Insuring Uncertainty in Value-Added Agriculture:
Ethanol Production

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Abstract

A wide variety of insurance products is available to agricultural producers to insure against yield or price risks in the markets for the raw commodities they produce. Value-added enterprises, such as ethanol production, have been expanding over the last decade. This paper outlines the development of an insurance product aimed at corn producers who are members of an ethanol production cooperative. The product has the potential to provide these producers with a new and useful risk management tool to insure against price risks in the markets for corn, distillers dried grains with solubles (DDGS), ethanol, and natural gas. Monte Carlo analysis is used to develop fair premiums at various coverage levels. A historical correlation structure is imposed on the simulated price data using a method proposed by Iman and Conover (1982), which maintains the marginal distributions of the variables. Historical analysis is carried out to examine how the product would have performed had it been offered over the last decade. The product is shown to perform as intended, paying indemnities in years of extreme price volatility.

Keywords: correlations, ethanol, insurance, risk management, value-added agriculture.

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Introduction

Value-added enterprises, such as ethanol production, have recently gained interest as tools farmers can use to create new markets for their products. According to the Renewable Fuels Association (2004), there are more than 80 ethanol production facilities operating, expanding, or under construction in the United States. These facilities comprise a total production capacity of more than 3.6 billion gallons annually in the United States, up more than 40 percent from the capacity in 2001. In 2004, the national ethanol industry will consume 1.35 billion bushels of corn, or 13 percent of expected 2004 corn production.

The majority of ethanol plants use corn as the feedstock in the production process, creating new markets for corn producers. Many of these production facilities are set up as cooperatives, in which producers are required to provide an initial investment to become a member of the cooperative and then receive premium payments based on plant profitability, in addition to the payments they receive for the grain they market to the facility. In most cases, membership "shares" are sold on a per bushel basis with a designated delivery requirement and with premium payments made based on each producer's proportion of total bushels processed.

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. These policies insure the commodity based on its value in its raw form. 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 not yet available.

This paper develops a risk management tool for corn producers who are involved in ethanol production to insure against poor financial performance of the facility. 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 Ethanol Production Process

The dry-mill process of producing ethanol using corn as a feedstock has reached a technological equilibrium in that the input-output ratio is a fixed relationship. According to the Iowa Value Added Resource Manual (Bryan and Bryan, Inc. 2000) and discussions with staff at the Iowa Renewable Fuels Association, the dry-mill process converts corn into ethanol according to the following input-output relationship:

Inputs: 1.0 bushel (bu) of corn

              0.165 million British thermal units (mmBtu) of natural gas

Outputs: 2.7 gallons of ethanol

              17 pounds of distillers dried grains with solubles (DDGS)

The insurance product is structured under these fixed technological assumptions and is aimed at agricultural producers who are members of an ethanol production cooperative. These cooperatives typically pay per bushel premiums on a quarterly or annual basis to their members, based on the performance and profitability of the cooperative. Therefore, this product mimics the level of gross margin an ethanol plant would achieve, which should be an adequate measure of the level of premiums paid out to the members. While the input-output ratio is fixed across operations, fixed and overhead cost structures will differ among ethanol plants. Therefore, the gross margin is insured rather than the net margin of an ethanol production facility.

Contract Details

This insurance product is an 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 contract insures the average annual gross margin of an ethanol production facility per bushel of corn processed. The contract is structured on an annual basis running from April through March to align insurance sales with the sales closing date for corn crop insurance policies sold in the Corn Belt. At sign-up, producers would need to provide information on the total number of bushels that will be marketed (or the ownership share in the facility expressed in bushels) to the ethanol facility during the contract year.

This product insures against price risks in two energy markets, ethanol and natural gas, and one raw agricultural commodity market, corn. The majority of the ethanol cooperatives have annual delivery requirements for each member based on their proportion of ownership in the facility. The construction of this insurance product is as an "add-on" product to existing crop insurance products. Only producers who are eligible to insure corn under a crop or revenue product would be eligible to purchase the product; therefore, production risk is not considered in the development of this product.

Projected commodity price levels and the fixed proportions of technology determine the guaranteed level of gross margin according to the following formula:

$$MarGuar = \frac{1}{12} * \left(2.7 * \sum_{t=1}^{12} ETHP_t + 0.0085 * \sum_{t=1}^{12} DDGP_t - \sum_{t=1}^{12} CORNP_t - 0.165 * \sum_{t=1}^{12} NGP_t \right) \qquad (1)$$

where *MarGuar* is the guaranteed level of average gross margin ($/bushel), $ETHP_t$ is the projected ethanol price in month t ($/gallon), $DDGP_t$ is the projected DDGS price in month t ($/ton), $CORNP_t$ is the projected corn price in month t ($/bushel), and NGP_t is the projected natural gas price in month t ($/mmBtu).

Price Projections

Projecting corn and natural gas prices can be accomplished directly using the futures markets for these commodities. However, there are currently no futures markets for ethanol or DDGS prices. Therefore, pricing proxies are developed for these two commodities in order to formulate the product.

DDGS is a type of feed ration additive used mainly in the dairy and poultry industries. Corn and soybean meal are two main substitutes for DDGS as a ration in

livestock feed. Both corn and soybean meal are traded on futures markets. Using a monthly average DDGS price data series from Lawrenceburgh, Indiana (1994-2002),[1] and average futures settlement prices for corn and soybean meal over the same period, the simple correlations between DDGS, corn, and soybean meal are calculated. The correlation between DDGS and corn prices is 0.775. The correlation between DDGS and soybean meal prices is 0.700. Because corn and DDGS exhibit a higher correlation, corn is used to develop a price proxy for DDGS. The data series for DDGS and corn prices are shown in Figure 1. The DDGS price data are regressed against the corn futures data using ordinary least squares (OLS) to estimate the following model:

$$DDGP_t = \alpha + \beta * CORNP_t + \varepsilon_t \tag{2}$$

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 zero-mean, homoskedastic error term.
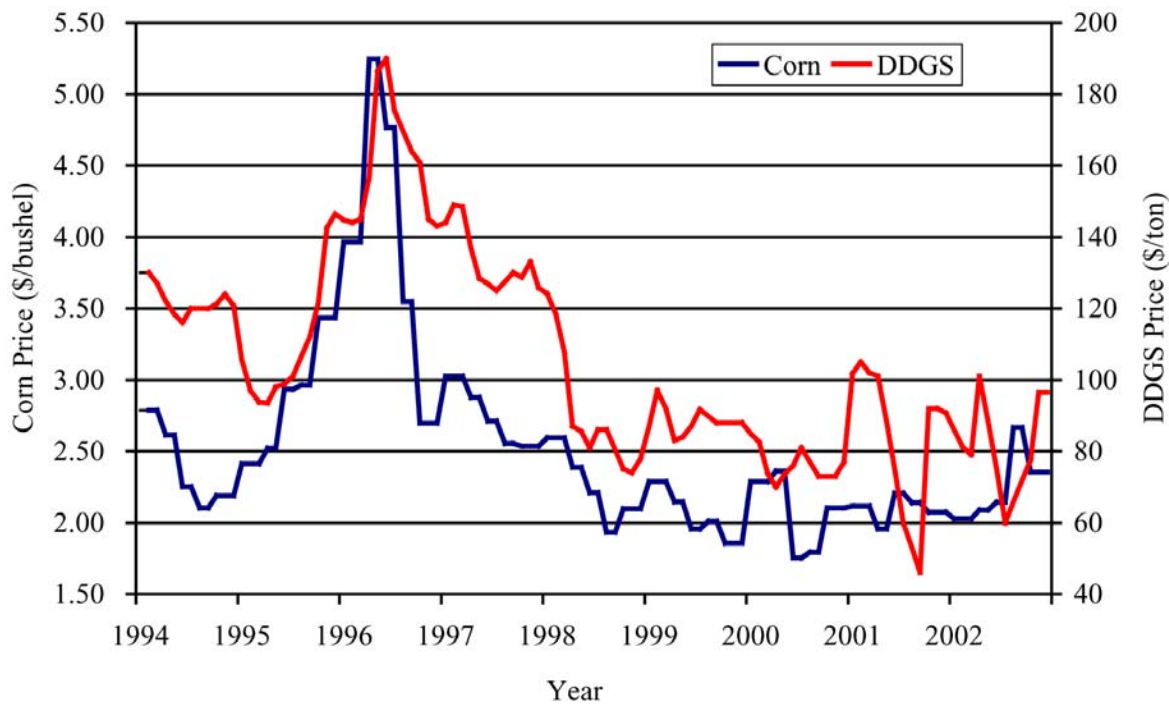
FIGURE 1. Monthly averages of distillers dried grains with solubles (DDGS) and corn (CBOT) futures prices, 1994-2002

Ethanol is used mainly as a fuel additive in unleaded gasoline to improve emissions and reduce dependence on nonrenewable fossil fuels. There is a fairly strong relationship between ethanol and unleaded gasoline prices. The simple correlation between unleaded gasoline and ethanol is 0.64. This correlation is calculated using an average monthly price series of ethanol rack prices from Omaha, Nebraska (Nebraska Ethanol Board 2004), and unleaded gasoline futures settlement prices averaged over the settlement month. The data series for ethanol and unleaded gasoline prices are plotted in Figure 2. The ethanol price series is regressed against the unleaded gasoline futures price series to estimate the following model:

$$ETHP_t = \alpha + \beta * UNLP_t + \varepsilon_t \qquad (3)$$

where $ETHP_t$ is the ethanol price in month t ($/gallon), $UNLP_t$ is the unleaded gasoline price in month t ($/gallon), and ε_t is a zero-mean, homoskedastic error term.
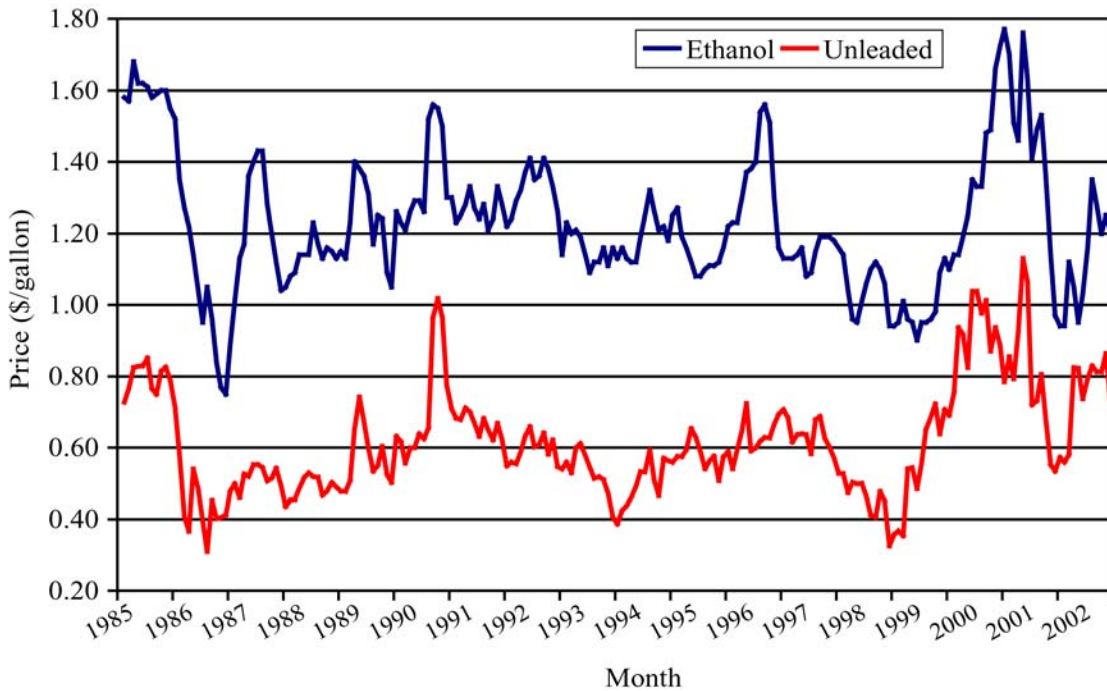

FIGURE 2. Monthly average prices for ethanol and unleaded gasoline, 1985-2002

The coefficient estimates, standard errors, and the R^2 value are reported in Table 1. According to Woolridge (2003), under the assumptions of the linear relationships for the price series and a zero-mean error term, the OLS regression coefficient estimates are unbiased (i.e., $E[\hat{\beta}] = \beta$). However, with the presence of serial correlation, the usual standard errors and t-statistics are not valid. Both regression models (equations [2] and [3]) are tested for first-order serial correlation. The results show strong evidence of first-order serial correlation. Given that we are not worried about t-statistics in rating this product, we choose to use the unbiased parameter estimates from the standard OLS approach. Results from equations (2) and (3) with the price data first-differenced are available from the authors.

The root mean squared errors (RMSE) are calculated for the pricing models to compare their predictive accuracy to that of the accuracy level in futures markets. Table 2 reports the RMSE for each commodity. The RMSE measures for corn, unleaded gasoline, and natural gas reflect the accuracy of the futures markets over the historical period

TABLE 1. Summary statistics for regression models (2) and (3)

Equation	Dependent Variable	Independent Variable	$\hat{\alpha}$ (S.E.)	$\hat{\beta}$ (S.E.)	R^2
2	$DDGP_t$	$CORNP_t$	19.52 (7.04)	34.00 (2.70)	0.60
3	$ETHP_t$	$UNLP_t$	0.72 (0.04)	0.82 (0.07)	0.42

Note: While the parameter estimates are unbiased, the standard errors are invalid because of serial correlation in the price series.

TABLE 2. Comparisons of root mean squared errors (RMSE) across commodities

Commodity	Market	RMSE	Average Price Level	RMSE
		(dollars)	(dollars)	(percent)
Corn	Futures	0.40	2.60	15.4
Unleaded Gasoline	Futures	0.12	0.60	19.6
Natural Gas	Futures	1.17	2.53	46.4
Ethanol	Regression	0.17	1.21	14.0
DDGS	Regression	17.45	105.14	16.6

analyzed. The RMSE measures for ethanol and DDGS reflect the level of accuracy of pricing models (2) and (3). The RMSE is reported in each commodity's typical measure of price per unit as well as on a percentage basis for comparison across markets. The base price level used in calculating the percentage-based RMSE is taken as the average over the predicted and actual price levels for each respective commodity.

Table 2 shows that the levels of accuracy achieved by the pricing models are quite comparable to the level of accuracy exhibited in the futures markets. In fact, the 14.0 percent and 16.6 percent levels of error calculated for the ethanol and DDGS regression models, respectively, are considerably lower than the level of error in the futures markets for unleaded gasoline and natural gas.

Projected prices are based on futures settlement prices[2] for corn from the Chicago Board of Trade and on unleaded gasoline and natural gas futures prices from the New York Mercantile Exchange. The projected prices for all commodities are 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 projected price for corn in December of the contract year is taken as the average of the futures quotes for the December corn contract over the first five trading days in March of the contract year. Non-contract month prices for corn are determined by linear interpolation between the previous and nearby contract months. The projected price levels for gasoline and corn are used with pricing models (2) and (3) to calculate price predictions for ethanol and DDGS.

Historically, unleaded gasoline futures have not always been traded out for a full year when analyzing March futures quotes. In years in which futures quotes were not traded a full year out, the crude oil market is used to create synthetic unleaded gasoline predictions. Oil futures historically have been traded over a full year out, with the historical monthly correlation between unleaded gasoline and crude oil futures prices averaging 0.98. The synthetic unleaded prices are 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 predicted price for gasoline. For example, in March 1997, the unleaded gasoline futures market was trading out through the December 1997 contract. The predicted 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 predictions.

At the end of the contract year, the actual gross margin level is determined using model (1) and actual price levels throughout the contract year. Actual corn prices are defined as the average futures settlement price over the first 10 trading days of the settlement month. Actual corn prices for non-contract months are determined by linear interpolation between the previous and nearby contract months. Actual unleaded gasoline and natural gas prices are taken as the average of the futures settlement prices over the entire settlement month.

At contract termination, contract owners would receive an indemnity payment for each bushel insured based on the following formula:

$$\text{Indemnity} = \max[0, CL*MarGuar - MarAct] \qquad (4)$$

where *CL* is the insured coverage level and *MarAct* is the observed level of the ethanol gross margin when the actual prices are placed in equation (1).

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

Premium Determination

To determine fair premium levels, Monte Carlo simulations are used. For this analysis, the projected prices are taken from the first five trading days of March. The analysis is based on 5,000 random draws of 29 commodity prices. Each set of 5,000 draws represents a distribution of commodity prices for a contract month. All prices are assumed to follow a lognormal distribution. Because the prices used in the insurance product are average prices, there is an 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 inverse gamma distribution to represent the required distribution. Turnbull and Wakeman (1991), and Levy (1992) have

supported the use of a lognormal distribution as a good approximation. However, Levy (1997) showed that the lognormal approximation does not fare as well when volatilities increase. For this analysis, the lognormal approximation is employed for all the price distributions.

The means for each price distribution are taken from the futures markets under the assumption that the efficient markets hypothesis holds. Implied volatilities, adjusted for time to maturity, are taken from at-the-money options quotes from the relevant commodity markets during the first week in March. As an illustration of this process, we use futures prices and price volatilities from March 2002. The Appendix contains a summary of the price distribution assumptions.

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 desired correlation structure is taken from historical price data, while a method proposed by Iman and Conover (1982) is used to impose the historical correlation structure. The correlations used in the procedure are the rank correlations among the price variables. The Iman and Conover method is fully transparent because the only manipulation to the original data is a resorting of the data. Thus, the technique preserves the original distributional structure of each data series while changing the relationships among the series.

Historical Rank Correlations

The rank correlation (r_s), also know as Spearman's rho, for a given set of paired data (x_i, y_i) is calculated by ranking the x's and y's from high to low (or low to high) and then substituting into the following formula:

$$r_s(x,y) = 1 - \frac{6 * \sum_{i=1}^{n} d_i^{\,2}}{n(n-1)^2} \tag{5}$$

where d_i is the difference between the ranks assigned to x_i and y_i and n is the sample size.

Historical corn futures prices from 1980 through 2002 and gasoline and natural gas price data from 1985 through 2002 and 1990 through 2002, respectively, were used to calculate the historical rank correlations. The difference between the predicted and actual

price levels for each commodity was calculated for each contract year, taking predicted and actual prices as defined in the contract details section. Rank correlations of these price deviates were then calculated pair-wise to maximize the amount of data available. The calculated historical rank correlation matrix is included in the Appendix (Table A.3).

For the Iman and Conover 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 historical correlation structure. The modifications performed differ by commodity. The intertemporal correlations for the corn price deviates are left unchanged. The intercommodity and intertemporal correlations between the corn, unleaded gasoline, and natural gas price deviates are set at their respective average values. The intertemporal correlations for the unleaded gasoline and natural gas price deviates are transformed using the following linear regression model:

$$RankCorr_{i,j} = \alpha + \beta * Lag_{i,j} + \varepsilon_{i,j} \qquad (6)$$

where $RankCorr_{i,j}$ is the intertemporal rank correlation between months i and j; $Lag_{i,j}$ is the time lag, in months, between months i and j; and $\varepsilon_{i,j}$ is a zero-mean, homoskedastic error term for lag between months i and j.

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 are negative for both models, which implies that as the time lag between contracts gets larger, the correlation decreases, which parallels the correlation structure in the historical matrix. The coefficient estimates, standard errors, and t-statistics for both correlation models are summarized in Table 3. The coefficient estimates were found to be statistically significant at the 1 percent level for both models. The modified rank correlation matrix (T) is included in the Appendix (Table A.4).

TABLE 3. Summary statistics for the rank correlation regression models

Dependent Variable	Independent Variable	$\hat{\alpha}$ (S.E.)	t-stat (p-value)	$\hat{\beta}$ (S.E.)	t-stat (p-value)
Unleaded correlations	Time lag (months)	0.71 (0.06)	12.84 (0.00)	-0.052 (0.011)	-4.75 (0.00)
Natural gas correlations	Time lag (months)	0.82 (0.03)	23.96 (0.00)	-0.024 (0.007)	-3.61 (0.00)

Results

Using model (1), fair premiums are determined for the 2002 contract year from March 2002 futures prices and using the transformed Monte Carlo draws as 5,000 simulated actual price scenarios. Premiums and indemnities are calculated at various coverage levels using the DDGS and ethanol price prediction models. The projected gross margin for ethanol is $1.57 per bushel of corn. Table 4 summarizes the fair premiums at various coverage levels.

Producers would pay only 13.5¢ per bushel for 100 percent coverage; this equates to a premium rate of 8.6 percent. As the level of coverage is lowered to 95 percent, the premium rate falls to 6.3 percent of the margin guarantee. The distribution of the uninsured actual gross margin values is illustrated in Figure 3.

Figure 4 illustrates the distribution of gross margin scenarios when insurance is purchased at a coverage level of 85 percent. Roughly 35 percent of the downside risk is eliminated through the purchase of the insurance.

TABLE 4. Premiums at various coverage levels

Coverage Level (percent)	Per Bushel Premium ($/bushel)	Percentage of Gross Margin (percent)
85	0.049	3.1
90	0.071	4.5
95	0.099	6.3
100	0.135	8.6
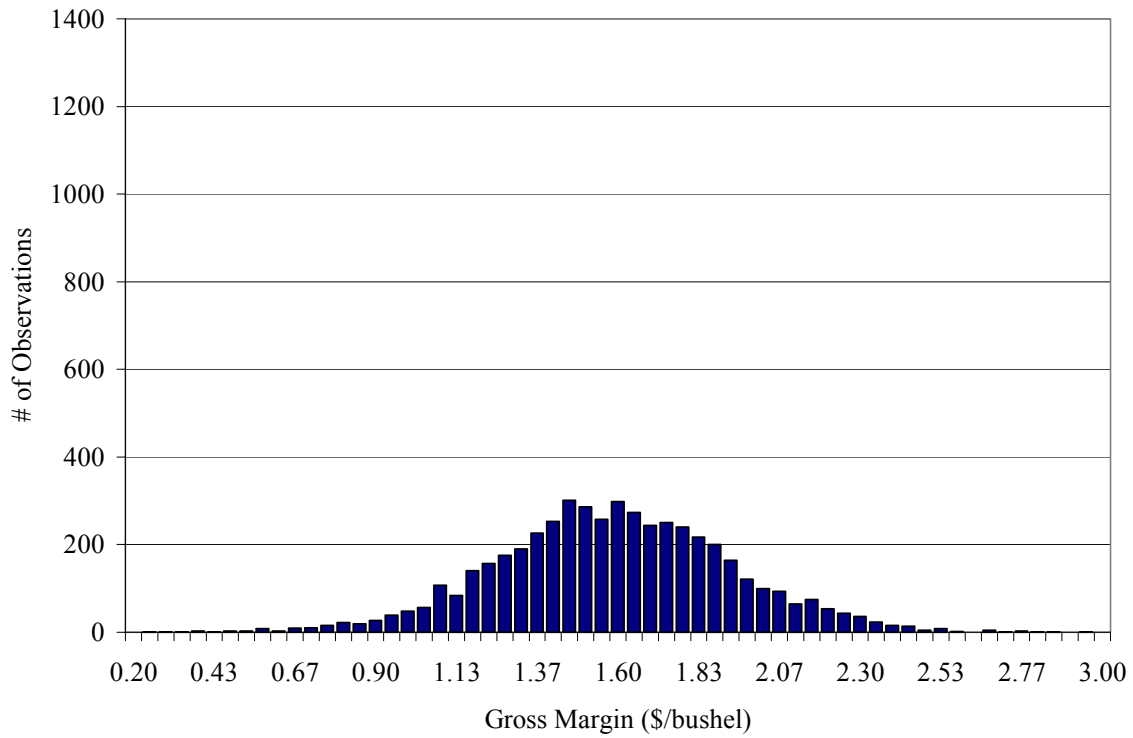
FIGURE 3. Distribution of uninsured ethanol gross margins
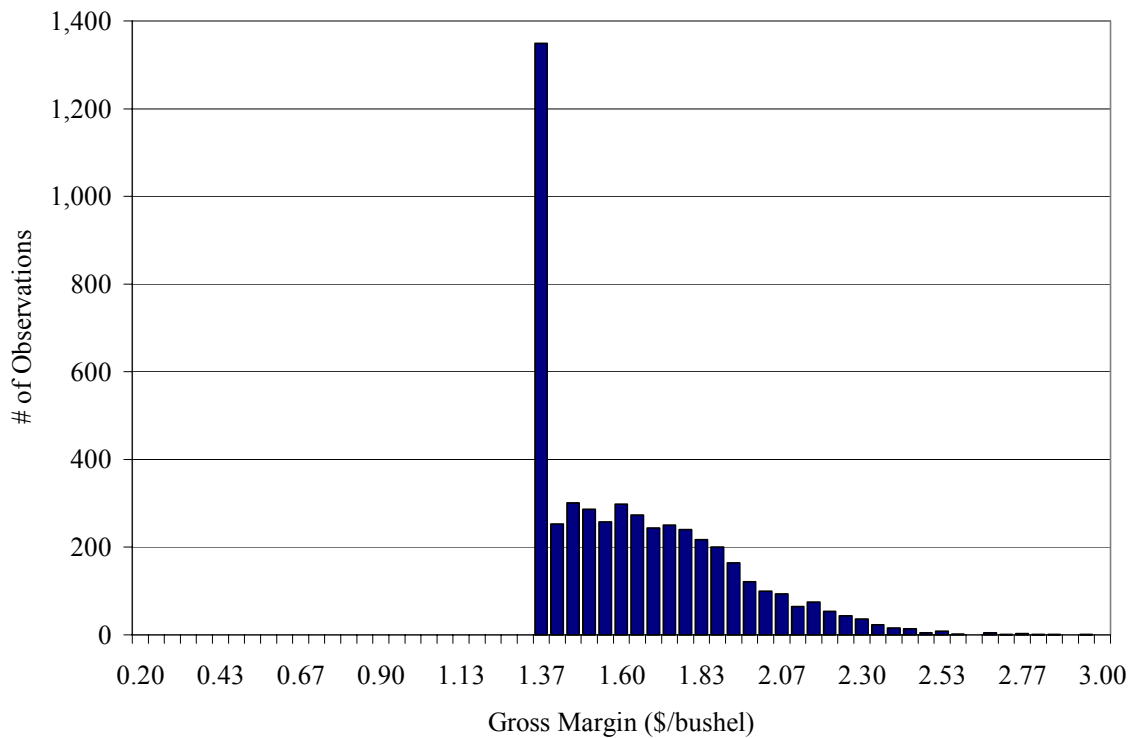
FIGURE 4. Distribution of gross margins with 85 percent gross margin coverage

Historical Analysis

Margin guarantees, actual margins, and indemnity payments are calculated from 1991 through 2002. Historical premiums are also calculated based on the percentages of the margin guarantee taken from the Monte Carlo results for the 2002 contract year for the various coverage levels. Table 5 shows projected and actual gross margins. Table 6 shows the calculated per bushel premiums for the insurance and outlines the indemnity stream that would have resulted from the insurance over the historical period.

Indemnities would have been paid in 1993, 1994, and 1996. Corn markets were highly volatile in 1993, 1994, and 1996. The predicted prices for corn are well below the actual levels in all three years. The predictions are $0.18, $0.56, and $0.34 below the actual values for 1993, 1994, and 1996, respectively. The price of unleaded gasoline is overpredicted in 1993 ($0.08); this would also increase the value of the insurance product. In 1994 and 1996, unleaded gasoline prices are underpredicted by $0.02 and $0.12, respectively, but these effects are outweighed by the extreme volatility in the corn market for those years. These results confirm achievement of the objective in developing this product. The policy has value under conditions of extreme price volatility.

The value of the stream of indemnity payments is less than the value of the stream of premium payments[3] required to carry the product over the historical period analyzed.

TABLE 5. Historical gross margins

Year	Projected	Actual
	($/bushel)	($/bushel)
1991	1.25	1.52
1992	1.17	1.51
1993	1.44	1.06
1994	0.79	1.31
1995	1.24	0.79
1996	0.53	0.48
1997	0.99	1.12
1998	0.85	1.16
1999	1.08	1.66
2000	1.67	1.83
2001	1.28	1.76
2002	1.57	1.61

TABLE 6. Historical per bushel premiums and indemnities

Year	Premiums for Coverage at				Indemnities for Coverage at			
	85%	**90%**	**95%**	**100%**	**85%**	**90%**	**95%**	**100%**
	(dollars)				(dollars)			
1991	0.04	0.06	0.08	0.11	0.00	0.00	0.00	0.00
1992	0.04	0.05	0.07	0.10	0.00	0.00	0.00	0.00
1993	0.04	0.06	0.09	0.12	0.16	0.23	0.30	0.38
1994	0.02	0.04	0.05	0.07	0.00	0.00	0.00	0.00
1995	0.04	0.06	0.08	0.11	0.26	0.33	0.39	0.45
1996	0.02	0.02	0.03	0.05	0.00	0.00	0.03	0.05
1997	0.03	0.04	0.06	0.09	0.00	0.00	0.00	0.00
1998	0.03	0.04	0.05	0.07	0.00	0.00	0.00	0.00
1999	0.03	0.05	0.07	0.09	0.00	0.00	0.00	0.00
2000	0.05	0.07	0.11	0.14	0.00	0.00	0.00	0.00
2001	0.04	0.06	0.08	0.11	0.00	0.00	0.00	0.00
2002	0.05	0.07	0.10	0.14	0.00	0.00	0.00	0.00
Total	0.43	0.62	0.88	1.19	0.42	0.56	0.72	0.88

However, as the level of coverage decreases, the difference between the two streams of payments decreases. The fact that the premium stream is larger than the indemnity stream is an interesting result. A fair premium, by definition, should equate the payments received from the product to the cost of carrying the product over a period of time. It may be possible that the time period analyzed was simply too small, but ethanol production did not become a major enterprise for corn producers until the early 1990s. Therefore, analyzing older historical price data may not reflect true relationships.

Another possible reason for these results is the presence of bias in the futures markets for the commodities used in structuring the product. The accuracy of the predictions for each commodity price market is analyzed for each period. On average, the predicted price of unleaded gasoline is $0.05 (7.38 percent) lower than the actual price levels used in contract settlement. The predicted prices for natural gas also exhibit a negative bias of $0.19 (7.68 percent). The predicted prices for corn are, on average, $0.12 (4.69 percent) higher than the actual prices used in contract settlement. The negative and positive bias in the gasoline and corn markets, respectively, both cause 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 effect of changes in natural gas

prices is shown to be marginally small relative to the effects of changes in corn and gasoline prices. It should be noted that these biases are 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.

Sensitivity Analysis

To determine the effect of price volatility on the premium rates for the product, fair premiums are calculated using higher levels of volatility in the Monte Carlo price draws. Volatilities are increased by 10 percent for each commodity price draw. Appendix Table A.2 reports the higher volatilities imposed on the price distributions used for premium determination. The premiums reported in Table 7 show that increasing the price volatilities by 10 percent causes the premium levels to increase by a substantial amount. Higher volatility implies more uncertainty, which raises the fair cost of the product. The higher volatility causes the premium rates to increase from 8.6 percent to 11.5 percent at 100 percent coverage.

At the higher levels of price volatility, the actual premium rates increase by about 39 percent at full coverage. At 95 percent coverage, the premium rates increase by about 48 percent. At 90 percent coverage, the premium rates increase by about 60 percent. As the coverage level falls to 85 percent, the premium rates increase by over 70 percent. This implies that premiums at all levels of coverage are extremely sensitive to the level of volatility assumed for the commodity prices. Premiums at lower levels of coverage are relatively more sensitive to the level of assumed price volatility.

TABLE 7. Premiums at various coverage levels given 10 percent higher volatility

Coverage Level	Per Bushel Premium	Percentage of Gross Margin
(percent)	($/bushel)	(percent)
85	0.089	5.6
90	0.114	7.2
95	0.145	9.2
100	0.181	11.5

Conclusions

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. Over the last decade, farmers have been diversifying by becoming involved with value-added enterprises such as ethanol production. This research supports development of an insurance product aimed at corn producers who are members in an ethanol production cooperative. The product has the potential to provide these producers a new and useful risk management tool.

The product is structured to insure against price risks in the markets for corn, DDGS, ethanol, and natural gas. Futures prices for corn, unleaded gasoline, and natural gas are used to develop a pricing model that is used to structure the product to insure the gross margin level of an ethanol production facility on a per bushel basis. The pricing model provides statistically unbiased estimators of the DDGS and ethanol prices and exhibits a comparable level of accuracy to the futures markets for corn, unleaded gasoline, and natural gas, as measured by root mean error.

Monte Carlo analysis is used to develop fair premiums at various coverage levels. A historical correlation structure is imposed on the simulated price data using a method proposed by Iman and Conover (1982), which maintains the marginal distributions of the variables.

Historical analysis is carried out to examine how the product would have performed had it been offered over the last decade. The product is shown to perform as intended, paying indemnities in years of extreme price volatility. The stream of indemnity payments is shown to be smaller than the stream of premium payments required to carry the product over the historical period analyzed. This result may come from the fact that the historical period analyzed is relatively small, or it may come from the bias exhibited in the futures markets for corn and unleaded gasoline over the historical period analyzed. Sensitivity analysis is also performed to determine the effect of volatility levels on the fair premiums. Premium rates increase as the level of price volatility is increased. This effect is shown to be more severe as the level of coverage decreases.

Endnotes

1. From various issues of the *Feed Outlook* and *Feed Situation and Outlook Yearbook*, U.S. Department of Agriculture, Economic Research Service.

2. All futures price data were obtained from www.barchart.com.

3. The indemnities and premiums are reported in nominal terms with no time discounting.

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Appendix

Summary of Price Distribution Assumptions and Historical and Rank Correlations

TABLE A.1. Price distribution assumptions and actual implied volatilities

Price Variable	Mean	Distribution Assumptions Annualized Volatility	Adjusted Volatility[a]
	(dollars)	(percent)	(percent)
Mar Corn	2.01	—	—
May Corn	2.08	17.1	7.0
July Corn	2.15	20.0	11.5
Sep Corn	2.22	25.2	17.8
Dec Corn	2.30	22.3	19.3
Mar + 1 Corn	2.39	19.7	19.7
Jan + 1 Unl	0.64	36.7	33.5
Feb + 1 Unl	0.65	36.7	35.1
Mar + 1 Unl	0.65	36.7	36.7
Apr Unl	0.73	39.6	11.4
May Unl	0.74	41.7	17.0
June Unl	0.74	42.3	21.1
July Unl	0.73	40.4	23.3
Aug Unl	0.71	39.4	25.4
Sep Unl	0.69	38.1	26.9
Oct Unl	0.66	36.7	28.0
Nov Unl	0.65	36.7	29.9
Dec Unl	0.64	36.7	31.7
Jan + 1 NG	3.41	45.1	41.2
Feb + 1 NG	3.35	48.3	46.3
Mar + 1 NG	3.25	41.7	41.7
Apr NG	2.53	48.6	14.0
May NG	2.57	46.8	19.1
June NG	2.63	43.5	21.7
July NG	2.68	43.1	24.9
Aug NG	2.73	43.5	28.1
Sep NG	2.74	43.7	30.9
Oct NG	2.78	43.8	33.5
Nov NG	3.04	44.3	36.2
Dec NG	3.30	44.8	38.8

Note: The month abbreviation is for the futures contract month, "+ 1" indicates the month is in the next (as opposed to the current) year, "Unl" stands for unleaded gasoline, and "NG" stands for natural gas.
[a]Based on time to maturity.

TABLE A.2. Price distribution assumptions and increased volatility

Price Variable	Distribution Assumptions		
	Mean	Annualized Volatility	Adjusted Volatility[a]
	(dollars)	(percent)	(percent)
Mar Corn	2.01	—	—
May Corn	2.08	27.1	11.1
July Corn	2.15	30.0	17.3
Sep Corn	2.22	35.2	24.9
Dec Corn	2.30	32.3	27.9
Mar + 1 Corn	2.39	29.7	29.7
Jan + 1 Unl	0.64	46.7	42.6
Feb + 1 Unl	0.65	46.7	44.7
Mar + 1 Unl	0.65	46.7	46.7
Apr Unl	0.73	49.6	14.3
May Unl	0.74	51.7	21.1
June Unl	0.74	52.3	26.1
July Unl	0.73	50.4	29.1
Aug Unl	0.71	49.4	31.9
Sep Unl	0.69	48.1	34.0
Oct Unl	0.66	46.7	35.6
Nov Unl	0.65	46.7	38.1
Dec Unl	0.64	46.7	40.4
Jan + 1 NG	3.41	55.1	50.3
Feb + 1 NG	3.35	58.3	55.8
Mar + 1 NG	3.25	51.7	51.7
Apr NG	2.53	58.6	16.9
May NG	2.57	56.8	23.2
June NG	2.63	53.5	26.7
July NG	2.68	53.1	30.7
Aug NG	2.73	53.5	34.5
Sep NG	2.74	53.7	38.0
Oct NG	2.78	53.8	41.1
Nov NG	3.04	54.3	44.3
Dec NG	3.30	54.8	47.4

Note: The month abbreviation is for the futures contract month, "+ 1" indicates the month is in the next (as opposed to the current) year, "Unl" stands for unleaded gasoline, and "NG" stands for natural gas.
[a]Based on time to maturity.

TABLE A.3. Historical rank correlations

	May Corn	July Corn	Sep Corn	Dec Corn	Mar+1 Corn	Jan+1 Unl	Feb+1 Unl	Mar+1 Unl	Apr Unl	May Unl
May Corn	1.000	0.580	0.328	0.322	0.334	0.358	0.536	0.364	0.195	-0.026
July Corn	0.580	1.000	0.774	0.597	0.686	0.174	0.255	0.129	0.245	0.313
Sep Corn	0.328	0.774	1.000	0.820	0.888	0.245	0.286	0.255	0.259	0.154
Dec Corn	0.322	0.597	0.820	1.000	0.848	-0.150	-0.009	-0.024	0.077	-0.065
Mar+1 Corn	0.334	0.686	0.888	0.848	1.000	0.224	0.288	0.284	0.112	-0.057
Jan+1 Unl	0.358	0.174	0.245	-0.150	0.224	1.000	0.785	0.725	0.393	0.218
Feb+1 Unl	0.536	0.255	0.286	-0.009	0.288	0.785	1.000	0.957	0.490	0.168
Mar+1 Unl	0.364	0.129	0.255	-0.024	0.284	0.725	0.957	1.000	0.391	0.137
Apr Unl	0.195	0.245	0.259	0.077	0.112	0.393	0.490	0.391	1.000	0.719
May Unl	-0.026	0.313	0.154	-0.065	-0.057	0.218	0.168	0.137	0.719	1.000
June Unl	0.139	0.141	-0.024	-0.088	-0.135	0.298	0.222	0.243	0.457	0.773
July Unl	0.133	-0.119	-0.154	-0.125	-0.090	0.465	0.490	0.523	0.300	0.319
Aug Unl	0.139	-0.082	0.112	-0.123	0.129	0.678	0.657	0.686	0.424	0.152
Sep Unl	0.238	-0.141	0.065	-0.247	0.059	0.761	0.593	0.567	0.214	-0.127
Oct Unl	0.412	0.065	0.079	-0.156	0.011	0.779	0.606	0.490	0.364	0.096
Nov Unl	0.321	-0.022	0.053	-0.201	0.046	0.798	0.633	0.548	0.337	0.018
Dec Unl	0.348	-0.038	0.030	-0.224	0.077	0.825	0.643	0.581	0.313	0.007
Jan+1 NG	0.804	0.259	0.392	0.252	0.343	0.622	0.643	0.608	0.070	-0.119
Feb+1 NG	0.790	0.315	0.371	0.280	0.364	0.517	0.566	0.510	-0.105	-0.175
Mar+1 NG	0.692	0.315	0.455	0.455	0.483	0.399	0.503	0.483	-0.105	-0.217
Apr NG	0.469	0.650	0.650	0.238	0.483	0.287	0.350	0.231	0.224	0.140
May NG	0.483	0.378	0.350	0.098	0.294	0.385	0.441	0.364	0.112	-0.035
June NG	0.601	0.119	0.315	0.294	0.322	0.406	0.503	0.517	0.028	-0.308
July NG	0.692	0.105	0.217	0.042	0.168	0.657	0.706	0.685	0.105	-0.147
Aug NG	0.699	0.042	0.070	-0.098	0.049	0.524	0.559	0.531	-0.063	-0.231
Sep NG	0.587	-0.123	0.049	0.070	0.112	0.399	0.469	0.497	-0.056	-0.399
Oct NG	0.413	-0.224	0.070	0.189	0.105	0.259	0.315	0.364	-0.042	-0.552
Nov NG	0.517	-0.126	0.140	0.133	0.105	0.427	0.455	0.483	0.112	-0.420
Dec NG	0.671	0.007	0.217	0.154	0.168	0.483	0.476	0.469	0.112	-0.350

TABLE A.3. Extended

	Jun Unl	July Unl	Aug Unl	Sep Unl	Oct Unl	Nov Unl	Dec Unl	Jan+1 NG	Feb+1 NG	Mar+1 NG	Apr NG
May Corn	0.139	0.133	0.139	0.238	0.412	0.321	0.348	0.804	0.790	0.692	0.469
July Corn	0.141	-0.119	-0.082	-0.141	0.065	-0.022	-0.038	0.259	0.315	0.315	0.650
Sep Corn	-0.024	-0.154	0.112	0.065	0.079	0.053	0.030	0.392	0.371	0.455	0.650
Dec Corn	-0.088	-0.125	-0.123	-0.247	-0.156	-0.201	-0.224	0.252	0.280	0.455	0.238
Mar+1 Corn	-0.135	-0.090	0.129	0.059	0.011	0.046	0.077	0.343	0.364	0.483	0.483
Jan+1 Unl	0.298	0.465	0.678	0.761	0.779	0.798	0.825	0.622	0.517	0.399	0.287
Feb+1 Unl	0.222	0.490	0.657	0.593	0.606	0.633	0.643	0.643	0.566	0.503	0.350
Mar+1 Unl	0.243	0.523	0.686	0.567	0.490	0.548	0.581	0.608	0.510	0.483	0.231
Apr Unl	0.457	0.300	0.424	0.214	0.364	0.337	0.313	0.070	-0.105	-0.105	0.224
May Unl	0.773	0.319	0.152	-0.127	0.096	0.018	0.007	-0.119	-0.175	-0.217	0.140
June Unl	1.000	0.480	0.154	0.040	0.203	0.038	0.090	0.147	0.007	-0.028	-0.224
July Unl	0.480	1.000	0.721	0.294	0.408	0.457	0.453	0.469	0.350	0.336	-0.126
Aug Unl	0.154	0.721	1.000	0.666	0.585	0.750	0.765	0.531	0.420	0.371	0.098
Sep Unl	0.040	0.294	0.666	1.000	0.837	0.891	0.893	0.483	0.287	0.294	-0.028
Oct Unl	0.203	0.408	0.585	0.837	1.000	0.928	0.816	0.664	0.476	0.462	0.189
Nov Unl	0.038	0.457	0.750	0.891	0.928	1.000	0.946	0.594	0.462	0.413	0.175
Dec Unl	0.090	0.453	0.765	0.893	0.816	0.946	1.000	0.497	0.329	0.210	0.000
Jan+1 NG	0.147	0.469	0.531	0.483	0.664	0.594	0.497	1.000	0.916	0.811	0.531
Feb+1 NG	0.007	0.350	0.420	0.287	0.476	0.462	0.329	0.916	1.000	0.902	0.643
Mar+1 NG	-0.028	0.336	0.371	0.294	0.462	0.413	0.210	0.811	0.902	1.000	0.636
Apr NG	-0.224	-0.126	0.098	-0.028	0.189	0.175	0.000	0.531	0.643	0.636	1.000
May NG	-0.224	-0.021	0.308	0.147	0.308	0.364	0.189	0.469	0.692	0.671	0.811
June NG	-0.175	0.259	0.483	0.420	0.545	0.524	0.336	0.713	0.797	0.881	0.594
July NG	0.021	0.490	0.664	0.531	0.685	0.692	0.573	0.867	0.895	0.790	0.566
Aug NG	-0.021	0.469	0.538	0.420	0.573	0.573	0.531	0.811	0.811	0.671	0.503
Sep NG	-0.084	0.448	0.524	0.490	0.587	0.552	0.476	0.664	0.650	0.713	0.357
Oct NG	-0.231	0.294	0.434	0.448	0.559	0.476	0.350	0.650	0.566	0.692	0.273
Nov NG	-0.154	0.308	0.538	0.531	0.671	0.594	0.476	0.769	0.671	0.685	0.371
Dec NG	-0.091	0.266	0.490	0.476	0.636	0.559	0.490	0.867	0.762	0.664	0.434

TABLE A.3. Extended

	May NG	June NG	July NG	Aug NG	Sep NG	Oct NG	Nov NG	Dec NG
May Corn	0.483	0.601	0.692	0.699	0.587	0.413	0.517	0.671
July Corn	0.378	0.119	0.105	0.042	-0.126	-0.224	-0.126	0.007
Sep Corn	0.350	0.315	0.217	0.070	0.049	0.070	0.140	0.217
Dec Corn	0.098	0.294	0.042	-0.098	0.070	0.189	0.133	0.154
Mar+1 Corn	0.294	0.322	0.168	0.049	0.112	0.105	0.105	0.168
Jan+1 Unl	0.385	0.406	0.657	0.524	0.399	0.259	0.427	0.483
Feb+1 Unl	0.441	0.503	0.706	0.559	0.469	0.315	0.455	0.476
Mar+1 Unl	0.364	0.517	0.685	0.531	0.497	0.364	0.483	0.469
Apr Unl	0.112	0.028	0.105	-0.063	-0.056	-0.042	0.112	0.112
May Unl	-0.035	-0.308	-0.147	-0.231	-0.399	-0.552	-0.420	-0.350
June Unl	-0.224	-0.175	0.021	-0.021	-0.084	-0.231	-0.154	-0.091
July Unl	-0.021	0.259	0.490	0.469	0.448	0.294	0.308	0.266
Aug Unl	0.308	0.483	0.664	0.538	0.524	0.434	0.538	0.490
Sep Unl	0.147	0.420	0.531	0.420	0.490	0.448	0.531	0.476
Oct Unl	0.308	0.545	0.685	0.573	0.587	0.559	0.671	0.636
Nov Unl	0.364	0.524	0.692	0.573	0.552	0.476	0.594	0.559
Dec Unl	0.189	0.336	0.573	0.531	0.476	0.350	0.476	0.490
Jan+1 NG	0.469	0.713	0.867	0.811	0.664	0.650	0.769	0.867
Feb+1 NG	0.692	0.797	0.895	0.811	0.650	0.566	0.671	0.762
Mar+1 NG	0.671	0.881	0.790	0.671	0.713	0.692	0.685	0.664
Apr NG	0.811	0.594	0.566	0.503	0.357	0.273	0.371	0.434
May NG	1.000	0.769	0.713	0.601	0.531	0.378	0.476	0.483
June NG	0.769	1.000	0.874	0.762	0.867	0.832	0.853	0.783
July NG	0.713	0.874	1.000	0.923	0.811	0.685	0.818	0.853
Aug NG	0.601	0.762	0.923	1.000	0.860	0.650	0.755	0.825
Sep NG	0.531	0.867	0.811	0.860	1.000	0.874	0.853	0.790
Oct NG	0.378	0.832	0.685	0.650	0.874	1.000	0.951	0.839
Nov NG	0.476	0.853	0.818	0.755	0.853	0.951	1.000	0.951
Dec NG	0.483	0.783	0.853	0.825	0.790	0.839	0.951	1.000

Note: The month abbreviation is for the futures contract month, "+ 1" indicates the month is in the next (as opposed to the current) year, "Unl" stands for unleaded gasoline, and "NG" stands for natural gas.

TABLE A.4. Target rank correlations

	May Corn	July Corn	Sep Corn	Dec Corn	Mar+1 Corn	Jan+1 Unl	Feb+1 Unl	Mar+1 Unl	Apr Unl	May Unl
May Corn	1.000	0.580	0.328	0.322	0.334	0.101	0.101	0.101	0.101	0.101
July Corn	0.580	1.000	0.774	0.597	0.686	0.101	0.101	0.101	0.101	0.101
Sep Corn	0.328	0.774	1.000	0.820	0.888	0.101	0.101	0.101	0.101	0.101
Dec Corn	0.322	0.597	0.820	1.000	0.848	0.101	0.101	0.101	0.101	0.101
Mar+1 Corn	0.334	0.686	0.888	0.848	1.000	0.101	0.101	0.101	0.101	0.101
Jan+1 Unl	0.101	0.101	0.101	0.101	0.101	1.000	0.659	0.607	0.246	0.298
Feb+1 Unl	0.101	0.101	0.101	0.101	0.101	0.659	1.000	0.659	0.195	0.246
Mar+1 Unl	0.101	0.101	0.101	0.101	0.101	0.607	0.659	1.000	0.143	0.195
Apr Unl	0.101	0.101	0.101	0.101	0.101	0.246	0.195	0.143	1.000	0.659
May Unl	0.101	0.101	0.101	0.101	0.101	0.298	0.246	0.195	0.659	1.000
June Unl	0.101	0.101	0.101	0.101	0.101	0.349	0.298	0.246	0.607	0.659
July Unl	0.101	0.101	0.101	0.101	0.101	0.401	0.349	0.298	0.556	0.607
Aug Unl	0.101	0.101	0.101	0.101	0.101	0.452	0.401	0.349	0.504	0.556
Sep Unl	0.101	0.101	0.101	0.101	0.101	0.504	0.452	0.401	0.452	0.504
Oct Unl	0.101	0.101	0.101	0.101	0.101	0.556	0.504	0.452	0.401	0.452
Nov Unl	0.101	0.101	0.101	0.101	0.101	0.607	0.556	0.504	0.349	0.401
Dec Unl	0.101	0.101	0.101	0.101	0.101	0.659	0.607	0.556	0.298	0.349
Jan+1 NG	0.301	0.301	0.301	0.301	0.301	0.304	0.304	0.304	0.304	0.304
Feb+1 NG	0.301	0.301	0.301	0.301	0.301	0.304	0.304	0.304	0.304	0.304
Mar+1 NG	0.301	0.301	0.301	0.301	0.301	0.304	0.304	0.304	0.304	0.304
Apr NG	0.301	0.301	0.301	0.301	0.301	0.304	0.304	0.304	0.304	0.304
May NG	0.301	0.301	0.301	0.301	0.301	0.304	0.304	0.304	0.304	0.304
June NG	0.301	0.301	0.301	0.301	0.301	0.304	0.304	0.304	0.304	0.304
July NG	0.301	0.301	0.301	0.301	0.301	0.304	0.304	0.304	0.304	0.304
Aug NG	0.301	0.301	0.301	0.301	0.301	0.304	0.304	0.304	0.304	0.304
Sep NG	0.301	0.301	0.301	0.301	0.301	0.304	0.304	0.304	0.304	0.304
Oct NG	0.301	0.301	0.301	0.301	0.301	0.304	0.304	0.304	0.304	0.304
Nov NG	0.301	0.301	0.301	0.301	0.301	0.304	0.304	0.304	0.304	0.304
Dec NG	0.301	0.301	0.301	0.301	0.301	0.304	0.304	0.304	0.304	0.304

TABLE A.4. Extended

	June Unl	July Unl	Aug Unl	Sep Unl	Oct Unl	Nov Unl	Dec Unl	Jan+1 NG	Feb+1 NG	Mar+1 NG	Apr NG
May Corn	0.101	0.101	0.101	0.101	0.101	0.101	0.101	0.301	0.301	0.301	0.301
July Corn	0.101	0.101	0.101	0.101	0.101	0.101	0.101	0.301	0.301	0.301	0.301
Sep Corn	0.101	0.101	0.101	0.101	0.101	0.101	0.101	0.301	0.301	0.301	0.301
Dec Corn	0.101	0.101	0.101	0.101	0.101	0.101	0.101	0.301	0.301	0.301	0.301
Mar+1 Corn	0.101	0.101	0.101	0.101	0.101	0.101	0.101	0.301	0.301	0.301	0.301
Jan+1 Unl	0.349	0.401	0.452	0.504	0.556	0.607	0.659	0.304	0.304	0.304	0.304
Feb+1 Unl	0.298	0.349	0.401	0.452	0.504	0.556	0.607	0.304	0.304	0.304	0.304
Mar+1 Unl	0.246	0.298	0.349	0.401	0.452	0.504	0.556	0.304	0.304	0.304	0.304
Apr Unl	0.607	0.556	0.504	0.452	0.401	0.349	0.298	0.304	0.304	0.304	0.304
May Unl	0.659	0.607	0.556	0.504	0.452	0.401	0.349	0.304	0.304	0.304	0.304
June Unl	1.000	0.659	0.607	0.556	0.504	0.452	0.401	0.304	0.304	0.304	0.304
July Unl	0.659	1.000	0.659	0.607	0.556	0.504	0.452	0.304	0.304	0.304	0.304
Aug Unl	0.607	0.659	1.000	0.659	0.607	0.556	0.504	0.304	0.304	0.304	0.304
Sep Unl	0.556	0.607	0.659	1.000	0.659	0.607	0.556	0.304	0.304	0.304	0.304
Oct Unl	0.504	0.556	0.607	0.659	1.000	0.659	0.607	0.304	0.304	0.304	0.304
Nov Unl	0.452	0.504	0.556	0.607	0.659	1.000	0.659	0.304	0.304	0.304	0.304
Dec Unl	0.401	0.452	0.504	0.556	0.607	0.659	1.000	0.304	0.304	0.304	0.304
Jan+1 NG	0.304	0.304	0.304	0.304	0.304	0.304	0.304	1.000	0.795	0.770	0.601
Feb+1 NG	0.304	0.304	0.304	0.304	0.304	0.304	0.304	0.795	1.000	0.795	0.577
Mar+1 NG	0.304	0.304	0.304	0.304	0.304	0.304	0.304	0.770	0.795	1.000	0.553
Apr NG	0.304	0.304	0.304	0.304	0.304	0.304	0.304	0.601	0.577	0.553	1.000
May NG	0.304	0.304	0.304	0.304	0.304	0.304	0.304	0.625	0.601	0.577	0.795
June NG	0.304	0.304	0.304	0.304	0.304	0.304	0.304	0.650	0.625	0.601	0.770
July NG	0.304	0.304	0.304	0.304	0.304	0.304	0.304	0.674	0.650	0.625	0.746
Aug NG	0.304	0.304	0.304	0.304	0.304	0.304	0.304	0.698	0.674	0.650	0.722
Sep NG	0.304	0.304	0.304	0.304	0.304	0.304	0.304	0.722	0.698	0.674	0.698
Oct NG	0.304	0.304	0.304	0.304	0.304	0.304	0.304	0.746	0.722	0.698	0.674
Nov NG	0.304	0.304	0.304	0.304	0.304	0.304	0.304	0.770	0.746	0.722	0.650
Dec NG	0.304	0.304	0.304	0.304	0.304	0.304	0.304	0.795	0.770	0.746	0.625

TABLE A.4. Extended

	May NG	June NG	July NG	Aug NG	Sep NG	Oct NG	Nov NG	Dec NG
May Corn	0.301	0.301	0.301	0.301	0.301	0.301	0.301	0.301
July Corn	0.301	0.301	0.301	0.301	0.301	0.301	0.301	0.301
Sep Corn	0.301	0.301	0.301	0.301	0.301	0.301	0.301	0.301
Dec Corn	0.301	0.301	0.301	0.301	0.301	0.301	0.301	0.301
Mar+1 Corn	0.301	0.301	0.301	0.301	0.301	0.301	0.301	0.301
Jan+1 Unl	0.304	0.304	0.304	0.304	0.304	0.304	0.304	0.304
Feb+1 Unl	0.304	0.304	0.304	0.304	0.304	0.304	0.304	0.304
Mar+1 Unl	0.304	0.304	0.304	0.304	0.304	0.304	0.304	0.304
Apr Unl	0.304	0.304	0.304	0.304	0.304	0.304	0.304	0.304
May Unl	0.304	0.304	0.304	0.304	0.304	0.304	0.304	0.304
June Unl	0.304	0.304	0.304	0.304	0.304	0.304	0.304	0.304
July Unl	0.304	0.304	0.304	0.304	0.304	0.304	0.304	0.304
Aug Unl	0.304	0.304	0.304	0.304	0.304	0.304	0.304	0.304
Sep Unl	0.304	0.304	0.304	0.304	0.304	0.304	0.304	0.304
Oct Unl	0.304	0.304	0.304	0.304	0.304	0.304	0.304	0.304
Nov Unl	0.304	0.304	0.304	0.304	0.304	0.304	0.304	0.304
Dec Unl	0.304	0.304	0.304	0.304	0.304	0.304	0.304	0.304
Jan+1 NG	0.625	0.650	0.674	0.698	0.722	0.746	0.770	0.795
Feb+1 NG	0.601	0.625	0.650	0.674	0.698	0.722	0.746	0.770
Mar+1 NG	0.577	0.601	0.625	0.650	0.674	0.698	0.722	0.746
Apr NG	0.795	0.770	0.746	0.722	0.698	0.674	0.650	0.625
May NG	1.000	0.795	0.770	0.746	0.722	0.698	0.674	0.650
June NG	0.795	1.000	0.795	0.770	0.746	0.722	0.698	0.674
July NG	0.770	0.795	1.000	0.795	0.770	0.746	0.722	0.698
Aug NG	0.746	0.770	0.795	1.000	0.795	0.770	0.746	0.722
Sep NG	0.722	0.746	0.770	0.795	1.000	0.795	0.770	0.746
Oct NG	0.698	0.722	0.746	0.770	0.795	1.000	0.795	0.770
Nov NG	0.674	0.698	0.722	0.746	0.770	0.795	1.000	0.795
Dec NG	0.650	0.674	0.698	0.722	0.746	0.770	0.795	1.000

Note: The month abbreviation is for the futures contract month, "+ 1" indicates the month is in the next (as opposed to the current) year, "Unl" stands for unleaded gasoline, and "NG" stands for natural gas.