An Insurance Approach to Risk Management in the Ethanol Industry

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The vast majority of crop and revenue insurance policies sold in the United States are single-crop policies that insure against low yields or revenues for each crop grown on the farm. But, increasingly, producer income is based more on the value of crops that have been converted into a value-added product such as ethanol. Moreover, the recent increases in energy and commodity price levels and volatilities emphasize the importance of risk management to ethanol investors. This paper uses an insurance approach to outline a risk management tool which mimics the gross margin level of a typical corn-based ethanol plant. The gross margin, premium, and indemnity levels are calculated on a per bushel basis to enable producers/investors to utilize the product based on their ownership share in the production facility. The fair premium rates are shown to be quite sensitive with respect to corn and energy price levels and volatilities.

Key Words: corn-based ethanol, insurance, risk management, correlation, Monte Carlo

Value-added enterprises, such as ethanol production, have recently gained interest as tools that farmers can use to create new markets for their products. According to the Renewable Fuels Association (RFA 2007), there are currently more than 100 plants producing ethanol in 26 states in the United States.[1] These facilities comprise a total production capacity of more than 5.5 billion gallons per year, nearly three times the production capacity in 2001. More than 80 plants, with the potential to double the production capacity in the United States, are reportedly under construction. In 2006, 4.9 billion gallons of ethanol were produced in the United States using nearly 1.8 billion bushels of corn, roughly 17 percent of total U.S. corn production (RFA 2007).

The majority of ethanol plants use corn as the feedstock in the production process, increasing demand for corn by creating new markets for corn producers. Generally, investors in ethanol production are required to provide an initial investment to purchase ownership rights in the facility and then receive premium payments based on plant profitability in addition to any payments they may receive for corn marketed to the plant. In the case of farmer-ownership, membership "shares" are often sold on a per bushel basis, potentially tied to a designated delivery requirement, with premium payments made based on each producer's proportion of ownership (share of total bushels processed). These new investment opportunities help to boost corn prices by enhancing demand through market creation. However, ownership in an ethanol production facility also exposes the investor to global and domestic energy market risk.

In March 2005, the Chicago Board of Trade (CBOT) introduced one of the first market-based risk management tools designed specifically for

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[1] The vast majority of U.S. ethanol plants are concentrated in the Midwestern states of Iowa, Illinois, Kansas, Minnesota, Nebraska, and South Dakota.

the ethanol industry in the form of a futures contract for denatured ethanol. However, the short trading history of the ethanol futures has shown relatively low trading volumes[2] and little price volatility relative to ethanol cash markets. Moreover, the market still lacks an exchange traded options contract on ethanol, further limiting the risk management options available to both plant managers and farmers invested in ethanol production.

It is estimated that ethanol production in the United States will reach over 12 billion gallons by 2010, with ethanol prices declining over the same period, as growth in production outpaces demand (FAPRI 2007). Ethanol's increasing demand for corn is expected to lead to higher corn prices and to more acres being devoted to corn, an effect already being seen with an estimated 90 million acres planted to corn in 2007. The dual effects of higher corn prices and lower ethanol prices will tighten profit margins in the ethanol industry and slow investment (Elobeid et al. 2006). Moreover, high price volatility for both corn and ethanol are expected over the next few years as the industry continues to rapidly expand (Hart 2005). Therefore, the availability of effective risk management tools for the ethanol industry is likely to become more important and valuable to ethanol investors and plant managers.

Farmers investing in an ethanol plant are employing a risk management strategy by diversifying, similar to investing in livestock operations. Many farmers have also chosen to participate in crop insurance to protect their livelihood, in addition to adopting diversification strategies. The vast majority of crop and revenue insurance policies sold in the United States are single-crop policies that insure against low yields or revenues for each crop grown on the farm. But, increasingly, producer income is based more on the value of crops that have been converted into a value-added product. Insurance against declines in the value-added portion of the crop is limited; for example, agricultural producers can insure the relative financial performance of livestock via products such as Livestock Risk Protection (LRP) and Livestock Gross Margin (LGM). Following a similar vein, this paper develops an insurance product/ risk management tool aimed at corn producers who are involved in ethanol production to insure against poor financial performance of the facility over a given time period.

The risks faced by an investor in ethanol production include both output and input price volatility in any single period as well as the narrowing of profit margins over time relative to the levels at which the investment decision was based. While the importance of the second longer-term source of risk should not be overlooked, the focus of this research is on the management of the risk created by price volatilities during a given time or production period. The use of the risk management tool outlined in this paper is limited to the period for which coverage is provided.

To maintain the linkage with crop insurance, this tool is outlined for corn producers, but arguably could be adapted for use by any ethanol investor and/or plant manager. By insuring against circumstances that cause low profits for ethanol plants, the product would provide value to its owner during periods of low premium payments from ethanol plants. The product mimics the gross margin level of a typical ethanol production facility that implements the dry-mill production process using corn as the feedstock. The gross margin, premium, and indemnity levels are calculated on a per bushel basis to enable producers to utilize the product based on how many bushels of corn they intend to market to the ethanol facility over the contract year. The fair premium rates are shown to be quite sensitive with respect to corn and energy price levels and volatilities. An historical analysis is also included to assess potential performance of the policy. Finally, a brief discussion of other risk management alternatives, including the ethanol futures market, and some concluding comments are provided.

Contract Design

Based on numerous sources (Bryan and Bryan, Inc. 2000, RFA 2007, Hart 2005, Elobeid et al.

[2] As of June 1, 2007, there have been a maximum of 966 (28 million gallons) contracts of open interest on the ethanol futures, with most trading days closing with 400–500 (11.6–14.5 million gallons) contracts of open interest. Total trading volume in ethanol futures is also quite low and relatively sporadic, with 5–10 days of zero trading being rather common. The Chicago Mercantile Exchange (CME) also offered a corn-based ethanol futures contract that was traded on its Globex electronic exchange. However, in August of 2007, CME announced that it would be delisting its ethanol futures contracts as of September 2007. This was attributed to low trading volumes, but could potentially be related to the recent merger between CME and CBOT to form the CME Group.

2006), the dry-mill process converts corn into ethanol according to the following relationship:

Inputs	1.0 bushel (bu) of corn
	0.165 million British thermal units (mmBtu) of energy (natural gas)
Outputs:	2.7 gallons of ethanol
	17 pounds of distillers dried grains with solubles (DDGS)

Given the fixed-proportions technology, price risk in input and output markets is assumed to be relatively more important than any source of production risk associated with the technology. However, while the technology outlined above characterizes most all dry-mill ethanol plants, fixed and overhead cost structures will typically differ between facilities and regions. Therefore, our focus was on covering a gross margin index for a typical dry-mill plant rather than a measure of a net profit margin.

The policy was designed as an exotic Asian basket option, where the payout at maturity will equal the difference (if positive) between the value of an asset portfolio and a set strike value. Hart, Babcock, and Hayes (2001) used similar methods in developing various types of livestock revenue insurance products for cattle and hog producers. The policy was designed to insure the average gross margin of an ethanol production facility, per bushel of corn processed, over the life of the contract.

Expected commodity price levels and the fixed proportions technology determine the guaranteed level of gross margin according to

(1)
$$MarGuar_t = E_t \begin{bmatrix} 2.7 * ETHP_{T>t} + 0.0085 * DDGP_{T>t} \\ -CORNP_{T>t} - 0.165 * NGP_{T>t} \end{bmatrix}.$$

The operator E_t denotes expectations at time t, $MarGuar_t$ is the guaranteed (expected) level of the gross margin index ($/bushel) at time t, and $ETHP_{T>t}$ is the average ethanol price ($/gal) over the life of the contract ending at $T>t$. Similarly, $DDGP_{T>t}$, $CORNP_{T>t}$, and $NGP_{T>t}$ are the average DDGS ($/ton), corn ($/bu), and natural gas ($/mmBtu) prices, respectively, over the life of the contract.

At the end of the contract year, the actual gross margin measure used for indemnification is calculated using equation (1) and realized futures settlement prices throughout the contract year. For each commodity, the realized price levels would be calculated as the average settlement price over the settlement month for each contract throughout the year. In our example, the price levels used for each commodity in equation (1) would be taken as the simple averages of the settlement prices for each contract month.

At contract termination, contract owners receive an indemnity payment for each bushel insured equal to

(2)
$$Indemnity_T = \max_T \left[0, CL * MarGuar_t - MarAct_T\right],$$

where $\max_T$ denotes the maximum operator taken at time T, CL is the elected coverage level, and $MarAct_T$ is the realized level of the ethanol gross margin index at time T using the actual futures settlement prices in equation (1). The policy insures against downward price movements in ethanol and DDGS prices and upward movements in corn and natural gas prices. As an illustrative example, we structured the contract on an annual basis, assuming constant production throughout the year simply as an example. The methodology could easily be extended to different contract lengths or to place more weight on different periods throughout the life of the policy.

Expected Price Levels

Expected corn and natural gas prices were taken directly from the existing futures markets for these commodities [CBOT and New York Mercantile Exchange (NYMEX)].[3] Unleaded gasoline (NYMEX) and corn futures are used to proxy for the ethanol and DDGS price components of the margin guarantee, respectively.

DDGS is a type of feed ration additive used in many livestock industries as a substitute for corn. A monthly average DDGS price data series from Lawrenceburg, Indiana (USDA, *Feed Outlook* and *Feed Situation and Outlook Yearbook*), and average futures settlement prices for corn over the

[3] All futures price data were obtained from www.barchart.com.

same period (1997–2006) were used to identify a relationship between corn and DDGS prices. The simple correlation coefficient for the DDGS and corn price series was equal to 0.70. The data series for DDGS and corn prices are plotted in Figure 1. The DDGS price data were regressed against the corn futures data using ordinary least squares (OLS) to estimate the following model:

$$(3) \qquad DDGP_t = \alpha + \beta * CORNP_t + \varepsilon_t ,$$

where $DDGP_t$ is the DDGS price in month t (\$/ton), $CORNP_t$ is the corn price in month t (\$/bushel), and ε_t is a mean-zero error term. The intercept coefficient was not statistically significant and restricted to equal zero. The slope coefficient for the restricted model was estimated to be 39.17, implying that the value of DDGS is roughly 70 percent that of corn on a pound-for-pound basis. The full set of regression results is reported in Table 1.[4]

While an ethanol futures market does exist, the short trading history does not provide a reliable historical relationship with prices in the corn and natural gas markets, and low trading volumes coupled with growing concentration in the industry could lead to potential moral hazard problems for the policy. Moreover, the lack of an ethanol options market restricted the use of ethanol futures for our purposes due to the lack of information on ethanol price volatility.

Ethanol is used mainly as a fuel additive in unleaded gasoline to improve emissions and reduce dependence on non-renewable fossil fuels. Historically, there has been a strong relationship between ethanol and unleaded gasoline prices. An average monthly price series of ethanol and unleaded gasoline rack (wholesale) prices from Omaha, Nebraska [Nebraska Energy Office (NEO)], and unleaded gasoline futures settlement prices averaged over the settlement month were used to estimate the pricing relationship and are plotted in Figure 2. The NEO ethanol and unleaded price series had a simple correlation coefficient of 0.89. The ethanol price series was regressed against the unleaded gasoline futures price series to estimate the following simple linear model:

$$(4) \qquad ETHP_t = \alpha + \beta * UNLP_t + \mu_t ,$$

where $ETHP_t$ denotes the ethanol price in month t (\$/gallon), $UNLP_t$ is the unleaded gasoline price in month t (\$/gallon), and μ_t is a mean-zero disturbance. The coefficient estimates, standard errors, and the R^2 value are reported in Table 1. Note that the regression results imply that wholesale ethanol in Omaha is priced at roughly 90 percent the price of wholesale gasoline plus the federal tax credit (\$0.51 per gallon).

Another alternative related to equation (4) would be to assume that ethanol is priced at its energy equivalent value of 67 percent of gasoline plus the federal tax credit of \$0.51 per gallon. The energy equivalence approach has been used to model long-term outlooks for the ethanol and corn industries (FAPRI 2007, Elobeid et al. 2006). All of the following results are reported using the regression estimates from equation (4) reported in the final row of Table 1. However, we have also calculated all results using the energy equivalence approach. These results are quantitatively similar to those reported here and are available from the authors upon request.

To establish the margin guarantee in equation (1), expected price levels for all commodities were taken as the average of the relevant futures contract settlement price over the first five trading days in March of the contract year. For example, the expected price for corn in December of the contract year was taken as the average futures quote for the December corn contract over the first five trading days in March of the contract year. The expected price levels for corn and gasoline were used with equations (3) and (4) to calculate predicted price levels for DDGS and ethanol, respectively.

Historically, unleaded gasoline futures have not always been traded out for a full year from the month of March. In years in which futures quotes were not traded a full year out, the crude oil market was used to create synthetic unleaded gasoline futures. Oil futures historically have been traded over a full year out, with the historical monthly correlation between unleaded gasoline and crude oil futures settlement prices averaging 0.98. The

[4] Data covering alternative time periods and alternative regression specifications were also examined. The regression estimates were found to be robust for the period analyzed, and the simple linear form provided the best fit to the data.

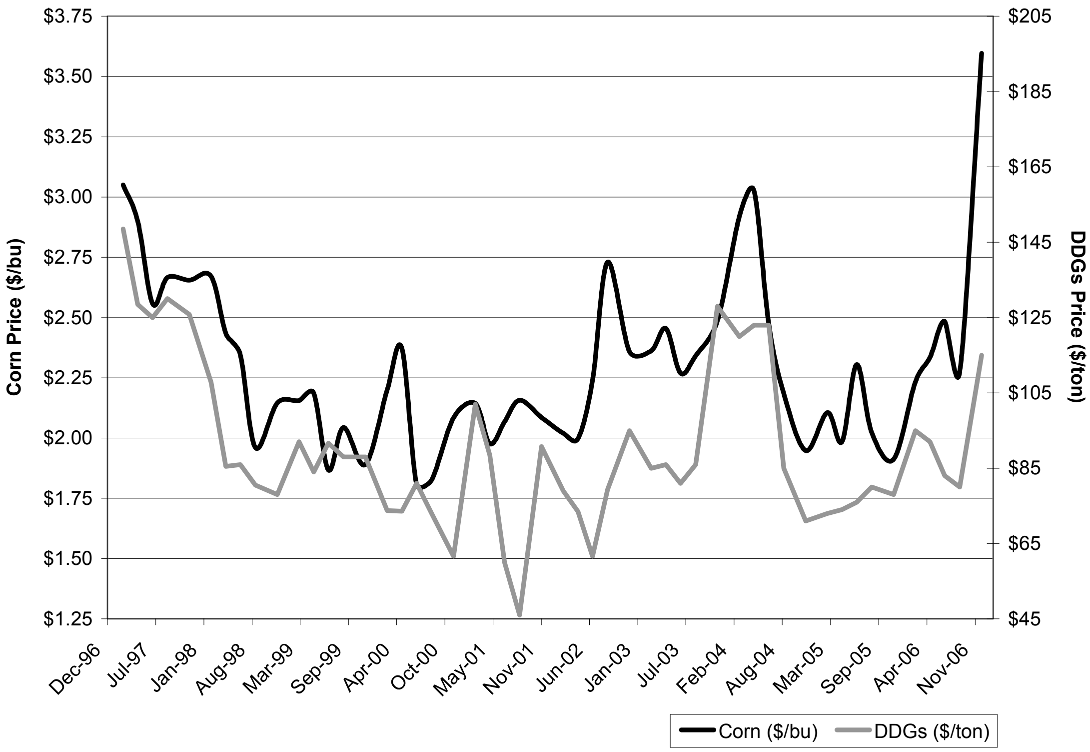

Figure 1. Monthly Averages of DDGS and Corn Futures Settlement Prices (January 1997 through December 2006)

Source: Barchart.com (for corn). USDA (*Feed Outlook* and *Feed Situation and Outlook Yearbook*) (for DDGS).

Table 1. Summary Statistics for Regression Equations (3) and (4)

Equation	Dependent Variable	Independent Variable	$\hat{\alpha}$ (S.E.)	$\hat{\beta}$ (S.E.)	R^2
(3)	$DDGP_t$	$CORNP_t$	0.00 (-)	39.17 (0.944)	*
(4)	$ETHP_t$	$UNLP_t$	0.54 (0.050)	0.90 (0.042)	0.78

* The conventional R^2 value is invalid when restrictions are imposed on the parameters.

synthetic unleaded prices were calculated by taking the percentage change in the predicted crude oil price from one contract month to the next and extrapolating that change onto the expected price for gasoline. For example, in March 1997, the unleaded gasoline futures market was trading out through the December 1997 contract. The expected price for unleaded gasoline for the January 1998 contract was calculated by extrapolating the percentage change in price from the December 1997 to the January 1998 crude oil contract quotes.

Because the value of the policy is determined solely by futures contract prices and a fixed technology process, any moral hazard problem is minimized. Single agents do not have the ability to affect price levels and therefore cannot affect the likelihood of receiving payments. The fact

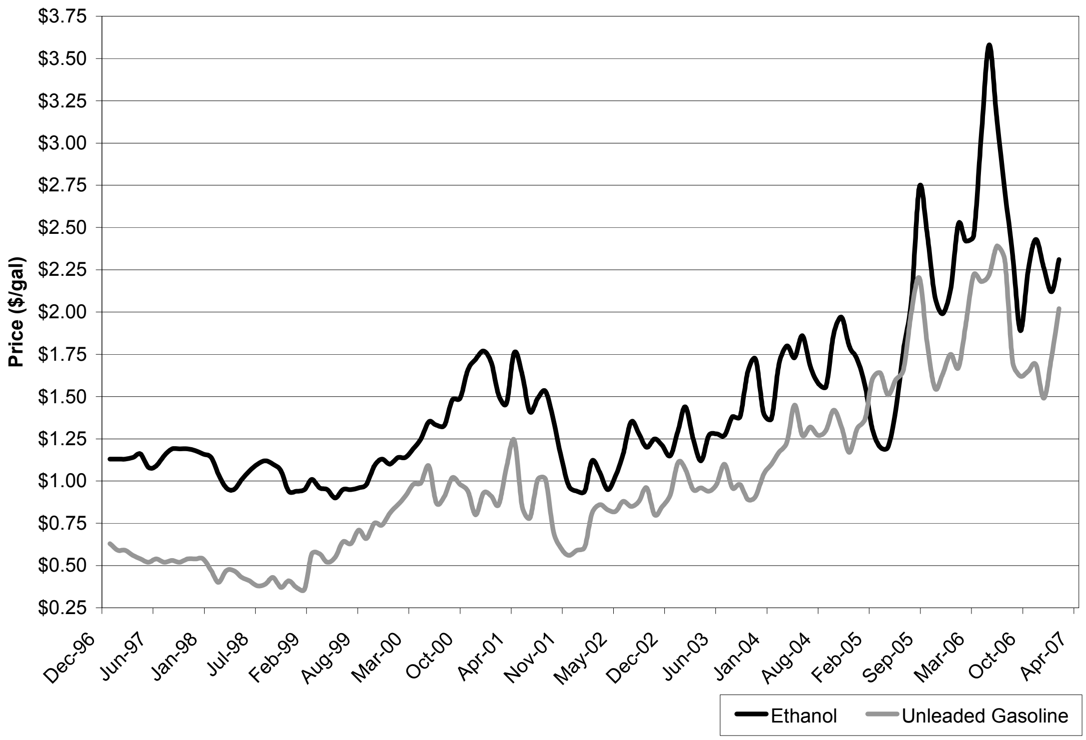

Figure 2. Monthly Average Wholesale Prices for Ethanol and Unleaded Gasoline in Omaha, Nebraska (January 1997 through May 2007)

Source: NEO (2007).

that the policy is based entirely on futures raises the question of why it is needed. Or, why would an investor choose insurance rather than cross-hedging directly using the existing futures and options contracts in such a way that mimics the margin index? One of the main benefits of the insurance approach is the ability to scale coverage to each individual investor's level of exposure rather than limiting the risk management ability to the size of futures and options contracts. The recent success of the livestock insurance programs (LGM and LRP), which are also based on futures, implies that there is demand for these types of products that are tailored to the buyer (in our case an ethanol investor).

Premium Determination

A Monte Carlo approach was used to calculate the fair premium levels and rates. For this analysis, the margin guarantee was calculated using expected prices taken from the first five trading days of March as outlined in the previous section. Assuming futures market efficiency, we generated 5,000 random draws for each of the 29 commodity prices.[5] The means for each price distribution were taken as the expected price levels from futures quotes for each contract at their trading levels in March. Implied volatilities, adjusted for time to maturity, were derived from at-the-money options quotes for the relevant commodity futures contracts over the first five days in March. As an illustration of this process, we used futures price quotes and implied volatilities from March 2007. A summary of the parameterization of the price distributions is available from the authors upon request.

[5] There are 5 corn futures contracts traded over any one-year period, and 12 futures contracts traded for both gasoline and natural gas, resulting in 29 price distributions.

Each set of 5,000 draws represents a distribution of commodity price realizations for a specific contract month during the coverage period of the policy. All prices were assumed to follow a lognormal distribution. Because the prices used in the insurance product are average prices over each settlement month, we faced the issue that the sum of lognormal random variables is not lognormal. The sum, or average, of lognormal random variables has no closed-form probability density function. Two analytical approximations have been employed in recent literature, using either a lognormal or an inverse gamma distribution as an approximation. Turnbull and Wakeman (1991) and Levy (1992) have supported the use of a lognormal distribution as a good approximation for volatilities ranging from 10–30 percent. However, Levy (1997) showed that the lognormal approximation does not fare as well when volatilities increase beyond 50 percent. For this analysis, the lognormal approximation was employed for all of the price distributions.

Imposing Correlation

In implementing the Monte Carlo procedure, incorporating the correlation among the variables is extremely important because it eliminates unrealistic price scenarios from the analysis. The target correlation structure was taken from the historical price data. A method proposed by Iman and Conover (1982) was used to impose the historical correlation structure.[6] The correlations used in the procedure are the rank correlations among the price variables. The method has recently been used in other related studies to design and rate livestock revenue insurance (Hart, Babcock, and Hayes 2001) and whole-farm insurance (Hart, Hayes, and Babcock 2006).

The Iman and Conover (IC) (1982) method is fully transparent; the only manipulation to the independently generated marginal distributions is a resorting of the data based on the Cholesky decomposition of the target correlation structure. Thus, the technique preserves the properties of each marginal distribution while changing the relationships among the series. The IC method can be used with any marginal distribution and is relatively simple in that Cholesky factorization and inversion of matrices are the most exotic steps used in the procedure. The only limitation to the IC method is that the target correlation structure must be positive definite.

The theoretical basis for the procedure is that given a random matrix X whose columns have a correlation matrix I (the identity matrix) and a desired correlation matrix D, there exists a transformation matrix T such that the columns of XT' (where T' is the transpose of T) have a correlation matrix equal to D . Since D is positive definite and symmetric, there exists a lower triangular matrix (the transformation matrix) T such that $D = TT'$. The IC procedure, given a set of independent random marginal draws (X), imposes the ranking structure by resorting the draws such that their rank correlation matrix equals the desired structure (D).

Historical corn futures settlement prices from May 1997 through March 2007 and gasoline and natural gas futures price data from April 1997 through March 2007 were used to calculate the historical rank correlations. The difference, in percentage terms, of the actual settlement price from the expected price levels for each commodity and contract month were calculated for each contract year, taking expected and actual settlement prices as defined in the previous section. The rank correlation matrix of these percentage price deviates were then calculated using Spearman's rho.

For the IC method to be employed, the target matrix must be positive-definite, a restriction that the calculated matrix did not meet. The historical rank correlation matrix was modified to create a positive-definite matrix that followed the same general historical correlation structure. The modifications performed differ by commodity. The intertemporal correlations for the corn price deviates were left unchanged. The intercommodity and intertemporal correlations between the corn,

[6] Two other methods are commonly used in the literature to impose correlation on random draws. Johnson and Tenenbein (1981) outline a method where correlation is imposed using a weighted linear combination of two independent draws. This method is better suited to situations where the number of marginal distributions is small. The copula approach is another alternative which is well known in the financial literature. The copula method provides an improvement to the Johnson and Tenenbein method as it is easily implemented for any number of distributions, and it is more flexible than the Iman and Conover (1982) method because positive definiteness is not required. Haas (1999) shows similar results from using the Iman and Conover and copula approaches. For comparison and validation, we use a copula approach to calculate fair premiums and rates for the example policy. The rates derived from the Iman and Conover and copula approaches differed by less than 0.2 percent at all coverage levels.

unleaded gasoline, and natural gas price deviates were set at their respective average values. The intertemporal correlations for the unleaded gasoline and natural gas price deviates were transformed using a simple linear regression model based on the time lag between contracts:

$$(5)\qquad RankCorr_{i,j} = 1 + \beta * Lag_{i,j} + \nu_{i,j}\ .$$

In equation (5) $RankCorr_{i,j}$ denotes the intertemporal rank correlation between contracts i and j; $Lag_{i,j}$ is the time lag, in months, between contracts i and j; and $\nu_{i,j}$ is a mean-zero disturbance.

For example, the January and March natural gas contracts have a time lag of two months. The dependent variable in the estimated model would be the value of the calculated correlation between January and March natural gas price deviations, while the independent variable for that data point would equal the time lag of two months. The estimated slope coefficients were negative for both models, implying that as the time lag between contracts gets larger the correlation decreases. This estimated relationship parallels the correlation structure in the historical matrix. The coefficient estimates, standard errors, and t-statistics for both correlation models are summarized in Table 2. The actual historical and modified rank correlation matrices are available from the authors upon request.

Table 2. Summary Statistics for the Rank Correlation Regression Models

Dependent Variable	Independent Variable	$\hat{\alpha}$ (S.E.)	$\hat{\beta}$ (S.E.)
Unleaded intertemporal correlations	Time lag (months)	1 (-)	-0.088 (0.004)
Natural gas intertemporal correlations	Time lag (months)	1 (-)	-0.067 (0.003)

Results

Fair premiums were determined for the 2007 contract year using the correlated Monte Carlo price draws and equation (1) to generate 5,000 gross margin realizations. The value of the indemnity was calculated for each margin realization, with fair premiums set equal to the average indemnity payment across the draws. The expected gross margin for ethanol for the 2007 contract year was $1.66 per bushel of corn processed.

Table 3 summarizes the estimated fair premiums at various coverage levels. In 2007, policyholders would pay $0.376 per bushel for full coverage; this equates to a premium rate of 22.6 percent. Premium levels and rates fall as the level of coverage is decreased. At a 65 percent coverage level, the gross margin insurance rate was estimated to be 9.4 percent with a $0.10 per bushel premium. While these premium rates seem high relative to typical crop insurance rates for crops grown in the Midwest such as corn and soybeans, they are quite comparable to typical insurance rates for other crops in higher risk regions. For example, rates for yield insurance on cotton in many areas of Texas can range from 15–20 percent at the highest coverage levels (85 percent). The high premium rates further illustrate the high level of volatility implied by market expectations in the ethanol industry.

The distributions of the uninsured actual gross margin and the gross margin when insurance is purchased at a coverage level of 75 percent are illustrated in Figure 3. The margin insurance eliminates a 33 percent chance of the gross margin index falling below the 75 percent coverage guarantee less the fair premium.

Sensitivity analysis was conducted on the fair premium rates with respect to the expected price levels and volatilities. A 20 percent reduction in expected price levels results in premium rate reductions of 3–4 percent, with slightly larger rate reductions at higher coverage levels. Similarly, reducing the annualized price volatilities for all commodities and contract months reduces premium rates at all coverage levels. The magnitude of the premium rate reduction is just slightly larger than the effect of the 20 percent reduction in expected price levels for each reported coverage level.

Historical Analysis

Margin guarantees, actual margins, and indemnity payments were calculated from 1991 through 2006. Table 4 reports historical expected and actual gross margins and indemnities at various

Table 3. Premiums at Various Coverage Levels

Coverage Level (percent)	Margin Guarantee ($/bu)	Premium ($/bu)	Rate (percent)
50	0.83	0.088	6.1
65	1.08	0.100	9.4
70	1.16	0.179	10.8
75	1.25	0.205	12.3
80	1.33	0.233	14.0
85	1.41	0.264	15.9
90	1.50	0.298	17.9
95	1.58	0.336	20.2
100	1.66	0.376	22.6

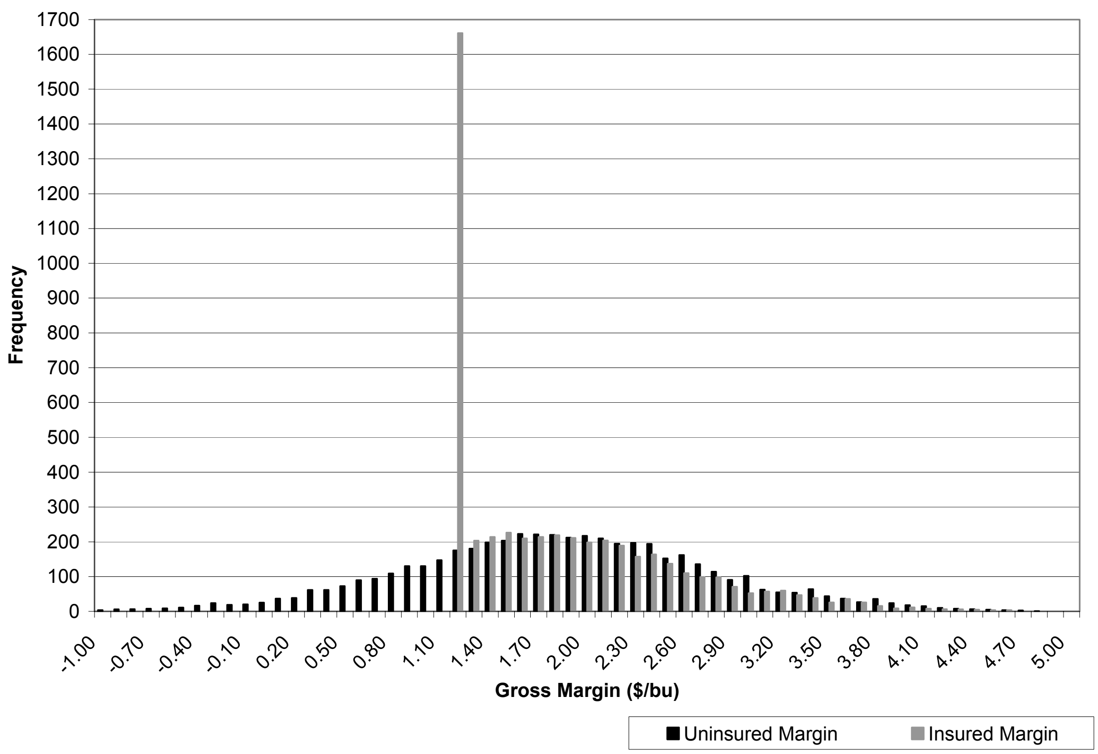

Figure 3. Distributions of Uninsured Ethanol Gross Margins and Insured Gross Margins at a 75 Percent Coverage Level

coverage levels. Indemnities would have been paid in 1993, 1995, and 1996. Corn markets were highly volatile in 1993, 1995, and 1996. The expected prices for corn were well below the actual settlement levels in all three years. The average expected values were $0.16, $0.59, and $0.47 below the actual average settlement prices for 1993, 1995, and 1996, respectively. The average

Table 4. Historical Margins and Indemnities ($/bushel)

			Indemnities			
Year	Projected Margin	Actual Margin	70%	80%	90%	100%
2006	2.86	2.94	0.00	0.00	0.00	0.00
2005	2.22	2.70	0.00	0.00	0.00	0.00
2004	0.95	1.89	0.00	0.00	0.00	0.00
2003	1.11	1.11	0.00	0.00	0.00	0.00
2002	1.16	1.24	0.00	0.00	0.00	0.00
2001	0.90	1.35	0.00	0.00	0.00	0.00
2000	1.28	1.46	0.00	0.00	0.00	0.00
1999	0.61	1.23	0.00	0.00	0.00	0.00
1998	0.42	0.69	0.00	0.00	0.00	0.00
1997	0.58	0.71	0.00	0.00	0.00	0.00
1996	0.13	0.02	0.07	0.08	0.10	0.11
1995	0.81	0.44	0.12	0.20	0.28	0.36
1994	0.34	0.86	0.00	0.00	0.00	0.00
1993	1.01	0.66	0.05	0.15	0.25	0.35
1992	0.75	1.07	0.00	0.00	0.00	0.00
1991	0.82	1.11	0.00	0.00	0.00	0.00
Total			0.24	0.44	0.63	0.83

Note: Margins and indemnities are reported in nominal terms with no time discounting.

price of unleaded gasoline settled below expectations in 1993 by $0.08, further increasing the level of the indemnity in that year. In 1995 and 1996, average unleaded gasoline prices settled below expected levels by $0.02 and $0.12, respectively, but these effects were outweighed by the higher than expected corn prices in those years.

On average, the expected price of unleaded gasoline was $0.07 (9 percent) lower than the actual price levels used in contract settlement. The expected prices for natural gas also exhibited a negative bias of $0.18 (5.2 percent). The expected prices for corn were, on average, $0.12 (4.6 percent) higher than the actual prices used in contract settlement. The negative and positive biases in the gasoline and corn markets, respectively, both caused a decrease in the net value (indemnity less premium) of the product. The negative bias in the natural gas market would increase the value of the product, but the marginal effect of changes in natural gas prices on the margin index is small relative to the effects of changes in corn and gasoline prices. It should be noted that these biases were calculated only as averages over the historical period analyzed. Futures market bias should be virtually eliminated by arbitrage, on average, if examined over a longer time interval.

Conclusions

Over the past 15 years, the corn-based ethanol industry in the United States has grown at an alarming rate, with a significant proportion of the investment capital coming directly from corn producers. These farmer-owned ethanol facilities provide a natural diversification vehicle to farmers similar to livestock production and have led to higher corn prices through market creation. However, investment in ethanol production will also increase the investors' risk exposure to global and domestic energy markets.

While the CBOT created a futures market for denatured ethanol, risk-management opportunities in the ethanol industry are still limited. Profit margins have been large thanks to government support at both the state and federal levels. However, as the industry continues to expand, corn prices are expected to continue to rise while ethanol margins shrink (FAPRI 2007, Elobeid et al. 2006). Moreover, the continued expansion of the industry is expected to lead to increased corn price volatility (Hart 2005). Therefore, the need for effective risk management tools may become increasingly important for the continued success of the industry.

Currently, a wide variety of insurance products are available to agricultural producers to insure against yield or price risks in the markets for the raw commodities they produce. But, increasingly, producer income is based more on the value of crops that have been converted into a value-added product. However, insurance against declines in the value-added portion of the crop is limited to just a few policies designed for livestock operations.

This research has outlined the development of an insurance product to provide coverage for an ethanol gross margin index based on corn, unleaded gasoline, and natural gas futures markets. The product was structured to insure against price risks in the markets for corn, DDGS, ethanol, and natural gas. The gross margin index and fair premiums and rates were calculated on a per bushel basis to enable buyers to scale their use of the policy based on their ownership share in an ethanol facility.

The historical correlation structure was imposed on the simulated price data using a method proposed by Iman and Conover (1982). Monte Carlo analysis was used to calculate fair premiums at various coverage levels based on expected corn, gasoline, and natural gas prices and implied volatilities for 2007. Actuarially fair premium rates were estimated to range from 22.6 percent of the margin index guarantee at full coverage to 6.1 percent at a 50 percent coverage level. While the estimated fair premium rates are much higher than typical unsubsidized rates for crop yield insurance for corn and soybeans in the Midwest, they are more comparable with rates for insurance for other crops and regions, such as cotton in many areas of Texas.

Historical analysis was carried out to examine how the product would have performed had it been offered from 1991–2006. The product was shown to perform as intended, paying indemnities in years when input and output prices deviated such that the realized value of the gross margin index was below expectations at contract signing. Sensitivity analysis was also performed to determine the effects of price and volatility levels on the fair premiums. Premium rates decrease (increase) as price levels and volatilities decrease (increase).

While a specific contract example was outlined, the methodology was shown to be robust and flexible to a variety of other policy specifications. A few contract design alternatives have already been mentioned, including varying the length of the contract life as well as using the energy equivalence approach in calculating the ethanol price index from unleaded futures prices. A standard option contract would be another way of approaching ethanol gross margin coverage, where the buyer would choose a strike level for the contract rather than a coverage level of the expected margin. This would provide buyers some flexibility in being able to lock in a given margin floor, such as their break-even level, no matter what margin levels are expected in any given period.

The ethanol futures market and its incorporation into the margin contract also warrants discussion. The biggest obstacles to the direct use of the ethanol futures in our example contract were the low trading volumes, short trading history, and lack of an ethanol options market to reveal price volatility. As ethanol futures trading continues, it may be easier to identify the relationship between ethanol, corn, and natural gas futures. However, the price volatility of ethanol would still need to be identified, and trading volumes would have to increase to a level that would restrict the opportunities for moral hazard. Alternative contract design and the incorporation of the ethanol futures market into the gross margin index are potential areas for further research.

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