Chicago Board of Trade Ethanol Contract Efficiency

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Firms producing ethanol may find management of the price risk associated with production of this leading alternative fuel a key factor to continued success. As with other agricultural commodities, the influence and ability of futures contracts to serve as a risk management tool deserves attention.

Key words: contract efficiency, ethanol, futures contracts

JEL Classification: Q13, Q43, M31

Growth in the production of ethanol has greatly impacted the agricultural commodity markets of feedstocks for biofuels plants and related crops that compete for productive farmland and access to markets that can alternatively utilize ethanol co-products. However, marketing and risk management strategies for pricing ethanol are key to the long-run sustainability of ethanol plants.

The 2006-2007 run up to historic highs in grain and soybean prices due (at least in part) to pressure for additional corn acres to meet the growing needs of the ethanol industry, has focused attention on the cost of inputs and the marketing of co-products. The importance of managing ethanol pricing opportunities as part of an overall risk management strategy must be emphasized. Ignoring the sales of ethanol for the marketing of ethanol co-products competing with traditional feeds would be analogous to a lamb feedlot operator looking to market wool without concentrating on the primary product being meat.

The policy incentives promoting U.S. ethanol production have spurred tremendous growth. From payments to increase production to excise tax credits, the federal and some state governments have contributed to the profitability of ethanol production. High returns on investment were noted for several ethanol plants prior to late 2006. But as the growth of the ethanol industry started to consume a large portion of U.S. corn production, ethanol feedstock prices have increased, putting pressure on operating margins. At the same time, the price for ethanol has been quite variable.

The Chicago Board of Trade (CBOT) launched ethanol futures contracts on March 23, 2005 created a method for businesses and producers to potentially manage price risk. Analyzing how well this tool has been accepted and how it has performed as a risk management tool for the ethanol industry is important. The efficiency of these contracts will determine to a large part the ability firms have to utilize the contracts to actively manage price risk with hedging tools in their business decision making.

The Structure of Ethanol Industry Sales

Ethanol is a non-differentiated commodity. Like other commodities, a hedge option allowing producers to manage inherent price risk is important. However, the ethanol production process is much different than other industrial processes because output cannot be priced based on production input costs. To further explain, ethanol is produced by grinding corn adding yeasts, enzymes, heat and allowing fermentation to occur. After fermentation, there is the need to separate the ethanol from the stillage and the mash. This process takes additional heat and drying often using natural gas. The process has major inputs of corn and natural gas to produce ethanol distillers grain and carbon dioxide. While corn and distillers grain may have some markets in which they may serve as incomplete substitutes, there is a financial disconnect between the price of inputs and products of the ethanol process. Eidman assumed DDGS prices increased at a rate of 92% the rate of corn price increases in estimating that the cost of producing ethanol increased \$0.26 for each \$1 per bushel increase in corn prices. He noted that while DDGS prices followed corn, they were not in proportion. In light of recent price increases for corn, hedging may be essential to the long-term viability of ethanol plants.

Ethanol production and marketing is relatively new to the financial and commodity world. The first ethanol produced and sold as fuel grade ethanol was in the late 1970s by Archer Daniels Midland Company (ADM). The number of producers has grown over the years to 134 at the end of 2007 with another 77 plants under construction according to the Renewable Fuels Association. The marketing of ethanol is completed by 8 marketers and sold to petroleum blenders. Because this industry started out with few producers and even fewer marketers, price discovery has been limited and held closely by those companies, unlike the corn market at the time the Chicago Board of Trade initiated corn contracts in 1848.

Most ethanol is contracted twice throughout the year. There is a summer blend period and a winter blend period with contracting occurring 6 to 9 months prior to the delivery period. Therefore, use of ethanol may not occur for up to one year from the contract date. Not all gallons are sold in advance of delivery, some are left to the spot market which represents about 10% of total production. The price risk for non-contracted ethanol production is significant.

Ethanol pricing information has been limited and is usually held between a few ethanol marketing companies and blenders in the U.S. Further difficulty for investors and ethanol producers is the price realization and transactional transparency. Due to a concern regarding the lack of market transparency and growth of the ethanol industry, the Chicago Board of Trade instituted an ethanol contract for domestically produced ethanol.

CBOT Ethanol Contracts

The CBOT ethanol contract, with a ticker symbol of AC in the open outcry and ZE in the electronic market, is traded in 29,000 gallon increments with each tick equal to $0.001 per gallon or $29 per contract. Contract months are the 12 consecutive calendar months with the last trading day to be the business day prior to the 15th of the delivery month. The contract can only move fifteen cents per gallon below or above the previous day’s settlement price. The spot month has no limits and starts on the first day of the month. The ethanol contract is a deliverable contract to a designated delivery point at the buyer’s terminal. It was anticipated that the majority of the delivery points would be in the Chicago area. The deliverable product must meet the American Society of Testing and Materials standard D 4806 for “Denatured Fuel Ethanol for Blending with Gasolines for Use as Automotive Spark-Ignition Engine Fuel” and meet the California specifications.

Contract Efficiency

Fama defined efficient markets using three forms of efficiency: weak, semi-strong and strong. These levels of efficiency are essentially determined by the effect information has on the movement of markets. This is particularly important to the ethanol industry as the quantity, timing and type of information the markets have access to is limited. Fama suggests that markets are inefficient in the strong form, when information is only available to those people within the industry or others having special knowledge. Weak form efficiency indicates that all past information is included in prices; the semi-strong form adds to the weak form and includes all relevant public information. The strong form efficiency includes information for the semi-strong along with insider or proprietary information. Some have argued that the above definitions do not take into the account the cost of information, and that for the above to hold exactly, the cost of information would need to be zero (Grossman and Stiglitz).

The definition of inefficiency will help us to better understand an efficient market. Simply put, if a model can be developed to better predict a future spot price then the underlying futures market is inefficient (Rausser and Carter). An efficient market is one where the movement of price is reflective of the information provided today.

For markets to exist, there needs to be participants exchanging contracts. Kastens and Schroeder (1995) state that a commodity being traded relies on the market being unbiased or efficient and that traders entering or leaving the market should have the perception that they have benefited from an efficient market. Both conditions are necessary for trades to occur. Participants can be made up of various groups. They can be people involved in the production of the item being traded, individuals who use the items produced, marketers or resellers of the items or they may be speculators. Each group may influence the market, especially since each may or may not have similar information.

Luo analyzed the roles of speculators and producers by trying to quantify a speculator's role in influencing the market outcome and how close or far the futures market varies from the spot price of a commodity. He determined those traders acting on better information accumulated more wealth than other traders. Moreover, as a contract gets closer to expiration, the available information is more accurate, and convergence of the futures price to the spot price will occur. He concludes that during the short run of a futures contract, participants' trades were based on emotions, current events and available financial information for a commodity, making the price representative of a compilation of noise being traded at the time.

Other items that can lead to discrepancy between futures markets and spot cash markets could be irrational participants, imperfect capital markets, government intervention, costs of information, timing of information, and the risk aversion of the participants (Rausser and Carter). However, current events, emotion and other information are exactly what Fama discussed, because this new information moves the market accordingly.

Wang and Ke suggest that short-term markets are not as efficient as long-term ones. As the futures markets price changes reflecting the available information, the spot price also changes. The reaction of the cash market to the futures markets provides the base for market efficiency.

Time prior to futures contract expiration is a consideration in markets. The closer a contract is to expiration, the more predictable the spot price should be. Current information, including spot prices, impact expectations of futures contract prices for a distant contract. However, beyond 6 weeks from expiration, research has found a futures contract is not an efficient tool for determining the spot market price at the time of the expiration of the contract (Bigman, Goldfarb, and Schechtman; Stein; Seiler and Rom).

A final consideration is to examine the effect of trading volumes on market efficiency. There are few studies that have analyzed this aspect of the market and no studies were found that observed this in commodity markets. Antoniou, Ergul, Holmes and Priestley looked at technical analysis, trading volume and market efficiency in an emerging market. They concluded that technical analysis with respect to volume can help the prediction of past returns that otherwise could not be done with past performance information alone. Volume is a more relevant price movement predictor in low volume stocks than in high volume stocks.

Determining whether a market is efficient is dependant on the data collected, time frame from which the data is collected, and analytical tools used to conduct the analysis. For the purpose of this paper, we will consider the time variables of both spot and futures prices of the Chicago contracts, the price of corn, the natural gas futures traded on the NYMEX, gasoline futures and the cash price of gasoline paid at the blending terminals, and the volume of ethanol contracts traded.

Building the Models to Examine Efficiency of Ethanol Contract

We will analyze the cash price of ethanol as dependant on variables related to the actual production of ethanol and those affecting the demand. Specifically, we examine the relationship of the cash price of ethanol to: the cash corn price, the price of natural gas, price of distillers grain, price of unleaded gasoline, stocks of unleaded gasoline, stocks of ethanol, and the price of crude oil 2 months prior. The cash ethanol prices after the launch of CBOT ethanol contracts should include the above factors plus the CBOT settlement price of ethanol, ethanol open interest and ethanol volume. The volume and open interest of the CBOT contracts will be analyzed for their importance to the efficiency of the contracts.

Corn currently represents the largest portion of the variable cost when producing ethanol. If the industry would follow a cost plus pricing mechanism, then ethanol producers would price ethanol according to its input prices and the price of ethanol should mirror the price movements in corn. However, ethanol is not priced according to its inputs; therefore, there may be little correlation between the price of ethanol and the price of corn.

Natural gas is the second major cost component in the production of ethanol. As the price of natural gas increases, the price of ethanol should also increase. Ethanol should follow the natural gas price, because natural gas trends with other energy sources and is a major cost component in the corn ethanol production process.

Distillers grain is an output from the process of converting corn into ethanol. Distillers grain provides a positive income stream to the plants and should follow the trend of corn price based on the protein markets. The correlation between the price of ethanol and the price of distiller grain would be positive if it is determined that the price of corn and the price of ethanol trend in similar directions.

The ethanol market is thought to be closely tied to the gasoline market and moves when gasoline price moves. The ethanol cash price reflects those gallons that have not been forward contracted during the time period less than 6 months prior to the contracts being exercised.

Ethanol contracts that are traded more than 9 months out should be influenced by the price movements of the CBOT ethanol contracts. Though it is generally assumed that the price of ethanol follows the price of unleaded gasoline, there have been times during certain blending months that the trend has not followed; typically the change from winter blends to summer blends.

Stocks of gasoline are thought to influence the price of ethanol. As the stocks of gasoline or the amount held in inventory increases, the price of ethanol would be expected to decrease. Likewise as the stocks of gasoline decrease, the price of ethanol should increase, thus stocks of gasoline may have a negative correlation with respect to ethanol prices. Stocks of ethanol would be expected to have a negative correlation on the price of ethanol. As the stocks of ethanol increase, the price of ethanol should decrease.

The time for crude oil to be processed (starting with its extraction from the ground) and converted into gasoline takes approximately 2 months. For our analysis we will consider the actual months it takes to convert crude oil to gasoline as 2 months prior to the current price time of ethanol. The correlation between crude oil and ethanol should be positive.

The ethanol contracts did not have large amounts of open interest or high volumes compared to several other commodity futures markets during the time period included in this analysis when the CBOT ethanol contracts were first launched. There were few trades that occurred during the trading day and this lack of volume may be important in determining the efficiency of the ethanol contracts. The number of open interest contracts is expected to have a positive correlation on the efficiency between ethanol and the CBOT price of ethanol.

Higher CBOT ethanol prices should have a positive influence on the cash price of ethanol. An exception to this would be if the cash price is on the opposite side of the closing settlement price at the end of the contract. Because we are assuming the contracts are efficient and we know the closer to the delivery months the closer the contract and cash prices are to equilibrium, they should converge.

The quantity of ethanol contracts should have a positive influence on the price of ethanol during the initial months the contract is introduced. John Litterio, Fuels Division Manager for US Bio Energy, suggested the CBOT ethanol contracts need volume in order to move the market. He also assumes that the movement will be positively correlated to the pricing of ethanol. That is to say, as there are more contracts being traded there should be a positive correlation to the movement of ethanol at this point in contract trading maturity. However, it is important to note that as we get more volume and more information to other traders, this volume may also have a negative effect on the price of the cash ethanol. For other commodities the amount of volume is not a predictor of the overall price movement. Open interest is expected to have a positive impact on the price of ethanol, because it is believed more volume is needed to make the markets move, therefore a positive correlation. With less open interest, many traders may offset their position at a discount because of the limited volume in the market.

When estimating equations for ethanol futures contract prices they should include cash ethanol prices paid at the Chicago terminals. The cash price of ethanol paid is expected to have a positive correlation to the ethanol futures contract price.

Three equations were estimated to determine whether CBOT ethanol markets are efficient and if there is importance to the lack of volume and open interest that was a characteristic of the ethanol contract markets immediately following the contract launch. Regression analysis was used to estimate the coefficients, T values, adjusted R squared values and error terms. The first regression equation included 27 months preceding the start of the

CBOT ethanol contracts. The next equation was estimated for the cash price of ethanol after the start of the CBOT ethanol contracts using daily pricing. The third equation estimated was for the cash price of ethanol after the start of the CBOT ethanol contract, and included the CBOT ethanol price, open interest, and volume.

The cash price of ethanol (PCE) prior to the opening of the CBOT ethanol contracts is explained with the following equation with variables listed in Table 1:

$$(1) \quad PCE = \beta_0 + \beta PUG + \beta PNG + \beta PCC + \beta PDDG + \beta QUG + \beta QE + \beta PCO_{(t-2)} + \beta QEST + \beta QESL + \beta PNYNG + \varepsilon_t$$

where β_0 is a constant, PUG is the price of unleaded gas, PNG is the price of natural gas, PCC is the price of cash corn, PDDG is the price of distillers grain, QUG is the quantity of unleaded gasoline, QE is the quantity of ethanol produced, $PCO_{(t-2)}$ is the price of crude oil two months prior, QEST is the quantity of ethanol stock, QESL is the quantity of ethanol sales, PNYNG is the New York Mercantile Exchange month closest to the current month for the price of natural gas and ε_t is the standard error term.

Data available prior to the CBOT contracts are thin and will be run on a monthly basis with available data points. This model will be run a second time utilizing daily data (as available) following the start of the CBOT ethanol contracts to estimate a second regression equation to analyze the impact of a richer data set for impacts on variable coefficients.

The cash price following the start of the CBOT ethanol contracts using the contract data is modeled as:

$$(2) \quad PCE = \beta_0 + \beta PUG + \beta PNG + \beta PCC + \beta PDDG + \beta QUG + \beta QE + \beta PCO_{(t-2)} + \beta QEST + \beta QESL + \beta PNYNG + \beta PCBE + \beta QCBOI + \beta QCBV + \varepsilon_t$$

The additional variables are PCBE - the price of ethanol on the CBOT; QCBOI - the quantity of open interest; and QCBV - the volume of contracts traded on the CBOT ethanol floor.

Table 1. **Model Variable Key**

Symbol	Variable
PCE	Cash Ethanol Price
PCC	Cash Corn Price
PUG	Unleaded Gasoline Price
QUG	Unleaded Gasoline Quantity
PCO	Crude Oil Price
PDDG	Distillers Grain Price
PNG	Cash Natural Gas Price
QE	Ethanol Production Quantity
QEST	Ethanol Stocks
QESL	Ethanol Sales
PNYNG	NYMEX Natural Gas
QCBOI	CBOT Ethanol Open Interest
QCBV	CBOT Ethanol Contract Volume
PCBE	CBOT Ethanol Price

Examining the Efficiency of CBOT Ethanol Contracts

Brealey and Myers suggest that if a market is efficient, the prices tomorrow are not influenced by the results of today. Determining the percentage change in price on day t and comparing that to the percentage change in price on t-1 allows that comparison to be made. Figure 1 illustrates the relationship before the CBOT ethanol contracts traded; Figure 2 expresses the same for cash ethanol markets after CBOT ethanol contracts traded. Figure 3 compares the daily CBOT ethanol price percentage change after the contracts started trading. Both before and after the introduction of the CBOT ethanol contracts the correlation is low and not statistically significant indicating a fairly efficient market. The random walk theory suggests little correlation between successive period price changes. This occurs in the monthly and daily data for cash ethanol and the daily data for the CBOT price.

Figure 1. Cash Ethanol Monthly Price Change Before CBOT

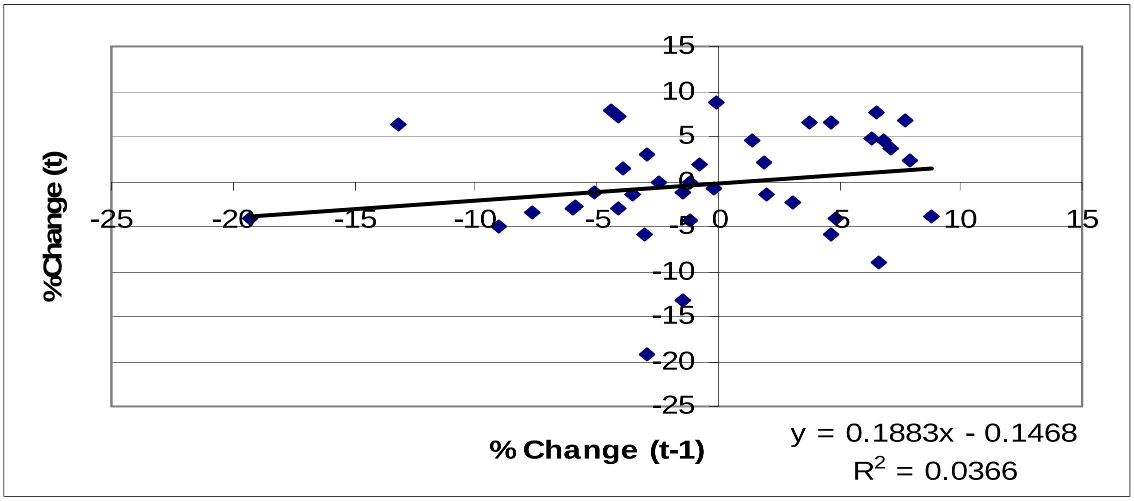


Figure 2. Cash Ethanol Daily Price Changes After CBOT

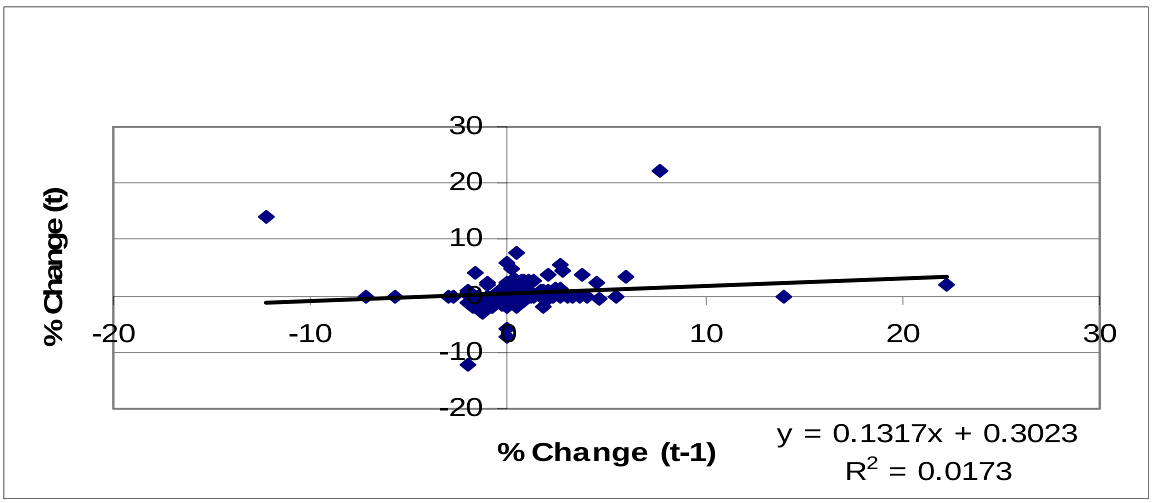
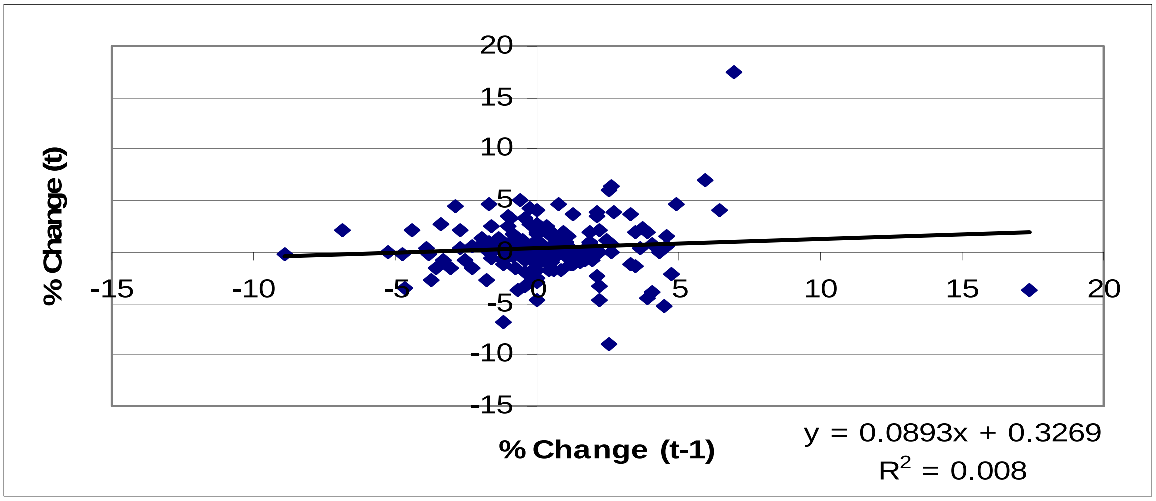


Figure 3. CBOT Ethanol Price Daily Price Changes



Cash corn, unleaded gas price, natural gas cash price, distillers grain price, unleaded gas quantity, and ethanol production quantity explained 73.8% of the price variation in cash ethanol price (Table 2). None of the variables are statistically significant at the 5% level. The correlation for all the independent variables moved as anticipated. The number of observations was a total of 27 from November 2002 to February 2005.

Table 2. Regression Results of Independent Variables for Cash Ethanol

Before CBOT Ethanol Contracts (Monthly Data)		
Variable	Coefficient of Variation	T Value
Unleaded Gasoline Price	0.303100	1.82
Cash Corn	-0.086200	-0.66
Unleaded Gasoline Quantity	0.000007	0.08
Distillers Grain Price	0.004066	1.66
Cash Natural Gas Price	0.043330	1.16
Ethanol Production Quantity	0.001946	1.74
* Denotes Statistically Significant	Observations	27
Adjusted R squared		73.8%

When equation 2 was estimated, more variables were shown to be significant using daily data than monthly data (Table 3). The equation explains 94.5 % of the variability of the cash ethanol price. The significant variables for this equation were the unleaded gas price, unleaded gas quantity, DDG price, natural gas price, and ethanol production quantity.

Table 3. Daily Data Comparison of CBOT Ethanol Variables

	After CBOT Ethanol Contracts without CBOT Ethanol Variables (Daily Data)			After CBOT Ethanol Contracts All Variables (Daily Data)		
Variable	Coefficient of Variation	T Value		Coefficient of Variation	T Value	
Cash Corn	-0.027700	-.033		0.015580	0.31	
Unleaded Gasoline Price	0.794930	12.72	*	0.318950	7.60	*
Unleaded Gasoline Quantity	-0.000163	-3.72	*	-0.000044	-1.71	
Distillers Grain Price	0.076104	10.40	*	0.007652	1.48	
Cash Natural Gas Price	0.049837	5.87	*	0.017231	3.48	*
Ethanol Production Quantity	0.009888	17.12	*	0.002157	2.94	*
Volume				0.001311	0.66	
CBOT Ethanol Open Interest				-0.000135	-3.33	*
CBOT Ethanol Price				0.802200	21.72	*
* Denotes Statistically Significant				Observations	215	
Adjusted R squared		94.5%			98.3%	

Three additional independent variables are used as predictors of the cash ethanol price following the introduction of the CBOT ethanol contracts: the CBOT ethanol price, CBOT ethanol open interest and CBOT ethanol volume. Including these variables increased the adjusted R square from 94.5 to 98.3 percent (Table 3). Five of the nine variables are significant with absolute T values greater than 2. Unleaded gas price, ethanol production quantities, cash natural gas price, CBOT ethanol price, and ethanol open interest are those independent variables that are statistically significant.

Unleaded gasoline price was a significant variable in predicting the price of cash ethanol. According to the model, the price of cash ethanol would increase $0.0319 per gallon with an increase of $0.10 in the price of unleaded gas. An increase in cash natural gas price of one dollar would increase the price of ethanol by $0.02 per gallon. A price variation of the CBOT ethanol price by $0.10 would be expected to vary the price of ethanol by $0.08 per gallon.

The coefficients for corn went from a negative 0.0277 to a positive 0.01558. Unleaded gasoline went from a positive coefficient of 0.79493 to a positive 0.31895. This change in slope may be a result that the CBOT ethanol contract is incorporating information contained in the independent variables, suggesting a move towards market efficiency. Distillers grain went from a positive 0.076104 to 0.007652. The significant variables that remained after the independent variables of the CBOT were added are the unleaded gas price, cash natural gas price, ethanol production quantity, CBOT ethanol open interest and the CBOT ethanol price. If the CBOT was efficient, the CBOT ethanol price would have been the only significant independent variable.

Analyzing the absolute ratio of cash ethanol to CBOT ethanol and comparing that to volume will determine the significance of volume to equalizing the cash and futures market. The regression indicates that the volume was not statistically significant with a T value of 1.82. Additionally, the individual regression equation of volume to ethanol cash was not significant.

Conclusions

There are equations that can be developed with accuracy on the past prices of cash ethanol. From the literature review, it was determined that if a regression can be developed with great precision, then the market being analyzed is inefficient. One may jump to the conclusion that the ethanol futures market is inefficient because of the developed regression equation, but proceed with caution. As McKenzie and Holt stated "Market efficiency implies that futures market prices will equal expected future spot prices plus or minus a constant or possibly, a time-varying risk premia." This definition would hold true for the ethanol futures price and the cash ethanol prices as they are traded within a month of the expiration of the futures contract.

The CBOT ethanol contracts seem to add efficiency to the cash ethanol price. The CBOT is a source to provide pricing information to the marketplace for producers, marketers, and purchasers of ethanol to consider ethanol values. This is a step to transparency of prices.

Volume of the CBOT was not significant in the developed regression equation. The interpretation that a futures contract needs an extreme amount of volume to move the prices together was rejected. Volume did not contribute any significance to the CBOT ethanol price, cash ethanol price or the ratio of CBOT to cash price.

The change in data availability was a significant factor in helping bring more transparency to the market. Prior to the CBOT ethanol contracts being traded, there were limited sources of daily cash ethanol prices.

The CBOT ethanol contract can be used as a tool for ethanol producers to spread their risk. Because the CBOT ethanol contract is a deliverable contract, liquidity is less of an issue to ethanol producers because they can deliver their position. This tool will allow producers to hedge their future production 12 months ahead.

Following Periods Post CBOT Ethanol Contract Launch

The data gathered for this research was constrained by the commercially available set obtained by one of the co-authors. The conclusions list the need for continuing analysis of this topic with more data available over a longer period of trading for the CBOT contracts. One of the more challenging areas since then has been the lack of publicly available data. While costly private industry data may be obtained (sometimes for a nominal fee or even free from some of our colleagues interested in the outcome of research from papers such as this), it is paramount for the success of an efficiency study or for an efficient market that this data be available. Truly the movement of the CBOT ethanol prices has lent support for obtaining richer data to examine ethanol pricing. However, the data to compare contract prices with cash prices still leaves much to be desired.

For instance, the correlation of CBOT ethanol nearby contract prices with cash prices obtained through a private data source earlier in this analysis from March 23, 2005 to February 3, 2006 was 98.3%. One might expect an increase in this correlation as the contract trade volume and open interest increased further beyond the date of the initial launch. However, using USDA's Agricultural Market Service Livestock and Grain Market News Branch data for cash ethanol prices in Iowa (there is only now data starting to be collected for Chicago and it is quite thin), and examining the correlation with CBOT ethanol contract prices, one can find a correlation coefficient of roughly 94%.

While the data from USDA-AMS provides publicly accessible data, it is reported in a weekly high-low format and is relatively thin due to a lack of reporting for this area. Arguably, the lack of daily price movement and using a midpoint of the high and low prices reported takes away from the richness one would expect from a "for-cost" private report. Just how reliable these private data sources are is also an unknown with no standard existing to benchmark against.

Data Requirements and Future Research

The Summary of the 2006 USDA Data Users Meeting expressed concerns over data available for energy and specifically co-products of the ethanol industry. While several governmental data resources exist, a great deal of estimation and backwards induction is used rather than factual reporting in the area of ethanol and biofuels in general. This was identified as an area of need and where feedback is sought from data users for the importance of this heretofore unavailable direct information. Indeed it is an area where more foundational data is needed for greater transparency and usefulness to the energy sector, consumers, and those who seek to participate in the supply and utilization of commodities associated with renewable fuels.

While conducting this analysis with updated information using the techniques put forth would provide useful results in examining the CBOT contracts in light of their expanded use and longer existence, utilizing more readily verifiable source data should provide even more rigorous results.

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