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SPECULATION AND HEDGING†

The study of futures markets has been hampered by an inadequate understanding of the motivations of market participants. As far as speculators are concerned, their motives are easy to interpret: they buy because they expect prices to rise; they sell because they expect prices to fall. Analysts may differ about the rationality of speculators, their foresight, or the shape of their utility functions, and these differences of opinion are both important and extensive, but there is little recorded difference of opinion on this central issue of motivation.

The theory of hedging, on the other hand, has been very poorly developed. Until Holbrook Working's paper (*45*), the conventional description of hedging in the economics literature was extremely oversimplified and in fact, demonstrably incorrect. Since then Lester Telser (*30*) and Hendrik Houthakker (*17*) have taken a substantially correct view of hedging.[1] The pre-Working view has maintained itself partly perhaps because of the inertia of established opinion, and partly because of general ignorance about the role of futures markets. Furthermore, many academicians find discussions of futures markets and hedging hard to follow. The object of this paper is to restate the theory of hedging in a more explicit theoretical, though informal, fashion hoping to clarify issues by using analogies with well-understood financial markets. I further intend to present some verifiable implications of that theory, and finally, to set forth some initial steps toward verification. I hope that by restating the theory comprehensively and elaborating on it, the reader will benefit, not suffer, from the necessary redundancy. The results are fully compatible with Working's exposition, but are not identical and there are likely to be some disagreements about the elaborations. These disagreements can be resolved by empirical testing, but the central purpose of this paper is to widen agreement, not to excite controversy.

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[1] A few minor confusions mar the Telser paper, however. He fails to allow for carrying costs in defining profitability of a hedge. This requires only a minor reinterpretation of the results in the fixed horizon case, but is somewhat more troublesome in the case of continuous review. A confusion about what is included in carrying costs also leads to the erroneous conclusion (*30*, p. 5) that forward prices cannot exhibit Keynesian "normal backwardation."

Hedging is usually defined by illustration. In the standard example, a buyer of (say) 5,000 bushels of wheat at $2 a bushel, fearful of the risk of price decline, simultaneously sells a futures contract representing 5,000 bushels of wheat at $2. If the price subsequently drops to $1.75 a bushel, the capital position of the buyer will be unaffected because the futures prices will also decline and the profit on his short sale of futures will exactly offset the loss on the inventory holdings. The exactness of the offset is guaranteed by the possibility of making delivery against the futures contract. Thus, by hedging, the holder of wheat eliminates the risk of price fluctuation.

This simple, but erroneous, version of hedging emphasizes the two supposed properties of the hedge: (1) that price movements of the warehouse inventory and the futures contract will be exactly offsetting (that the expected value of the hedged position is zero); and (2) that the hedge "eliminates the risk of price fluctuation" (that there is no variance around this expected value). Both of these ideas are incorrect. In normal hedging practice price changes are not expected to be offsetting, and while risks will be reduced, they will not be eliminated.[2]

The standard definition falls short in the two fundamental ways. First, it abstracts from the costs of, and motivations for, the holding of inventory. In carrying a commodity from one point in time to another, the holder incurs carrying charges such as interest and insurance, takes on the risk of price fluctuation, and benefits from the convenience yield of the commodity. His willingness to carry the asset must depend on his ability to recoup the net costs of storage. Since in selling a futures contract as a hedge, the merchant is setting the return he will earn on the spot[3] commodity *if* he holds it until the futures contract matures, the relation between the spot and futures prices is of utmost importance to the hedge transaction. It is not a subsidiary matter which can be ignored without essential concern. Like the finance company that borrows at one rate to lend at another, a merchant normally earns his profits from reaping a return on his inventory greater than the costs of storage. This is equally true whether or not he hedges. To say that a merchant hedges in anticipation of profit does not necessarily mean that he will not settle for a smaller profit if accompanied by lower risk, but he measures the profit as carefully as the risk reduction.

Secondly, hedging does not *eliminate* risk. One of the elements in the supply of storage is the convenience *yield* of the commodity which offsets some or all of the carrying costs. These yields arise from the ability to use the holdings at the owner's discretion, for nonstorage purposes. The manufacturer-owner can save production costs by using inventory instead of making unplanned purchases: the merchant earns revenues by selling the goods. The convenience yield arises because of the "spot" nature of the commodity—because of its immediate usefulness and availability. The future contract, on the other hand, has a fixed maturity;

[2] This does not necessarily imply that everyone who uses the standard definition is not aware that it differs from reality. In general, it is believed that the example is an abstraction from reality which preserves its essential elements. For many purposes, it is a useful abstraction. On the other hand, this paper argues that this abstraction stands in the way of a deeper understanding of the interrelationship between hedging and speculation.

[3] In what follows I will use Working's convention of using "spot" to represent the asset in storage or for immediate delivery. The term "cash commodity" will represent all nonfutures transactions in the commodity, for either immediate or deferred delivery.

it calls for delivery during a specific period. Now, the sale of a future for a short hedge does not commit the merchant to holding the inventory until the maturity of the futures contract. In fact, he will customarily *plan* on using his inventory prior to the maturity of the hedge: if he holds the inventory to maturity it can generally be assumed that expected commercial opportunities did not develop. He is likely to hedge in the full knowledge that the quoted difference between spot and futures will not provide returns in excess of costs unless he gets an opportunity to sell or use the inventory prior to the maturity of the futures contract. He hedges in the expectation that he will *get* such an opportunity. It is the expected value of that selling opportunity which comprises the convenience yield. Once the possibility arises of not holding the hedge to maturity, the hedge is no longer a *riskless* alternative to holding inventories unhedged, but merely a less risky one.

A short hedge[4] in six-month futures is no more risk-free than the banker's acceptance of a demand deposit to buy a six-month U.S. Treasury bill, or selling a one-year certificate of deposit and using the proceeds to make a six-month loan (27). Any of these operations may make good business sense in any given situation, but only after a judicious balancing of risks and returns. Using the conventional definition of hedging is like trying to explain banking operations without regard to the rate of interest (or the cost of servicing deposits) on the one hand and without making a distinction between demand deposits and one-year U. S. Treasury bills on the other. In each case the more abstract depiction imparts information of value, but some important aspects of the situation can only be treated with a more detailed model. As a matter of fact, while the portfolio details are different the analogy can be stretched a bit further without distortion. The hedging practices of a grain merchant with respect to his portfolio are quite analogous to the portfolio management practices of a bank or insurance company; they are of about equal importance to the success of the enterprise and bear about the same relationship to risk aversion. The daily decisions about magnitude of purchases and sales, and about asset and liability maturities are part and parcel of business operations, and yet in all cases the profitability of the enterprise rests primarily on the nonportfolio aspect of the business—actual commodity sales for the merchant, business loans for the banks, and policy sales for the insurance firm. I have some hopes that the roots of the convenience theory of hedging lie in the recognition of this central role of hedging in daily merchandising operations for, if I am right, that theory is reconcilable with the Keynes-Hicks theory in much the same way that bank portfolio management is reconcilable with liquidity preference.

To achieve that reconciliation (and indeed, to fully establish my propositions) will require further elaboration. To make my assertions more precise, I will need to first detour to a reexamination of the supply curve of inventory-holding. In doing so I will follow the Working-Telser-Brennan theory quite closely, but I will make some minor changes and stress some aspects that have not been given careful treatment previously.

[4] A short hedge will always describe a hedge involving a short sale of futures. It will never be used to mean a hedge of brief maturity.

The Supply Curve of Storage

No rational person will hold inventories unless he expects the benefits from such inventories to at least equal their costs. Competition, then, will ensure that inventories will be held by those who have the lowest costs or who receive the greater benefits. Since an item can always be considered either a cost or a negative benefit, certain conventions will be useful in dealing with those items. In what follows, I will follow tradition and separate out one item, expected price appreciation, as benefit or revenue, and consider all other items as (possibly negative) costs. These items fall naturally into three categories: the direct costs of storing and financing the inventories, the indirect costs associated with inventory holding, and the indirect benefits of such holdings.

The direct costs of storage are the most straightforward. They are the marginal costs of warehouse space, interest charges, and insurance against physical damage, theft or deterioration. Insurance and interest costs will vary with the price of the goods, but virtually all of the costs will be substantially constant with respect to inventory level at a given price over a wide range (*2*). In the short run more capacity is available at ascending costs, but the conditions for the reproduction of storage space are such that long-run average costs are probably constant.

The indirect cost, if any, of inventory, is the threat it poses to the capital position of the holder. It is, of course, possible that a merchant will cool-headedly value inventory without any allowance for the disutility of capital variance, but if he *is* averse to risk, he will count it as a real cost of doing business.[5] Furthermore, while the risk itself is not a money cost of doing business, the risk-averse merchant will stand ready to pay to avoid the risk, just as he buys insurance against fire damage for a larger premium than justified by the expected cost of fire. And if he cannot buy insurance directly, he will refuse many opportunities to profit rather than incur incremental risk, thus paying for "insurance" indirectly. For any individual merchant, the marginal payment he is willing to make to reduce the risk associated with carrying another bushel of inventory doubtless rises with the level of inventory he is already carrying. For the industry as a whole, the shape of the marginal cost curve depends upon whether additional inventories are held by newly entering firms or existing firms and, if new firms, whether or not they are identical with old ones. If increased inventories are held by new firms, the risk premium will not have to rise as the inventories increase. In the short run, i.e., with firms' capital limited, however, we would expect industry risk premiums to rise with inventory.

It is the indirect benefits of inventory holding that have been least carefully spelled out. To make the discussion more specific, take the case of the merchant. Inventories are the "liquidity stocks" of his profession. Out of such holdings he can meet importunate demands of customers for immediately available supplies. If such supplies are restricted, he will be able to derive revenues somewhat greater than normal in addition to securing business that would go elsewhere if he did

[5] In what follows I am usually going to assume that the merchant is risk averse for ease in exposition.

not have the goods available. For example, transportation costs of alternative supplies can give the merchant an economic rent on the last supplies available in an area. Even when alternative supplies are available, relative scarcity increases the probability of a later shortage and thus the present value of local supplies, and increases the costs of "shopping around" as well. In general, the merchant knows that the lower his inventories in terms of the level and variability of demand, the more likely it is that he will have to forego some lucrative business. Since these foregone revenues increase as inventories decline, we can attribute to each marginal unit of inventories a return or yield which increases as the level of inventory decreases. This is what Working, Brennan, Kaldor, and Telser call the "convenience yield" of inventory.

We can look on the convenience yield of inventory as the present value of an increased income stream expected as a result of a conveniently large inventory. It is an expected value concept, quite independent of any attitudes the inventory holder may have toward risk. This is important to recognize, because the fact that a convenience yield would not exist in the absence of uncertainty or transactions costs sometimes leads to the erroneous conclusion that such a yield arises out of an attitude toward risk.

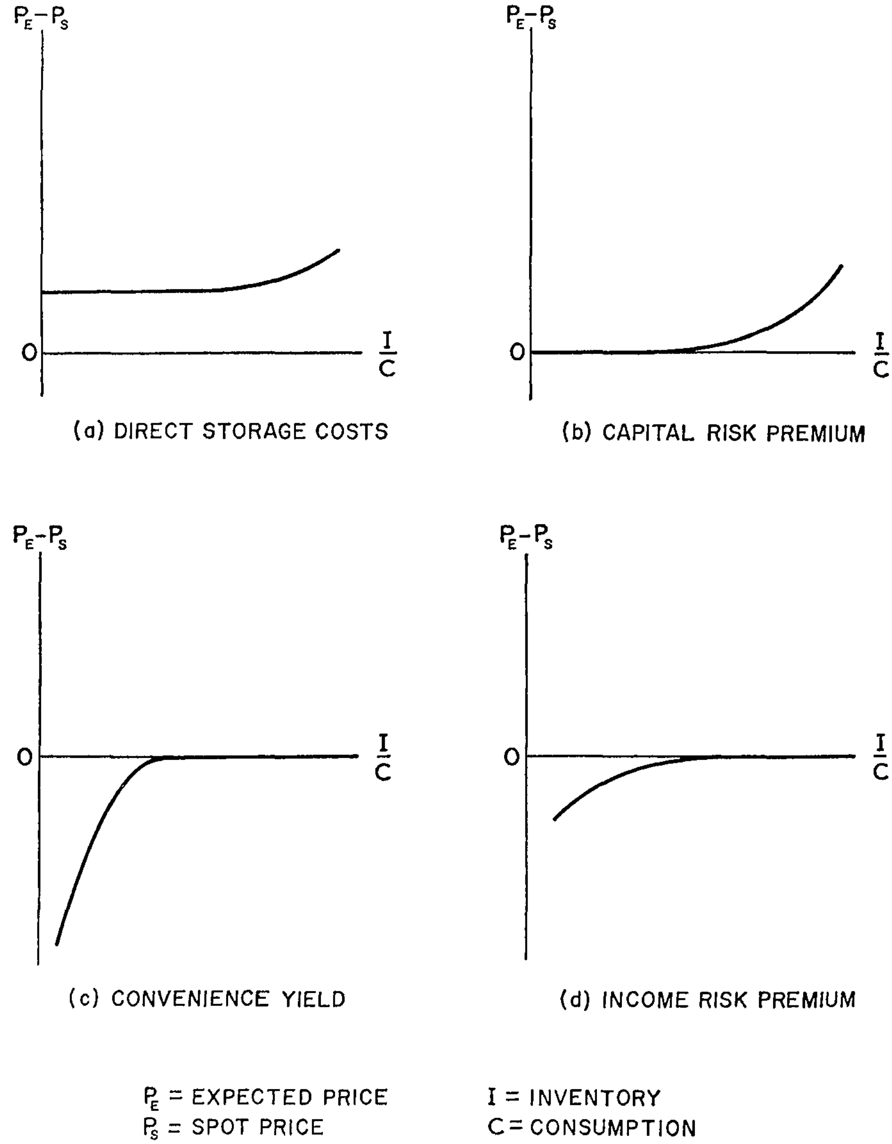
There is, however, an analogue to capital risk which can arise out of income variability. Just as increasing inventory increases the holder's exposure to the risk of price fluctuation, decreases in inventory holdings increase the prospect of income variability. When inventories are quite low the prospect of such income variability may very well induce the holder to carry somewhat more stocks when the level is low than would be justified on the basis of present value in much the same way that he might carry somewhat less inventory when stocks were already high. Such an attitude of aversion to income variability would produce an income risk premium, analogous to the capital risk premium, which would be large when inventories were low, but decreased monotonically with stocks.

It would be conceptually more pleasing simply to recognize that income fluctuations impair capital just as price fluctuations do and combine the two risk premiums into one. However, since most discussion of inventory holding has been oriented to the price risks, it is pedagogically worthwhile to distinguish the two.

Market institutions arise out of opportunities for shifting economic activities from high-cost to low-cost participants. The merchandising function itself seems to be one of these. When total inventories are high, the benefits to production costs ascribable to a marginal unit of a manufacturer's inventory are likely to be less than the possible increment to merchandising income derivable from adding them to the central stock of some merchant. When total inventories are low, their value to a manufacturer is likely to exceed their value to the merchant, and they tend to accumulate with such consumers. The merchant arises because of the relative cheapness of centralizing surplus stocks when inventories are low and distributing them when inventories are high.

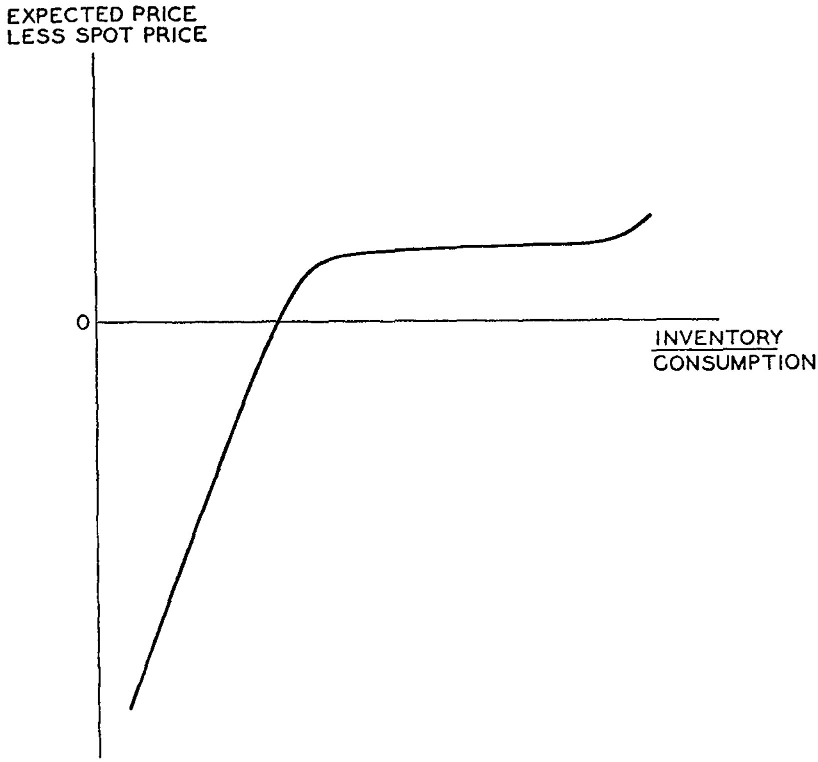
In the same fashion, futures markets serve to allocate risk among the cheapest suppliers of risk taking. When inventories are low, the risk of holding them is low and the premium that anyone is willing to pay to avert price risk is also low.

Chart 1



As inventories grow, so do the risk premiums. If there is an insurance at some fixed premium, then merchants would hold inventories unhedged until their "demand" for insurance rose to that level. They would "self-insure" until that point. Beyond that level of inventory, speculators would be willing to write insurance more cheaply than merchants could self-insure. Since speculative participation reduces costs of this insurance, futures markets have grown up largely to facilitate speculative entry. The fact that merchants are not always hedged, or if

CHART 2



hedged, are often not fully hedged is often taken as evidence that they only hedge when prices are expected to fall rather than to avert risk[6] with the subsidiary implication that since they are more knowledgeable than speculators they are likely to outwit them. The conclusion may be valid, but it is certainly not a defensible deduction from the premise. In fact, the reverse hypothesis is much more defensible. If speculative services are provided free or at a loss, then we should expect hedging to be universal, since the hedger reduces his risk at no cost to himself (or perhaps even a profit).

These different elements of the cost of storage are indicated in Chart 1. While they can, when added, produce almost any positively sloped supply curve, the pattern shown in Chart 2 is the one indicated by all empirical studies (*2; 31; 39;* 40).

While empirical studies generally confirm our expectations about the supply of storage, it must be noted that the relationship they measure differs in an important manner from the theoretical relationship. The theoretical curve depicts the relationship between demand for current inventory (or inventory-consumption ratio) and the marginal costs over some finite period of time. Costs for some

[6] I believe that it is one of the implications of Working (*46*, pp. 325–26), though his concept of hedging permits both kinds of hedging.

finite period are the integral of the instantaneous costs over that period. As Helmut Weymar (*37*) pointed out, different expected time patterns of inventory levels during that period should yield different estimates of the costs of holding. Thus, the empirical relationship examined reflects the average pattern of inventory accumulation or decumulation during the period of study. This fact does not impair in any important way the validity of the empirical support for the postulated shape of the supply curve of storage, but it does (1) bring into question some of the behavioral conclusions drawn from them, (2) give us more insight into the behavior of hedges, and (3) yield some testable propositions about the behavior of futures price spreads. Since the basis reflects not only current inventories, but the time pattern of expected demand for those inventories as well, it can be expected to fluctuate in response to revisions in those expectations. Furthermore, since changes in the basis affect the profitability of the hedge, this uncertainty about future demand introduces riskiness into the hedge, *and* the ability to profit from more accurate predictions about basis changes.

Weymar has shown, for example, that the proposition (*42,* p. 15) that changes in supply and demand expected in the future will affect spot and future prices equally is not strictly true, either theoretically or empirically. It is approximately true, and much more accurate than the theory which Working was rebutting. It is also true for the theoretical supply of storage curve, which depends only on current inventory. However, the difference between September and December corn futures depends not only upon expected inventories in September but also on the expected size and timing of corn marketing and use in the period between September and December. For agricultural commodities and periods which do not include harvest, the relationship between beginning inventories and those at later dates in the period are usually stable, since price elasticities are relatively low and price changes usually small. It is this stability which makes the empirical approximation useful to economists. However, the variations from this "stable" relation are of vital importance to the hedging decisions of merchants.

One merchant can only outdo another by earning a better return on storage of his inventory. To earn the exceptional returns that raise the average, a merchant must hold inventory apportioned among those grades and locations which will earn him the greatest yield on resale. We can arbitrarily divide these yields into two portions: the returns from holding wheat of a standard grade and location (futures grade); and the differential between that return and those from holding other grades at other locations. The former operation is usually much the more competitive, since all participants in the futures market are potential competitors. It is the latter operations which have the most profit potential for the merchant. However, yields on the standard grade are vitally important for hedging behavior and every hedger will find his returns on the holding of nonstandard grades either reduced or increased by any errors in his judgment concerning the hedge.

The precise pattern of inventory liquidation is of the essence to the merchant. If demand is to be weak next month and strong in the following month, it would be best to sell the commodity now and buy it back later even if both spot and future prices remained unchanged. In particular, and more important, if a merchant as of March 1 is hedged in the March future, it is of the utmost importance to him whether demand in the March-May period will be greater or less than is currently reflected in the spread. In the former case, he should shift his hedge to May and thus earn the greater return on his inventory. In the latter case he should sell now (or possibly deliver)[7] reacquiring his inventory at a later date when the anticipated lower demand has resulted in greater discounts on spot. In a competitive market like a futures market, we cannot expect all merchants to have expectations about storage returns different from those reflected in futures price spreads. But it is quite possible for all merchants to have expectations different from normal past patterns, and if the merchant operated solely on such normal relations he would find himself unwilling to buy merchandise when it is profitable to do so and excessively willing when it is not. There are times when spreads are less than normal but are expected to become still smaller and conversely.

Finally, while it is not possible for all merchants to expect returns from storage different from those reflected in futures, it is possible (and indeed likely)[8] for them to all feel that it is more likely for the nearer future to fall relative to the most distant. To see this, one must note that merchants will not seek the return commensurate with the expected level of inventory—they will instead seek the expected return commensurate with the possible levels of inventory. The issue arises because, given the shape of the supply curve of storage shown in Chart 2, equal errors of understanding or overstating inventory charges do not have consequences of equal and opposite value. If total stocks are smaller than anticipated, spot prices will gain on futures to a much greater extent than they would have fallen relative to futures if inventories had been larger than anticipated by an equal amount. This is particularly so when inventories are relatively small, i.e., to the left of the horizontal portion of the supply curve. This means that the probability distribution of basis changes is highly skewed to the right and in all such cases the expected value is to the right of the median. In view of this, we would expect the near future to lose ground to the distant future much more often than the reverse, but that the rarer occasions when near futures gain on distants will yield greater profits. If hedgers are not risk averters, we would expect the infrequent large gains to just offset the more frequent small losses. If hedgers are risk averters, the result will depend upon hedgers' positions in the two futures. The full results cannot be discussed until a broader basis is laid. The major result is empirically valid, however, as Working (*40,* p. 191) has shown for the May-July wheat spread, the May future usually loses ground to the July from the time it is first quoted to the maturation of the May contract, but that when the reverse movement occurs it is much larger in magnitude.

The Maturity of a Hedge

When a merchant buys deliverable wheat on July 1 and hedges it in the March future, he is buying an asset and simultaneously incurring a liability. The liabil-

[7] Contrary to common misapprehension, delivery does not usually take place because of a gap between spot and prices of the expiring future during the delivery period. It occurs because the delivering merchant feels the recipient will not be able to use the delivery and will have to redeliver or to sell at a greater discount under forward months while paying storage charges to the deliverer. Frequently, perhaps usually, the merchant delivers early in the month in full expectation of taking delivery again late in the month.

[8] It is certainly "likely" as a logical matter if they are profit maximizers. If they are utility maximizers it is only "likely" if, as an empirical matter, risk aversion does not completely offset the primary effect. The empircal question is discussed below.

ity, the "debt" payable in wheat, matures in eight months. The asset, like cash, can be used at any time. To extend the analogy, the difference between the asset price and the price of the liability i.e., the difference between the future and spot prices (henceforward, the "basis"), is the market "yield" on wheat for an eight-month term loan. It is the yield the merchant will receive if he actually holds the wheat to maturity. This may or may not be what the merchant intends to do, but assume for the moment that it is. In other words, he has made an estimate of probable demand for his inventory and has come to the conclusion that this asset (inventory) will not be "called" (sold) until March. Suppose further, however, that he underestimates demand and finds a demand for that wheat which arises as early as January. Since inventories are lower than expected, and the marginal return to inventory-holding decreases monotonically with quantity held, this means that (a) the spot price of wheat will be higher, relative to March futures, than he predicted at the time the hedge was placed, and (b) the change in his "basis" is greater than his costs of carrying the wheat up to that point. In other words, he now shows a *profit* on the hedged position over and above his "costs" for carrying the wheat. He can sell the wheat in January and uncover the hedge at that time rather than holding the position to March and convert that profit to cash. Whether he will want to liquidate the wheat will, of course, depend upon his view of the future as of January, but the opportunity would be there. This opportunity arises because of the different *maturity* of the wheat and and the futures contract.

In exactly the same fashion, the merchant could have been faced by unexpectedly low demand. In that case, January inventories would have been greater than expected and March futures would have sold at a greater premium over spot wheat than was foreseen. Conversely, the change in the basis up to January would have been less than that required for carrying the stocks. The merchant could still earn the return that was promised when the hedge was put on in July by continuing to hold the hedged wheat until March, but he would nevertheless have incurred an opportunity loss. The increase in the actual spread over the spread expected is a loss, or higher than expected cost, to the merchant. He is now poorer. The increase in that spread now promises a greater yield for *subsequent* inventory-holding. But although subsequent increase in yield may offset the first loss, it does not eliminate the first loss. In other words any merchant who had correctly foreseen the first failure of the spread to be reduced in the initial interval could have earned greater return on his inventory by not hedging so much. He would have had lower costs and thereby obtained a competitive advantage. This opportunity loss arises from the difference between the maturity of the future and the basic inventory asset.

The gains and losses arising from errors in forecasting the demand for the inventory are among the residual, unavoidable, risks involved in hedging. While better forecasts could eliminate any particular error, the basic risk will remain, since no hedging policy and no future contract maturity can assure a merchant that he will receive the opportunity rate of return on his inventory. It is for this reason that hedging cannot properly be described as arbitrage. It is arbitrage only in the extreme case when the basis exceeds the actual costs of carrying inventory with no allowance for any convenience yield, since only in that circumstance is the profit a certain one. In most circumstances, hedging is really a form of speculation—speculation on the basis. It has all the characteristics of speculation even though it is an essential normal aspect of doing business. It differs from the speculation of buying or selling futures only because the variance of the outcome is usually much less. In fact, in those cases where the basis is as volatile as the price of the spot commodity, the hedger moves naturally into holding inventories unhedged, i.e., into ordinary speculation, because there is no risk reduction from hedging.

While each individual merchant will arrive to earn a rate of return on his inventory greater than that earned by others, they obviously cannot all succeed in doing so. They can, however, as a group earn more than the "promised" rate of return, the basic implied by the current difference between the spot price and any given future contract. For example, the spot price could rise above the future prior to its maturity and merchants, *as a group* could liquidate their inventories and futures contracts at that point. Such a situation may imply that consumers will take an opportunity loss, but there is no strong a priori reason to believe that it could not happen. The very existence of specialized merchants suggests that they have competitive advantages over either consumers or producers and, indeed, all merchandising profits constitute such opportunity losses.

A key element of this picture of hedging is that it is not a zero sum game between merchants and speculators. It is possible for a hedge transaction to be profitable for the merchant without it being unprofitable for the speculator who bought the short hedge. It is, of course, true that if speculators make any profit at all, then the merchant-hedger could have made a still greater profit, but the a priori risk to merchant-hedgers associated with such a profit would also have been greater. The possibility of economic profit (excluding risk premia, if any) on the part of both merchant-hedgers and speculators implies economic opportunity losses for either producers or consumers or both, but such an outcome must be considered as one of the possibilities.

Another way to see that the interests of speculators and merchants are not in complete conflict is to examine the rational behavior of a merchant in the face of an expected decline in prices. Under most circumstances, the rational action would be the sale of the actual inventories held rather than the sale of futures to a speculator as a hedge. In fact, a merchant who is *already* short hedged and foresees a price decline would be better off to sell his spot inventories and lift his hedge. If the foreseen decline in price is due to an expected reduction in demand below previously expected levels, spot prices will be expected to decline more than futures because inventories would be less valuable and the costs of storage higher. The same would be true if the decline were expected to arise from an imminent increase in supplies. Only if the sales decline or production increase were expected to begin at some time in the distant future would sale of a nearer future possibly be more profitable than outright sale of actual inventories, if net transactions costs in the two markets are equal.[9] This is because only in that situation will the levels of inventory desired at the futures maturity date be re-

[9] As will be discussed below at greater length, futures markets are typically more liquid than cash markets and on that basis future transactions might be cheaper. On the other hand, cash transactions normally yield merchandising income that futures do not.

duced. Even in this case, only the *possibility* of profit arises, since the final outcome depends upon the size of the expected price change and the elasticities of demand and supply. For example, assume that in December 1966 we conclude that on the basis of the condition of the winter wheat crop, the 1967–68 crop will be 10 per cent larger than previously foreseen. This implies that the March 1967 wheat inventories should be lower than previously assumed, based on present prices. All prices should then start to fall, but the change in the spot-March future price difference will depend solely on the amount of change in inventories in that period due either to increased demand or decreased supply at the lower prices. To the extent that merchants can forecast price changes, however, it is most likely that they would foresee events just ahead and in those circumstances the sale of spot would be the preferable option. Where price rises are forecast, the situation is quite symmetrical.[10]

The prevalence of this pattern of behavior depends on an empirical, rather than a logical, proposition. If the spot price is positively correlated with the basis, it will prove unprofitable to hold inventories either hedged or unhedged if declines are expected (*30*). Working (*40*) has shown that this correlation does exist in the case of wheat and that it is most likely to be true when inventories are greatest, i.e., when hedging is most widespread.

Hedging Maturity and Risk Exposure

Hedging, unlike arbitrage, is not riskless. What it accomplishes is not the elimination of risk, but its specialization: its decomposition into its components. Once he is hedged, the fortunes of the merchant turn on his ability to properly anticipate the yield on his inventory holdings; on his ability to forecast the volume and timing of consumer demand. He is still susceptible to error, but the risks are risks inherent in merchandising. By hedging, he has passed on to the speculator the risks of anticipating changes in absolute prices but he still has basis risks to bear. The hedger may be quite competent at evaluating such price changes, but if he savors such forecasting he need not enter the merchandising business to attempt it. Unless basis changes are perfectly correlated with price changes, he cannot have a comparative advantage in both fields. Given that fact, we would expect merchants with a presumed comparative advantage in basis speculation (i.e., in predicting demand for stocks), to specialize in that field and to buy from others the specialty of speculation on absolute price. Thus, a merchant carrying unhedged stocks can generally improve his profitability by substituting hedged stocks for unhedged ones.

This does not mean that the improvement takes place by simply hedging existing stocks. Basis changes are typically smaller than absolute price changes and entail less risk. What comparative advantage means, in this case, is that for a given level of risk, the merchant can earn more by holding inventories hedged than unhedged, but this may well mean holding a much larger volume of hedged inventory than he could hold unhedged. In fact, the evidence suggests that merchants do not hedge to reduce the absolute level of risk that they face but they hedge to increase their profits by being able to hold a larger volume of inventory.

[10] See *28* for the situation under stationary stochastic conditions.

For example, assume that the unconditional (observed) variance of basis changes is only 20 per cent of the observed variance of price changes. It is quite possible that a merchant might prefer to hold more than five times as much inventory hedged as unhedged if he feels that he has a comparative advantage in predicting basis changes as against predicting price changes. The same behavior is feasible if a merchant feels that he can earn some rent from his superior ability in merchandizing and wants to increase their inventory-holding capacity in a situation where his banker will not extend as much credit against unhedged as against hedged positions.[11]

If inventory-holding was a constant cost industry in terms of risk, this argument would call for merchants to always remain completely hedged, but the promise clearly does not hold. When inventory levels are low, the marginal unit may increase risk negligibly (or, as indicated above, actually reduce *income* variability). However, increases in inventory increase the risk of the marginal unit, so it is quite normal to expect some relatively constant amount of inventory to be held unhedged, with hedging only beginning once the marginal risk "cost" to the hedger begins to exceed the premium demanded by hedgers. If no risk premium is demanded, hedging should be universal. Of course, since the size of the premium is subjective, it is quite conceivable that we would observe merchants changing their fraction of inventories hedged as their expectations change due to changes in either futures prices or exogenous conditions. There is no reason to expect merchants to hedge like automatons. Hedgers will certainly try to hedge as cheaply as possible and take advantage of whatever errors speculators may make. All the theory requires is that they will continue to hedge even if their net cost is positive.

Until now we have been assuming that the merchant who finds the cost of hedging to be excessive has only the alternative of holding his inventories unhedged. In practice, he has another alternative to risk premia that he considers excessive. We have already indicated that the risk associated with hedging arises from the difference in maturity between the spot asset and the future sold as a hedge. We have also shown that, as expected, the spot price is positively correlated with the basis. Under these conditions, the more distant is the maturity of the futures contract relative to the expected duration of inventory holding, the more of any expected increase in spot prices will be reflected in changes in the basis and the greater will be the variance of changes in the basis. As a result of this, hedgers can take a more or less aggressive policy with regard to price expectations depending on their confidence about their expectations. While the unconditional variance of the basis with respect to distant futures is greater than with respect to near futures, an increased confidence in the expectation of a price rise may reduce the conditional variance of the distant basis to a level low enough to make it more attractive than the safer hedge.

Putting it another way, every hedger can choose among a series of possible hedges yielding larger prospective gain at the expense of greater risk. At any particular time one of these hedges seems most attractive in light of his attitudes toward risk. However, as expectations about gains and risks change, his choices

[11] H. S. Houthakker (*18*) has developed this argument (with numerical examples).

include shifting to longer or shorter hedges as well as deciding simply to hedge or not to hedge. Since not hedging usually involves a substantial increase in risk, there may be an intermediate alternative which involves shifting hedges to more distant futures. A merchant who confidently foresees an increase in demand under present conditions but who does not want to completely expose himself to the risks of legislation, regulatory activity, foreign policy, and weather may prefer to shift his hedge forward rather than lift it altogether.

In discussing the decision to hedge or not to hedge, the critical variable was the risk premium the merchant was willing to pay and the premium demanded by the speculator. Whatever the level of those premiums, the decision of the hedger to shift hedges forward depends critically not only on the merchant's comparison of the risks of hedging in futures of different maturities, but also the speculator's comparison of the risks of speculation in futures of different maturities. If the variance of futures prices decreases with the maturity[12] and if speculators are risk-averters and measure risk in terms of variance, they will require a smaller premium per unit time on the more distant futures. Thus hedgers should be expected to be able to hedge more cheaply, but with greater risk, in more distant maturities.[13] When increased confidence in a rise in spot price takes place, the hedger can reduce the premium he pays by shifting hedges forward, and in general, speculators will be willing to accommodate such a shift because they will be able to earn premiums at least as large as they previously required.[14] Since such a shift is desired by both hedgers and speculators when hedgers foresee a price risk more quickly than speculators, the shift can actually be accomplished, unlike some changes in competitive markets which cannot be accomplished because of instantaneous reactions.

Clearly, this pattern of behavior is not possible if *all* merchants foresaw a future price rise since, in that case, the rise would be effected immediately. Also, if the price rise that was foreseen was quite large, shifting hedges forward would seem a poor alternative to lifting them altogether. For small expected increases, however, merchants can move in all of three directions: they can lift some hedges, shift others forward, and buy additional spot assets. In view of the lower transactions costs and greater liquidity of futures markets, the first impact may be felt in that sector, although eventually the impact will spread to the spot market.

In the foregoing, we discussed the case in which some hedgers' opinions about expected spot prices change while speculators maintained their expectations. At least two other alternatives and their symmetrical opposites are pos-

[12] Samuelson (*28*) has suggested a theoretical reason why this might be the case. In addition, Working's empirical work (*40*) suggests it is generally true. The theoretical argument in Samuelson would seem to be most applicable within a given crop year and less so across crop years. However, Working's data suggest that the empirical relation holds across crop years as well. This should not be confused with our earlier proposition that basis risks *increase* as maturity lengthens. While the latter proposition follows from the former, the reverse is not true.

[13] The phrase "more distant maturities" should always be understood with regard to the expected maturity (liquidation) of the inventories. Just after harvest, the expected maturity is naturally greater than later in the season, so a hedge in May wheat future on February 1 may be more risky than a hedge in the March future on November 1.

[14] To the extent that capital gains treatment of futures trading has any effect, it will tend to reduce the premium required by speculators on futures maturing in more than six months, but while this phenomenon will strengthen the effect referred to, it is not necessary for the conclusion.

sible but cannot be discussed at this point. Some empirical implications of this general argument will be discussed below.

With this discussion behind us, we can once more point up the analogy between hedging and the portfolio policies of financial institutions.[15] In both cases, the firms involved handle portfolios of assets and liabilities in such a way as to maximize return for a given risk or minimize risk for a given return. In both cases the main tool for accomplishing this result is by varying the maturity of assets or liabilities to alter the opportunities for gain at the expense of increasing exposure to risk. In the limiting case, both kinds of institutions can keep their positions unhedged—either by holding inventories unhedged or by holding cash, but in each situation the extreme position is not normal business practice. In each case, the firms generally pursue their portfolio adjustments in a specialized market that is much more liquid than the market in which the central business of the firm is conducted. Thus the futures market and the U. S. government securities market are the main arenas for adjusting portfolios, although it is the cash commodity market and business loan which are the central business of the firm.[16]

To mention these analogies does not imply that the problems are identical. At least until the advent of the certificate of deposit, the bank usually was passive with regard to the volume of liabilities and controlled risk exposure primarily by "buying" assets. The merchant is a more active participant on both sides but his hedging is usually done by taking on liabilities (selling assets). The merchant generally holds call assets; the banker, call liabilities.[17] The merchant earns the main component of his income from transferring *ownership* of his inventory from low-yielding hedges to final consumers. The banker earns it by lending money to business firms instead of holding low-yielding riskless assets. But despite these differences, the analogies are important and worthwhile, and, hopefully, they eliminate some unwarranted concern on the "naturalness" of merchant hedging.

Intermarket Spreading and Risk

As I have described it, all hedging contains an element of risk. Part of that risk arises from fluctuations in the rate of return earned from storage of the standard, or futures, grade of the commodity and part from fluctuations in price differences between inventory of the standard grade and at the standard location and stocks of the specific grade and location being hedged. I have further argued that hedgers expect to profit from their ability to predict movements in both parts of the basis.

[15] This point is also discussed in Cootner "Speculation, Hedging and Arbitrage," *Encyclopedia of the Social Sciences* (forthcoming).

[16] Discussions of bank portfolio policy sometimes imply that the risklessness of U.S. government bonds plays a vital part in their portfolio role. While that is an important and desirable trait it is not the quintessential feature. Even if no riskless security were available, a counterpart market would (and did) arise in its absence, e.g., commercial paper in the nineteenth century and short-term municipals in the early twentieth). Such a market would be less desirable, however, and hence would be used more sparingly.

[17] In both cases, the immediate availability of the assets of liabilities may be more apparent than real, and the "average maturity" of both the bank deposits and the commodity inventories may be quite long. This does not, however, alter the general picture. See, for example, 27 on this point. Modigliani's concept of "natural habitat" is related to "average maturity" but is much vaguer.

Regardless of the degree to which the grade-location basis[18] is predictable, it is generally unhedgeable. The merchant does not usually have any way of avoiding that risk. There is no futures market for No. 3 soft wheat in Toledo or No. 2 yellow corn in St. Louis. And so a merchant who hedges grain of those kinds can gain or lose on his hedges even if the basis of the standard grade behaves exactly as expected. In fact, the lack of such markets generally speaks for the conclusion that the extra premium which the merchant is willing to pay for insurance against grade-location basis risk is less than whatever increase in transactions costs that might results from the dilution in market liquidity produced by proliferation in markets. In most cases, multiple futures markets designed to reduce location basis risks have not been viable. The soybean oil market in New York and the "soft wheat" Kansas City market (*48*) are but two older examples, and the more recent looming failure of the western live cattle contract in Chicago in the presence of a very satisfactory midwestern live cattle market is equally illustrative. On the other hand, when speculative interest is relatively strong and grade-location basis variance is quite large, more than one domestic market can exist. The three U. S. wheat markets are one obvious example.[19] Less obvious are the existence of separate corn and oats markets which is probably due to the basis risks arising from differing seasonality and oats' varying premium market as a horse feed, although the more interchangeable grain sorghums and millfeed could not support separate markets. Similarly, it *may* be feasible to have separate markets for pork bellies and live hogs because of different seasonal demand and storability situations, although one can almost surely forecast the failure of the two Chicago markets in dressed beef and beef carcasses in the face of a successful midwestern live cattle market and the demise of one of the two competing Chicago live cattle contracts. Similarily, the fate of the New York soybean contract would seem to be in doubt.

The existence of duplicate markets is more likely across international frontiers because greater transport costs, or barriers to international trade or dangers of devaluation increase basis risk. Thus, national and world markets for sugar in New York coexist with markets in London and Paris, wool markets exist in those cities plus Nagoya and Sydney, etc. These markets offer additional testing grounds for hypotheses about hedging. Given the advantages of liquidity in markets, the existence of separate markets implies that the basis risks are large enough to render the markets imperfect substitutes for price insurance, and the price that hedgers are willing to pay to avoid that grade-location risk is large enough to attract enough speculators to support both markets. It also suggests something about the nature of the risks against which hedgers would like to protect themselves. The more frequent occurrence of futures markets in the same commodity in different countries, but not in two quite unrelated market areas in the same country (*48*) suggests that merchants are particularly anxious about

[18] By grade-location basis I mean that difference between the price on a unit of nonstandard spot inventory and the price of the standard spot commodity. Unlike previous use of the term "basis" it does not imply a relation to futures prices in the future, unless otherwise stated. The term "basis" will continue to refer to the spot price of the standard grade and futures. If grade location basis is meant, it will be so stated.

[19] For an excellent analysis of the factors supporting the existence of the two smaller wheat markets, see *13*.

changes in national economic policies or about economic developments about which they are likely to be ill-informed because of different institutions or language. This does not in itself tell us anything about the level or existence or risk premiums. However, if the seasonality of risk exposure differs for different markets, then the existence of systematic differences in seasonal behavior in *futures* prices will provide such evidence. For example, the London and Sydney wool markets largely reflect the movement of Southern Hemisphere commonwealth wool while being only indirectly affected by U. S. wool production. The situation in New York is reversed. Since the seasonality of the two hemispheres is quite different, we would expect hedging patterns to be different and, if risk premiums exist, seasonal patterns in *price differentials* to develop.

The same kind of phenomena would be expected to show up in domestic markets with different seasonality. This would be true whether or not the two commodities were close substitutes. However, where the commodities *are* close substitutes, some of the noise due to random (but common) changes in the supply and demand picture will be eliminated, making it easier to detect small risk premiums, if they exist, and to reject "apparent risk premiums" arising out of noise. In addition, the seasonals in prices are greater the more "countercyclical" are the seasonals in hedging.

The Supply of Speculative Services

The question of the existence of risk premiums has had a long and controversial history. In the hands of some scholars, the evidence seems to indicate that speculators do receive such premiums. In the hands of others it indicates that they do not. Quite possibly the truth lies in between: for some commodities over some (long)[20] periods, speculators may earn risk premiums, while in others they may not. Some commodity markets are reputed by brokers to attract a large unsophisticated element that does not require risk premiums to induce it to speculate because of the lottery-type characteristics, unusually small (dollar amount) margins and highly skewed outcomes. In others, institutional changes over time may alter the character of volume of hedging and speculating. There need be no "universal truth" about speculative returns. Certainly, this paper will not settle the question and does not intend to.

What I will try to do, however, is to clarify some of the issues. First, I will restate the theory of risk premiums as I see it. Then for a few markets, I will show that seeming contradictions in the evidence are more apparent than real, and raise the possibility that other contradictions will disappear when the data is uniformly analyzed. Third, I will present some further empirical hypotheses derived from the theory presented and subject them to testing as well.

If a speculator is risk averse, he will only buy futures contracts at prices below those expected at the expiration of the contracts, and will sell short such contracts above the expected price. The smaller the risk premium demanded, the smaller will be the range around expected price at any point of time at which the speculator will initiate positions of any given magnitude. On the other hand, a risk

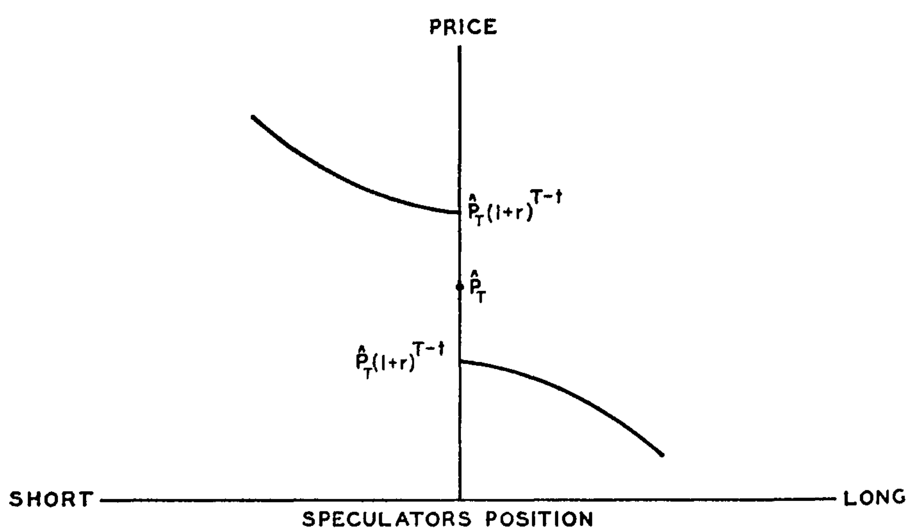
[20] Unless we take long periods, we run the risk of defining the problem away. The question of risk premiums does not turn on whether speculators *ever* make money, but whether they can reasonably expect to profit over a period of time.

premium of a given amount will imply a smaller range around expected price when there is only a short time to maturity than when maturity is farther away. Finally, a given risk-averse speculator will require a larger risk premium the larger the open position he assumes. Looking at Chart 3, if P_t is the price at t of a future maturing at time T, P_T is the expected price at maturity and r is the desired minimum rate of return, then $(1 + r)^{T-t}$ will obviously be smaller, the smaller is r and the larger is t. Thus, if with unchanged P_T, the price P_t rises at a rate slower than r, the implicit rate of return becomes larger than r.

Even for an individual speculator there are many possible shapes for the demand curve. The required minimum return may be large or small and the elasticity of demand beyond the minimum rate of return point may be large or small. The demand curve for all speculators has even more flexibility as to shape. Even if all speculators shared the same price expectations, the discontinuity would be softened by the existence of diversity of required risk premiums. The elasticity of total demand would be greater, for any given level of r, the greater are the number of participating speculators with the indicated individual demand curves. The possibility of varying estimates of expected price make the curve even more interdeterminate a priori. Some speculators, of course, may expect prices far above those that eventuate and will lose money. If, however, speculators as a group make money, they will buy at an average price which is lower than that at which they sell.

Regardless of how the present futures price stands with respect to the expected spot price, no rational speculator will buy unless he also expects the rate of change of price in the short run to be at least equal to his desired rate of return. Under most circumstances this will mean that he will not buy because the price is low relative to expectations, *if* he expects it to become still lower first. The one excep-

CHART 3



tion I can think of is the case where buying "now" will produce long-term capital gains but buying later (and cheaper) must be done with ordinary tax treatment in mind. In that case the lower gross return attainable now may be greater on a net basis than the larger gross return available later. Speculators may, of course, buy before the end of a price decline if they hold erroneous expectations. The statement only says that they will not do so intentionally. Therefore, except for errors of judgment or long-term capital gains problems, each future should be expected to rise from the time hedging in the future becomes net short, i.e., from the time when speculators are more "long" contracts than they are "short."

In this sense, the "hedging pressure" theory of futures prices trends is contrary to our theoretical expectations. Unless one specifically assumes that a market is marked by risk-loving or irrational speculators on the one hand or wealthly speculators expecting the post-harvest price rise to last less than six months, short hedging pressure should not be expected to depress prices during harvest. Only if the harvest hedging gradually *shifts from* liquidation of long hedges to short hedging should futures prices be expected to decline during the harvest.[21]

Simultaneous Long and Short Hedging

Another careful distinction is necessary about price movements in different futures contracts over the same period. It is not uncommon for one futures contract in a commodity to have a substantial long hedging position while other contracts show net short hedging. In such a situation, one would expect on the basis of what has gone before, that the former contract should fall in price *and* the latter contract should rise is price. Actually the price changes in the two contracts will not be independent because of portfolio effects. Since a spread position—short in the former and long in the latter contract—will probably have no more variance than either outright position, the relative price movements of the two contracts will be in the direction indicated but possibly of less magnitude than would be expected independently. This would be true if the prices of the two contracts show any non-negative correlation. For example, if the two hedging positions are equal in magnitude but opposite in sign and are placed in contracts whose price movements are independent, the relative price change required by speculators as recompense for risk taking should be less than would be necessary in either future alone, if variance is a criterion of risk(*25*). Thus, if an outright long position will normally call for a 6 per cent per annum risk premium, a spread between two futures with independent expected price changes would require no more than 6 per cent for the two together. If the two futures contract prices are correlated, the required risk premium will be even smaller[22] being zero in the case of perfect positive correlation. If the two positions are not equal in magnitude

[21] I must admit that although the formal statement of the argument in *4* was correct, the discussion is at best vague and confusing, leading to Telser's erroneous but perhaps justified comment (*33*, p. 405). While it is true that prices of futures will decline during harvest if the balance of hedging is shifting from long to short (as I assumed) and it is true that futures prices will rise subsequent to the harvest peak, it is also true that they should start rising even earlier, which I correctly noted in the "rejoinder," though not with the greatest clarity (*5*, pp. 415–18).

[22] Since one position is short and the other long, the positive correlation in price results in negative covariance in returns.

(say if the long hedging is larger), then the smaller position should be largely spread against the smaller (cf. *13*). With perfect correlation in prices there would be no expected change in the price of the future with the smaller position. For obvious reasons there is little reason for individual hedgers to take such positions when there is perfect correlation between prices, but merchants as a whole might take such positions if different individuals were faced by different trade situations. However, no profitable price movement would be expected, since it would be riskless to arbitrage it. In fact, however, such long-short positions typically develop only in futures near the beginning and end of the crop year when inventories are minimal and the covariance of futures contract prices is relatively low. Without perfect correlation, one would expect there to be a predictable (in the mean) relative price change, reflecting the riskiness of the spread position.

The direction of expected price movement of the individual futures comprising the spread is less predictable, but we can make some general statements. If the two futures are equally risky, if these price changes are independent of each other, and if the speculative demand for futures is perfectly elastic at some given risk premium, then we would expect both futures to move in the direction opposite to the larger of the two hedging positions. Since the positions are equally risky and independent, spreaders will be willing to outbid outright speculators, but will only be able to take positions up to the limit of the smaller hedge position. Outright speculators will have to take the remaining positions and will earn a larger return than spreaders. Since the relative price movement will be less than the absolute, this implies both prices will move in the direction of the net position, but the price of the dominant future will move by a greater amount. This result will be even stronger if the futures are positively correlated or if there is any inelasticity in the supply of speculators' services. On the other hand, it may not hold at all if, as is generally true, the nearer future is marked by substantially greater variance than the more distant. In that case, knowledge of the shape of speculators' utility curves will be necessary to determine the outcome. If the nearer position requires a larger risk premium and the prices of the futures are not highly correlated it is quite possible that it will be necessary for both futures to move in opposite directions in order to yield the appropriate returns. Long positions in one future and short positions in another are more likely to occur when inventories are low, since this is the period when the nearer future is likely to have the greatest variance relative to the distant (because of the steep slope of the supply of storage curve and the positive correlation between spot price and basis). In addition, this is the period of smallest correlation between adjacent futures. As a result, it is in exactly this most likely period of occurrence of the phenomena that it is most difficult to predict the outcome.[23]

The Empirical Research

There are many possible hypotheses about hedging that could be tested and clearly they cannot all be tested here. Without being invidious in the use of the terms, I can distinguish between static and dynamic aspects of hedging and

[23] Of course, the obverse side of the coin is that relative price movements are more stable and should move in predicted fashion even when absolute price movements are unpredictable.

speculation. In the static group I would place the determinants of hedging, the supply curve or storage, the demand curve for hedging, the supply of speculation, etc. In the dynamic area I would include some of the new topics I have raised in this paper—the relationship of basis changes and spread changes to changes in the "maturity" of hedges with expectations about changes in futures prices.

In the static area, I am going to confine myself to measurement of risk premiums. The question has been controversial, but it is my feeling that most of the controversy turns on different theories (usually implicit) rather than argument about the data. There is therefore a great need for precision about hypotheses. As a result, I am not going to discuss the existence of risk premiums in a wide range of commodities, but rather to illustrate the theory by careful testing of a few commodities. First, I plan to reinvestigate the question of risk premiums in wheat futures, trying to account for and reconcile all of the differences in existing empirical work, for if we cannot agree on what the data show for a single commodity, our knowledge will not be enhanced by similar controversies about additional commodities. I will present some data on other markets based on the techniques used in the wheat market but will break little new ground in this direction. I will, however, present a new approach to risk premiums by examining the behavior of intramarket and intermarket spreads.

There are many different hypotheses about risk premiums that can be tested.

(1) Speculators as a whole earn a profit *in futures markets* from hedgers taken as a group.

(2) There are trends in futures prices which make it possible for some speculators to profit at the expense of some hedgers in futures markets, but because of the presence of poor speculators and acute hedgers, neither group as a whole can be proven to profit from the other.

(2a) Futures prices are biased against short hedgers but not against long hedgers.

(2b) Futures prices are biased against both long and short hedgers.

(3) Futures prices are unbiased estimates of spot prices except when the general (wholesale) price level is rising.

(4) Futures price trends may exist, but are simply an adventitious product of the government loan program (*14*).

A sufficient condition for the payment of a risk premium by hedgers as a group is that the price of a futures contract should rise monotonically from the time that net short hedging first occurs to the time when it first becomes zero, *and* the price declines monotonically from the moment net long hedging begins to the time it becomes zero. This statement cannot be weakened as can be shown by counterexample. While it is clearly not a necessary condition, it is the only way one can establish the profitability of speculation without information on the size of positions at every instant. This paper will therefore present no direct evidence on the first proposition. Only one direct study of profitability has been made (*17*),[24] and I find its results convincing. But because speculators' positions are only known at twice monthly intervals, some authors have questioned the validity of the result. Such questioning has good logical results, but in the fact

[24] This was written before I saw Rockwell's paper at this conference.

of skepticism like that, no statement about speculative profitability is possible until new data become available.

There are, however, many interesting propositions about futures prices and hedging that can be stated and tested. I will test version (b) of proposition (2) and establish its validity for a number of markets. I will also show that propositions (3) and (4) are invalid. I cannot demonstrate the universal existence of risk premiums or biased future prices. Even if I could test all markets, my casual observation suggests that in some of the thinner markets and some of the more volatile thick markets, we would find either an absence of risk premiums or evidence of a willingness of speculators to pay for unusually skewed risks as found by Rossett in the call option market.

Samuelson (*28*) has shown that in a market with participants maximizing expected value a futures price will be an unbiased estimate of expected spot price: futures price changes from any point *t* are independent of all information (including past prices) as of time *t*.[25] That this is not the case for futures prices has been shown by a wide range of writers.[26] Furthermore, while the studies have not generally considered transaction costs, it is clear for all but the Larson study that the lack of independence would produce profitable opportunities for speculation.[27] This is far from a general proposition for all financial markets, since much more intensive and careful research on stock markets has failed to produce any evidence of such predictability or bias. Under these circumstances, the fact that investigators with such a wide range of beliefs about futures trading do find such trends, strongly suggests that they exist.

What the investigators do not agree on is whether such trends arise from risk premiums, convenience premiums, overreaction to items of news, etc. If these trends are to be related to the capital risks of carrying inventories, the biases must be shown to bear a relation to the pattern of hedging. The existence of any detectable trend at all implies that some people can make money from futures markets. Without relating trends to hedging, however, we cannot tell whether speculators earn money at the expense of hedgers or hedgers earn at the expense of speculators, or that those with a knowledge of statistics earn at the expense of believers in perfect markets. If hedgers are indifferent to risk, they should not only pay risk premiums as a group, but *they should not tolerate the existence of any predictable trends in futures prices.* Even if some incompetent hedgers were willing to make such payments, the knowledgeable, risk-indifferent ones should eliminate any trends before they arose.[28] If, therefore, it can be established that

[25] Samuelson explicitly shows however, that the variance on such price changes may change in a predictable manner.

[26] Telser (*33*) finds evidence for an upward trend in the price of wheat and cotton futures and I have shown (*5*, p. 417) that the trends are greater after the peak in hedging. Telser finds no evidence of a *significant* trend in corn although the trend coefficient is positive. I found evidence of seasonality in wheat (*4*, pp. 401–03). Telser found little evidence for seasonality, but I suggested reasons for that in "Rejoinder." Vaile (*35*) showed evidence for a seasonal in corn futures, and this evidence persisted after several adjustments in the data by Working (*41*). In neither article was a test of significance made. I should point out that the interpretation of Vaile's results by both Vaile and by Lawrence Vance (*36*) is incorrect. Gray (*14*) finds a seasonal in the postwar wheat market and Larson (*23*) finds short term imperfections in the corn market.

[27] This does not mean that commodity speculation is more profitable than investment in common stock since common stocks do show an expected upward trend and pay dividends which together represent a yield on invested capital.

[28] Of course, any knowledgeable risk-indifferent group could do this, but I know of no one who argues that speculators can be both knowledgeable and risk-indifferent.

there are trends in future prices, we can nevertheless conclude that hedgers are averse to risk, whether the trends are in their favor or against them,[29] it would mean that at least some hedgers would pay a premium for risk avoidance.

While we do not have the data to prove that one group profits at the expense of the other, we could establish a presumption by testing the following weaker hypotheses.

> Prices of futures contracts rise on the average during the period of net short hedging and fall on the average during the period of net long hedging.

This proposition will not guarantee a profit to speculators since the *size* of positions could change in such a manner as to produce losses nevertheless. A still weaker hypothesis consistent with the possibility that some speculators, either through ignorance or in the search for long-term capital gains, consistently bought futures contracts before prices had reached a trough, but that the participation of other rational knowledgeable speculators was also required, one might prefer the following hypothesis:

> Prices of futures contracts rise on the average after the peak of net short hedging and fall on the average after the peak of net long hedging.

Unfortunately, the data available to test these hypotheses properly are available for only a short period of time. When Telser (*31*) first discussed the existence of trends in futures prices, he examined the Keynes-Hicks hypothesis since hedging in futures is normally short, the existence of risk premiums implies a downward bias to futures prices. If the premise is true, the conclusion follows. Actually, although Telser's tests in the 1958 paper found no evidence of bias in futures prices, a more powerful test in 1960 found such trends in May wheat and May and December cotton but not in corn or December wheat. To test the broader hypotheses about bias in both directions we need data on hedging positions by futures contracts. Such data is published for only the 1937–40 and 1946–51 periods. Because Telser restricted himself to "stable price years,"[30] only two out of the ten years he studied were covered by the hedging data.

In testing the hypothesis about two-way price bias on Telser's data (*4*), I used visible supply data as a proxy for hedging data. By the time visible supplies peaked, I reasoned that hedging could safely be assumed to be net short. I then chose a fixed date in the spring when long hedging might be expected to become ascendant. I then measured price trends from the peak of hedging to March 30 which by hypothesis should be rising, and trends from March 30 to peak of hedging which, if long hedging was prevalent, should be declining. The hypothesis was established on the data used, but it is, of necessity, a weakened hypothesis. Since there was no direct observation on hedging, the decline from March 30 to the harvest peak could be due to a risk premium paid by long hedgers, or to losses by long speculators. Regardless of the implication of the result for hedging costs directly, it should not be overlooked that all the results about wheat in

[29] I suppose I cannot completely exclude the conclusion that hedgers are not risk-averters but that they do not take advantage of futures price trends because it is "inconvenient."

[30] In which the wholesale price index changed less than 5 per cent. In Telser (*31*) the relevant years were 1928–29, 1933, 1935–36, 1939–40, and 1952–54.

Cootner (*4; 5*) and Telser (*33*) contradict the earlier hypothesis (*31*) about the unbiasedness of futures prices. Furthermore, *for hedgers to profit from the bias requires that they be long when they already hold maximum inventories and short when they hold minimum inventories.*

The fact remains that the earlier results have been questioned (*14; 33*) because of the use of visible supplies as a proxy for hedging.[31] Hedging data, while not available to the extent desired, are available, and in this paper I shall use them to support the earlier results. As I said earlier, hedging data are not available for all the years studied by Telser and Gray. Nor are data available by contract except for the brief period noted earlier. For the period 1937–40 and 1946 to the present, hedging and speculative positions are available for "large traders," as defined by the Commodity Exchange Authority. It is well known (*24; 50*) that these data tend to understate all hedging but understate long hedging more than short hedging. They also give no indication of the simultaneous existence of long hedging positions in the May or July wheat contracts and short hedging positions in the forward or nearer contracts. This may and does occur because inventories late in the crop year (May) are usually low and require little short hedging but encourage long hedging to protect commercial and industrial requirements. In such circumstances, fears about the size of lateness of the crop will also encourage long hedging in early new crop-year futures (July and September).

To test the relationship between hedging and bias in futures prices, one must introduce some element of judgment about the relationship between *actual* long hedging in the May and July contracts and total *reported* hedging in all contracts. For the test used in this paper, I assume that when reported net short hedging fell below 3,000 contracts, actual net short hedging was markedly lower (as is usually the case) and hedging was probably long in the May and July contracts. Since I have no way to prove this, these assumptions must be kept in mind in interpreting the results. The results (see Table 1) are quite striking. Long positions are initiated at the semimonthly point at which net short hedging falls below that level. Short positions are instituted in May when long positions are sold and are maintained until May 15. If short hedging is still below the critical level at that date, the short position is shifted to the July contract. The long positions are taken in the contract which expires soonest after the selling point (usually March but occasionally May). Both positions are profitable on the average from 14.8 to 17.9 cents per year or 7 to 8 per cent of price. Note that since all modifications tested are reported here, the question of producing results by trial and error does not arise here.

Interpretation of the results must be modified by one's a priori beliefs about the results produced by my cut-off point. If my technique for establishing the point where long hedging begins is accurate, then the test is evidence that both long and short hedgers must have been willing to pay a risk premium for hedging, and that they probably have done so. If it is not deemed the correct cut-off point then the conclusion still must be that most short hedgers (all except those who hedge early) are willing to pay such a premium, but that fewer of them actually pay such premiums. Under these circumstances it is harder to determine if short hedgers as a group actually pay premiums and it is impossible to say

[31] See below, p. 95, for evidence of this point.

TABLE 1.—WHEAT: AVERAGE GAIN PER YEAR 1947–65 UNDER INDICATED STRATEGIES

Specifications	Strategy I	Strategy II	Strategy III
Cents per bushel			
Short only	7.8[a]	8.5[a]	6.2
Long only	8.6[a]	9.4[a]	8.6
Long and short	15.9[a]	17.9[b]	14.8
Per cent of price			
Long and short	7.7	8.7	7.3

Strategy I
Go short at bimonthly point when reported short hedging first drops below 3,000 contracts. Cover short sales and go long at bimonthly point when reported short hedging first rises above 3,000 contracts. Sell long positions when you go short. All positions are taken in the nearest future in which the position can be held for the entire period.

Strategy II
Same as Strategy I except all positions are liquidated at the point *prior* to the change in the balance of hedging.

Strategy III
Same as Strategy I except that all short positions are initially taken in May and are switched to the July future (if necessary) on April 30. Long positions are initially taken in March and switched to May if necessary. Not tested for significance.

[a] Significant at the 5 per cent level.
[b] Significant at the 1 per cent level.

anything substantial about long hedgers. The periods in which *reported* hedging is unqualifiedly long in all futures are brief and so few in number that no meaningful conclusions can be drawn.

It may be worthwhile to review briefly some of the published work on risk premiums in wheat futures because of the considerable confusion in the literature. In Cootner (*4*) I showed that a statistically significant seasonal pattern could be found in wheat futures if the pattern were keyed to the pattern of the harvest. The period chosen for that test was a number of years chosen by Telser (*31*) on the basis that wholesale prices had changed by less than 5 per cent in those years. In later testing, Telser (*33*) confirmed that the May wheat futures price showed an upward trend, but a related test, not keyed to the harvest, showed no trend in December wheat futures. In Gray (*14*) the hypothesis was presented that my results were due to some unspecified bias resulting from use of percentage rather than absolute price changes. A test in that paper, again not keyed to the yearly pattern of harvest, showed a markedly lower level of statistical significance than indicated in my work[32] Although the test differed from mine with regard to both treatment of the harvest and use of absolute price changes, Gray concluded that my results arose from the latter "bias." He also voiced some reservations about the proper way to account for inflation. After private correspondence, Gray later concluded that a season did exist in postwar futures prices (*14*), but that it was an adventitious effect of the government loan program. This latter conclusion was derived from some empirical work which showed that while a strong seasonal showed up (on a calendar rather than a harvest basis) in the postwar years, the seasonal was much weaker in the prewar years. At this stage,

[32] The significance of the difference may have seemed greater to some readers due to typographical error (*12*, pp. 259–60).

therefore, both Telser and Gray agree that postwar years show an upward trend in futures prices after harvest, and Gray accepts a preharvest futures price decline, but ascribes it to the government loan program rather than risk aversion.

Inflation and Risk Premiums

While the additional investigations in this paper offer added support for my hypothesis about a seasonal, it is worthwhile to account for the new points raised by Gray. I will show that his points about inflation, like Telser's (*31; 33*), are not well taken. Though Telser and Gray agree on the question of eliminating "inflationary" years, they disagree on the appropriate procedure. Telser (*31*) takes the position that only "stable-price" years—those in which the wholesale price index moves less than 5 per cent—are suitable for measuring risk premiums. Gray (*12*) deems as suitable any consecutive period in which the initial and terminal spot (future) prices are equal. The Gray-Telser distinctions do not impart any bias to their own results, they are not relevant to any question of bias.[33] Before proceeding to the empirical question, however, I want to dwell briefly on the theoretical question about the effect of "inflation" on risk premiums.

For speculators to earn risk premiums, futures prices must rise while speculators are long. They may earn those premiums because hedgers subjectively undervalue the likelihood of drought and war and overvalue the probability of good weather or peace. Or they may earn those premiums because of similar errors of estimating probabilities of certain behavior of crop yields, planting intentions, legislative activity, and foreign economic policies. Or it may arise because of underestimation of the likelihood of inflation. Let us say for the sake of argument that speculators do profit from futures purchases, but only during periods of inflation, but they lose on such transactions during periods of deflation. Does this tell us that the profits are not "real," or that they are fortuitous? It does not: since such results are perfectly consistent with the profitable writing of insurance against deflation. It is no different a procedure than comparing speculative profits in those years when crop yields were larger than normal with those years when they were smaller or years *with* wars and those without. To separate out each class of insurance hazard may give us valuable information about the price-insurance business, but inflation does not merit any special treatment as a hazard.

My own impression of good practice is to include all years available, but since men may differ some may wish to exclude "inflationary periods." On the other hand, it should be clear that there is no a priori bias in including such periods and in fact imposing the Gray restriction *may enforce a downward bias* to risk premiums. (This is not true of Telser's restriction.) Let me illustrate by an example. On May 1, 1961, the spot price for No. 2 yellow corn at Chicago was \$1.15. The July 1961 future closed at \$1.16⅜. The March 1962 futures sold at \$1.24¼. Gray's strategy would be to buy the July future on May 1, hold it until July 1, sell it and buy the September 1 future, etc. Now, if on March 1, 1962 the March future sold at \$1.24¼, Gray would argue that there was a "presumption"

[33] In addition, there is the confusion between p. 253 of Gray's paper (*12*) where he implies in criticizing Houthakker that rising *futures* prices breed bias and on p. 260 where he states (in critizing me) that rising spot prices create bias. The error in the second statement should be obvious.

of upward bias in measuring risk premiums over the period, because the ending price of the period was 7⅞ cents higher than the beginning price.[34] There is patently no such bias. If instead, the March 1, 1962 price of the March 1962 future was $1.08⅜, Gray would say there was no "bias" but the result would necessarily show a negative risk premium, ex post.

I do not mean to imply that my example is more likely to be the usual case than is Gray's "presumption." I merely wish to point out this is an empirical point and that "inflation" as defined by Gray does not necessarily imply speculative profits in commodities. As both Samuelson (*28*) and Working (*39*) have shown, only spot price increases which are greater than opportunity costs of storage necessarily imply increases in future prices. Maximum storage charges (including cost of money, etc.) for wheat are greater than one cent a month at the present time. To be conservative then, we can show that it is possible for wheat prices to rise 10 per cent a year without *necessarily* producing any increase in the price of any particular futures contract. All that may happen is that successive futures contracts will usually begin trading at a higher price than earlier ones. As long as futures prices at the end of a year are not more than 10 per cent higher than those at the beginning, there is no theoretical reason for supposing that a "statistical bias" has been introduced into the data. Any profits earned by speculators may simply reflect a return for their risk-taking. If prices rise at an annual rate greater than 10 per cent, it does presuppose a rise in futures prices, but while this may be true in some given years it has not been true for any moderately long period. Where it is not true, it is difficult to give a condition on the spot or futures prices, which will eliminate "statistical bias" without also eliminating risk premiums by definition.

Absolute vs. Percentage Risk Premiums

Still another source of confused controversy in the measurement of risk premiums has turned on whether to use percentage or absolute price changes as a measure of the premium. This makes little difference in any one year, but it could conceivably make considerable difference in averaging across a large number of years.

The controversy cannot be completely cleared up by reference to theoretical considerations. On the one hand, the risk to a potential hedger seems likely to be related to the possibility of large percentage changes in his portfolio, since *for any given degree of leverage and* different price levels, similar *percentage* price changes are required in order to affect his capital to the same degree. If the supply of speculators is unaffected by price levels per se, the risk premium received by speculators will be determined by what hedgers are willing to pay. On the other hand, we have no assurance that hedgers would want to leverage equally with grain at different price levels or that the supply of speculation is unchanged with

[34] To be perfectly precise, Gray claims it is not the expiring future but the one following it that should be the same as the starting future. That does not affect the example, however, since the May 1962 corn futures had sold above the March 1961 contract from the beginning of trading in it. As of October 2, 1961, for example, the March 1962 future was selling at $1.16½, a decline of 4¼ cents from the April 3 level. The next (May 1962) future sold at $1.20 or 3⅞ cents above the level of the July 1961 future on May 1, 1961. If prices were to expire at these levels, Gray's method would indicate an inflationary "statistical bias" which simply does not exist.

TABLE 2.—WHEAT: AVERAGE GAIN PER YEAR UNDER SPECIFIED CIRCUMSTANCES*

(Arithmetic gain in cents per bushel)

Period	Long only: Nov. 30 to April 30	Long only: Aug. 30 to April 30	Long only: Peak to April 30	Long only: Peak to March 30	Short April 30 to peak, long peak to March 30[a]
10 "Stable-price" years[b]					
Arithmetic gain	(35%) 2.0	(20%) 5.7	(9%) 8.0	(1%) 11.3	(2%) 23.90
Geometric gain			(8%) 10.5	12.2	
			(5%) 12.7	(4%) 14.2	
15 "Stable-price" years[c]					
Arithmetic gain	(35%) 2.4	(10%) 6.8	(3%) 8.0	(2.4%) 7.7	(7%) 13.63
Geometric gain			7.8	8.9	
Percentage gain			9.5	(10%) 10.4	
Gray's 9 years[d]					
Arithmetic gain	−1.3	(20%) 6.7	(26%) 3.93	(11%) 6.08	(1%) 9.13[e]
1927–60[f]					
Arithmetic gain	(28%) 2.3	(7%) 6.0	(2%) 5.33	(4%) 6.12	(8%) 7.93
1930–44[g]					
Arithmetic gain	2.3	1.3	(26%) 3.21	(26%) 3.21	(12%) 8.39

* Calculations by the author for the periods indicated. Long positions are taken in the May future or, if that is not yet trading, in the most distant contract available, and are switched into the May contract on the last day of the month preceding expiration. Short positions are taken in the July futures contract and, if necessary, shifted forward to the December contract on the last day of June. The numbers in parentheses are significance levels. Where no significance levels are given, they were not computed because of their similarity to related figures in the table. "Peak" refers to the peak in visible supplies.

[a] The short positions referred to run from April 30 preceding the year indicated to the harvest preceding the year indicated, except see note *e*. In this column, the long positions were sold on March 30 only in the years *1946–60 inclusive*. Since the rationale for the earlier termination date involved the earlier harvest in the postwar years, it would be pointless to extend this adjustment to earlier periods.

[b] These years, selected by Telser because they were marked by changes of less than 5 per cent in the Wholesale Price Index, are 1928, 1929, 1933, 1935, 1936, 1939, 1940, 1952, 1953, 1954.

[c] The ten "stable-price" years plus 1955–58 and 1951. These years were used by Telser (*33*, p. 407).

[d] Gray (*12*, p. 257); the years are 1950–58. Gray's period actually starts on September 1, 1949; I included the May 1950 contract but not the short sale which would have preceded it. Gray's period ended on December 1, 1958. I included the short sale from April 30, 1958 to the harvest peak on August 31, 1958, but did not include the May 1959 future from August 31 to November 30. The latter transaction would have resulted in a loss of ¾ of a cent.

[e] In calculating standard deviations of annual returns from this strategy, a year ran from April 30 to April 30, except for "Gray's 9 years." Since that strategy started with a long position, an annual return was calculated from one visible supply peak to the next.

[f] Years suggested by Gray (*12*, p. 260).

[g] In this 15-year period, like Gray's 1950–58 period, beginning and ending prices of futures were about the same.

the level of prices. When we realize that these references to supply and demand refer to curves rather than points, it can be seen that no a priori position can be maintained without additional assumptions about hedging and speculative behavior. Though Gray does not explain why he felt that absolute price changes are the relevant variable,[35] an argument for using them can be constructed. If hedging is the same in each year, and if each speculator thinks in terms of buying a fixed number of bushels of wheat each year, regardless of price, then absolute price changes will measure the total gain to speculators and the total risk premium paid by hedgers. Hedging is *not,* as a matter of easily determined fact, constant from year to year. But even if it were, if one believes that speculators think in terms of a per cent return on their *dollar* investment and allocate their funds among alternatives so as to maximize their profits subject to risk, my method of calculation is clearly superior. The same applies if hedgers decide whether or not to hedge based upon the proportion of their inventory investment they may lose as a result of price change. This seems also a kind of capital-budgeting decision in which rate-of-return is clearly relevant.[36]

Empirically, however, any of these competitive strategies seem to do equally well. My hypothesis was that wheat futures tended to rise after the harvest. I tested this by supposing a purchase at the peak of hedging in ten years during which the wholesale price index rose by less than 5 per cent. In recomputing my data, Gray decided to start his buying program on a fixed date, November 30, well after hedging has usually started to decline. By buying on November 30, Gray finds a profit of only 20¼ cents for 10 years (1½ per cent per year). If he had bought at an earlier fixed date, such as August 30, he would have found profits of 56⅜ cents (5 per cent per year), and if he would have bought at the peak of visible supplies, he would have made 79⅞ cents, *almost as much* (6 per cent per year) *as he indicated.* The probability of getting a value that great if there were no trend is less than 8 per cent. If we take advantage of the full seasonal, i.e., sell short on April 30, cover short positions and go long at the harvest peak and hold until April 30, the total gain is $1.83 and the *t*-ratio is significant at the 3 per cent level.[37]

Gray also suggests that the longer period, 1927–60, provides a better test for the existence of risk premiums. So he examines the results of buying the May futures on November 30 and selling them on April 30 in every year since 1927

[35] Gray has suggested privately that since speculative margins do not rise proportionately with price, the absolute price change (i.e., percentage return on margin) might be more indicative of risk premium than percentage change in price. I am not sure the premise is true. It is certainly true that futures prices can change dramatically without changes in margins, but my equally casual observation is that, while margin changes are discontinuous, they tend to be proportional or more than proportional.

[36] One might think that the Modigliani-Miller leverage theorem of corporate finance might be applicable to this problem, but it does not seem to be. That theorem says that changes in leverage should not affect the value of the asset being financed in a nontax world, because arbitrage would wipe out such differences. In this case, however, since margins do not imply borrowing (or at best borrowing at zero interest) there is an asymmetry between margins smaller than desired by a speculator and margins higher than those desired by him.

[37] This strategy is comparable to a strategy of Gray's which yields only 93⅜ cents. A typographical error on pp. 259–60 (*12*) may have misled some readers. The trading rule mentioned in the paragraph starting at the end of p. 259 is to *sell short* the December future on May 21, cover the short sale on November 30, and switch to buying the May future on that day, and holding it until April 30. In the Gray article, the italicized words read "buy."

and finds profits of 76½ cents and significant only at the 28 per cent level.[38] But again if he had chosen the August 30–April 30 period he would have found profits of $2.03⅜ which in this case is a little better than looking for the actual harvest peak. This is significant at the 7 per cent level. Furthermore, even though buying at the harvest peak[39] shows somewhat smaller profits, the variance of those profits is so much reduced that the significance level of the "Cootner strategy" falls to 4 per cent. If we include profits from the short position the gain increases to $2.69¾. This is particularly striking because these *combinations* of short *and* long positions are especially effective against the charge that all the good results are due to inflation. In effect, this strategy puts us short almost half of the year, so that any inflation should penalize the position almost as much as it helps it. In fact, however, this strategy increases the profits (and the variance).

Table 2 summarizes the results of a large number of tests of a number of strategies for a number of periods mostly suggested by either Telser or Gray. It is apparent that the strategy suggested by Gray yields the poorest results in almost all cases, while in general, strategies keyed to the harvest peak yield the best results. Some readers may be doubtful about the possibility of determining the harvest peak ex ante instead of ex post. In one sense, that is irrelevant since I am interested in establishing that prices rise after the harvest is past and not in running an investment advisory service.[40] As a matter of fact, however, the curve of visible supplies rises and falls very smoothly and the data are published promptly so that the peak can usually be determined within a few weeks at most.

Visible Supplies and Hedging

Another question may arise because of the possibility that changes in visible supplies may not correspond to changes in hedging. Although there is an excellent published study of this subject for the 1935–37 period by G. Wright Hoffman (*16*) which shows a good relationship, there is always the possibility that conditions have changed since then. Unfortunately, we do not have data on the volume of hedging for all the relevant years. We do, however, have end-of-month hedging data for 1937–40 and for the postwar period after 1946. We can observe the correspondence between hedging and visible supplies in that period in several ways.

One approach is to note the number of months by which the hedging peak leads or lags that of visible supplies.[41] The mean of these leads and lags is zero—

[38] Gray gives this figure at "over 50 per cent." Apparently, he gave the figure for a two-tail test rather than for the one-tail test.

[39] For the longer period, hedging data is not available, so the harvest peak is determined by using the peak of "visible supplies" in major terminals.

[40] There is, as a matter of fact, at least one investment advisory service which has advocated this kind of seasonal purchase. The Commodity Research Bureau's *Futures Market Service* (August 11, 1961, p. 8) has computed gains from a holding from August 15 to April 15. Buying on August 15 and selling on April 15 starting with the 1947–48 season and continuing to the present, this has resulted in gains of $1.16⅞. On August 15, 1947 the price of the May wheat future was $2.32½. On April 15, 1961 the price was $1.91¾, a decline of 40¾ cents. This is added evidence that the "inflation" in futures prices has nothing to do with the risk premiums.

[41] The Commodity Exchange Authority, which regulates domestic commodity exchanges, published data on speculative and hedging positions of "large" traders. (*Grain Futures Statistics, 1921–1951*; (1953) and the annual reports, *Commodity Futures Statistics*.) A large trader is defined as one who holds 200,000 or more bushels of wheat or corn in any one future. For the 1921–51 period, the

by that standard, the two series are coincident. Furthermore, in only one year out of the 16 does the lead or lag exceed one month. (In 1938 hedging peaks two months earlier.) This is hardly significant in view of the fact that the observations are *month-end* data, so that there may well be a one-month observational error from this source alone. In addition, the hedging data which are published account only for the activities of *large* hedgers. The pattern of "small" hedging is unknown but there is at least the possibility that the discrepancies may arise from this source. It is also true, however, that some wheat is undoubtedly hedged before it arrives at terminals. The data, however, suggests that visible supplies are a good proxy for hedging. As one last check we can recalculate the data for Gray's period (from 1949 to 1958) using the peak in hedging instead of the peak in visible supplies. The net result is to reduce the reported profits from long positions by about 0.3 cents per year, or 3½ cents for the whole period and about 0.4 cents per year for the short positions. These differences are hardly significant.

Seasonals in Wheat Futures and the Loan Program

Finally, Gray's imaginative hypotheses about seasonals being due to the question of the government loan program is hard to support. The hypothesis arose in explaining why seasonals based on calendar dates show a much clearer postwar pattern than in the prewar years. Actually, the difference in behavior seems primarily due to the changing seasonal pattern of the wheat harvest. Since the turn of the century, the wheat harvest has tended to come earlier in the year. In the early years of the century, the trough in visible supplies tended to come in August. In the 1920's and 1930's July was the usual date. Since the Second World War, the trough in visible supplies has come in May about as often as in June.[42] One result of this is that processors and merchants who wished to be sure of end-of-season supplies have tended in recent years to place their long hedges in the May future instead of the July and September futures. As a result the balance of hedging in the May future may become negligibly short or may shift to the long side well before the expiration of the contract. This has shown up in a postwar tendency for the May future to decline sometime after around March 15th. It also means that there has been less long hedging in the July and September contracts and less profit from preharvest short positions other than that derived from straddled positions—short May or July and long December. In one sense, of course, Gray is right, since the government loan program has helped to

data are given as of both the 15th and the end of the month for all futures combined only. Consequently, I have used gross hedging data on an end-of-month basis in these calculations. For some of the distortions that arise from the use of hedging data see Cootner (5, p. 416), especially footnote 3. For the purpose of this paper, visible supply is probably a safer measure to use for measuring the peak of hedging in old-crop contracts. One should not be misled by the fact that the "hedging" series is so titled into believing that it is necessarily more accurate.

[42] See the various volumes of the *Annual Report of the Board of Trade of the City of Chicago.* The growing importance of the March futures contract is probably due in part to this phenomenon. Before the war, this contract was only used sporadically, while in recent years it has been almost as important as the May future. Holbrook Working has pointed out to me that in earlier years the March contract was of little interest because the trade found basis changes between December and May fairly predictable. The earlier harvest has changed this since May is affected by late or early harvest. On the other hand, use of the March contract has probably also been stimulated by the March 30 deadline on withdrawals from government loan. Once such withdrawals have ended, the risks of holding wheat are more easily evaluated and some holders undoubtedly use hedges in the March futures as a "wait-and-see" device.

TABLE 3.—WHEAT: ANNUAL AVERAGE SEASONAL PRICE CHANGES DURING THE GOVERNMENT LOAN PROGRAM PERIOD, COMPARED WITH EARLIER YEARS*

(*Cents per bushel*)

Period	April 30 to peak	Peak to April 30	Absolute sum
Pre-loan, 1921–43	−7.15	+4.40	11.56
Loan period, 1949–61	−3.72	+1.41	4.68

* For "April to peak" periods averages of price changes in the nearest wheat future for which the position can be held for the entire period. For "Peak to April 30" periods, averages of price changes in the May wheat future. The "peak" is the month-end date nearest to the weekly peak in visible supplies.

alter the seasonal. Only commercial stocks need be hedged, so the diminution of stocks by the loan may have helped change hedging patterns. In particular, since in many years only the loan held prices up, the "free carry-over" in those years was much smaller than average, encouraging long hedging. Without long hedging, there is no reason for futures price declines, so the smaller carry-overs induced by the loan program might have increased the amplitude of the postwar seasonal. If the loan program had such an effect, however, it would not be because of the Gray reasoning, but as a result of normal risk averting behavior.

At any rate, even this hypothetical effect is not apparent in the data (Table 3), largely perhaps because in a number of postwar years prices were not supported by the loan. In fact, in Cootner (*4*) I observed that the seasonal price change based on the harvest timing was actually lower in the postwar period.

As a final test, I analyzed Gray's results for the 1949–58 period for wheat futures by another technique similar to that used by Telser in his earlier article. Gray's strategy was to buy the second nearest future on the date that delivery began on that contract, continuing the process until the end of the period. From 1949–58 that strategy produced a loss, which Gray interpreted as evidence that no risk premium existed in wheat. In fact, a strategy designed to sell futures prior to the harvest (April 30), to buy them after the harvest peak and hold them until March 30, produces profits of 82⅜ cents, a result which is significant at the 1 per cent level. To emphasize that these results are not dependent upon the technique used to measure the size of the speculative profits, I decided to try a nonparametric test of the same data.

In his earlier paper, Telser tested for a trend by comparing the *direction* of month-to-month price changes with the results to be expected from a random model, but without examining the possibility of seasonality. Gray's strategy produces five transactions per year, and I proposed to examine the *signs* of the net changes of those transactions for seasonality. To do this, I used a "restricted X^2 test" developed by E. Fix, J. L. Hodges and E. L. Lehman. This is a test of randomness over the year which is very powerful against the alternative of a sine-wave seasonal.[43] The rather impressive-looking test statistic

$$2n\left[\sum_{i=1}^{K}\sin\,(2i-1)\frac{\pi}{K}R_i\right]^2 + 2n\left[\sum_{i=1}^{K}\cos\,(2i-1)\frac{\pi}{K}R_i\right]^2$$

[43] "The Restricted Chi-Square Test," in H. Grenander, ed., *Probability and Statistics* (New York, 1959), pp. 92–107. The ordinary X^2 test has much less power against any specific alternative, although it is more powerful against all alternatives taken together. In the form presented here, the test has over 90 per cent of the limit power, which is less than 5 per cent.

is distributed as X^2 with two degrees of freedom. In this statistic, K is the number of transactions per year, R_i is the number of plus (minus) signs in transaction period i over the 10-year period, and n is the total number of transactions. The probability that the observed distribution is random is less than 0.1 per cent.

Soybean Seasonals

Table 4 presents, for the record, some evidence for a seasonal in soybeans, a commodity which has not yet been studied with respect to this hypothesis. This evidence is clearly consonant with the argument I have presented here, and it stands up particularly well to Gray's warnings about spurious results. The period covered is from the fall of 1949 to the fall of 1960. One strategy was to buy the May future at the harvest peak and sell on April 30. The starting price of May 1949 future was $2.32⅜. The price of the May 1960 future on April 30, 1960, was $2.12⅞ and the price of the next (July 1960) future was $2.15½, so the results cannot be ascribed to what Gray calls inflation. This is particularly so because the "long *and* short" strategy, which leaves the speculator long for 6 months and short for 5⅔, is good protection against any simple inflationary trend. Moreover, these results *omit* the 1960–61 crop year which proved wildly profitable for speculators (about 100 cents profit on the long position and 80 cents profit on the short). It should be noted that the results from using hedging data yield an even more favorable outcome than the results using visible supply data, and that the *difference* between the pre-October price decline and post-October 30 price rise is also significant at well beyond the 1 per cent level. The details of the strategies are indicated in the notes to Table 4.

TABLE 4.—SOYBEANS: AVERAGE GAINS PER YEAR, 1949–60*
(*Cents per bushel*)

Positions	Autumn 1949 to Autumn 1960[a]
Long positions	
From peak in visible supply to April 30	18.2
From peak in hedging to April 30	21.3
Short positions	
From April 30 to September 20	14.7
Long and short positions	
Long from October 20 to April 30 and short from April 30 to September 20	38.7

* Since soybeans have been in shorter supply than wheat during this period, long hedging has tended to predominate earlier in the crop year than was the case for wheat even though it is earlier in the soybean crop than in the wheat crop year.

Long positions were always taken in the May future.

Short positions were taken in the September future except in 1949/50 and 1950/51 where the September future was not used. In those years, the position was taken in the November future.

The September 20 terminal date was near the last day of trading in the September future. The last day was chosen because the long hedging positions in that month are usually taken to protect against late or poor harvests. The harvest usually begins late in September and the hedging position is generally liquidated very late. It is the *late* September results which truly indicate the outcome. A smaller, but still significant profit is obtained by terminating the short position on August 30.

[a] All results are significant at the .1 per cent level.

Intermarket Spreads

If the premiums are associated with the impact of hedging, then such premiums should also be detectable in the movement of prices in different markets in which the impact of hedging comes at different seasonal periods. In this section I plan to present evidence on three such intermarket spreads. One is the difference in price movement between the New York and Sydney grease wool contracts and the London wool tops contract. The second is the differential in movements of soybean prices and those for soybeans and products. The other is the relation between oats and corn futures prices at Chicago. In all cases, the price movements are as predicted. Furthermore, it is quite clear that members of both the wool and grain trades are quite aware of these seasonals. The fact that these seasonals persist in the face of such knowledge indicates that the risks involved in taking advantage of them outweigh the gain involved. This is further evidence that the trade does not act on the basis of expected values; that it is willing to pay premiums to avoid risk.

In 1964, Andre Toulemonde (*34*) undertook a study of price differentials in the London, Sydney, and New York wool markets. The London market is a market in wool tops, a semiprocessed form of wool used in worsted fabrics. The New York and Sydney markets deal in grease wool futures a raw form of wool, and the futures grade is the high-quality wool used as a raw material in the wool tops industry. The U.S. places a tariff on grease wool imports and from time to time has enforced quantitative restrictions on imports of manufactured wool. Thus intramarket basis risks arise from changes in manufacturing margins, freight rates, tariffs, foreign exchange rates, and (to a lesser extent) quality differentials. The wool "harvest" starts as soon as the weather turns warm which in the U.S. and Britain would mean about March and in Australia in August, but in each country the peak of commercial movement comes about four months later. Most hedging in the U.S. occurs in May–June and in Sydney in October–November, but because Britain is much more dependent on imports than the U.S. and because of commonwealth preference the London market is primarily used to hedge Southern Hemisphere wool and tends to follow more closely the Australian hedging pattern.

If hedgers pay risk premiums and the markets were completely disconnected, we would expect U.S. wool futures price to rise from at least June to January, and London and Sydney futures to rise from November to June. The patterns in the remaining parts of the years would depend on the precise pattern of the "harvest" and the timing and magnitude of long hedging. If speculators were able to operate in both markets, we could only be sure about relative price movements; the absolute price movements depending upon the relative magnitude of short and long hedging. Toulemonde's hypothesis, developed from Cootner (*3*), was that from July 1 to December 1, we would expect New York futures would gain relative to Sydney and London, since that was the postharvest period in the U.S. and included the harvest in the Southern Hemisphere. Conversely, he expected that from December 1 to July 1, the reverse would occur. He further speculated that the relative price movement would be greater between New York and Sydney than between New York and London because wool trade sources told him that manufacturers frequently placed long hedges in the London market during the harvest period but avoided the most distant Sydney market.

Since hedging data are nonexistent on the London and Sydney markets, Toulemonde's choice of dates is justified solely by general harvest considerations plus his own desire to test a period long enough to earn long-term capital gains. If risk premiums *are* paid, we would expect a more accurate specification of hedging to yield better results. As it is, however, the expected trends do, in fact, appear and are statistically significant. The average profit per transaction over the period 1956–63 (two transactions per year) was 3.9 cents, a result which was statistically significant at the 1 per cent level. The indicated profit is 7.8 cents per year which amounts to about 6 per cent of the New York grease wool price during the period. The Sydney market is the newest of the three so that the price differentials could only be observed during the 1961–63 period. While the period is rather short for a convincing test, the observed relative price changes in Sydney vs. New York were not only 50 per cent higher than in the New York–London spread, but showed no period of loss, as did the New York–London transactions on one occasion.

The importance of examining relative prices is emphasized if we also look at the absolute price changes over the same interval. Thus, if we look just at the indicated positions in New York futures alone, we see that they would have yielded a profit of 1.4 cents which is not only smaller in magnitude than the profits from the spread operation but is very much smaller relative to its variance.[44] By symmetry, the London part of the spread produced profits of 2.5 cents but again the range was very large, running from a maximum gain of 28.6 cents to a loss of 44.9 cents. The relatively small trends in the individual futures can apparently be achieved only because of the opportunities for risk reduction through spreading.

A similar situation arises domestically in the futures markets for domestic feed grains. The domestic oats crop is harvested starting in the spring and lasting through the summer months. The corn harvest starts in September and is generally complete by the onset of winter, although when winter is early, marketing may continue well into the following calendar year. For corn, therefore, short hedging is generally increasing in the period just prior to the expiration of the December contract. For the corresponding oats contract during the same period, the customary pattern is one of hedgelifting.

Oats and corn are competitive feeds but not perfect competitors. Since oats are almost half as light as corn, two bushels of oats supply roughly the same feed volume as one bushel of corn. The kind of basis risk involved in the two feeds is large, since two bushels of December oats have varied in value from 42 cents more than a bushel of December corn to 6 cents less in different years. While the fluctuation within any given year is much less, the size of these risks has tended to keep the two different markets alive. On the other hand, since there clearly is positive correlation between the two feeds, speculators can use spreading operations between the two markets to reduce both the risk and the required risk premiums between them. Whether or not the speculators do spread to reduce

[44] The largest profit would have been 38.4 cents: The greatest loss, 23.9 cents.

TABLE 5.—OATS–CORN: CHANGE IN PRICE DIFFERENTIALS OF DECEMBER CONTRACTS, 1947–64

Strategy[a]	Mean annual change (*cents per bushel*) To December 15	To November 30
1	4.79[b]	2.67
2	5.62[b]	3.45[c]
3	3.84[b]	1.67
4[d]	2.37	−1.20
5[d]	− .54	−1.72

[a] Hedging-oriented strategies: Buy two bushels of December oats and sell one bushel of December corn on bimonthly date when
1. Reported oats net short hedging first exceeds reported corn net short hedging.
2. Reported oats net short hedging exceed 2,000 contracts.
3. Reported oats net short hedging minus reported corn net short hedging reaches peak.
When oats short hedging always meets the conditions, trades are initiated on April 15.
Calendar strategies: Buy two bushels December oats and sell one bushel December corn on:
4. July 30.
5. April 15.
[b] Significant at the 5 per cent level.
[c] Significant at the 10 per cent level. All other numbers are not statistically different from 0.
[d] The figures are not significant at the 10 per cent level.

the risk, the existence of risk premiums should show up in an earlier rise in December oats futures, while December corn may actually be expected to decline during the summer and early fall if hedging had been long in the preharvest months. If spreading *is* done to reduce risk, we would expect the different harvest pattern to show itself more clearly in the price differentials than in either futures contract by itself, as we have already seen in wool.

The pattern does show up in price differentials (Table 5). Since short hedging shows up in oats first we should expect the oats contract to gain on corn as soon as reported short hedging in oats exceeds that in corn, and it does. Very similar results are obtained if we measure the price differential from the point where net reported short hedging in oats exceeds 2,000 contracts.[45] As added evidence that hedging plays an important role in this process, I would point out that an index of the price differential on a calendar basis shows a much smaller tendency for the differential to rise. Thus, while the average rise is about 5 cents on a hedging basis, it is only about 2 cents on a calendar basis.

The effect of occasional long hedging in the July wheat contract should also show up in a tendency, over a period of years, for July to decline relative to contract months later in the crop year which are less likely to be marked by long hedging. This expected effect is clear in the postwar years. The tabulation below is the 1948–66 average of the July futures price minus the December futures price on the indicated dates, in cents per bushel:

January	31	−5.10
February	28	−5.35
March	31	−5.62
April	30	−5.69
May	31	−6.55
June	30	−7.55

[45] The principle involved here is the same as in the case of wheat; the use of 2,000 contract cutoff is justified by the smaller magnitude of oats hedging.

On a calendar basis, without making allowance for the balance of hedging in any given year, July has lost an average of 2½ cents relative to December during the period January 31 to June 30. Furthermore, while this tendency is monotonic over the period, it is very slight until the onset of the wheat harvest in May and the largest part of the decline occurs in the month of June. I have not yet had an opportunity to examine this tendency with respect to changes in the balance of hedging.

In testing these results, one must keep in mind the expected tendency of the July future to lose ground to December more often than the reverse even in the absence of risk premiums. In that case, we would expect relatively infrequent but large gains for July to counterbalance this tendency. In the postwar period, however, there has been only one year (1955) in which July gained on December from January 31 to June 30 and that was only five-eighths on one cent.[46]

A somewhat different kind of spread involves comparing the price of soybeans with the price of the soybean oil and meal into which it is processed. The preharvest risk to processors centers around the availability of enough soybeans to economically utilize plant capacity. Since a substantial portion of total costs are fixed, a manufacturer, if so required, would be willing to crush soybeans as long as he could earn a processing margin large enough to cover only marginal costs, which may be substantially less than his full costs. On the other hand, if demand for final products was just equal to crushing capacity, a manufacturer would be able to extract a crushing margin equal to the full costs of the least efficient processor, *if* he were willing to wait until all other capacity were filled before making his raw material commitments and his forward sales. Such a procedure may entail considerable risk, however.[47] In particular, in the preharvest period, processor expectations about the size of the crop must play an important role in expectations about processing margins, since a short crop is likely to mean that processing plants will operate below capacity. If processors are risk averters, we would expect them to be willing to make commitments for both raw materials and processed products at margins smaller than they ultimately expect to prevail.

The foregoing is a statement about hedging *demand* not necessarily the cost of a hedge. If speculators preferred to buy soybean product futures rather than soybeans, their preferences might offset those of the hedgers. However, the reverse is actually true. Under most conditions speculation in soybeans should be less risky than speculation in either product alone.[48] Demand for soybean products are independent of one another, and the link to a common source of supply implies negative covariance of prices. Therefore, a portfolio of soybean meal and oil (e.g., soybeans) will be less risky than either entity separately, though the possibility of constructing such portfolios should give long speculation in soybean products the same mean and variance as soybeans. This implies that we

[46] In 1946, price controls were effective. In 1947 both months were not traded simultaneously until March, but July lost substantial ground to December from March 31 to June 30. If I had used the March 31 date throughout, 1955 would not have been an exception, but *1965* would have been (by ⅜ cent).

[47] He might not *have* to wait until all other processors were committed, if they all shared his expectations.

[48] Here it is important to stress that risk means variance around expected return, not probability of loss.

TABLE 6.—SOYBEANS AND SOYBEAN PRODUCTS: VALUE OF PRODUCTS LESS PRICE OF SOYBEANS (JANUARY CONTRACTS), AND ANNUAL PROFITS, 1955–64*

A. Value of Products Less Price of Soybeans, 1955–64 Average

Date[a]	Cents per bushel	Date[a]	Cents per bushel	Date[a]	Cents per bushel
September 17	−2.9	October 29	−1.4	December 10	+3.0
September 24	−2.3	November 5	−.9	December 17	+3.9
October 1	−3.6	November 12	−.8	December 24	+5.2
October 8	−4.0	November 19	0	December 31	+5.0
October 15	−2.5	November 26	+.2	January 7	+6.2
October 22	−2.6	December 3	+1.8	January 14	+7.8

B. Annual Profit (*cents per bushel*)[b]

Year	Profit	Year	Profit	Year	Profit
1955	+9.8	1959	+23.7	1963	+13.1
1956	+3.2	1960	+11.4	1964	−11.3
1957	+13.7	1961	+3.7		
1958	+8.2	1962	+9.6	Average	+7.9

* Each 60-pound bushel of soybeans produces approximately 11 pounds of soybean oil and 47 pounds of soybean meal and about 2 pounds of miscellaneous by-products. The actual output of oil and meal per bushel of soybeans crushed is valued at Chicago Board of Trade soybean products futures prices and related to the corresponding Chicago Board of Trade soybean futures prices.

[a] Value on the Friday nearest the indicated date.

[b] Profit per bushel of soybeans from selling, on the Friday nearest September 17, Chicago January soybean futures and buying (in proportion to actual oil and meal output) Chicago January soybean product futures, and subsequently reversing these transactions on the Friday nearest January 14.

should not expect soybean processors to *have* to pay a risk premium to speculators by accepting low prices for sales of soybean product futures relative to their purchases of soybean futures, *unless* speculators tended to be short in soybeans and long in soybean products in the preharvest period. In that case, soybeans and products are not substitutes.

The data in Table 6 suggest that processors do have to make such payments.[49] Consistently, in the postwar period, January soybean futures prices have declined relative to January soybean oil and meal futures.[50] On the other hand, the data on hedging are only partially consistent with our expectations. To be sure, reported hedging is generally long in soybeans through September and generally short in products throughout the year. Most of the change in relative prices, however, takes place in November and December when reported hedging is short in all the commodities. Furthermore, the years like 1960/61 when hedging was never long prior to the soybean harvest and sporadically long in soybean products still showed the improvement in margins.[51] These facts are not neces-

[49] Actually we cannot detect the volume or direction of such processor "margin" hedging, but it is common belief in the trade that processors hedge in the manner indicated by the theory. We do know, however, that preharvest reported hedging in soybeans is long and in soybean products is short in most years.

[50] January is the first postharvest month for which futures in both soybeans and soybean products are traded.

[51] Parenthetically, it should be noted that this year, one of the few in which reported hedging was never long, was a year of extremely large price rise.

sarily a contradiction of the foregoing reasoning, since it is still possible that the individual contracts concerned did have hedging in the "right" direction. However, until that is demonstrated, the facts must raise a question in our minds.

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Appendix Note on Sources of Statistical Data

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