PRELIMINARY DRAFT



# An Econometric Model of Hedging, Speculation and Volume in Commodity Futures

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## Introduction

Futures markets exist to meet the needs of commercial trade having forward commodity dealings. The dynamics of commodity markets lead to continual changes in forward pricing needs as well as price risk. Market structures change and markets often deviate from the competitive model. Much of the variability in the use of futures markets can be traced not only to the basic characteristics of each commodity but also to many of the structural related characteristics of the markets. In the following analysis, an econometric model incorporating many of these characteristics is developed to partially explain changes in hedging, speculation and volume activity.

## Futures Trading Theory

Hedging (H) and speculative (S) positions are established because of the benefits realized from holding futures contracts. Similarly, the cost of trading futures relates to those positions as well as to the total volume (V) of trading taking place. The net benefits from futures commitments relate to the futures trading activities variables, i.e., N = N(H, S, V). Optimally, the level of each activity increases to the point where $N_H = H_S = N_V = 0$ and the solution to these first order conditions suggest that H = H(S, V), S = S(H, V), and V = V(H, S). Futures trading activities differ across commodities and time thus suggesting that the net benefits are also predicated on the economic environment in which trading takes place.

Define X as a matrix of external variables influencing the benefits accruing through each activity, then $X_H$, $X_S$, and $X_V$ includes those variables that influence hedging, speculation, and volume, respectively, i.e., $H = H(S, V, X_H)$, $S = S(H, V, X_S)$, and $V = V(H, S, X_V)$. Inclusion of $X_i$ in each activity equation assumes that the exogenous effects were in the initial net benefit function.

Exogenous Effects

Futures trading differs across commodities in part as a result of the unique aspects of each commodity market. Since trading activities are measured across markets, cross sectional effects on the activity equations can be expected. Even with the cross sectional differences, there are a number of variables that should influence the level of trading irrespective of the commodity market. A list of variables included in the activity equations are reported in table 1.

Historically, the existence of a highly competitive industry has been setforth as a prerequisite for a successful futures market. Competition is often measured by industry concentration (CN) and as concentration increases trading is expected to decline. An argument can also be made that some concentration may be indicative of firms being of sufficient size to effectively use the market and, hence, a positive relationship between concentration and hedging could be expected in the lower ranges of concentration. Ultimately, as concentration increases to the point that prices can be influenced by a few firms, the level of commercial use of the market should decline.

The level of hedging should be related to the potential for using the market as will be discussed in the next section. Also, increases in the number of potential traders should increase the level of hedging activity.

Table 1.--Exogenous effects on futures trading.

| Activity Equation | Variable Description[a] | Theoretical Effect |
|---|---|---|
| Hedging (H) | Industry concentration (CN) | (±) |
| | Firm numbers (FN) | (+) |
| | Price risk (CV) | (+) |
| | Futures performance (RR) | (+) |
| | Government support (LN) | (-) |
| | Market maturity (AG) | (+) |
| | Product perishability (PE) | (?) |
| Speculation (S) | Price risk (CV) | (+) |
| | Opportunity cost (IR) | (-) |
| | Spreading opportunities (SV) | (+) |
| | Product perishability (PE) | (?) |
| | Market maturity (AG) | (+) |
| Volume (V) | Product perishability (PE) | (?) |
| | Number of exchange pits (NP) | (+) |
| | Spreading opportunities (SV) | (+) |
| | Exchange ranking (ER) | (+) |
| | Time adjustment (TT) | (+) |

[a]Space limits a detailed explanation of each variable. However, variable descriptions are available upon request to the authors.

Total firm numbers (FN) can be used as one measure of this potential and a positive relationship between firms and total hedging should exist.

The degree of price risk (CV) differs with each commodity and as such forward pricing needs vary across markets. Increases in cash price risk should lead to greater commercial use of futures contracts. Similarly, high levels of price risk suggest the potential for windfall speculative gains. Speculative activities would be expected to rise with those markets having a greater potential payoff. While price risk indicates the need for trading, poor performance in the futures market relative to the cash price would deter hedging, i.e., basis risk reduces hedging use. Using the correlation coefficient (RR) between the cash and futures market as a measure of performance, then a positive relationship with hedging should be observed. The performance variable would not be in the speculative equation since basis has no direct effect on speculative returns.

Futures markets do not exist in markets where prices are completely regulated. In concept, many agricultural markets have some elements of price regulation via price supports and related programs. As price supports (LN) increase, the need for forward pricing is likely to decline and hedging activities would be reduced.

The cross section of futures contracts includes markets that have existed for a number of years as well as relatively new markets. Conceptually, there exist a maturation period (AG) in which commercial use of the market is developing. Both hedging and speculative activities would be expected to rise as the markets mature. In addition to maturity, the actual levels of trading may also be influenced by the general characteristics of the product, e.g., is the product perishable or non-perishable (PE). Storability has long been thought to be a prerequisite for futures trading, yet the introduction of futures in semi-storables such as livestock raises questions as to the validity of the initial storability argument. Inclusion of a storability variable in the activity equations can be used to address this issue.

Five additional exogenous variables are introduced into the analysis and are briefly identified below. Rising interest rates (IR) raise the opportunity cost for speculative capital channeled into futures markets and speculation should decline with the higher rates. Futures spreading opportunities (SV) should influence speculative activity. Spreading potentials either increase total speculation or it could spread existing speculation over more markets. While the direction of effect can not be stated, there is no question that spreading opportunities influence both speculation and the volume of trading. The number of pits (NP) and exchange ranking (ER) are expected to account for part of the volume differences across the markets. Both of these should reflect larger volume activity. Information on futures markets has increased over time and the markets are generally more accessible to potential users. The growth in volume of trading for fixed levels of hedging and speculation is likely to have increased over time. Hence, a trend variable (TT) is included in the volume equation to capture this effect.

Endogenous Effects

The first order conditions show each activity to be related to the others, hence, the activity equations represents a simultaneous system. The parameters for speculation and volume in the hedging equation show the importance of liquidity in the market place if commercial use of the market is to succeed. The relationships among the endogenous variables in each equation can be used to show the impact of too little hedging and/or speculation as well as establishing some indication of the optimal ratio of speculation to hedging.

Each activity variable is defined in contract units corresponding to each commodity market. Since the empirical analysis is over cross sections the units of each endogenous variable must be comparable. A study by Telser of total futures trading activity addressed the scale problem by expressing all contracts in terms of dollar value [Telser]. This procedure while valid does interject additional trading variability due to substantial price differences across commodities. An alternative would be to define the user size of each market (TS) measured in contract equivalence and then express each activity relative to the market potential, i.e., $\tilde{H} = H/TS$, $\tilde{S} = S/TS$, and $\tilde{V} = V/TS$. Clearly, $0 < \tilde{H} < 1.0$ and $\tilde{S}$ and $\tilde{V}$ would generally be less than one depending on the precise period of measurement of each variable.[1]

## Empirical Futures Model

The activity equations are simultaneous and are measured over both cross sections and time; hence, estimation procedures must deal with pooling cross sectional and time series data within a simultaneous system. The problem is further complicated in that the number of observations per cross section are not constant. Time does not permit a complete development of the explicit functional form, however, the final model was shown to be similar to the logistic model. Given this functional form, the activity equations are shown in equations (1a, b, c). Each variable carries the ith cross sectional and t time period subscripts but the subscripts have been dropped for editorial convenience and equation 1 represents the linear form of the logistic equation. The residual in each equation is assumed to have

$$\text{(1a)} \quad H^* = \gamma_{12}S^* + \gamma_{13}V^* + \beta_{10} + \beta_{11}CN + \beta_{12}CN^2 + \beta_{13}FN + \beta_{14}CV + \beta_{15}CV^2 + \beta_{16}RR + \beta_{17}LN + \beta_{18}AG + \beta_{19}PE + u_1$$

$$\text{(1b)} \quad S^* = \gamma_{21}H^* + \gamma_{23}V^* + \beta_{20} + \beta_{24}CV + \beta_{25}CV^2 + \beta_{28}AG + \beta_{29}PE + \beta_{2,10}IR + \beta_{2,11}SV + u_2$$

$$\text{(1c)} \quad V^* = \gamma_{31}H^* + \gamma_{32}S^* + \beta_{30} + \beta_{39}PE + \beta_{3,11}SV + \beta_{3,12}NP + \beta_{3,13}ER + \beta_{3,14}TT + u_3$$

and $H^* = \log(1/\tilde{H}-1)$, $S^* = \log(1/\tilde{S}-1)$, $V^* = \log(1/\tilde{V}-1)$.

a cross sectional effect where $u_{jit} = v_{ji} + \varepsilon_{ijt}$. Using variance components pooling procedures, the variance of each equation (j) is defined as $\sigma_j^2 = \sigma_{vj}^2 + \sigma_{\varepsilon j}^2$ and $\rho_j = \sigma_{vj}^2/\sigma_j^2$. A solution to the pooling problem follows by estimating that portion of the overall variance due to the cross section ($\rho_j$) and then making the appropriate transformations on the covariance matrix [Ward and Davis, p. 395]. Since the system is simultaneous, reduce form estimates of H*, S*, and V* were calculated. Estimates of each activity were substituted back into equation (1) and the $\rho_j$ values were calculated by maximization of the concentrated likelihood for each equation. After correcting for $\rho_j$, the equations were re-estimated using seemingly unrelated regression since the residuals were expected to be related across the three activity equations [Parks].

The third stage estimates are reported in table 2 along with the t statistics. The signs for nearly all parameters were as expected and statistically were acceptable. The pooling ratio for hedging was largest (i.e., $\rho_1$=.7), thus indicating that the most cross sectional difference occurs with the commercial use of the market. Speculative variation would be expected to be less related to specific markets and the lower value of $\rho_2$ (i.e., $\rho_2$=.3) confirms this hypothesis. The weighted $R^2$ for the system equals .61, indicating a reasonable level of explanatory power of the system.

Table 2.--Third stage estimates of futures trading response functions (see equation 1).

| Variables | Activity Equations | | |
|---|---|---|---|
| | Hedging | Speculation | Volume |
| Hedging | | -.12467 (-.7405)[a] | .63549 (5.4016) |
| Speculation | .52924 (2.8188) | | .01598 (.1068) |
| Volume | 1.15006 (4.9248) | 1.05694 (4.6166) | |
| Intercept | -3.33861(-1.4874) | -5.34745(-3.4715) | 4.48053 (4.3128) |
| Concentration | - .05517(-1.0634) | | |
| Concentration Squared | .00125 (1.8980) | | |
| Firm Numbers | - .00002(-1.8120) | | |
| Risk Ratio | .16372 (.4584) | | |
| Price Risk | .15867 (5.4478) | .10507 (4.8498) | |
| Price Risk Squared | - .00282(-4.9745) | -.00199(-4.5791) | |
| Government Price Support | .35389 (1.2020) | | |
| Perishability | - .25286 (-.2600) | .23679 (.5615) | .73004 (1.2652) |
| Maturation | - .02967(-3.9250) | -.00130 (-.3657) | |
| Interest Rate | | .10809 (3.2558) | |
| Spreading | | .02436 (2.3436) | -.02341(-2.1930) |
| Number Pits | | | .00124 (.1051) |
| Exchange Ranking | | | .13811 (1.8365) |
| Time Adjustment | | | -.04943(-3.5172) |
| Pooling Coefficient | .7 | .3 | .4 |
| Number of Observations | 244 | 244 | 244 |
| Number Cross Sections | 16 | 16 | 16 |
| Weight $R^2$ | | .6163 | |
| MSE | | .9364 | |
| Total d.f. | | 703 | |

[a]t statistics in parentheses.

## Futures Response Surfaces

The empirical results in table 2 provide a number of new insights for quantitatively understanding futures trading activity. Some of the more important response surfaces are shown in figure 1. For each case discussed below, the response function is calculated over values of a particular variable under the conditions that the combination of all other variables yield either a relative high or low initial value of the activity variable being considered.

The impact of some level of industry concentration on futures trading is clearly evident in figure 1a. Using low concentration as the competitive norm the model shows an increase in hedging with moderate increases in concentration, thus the argument that some size advantages among firms is necessary to effectively use the market is supported. However, as concentration continues to increase, the level of commercial use of the market declines rapidly once concentration exceeds approximately 20 percent. This general relationship provides new evidence showing the impact of moving away from the competitive model. The effect is eventually negative, but structures other than highly competitive can effectively support futures markets. One can take this response surface as a general guide for judging the likely success of futures across market structures or as structures change over time.

Figure 1b and c give a comparison of hedging and speculative activity as the level of market price risk increases. The response surface shows that as the level of price risk increases, eventually both commercial and speculative activities increase. Hedgers are trading against price risk and speculators are trading for the larger potential payoff. For low levels of risk, the response function is somewhat confusing in that it suggest an initial decline in trading activity. For the declining portion

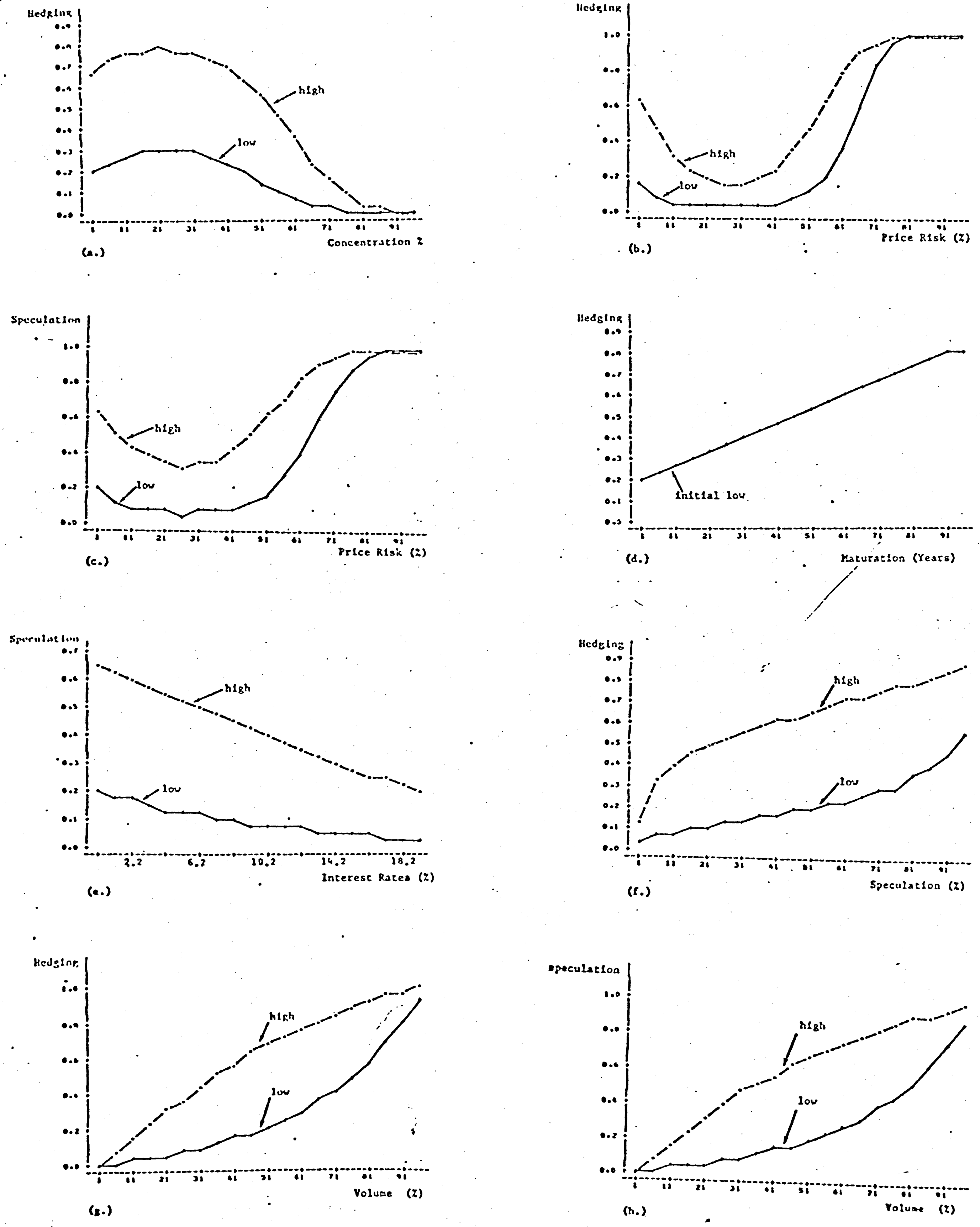


Figure 1.--Futures trading response functions (see table 2).

of the function the data seldom ranges down to the lowest values included in the figure. Likely, there is a range of price variability in the lower portion in which considerable trading experimentation takes place whereas for the more volital markets the use of forward pricing becomes an integral part of the commercial operations. Parallel arguments follow for speculative entry and exit. Speculative entry into low risk markets may initially be high but exit occurs since the potential payoff is low. One hypothesis could be that much of this entry is with new speculators.

The results for futures market performance was not statistically significant as seen in table 2. Overall, the correlation coefficients were relatively high across most of the commodities and, hence, the data did not include a market that persistently performed poorly according to the criteria used. Also, the parameter for perishability was not particularly important in either the hedging or speculative equation. That is, the levels of commercial use of futures markets were not related to perishability once all other factors are considered. The volume equation does indicate that an increasing level of trading turnover is evidient where comparing the storable to the semi-storable commodities.

Market maturation is important when evaluating the potential growth curve for a new contract. The growth process for the hedging activity is given in figure 1d. The positive relationship with age immediately indicates that a maturing period exist after the introduction of a contract and that hedging use increases over the age range of contracts.

Artifical regulations were considered by evaluating the effects of price supports relative to existing cash prices. When the loan rate is one, the cash price has declined to the support level and the loan parameter in table 2 shows this to reduce the level of hedging. The amount of change is small relative to the other effects but the direction of effect is as hypothesized. While price controls dampen hedging use, rising interest rates yield an almost linear decline in speculation. Returns for alternative investments are high and often less risky, hence speculative capital flows from the futures markets as illustrated in figure 1e.

The activity equations are simultaneous and the estimates in table 2 can be used to show the partial and total effects of each endogenous variable. While time does not permit an exhaustive analysis of these responses, three partial effects are illustrated in figures 1f, g, and h. Figures 1f and g show hedging directly responding to increases in speculative activity and to total volume of trading. Clearly commercial use of futures trading is attracted by greater market liquidity. Comparison of the activity parameters show volume to be more important than speculation in attracting additional hedging. Similarly, increased volume leads to a direct increase in speculation as shown in figure 1h. In contrast, hedging activities tend to have little direct effect on speculation (i.e., speculators are more concerned with total activity and not just the source of trading). Hedging does have an indirect effect on speculation in that hedging is highly significant in the volume equation and volume enters the speculative equations. A complete analysis at this point would include estimation of the hedging relative to the total volume as well as to speculation. Total effects would be measured and the importance of market liquidity setforth.

## Conclusion

Both commercial and speculative use of futures markets differ across commodities. However, much of the differences in use have been explained by variables not unique to any particular commodity. A pooled cross sectional-time series simultaneous system has been estimated to empirically measure the futures trading activity.

## References

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## Footnotes

*Dr. Ward is a professor and Mr. Behr is a Ph.D. candidate in the Food and Resource Economics Department, University of Florida.

[1]Two different weighting schemes were considered for inclusion of non-reported (NR) data. This summary paper used the weighting scheme where: $H = H_R + H_{NR}$ and $H_{NR} = (\frac{H_R}{H_R + S_R})(1 - \frac{OI_{NR}}{OI})$ letting OI = open interest. The following commodities are included in the analysis: wheat, corn, oats, soybeans, soybean oil, soybean meal, potatoes, hogs, pork bellies, live cattle, feeder cattle, eggs, FCOJ, and cotton.