage intervals as under the anticipatory hedging practice. The third was not significant at the 70 percent probability level for the anticipatory hedging practice. However, it does occur during the same period of the crop year as the others. This result further illustrates that annual changes in the basis on a given date have tended to be accompanied by a change in earnings that is not proportional to the change in the initial basis during certain periods of the crop year.

Average initial bases at the beginning of each storage interval display approximately the same magnitude of change during the crop year as they did under the anticipatory hedging practice. In summary, the equations for the practice of simultaneous hedging exhibit the same characteristics as those for the anticipatory hedging practice. A comparison of the returns from these two practices will be considered in a subsequent section.

"Any Month" Hedging

The third hedging practice to be evaluated is denoted as "any month" hedging. This name does not precisely describe the practice since certain rules still will be followed. The hedge must be placed in a futures contract which expires after storage is terminated. The futures month to be used is the one for which the spread between the futures and the cash price is the least at the beginning of the storage interval. Thus, hedges could be placed in new crop futures contracts as well as current crop year contracts.

The practice of "any month" hedging could be used to minimize the effects of short run changes in the market. For example, a hedger may think that producers will be reluctant to sell during the next few months. If this event does occur, the price of cash wheat may be bid up in view of the relative scarcity of the physical commodity. If this condition is expected to exist until the nearest delivery month, the price of this contract may also increase. However, this condition should not increase the prices of more distant futures contracts—these prices may decline to reflect a larger expected supply during these periods. The concept of hedging under this condition then is to avoid increases in the price of the near futures caused by short run changes in demand or supply expectations, but at the same time derive the benefits of the increased price in the cash market. It should be noted that losses probably will be incurred under this practice if the changes in short-run expectations cause price decreases.

Regression estimates of the relationship between the initial basis and the seasonal change in the basis with the practice of "any month" hedging are reported in Table 3. Only eight storage intervals are given in this table; the July to May and the September to May storage intervals were excluded. During the five years included in this analysis, the basis with respect to the May contract tended to be smallest. As a result, the hedges for the September to May storage interval would have been placed in the May contract in each of the five years. Thus, the prices which would be used to evaluate basis changes for the "any month" hedging practice for these two storage intervals would be identical to those used to evaluate the anticipatory hedging practice.

The results of using this practice during the five-year period would have been mixed relative to results under the anticipatory hedging practice. The anticipatory and the "any month" practices both use the Thursday closing futures price and the Thursday cash price. A substantially lower degree of correlation between the initial basis and change in the basis would have existed early in the crop year. There is a substantial decrease in the coefficient of determination for the storage interval extending from July to September, and a lesser decrease for the storage interval extending from July to December. Smaller decreases occurred for the September to December and December to March storage intervals. Coefficients of correlation for the other four storage intervals are essentially equal to the coefficients of determination for the anticipatory hedging practice.

Since hedges could have been placed in new crop futures contracts under this hedging practice, the contracts in which the hedges were

Table 3. **Statistical Coefficients for Regression of the Seasonal Basis Change on the Initial Basis for No. 1 Hard Red Winter Wheat Stored at Gulf Ports and Hedged in the Kansas City Futures Market with an "Any Month" Hedging Practice**

Storage Interval	Average Initial Basis (s_x)	a	b (t)	$s^2_{y \cdot x}$	R^2
	(Cents/Bu.)				
July-September	15.5500 (3.378)	2.94038	— .13282 (1.4603)*	16.09617	.02
July-December	15.5500 (3.378)	20.58682	— .78372 (.5473)	7.12788	.57**
July-March	14.3250 (3.724)	24.31973	—1.06769 (—.4397)	1.31524	.94**
September-December	16.5250 (4.517)	24.51803	—1.03437 (—.1112)	7.80743	.79**
September-March	16.5250 (4.518)	21.09429	— .86349 (1.3052)*	.89295	.96**
December-March	23.6500 (2.706)	22.79010	— .98901 (.0391)	2.31757	.80**
December-May	26.4750 (4.945)	17.04789	— .84222 (.3784)	17.00494	.58**
March-May	22.6000 (7.708)	5.25331	— .39727 (2.7575)*	11.35508	.52**

*$t_{(3,\ 0.70)} = 1.250$. Therefore, $H_0: \beta = -1$ may be rejected in favor of $H_a: \beta \pm -1$.
**Hypothesis of no linear relationship between the variables may be rejected with $F_{[0.75,\ (1,\ 3)]} = 2.02$.

placed should be identified. For the first five storage intervals given in Table 3, the hedges would have been placed in the March futures contract during the first four years, and in the May contract during the last year. For the sixth interval, December to March, hedges would have been placed in March contract during the first three years, and in the new crop September contract during the last two years. Hedges would have been placed in the May contract during the first three years and in the new crop September contract during the last two years for the December to May storage interval. Finally, the March to May storage interval would have been hedged in the May contract during the first year and in the new crop December contract during the last four years. Thus, hedges would have been placed in new crop futures contracts only during the last three storage intervals given in Table 3.

These results can provide some information concerning the appropriate futures months for hedging transactions. Lower coefficients of determination for the storage intervals ending in the first half of a crop year for the "any month" as compared with the anticipatory hedging policy indicate that cash-futures price spreads provide fairly accurate forecasts of prospects of gross earnings from hedged storage for hedges placed in futures contracts which mature during this period of the crop year. This implication is best illustrated by the results which pertain to the July to September storage interval. These results indicate that cash-futures price spreads are virtually worthless as predictors of gross earnings during this storage interval if the hedge is placed in a futures contract maturing late in the crop year.

The predictions are better for contracts maturing early in the crop year or when the hedge is placed in a futures contract which matures either during or immediately after storage is terminated. There appear to be two exceptions to this general tendency. The coefficients of determination for the December to May and the March to May storage intervals are essentially unchanged although hedges were placed in new crop futures contracts. However, without the effect of the 1965 crop year, these two storage intervals may have exhibited the same tendencies as the other six storage intervals.

Regression Estimates of Basis Changes at Gulf Ports With Respect to Chicago Futures Contract Prices

The nature of the Chicago wheat futures contract is such that it should provide a poorer indication of the price prospects for Hard Red Winter wheat at Gulf ports than does the price of the Kansas City wheat futures contract. Different types of wheat than that produced in the Southern Great Plains can be delivered on the Chicago contract, and the cash export market in Chicago does not function for part of each year due to adverse weather. Wheat produced in the Southern Great Plains may be exported during the entire year through Gulf ports.

The same procedure as outlined in the previous sections is used for estimating earnings from hedged wheat storage using prices of futures contracts on the Chicago Board of Trade. The Thursday closing price of the relevant contract on the Chicago Board of Trade and the price of No. 1 Hard Red Winter wheat f.o.b. vessel Gulf ports are used to develop linear predictive equations. The results of these regressions are reported in Table 4.

The results reported in Table 4 indicate that the initial basis relative to the Chicago Board of Trade wheat futures contract generally provides a poor predictor of earnings from hedged wheat stored at Gulf ports. This is especially true for the shorter storage intervals, and for those early in the crop year. This result is opposite of the pattern of the Kansas City market, in which the shorter storage intervals and those early in the crop year had the higher coefficients of determination. This difference can be partially attributed to the structural differences between the two markets.

Table 4. Statistical Coefficients for Regression of the Seasonal Basis Change on the Initial Basis for No. 1 Hard Red Winter Wheat Stored at Gulf Ports and Hedged in the Chicago Futures Market with an Anticipatory Hedging Practice

Storage Interval	Average Initial Basis (s_x)	a	b (t)	$s^2_{y \cdot x}$	R^2
	(Cents/Bu.)				
July-September	24.1250 (3.194)	5.76149	—0.13208 (1.8305)	9.17516	.02
July-December	18.4500 (2.862)	—4.59257	0.87765 (1.6193)*	44.05939	.16
July-March	15.0500 (2.809)	42.24318	—1.92479 (—0.5887)	77.94046	.33
July-May	16.025 (3.549)	40.01461	—1.75130 (—0.6892)	59.87783	.46**
September-December	20.7000 (3.978)	7.11404	0.10802 (1.1711)	56.66422	.00
September-March	16.1750 (4.983)	31.08359	—1.17055 (—0.1833)	85.98069	.34
September-May	16.9500 (5.307)	40.00918	—1.70998 (—1.0611)	50.43140	.68**
December-March	25.9750 (7.969)	17.21778	—0.57239 (0.8062)	71.46153	.28
December-May	25.1000 (7.905)	30.60160	—1.10464 (—0.1999)	68.44585	.60**
March-May	26.2750 (9.024)	13.52430	—0.45002 (1.9864)*	36.59144	.38

*$t_{(3, 0.70)} = 1.250$. Therefore, $H_0: \beta = -1$ may be rejected in favor of $H_a: \beta \pm -1$.
**Hypothesis of no linear relationship between the variables may be rejected with $F[_{0.75, (1, 3)}] = 2.02$.

One difference between the Kansas City and Chicago wheat markets has already been noted—the Chicago wheat export market is inaccessible to ships during part of each year. However, the differing results cannot be attributed exclusively to this factor. The St. Lawrence Seaway normally is closed to shipping from mid-December until March. If the inaccessibility of the Seaway were the only factor causing the different pattern of basis movements, then the storage intervals ending in March should be affected the most. However, this is not the case.

A second reason for the differing results in those two markets may be due to the differences in the harvesting season in the regions adjacent to the two markets. The wheat harvest normally begins in the southern United States in mid-May, progresses northward, and ends in late August or early September in the northern United States. The different timing of the movement of wheat to the markets in the northern and southern regions of the United States could be one cause of unpredictable basis movements of Gulf-stored wheat relative to the Chicago futures contract. This reasoning would also be consistent with the higher coefficients of determination in the Chicago market for the storage intervals ending in March and May. The March contract on both markets would be least influenced by uncertainty concerning the selling intentions of producers. This factor should also apply to the Chicago May contract.

ESTIMATED AVERAGE NET RETURNS FROM HEDGED STORAGE

Changes in cash-futures price spreads in a relatively free market environment appear to be predictable from the initial spreads when wheat at the Gulf is hedged in the Kansas City futures market. Although these changes appear to be predictable, a question of interest to prospective users of carrying-charge hedging is the amount of the earnings which may be expected from this practice. For some firms, the decision of whether or not to store wheat on the elevator's account (wheat owned by the elevator) will depend on the prospective earnings. Firms which must store owned wheat may use the prospective earnings as a guide for determining the volume to be stored.

Average Gross Earnings From Alternative Storage Practices

Average gross earnings which would have been realized from fully hedged positions in the Kansas City and Chicago futures markets in the specified storage intervals during the 1962 and 1964 to 1967 crop years are given in Table 5. The average gross earnings from unhedged storage (cash price change) are also reported. At this point, costs such as storage or broker's fees have not been deducted. Since the storage intervals are of varying lengths, these returns are converted to average earnings per month and tabulated in Table 6.

The pattern of the average gross returns from a fully hedged position in either of the futures markets during a crop year displays the same characteristics as that of the average initial basis. Relatively small average gross earnings were realized in the interval from July to September, larger earnings were realized from September to December, and losses were realized during the remainder of the year when the hedges were placed in the Kansas City market. The small average basis decrease

Table 5. Average Gross Earnings and Standard Deviations of Gross Earnings from Unhedged Storage of Wheat and from Fully Hedged Positions in the Kansas City and Chicago Wheat Futures Markets Under Alternative Hedging Practices During Specified Storage Intervals, 1962 and 1964 Through 1967 Crop Years.

Storage Interval	Hedged				Unhedged
	Kansas City			Chicago	Gulf Cash
	Anticipatory	Simultaneous	Any Month	Anticipatory	Price Change
			—Cents/Bu.—		
July-September	1.47 (2.89)	1.92 (2.28)	0.88 (3.50)	2.57 (2.23)	2.20 (7.73)
July-December	6.60 (2.76)	7.10 (3.33)	8.40 (3.51)	11.60 (6.27)	6.80 (8.17)
July-March	7.70 (3.49)	9.38 (2.75)	9.02 (4.10)	13.27 (9.36)	3.80 (11.37)
July-May	2.97 (4.53)	3.75 (3.66)	2.97 (4.53)	11.95 (9.14)	—1.80 (16.11)
September-December	4.67 (3.55)	4.82 (3.66)	7.42 (5.26)	9.35 (6.53)	4.60 (4.93)
September-March	6.67 (3.76)	7.27 (3.28)	6.82 (3.98)	12.15 (9.92)	1.60 (10.01)
September-May	2.07 (4.54)	2.62 (4.80)	2.07 (4.54)	11.02 (10.96)	—4.00 (12.39)
December-March	—0.62 (2.94)	0.05 (2.14)	—0.60 (2.98)	2.35 (8.62)	—3.00 (8.57)
December-May	—5.00 (4.66)	—4.72 (6.25)	—5.25 (5.48)	2.88 (11.30)	—8.60 (13.28)
March-May	—3.80 (3.98)	—3.85 (4.37)	—3.72 (4.20)	1.70 (6.62)	—5.60 (7.37)

Table 6. Monthly Average Gross Earnings from Unhedged Storage of Wheat and from Fully Hedged Positions in the Kansas City and Chicago Wheat Futures Markets During Specified Storage Intervals, 1962 and 1964 Through 1967 Crop Years

Storage Interval	Hedged				Unhedged
	Kansas City			Chicago	
	Anticipatory	Simultaneous	Any Month	Anticipatory	Gulf Cash Price Change
			—Cents/Bu.—		
July-September	0.735	0.960	0.440	1.285	1.100
July-December	1.320	1.420	1.680	2.800	1.360
July-March	0.962	1.172	1.128	1.659	0.475
July-May	0.297	0.375	0.297	1.195	—0.180
September-December	1.557	1.607	2.473	3.117	1.533
September-March	1.112	1.211	1.137	2.025	0.267
September-May	0.259	0.328	0.259	1.375	—0.500
December-March	—0.207	0.017	—0.200	0.783	—1.000
December-May	—1.000	—0.944	—1.050	0.576	—1.720
March-May	—1.900	—1.925	—1.860	0.850	—2.800

which occurred with respect to the Kansas City May futures contract during the interval from December to March is reflected in the small average loss during this interval under two of the hedging policies. A very small gain would have been realized under the simultaneous hedging policy. Relatively large losses occurred during the interval from March to May.

The seasonal pattern of the spread between the Gulf cash price and the Kansas City futures price may be partially caused by the selling habits of producers. Conversations with elevator operators in Oklahoma indicated that the heaviest selling periods of producers are the period during and immediately after harvest and during December and January. If the producers in the other areas in the Southern Great Plains which supply the Gulf export market also act in this manner, then the cash price at the Gulf would be expected to decrease relative to futures prices during the periods of heavy producer selling and to increase during periods with light producer sales. Depending on the amount of carry-over held by commercial interests at Gulf locations, the price at the beginning of the harvest would be expected to be high relative to distant futures months, and this condition would exist until the market channels are filled with new crop wheat. A decline of the cash price relative to futures contract prices would be expected until the period of lighter producer sales later in the summer. At this time, the price would again advance relative to the distant futures to reflect the condition of tighter supplies. This type of a pattern is exhibited by the spread between the Gulf cash price and both futures markets. The different pattern with respect to these two futures markets during the last half of the crop year probably is the result of different economic forces affecting these two markets.

The average gross returns from the three hedging practices when the hedges are placed in the Kansas City futures market are approximately the same in most of the storage intervals. Two major differences are evident. The average monthly earnings during the September to December storage interval are approximately nine-tenths of a cent greater from the "any month" hedging practice than from the other two practices. Average earnings in the storage interval from July to December also would have been slightly higher. This is a reflection of the large average advance of the cash price with respect to both the March and May futures contracts during the interval from September to December. With the "any month" hedging practice, the hedges were placed in either the March or May contracts. The hedges were placed in the December futures contract with the other two practices. Except for these two storage intervals, there would have been no particular advantage from using this practice. However, during the early part of the crop year, average gross earnings would have been lower from the use of the "any month" hedging practice relative to the other two hedging practices in the Kansas City market. These results strengthen the inference that hedges should be placed in a futures contract which matures soon after storage is terminated.

Average gross earnings from hedges placed in the Chicago futures market would have been substantially larger in all of the storage intervals during this five year period. On the average, a loss would not have been incurred in any of the storage intervals by hedging in this market. This condition may be indicative of a greater preference for No. 1 Hard Red Winter wheat at Gulf ports relative to contract quality wheat delivered in Chicago. However, these higher gross earnings are also subject to greater variability than are the gross earnings from hedges placed in the Kansas City futures market. This increased variability is to be expected since the type of wheat priced by the Chicago contract is more likely to be Soft Red. This result illustrates the contention that risks are likely to increase when the type of wheat hedged differs from the contract type, or when the location is remote from the futures market.

Although the average gross earnings from hedging in the Chicago futures market would have been larger than from hedging in the Kansas City futures market, larger losses also could have been incurred in any given year. The minimum and maximum basis changes under the anticipatory hedging practice in the two markets are listed in Table 7. The minimums indicate losses in seven intervals for Kansas City and eight intervals for Chicago. However, the minimum basis change was more favorable for Kansas City than for Chicago in six of the 10 storage intervals. The more favorable minimum outcome for Chicago tended to be those storage intervals ending late in the crop year, but did not include all such storage intervals. The maximum basis changes indicated positive returns for all storage intervals for both markets with the basis changes less favorable for Kansas City than for Chicago in every case.

The data of Table 7 cannot be used to indicate that one futures market is better than the other. Losses could have been incurred during these five years in most of the storage intervals with hedges placed in either market. However, a substantially larger range of possible outcomes did exist for hedges placed in the Chicago futures market.

Hedging in either market would have resulted in a more favorable average outcome during these five years than the outcomes from holding unhedged wheat. Hedging would have resulted in larger average profits (or smaller losses) in every storage interval except the one from July to September with hedges placed in the Kansas City futures market. In addition, the minimum basis change for all storage intervals would have been greater than the minimum change in the cash price.

Table 7. Minimum and Maximum Gross Earnings from Unhedged Storage and from Fully Hedged Positions in the Kansas City and Chicago Wheat Futures Markets Under Alternative Hedging Practices During Specified Storage Intervals, 1962 and 1964 Through 1967 Crop Years

Storage Interval	Kansas City Hedges						Chicago Hedges		Gulf Cash Price Change	
	Anticipatory		Simultaneous		Any Month		Anticipatory			
	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max
July-September	—3.000	3.75	—1.500	4.500	—4.375	5.500	—0.750	6.375	—7.000	14.000
July-December	3.750	10.750	4.000	12.375	3.750	12.375	0.750	16.625	—1.000	16.000
July-March	3.875	12.250	6.500	13.500	4.750	15.750	4.250	27.500	—13.000	11.000
July-May	—3.000	7.875	—0.750	7.250	—3.000	7.875	—2.500	20.250	—17.000	21.000
September-December	—0.250	8.125	0.000	8.625	—1.750	11.375	—2.000	14.750	—2.000	11.000
September-March	1.750	11.000	2.000	10.500	1.750	11.750	—0.125	25.375	—14.000	12.000
September-May	—3.000	6.875	—3.500	6.500	—3.000	6.875	—6.125	20.375	—18.000	10.000
December-March	—4.500	3.500	—1.625	3.750	—4.500	3.500	—11.000	10.875	—12.000	7.000
December-May	—13.500	0.750	—13.750	1.750	—13.500	0.750	—16.875	9.25	—25.000	5.000
March-May	—8.375	1.000	—8.000	1.750	—8.375	0.375	—5.875	8.000	—13.000	4.000

Variable Costs of Storage

An assessment of the relative profitability of hedged wheat storage as a regular activity of country elevators in Oklahoma requires a realistic appraisal of the variable costs associated with this activity. The amount of variable costs to be covered would greatly affect the net returns from this activity.

Normal storage charges of Oklahoma country elevators for storing producer-owned wheat range from one to one and one-half cents per bushel per month.[24] Fixed as well as variable costs are included in these charges. The size of the warehouse is partially dependent upon the needs of producers for off-farm storage, and producers should be charged for the costs of constructing, operating, and maintaining that portion of the warehouse which they utilize for this purpose. The remainder of a country warehouse is needed only to hold stocks of grain when transport equipment is temporarily unavailable, and to maintain working stocks for allied enterprises (such as a feed mill).

Terminal elevators have nearly the same needs as country warehouses, but generally are required to maintain relatively large stocks to meet the needs of the business. However, the type of storage considered in this analysis is the same for both types of elevators.

It is assumed that the wheat which is to be stored on the account of the elevator is purchased from producer-owned stocks which were stored in the elevator. Thus, any costs which would be necessary to prepare the wheat for storage would already have been incurred. Given this assumption, one variable cost which might be incurred is the cost associated with turning the inventory, if this should be necessary. Cost data for a country elevator engaged in an all-grain operation (no feed mill, fertilizer plant, gasoline station, etc.) indicate that the elevator had handled 816,000 bushels of grain during 1960, and had a utility cost of $1,220.[25] The utility cost per bushel, assuming two elevations of each bushel of wheat, would be .14 cents per bushel if the total electricity cost were allocated to the warehouse operation. However, some of this cost should be assessed against the office. Increased handling, if necessary, may also lead to a greater frequency of breakdowns as the machinery is used more intensively. Mill repair costs for the elevator were lower than electrical costs. The evidence suggests that the monthly variable costs of electricity and mill repairs are greater low. There are other costs incident to the ownership of grain which are unrelated to the costs of utilizing storage space. One of the most important is the financial cost of inventory ownership. The variable financial costs of storage consists of four elements: 1) the opportunity cost (or the interest cost) of capital invested in the inventory; 2) insurance costs; 3) comission fee; and 4) interest costs on margin requirements.

Some of the financial costs are fixed in amount but variable with respect to the length of the storage interval. Others are constant per month regardless of the length of the storage interval. For example, the monthly interest cost of the capital invested in inventory will be constant regardless of the length of the storage interval. The monthly variable costs for commission fees will vary with the length of time the grain is held in storage and the volume held since these fees are a fixed amount per transaction. However, all four of these cost items are variable costs of storage since they would not be incurred if hedged wheat were not stored by the elevator.

Margin requirements are stated in cents per bushel and are subject to revision as the exchange deems necessary. Typically, initial margin requirements and maintenance requirements are equal for hedging transactions, but brokerage firms usually require higher initial deposits than the exchanges prescribe in order to avoid frequent margin calls. The amount of margin which brokers require may vary from customer to customer and depends largely on the customer's credit rating.

The insurance expense of a grain elevator is partially dependent upon the amount of inventory which is stored in the elevator. Since the type of storage considered in this analysis would result in an increase in the utilization of the warehouse, an increase in the insurance premium could be expected. The amount of this premium increase is difficult to specify since the insurance against physical loss is partially dependent upon factors unique to a given elevator, such as cleanliness, type of construction, etc.

The above discussion indicates that "the" monthly variable cost of storage is impossible to determine. This cost is dependent upon the price of the wheat when it is purchased, the interest rate at which the inventory is financed, the length of time the inventory is held, the amount of the required margin, and any handling of the wheat which may be necessary. Any estimates of the monthly variable costs of hedged storage thus become dependent upon rather strict assumptions which underlie the estimates.

The monthly variable costs of storage were estimated for six situations. Situation (1) was formulated as a base. The price under situation (1) is $1.20 per bushel, the interest rate is seven percent, the required margin is ten cents per bushel ($500 per 5,000 bushel contract), insurance costs are assumed to be $5 per thousand dollars value of the inventory, and the commission fee is $22 per 5,000 bushel contract. The variables are increased in the next four situations. The changes are as follows: in (2) the price is increased to $1.21 per bushel; in (3) the interest rate is increased to eight percent; in (4) the insurance premium is increased to $5.10 per thousand dollars value of the inventory; and in (5) the required margin is increased to eleven cents per bushel ($550 per 5,000 bushel contract). For situation six, the previous changes are aggregated.

Monthly storage costs for storage intervals ranging from one to twelve months in length were estimated for each of the six situations and are given in Table 8. The estimates range from 0.845 cents per bushel up to 1.371 cents per bushel per month. Actually, costs for an individual may be quite different because of alternative assumptions of cost items to include and opportunity cost levels. For this reason five alternative cost levels ranging from zero to 1.40 cents per bushel per month were selected and used to determine profitability in the following section.

Estimated Average Net Returns From Alternative Hedged Storage Practices

Net returns from storage can be computed by subtracting the variable costs of storage from the gross returns reported in previous sections. Variable costs of storage rather than total cost are specified as the appropriate costs since it is assumed that elevator operators will be making decisions regarding fuller utilization of existing facilities. The type of decision which is considered is an annual decision regarding the use of storage space which is not utilized to store grain for other owners or for other facets of the elevator operation (such as a feed mill).

Two estimates of net returns from hedged storage were computed. The first assumes that storage will occur every year regardless of apparent profitability. The second assumes that storage will occur only if it appears profitable.

For the second alternative, a Monte Carlo procedure was used to estimate the net returns from hedged storage on the condition that storage would take place only when the predicted basis change exceeded the variable costs of storage. The predicted basis change was compared for each of five cost levels. Average net returns were computed at these five cost levels for those trials in which the storage criterion was met. The trials in which the criterion was not met were excluded from the computation of the average net returns. The proportion of times the criterion was met at each cost level was also computed.

Table 8. Estimated Monthly Variable Costs of Storage for Alternative Lengths of Storage Intervals Under Specified Situations.

Situation	Length of Storage Interval (Months)											
	1	2	3	4	5	6	7	8	9	10	11	12
	—Cents per Bushel—											
1	1.248	1.028	.955	.918	.896	.882	.871	.863	.857	.852	.848	.845
2	1.255	1.035	.961	.925	.903	.888	.877	.870	.863	.859	.855	.851
3	1.357	1.137	1.063	1.027	1.005	.990	.979	.972	.965	.961	.957	.953
4	1.249	1.029	.956	.919	.897	.883	.872	.864	.858	.853	.849	.846
5	1.254	1.034	.961	.924	.902	.888	.877	.869	.863	.858	.854	.851
6	1.371	1.151	1.078	1.041	1.019	1.005	.994	.986	.980	.975	.971	.968

The initial basis generated for this procedure was defined as:

$$(1) \quad x_{it} = \bar{x}_i + s_x d_{jt};\ i = 1, \ldots, 10 \text{ storage intervals}$$
$$t = 1, \ldots, T \text{ trials}$$

where $\bar{x}_i$ = the average basis observed at the beginning of storage interval i;

s_x = the standard deviation of the initial basis for storage interval; and,

d_{jt} = a random variable whose distribution is assumed to be standard normal.[21]

The results obtained from the Monte Carlo procedure cannot be accurate if the data utilized for the analysis are not realistic. Successful application of Monte Carlo procedure requires that the distribution of the random variables from which a sample is drawn be closely related to the distribution of the variable in question. The theoretical distribution of the initial basis is unknown. Demand and supply conditions do change from year to year, but these changes should cause only relatively small variations in either direction from the mean. The conditions should not exhibit radical year-to-year variability, and there should be a small probability of an extremely large change in this value in either direction from the mean. Therefore, the distribution of the initial basis was assumed to be normal.

The second step in the procedure was to establish a check on the results to determine how closely they conformed to the observed gross storage earnings. This step was accomplished by defining an "actual" basis change as:

$$(2) \quad \hat{Y}_{it} = a_i + b_i x_{it} + s_{y \cdot x} d_{ht}$$

where the range of the subscripts i and t is defined as in (1), a_i, b_i and $s_{y \cdot x}$ are estimates of the corresponding parameters of the regression equation for the ith storage interval, d_{ht} is a second standard normal random deviate, and s_{it} is the initial basis generated in (1).

Equation (2) was used to determine whether or not the average value of $\hat{Y}_{it}$ after T tails was approximately equal to the average gross storage earnings given in Table 7. The procedure of (2) consists of adding a random amount to the value of the basis change associated with the value of the initial basis generated in (1). This random amount is the product of the unexplained variability about the regression line ($s_{y.x}$) and a random deviate d_{ht}. The procedure thus generated T basis changes which would be concentrated within a known and constant interval about the regression line. The average value of $\hat{Y}_{it}$ computed from these T observations should be equal to the average observed gross storage earnings if the procedure is accurate.

The third step of the procedure was to obtain a predicted value of the change in basis. The predicted value is defined as:

$$(3)\bar{y}_{it} = a_i + b_i x_{it} + s_{y \cdot x} \left[\frac{1}{n} + \frac{(x_{it} - \bar{x}_i)^2}{(n-1)\ s_x^2} \right]^{1/2} d_{mt}$$

where a_i, b_i, x_{it}, $s_{y \cdot x}$, $\bar{x}_i$, s_x^2 and the subscripts i and t are defined as previously, n is the number of observations used to estimate the regression equation, and d_{mt} is a third standard normal random deviate. The portion of the term on the right hand side of the equation (3) is:

$$s_{y \cdot x} \left[\frac{1}{n} + \frac{(x_{it} - \bar{x}_i)^2}{(n-1)\ s_x^2} \right]^{1/2}$$

This is the error associated with predicting the mean value of the dependent variable associated with a given value of the independent variable.[22] The value of $\bar{y}_{it}$ obtained for each value of the initial basis (x_{it}) was compared with each of the five cost levels The average of $\bar{y}_{it}$ minus a cost level is the expected net returns at that cost level from hedged storage which is conducted only when this activity is predicted to be profitable.

Two sets of estimated net returns under three hedging practices and five variable cost levels are given in Tables 9, 10, and 11. Columns with a heading of (1) give the estimated average net returns from storage every year, and columns headed with a (2) give the estimated average net return from storage only when earnings are predicted to exceed variable costs. Columns headed by a (%) give the percent of the total trials in which the predicted earnings exceeded variable costs. A total of 5,000 trials for each storage interval and hedging policy was used to obtain these results.[23]

The estimated net earnings in columns numbered (1) are derived from equation (2). At the zero cost level, estimates from equation (2) should be equal to the average earnings realized from these hedging practices during the period included in the analysis. The estimated net storage earnings in the columns numbered (2) in the tables are derived from equation (3), and are computed by deducting the total variable costs of storage for the storage interval from the predicted gross average earnings.

The absolute values of the deviation between the estimated average returns from equation (2) at the zero cost level and the average earnings from these practices during the 1962 and 1963 through 1967 crop

Table 9. Predicted Net Returns for Specified Storage Intervals and Standard Errors of Predicted Net Returns for No. 1 Ordinary Hard Red Winter Wheat Stored at Gulf Ports and Hedged in the Kansas City Futures Market with an "Anticipatory" Hedging Practice

Storage Interval	Variable Costs of Storage, Cents Per Bushel Per Month														
	0.00			0.75			1.00			1.25			1.50		
	1[a]	2[b]	%[c]	1	2	%	1	2	%	1	2	%	1	2	%
							—Cents per Bushel—								
July-Sept.	1.50	2.78	71.3	0.00	2.16	49.5	— 0.50	2.01	41.8	— 1.00	1.88	34.5	— 1.50	1.80	27.5
	(2.99)	(1.99)			(1.77)			(1.71)			(1.65)			(1.60)	
July-Dec.	6.55	6.63	99.1	2.80	3.49	86.3	1.55	2.78	72.5	0.30	2.23	54.5	— 0.95	1.82	35.6
	(2.79)	(2.58)			(2.14)			(1.91)			(1.69)			(1.50)	
July-Mar.	7.64	7.76	98.9	1.64	3.38	69.0	— 0.36	2.59	45.6	— 2.36	2.10	23.6	— 4.36	1.85	9.7
	(3.50)	(3.29)			(2.42)			(2.10)			(1.87)			(1.68)	
July-May	2.80	4.34	79.1	— 4.70	2.43	11.5	— 7.20	2.37	4.2	— 9.70	2.52	1.4	—12.20	2.19	0.5
	(4.93)	(3.07)			(2.37)			(2.30)			(2.18)			(1.82)	
Sept.-Dec.	4.73	5.34	90.9	2.48	3.89	76.0	1.73	3.52	68.6	0.98	3.19	60.6	0.23	2.87	52.5
	(3.54)	(2.99)			(2.59)			(2.44)			(2.30)			(2.16)	
Sept.-Mar.	6.67	7.00	96.2	2.17	3.86	72.5	0.67	3.19	57.1	— 0.83	2.66	40.8	— 2.33	2.34	25.2
	(3.77)	(3.36)			(2.66)			(2.38)			(2.14)			(1.90)	
Sept.-May	2.08	3.92	73.3	— 3.92	2.66	14.9	— 5.92	2.44	7.5	— 7.92	2.26	3.5	— 9.92	2.46	1.3
	(4.81)	(3.02)			(2.46)			(2.30)			(2.24)			(2.21)	
Dec.-Mar.	—0.63	2.08	41.9	— 2.88	1.52	16.2	— 3.63	1.42	10.4	— 4.38	1.30	6.6	— 5.13	1.20	3.9
	(3.00)	(1.66)			(1.34)			(1.26)			(1.19)			(1.16)	
Dec.-May	—5.11	3.13	13.2	— 8.86	2.97	4.1	—10.11	2.98	2.7	—11.36	3.04	1.7	—12.61	3.25	1.1
	(5.83)	(3.03)			(2.96)			(2.92)			(2.90)			(2.84)	
Mar.-May	—3.76	3.49	16.5	— 5.26	3.64	10.4	— 5.76	3.60	9.2	— 6.26	3.54	8.1	— 6.76	3.70	6.7
	(4.25)	(3.71)			(3.80)			(3.82)			(3.85)			(3.89)	

[a]Predicted net returns at the *ith* cost level from storage of wheat during the *jth* storage interval every year.

[b]Predicted net returns at the *ith* cost level from storage of wheat during the *jth* storage interval when the predicted returns were greater than the variable costs of storage.

[c]Percentage of trials in which the predicted returns from storage were greater than the variable costs of storage.

Table 10. Predicted Net Returns for Specified Storage Intervals and Standard Errors of Predicted Net Returns for No. 1 Ordinary Hard Red Winter Wheat Stored at Gulf Ports and Hedged in the Kansas City Futures Market with a "Simultaneous" Hedging Practice

Storage Interval	Variable Costs of Storage, Cents Per Bushel Per Month: 0.00			0.75			1.00			1.25			1.50		
	1[a]	2[b]	%[c]	1	2	%	1	2	%	1	2	%	1	2	%
							—Cents per Bushel—								
July-Sept.	1.92	2.61	82.5	0.42	1.85	58.2	—0.03	1.69	48.1	—0.58	1.57	37.9	—1.08	1.50	28.7
	(2.38)	(1.73)			(1.51)			(1.45)			(1.40)			(1.34)	
July-Dec.	7.09	7.25	98.0	3.34	4.17	86.1	2.09	3.42	75.3	0.84	2.83	60.9	—0.41	2.37	44.9
	(3.41)	(3.02)			(2.56)			(2.34)			(2.12)			(1.92)	
July-Mar.	9.37	9.38	99.9	3.37	3.86	90.7	1.37	2.63	71.0	—0.63	1.87	39.8	—2.63	1.46	15.0
	(2.83)	(2.62)			(2.22)			(1.87)			(1.56)			(1.36)	
July-May	3.71	4.35	90.0	—3.79	2.00	9.6	—6.29	1.89	3.0	—8.79	2.56	0.7	—11.29	2.21	0.2
	(4.00)	(2.56)			(2.05)			(2.00)			(1.92)			(1.48)	
Sept.-Dec.	4.83	5.55	90.5	2.58	4.07	76.7	1.83	3.71	69.3	1.08	3.37	61.8	0.33	3.08	53.6
	(3.74)	(3.13)			(2.74)			(2.60)			(2.46)			(2.32)	
Sept.-Mar.	7.28	7.39	98.7	2.78	3.86	80.7	1.28	3.10	65.0	—0.22	2.46	47.6	—1.72	2.11	28.7
	(3.29)	(3.11)			(2.53)			(2.24)			(2.01)			(1.80)	
Sept.-May	2.62	4.34	75.9	—3.37	2.93	18.2	—5.37	2.73	9.5	—7.37	2.80	4.4	—9.37	2.78	2.1
	(5.15)	(3.21)			(2.73)			(2.66)			(2.63)			(2.56)	
Dec.-Mar.	0.03	1.56	50.3	—2.22	1.17	12.6	—2.97	1.09	7.0	—3.72	1.12	3.4	—4.47	1.11	1.8
	(2.20)	(1.32)			(1.09)			(1.06)			(1.03)			(0.93)	
Dec.-May	—4.46	3.56	16.4	—8.21	3.37	5.8	—9.46	3.35	4.0	—10.71	3.24	2.9	—11.96	3.15	2.0
	(6.37)	(3.32)			(3.10)			(2.98)			(2.80)			(2.62)	
Mar.-May	—3.93	2.32	12.1	5.43	2.41	6.2	—5.93	2.37	5.1	—6.43	2.43	4.0	—6.93	2.37	3.4
	(4.74)	(2.33)			(2.32)			(2.30)			(2.27)			(2.23)	

[a]Predicted net returns at the *ith* cost level from storage of wheat during the *jth* storage interval every year.

[b]Predicted net returns at the *ith* cost level from storage of wheat during the *jth* storage interval when the predicted returns were greater than the variable costs of storage.

[c]Percentage of trials in which the predicted returns from storage were greater than the variable costs of storage.

Table 11. Predicted Net Returns for Specified Storage Intervals and Standard Errors of Predicted Net Returns for No. 1 Ordinary Hard Red Winter Wheat Stored at Gulf Ports and Hedged in the Kansas City Futurns Market with an "Any Month" Hedging Practice

Storage Interval	Variable Costs of Storage, Cents Per Bushel Per Month														
	0.00			0.75			1.00			1.25			1.50		
	1[a]	2[b]	%[c]	1	2	%	1	2	%	1	2	%	1	2	%
	—Cents per Bushel—														
July-Sept.	0.80	3.99	58.0	— 0.70	3.48	44.5	— 1.20	3.37	39.8	— 1.70	3.28	35.2	— 2.20	3.20	30.9
	(3.96)	(3.32)			(3.18)			(3.15)			(3.12)			(3.10)	
July-Dec.	8.42	8.54	98.9	4.67	5.18	93.1	3.42	4.18	88.1	2.17	3.36	78.4	0.92	2.72	63.9
	(3.74)	(3.09)			(2.75)			(2.61)			(2.43)			(2.29)	
July-Mar.	9.02	9.17	98.8	3.02	4.54	78.1	1.02	3.57	60.4	— 0.97	2.89	39.8	— 2.97	2.40	22.4
	(4.10)	(3.85)			(3.02)			(2.66)			(2.32)			(2.04)	
Sept.-Dec.	7.44	8.09	93.9	5.19	6.44	86.2	4.44	5.92	83.1	3.69	5.48	78.7	2.94	5.11	73.2
	(5.45)	(4.36)			(4.02)			(3.92)			(3.79)			(3.66)	
Sept.-Mar.	6.76	7.14	95.9	2.26	4.08	72.2	0.76	3.40	57.8	— 0.74	2.84	42.6	— 2.24	2.45	27.9
	(3.95)	(3.53)			(2.79)			(2.50)			(2.26)			(2.02)	
Dec.-Mar.	—0.55	2.06	40.0	— 2.80	1.70	14.6	— 3.55	1.61	9.8	— 4.30	1.64	6.0	— 5.05	1.68	3.8
	(3.05)	(1.80)			(1.62)			(1.60)			(1.60)			(1.56)	
Dec.-May	—5.28	3.40	12.7	— 9.03	3.13	4.4	—10.28	3.34	2.8	—11.53	3.40	1.9	—12.78	3.29	1.4
	(5.88)	(3.25)			(3.17)			(3.10)			(3.01)			(2.82)	
Mar.-May	—3.83	3.46	17.8	— 5.33	3.53	11.4	— 5.83	3.59	9.7	— 6.33	3.64	8.3	— 6.83	3.62	7.3
	(4.58)	(3.49)			(3.49)			(3.49)			(3.46)			(3.44)	

[a]Predicted net returns at the *ith* cost level from storage of wheat during the *jth* storage inteıval every year.

[b]Predicted net returns at the *ith* cost level from storage of wheat during the *jth* storage interval when the predicted returns were greater than the variable costs of storage.

[c]Percentage of trials in which the predicted returns from storage were greater than the variable costs of storage.

years are given in Table 12. Eighty-nine percent (25 of 28) of the differences are less than 0.10 cent.

The estimates of the variable costs of storage in a previous section tend to center around one cent per bushel per month. Consequently this cost level is used as a foundation for assessing the profitability of hedged storage. Comparing expected returns from storage every year at the one cent cost level in Tables 9, 10, and 11 reveals that a profit can be expected, on the average, in only a few of the storage intervals, primarily those beginning early in the crop year. Among the three hedging practices considered, the positive net returns from storage every year range from .67 cent to 4.44 cents per bushel. Average net returns per month at this cost level range from .112 cent to 1.48 cents per bushel. The returns are lower at higher variables cost levels, and are higher at lower cost levels.

The intervals in which hedged storage may be expected to show a profit are the intervals in which a country elevator in Oklahoma would feel the least need to store on its own account. Substantial quantities of producer owned wheat are usually in the elevators during these intervals. In addition, barley and grain sorghum are also stored by producers during these intervals in some areas. Late in the crop year, when country elevators would have a greater amount of space to store on their own account, the expected returns from storage every year are negative.

Under the condition that storage is not conducted unless storage returns exceed variable costs (column 2), positive returns are possible. However, the percent of times which this condition occurred for the storage intervals late in the crop year indicates that these returns will be

Table 12. Absolute Value of the Deviations Between the Estimated Storage Returns and the Observed Storage Returns from Hedges Placed in the Kansas City Futures Market During Specified Storage Intervals Under Alternative Hedging Practices

	Hedging Policy		
Storage Interval	**Anticipatory**	**Simultaneous**	**Any Month**
		—Cents/Bu.—	
July-September	.03	.00	.08
July-December	.05	.01	.02
July-March	.06	.01	.00
July-May	.17	.04	
September-December	.06	.01	.02
September-March	.00	.01	.06
September-May	.01	.00	
December-March	.01	.02	.05
December-May	.11	.26	.03
March-May	.04	.01	.09

realized only infrequently. The expected frequency of positive returns during those storage intervals late in the crop year ranges from approximately one year in ten to one year in thirty years.

The results indicate that terminal elevators and other firms in Oklahoma that must maintain stocks of wheat to conduct their business transactions generally would have benefited from hedging. Average losses on hedged storage during the latter part of the crop year during the period analyzed were less than the average losses from unhedged storage (Table 5), and the average gains during the early part of the crop year were approximately equal to or greater than the average increase in the cash price. For stocks of wheat that must be held, hedging would have been preferable during most of the crop year regardless of which futures market was used. However, during individual crop years, larger losses could have been realized by hedging in the Chicago futures market instead of the Kansas City futures market.

Two alternatives available to grain elevators in Oklahoma during the crop year are: 1) wheat could be sold as soon as possible after it is purchased; or, 2) wheat could be held after its purchase if the prospects of a profit appear favorable. Since basis changes at Gulf ports with respect to Kansas City futures contract prices appear to have been correlated with the initial basis in past years, analysis of price spreads could enable firms in Oklahoma to profitably increase the use of their fixed storage facilities. The first alternative could be utilized whenever the prospects of a profit appear unfavorable, and the second alternative could be utilized whenever the prospects of a profit from storage appear favorable. The Chicago futures market also could be utilized in this manner, but price spreads appear to be less valuable as decision variables for this market.

Seasonal variations in the cost of transportation of wheat to the Gulf could affect the effective price of wheat at locations in Oklahoma. If the transportation rate is constant, then basis changes at locations in Oklahoma will be equal to basis changes at the Gulf, and the estimated storage earnings given in this chapter are applicable to firms in Oklahoma.

A problem arises when transportation rates are variable. Depending on the sequence of the higher transportation rate, the basis change in the country will be increased or decreased relative to the basis change at the Gulf. The basis change at the country point will be increased if the higher transportation rate occurs when the wheat is placed in storage. Expected returns are the advance in the cash price relative to the futures plus the decrease in the transportation rate. The reverse would be true if the wheat were placed in storage at the lower transportation rate. Expected returns then would be the advance in the basis minus the increase in the transportation rate.

It is debatable whether the returns caused by changes in the transportation rate should be classified as storage earnings, merchandising earnings, or windfall profits. The fact that firms may derive additional benefits from changes in transportation rates by a well-timed practice of hedged storage is only recognized.

SUMMARY

Changes in the institutional structure of the wheat marketing system in the United States result in a relatively "free" marketing system during certain years. It is relatively "free" when price support programs of the Government are set at levels which have less direct influence on the level of the domestic price. This situation existed from 1964 through 1968. Also, new programs designed to encourage the disappearance of wheat have been relatively successful. The disappearance of wheat exceeded production for six consecutive crop years (1961 to 1966) and CCC inventories of wheat decreased approximately one billion bushels from 1961 to 1967.

The decline in CCC inventories has resulted in substantially reduced opportunities for elevator operators to utilize owned storage capacity in excess of that required for handling operations. Some firms may desire to utilize excess storage space by storing wheat owned by the elevator. However, this practice exposes the firm to greater price risks than it would face in a handling operation or by storing wheat for other inventory owners. Such price risks may be greater under the new structure than under the high price support programs.

Hedging has been advocated as a means of reducing price risks associated with inventory ownership. However, some persons in Oklahoma view hedging as relatively ineffective for grain elevators in Oklahoma. This belief is based upon the premise that the price of wheat in Oklahoma is determined by the price in the Gulf export market and that futures prices are strongly influenced by domestic market conditions. According to this belief, the conditions affecting the price in the two markets are sufficiently different so that an unpredictable relationship exists between the two prices. This contention was the principal question investigated in this study.

In an equilibrium situation, the cash price should be discounted relative to the expected cash price at a point in time later in the crop year by an amount which reflects the cost of storing the commodity until this later date. An equilibrium would be achieved when the supply of the commodity is sufficient to satisfy the needs of consumers and the commodity moves into consumption at the rate desired by consumers. This ideal situation will rarely, if ever, be achieved. However, the marketing system still must ration a fixed supply among alternative users during a crop year. Futures markets can assist the marketing system in the performance of this function by providing price signals which may be used for inventory accumulation, production scheduling, etc.

The contribution of futures markets to the marketing of a commodity has been subject to controversy. Keynes and Hicks were perhaps the first economists to formulate what might be called a theory of futures markets and prices. These men viewed futures markets as analogous to insurance. Hedgers (the insured) purchase price insurance from the speculators (the insurers). Hedgers must expect to pay a premium for this insurance, and the futures price must therefore be less than the expected cash price at maturity by an amount sufficient to induce speculators to assume the risk. According to this theory, futures prices must be biased estimators of expected cash prices. The theory appears to be invalid. Research has indicated that futures prices generally are not biased in favor of either hedgers or speculators.

Other research results indicate that current cash prices tend to respond to changes in futures prices. For example, if new information indicates that a one cent adjustment in futures prices is necessary, the current cash price tends to adjust by the same amount. This means that, in the short run, current mraket differentials between a cash price and a futures contract price are maintained. Market differentials at the delivery point for the contract type and grade of wheat thus have come to be regarded as the price of storage, and measure the earnings which could be earned by storing the wheat until the maturity date of the futures contracts. In this respect, cash-futures price spreads tend to measure the competitive price of storage facilities at any time during the crop year. These prices of storage are strictly applicable only at the delivery point and for the delivery grade, but also may provide good estimates of the storage returns for other locations and for other types and grades of the commodity. The price of storage is sometimes called the carrying charge.

Hedging is done by firms in the grain trade for many different purposes, and any futures market transaction which is incident to the normal functioning of the firm should be classified as hedging. Therefore, this study cannot be interpreted as evaluating the effectiveness of all types of hedging. Only the specialized purpose of carrying charge hedging was evaluated. This evaluation was conducted by determining whether or not the change in the cash-futures price relationship can be predicted from the spread between these prices at the beginning of a specified storage interval. Changes in this spread, commonly called the basis, determine the gross returns from a fully hedged position. The study thus is an application of the price of storage concept to wheat stored at a location other than the location of the futures market.

The returns to Oklahoma grain elevators from the practice of carrying charged hedging were determined by using a cash price of No. 1 Hard Red Winter wheat. f.o.b. vessel at Gulf ports. The cash price is the price at which exporters have sold wheat which is to be loaded on a vessel within the next 30 days. The price which exporters would be willing to pay in order to obtain the wheat to fulfill this commitment is the selling price minus handling charges and profit and pertains only to contracts for delivery which they negotiate with country suppliers. The 30-day f.o.b. vessel price may change by the next day, and this change should be reflected in the price paid to country suppliers.

The futures contract prices used in the analysis were from the Kansas City and Chicago Boards of Trade. The price of a futures contract on the Kansas City Exchange is also the price for Hard Red Winter Wheat, but for "skin" No. 2 Hard Red Winter Wheat, i.e., the lowest possible quality of wheat that may be delivered with no penalty. The Chicago futures contract allows delivery of several types and grades of wheat at the contract price. The Chicago futures contract permits delivery of soft as well as hard wheats.

Several hedging practices were evaluated to determine the expected returns from a consistent application of each practice. This evaluation was performed in a static framework. The hedging transaction takes place at the same points in time each year. Thus, any changes during the storage interval which would provide a more favorable outcome for the hedger are ignored. For example, a higher average return might have been possible if the hedger had kept informed of market conditions and terminated the transaction when he felt that further gains were impossible.

CONCLUSIONS

The price of wheat at Gulf ports does show a predictable relationship with the Kansas City futures price. A high degree of predictability is attained for those storage intervals which end in the near month futures contract. A lower degree of predictability is attained for other intervals, but in all cases there is a relatively high degree of correlation between the initial spread of the cash and futures prices and changes in this spread when hedges are placed in the Kansas City futures market.

A substantially lower degree of predictability is attained when hedges are placed in the Chicago wheat futures market. This result was expected and implies that the wheat contract of the Chicago futures market provides a less reliable price upon which to base price expectations concerning Hard Red Winter wheat. Spreads between cash prices at Gulf ports and Chicago futures contract prices appear to provide a less reliable foundation upon which to predict the earnings from hedged storage at Gulf ports than do price spreads with respect to Kansas City futures contract prices. However, for storage intervals ending in May, the degree of predictability with respect to both markets is approximately the same.

The pattern of seasonal changes in the basis with respect to the May contract is approximately the same for the two markets during the first half of the crop year. There is relatively small average increase in the basis from July to September and a large average increase from September to December when the change in the cash price is taken with respect to the May futures contract.

The pattern differs for the two markets during the period from December to March. The Chicago futures market shows a small increase in the cash price relative to the May contract, whereas the cash price decreases relative to the Kansas City May contract during this period.

Average returns from hedges placed in the Chicago futures market are generally greater than the average returns from hedges placed in the Kansas City futures market. However, the results indicate that these higher returns cannot be expected with any degree of certainty when the initial price spread is used as the variable to analyze prospects for hedges placed in the Chicago wheat futures market. This implies that substantially greater knowledge is required before the Chicago futures market may be intelligently and effectively used by grain elevator operators in Oklahoma.

The results indicate that hedged storage may not be particularly favorable for elevators with options to choose whether or not to engage in this activity. If hedged storage is conducted regularly, the expected returns are relatively low. The results possibly are not large enough to induce elevator operators to subject themselves to the increased risk of inventory control. Although the expected returns from hedged storage are small, those firms which must engage in a storage activity probably could benefit through the use of hedging. The expected returns from hedged storage are greater than or approximately equal to the average cash price increase which occurred during certain of the intervals considered in this analysis when hedges are placed in the Kansas City futures market. During the intervals that the cash price decreased on the average, the average basis decrease on wheat hedged in Kansas City futures market was smaller than the cash price decrease.

The results also provide some indications concerning the desirability of alternative hedging practices. The sale of futures contracts at the market close in anticipation of overnight purchases of cash wheat appears to be slightly less favorable than a practice of selling futures contracts at the open after the purchase of cash wheat has been made. These two practices are denoted in this study as anticipatory and simultaneous hedging respectively.

Placing hedges in futures contracts that mature later than the month storage is terminated also appears to be a less desirable practice during certain periods of the crop year. This practice was denoted as "any month" hedging in this study. During the early part of the crop year (July to September) this practice would have yielded smaller average returns than from simultaneous or anticipatory hedges placed in the Kansas City futures market. Average returns from this practice also would have been smaller than from hedging in the Chicago futures market or from unhedged storage. However, even during the early part of the crop year, the "any month" hedging practice still would have reduced the largest loss which would have been incurred on unhedged storage.

These results may be summarized by the following rule: if storage is to be terminated prior to the near futures month, a hedge should be placed in a later futures month only when the spread between the near month contract and the later contract is expected to decrease or remain unchanged. During the five years analyzed, this action would have been appropriate primarily for storage intervals ending in December.

There appears to be no reason why grain elevators in Oklahoma cannot effectively utilize hedging in those operations of the business which require the storage of wheat. Most grain elevator operators have access to more information regarding market conditions than was used in this study. This knowledge, along with an understanding of the nature of hedging transactions and the normal seasonal pattern of the basis, can be effectively utilized by grain elevator operators in Oklahoma.

FOOTNOTES

[1]U.S. Department of Agriculture, *Agricultural Statistics 1967,* (Washington: Economic Research Service, 1967), p. 12.

[2]U.S. Department of Agriculture, *Grain Market News,* (Washington: Consumer and Marketing Service), selected issues.

[3]Ibid.

[4]Lester Telser, "Futures Trading and the Storage of Cotton and Wheat," *Journal of Political Economy,* LXVI (1958), pp. 235-236.

[5]Rollo Ehrich, "The Impact of Government Programs on Wheat-Futures Markets," *Food Research Institute Studies,* VI (1966), p. 320.

[6]J. R. Hicks, *Value and Capital* (2d ed., London, 1946), p. 138.

[7]Lester Telser, "Futures Trading and the Storage of Cotton and Wheat," *Journal of political Economy,* LXVI (1958), p. 234.

[8]Roger Gray, "The Characteristic Bias of Some Thin Futures Markets," *Food Research Institute Studies,* I (1960), p. 312, quoted in Seymour Schmidt, "A Test of the Serial Independence of Price Changes in Soybean Futures," *Food Research Institute Studies,* V (1965), p. 133.

[9]Holbrook Working, "New Concepts Concerning Futures Markets and Prices," *American Economic Review,* LII (1962), p. 452.

[10]Ibid., pp. 445-447.

[11]Random walk may be illustrated by means of an example. Consider an experiment which consists of flipping a fair coin n times. Prior to each flip of the coin, move forward one step. After each flip, move one step to the right if a head appears, and one step to the left if a tail appears. If the results of this experiment were plotted on a graph, the resulting curve would exhibit random walk. A characteristic of random walk is that although the cause of a change is known, knowledge of what has happened on previous trials of the experiment cannot be used to predict what will happen on the nth trial.

[12]Working, "New Concepts Concerning Futures Markets and Prices," p. 446.

[13]Ibid., p. 447.

[14]Ibid., p. 438.

[15]Ibid., p. 442.

[16]Holbrook Working, "Futures Trading and Hedging," *American Economic Review,* XLII (1953), pp. 333-336.

[17]"Long basis hedging" and "short basis hedging" are sometimes used in place of "short hedging" and "long hedging" respectively. Any trader on a futures contract exchange may be short (sold futures) or long (bought futures) in his futures market commitments. However, only hedgers have established a position in both markets and thus may be described with respect to a basis position.

[18]This statement must be qualified in order to recognize that futures prices are not perfect estimates of the prospective price. If futures prices were perfect estimates, then no change in the price relationship necessarily means that the cash price would be unchanged. This definition then implies that both prices must move in the same direction and have the same magnitude of change when futures prices are not perfect estimators.

[19]Holbrook Working, "Hedging Reconsidered," *Journal of Farm Economics,* XXXV (1953), p. 560.

[20]Roger Gray, *Food Research Institute Studies,* III (1962), p. 23, cautions ". . . against misinterpreting a loan induced seasonal price pattern as being a typical futures price pattern." Gray looks only at futures prices, but this conclusion also suggests that cash-futures price relationships were also affected by the loan programs in the high price support era.

[21]A standard normal variate has a zero mean and unit variance, with a range of minus infinity to plus infinity. The process of generating the initial basis consists of transforming a $N(0, 1)$ variate to one having a $N(\mu, \Sigma^2)$ distribution.

[22]The best linear unbiased estimator of the mean value of the dependent variable corresponding to a given value of the independent variable is

$$\hat{Y}_0 = a + bX_0.$$

The variance of this estimator is

$$E\left\{[\hat{Y}_0 - E(\hat{Y}_0|X_0)]^2\right\} = \text{var}(a) + X_0^2\ \text{var}(b) + 2X_0\ \text{cov}(a,b).$$

Substitution of the various expressions for the variances yields

$$\text{var}(\hat{Y}_0) = s^2_{y\cdot x}\left[\frac{1}{n} + \frac{(X_0-\bar{X})^2}{\sum_{i=1}^{n} x_i^2}\right].$$

The term in equation (3) is the square root of this statistic. This expression for the variance of Y_0 yields a curvilinear interval about the regression line, i.e., the variance of the prediction increases as X_0 increases relative to $\bar{X}$.

[23]The Monte Carlo Procedure consists of subjecting a known relationship to a number of random outcomes to simulate the effect of unknown forces. The distribution of a random variable is sampled to obtain these random outcomes. As the number of trials increases, the mean of the random variable in question should converge to some value. Theoretically, deviations of an estimate from a population characteristic can be made as small as desired by increasing the number of trials. A large number was necessary in this analysis since it would be possible that only a small proportion of the predicted basis changes would be greater than the cost. For example, if only ten percent of the predicted basis changes in a sample of 500 exceeded a cost level, then the estimated average returns at the cost level would be based on only 50 sample values.

[24]James Enix, "Grain Marketing at Country Elevators," *OSU Extension Facts* No. 405, p. 405.3.

[25]Charles W. Brown, "Cost Characteristics and Management Decisions of Oklahoma Cooperative Grain Elevators," (unpub. Ph.D. dissertation, Oklahoma State University, 1963), p. 59.

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