WESTERN AGRICULTURAL ECONOMICS ASSOCIATION

PAPERS OF THE

1989 ANNUAL MEETING

WESTERN AGRICULTURAL ECONOMICS ASSOCIATION

COEUR D'ALENE, IDAHO

JULY 9-12, 1989

SESSION 8

DETERMINING FUTURES 'HEDGING RESERVE' CAPITAL REQUIREMENTS

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ABSTRACT

A model for determining funding requirements for uninterrupted operation as a hedger is presented. Hedging marking-to-market requirements are reduced as cash market liquidity increases and basis risk is reduced. Yet, trading limitations hedgers face raise funding requirements. Therefore, some hedgers' funding requirements are higher than those of speculators in the same market.

A debate appears to be developing over the effects of margin calls on hedgers. Many analysts have ignored marking-to-market[1] requirements of hedgers either because they assumed hedgers would have an established line of credit with a lender to cover margin 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, 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 of Futures Markets, Kenyon and Clay (1987) find margin effects to be significant when hedging hogs due to the capital liquidity problems they can create for high-risk producers. Also, in financial markets, Chang and Loo (1987) find that the marking-to-market feature of futures trading alters some price relationships.

The central question coming out of the debate over margin effects is how large a "hedging reserve" of capital needs to be to meet a hedger's desired probability level of covering all marking-to-market requirements. Analysts who have ignored margin requirements of hedgers implicitly assume there is no need to consider the size of reserves (sometimes called "variation margin"[2]) because there are no impediments to capital availability or no significant costs associated with using capital for futures hedging. This is equivalent to assuming there is a frictionless

1. "Marking-to-market" or "daily resettlement" is the process used by futures exchanges to adjust account balances at the end of each trading day to insure market liquidity. All losses incurred must be met by a cash payment, even if the position remains open. Any profits accrued to futures positions may be used to cover losses, and surplus profits can be withdrawn in cash if desired.

2. "Hedging reserves" or "variation margin" is the capital required to compensate for reductions in a hedger's equity in a futures position. This is the amount which must be marked-to-market.

market for hedging capital. However, Schmiesing et al. (1985) show that access to funds and interest rates paid vary between individual firms. Therefore, it is expected that transactions costs associated with reserves will vary also. This means that costs can be significant for some firms, as argued by Kenyon and Clay (1987), but Peterson and Leuthold (1987) disagree. The first step in clarifying this debate is to determine the size of hedging reserve requirements so that estimates of associated transaction costs can be measured.

This article addresses the issues related to determination of the threshold level of funding required for uninterrupted operation as a futures hedger and presents a simple model for use in empirical assessments of this question. To begin, the model will be limited to only futures markets in the very short term. Then the model will be expanded to cover long-term hedging with futures, and the effects of cash markets and product liquidity will be outlined.

SHORT-TERM REQUIREMENTS

Determining the threshold level of necessary hedging reserves is an empirical process; there is no general theory to guide the effort (Hill et al. 1983). Each hedger may require a different amount depending on which futures markets are being used, the size of possible losses and the probability of any hedge position losing money. Obviously, the larger the hedging reserve, the more losses which can be marked-to-market against it, but for any reserve there is some probability that losses will deplete it of sufficient funds required to continue hedging (Kolb et al. 1985). Therefore, when developing futures strategies, a hedger needs to be aware of the relationship between that probability level and the amount of reserve capital available.

First, the minimum amount of hedging reserve capital needed to operate in the very short term must be calculated ignoring cash market effects. This amount is defined here as the capital needed to withstand a streak of trading days during which the futures side of a hedge is unprofitable. In other words, a hedger needs to decide how many losing days must be funded until the futures price trend reverses. Also, the average amount which will be marked-to-market on each losing day must be determined. Combining these gives

$$H_s = N_s(L) + M \tag{1}$$

where H_s is the hedging reserve capital which must be marked-to-market during a short-term losing streak, N_s is the number of days in the losing streak, L is the average amount lost on each unprofitable day, and M is the maintenance margin[3] per contract.

3. Maintenance margin is the minimum amount of capital which must be on deposit with a futures exchange to keep a futures position open. The minimum level per futures contract is set by exchanges, but brokers may require higher amounts.

The value of L is calculated using historical data for the relevant futures market. An approach similar to Holthausen's (1981) target-deviation specification can be used to define profits and losses. For any market:

$$\pi = \int_{0}^{\infty} (K-X)F'(K)dK \tag{2}$$

$$D = \int_{-\infty}^{0} (X-K)F'(K)dK \tag{3}$$

where π is the total value of all profitable days, X is the previous day's closing equity, D is the total loss from all unprofitable days, and F'(K) is a probability density function for outcome K. The value of K is defined as the change in a hedger's equity in a futures position. A profit is any outcome in which equity is increased during the day (meaning that the contract price moved in the required direction). Total losses are defined as the total absolute value of all unprofitable days (those in which futures equity is reduced by futures price changes).

The amount lost per unprofitable day, L, is an average calculated from empirical data:

$$L = \frac{D}{N_L} \tag{4}$$

using D as defined in equation 3 divided by the total number of days during which losses occurred, N_L.

The value used for N_s in equation 1 is selected by the hedger so as to reflect the desired probability level of meeting all margin calls. The probability of N_s consecutive losing days is calculated as $(\alpha_L)^{Ns}$, where α_L is an empirical estimate of the probability of a position losing money on a particular day in a specific futures market.

This paper's emphasis on using estimates of probabilities derived empirically from the relevant data contrasts with approaches of earlier studies. For example, Kolb et al. (1985) assume a Wiener process with zero drift is an appropriate (normal) distribution for use in analyzing futures prices and the "risk of ruin". However, Helms and Martell (1985) reject the normality assumption concerning the distribution of futures price changes. They noted that the underlying generating process did not appear to be stationary, possibly being a subordinated stochastic or compound process. Therefore, it is argued here that empirical evaluation of price change distributions should be part of the calculations involved in determining hedging reserves for particular markets; such evaluations should not be eliminated by assuming a standard distribution applies to all markets.

An example of how to calculate the value of equation 1 follows. A hedger wishing to be 95% confident of having sufficient margin to cover a losing streak in a market with a 50% probability of taking an average loss of $100 on any day finds: $(.5)^{Ns} < .05$ when $N_s > 4$; since N_s must be an integer, the hedger selects $N_s = 5$ and finds $H_s = \$500 + M$. This means that in addition to maintenance margin requirements, a minimum hedging reserve of $500 is needed in this hedging account.

LONG-RUN REQUIREMENTS

For a hedger to operate without interruption in the long-run (still ignoring cash market effects), two necessary conditions must be met. First, the hedger must at least break-even, on average, in all futures trading activities. Second, sufficient hedging reserve capital must be available to cover all daily fluctuations caused by marking-to-market losses and still be able to keep a futures hedge position open.

The first condition indicates that futures hedging must sustain itself in the long-run; new injections of hedging reserve capital are not considered because debt limits may prevent an individual hedger from borrowing additional funds. This requires that over time $|D| = \pi$, where $|D|$ is the absolute value of all losses. Since the probabilities of making a profit are different than the probabilities of suffering a loss on any particular day, the average amount of profit or loss will differ also. The break-even relationship between these variables is

$$\left(\frac{\alpha_L}{1-\alpha_L}\right)|L| = P_f \tag{5}$$

where P_f is the average daily futures profit calculated by dividing π from equation 2 by the number of profitable days. The historical probabilities, losses and profits can be calculated after a hedging plan is specified. If the hypothetical profit resulting from using the proposed hedging plan with historical data exceeds the break-even profit level calculated from equation 5, the first condition is likely to be met. If the break-even profit is not exceeded, the proposed hedging plan must be adjusted until the condition is met. If no plan can be found to fulfill this condition, futures hedging will be a continuous cash drain, possibly prohibiting some individuals from operating in the futures market.

The second necessary condition requires that a hedging account be funded adequately relative to the market's variance over time, always having at least enough capital to maintain an open position, M_m. This can be specified as

$$H_L \geq |D| - \pi + M \tag{6}$$

where H_L is the reserve capital required for long-term operation, and other variables are as defined earlier. The maximum value of H_L would occur if a hedger suffered a losing streak lasting the entire period a hedge was held: no futures profits were generated on any day. The total number of days a hedge is normally held, *T*, depends on a hedger's strategy, based on necessary cash market activities. To calculate the long-run loss potential of a hedging strategy in a particular futures market (where N_L=T and π=0), expected value concepts can be applied. Total expected losses are calculated from

$$E(D) = \sum_{1}^{T} [(\alpha_L)^T \cdot T(L)] \tag{7}$$

where *E* is the expectations operator. From the empirical results, the limit of equation 7 is substituted into equation 6 and if

$$H_L \geq \lim_{T \to \infty} E(D) + M \tag{8}$$

trading can commence, if not, a new hedging plan is needed or additional reserve capital must be added to raise H_L sufficiently. One restriction on the minimum value of H_L, dictated by logic, is that $H_L \geq H_s$.

The second condition is the most binding of the two. Whereas condition two must be met at all times for futures hedging to continue, condition one must be met on average only, if some profits have been accumulated. Temporary failures in meeting the first condition can be funded out of profits or H_L.

Extending the earlier example, in a market with a 50% probability of taking an average loss of $100 on any day, the limit of equation 7 is $200. Therefore, the minimum size of H_L is the greater of H_s ($500 + M in the first example) or *M* plus the limit of expected value of total losses as the number of days a hedge is held goes to infinity ($200 + M in this case).

MULTIPLE-MARKET AND LIQUIDITY EFFECTS

Thus far a hedger's cash market position and its effects on reserve requirements have been ignored. As discussed below, these effects can be quite significant. For example, contrary to common belief, required hedging reserve levels can be higher than those of speculators due to cash market liquidity effects combined with futures trading limitations faced by hedgers only.

Generalizing the single futures market model presented earlier to a model of hedging reserve requirements considering futures and cash markets for one or more products gives:

$$H_s^* = M^* + \left[\sum_{f=1}^{i} N_{sf} L_f\right] - \left[\sum_{f=c=1}^{i} \Gamma_c r_{cf} |N_{sf} L_f|\right], \text{ and} \tag{9}$$

$$H_L^* \geq M^* + \sum_{f=1}^{i}\left(|D_f| - \pi_f\right) - \left[\sum_{f=1}^{i}\Gamma_c(\pi_c - |D_c|)\right] \tag{10}$$

where H_s^* is the reserve capital which must be marked-to-market during a short-term losing streak in each of *i* futures markets, H_L^* is the long-term hedging capital required to operate in futures (f) and cash (c) markets for *i* different products, M^* is the maximum of the sum of maintenance margins for all futures positions held open simultaneously at any point during the time period under consideration, Γ_c is a short-term liquidity factor ($0 \leq \Gamma \leq 1$) for each cash market, and r_{cf} is the correlation coefficient describing the relationship between price changes in the relevant cash and futures markets.

This specification of the model appears to contradict the risk-reducing properties of diversification. According to portfolio theory, diversifying into multiple markets reduces risk and return levels (Markowitz 1959). This implies that multiple-market futures hedging may require relatively smaller amounts of risk capital per market than does futures speculation because hedging can be viewed as a two-product (market) portfolio (Johnson 1959-60). It is commonly assumed that hedgers need less reserve capital than speculators (Hill et al. 1983) because profits from a hedger's cash position can offset futures losses. Such assumptions appear to be supported by studies of futures trading like that by Hartzmark (1987), who found that hedgers are the most profitable group of traders while speculators earn negative or zero profits. Unfortunately, the nature of futures hedging makes this assumption wrong if the spot commodity cannot be sold to raise the capital needed to meet futures mark-to-market requirements each day a loss occurs, as described below.

The size of a sufficient hedging reserve is inversely related to the degree of liquidity of the cash product. Cash product liquidity, Γ in equations 9 and 10, is the most significant impediment to capital availability for hedgers.

Beginning with the case of perfect cash product liquidity (Γ=1), there are still structural effects of futures trading which complicate hedging. If the product being hedged can be sold immediately in the cash market, the common assumption of reserve hedging levels being reduced is accurate. In a frictionless cash market for a perfectly liquid product, a hedge works much like a futures spread; profits from one position can be instantly applied against any losses on the other position. However, in the real world there are structural differences in these two types of two-product portfolios which cause hedging margins to be higher than spread margins. Principally, the differences are due to time delays and costs of marking-to-market transactions involving cash positions, both of which are zero for futures spreads.

Another major difference between a futures spread and a hedge is that futures positions do not have to be closed to capture profits for use in marking-to-market, cash positions do. Liquidating portions of a cash position to meet futures margin calls raises the hedge ratio and might lead to unintentional speculation (if the hedge ratio becomes greater than 1.0). To maintain an optimal hedge ratio, futures positions need to be reduced proportionately with cash positions. This creates two problems for a hedger. First, the fixed size of futures contracts may inhibit a hedger's ability to keep the ratio exactly at the desired level. Second, a hedger may not want to reduce a cash product inventory before the end of the planned hedge period because the entire volume is needed to meet cash market commitments at that later date. In such a case, reducing the long cash position makes the hedger short (and speculating) in the cash market by the amount liquidated.

For products which are perfectly illiquid ($\Gamma=0$), hedging is equivalent to speculating in the futures market, in terms of funding arrangements, and requires as much or more reserve capital. This is the case for "anticipatory hedges". If a hedger's trading plan requires that futures positions be held whenever holding cash positions (a "traditional" hedge), that hedger may require <u>more</u> cash in the short term than does a speculator in the same futures market because a speculator will use stop-loss orders to reduce margin calls, but a hedger cannot do the same without becoming a "selective hedger (speculator)". Also, a hedger cannot mark-to-market cash market profits for an illiquid product. This situation is very risky for hedgers who have limited capital available due to debt ceilings placed on them by lenders; individuals may have to drop hedges due to shortfalls in hedging reserve, forcing them to "speculate" on their unhedged cash position.

If a cash market is liquid to some degree, the next factor influencing whether profits from that market can be used to reduce short-term hedging reserve levels is the correlation between cash and futures price changes during the period a hedge is held (r_{cf} in equation 9). Correlation between product returns is the key to diversification in portfolio theory. Portfolio risk is reduced most by including a product which has returns perfectly correlated with the portfolio's returns. If products are positively correlated, a trader can go long in one and short the other, which is done in hedging. As long as both products are held it is expected that profits would accrue to one and losses to the other, no matter which direction prices moved. Therefore, total variance in returns would be reduced significantly, requiring less margin money. However, as the level of correlation goes down (as it would for cross hedges, for example), higher reserves are needed because cash market profits would not be expected to equal futures market losses. In other words, basis risk raises hedging reserve requirements.

In summary, it is expected that hedging illiquid products in multiple markets is nearly equivalent in its capital requirements to speculating in the same futures markets. As noted above, hedging reserve requirements are reduced as the degree of cash market liquidity increases and basis risk is reduced. On the other hand, limitations hedgers face in using stop-loss orders raise reserve requirements. When these limitations are faced by a hedger of an illiquid product, that hedger's reserve requirements are higher than those of a speculator in the same futures market. Also, the restriction that $H_L^* \geq H_s^*$ is significant because short-term hedging reserve requirements will be relatively more binding; diversification is expected to lower the probability that all futures markets traded will have a zero π in equation 10.

However, the short-run threshold for reserves is still $N_{sf}(L)$ at the desired level of α_L due to very short-term variance and futures marking-to-market effects.

The model presented here is applicable to any type of hedge: single-product, multiple-product or single portfolio. Just like hedging a single product, multiple-product hedging generates results with some probability density function which can be described using equations 2 and 3. The same is true if a hedger chooses to take open positions in multiple cash and futures markets simultaneously, making the entire account one large portfolio trade with a single result over a long time period.

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