An Analysis of the Performance of the Diammonium Phosphate Futures Contract

by

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This paper investigates the price relationships between diammonium phosphate cash and futures prices to evaluate pricing and risk management in the fertilizer industry, the potential demand for hedging within the industry, and the price linkages through the market system. The results indicate poor market integration among the DAP cash and futures markets. The results also show the current DAP futures contract behaves as a forward contract with a high rate of delivery causing the contract to be a poor hedging tool.

Introduction

October 1991, the diammonium phosphate (DAP) futures contract began trading on the Chicago Board of Trade. Prior to futures contracts, the DAP cash market extensively utilized tender offers, phone calls, price negotiations, and fill programs to distribute their product. This type of marketing system is prone to uncompetitive and inefficient market prices. Industry representatives believed a better means of risk management, hedging, would provide liquidity to the industry and create a more efficient and timely means of price discovery. Futures trading has been shown in past studies to improve the extent to which cash prices reflect market information.

A key reason futures markets are utilized is that price uncertainty exists for a specific commodity and a means of dealing with the uncertainty is needed by commercial users. Commercial buyers and sellers of the commodity must have reason to want to substitute futures contracts temporarily for merchandising contracts (Gray, 1978). In order to attract hedgers, the contract, delivery terms, locations, and prices must all conform closely to commercial movement. Hedgers use futures markets for protection against price risks of cash market transactions. Hedging involves the exchange of price risk for basis risk. For hedging to reduce price risk and warrant commercial use of futures markets, the basis must be less variable than the cash prices (Leuthold et al., 1989).

If hedgers are to use futures as a merchandising tool, they want cash-futures price relationships to be predictable. In order for the temporary substitute of cash prices to function and be useful, the futures price must behave like the cash price. Hence, the futures market is really pricing the cash market. The market also must attract speculation to promote a balanced futures market since hedging firms have a tendency to favor the short side (Gray, 1978). When these two conditions are satisfied, commodity prices can respond to market forces and provide balanced price estimates such that an equilibrium price is established.

Changes in short-run supply and demand conditions can cause mixed cash market signals, impede the efforts of arbitragers to bring cash and futures together, and increase price differences

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between markets. Understanding cash and futures price relationships can assist in understanding the spatial and temporal marketing costs of the industry. Futures trading has been shown to improve the extent to which cash and futures prices reflect spatial and temporal marketing costs (Faminow, 1981, Koontz et al., 1990, and Leuthold et al., 1992).

The integration of cash and futures prices is an important process in managing price risks, or hedging. The greater the degree prices reflect market information, the greater the degree of market integration. Futures contracts are constructed such that futures prices reflect underlying cash market prices. The cash and futures prices remain integrated through the possibility of delivery of the underlying commodity in the expiring futures contract (CBOT, 1992). Market integration measurement is important in order to understand how specific markets work. Specifically, the degree of market integration analysis provides information about arbitrage and resource allocation; informational efficiency and price linkages; the competitive nature and efficiency of the market; and the hedging effectiveness of the futures market. A complete understanding of any market is necessary for making informed marketing decisions.

This paper analyzes a time series of cash and futures prices for diammonium phosphate for four markets to investigate and evaluate pricing and risk management in the fertilizer industry, the potential demand for hedging within the industry, and the price linkages and hedging effectiveness throughout the market system. The DAP futures contract suffers from a lack of participation. This study identifies factors that limit participation in the contract. The results will be valuable to the Chicago Board of Trade in considering modifications to the contract.

Literature Review

The trading of similar commodities in different markets may be associated with positive intermarket information costs and marketing services. The degree to which different markets are interrelated depends largely on these transactions costs. Prices in alternative markets can be independent when costs are sufficiently high to prevent or prohibit almost all intermarket communication and arbitrage. With a reduction in transactions costs intermarket price differentials can be reduced, thereby integrating market prices. In equilibrium, a competitive marketing system with positive transactions costs can be characterized by price differences between markets over space consistent with these transactions costs. If price changes in one market are mirrored by price changes in other markets, then the markets are perceived to be highly integrated and transactions costs are relatively small.

The introduction of new supply and demand conditions can disturb market equilibrium and affect the level of market integration. In a perfectly integrated system, all markets incorporate new information at the same time and prices adjust simultaneously. If markets are not perfectly integrated, then one market may be able to register the impacts of new information more quickly than others. Consequently, this new information may induce price differences to arise between markets which differ by more than the cost of marketing services. Any market which registers new information more quickly than others or is the most informationally efficient will lead the other secondary markets. This asynchronicity may cause temporary price discrepancies which can be arbitraged for profit if the price discrepancies are greater than marketing costs.

The strength of the relationship between futures prices and cash prices depends in part on which cash markets most closely relates to the futures market and whether cash markets are integrated (Thompson et al., 1990). If cash markets are not well integrated, then the cash market most integrated with the futures market may more fully register the impacts of new information. Essential to any well functioning market is effective information flow. Transmission of price information allows limited resources to be correctly allocated towards the market with the greatest demand. New information may induce price differences between cash markets offering temporary profit opportunities for arbitragers.

In examining resource allocation, economists are concerned with the difficulties in measuring the markets operating efficiency. Studies of market efficiency have concentrated on the price behavior of homogeneous goods at spatially separated market locations. Key to these studies is the condition of arbitrage. Arbitrage reduces the transaction costs between markets and forces prices at different markets to differ by at most the cost of transportation. Therefore, arbitrage promotes economic efficiency by linking geographically spread markets.

Market efficiency also has been examined through market integration analysis. Markets are said to be integrated if price differences between spatial markets equal minimum marketing costs. This implies market information will equally affect prices in all separated markets and result in similar price movements. Ravallion (1986) indicates that markets can be spatially integrated if prices between two markets differ by only transport costs, but this does not imply an efficient market. He applies this theory to rice markets using a radial market structure model. Faminow and Benson (1990) argue positive transfer costs exist which affect buyer and seller decisions. They apply spatial oligopolistic competition models (basing-point pricing) to hog prices. Delgado (1991) insists that market integration depends on assessing the covariance of price information. His approach decomposes the variance of food grain prices into separate components. Sexton et al. (1991) examines celery market integration by testing arbitrage between trading regions with both an efficient f.o.b. pricing system and a spatial price discrimination model. Finally, Williams and Bewley (1993) argue that an effective information transfer promotes price adjustments. They model price transmission using a Vector Autoregressive approach on cattle auction markets. Researchers have tested price (or price changes) correlation between cash markets and the linkage between cash and futures markets. Thompson et al. (1990) investigated the price relationships for corn and soybeans with the premise that arbitrage forces price differences between markets to be less than or equal to minimum marketing costs. First-differenced cash and futures prices were used in bivariate correlation regressions. If price changes are correlated, then this is an indication that the futures contract for this commodity can be utilized as a temporary substitute for a later cash market transaction. The commercial market users, who use the futures market as a temporary substitute, also are concerned with the contracts hedging effectiveness. Hedgers are concerned with the effectiveness of which futures reduce their cash price risk.

The efficiency and level of hedging also are directly related to the relationship between cash and futures prices (Thompson et al., 1990). Optimal hedge ratios can be measured by the slope coefficients from a regression of cash price changes on futures price changes, while hedging effectiveness is measured from this regression by squaring the correlation coefficient between the cash and futures price changes. The hedging effectiveness measure indicates the level of cash price variability that can be eliminated by a hedge equal to the hedge ratio (Thompson et al., 1990). The effectiveness of hedging becomes greater with increases in the correlation between the futures price and the cash price (Pirrong et al., 1993). Wilson (1984) used expected return theory for wheat where he measured HE as a relationship between the variance of return in an unhedged position and the optimal hedge position. When the cash position was spread over two wheat futures markets, risk reduction was enhanced. Myers and Thompson (1989) compared a generalized model utilizing conditional information to simple regression estimation which is derived from unconditional information. Simple regressions employing price changes provided reliable estimates in comparison to the generalized approach. Hauser et al. (1990) stress the ability to predict the basis is an important component to HE. They use a lognormal-diffusion process which incorporates basis expectations and performs comparably to minimum variance models. Thompson et al. (1993) use ordinary least squares and regress change in cash prices on change in futures prices. The resulting slope coefficient is the minumum variance hedge ratio and the coefficient of determination is the HE measure. They incorporate basis predictability by using intercept and slope shifters.

Futures markets offer an attractive risk management tool when they can be utilized as a temporary substitute for later cash transactions. Futures markets promote efficient information transfer allowing arbitrage forces to allocate resources and promote spatial integration among the cash markets. In a perfectly integrated system, all markets incorporate new information at the same time and prices adjust simultaneously. The strength of the relationship between futures prices and cash prices depends on how closely the cash markets are integrated. The efficiency and level of market integration directly relate to the hedging effectiveness of a futures contract. The greater the level of hedging effectiveness, the greater the reduction in price risk from an unhedged cash position.

The success and efficiency of a futures market depend on the underlying futures contract's characteristics. Successful futures contracts are associated with a homogeneous product, standardized contracts which secure a high degree of correlation between cash and futures prices, price variability and uncertainty, an active and large commercial market, available public information, and an accurate contract design. A well designed futures contract promotes more effective hedging and more efficient prices due to 1) a high correlation between cash and futures prices; 2) market liquidity, and low transactions costs; 3) a futures price that is representative of market conditions; and 4) freedom from market manipulation.

DAP Industry

DAP is a global market. The U.S. produces the greatest share of the world consumption. The U.S. DAP industry is highly concentrated with the top five firms controlling 74.5 percent of production, most of which is concentrated in Central Florida. Since there is such a great foreign demand for DAP, the export market has been described as the price leader. U.S. producers have been accused of keeping prices high, receiving a greater margin in the export market, and not being concerned about the U.S. demand. Three of the major U.S. producers are allowed by the U.S. government to collude and have formed an export cartel to compete against international monopsony buyers. Even though price collusion is illegal in the U.S., many U.S. DAP buyers are concerned with the industry's recent producer concentration and the potential for domestic collusion.

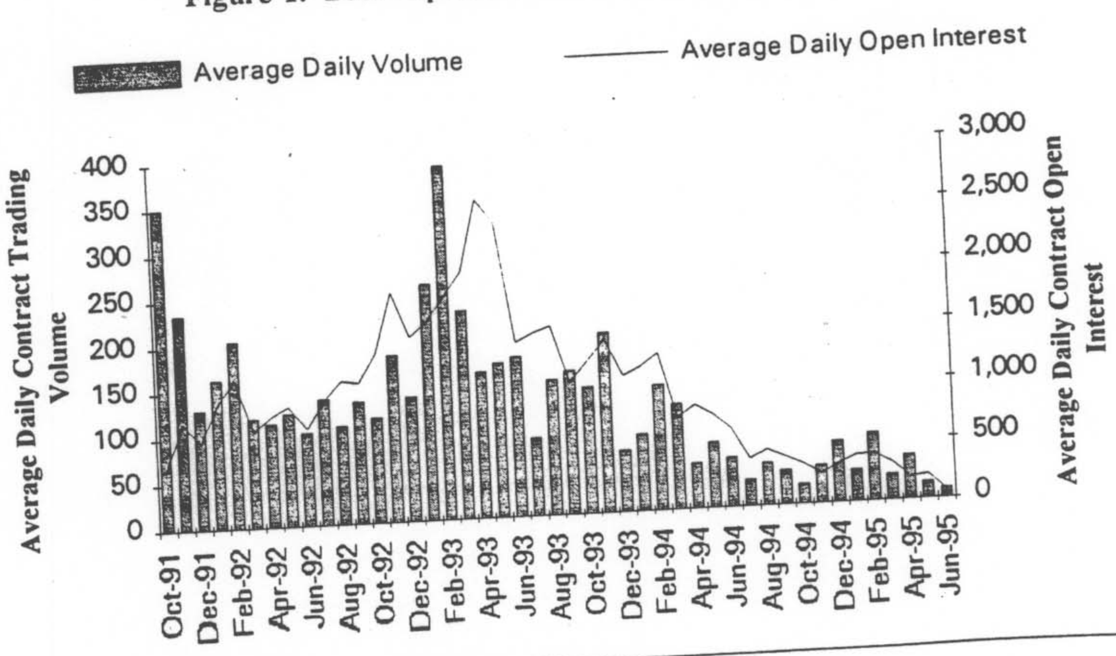
Producers are in the market to produce DAP. Desiring to maintain continuous production at capacity levels, producers forward contract 60 to 90 days ahead of production to keep product moving on a timely basis. With DAP production concentrated in Central Florida, the industry naturally utilizes this market as the basis for product pricing. Much of the contracting and pricing in this market is done through private negotiations. Product can be taken by barge, rail, or truck in the U.S., and rates are often a function of volume and frequency of shipments.

DAP industry members do not have a direct means of protecting against price risk in the cash market. Many producers believe prices always will increase and they can continue to produce more product. Therefore, hedging would only reduce profit margins when prices rise. Several industry members are concerned with reducing price risks and rely on "fill" programs to control price risk. Member companies of the two producing cooperatives utilize this program extensively. In this manner, buyers receive price protection through their supplier. Prices are often a reflection of the market's supply and demand. When producers, other than cooperatives, cannot sell into the export market they may also offer a fill type program. Producers may publish a list price, however the final sale price is negotiable depending upon volume and delivery terms. Distributors and dealers also often rely on market trends to source product for "good buys" relative to the market.

DAP Futures Contract Trading

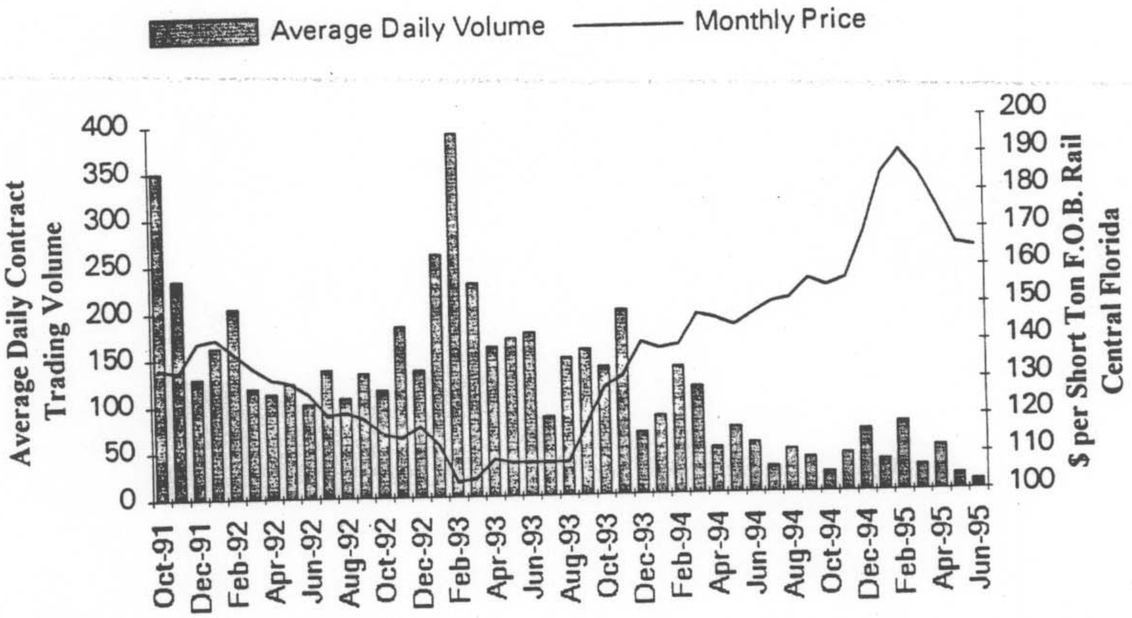
The DAP futures market initially attracted many participants. As participation increased, so did trading volume and open interest. Figures 1 and 2 present the historical progression of the average daily contract trading volume, open interest, and the monthly Central Florida price. These figures indicate that volume and open interest continuously increased, peaking in the first quarter of 1993. The average daily trading volume was 389 contracts in February 1993, or 389,000 short tons of DAP (260 barges or 3,890 railcars). After the expiration of the March 1993 contract, volume and open interest began to decrease. The contract maintained an average daily trading volume of 100 contracts until April 1994, when daily trading volume dropped to 50 contracts and has yet to recover.

Figure 1. DAP Open Interest and Trading Volume



Further examination of figure 2 reveals an inverse relationship between the trading volume and price. Starting in January 1992, DAP prices steadily declined, reaching industry lows during February 1993. Conversely, the levels of trading volume and open interest increased sharply. The DAP futures contract was most actively traded when the market price was depressed. Figure 2 also shows the inverse relationship as price has continued to rise and trading volume and open interest has declined.

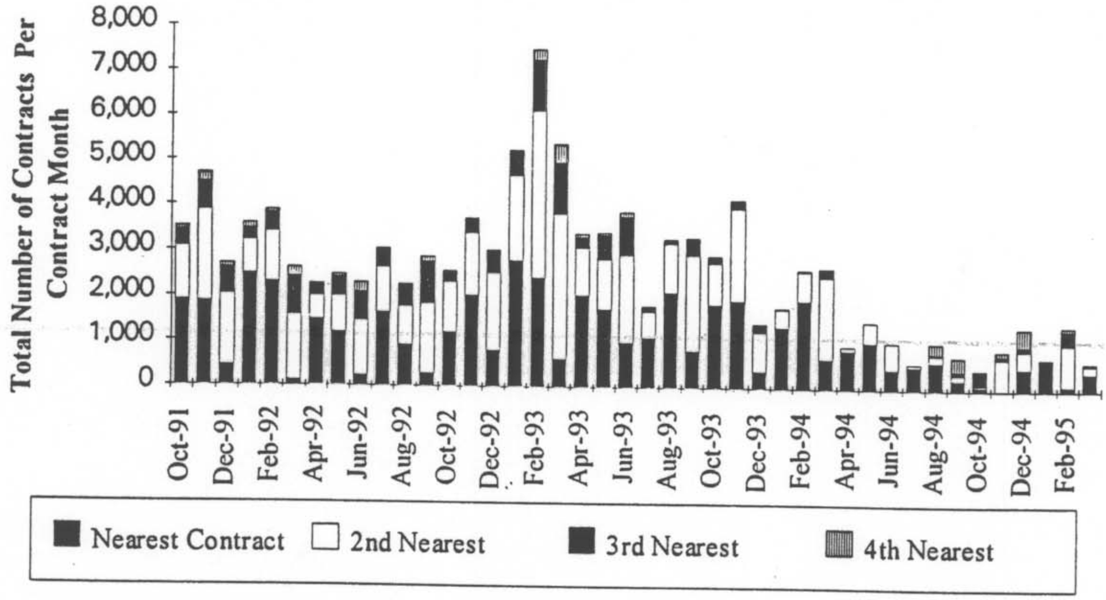
Figure 2. DAP Trading Volume and Price



Trading volume is further delineated into near and distant contracts by trading months in figure 3. In general, the nearest contract has the largest number of contract positions with two exceptions. One, when the March contract is the next nearby contract, then the largest number of contracts traded are most often traded in this contract. Second, when the nearby contract is in the delivery month, then the nearest contract doesn't contain the greatest volume of trading. Open interest, not presented here, is similar to trading volume. Usually open interest is greatest in the interest, not presented here, is similar to trading volume. Usually open interest is greatest in the nearby contract. When the delivery month is excluded, 83 percent of the open interest is held in the nearby contract. From trading volume and open interest totals, the March contract seems to be the most heavily traded contract which corresponds to the spring demand in the domestic market.

The added volume during early 1993 may have been attributable to producers. However, these firms were the most reluctant to utilize the DAP futures market during the contract's inception. Thus, there is reason to believe that the hedging efforts of distributors and dealers

Figure 3. Trading Volume in Near and Distant Contracts by Trading Month, Oct 91 - Mar 95



generated the market's increased trading volume during this period. These market participants, many of which were familiar with grain contracts, understood the benefits of the DAP futures contract. The period in which trading increased corresponds to the preparation for the Midwest's spring demand.

Trading in the nearby contract drops to below 1,000 contracts, and in most cases well below this point, during the delivery month. This suggests traders fear contract liquidation and consequently do not wait until the delivery month to unwind their market positions. They may liquidate or roll over their positions in the months prior to the delivery month. Therefore, the futures price may reflect the cash prices and converge a month (4 or 5 weeks) prior to contract expiration. Beginning in October 1993 there was no trading beyond the nearest three contracts. And beginning in April 1994 there was no trading beyond the nearest two contracts. This pattern continued until serial trading months were added to contract specifications in August 1994. From the limited data available, the volume and open interest positions strongly favor the original quarterly contracts even with the addition of serial contract months. This suggests serial contract months has detracted trading volume and liquidity away from the market. That is, if serial contract months were excluded and the trading volume was placed in the quarterly contracts, then these contracts would have greater volume and open interest. With more liquidity, hedgers would be better enabled to trade the DAP contract. One industry member agreed that the serial months adds flexibility for traders but has reduced the trading volume in all contracts. The current market is illiquid, making it increasingly difficult to enter and exit a market position. The limited trading volume may not allow effective hedging.

Methodology

Correlations between the spatially separated cash prices before and during futures trading provide some indication of the degree of integration between cash markets. In addition, graphical analysis examines spreads between cash prices before and during the futures trading time periods. Cash markets may be integrated by trade if price differentials correspond to marketing costs. The DAP futures contract established the following differentials: $8 from Central Florida to Export, $12 Central Florida to New Orleans, and the Midwest market is dictated by the market and was not specified. Market linkages may change over time due to regional shifts in supplies and demand. Analysis of the different time periods will indicate whether the introduction of the DAP futures contract has altered cash market price relationships. The change in cash prices at one location are regressed on the change in cash price at another location. This model was generated from Thompson et al. (1990) who looked at similar issues in the grain markets. The regression model is represented as follows:

(1) $$\Delta C_{yt} = a + b\Delta C_{xt} + e_t,$$

where C_{yt} and C_{xt} are cash prices at location y and x at time t and e_t is the error term. The null hypothesis testing for a one-to-one relationship between cash price changes is H_0: b=1.

An analysis of the basis (cash price minus the near futures price) between cash market locations will further examine the coordination of the markets during the futures trading time period (an extension of the cash price changes on cash prices changes relationship addressed earlier). The cash market relationships may be a function of their relationship to the futures market. Futures trading may effectively increase the level of integration among the cash markets. One method to measure the linkage between and among the cash and futures markets is to regress one basis change on another. This method considers the proportion of the cash market price change at one market that is explained by the price change at another market, and not by the change in the futures price. If futures trading exhibits no effect on the cash markets' integration, then the cash market relationships will be the same as the previous regressions of the change in cash price on the change in cash price. Regressing two bases on one another effectively removes the futures market price variability from the cash prices. This will allow the price variability at one cash market to be explained by the variability in another cash market. This model was chosen following Thompson et al. (1990) who examined similar issues in the grain markets. The regression model may be written as follows:

(2) $$\Delta(F_t - C_{yt}) = - a + b(\Delta(F_t - C_{xt})) + e_t,$$

where C_{yt} and C_{xt} are cash prices at location y and x at time t and e_t is the error term. This regression imposes a restriction on the change in C_{yt} such that the cash price change at one location (ΔC_{yt}) is a weighted sum of both the futures price change (ΔF_{yt}) and cash price change at another location (ΔC_{xt}). Thus, equation (2) can be rewritten as

(3) $$\Delta C_{yt} = - a + (1 - b)\Delta F_t + bC_{xt} + e_t,$$

where the coefficients on ΔF_t and ΔC_{xt} sum to one. The null hypothesis of equation (2) is that b=1. That is, that cash price changes at one location correspond directly to cash price changes at another location rather than to futures price changes. As shown in equation (3), small slope coefficients (b) imply that cash price changes are more integrated with futures price changes rather than with other cash market price changes. Seasonal effects are considered in the regression analysis to determine whether the slope coefficients vary seasonally with changes in fertilizer flows and transportation costs. Significant intercept shifters indicate either strengthening or weakening of the basis seasonally. Significant slope shifters indicate whether cash markets are seasonally more integrated. A delivery month dummy variable indicates whether markets become more integrated during the delivery month due to convergence of cash and futures prices.

The linkage between futures and cash market prices is a primary concern in hedging effectiveness studies. The futures price should reflect the value of the commodity cheapest to deliver on the futures contract. The relationship between cash and futures prices reflects the extent to which futures prices are substitutes for cash prices. The bivariate regression is represented as follows:

$$\Delta C_{yt} = a + b\Delta F_t + e_t, \qquad (4)$$

where ΔF_t is the change in futures price at time t, C_{yt} is the change in the cash price at location y at time t, and, e_t is the error term. The null hypothesis testing for integration between the cash and futures price changes is H_o: b=1. This model of hedging effectiveness (HE) follows Thompson et al. (1993) who examined the HE of soybean futures markets for reducing price risk in canola. The correlations between cash and futures price changes indicate the degree of temporal integration between the cash and futures markets. The slope coefficients from the regressions indicate whether price changes are of similar magnitude as well as provide a measure of the optimal hedge ratio.

The relationship between the cash and futures prices directly relates to the efficiency and ability to hedge risk. Then "optimal hedge ratio" is the slope coefficient from the regression of cash price changes on futures price changes. Hedging effectiveness can be measured by the coefficient of determination between the cash and futures price changes.

The slope coefficient from equation (4) can be decomposed to yield the equivalent expression $r_{yf}(\sigma_y/\sigma_f)$, where r_{yf} is the correlation between the cash and futures price changes. When this correlation coefficient is squared, the coefficient of determination, R^2, is obtained.

Data

Cash prices for Central Florida, Midwest, New Orleans, and Tampa-Gulf were supplied by Green Markets, an industry service which publishes weekly cash prices. The price published by Green Markets is an average price based on a survey conducted on Wednesday and Thursday throughout the industry. This price is subsequently printed and published on the following Monday for 51 weeks of the year. These series were adjusted to include a 52nd week by simply averaging the two prices adjacent to the missing data point. The cash price series published on the Monday really reflects the previous week's cash market survey prices. Therefore, the cash price series was adjusted backwards by one week to correspond correctly to the appropriate futures contract prices.

An average of the closing futures prices on Wednesday and Thursday was used to correspond to the average cash prices reported in Green Markets. This procedure allows for testing instantaneous information transfers without subjecting the data to prior bias. Therefore, the Wednesday and Thursday closing futures prices were averaged to produce one futures price per week. The futures price series reflects the nearby futures contracts. When the futures contract changed to serial delivery months, the nearby futures price series continued on a quarterly contract basis throughout all the analyses. If the nearby futures contract month happened to end splitting the Wednesday and Thursday prices, then the series was switched to the next nearby contract for that week's price.

The effects of switching (roll over) between the expiring futures contract and the next nearby contract at the end of the nearby contracts expiration were examined. A dummy variable was utilized to measure this contract switch in the change-in-cash on change-in-futures regressions. Test statistics were insignificant, thereby supporting the existing switch methods. In addition, the issue of keeping the delivery month in the data series was also tested with a delivery month dummy variable in change-in-cash on change-in-futures regressions. The test provided no evidence that there is a significant effect by keeping the delivery month observations in the time series.

To avoid an abrupt price change when switching from the expiring futures contract to the next nearby contract, the switch was made one week prior to contract expiration. Consequently, all data series are first differenced which follows the methodology of Thompson er al. (1990) and others from the literature. Stationarity existed in both cash and futures price series, as reflected through unit root tests.

Results

The relationship between cash prices (equation (1)) was analyzed in two time periods, before futures trading and during futures trading. Results of regressions of cash price changes on cash price changes are presented in table 1.

Table 1. Results of Regressions of Cash Price Changes on Cash Price Changes, Feb '88 - Jul 95.

	192 Obs. Before Futures			192 Obs. After Futures		
DEP	CF	NO	NO	CF[h]	NO	NO[h]
INDEP	EXP	EXP	CF	EXP	EXP	CF
CONSTANT	-0.1684	-0.1408	-0.0678	0.0611	0.1459	0.0631
	(.1523)	(.1667)	(.1587)	(.0919)	(.1792)	(.0816)
CASH	.1444*†	.3224*†	.6071*†	.3840*†	.2252*†	.6709*†
	(.0418)	(.0567)	(.1354)	(.0418)	(.0532)	(.0473)
RSQ	0.1316	0.1453	0.1960	0.3053	0.3310	0.4627
ADJ-RSQ	0.1270	0.1408	0.1918	0.3016	0.3275	0.4598

CF (Central Florida), EXP (Gulf, Export), and NO (New Orleans) are the three cash markets.

CASH is the change in the independent (cash) variable's price.

* indicates significantly different from zero at the 5 % level

† indicates significantly different from one at the 5% level.

[h] indicates heteroskedasticity-consistent standard errors are reported.