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## **Spreading, Hedging and Speculating in Forward, Futures and Spot Markets**

by

Ray Nelson, Dan Aguiar, and Tim Park

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Spreading, Hedging and Speculating  
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Ray Nelson, Dan Aguiar, and Tim Park\*

Introduction

Speculators, spreaders, and hedgers continuously monitor forward, futures, and cash markets hoping to identify potentially profitable trading opportunities with acceptable levels of uncertainty. All three types of agents seek optimal combinations of return and risk for their personal portfolios of trading activities. Speculators assume a high risk posture by exposing themselves to the full impact of common economic, agronomic, and meteorologic influences on overall market prices. Although spreaders and hedgers perceive the strong influence of these common factors on the forward, futures, and cash prices, they also recognize the differential effects of these macroenvironmental influences on the separate markets. Hedgers and speculators attempt to profit from these potentially rewarding differential effects by assuming combinations of long and short trades. The relatively smaller risk levels of these combinations often yields a portfolio with less expected return than those of traders speculating on the overall price level.

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\*Ray Nelson, Daniel Aguiar, and Tim Park are, respectively, Assistant Professor, Research Associate, and Research Assistant in the Department of Agricultural Economics, University of California, Davis.

Economic models of the portfolios of these diverse traders who share a pool of common marketing activities find importance in two different contexts. First, such models often attempt to generate marketing strategies executable at the firm level. Second, studies attempting to explain the joint equilibria among the forward, futures, and cash markets use portfolio models to motivate the behavior of the individual agents in the markets. Both modeling attempts would benefit from a portfolio framework with the sophistication necessary for efficient prescription of trading strategies for microeconomic agents yet simple enough to contribute to a tractable discussion of a general equilibrium among the markets. A portfolio selection model patterned after Sharpe's single index model potentially provides both benefits by capturing the common macroenvironmental influences in commodity markets and by providing spreaders, hedgers, and speculators a common framework useful in evaluating the relationships among forward, futures, and cash prices.

#### Literature Review

Portfolio constructs pervade the economics literature which discusses both hedging behavior of the microeconomic firms and general equilibrium among forward, futures and spot markets. Portfolio models eclectically combine two very different approaches to hedging. This literature, which is summarized by Gray and Rutledge, begins with a group of researchers who follow the lead of Keynes by attributing a

risk management objective to hedgers. A second group composed of Holbrook Working and others characterize hedging as profit seeking or basis speculation behavior. Portfolio analysis as shown by not only the Gray-Rutledge summary but also recent articles such as Peck, McKinnon, Ederington, Rolfo, and Anderson and Danthine, allow hedgers to balance return against risk as they choose their marketing activities.

Stein uses portfolio theory both in his original consideration of the joint determination of futures and spot prices and in a later model for forward, futures, and spot markets. Anderson and Danthine approach equilibrium in futures and spot markets by modeling the activity choices of producers, merchants, and speculators under the condition of uncertainty. All of these agents try to maximize the expected utility of their portfolios.

Sharpe utilizes the idea of the single index model to both simplify selection of securities for inclusion in portfolios of common stocks as well as in his capital assets pricing explanation of equilibrium in financial markets. The single index model finds service in Dusak as well as Carter, Rausser, and Schmitz's conflicting searches for risk premiums. Lee and Leuthold apply the single index model to study the nature of risk and return in commodity markets. No other studies known to the authors apply the simplification or equilibrium modeling power of the single index model to forward, futures, and cash commodity markets.

Because the single index model is so important in the present discussion, its basic features are now reviewed.

### The Single Index Model

Since Sharpe, Elton and Gruber, Francis and Archer, and others all detail the single index model, the present brief overview does not reconstruct this entire methodology. Rather, it highlights the major concepts of the single index model in order to provide the foundation for its application to the commodity market situation.

The major point underlying the idea of index models suggests that common, pervasive macroeconomic influences cause the strong positive covariations among rates of return in the stock market. A single index such as the Standard and Poor's 500 Stock Composite Index often finds use as a proxy for this systematic risk inherent in a portfolio containing shares of all possible securities. The following simple regression equation formalizes the postulated relationship between the rate of return  $R_i$  of security  $i$  with the rate of return on the market portfolio  $R_m$ :

$$R_i = \alpha_i + \beta_i \cdot R_m + \varepsilon_i \quad (1)$$

The parameters  $\alpha_i$  and  $\varepsilon_i$ , respectively, represent the average and random components of security  $i$ 's return. Both components are independent of the overall stock market's performance.

The beta coefficients comprise an especially important part of the single index model by serving as a measure of a security's



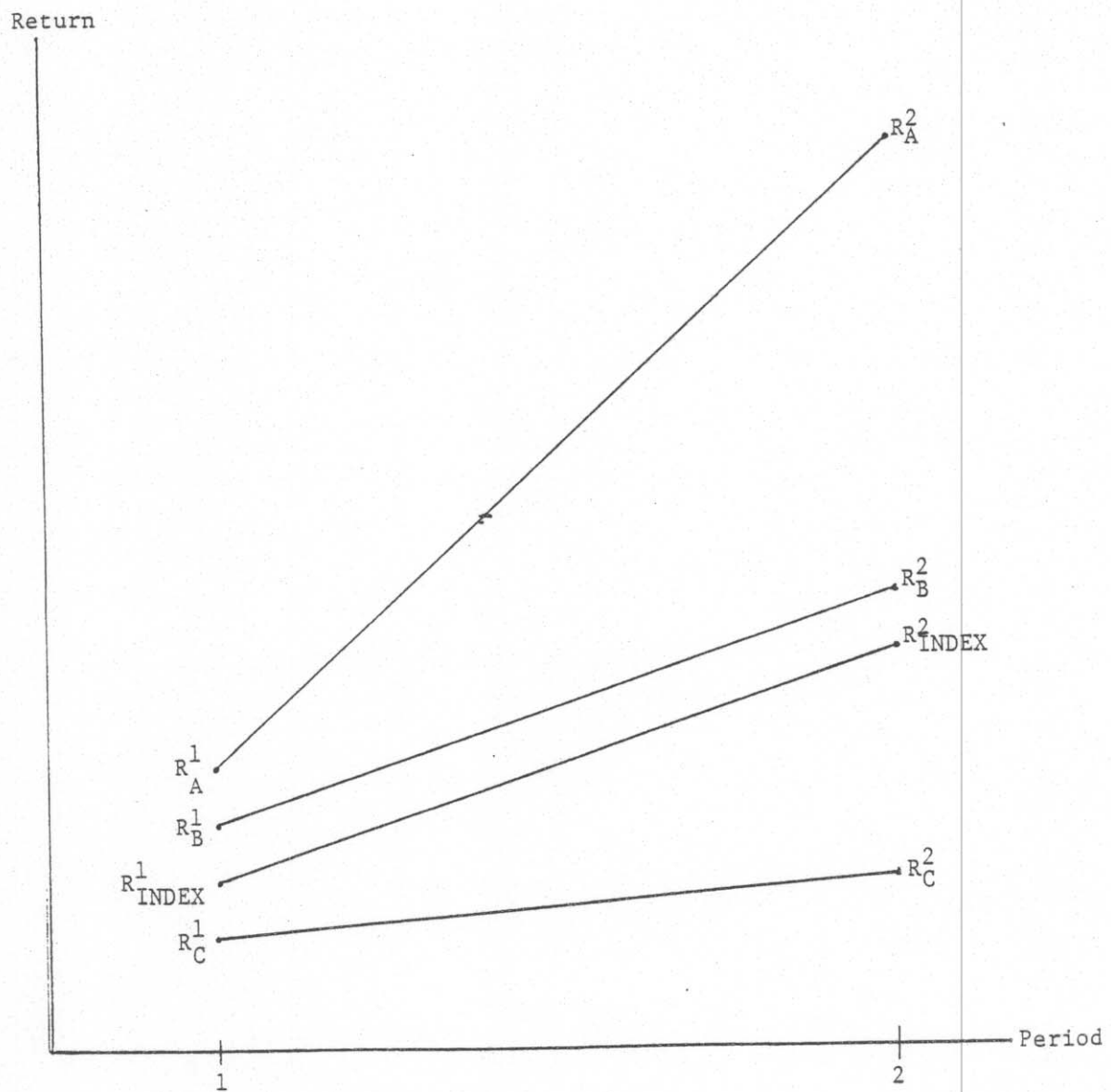
volatility relative to that of the market portfolio. Since the covariance of any random variable with itself equals one, the benchmark beta value for the market portfolio is one also. If a security or portfolio has a beta of one, this means that its return moves in lockstep with that of the market portfolio. In Figure 1, the line  $R_B^1 R_B^2$  represents the time path of the return on portfolio B whose beta equals one. As shown in the diagram, this line exactly parallels the time path of the returns on the market portfolio,  $R_{INDEX}^1 R_{INDEX}^2$ . If the rate of return on the market portfolio increases by 1 percent, so does the rate of return on portfolio B.

Those securities with betas greater than one rank in the relatively more volatile category since 1 percent changes in the market index correspond to either increases or decreases of more than 1 percent in the rates of return of these more risky securities. The steeper slope of line  $R_A^1 R_A^2$  in Figure 1 represents a portfolio with a beta greater than one. Less volatile securities have betas less than one indicating their rates of return change relatively less than the return on the market portfolio. The time path of returns for such a security slopes more gently than that of the market portfolio as illustrated by line  $R_C^1 R_C^2$ .

#### The Single Index Model and Ederington's Approach to Hedging

Just as common macroeconomic influences cause stock prices to move together, a similar pervasive phenomenon underlies the strong positive

Figure 1  
Volatility Relative  
to an Index



correlations among movements in commodity prices. These positive covariances, in fact, underly the rationale of risk management through hedging. Although one group of models, which all use a common approach formalized by Ederington, do not formally employ the idea behind a single index model, they nonetheless utilize the spirit of the methodology.

Ederington establishes an often cited framework for determining an optimal hedging ratio. The minimum variance hedging ratio or the quotient of the futures position  $X_{FUT}$  and a predetermined spot commitment  $X_{CASH}$  depends on the covariance between the changes in the futures prices  $P_{FUT}$  and cash prices  $P_{CASH}$  relative to the variance of the futures price changes or:

$$\beta = - \frac{X_{FUT}}{X_{CASH}} = \frac{\text{Cov } P_{FUT} \cdot P_{CASH}}{\text{Var } P_{FUT}} \quad (2)$$

Ederington emphasizes the ease of determining beta by simply regressing the cash price on the futures price using the equation:

$$P_{CASH} = \alpha + \beta \cdot P_{FUT} + \epsilon. \quad (3)$$

An alternative interpretation of the Ederington framework classifies this approach as a special case of the single index model. In this instance, a futures price serves as the index giving the futures price itself a  $\beta_{FUT}$  equal to one and the cash price a  $\beta_{CASH}$  equal to the  $\beta$  estimable using expression 3. The portfolio beta for a minimum variance hedge results from weighting these two beta values by the respective sizes of the cash and futures positions. Since the optimal futures commitment implied by expression 2 means that:



$$X_{FUT} = -\beta \cdot X_{CASH}, \quad (4)$$

the portfolio beta  $\beta^*$  for the minimum variance hedge equals zero as demonstrated by expression 5.

$$\begin{aligned} \beta^* &= X_{CASH} \cdot \beta_{CASH} + X_{FUT} \cdot \beta_{FUT} = \\ &X_{CASH} \cdot \beta + [-\beta \cdot X_{CASH}] \cdot 1 = 0 \end{aligned} \quad (5)$$

This suggests that Ederington hedgers attempt to neutralize the systematic risk measured by the futures price index.

Four problems arise in trying to generalize or apply the Ederington approach. First, hedgers must preselect the maturity and market of the futures hedging instrument since the analysis allows only one contract. Second, since forward contracts also provide a feasible means of hedging, more realistic portfolios should include this opportunity. Third, the framework does not include speculators and spreaders, who according to Schöles do share much in common with hedgers. Finally, the questionable constancy of the covariation between futures and cash prices may compromise the effectiveness of the model in prescribing usable decision strategies.

#### Construction of a Composite Price Index

A model applicable to hedgers, spreaders, and speculators and inclusive of forward and futures contracts of multiple maturities results from using single index models in their more traditional sense. Rather than choosing a single futures price as an index, this approach can utilize a composite of cash prices from a variety of locations,

forward quotes for different maturities, and futures prices for all expirations and exchanges.

The methods used to construct a commodity price index mimic the procedures employed to determine stock market indicators such as the Dow Jones Industrial Average and the Standard and Poors 500. In the original formulation of the Dow Jones Industrial Average, analysts constructed a portfolio containing a single share of 30 stocks. The changing value of this portfolio over time, therefore, reflected the path of stock prices in general. The analysts anticipated the effects of bankruptcies, stock splits, and dividends by a clever reallocation process. They accomplished this by utilizing the adjusting divisor method detailed in Levine.

The construction of the commodity price index postulates a portfolio containing one bushel for each separate trading option. The market price of each option determines its contribution to the value of the portfolio. The average of these prices meters the general level of the prices in the commodity market. A problem arises because the maturities of the futures contracts require frequent adjustments during the process of index calculation. Since each futures contract matures annually, a continuous time series for a specific contract does not exist beyond one year. Therefore, when a futures contract goes off the board, maintaining a consistent index requires adjusting the average's divisor. The determination of the size of this adjustment utilizes the same methodology invented to replace a less important old

corporation with a more representative new one in the Dow Jones Industrial Average. By methodically including prices for all decision options in the commodity price index, the single index model can accommodate the decisions of speculators and spreaders as well as hedgers.

Single Index Model for Hedgers, Speculators, and Spreaders

In order to achieve the generality able to include hedgers, speculators, and spreaders, the model assumes that decision agents concern themselves with the changes in their wealth wrought by their forward  $X_{FOR}$ , cash  $X_{CASH}$ , and futures  $X_{FUT}$  commitments. Therefore, their change in wealth  $\Delta W$  depends on the change in the cash  $\Delta P_{CASH}$ , forward  $\Delta P_{FOR}$ , and futures prices  $\Delta P_{FUT}$  or:

$$\begin{aligned} \Delta W = & X_{FOR} \cdot \Delta P_{FOR} + X_{CASH} \cdot \Delta P_{CASH} + X_{FUTA} \cdot \Delta P_{FUTA} \\ & + X_{FUTB} \cdot \Delta P_{FUTB} \end{aligned} \quad (6)$$

The two different futures positions  $X_{FUTA}$  and  $X_{FUTB}$  allow the decision makers to buy or sell contracts in more than one maturity.

Applying the single index model in the present case requires that general trends underlie cash, futures, and forward commodity markets. These trends, proxied by a price index, constitute the systematic part of the variation or risk inherent in the commodity markets. Stochastic error terms corresponding to each market or contract and independent of the index indicate the nonsystematic deviations of cash, futures, and forward prices from the average level present in the commodity market. Expressions 7 formalize these relationships:

$$\begin{aligned}
P_{\text{CASH}} &= \alpha_{\text{CASH}} + \beta_{\text{CASH}} \cdot P_{\text{INDEX}} + \epsilon_{\text{CASH}} \\
P_{\text{FOR}} &= \alpha_{\text{FOR}} + \beta_{\text{FOR}} \cdot P_{\text{INDEX}} + \epsilon_{\text{FOR}} \\
P_{\text{FUTA}} &= \alpha_{\text{FUTA}} + \beta_{\text{FUTA}} \cdot P_{\text{INDEX}} + \epsilon_{\text{FUTA}} \\
P_{\text{FUTB}} &= \alpha_{\text{FUTB}} + \beta_{\text{FUTB}} \cdot P_{\text{INDEX}} + \epsilon_{\text{FUTB}}
\end{aligned}
\tag{7}$$

The following equivalent notation simplifies later discussion:

$$\begin{aligned}
\Delta P_{\text{CASH}} &= \beta_{\text{CASH}} \cdot \Delta P_{\text{INDEX}} + \Delta \epsilon_{\text{CASH}} \\
\Delta P_{\text{FOR}} &= \beta_{\text{FOR}} \cdot \Delta P_{\text{INDEX}} + \Delta \epsilon_{\text{FOR}} \\
\Delta P_{\text{FUTA}} &= \beta_{\text{FUTA}} \cdot \Delta P_{\text{INDEX}} + \Delta \epsilon_{\text{FUTA}} \\
\Delta P_{\text{FUTB}} &= \beta_{\text{FUTB}} \cdot \Delta P_{\text{INDEX}} + \Delta \epsilon_{\text{FUTB}}
\end{aligned}
\tag{8}$$

The analysis assumes that the stochastic error terms have expected values equal to zero.

Substituting expressions 8 into expression 6 gives the wealth change in terms of three components. The first includes the forward, cash, and futures positions weighted by their respective betas. The second denotes the systematic variation represented by the price index. The third comprises a weighted combination of unsystematic error terms.

$$\begin{aligned}
\Delta W &= [X_{\text{CASH}} \cdot \beta_{\text{CASH}} + X_{\text{FOR}} \cdot \beta_{\text{FOR}} + X_{\text{FUTA}} \cdot \beta_{\text{FUTA}} + \\
&\quad X_{\text{FUTB}} \cdot \beta_{\text{FUTB}}] \cdot \Delta P_{\text{INDEX}} + [X_{\text{CASH}} \cdot \Delta \epsilon_{\text{CASH}} + \\
&\quad X_{\text{FOR}} \cdot \Delta \epsilon_{\text{FOR}} + X_{\text{FUTA}} \cdot \Delta \epsilon_{\text{FUTA}} + X_{\text{FUTB}} \cdot \Delta \epsilon_{\text{FUTB}}]
\end{aligned}
\tag{9}$$

For expositional simplicity, recognize the first bracketed term on the right-hand-side of expression 9 as the weighted sum of beta values equal to the portfolio's beta,  $\beta^*$ . Also, redefine the last bracketed term as simply  $\epsilon^*$ . Therefore, the change in wealth is:

$$\Delta W = \beta^* \cdot \Delta P_{\text{INDEX}} + \epsilon^*
\tag{10}$$

If the decision agents concern themselves with the expected values and variances of their portfolios, they choose a portfolio whose  $\beta^*$  gives the optimal combination of expressions 11 and 12:

$$E[\Delta W] = E[\beta^* \cdot \Delta P_{\text{INDEX}}] \quad (11)$$

$$\text{Var}[\Delta W] = \text{Var}[\beta^* \cdot \Delta P_{\text{INDEX}}]. \quad (12)$$

Aggressive decision makers select  $X_{\text{CASH}}$ ,  $X_{\text{FOR}}$ ,  $X_{\text{FUTA}}$ , and  $X_{\text{FUTB}}$  so as to achieve a  $|\beta^*| > 1$ . Those of more conservative preferences design their portfolios such that  $|\beta^*| < 1$ .

Whereas the choice of  $\beta^*$  indicates the aggressiveness of the portfolio, the selection of marketing options within a portfolio determines the classification of decision makers as hedgers, speculators, or spreaders. The following three examples illustrate how the single index model applies to each category of trader.

#### The Speculators

The portfolios of many speculators contain only one trading option and thus offer no opportunity to manage risk by concurrently balancing short against long positions. Speculators bet on the change in the overall level of prices by assuming an open cash, forward, or futures position. A typical short speculator, for example, may anticipate a price decline and thus sell futures contracts. The following expression gives the change in such a speculator's wealth resulting from the short commitment in futures contract A:

$$\Delta W = X_{\text{FUTA}} \cdot \beta_{\text{FUTA}} \cdot \Delta P_{\text{INDEX}} + \Delta \epsilon_{\text{FUTA}}. \quad (13)$$



With a short futures position,  $X_{FUTA}$  indicates a negative quantity which when paired with a price decline causes a positive profit. Other traders assume another common speculative stance by maintaining an open long cash position while hoping for a price increase.

### The Spreaders

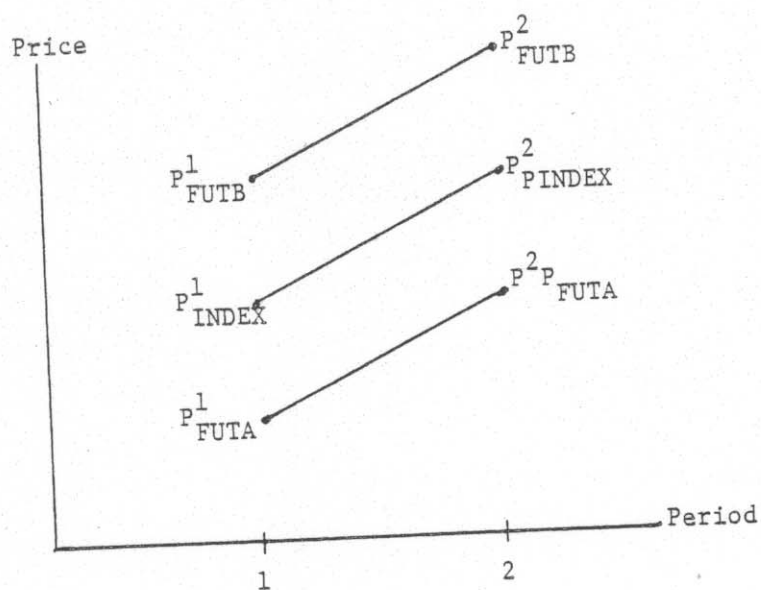
Spreaders eschew exposure to the full impact of changes in the price level yet attempt to glean profits from changing price differentials. They commonly choose offsetting positions in futures contracts of different maturities, exchanges, or commodities. When the price differential between a distant contract B and near futures contract A seems too large, for example  $P_{FUTB} - P_{FUTA}$  exceeds its normal magnitude, spreaders short contract B and buy contract A. They use the flipside of this procedure when the price spread appears too small.

Spreaders may identify price differentials which vary from the norm and then correctly anticipate the regression of such differences towards their average. Figure 2(a), for example, could represent regular conditions in a market since in period one the prices of futures contracts A and B rest at their normal levels relative to the index. The differences between the prices and the index remain unchanged during the price increase between periods one and two. Spreaders cannot make profitable combinations of trades under these circumstances.

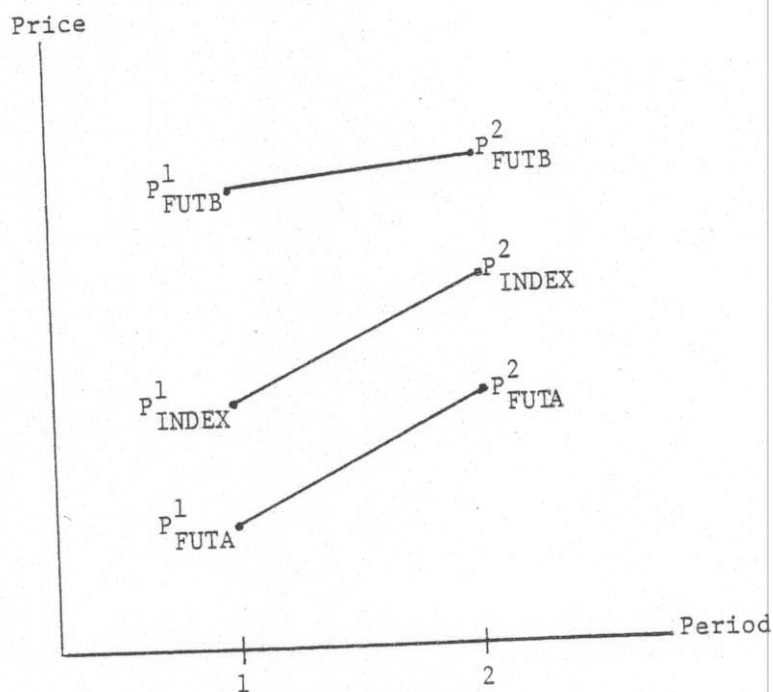


Figure 2

Spreading Opportunities and Volatility  
(a) No Spread Opportunity



(b) Spread Opportunity



A potentially lucrative spread arises when the price of a futures contract B, as shown in Figure 2(b), reaches a high level relative to the price index and the price of a second futures contract A remains at its average distance below the index. Traders identifying such an unusually large difference between the prices of two contracts might anticipate a narrowing of the spread during an overall increase in the price level. In such an instance, the higher priced contract B would increase less relative to the price index than would the lower valued A. If the lower priced A increases at the same rate as the price index thus maintaining their average difference, its beta value equals one. The slower ascent of contract B gives it a beta less than one and causes the distance between itself and the price index to reach its customary level in period two.

In the context of the single\_index model, spreaders anticipate unequal beta values for the two different contracts. Then by selling and buying the respective futures contracts, the spreaders achieve nonzero portfolio  $\beta^*$  values. The following expression gives a typical spreader's change in wealth:

$$\begin{aligned} \Delta W = & [X_{FUTA} \cdot \beta_{FUTA} + X_{FUTB} \cdot \beta_{FUTB}] \cdot \Delta P_{INDEX} \\ & + [X_{FUTA} \cdot \Delta \epsilon_{FUTH} + X_{FUTB} \cdot \Delta \epsilon_{FUTB}]. \end{aligned} \quad (14)$$

Even though the two futures positions have exactly opposite magnitudes, i.e.,  $X_{FUTA} = -X_{FUTB}$ , the unequal betas for the two futures contracts cause the nonzero  $\beta^*$  or:

$$\beta^* = X_{FUTA} \cdot [\beta_{FUTA} - \beta_{FUTB}] > 0. \quad (15)$$

Spreaders can anticipate changes in futures price differentials and construct profitable portfolios by comparing the volatilities of different contracts, commodities and exchanges.

### The Hedgers

Categorization of traders as either hedgers or speculators raises some very difficult semantic problems. In order to avoid a protracted discussion of the factors which distinguish between the two types of individuals, simply assume that hedgers include a general class of traders who produce, merchandise, or consume the commodity in question and who limit their exposure to the risk of price changes by balancing short against long positions.

Although many different vocations fit under this definition of hedgers, the general principles of hedging require minimal customization to fit each type of trader's specific situation. Since grain merchandisers serve well as representatives of most persons accommodated under the hedging rubric, the remaining discussion focuses on this type of trader.

During the growing season for a given commodity, merchandisers such as elevator operators may maintain spot stocks and long forward contract liabilities. In order to hedge the risk of wealth changes, these merchants must first assess the worth of their current assets and liabilities. They value their present inventory at the current cash price since this represents the immediate replacement cost. Similar reasoning appraises forward purchase liabilities at the current

forward cash price. Merchandisers profit from cash and forward commitments when prices rise above their current levels. By selling futures contracts of one or a combination of maturities, merchandisers limit the effect of price changes on the wealth represented by their portfolios.

Since variations in merchandisers' wealth depend on changes in the cash, forward, and futures prices, these merchants' portfolios can include all four of the marketing options defined for the present discussion. Expression 9 formally represents these wealth changes using the notation of the single index model. Merchandisers pursuing a minimum risk position would attempt to achieve portfolios with zero beta values or:

$$\begin{aligned} \beta^* &= X_{\text{CASH}} \cdot \beta_{\text{CASH}} + X_{\text{FOR}} \cdot \beta_{\text{FOR}} + X_{\text{FUTA}} \cdot \beta_{\text{FUTA}} \\ &+ X_{\text{FUTB}} \cdot \beta_{\text{FUTB}} = 0. \end{aligned} \quad (16)$$

This parallels the Ederington approach to hedging discussed previously.

Rather than blindly minimizing risk, however, merchandisers more likely search for abnormally small or large differences between cash quotes and futures prices. When these differences, known as basis values, reach unusually small arithmetic magnitudes, merchandisers anticipate opportunities to undertake potentially profitable combinations of trades. By selling futures opposite their long cash positions, merchandisers would expect to earn profits from basis increases. As suggested by Scholes, hedgers speculating on the basis in this manner use the same reasoning as spreaders who themselves speculate on price spreads between futures contracts.

Like spreaders, hedgers can also look for favorable basis conditions before initiating hedges by searching for differing volatilities among marketing options. Throughout this process, however, hedgers must remember that volatility means the covariance of the price of a given marketing option with the commodity price index divided by the variance of the commodity price index itself. Since the value of the covariance can change with the marketing environment, hedgers should condition estimates of volatility on current levels of market influencing factors.

#### Conditional Covariances and Volatilities

The majority of portfolio models ignore the empirical evidence which suggests that the covariances among commodity prices vary with different combinations of market conditions. Before showing how the single index model highlights this nonstationarity, however, a brief review of Houthakker confirms the importance of tailoring covariance estimates to market conditions.

Houthakker makes two very important generalities. First, he states that the current level of the basis strongly affects the probability of a favorable change. Empirical evidence reported by Heifner supports this assertion. Second, he claims that the expected basis change and the correlation between futures and spot prices exhibit a strong interrelationship. If there exists a tendency for an abnormally large or small basis value to regress towards its average,



Houthakker's claim certainly seems correct. If a basis at its normal level exhibits little tendency to vary, a constant basis between two time periods implies perfect correlation between spot and futures prices. The larger the basis change as it adjusts towards its normal level, the smaller the correlation between the two prices.

Since volatility depends on the correlation between a price and the commodity index, Houthakker's conclusions imply that a given beta's value should depend on the initial difference between the price and the level of the index. Figure 3 illustrates the effect of this difference on volatilities. The diagrams also introduce the influence of the sign of the expected price change on beta estimates.

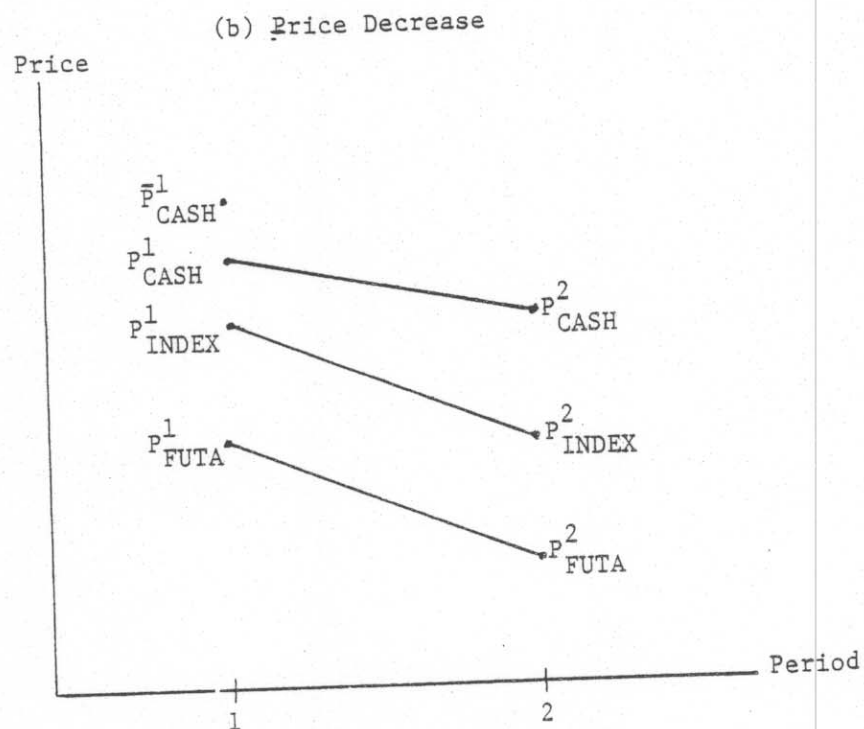
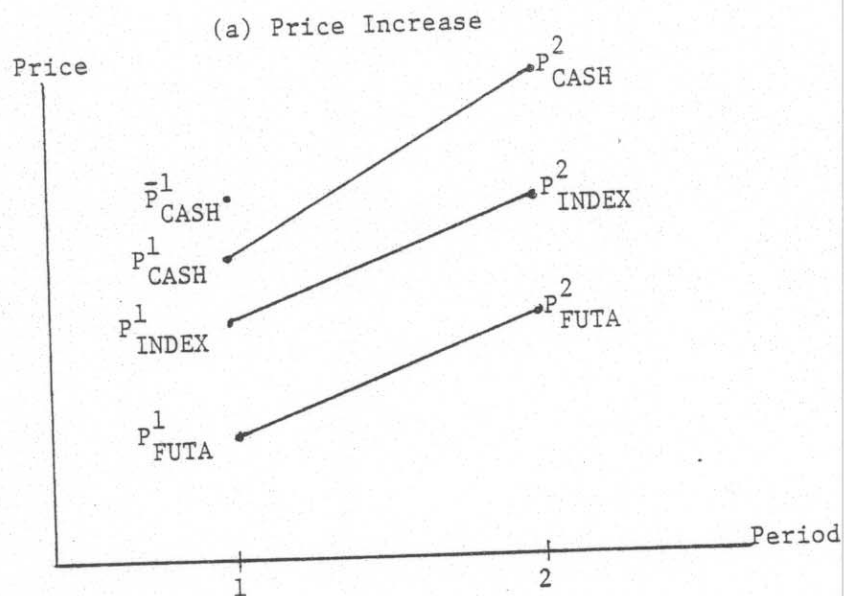
This illustration utilizes an example of a basis smaller than normal. This narrow basis results from the cash price being low relative to its normal distance above the index. The futures price lies at its average span below the index. In both 3(a) and 3(b) the points  $P_{CASH}^1$ ,  $P_{FUTA}^1$ , and  $P_{INDEX}^1$  represent the respective levels of the cash price, futures price, and the commodity index in period one. If the cash price were at its customary position above the index, it would be at  $\bar{P}_{CASH}^1$  rather than  $P_{CASH}^1$ . In period 2, relative price changes return the difference between the cash price and the index to its customary magnitude. Equal changes in the futures price and the index leave unchanged the relative position of the futures.

The difference between the cash price and index returns to its normal level, a distance of  $\bar{P}_{CASH}^1 - P_{INDEX}^1$ , during the price increase



Figure 3

Dependence of Price Volatility  
on Direction of Price Changes



depicted in Figure 3(a). This requires that the cash price must ascend more rapidly than the index. Its volatility then exceeds one, the common beta values shared by the index and futures price. Only with a cash volatility less than one can the difference between the cash price and index reach its regular magnitude during a price decline as shown in Figure 3(b). Thus, the cash volatility differs depending on whether prices increase or decrease. Using the single index model in this manner to analyze relative price changes reemphasizes the important effects of present and future market conditions on price volatilities.

#### Conclusions and Extensions

Although some difficulties still remain before completing the successful adaptation of the single index model to commodity trading, this methodology does show promise. Using a commodity price index allows the simultaneous inclusion of forward, futures, and cash trading activities within the portfolio. The generality for the portfolio construction allows application to speculators, spreaders, and hedgers who all seek their personally best combination of risk and return. It specifically points to the importance of variable volatilities conditional on present and future market conditions.

Primary among the hurdles yet impeding the application of the single index model stands the need for a methodology capable of estimating the conditional volatilities. The random coefficients approach of Carter, Rausser and Schmitz offers some direction to a possible solution in this regard.

The further effort needed to complete the adaption appears all the more alluring when considering the value of the capital assets pricing model in explaining equilibrium in financial markets and the computational efficiency of the single index model in individual portfolio construction. Should the single index approach afford commodity markets the same two advantages, all research efforts directed towards this end shall indeed be fruitful.

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