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# Research on Futures Markets: Issues, Approaches, and Empirical Findings

Steven C. Blank

This paper presents a brief assessment of the recent futures and options literature with reference only to agricultural markets. The discussion centers on the markets' social value and economic value to firms. Issues currently unresolved are highlighted, in some cases by presenting hypotheses contrary to standard positions. Overall, the current literature describes these markets as having positive social value and serving useful functions at the firm level, but existing theory and empirical methods are criticized for many weaknesses.

*Key words:* futures, literature survey, options.

Futures market research and its resulting literature have increased in volume tremendously over the past decade. The successful introduction of financial and industrial products on futures markets and the legalization of trading options on futures have attracted market analysts from nonagricultural disciplines. These researchers brought with them a different perspective for viewing futures markets which has greatly expanded the number and type of issues being evaluated. In particular, futures market analysts with a business finance background are much more common than a decade ago. These researchers have begun applying methodologies and testing hypotheses found only in the finance literature of the 1970s. To facilitate dissemination of the new wave of futures research results, entirely new journals have appeared during the 1980s, such as *The Journal of Futures Markets* and *The Review of Futures Markets*. Along with new contributions in traditional outlets for agricultural futures research, these journals have expanded and altered the nature of the futures literature.

The changing composition of futures research brought on by the changing composition of futures trading activities can give the impression that the economic purpose and functions of futures markets also may have

changed in recent years. However, the fact that futures exchanges have expanded their product lines to attract customers from nonagricultural sectors of the economy has not altered the availability or operation of "agricultural" futures markets. Still, questions remain concerning how the new research focus and literature have affected the list of topics considered to be important in futures markets for agricultural products. This can be seen by comparing this paper to earlier surveys of futures literature (such as those by Gray and Rutledge; Leuthold and Tomek; and Kamara).

Therefore, the objective of this paper is to present a brief assessment of the issues, methods, and results reported in the recent literature, with reference only to agricultural futures and options markets. These topics are discussed in the sections below, followed by an outline of future directions the literature may take.

## Issues

Economic analyses of futures markets continue to center around two basic questions: Do the markets have social value, and economic value to firms? Issues related to these questions are summarized below.

### *Social Value Issues*

Economists tend to credit market instruments with positive "social value" if they are judged

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Steven C. Blank is a visiting associate professor in the Department of Agricultural Economics at the University of California, Davis. This is Giannini Foundation Research Paper No. 897.

to be contributing to pricing efficiency and/or improving resource allocation (Kamara). Kawai supports the long-held view that, in theory, futures have potential for much social value through gains in both pricing and allocation performance. The steady stream of empirical evaluations of potential markets (such as that by Miller, Smith, and Williams) implies that market improvements are expected with the introduction of futures trading in product markets, thereby implying social value for futures. Also, a number of papers have evaluated the use of futures as policy tools designed to alter resource allocation (Chavas, Pope, and Kao; Kahl 1986; Kawai). It is likely that policy-related research will be prominent in the literature for some time because the U.S. Department of Agriculture currently is conducting a national pilot program aimed at encouraging more farmers to use futures and options markets.

Recent assessments of futures market pricing efficiency have considered issues ranging from factors affecting price variance (Kenyon et al.; Helms and Martell) to identifying risk levels and risk premiums (Ehrhardt, Jordan, and Walkling; Elam and Vaught; Hartzmark; Hayenga et al.; Lien; Rzepczynski; So). In particular, the existence of "normal backwardation"<sup>1</sup> and its expected effects on price relationships and risk premiums are still being debated.<sup>2</sup>

Although new models are being introduced, research on options pricing efficiency continues to center on evaluating the "Black Model"<sup>3</sup> (Jordan et al.; Koop; Wilson, Fung, and Ricks; Wolf, Castelino, and Francis). However, re-

cent studies have noted that actual premiums for options on agricultural futures contracts are not expected to always equal premiums predicted by the Black Model as thought earlier. Instead of defining the existence of discrepancies between the two premiums as evidence of market inefficiency, analysts are now trying to identify what factors cause the differences (Hauser and Neff; Wilson, Fung, and Ricks). This means that new definitions of efficiency are needed for options markets.

### *Firm-Level Issues*

Futures markets were established to have economic value for firms by facilitating forward pricing of products. Questions receiving attention deal with how to use the markets to gain the greatest benefit. It appears that empirical research has dealt with separate questions which fit together in a logical progression from hedging, to determining optimal hedge ratios, to placing hedges into a portfolio framework, to seeking decision rules to aid in marketing decision making.

Traditional hedging was the focus of most early firm-level futures market research. The central issue was "to hedge or not to hedge?" Despite Working's arguments to the contrary, it often was assumed that risk reduction was the primary goal of hedgers. This meant that many empirical analyses simply sought to determine whether futures and spot prices were sufficiently correlated to allow producers to reduce their risk exposure by forward pricing using futures. If price correlation was found regularly over a period or season, strategies were developed which most often recommended full, one-period hedging over that time span.

The next issue addressed concerned risks not eliminated by hedging. Correlation between spot and futures prices could not be perfect for numerous economic reasons.<sup>4</sup> Therefore, basis<sup>5</sup>

<sup>1</sup> Normal backwardation has been defined in different ways since Keynes first described the concept as a situation in which spot prices are higher than forward prices for a commodity. It is sometimes defined as the process where a futures price is a systematically downward biased estimate of an expected spot price over time. It has come to be accepted as a situation where, on average, futures prices rise over the life of a futures contract so that the current futures price is lower than its expected value in later periods (Lien).

<sup>2</sup> Issues debated concerning backwardation are empirical questions and, therefore, are discussed in the section on research approaches.

<sup>3</sup> The Black model of option pricing is based upon "European" options, which may be exercised only at the end of trading for the option, rather than "American" options which may be exercised at any time prior to the end of trading. Models have since been developed that are directly appropriate to American options, but these models are much more complex and produce estimates of option premiums that are very similar to those produced by the Black model. The Black model estimates option premiums based upon values of five variables: current price of the associated futures contract, the option strike price, number of days to option maturity, volatility of the associated futures contract price, and the interest rate on a relatively safe investment.

<sup>4</sup> In general, arbitrage forces spot and futures prices of storable and nonstorable products together at the time of futures contract delivery. During the life of a futures contract for a storable product, arbitrage keeps futures prices at or below a level equaling spot price plus per unit carrying costs. Nonstorable product futures prices are expected to reflect spot prices anticipated at a later date which may have different supply and demand conditions operating than those operating at present, so correlation between spot and futures prices may be low (Blank, Carter, and Schmiesing).

<sup>5</sup> Basis is the difference between spot and futures prices, or between prices of two different futures contracts. Although the price "spread" between two futures contracts is not usually referred to as basis, its behavior is quite similar to basis in some markets. This is especially true if one of the futures contracts is the "nearby."

risk remained and hedging the entire spot position (a ratio of one for hedged output to spot output) was not the lowest risk strategy. As a result, analysts began estimating "optimal" hedge ratios for particular products (Bond, Thompson, and Geldard; Kahl 1983; Karp, Peterson and Leuthold 1987; Sheales and Tomek).

Analysts studying basis risk recognized that it was more relevant to evaluate the two components which together generated basis (spot and futures prices) rather than basis itself. This led to the idea of studying hedgers' positions in spot and futures markets as a two-product portfolio (Berck; Berck and Cecchetti; Brooks and Hand; Brown; Gjerde; Peterson and Leuthold 1987). This method of evaluation was expanded to cover more than two-product portfolios. In particular, cross hedging<sup>6</sup> was assessed as a risk-reducing strategy (Blank; Bond, Thompson, and Geldard; Witt, Schroeder, and Hayenga; Wilson; Zacharias et al.).

The usual Johnson-Stein approach to portfolio modeling describes spot/futures portfolios as a means of risk reduction, so determination of the optimal hedge is the goal of such studies.<sup>7</sup> However, basis is just one source of risk affecting portfolios. For example, Grant concludes that it is impossible to derive an optimal hedge ratio when both price and quantity uncertainty are present, a conclusion which questions the entire exercise of calculating hedge ratios.

These problems lead to issues concerning how to identify and use risk in decision making. In particular, much empirical research seeks to determine whether there are useful technical trading methods (Brandt; Irwin and Brorsen; Kenyon and Cooper; Kenyon and Clay; Lukac, Brorsen, and Irwin; Peterson and Leuthold 1982; Tesar). Draper's comment on the paper by Koop notes that technical systems are common, despite claims by academics that such systems are of "no value" because they violate the concepts of market efficiency. The fact that technical systems are so widespread, especially in futures trade literature (see almost any issue of *Futures Magazine*), implies that many people believe price risk levels vary;

therefore, positive rates of potential return are occasionally available to traders who can identify and capture them.

Finally, the debate over trading systems and optimal hedging ratios raises questions concerning the relevant range of the ratio itself and the choice of which market to use when hedging: forward cash, futures, or options. Technical trading systems generate price forecasts with different "confidence levels," usually expressed informally as the probability that prices will move in the direction forecast by a system (Brandt). Logically, the hedging decision may depend on price level expectations and the degree of confidence in the forecast underlying the expected price. A short hedger confident of an impending price decline might find that a high hedge ratio using forward cash contracts will produce the most profit. Strong expectations of a favorable price increase may dictate that options be used for hedging. Futures may prove to be the best hedging vehicle only when confidence in a forecast price trend is not strong or when the forecast is for a "flat" trend in price movements. For example, in her comments concerning the paper by Tesar, Peck notes that although Working described three forms of commercial usage of futures (operational convenience, anticipatory pricing, and arbitrage), anticipatory pricing appears to be the sole commercial use of options. She notes that options are preferred when price expectations are strong, but options are not replacing futures in other uses.

In the extreme, if confidence is very high concerning expected price movements, the most profitable hedge ratio could be greater than one or less than zero. This range has been considered irrelevant to agricultural hedgers by researchers because it represents market activities that increase, rather than reduce, risks. This limitation in past research reflects the debate over what is hedging versus speculation. It assumes that hedgers are highly risk averse and use futures and options markets only to reduce risk exposure. A contrary opinion is that farmers reveal a preference for some (production) risk by choosing farming over alternative investments for their labor and capital and that it is rational for agricultural market participants to use futures and options markets as vehicles to adjust their total level of risk exposure up or down as dictated by their utility expectations. As market conditions become more favorable, a producer (for example) may

<sup>6</sup> Cross hedging involves holding spot and futures positions in two or more products which are not identical.

<sup>7</sup> Johnson and Stein applied the Markowitz two-product portfolio model to spot and futures markets. Using the full covariance model, the approach provides a method to identify the lowest risk portfolio for each level of return.

want to increase expected utility by increasing output, which would increase his total level of production risk if it could be done. If it is too late to plant additional acreage (or no additional acreage is available), futures or options transactions would enable the producer to "market" the desired amount of additional output and have an opportunity to gain higher levels of utility. In such a case, raising the hedging ratio above one reflects the same type of production decisions which lead to producing less than 100% of capacity in other cases (by leaving some acreage fallow)—the decisions reflect an assessment of expected utility based upon some confidence level in a forecast. These marketing decisions are analogous to decisions of an investor selecting the desired portfolio from those along the "borrowing" or "lending" sections of the capital market line which is tangent to the mean-variance efficient frontier.

A new debate appears to be developing over the effects of margin calls on hedgers. Many analysts have ignored margin requirements of hedgers either because they assumed hedgers would have an established line of credit with a lender to cover calls as needed, or because they assumed the interest expense on margins was zero since T-bills or some other interest-producing security could be used as collateral for margin requirements while hedges were held. For example, in a recent issue of *The Journal of Futures Markets*, Peterson and Leuthold (1987) exclude margin call effects from their analysis of cattle hedging strategies, describing them as trivial. Yet, in the same issue of the *Journal*, Kenyon and Clay find margin effects to be significant when hedging hogs due to the capital liquidity problems they can create for high-risk producers. Clearly, more firm-level analysis of this issue is needed.

### Research Approaches

Hypotheses concerning pricing efficiency and improving resource allocation through risk reduction have been the center of most empirical research addressing issues of the markets' social value. Questions involved in this type of analysis include whether the markets respond quickly (efficiently) to information and whether the response is "accurate" in that resulting price levels make resource allocations more efficient. The various hypotheses have been

tested using methods often applied to equity markets in the finance literature, as noted in the following sections. Firm-level decisions focus on profitability and, therefore, so does research regarding these decisions.

### Social Value Analyses

Efficient capital market theory provides alternative efficient market hypotheses (EMHs). For futures markets these have all led to research approaches focusing on pricing efficiency as a reflection of the level of informational efficiency in the markets (examples include: Carter; Chavas and Pope; Epps and Kukanza; Hudson, Leuthold, and Sarassoro; Murphy; Shonkwiler). The null hypothesis is expressed in three forms (Schwartz pp. 293–302):

- (a) Weak form: The information contained in the past sequence of price movements is reflected in current prices.
- (b) Semistrong form: All public information is reflected in current prices.
- (c) Strong form: All information is reflected in current prices.

Empirical tests of the weak form EMH most often have evaluated time series of spot and futures price data by using the equation

$$(1) \quad S_t = \alpha + \beta F_{t-1} + e_t,$$

or

$$(2) \quad F_t = \alpha + \beta F_{t-1} + e_t,$$

where  $S_t$  is the spot price,  $F_t$  is the price at time  $t$  of a futures contract expiring at some time  $t + i$ ,  $F_{t-1}$  is the previous period's price for the same contract,  $e_t$  is an error term at time  $t$ , and  $\alpha$  and  $\beta$  are, respectively, the intercept and regression coefficient relating the two prices. Data used have been both price levels and price changes, but in most studies published recently, price change data are used to reduce statistical problems. Since transforming the original price level data into price changes usually produces stationary series, ordinary least squares (OLS) is most often used to estimate the regression equation. The (joint) hypotheses implied in the weak-form model are tested by simply computing  $t$ -statistics for  $H_0: \alpha = 0$  and  $\beta = 1$ .

Studies by Maberly and by Elam and Dixon have criticized use of pricing efficiency tests based in equation (1), noting that results can

be misleading.<sup>8</sup> Elam and Dixon note that in earlier empirical work estimates of  $\alpha$  typically become larger and estimates of  $\beta$  become smaller as the time to maturity of a futures contract increases. They attribute these results to an inherent bias in the OLS estimates of  $\alpha$  and  $\beta$  rather than inefficient pricing. They also present Monte Carlo evidence to argue that the customary  $F$  test of the joint hypothesis  $\alpha = 0$  and  $\beta = 1$  is not valid, concluding that a new test is needed.

Different versions of the weak-form test have been evaluated through applications of other estimation techniques. For example, Canarella and Pollard tested the EMH within the framework of the theory of the rational expectations hypothesis (REH) using a vector autoregression approach. The REH states that futures market participants use all available information when making forecasts of the future spot price. The hypothesis can be written in the form of equation (1) above. However, Canarella and Pollard note that a number of statistical problems are encountered when estimating the single-equation model which make  $\beta$  inefficient. They used a modified Full Information Maximum Likelihood (FIML) procedure to estimate a two-equation system using first differenced data (necessitated by the autoregressive structure of the spot and futures price data). The two equations took the general form:

$$(3) \quad S_t = \sum_{a=1}^i (a_i S_{t-i}) + \sum_{b=1}^i (b_i F_{t-i}) + u_t,$$

$$(4) \quad F_t = \sum_{c=1}^i (c_i S_{t-i}) + \sum_{d=1}^i (d_i F_{t-i}) + v_t,$$

where the current spot price ( $S_t$ ) and futures price ( $F_t$ ) are each specified as a function of lagged values of the two time series;  $a$ ,  $b$ ,  $c$ ,  $d$  are regression coefficients; and  $u_t$  and  $v_t$  are error terms. By jointly estimating the two equations with and without cross-equation constraints, the likelihood ratio test statistic could be computed for use in hypothesis testing. Using data from 1960–82, Canarella and Pollard found that this procedure led to statistical support for the EMH for five agricultural futures markets: corn, wheat, soybeans, soybean oil, and soybean meal. They noted that other studies (such as Just and Rausser)

have produced similar results concerning implications for the effectiveness of technical trading systems' forecasting performance relative to that of futures markets.

Studies using semistrong form tests of the EMH are typified by the paper by Gross. He says that a market is defined to be efficient if there exists no profitable trading strategy. Using this definition, semistrong form tests of efficiency focus on comparing price forecasting errors of econometric models with that of futures prices. This method is an improvement over the weak-form test but still has a major shortcoming. Although the forecasting model is reestimated for every new observation (piece of information) which is added, the hypothesis test (using mean squared error usually) results are still dependent upon the analyst's choice of model. Therefore, mixed results are likely from different studies. For example, Garcia et al. find no inefficiency in live cattle; Leuthold and Hartmann are somewhat inconclusive on the efficiency of hog markets; and Gupta and Mayer decide that futures markets for coffee, cocoa, sugar, copper, and tin are efficient. Due to this shortcoming of the semistrong form test, Rausser and Carter argue that finding a model which forecasts better than futures prices is a necessary, but not sufficient, condition for inefficiency.

Empirical examples of strong-form tests of futures markets are rare due to lack of data. The test of asymmetry in market information among participants requires an analyst to identify forms of "insider trading" which produce abnormal returns to one or more groups of traders. Although trade publications occasionally have reported the differences in average returns going to professional futures traders and to nonprofessionals,<sup>9</sup> it is not clear whether this performance disparity is due to differences in information available to each group or to differences in trading skill.

Empirical tests of the "accuracy" of futures markets' response to information have sought to identify bias in the pricing process. Bias in the form of normal backwardation has been analyzed since Keynes first defined it. Al-

<sup>8</sup> See the paper by Buccola in this issue for more detail on the topic of pricing efficiency.

<sup>9</sup> Nonprofessionals usually are considered to be people whose primary source of income is something other than futures trading. The data published by the Commodity Futures Trading Commission concerning positions held by "large" and "small" traders give some indication of differences in performance of various groups of traders but offer no explanation of information flows in the markets.

though Berck and Cecchetti showed that the Keynes-Hicks hypothesis of a risk premium offered by commodity storers to attract speculators need not hold true, even in theory, empirical investigations of the issue continue to appear in the literature.

Dusak was the first to use the Capital Asset Pricing Model (CAPM) to test hypotheses related to normal backwardation (Ehrhardt, Jordan, and Walkling). The CAPM methodology compares the performance of a particular asset to the performance of the market as a whole to estimate the degree of "systematic" risk in that asset and whether a market-determined risk premium exists. Dusak found no systematic risk in grain futures. A later study by Carter, Rausser, and Schmitz (CRS) criticized Dusak's use of the Standard and Poor's 500 Index as the only measure of futures market performance. CRS used an equally weighted index incorporating futures and stock markets and found that systematic risk was present in grain futures pricing behavior. The CRS approach to developing a relevant index was criticized by Marcus and by Baxter, Conine, and Tarmarkin. Both of those studies proposed different weightings heavily favoring the stock market component in the market index and, consequently, joined Dusak in concluding that no systematic risk existed in grain futures. Finally, separate studies by So and by Elam and Vaught used a range of weightings for the market index and found low (statistically insignificant) systematic risk and zero risk premiums in crop and livestock futures markets, respectively. However, Elam and Vaught noted that significant risk would be detected if the weighting given to futures in the index was increased sufficiently.

Alternate approaches to evaluating backwardation are illustrated in the papers by Lien and by Murphy. Lien defined backwardation as rising futures prices over time and proposed that it was due to seasonality in the actions of long and short hedgers. It was implied that speculators need not be attracted. They come when profitable price changes are expected,  $E(P_{t+i}) \neq P_t$ , and seasonal changes in inventory levels will create these situations. The fact that Lien found no support for the "inventory effect" in corn or wheat futures markets implies that those markets are efficient year-round. Murphy came to a similar conclusion, finding no seasonality using spectral analysis of CAPM risk and return in crop and livestock

futures contracts. In that study, a market portfolio of stocks, bonds, and T-bonds was used, purposely ignoring agricultural assets, because the portfolio is for speculators (who are assumed to be interested only in futures trading not marketing agricultural products).

Although futures are risky in Keynes' concept of total risk, they are found to be riskless in the CAPM because their beta is low, usually not significantly different from zero, as in the studies cited. Beta is a commonly used measure of the degree of variability in returns of an asset compared to variability in returns of the market as a whole. Tests for the CAPM typically regress excess returns for the futures contract on excess returns for the market, using an equation of the form

$$(5) \quad R_{it} - R_{ft} = \alpha + \beta[E(R_{mt}) - R_{ft}] + e_{it}$$

where, at time  $t$ ,  $R_{it}$  is the return on futures contract  $i$ ,  $R_{ft}$  is the risk-free return,  $E(R_{mt})$  is the market's expected return,  $\alpha$  is expected to be zero,  $\beta$  is the estimate of beta (systematic risk), and  $e$  is the asset-specific disturbance term (unsystematic risk). In this form of the equation, a beta of zero indicates that the asset does not have any systematic risk;  $\beta > 0$  indicates the presence of systematic risk.

Recent futures literature has followed equity market analyses in noting weaknesses of the CAPM. In particular, reliance on a market index as the basis for comparison is considered to be a major shortcoming of the CAPM for futures markets. As a result, So concludes that Arbitrage Pricing Theory (APT) is more theoretically sound than the CAPM.

In one of the first applications of APT to agricultural futures, Ehrhardt, Jordan, and Walkling (EJW) find a high degree of systematic risk, yet excess returns (risk premia) are zero for corn, wheat, and soybeans. This conclusion is intuitively more reasonable than those produced by CAPM analyses which may lead more researchers to adopt this methodology.

The APT assumes that the return on an asset equals an expected return plus a linear combination of zero-mean disturbances to underlying factors, plus a zero-mean, asset-specific disturbance (EJW). The equation to be estimated takes the form:

$$(6) \quad R_{it} = F_{0t} + B_{i1}(R_{1t} - R_{ft} + D_{1t}) + \dots + B_{ik}(R_{kt} - R_{ft} + D_{kt}) + e_{it}$$

where  $R_{it}$  is return on an asset, defined as ( $P_{it}$

$-P_{i,t-1}/P_{i,t-1}$  (EJW calculated it over a two-week period);  $R_{ft}$  is the risk free rate;  $F_{0t}$  is the intercept (expected to be zero in an efficient market);  $D_{kt}$  is a zero-mean disturbance to factor  $k$ ;  $B_{ik}$  is a measure of sensitivity to the disturbance (systematic risk coefficient); and  $e_{it}$  is a zero-mean, security-specific disturbance (nonsystematic risk).

The factors ( $R_{kt} - R_{ft} + D_{kt}$ ) as well as the coefficients ( $F_{0t}$  and  $B_{ik}$ ) in an APT model are estimated from the correlation matrix of security returns by using factor analysis. Only factors which are significant for pricing the futures contracts of interest are used in the analysis. Generally, a subjective procedure judging the improvement in a Chi-squared statistic and/or the percentage of variance explained is used to decide whether factors are to be included in the equation. Despite this weakness in its procedure, the APT is considered to have greater power than does CAPM in testing normal backwardation hypotheses of systematic risk and risk premia.

In the few years since options on agricultural futures have been available, a sizable body of literature has developed concerning the pricing efficiency of those markets (examples include Catlett and Boehlje; Hauser and Andersen; Hauser and Eales; Koop; Ogden and Tucker; Tesar; Webb). The methodology used in most early work concentrated on evaluating the performance of individual markets compared to the Black-Scholes Model of option pricing. This meant modifying the weak-form tests in equations (1) and (2) and using statistics such as mean squared error in hypothesis tests. However, recent studies (Hauser and Neff is an example) have noted that discrepancies between actual premiums and Black premiums are expected to exist because American options are compared to European options on the basis of the Black model. Black's model was developed assuming the option is European, meaning that it can be exercised only at maturity. American options can be exercised at any time. Therefore, their premiums should reflect the privilege of early exercise. Wilson, Fung, and Ricks point out that this means the existence of significant discrepancies implies neither market inefficiency nor the model's inaccuracy. It simply indicates that the right to exercise an option early may have some positive value.

New approaches to defining and testing for pricing efficiency of options markets are typified by Ogden and Tucker's study of currency

futures options. They apply a methodology which tests the efficiency of an options market by determining whether arbitrage relationships are maintained in prices. They specify six arbitrage conditions applicable to American options which should not be violated in an efficient market. They point out that any such violations represent unexploited riskless arbitrage profit opportunities. Although the procedure does not yet appear in the empirical literature for agricultural options, it is likely to be applied widely as analysts reconsider the definition of efficiency for options markets.

### *Firm-Level Analyses*

Individual firms use futures as part of management strategies aimed at hedging cash positions of a single product and spreading risk through the development of a portfolio of products. Central to these management decisions is an understanding of the optimal hedge ratio. Deriving this ratio is an empirical issue—it cannot be estimated theoretically. Also, a number of versions of the optimal ratio have been specified and estimated using different methods (examples include Bond and Thompson 1985, 1986; Bond, Thompson, and Lee; Hayenga et al.; Nelson and Collins; Wilson; Witt, Schroeder, and Hayenga). The strengths and weaknesses of each estimation method are still being debated. Therefore, this section first will present some of the most widely used single-product optimal hedge ratio models before discussing multiple-product portfolios.

Two questions are being debated concerning empirical estimation of hedge ratios: What is the decision maker's objective when hedging?, and What type of data should be used? The first question arises from the debate over whether hedging is a risk-minimizing or utility-maximizing activity. The second question comes from debate over theoretical, statistical, and practical concerns about the estimation process itself. Depending on which data are used, the choice of equations to be estimated will vary. Three types of data have been used in estimating hedge ratios: price differences, percentage change, and price levels (Witt, Schroeder, and Hayenga).

Price difference models of hedge ratios vary depending upon the decision maker's goal. If the goal is to minimize the variance of returns, the hedge ratio is

$$(7) \quad \frac{-X_f}{X_c} = \frac{\sigma_{cf}}{\sigma_f^2},$$

where  $X_c$  is the quantity of cash commodity,  $X_f$  is the quantity of futures commodity,<sup>10</sup>  $\sigma_f^2$  is the variance of futures price changes, and  $\sigma_{cf}$  is the covariance of cash and futures price changes. This hedge ratio can be estimated by regressing cash price changes on futures price changes. On the other hand, if the goal is to maximize expected utility, Kahl (1983) presents the model

$$(8) \quad X_f = \frac{E(F_2 - F_1)}{\gamma \sigma_f^2} - X_c \left( \frac{\sigma_{cf}}{\sigma_f^2} \right),$$

where  $F_{1,2}$  is the futures price expected at the time a hedge is placed, or lifted, respectively, and  $\gamma$  is a risk-aversion parameter.  $X_f$  is positive (negative) assuming  $\gamma > 0$ , which will be the case for a risk-averse person.

Models using percentage change data also distinguish between the two possible goals of hedgers. The hedge ratio when minimizing variance is

$$(9) \quad \frac{-V_f}{V_c} = \frac{\sigma_{rcf}}{\sigma_f^2},$$

where  $V_i$  is the total value of the cash ( $V_c$ ) and futures positions ( $V_f$ ),  $r_i$  is the return from period 1 to period 2 on the values of the cash ( $r_c$ ) and futures ( $r_f$ ) positions, and the variances and covariances are now of returns rather than prices. This hedge ratio is the slope coefficient of a regression of cash percentage price changes on futures percentage price changes. When maximizing expected utility, the hedge ratio is

$$(10) \quad \frac{-V_f}{V_c} = \frac{\sigma_{rcf}}{\sigma_f^2} - \frac{r_f}{V_c \gamma \sigma_f^2}$$

using the same notation.

For a hedger concerned only with variance about the expected return in an anticipatory hedge (there is no current cash position), the optimal hedge ratio is

$$(11) \quad \frac{-X_f}{X_c} = \frac{\sigma_{c2f2}}{\sigma_f^2}.$$

This equation is similar in form to equation (7), but in this case the hedge ratio is the regression coefficient of cash price levels regressed on futures price levels during the period when the hedger would be closing the futures position and entering the cash market.

After considering statistical,<sup>11</sup> theoretical, and practical questions about the appropriateness of using one model over another, Witt, Schroeder, and Hayenga point out that:

In comparing the price difference models with the percentage change models, the gauge is the degree of linearity between the cash price and futures price differences. If the cash price of the commodity to be (cross) hedged responds linearly with the futures price, the price difference model would be preferred because a goal is to keep the model as simple as possible. If a definite nonlinear relationship exists between the parties, the percentage change model may be preferred. (pp. 141-42)

Theoretically, the proper hedge ratio estimation technique depends upon the objective function of the hedger and the type of hedge being considered. Witt, Schroeder, and Hayenga conclude that the best method for anticipatory and storage hedges, respectively, is a price-level regression and the price change model. If the hedger's objective is to maximize utility as opposed to minimizing the variance of returns, then none of these estimation techniques will provide the appropriate hedge ratio. In that case, factors in addition to cash and futures price variance will be significant in determining the optimal hedge ratio.

When presenting the results of optimal hedge position analysis, most empirical studies have generated a mean-variance ( $E$ - $V$ ) efficient frontier to illustrate the relationship between expected returns and risk (Chavas and Pope; Karp; Levy; Peck). The  $E$ - $V$  frontier is simply defined as the two-dimensional plot of the variance in returns (usually measured in terms of standard deviations or the coefficient of variation) for each level of expected mean returns in a single period. The relationship is often expressed as a preference function such as the one used by Chavas and Pope:

$$(12) \quad L = E(\pi) - \left( \frac{\alpha}{2} \right) V(\pi),$$

where  $L$  is the objective function,  $E$  and  $V$  denote mean and variance, respectively,  $\pi$  is profit and  $\alpha$  is a measure of risk aversion. It generally is used in the context of expected utility maximization with constant absolute risk aversion and normality of  $\pi$ .

Analysts' assumptions of (a) constant ab-

<sup>10</sup> A positive (negative) sign preceding either cash or futures quantity indicates a long (short) position.

<sup>11</sup> They note that generalized least squares procedures may be needed to produce more efficient estimates of the hedge ratio due to the influence of autocorrelation in the residuals.

solute risk aversion on the part of hedgers and (b) a single decision period covering the time a cash position may be held have limited this type of study. Clearly, the level of risk aversion is significant in its effect on hedge ratio levels, as noted in equation (12) and most other forms of the  $E-V$  function. Therefore, empirical work is needed to establish criteria for use in guiding the selection and/or definition of "optimal hedges" over time for individuals with different risk attitudes, not just the risk-averse case. These criteria obviously need to include some measure of a decision maker's level of risk aversion. This work is progressing through applications of elicitation methods (Wilson and Eidman; Halter and Mason; Tauer) but is hindered by the unresolved issue of how to measure risk (uncertainty) itself (McSweeney, Kenyon, and Kramer).

One approach to dealing with the problem of incorporating risk aversion levels into the hedging decision over time was illustrated by Karp. He defined determining optimal dynamic hedges as a linear exponential Gaussian control problem. He allowed for differing levels of risk aversion by generating probability distributions of profits, thereby enabling hedgers to select their desired distribution. This method avoids having to measure risk aversion directly; it simply allows individual decision makers to "reveal" their risk preferences as related to profits. Karp's approach to selecting optimal hedges by selecting the strategy which will produce the desired probability distribution of profits may imply that profit, not risk reduction, is the goal of hedgers (as argued by Working). However, a hedger may select a profit distribution which has a minimum probability of loss, which can be considered a risk-reduction goal.

Portfolio models have increasingly been used to estimate optimal hedge ratios when more than one asset is held at a time. Methods for evaluating strategies appropriate in this situation have centered on techniques similar to those developed by Markowitz and expanded on by Johnson and Stein in the early 1960s (Peterson and Leuthold 1987; Berck; Berck and Cecchetti; Wilson). The Johnson-Stein approach tended to support the traditional theory of hedging which held that the primary motivation for hedging was risk reduction. Defining spot and futures positions as two different assets, hedging was viewed as a two-product portfolio approach to risk reduction. Johnson-

Stein define the risk-minimizing hedge ratio as

$$(13) \quad b^* = \frac{\sigma_{sf}}{\sigma_f^2},$$

where  $\sigma_{sf}$  is the covariance of spot and futures prices and  $\sigma_f^2$  is the futures price variance. In this formula the hedge ratio,  $b^*$ , is the slope coefficient for a simple regression of spot on futures price levels. Brown reformulated this model to use variances and covariances of expected returns<sup>12</sup> rather than prices.

Applications of portfolio analysis have become much more complicated in the number of products included in the portfolio and in the estimation techniques used in determining hedge ratios. For example, Peterson and Leuthold (1987) evaluated some multiple-product (inputs and outputs) and multiple-period hedging strategies available to a cattle feedlot by applying a discrete nonlinear programming routine to the general function

$$(14) \quad \min \gamma \sum_i \sum_j X_i X_j \sigma_{ij} - \sum_i X_i R_i,$$

where  $\gamma$  is a risk aversion parameter;  $X_i$  is the percentage of the total market value of the portfolio invested in  $i$ ;  $\sigma_{ij}$  is the variance of returns on the  $i$ th investment,  $i = j$ , or covariance of returns on the  $i$ th and  $j$ th investments,  $i \neq j$ ; and  $R_i$  is the mean of returns on the  $i$ th investment.

Cross hedging is a special type of hedge which has been analyzed using traditional mean-variance methods as well as portfolio techniques. The study by Zacharias et al. typifies recent approaches to this firm-level problem. As an alternative to mean-variance analysis, they used a numerical simulation approach in combination with stochastic dominance to evaluate a variety of cross hedging strategies for a rice grower. First-, second-, and third-degree stochastic dominance criteria were used to rank alternatives produced by simulating the equation below for two representative farms:

$$(15) \quad \pi = P_s Y + (P_0^f - P_1^f) X - C(X),$$

where  $\pi$  is expected net revenue;  $P_s$  is expected spot price at harvest of the cash commodity;  $Y$  is expected output;  $P_0^f$  is the futures price used to open the cross hedge;  $P_1^f$  is the expected futures price of the commodity;  $X$  is the futures position taken; and  $C(X)$  are commission and

<sup>12</sup> Returns are calculated as in equation (6). A return is simply the percentage change in price from one period to the next.

margin costs as a function of the futures position taken.

Zacharias et al. compare the stochastic dominance results to results from a traditional regression approach to optimal hedge determination. They conclude that the regression analysis may or may not be a risk-efficient choice depending upon the decision criteria employed.

In summary, it appears that some key questions remain concerning hedging and analysis of hedges. First, Brown found that the traditional portfolio model is not empirically supported in some agricultural product markets. The implication was that risk reduction is not the primary motivation for hedging or cross hedging. Therefore, the relative weights of profit seeking and risk reduction in firm-level decision making must be determined in some yet to be established manner and applied in empirical studies to improve the validity of results.

Finally, the question of whether any of the "optimal hedge ratio" measures can be truly considered "optimal" is being debated. Bond, Thompson, and Lee evaluated a simple hedging rule and concluded that due to the empirical estimation processes required, the rule is "indicative" not "optimal."<sup>13</sup> Similar estimation problems are encountered with virtually all hedge ratio measures, implying that at least a change in the label (dropping "optimal") is in order.

Turning to options, empirical studies of hedging strategies using these relatively new marketing tools are still few in number (examples include Hauser and Andersen; Hauser and Eales; Hauser and Neff; Wolf, Castellino, and Francis). Theoretical and empirical issues concerning hedging with options are presented by Hauser and Andersen. They also contribute to the evolution of empirical methods of analysis by applying alternative definitions of return and risk. By recognizing the unique feature of options (compared to futures contracts) of being able to select price "ceilings or floors" for hedges by selecting a particular strike price,

Hauser and Andersen argue that evaluating options' hedging performance must center around those target prices. They do so by using Holthausen's target deviation model:

$$(16) \quad RK = \int_{-\infty}^l (l - a)^{\alpha} G'(a) da,$$

$$(17) \quad RT = \int_l^{\infty} (a - l)^{\beta} G'(a) da,$$

where  $RK$  is risk,  $RT$  is return,  $l$  is the target,  $\alpha$  and  $\beta$  are risk preference parameters, and  $G'(a)$  is a probability density function for outcome  $a$ . They conclude that options are especially useful as a marketing tool for agricultural producers with price expectations different from those of the market.

### Summary of Empirical Findings

In this section the question, "What have we learned about these markets?" is addressed by reviewing some empirical questions asked continually by analysts. The "answers" to these questions continue to change; therefore, the goal here is to present only a progress report.

Social issues often center around the question, "Are the markets 'working'?" The first issue involved with this question has to do with whether the markets make efficient use of information.

The results discussed in this paper are mixed concerning futures market efficiency. The presence of technical trading systems implies that futures markets are inefficient. Yet, these trading systems focus mostly on very short-term periods only. Therefore, it may be that futures markets are "inefficient" only over certain, short periods. Several studies have shown that the markets are efficient in the long term (Garcia, Hudson, and Waller); however, trading systems and hypotheses are tested in the short term leading to conclusions of inefficiency. Could it be that the testing time frame is inappropriate? Information-efficient markets may have detectable trends for short periods at the end of trading for particular contracts due to "real-world" arbitrage limitations which are known and used in trading systems.

The definition of "efficient" may need to be changed when considering futures markets. Schmiesing, Blank, and Gunn suggest that a more appropriate criterion might be the efficiency of the arbitrage process performed by

<sup>13</sup> They note that the simple price difference regression model may sometimes be inappropriate leading to biased estimates of the optimal hedge ratio. They also find that "simultaneous equation bias may be present in regressions of spot on futures prices, implying biased and inconsistent estimates of the optimal hedging strategy." Applying instrumental variable techniques in this case alters the slope coefficient such that it no longer is exactly the optimal hedge ratio.

a market. (Ogden and Tucker use this approach in judging options market performance.) Are futures markets "inefficient" because they reflect expectations and not real (local) supply and demand factors for most of a futures contract's life? Or is the problem that futures become "cash" market prices for contract delivery points at the end of each contract, and this is when prices become more "predictable" (due to arbitrage limitations), which reflects "inefficiency" in current terminology? Using the current definition, Garcia et al. conclude that efficiency probably never can be proven; we only can fail to disprove it.

The second general question concerning the social value of futures markets is "Where is the money going?" Hartzmark studied income redistribution effects of futures trading and found that commercial (hedging) traders are most profitable while noncommercial (speculative) traders earn negative or zero profits. He noted that because speculators are not receiving rewards for the risks they absorb, the theory of normal backwardation and its extensions can be rejected.

The most significant firm level question facing futures market analysts is, "Why do people trade?" Intuitively it is obvious that people will continue to use the markets only as long as their business and/or personal goals are being met. Since the growing volume of trade indicates continued success of the markets, it is clear that traders' goals are being met. Surprisingly, analysts still do not agree over what those goals are: risk reduction, profit seeking, or a combination of the two (utility maximization). However, evidence seems to be favoring the position put forward by Working decades ago, that risk-adjusted profits (utility) are the primary goal of traders and, therefore, provide the incentive for market actions taken. As noted earlier, Brown found that the traditional portfolio model is not empirically supported in some agricultural product markets, implying that risk reduction is not the primary motivation for hedging or cross hedging. Therefore, questions of hedger motivations and goals urgently need resolution before detailed analyses of strategies can be undertaken.

A general question facing futures and options market analysts is, "How do we keep score?" The mixed results of the studies cited here makes one wonder whether the methods of analysis currently being used are appropriate/relevant to the issues needing attention.

Specifically, concerns have been raised in a number of studies about the data used in empirical work and about the appropriate definitions of "risk" and "return." Data in the form of price levels, absolute and percentage price change, and returns have all been described as the "best" input for the statistical model of preference. Also, alternative definitions of risk and return have been proposed. In particular, the debate over whether CAPM or APT pricing models are more appropriate for futures indicates that several theoretical and empirical issues need additional analysis.

### Future Research Directions

When considering the unresolved issues noted above, two other questions come to mind: "Are academic and industry analysts going in the same direction?" and, "Who is leading (following)?" To answer these questions, trade publications were reviewed as well as the scholarly literature cited above. Below is one opinion of where the two groups are going and how they might collaborate in the future.

It does not appear that industry and academic researchers are going in the same direction. Analysts in industry focus their research efforts almost entirely on short-term price analysis which leads to price forecasting models. On the other hand, academic analysts consider technical analysis and its resulting forecasting models to be a virtual waste of time because those models contradict the efficient market hypothesis (as it is now defined). Academic analyses of trading systems have had relatively long-term perspectives—much longer than that of industry models.

The question concerning which group is leading the way in futures and options market research appears to lead to a split decision. The markets were developed long ago by industry to fill its needs; academic attention came after the markets were well established. Industry-produced research clearly was the leader concerning firm-level decisions before the 1980s; until *The Journal of Futures Markets* appeared in 1981, the volume of scholarly research on futures was far outweighed by industry research output. It appears that industry is still leading academia in identifying firm-level problems and possible solutions. Yet, it makes sense that business issues are first found in business publications and then expanded on

later in academic journals. One significant exception to industry's lead was the development of the Black-Scholes model by academics.

Concerning social, macrolevel policy decisions affecting these markets, academic analysis has been in the lead, as would be expected. Individual firms and analysts do not often spend time on economy-wide issues. However, the shortcoming of academic research is that too often it ignores the relevant period of real business decision making (very short run) and, therefore, is of little direct value to traders (hedgers or speculators).

This leads to the conclusion that academic researchers can continue to fill the need for macroanalysis of the markets but should also focus some attention on the short-run decision-making processes used by hedgers and speculators. It may be that academic analysts have resources better suited to explaining why industry's technical trading systems work for periods of time. Academic researchers need to pay more attention to the "real world" decision calculus of firms, using the same time horizon as used by agribusiness managers, or they may miss significant structural attributes of the price-setting process and ultimately reach poor conclusions concerning policy directions. Industry analysts can assist in this process through their knowledge of, and access to, empirical data regarding actual decision processes of decision makers. Therefore, increased contact between academic and industry analysts in forums such as those sponsored by the futures exchanges can serve as an "arbitrage" process to keep research progressing efficiently in useful directions.

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