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Cash Ethanol Cross-Hedging Opportunities

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Abstract

Increased use of alternative fuels and low commodity prices have contributed to the recent expansion of the US ethanol industry. As with any competitive industry, there exists some level of output price risk in the form of volatility. Yet, no actively traded ethanol futures market exists to mitigate output price risk. This study reports estimated minimum variance cross-hedge ratios between Detroit spot cash ethanol and the New York Mercantile Exchange (NYMEX) unleaded gasoline futures for 1-, 4-, 8-, 12-, 16-, 20-, 24-, and 28-week hedge horizons. The research suggests that a one-to-one cross-hedge ratio is not appropriate for some horizons.

Key words: Gas, Ethanol, and Cross-Hedging

Cash Ethanol Cross-Hedging Opportunities

The high demand for fuel and resulting fuel prices have contributed to the recent expansion of the US ethanol industry. Additionally, government grants and subsidies have increased interest in producing ethanol.[1] Ethanol production has reached record levels (Figure 1), becoming a substantial source of corn demand with potential for and expectations of further growth.[2] As with any competitive industry, there exists some level of price risk for ethanol in the form of price volatility. Contracting exclusively in cash markets may leave ethanol producers and purchasers exposed to price volatility, depending on contract terms. Contractual agreements are widely used in this industry, and are often based on the New York Mercantile Exchange (NYMEX) unleaded gasoline futures (Gerhold). Industry expansion is likely to heighten the demand for price risk management tools. Ethanol plant owners (e.g. agricultural producers and industry) and purchasers of ethanol may benefit from various techniques to manage price volatility. For ethanol, however, no futures market is actively traded. Producers and purchasers of ethanol may find cross-hedging ethanol with unleaded gasoline futures contracts to be effective in reducing exposure to price volatility. The objective of this study is to estimate the cross-hedge relationship between spot ethanol and the NYMEX unleaded gasoline futures market for various cross-hedging horizons.

[1] In October of 2002, the USDA announced the awarding of nearly $40 million in producer value-added grants. Of this amount, $6.5 million was awarded to twenty-four ethanol projects for planning purposes, e.g., market analysis development, legal counsel, and business plan development. This announcement provided further evidence of planned expansion in the ethanol industry.

[2] The National Corn Growers Association has publicly stated its support for the Renewable Fuels for Energy Security Act that would potentially boost annual ethanol production to 16 billion gallons within the next 10 to 15 years.

A cross-hedge is performed by hedging the cash price of one commodity with the futures contract price of a different, but related commodity. A hedger locks in a price for a cash commodity by cross-hedging that commodity with a related commodity traded at one of the commodity exchanges. Therefore, a cross-hedge utilizes information in one market, e.g., the NYMEX unleaded gasoline futures market, to predict the price of a different commodity in another market, e.g., a spot ethanol market.

In order for cross-hedging to reduce exposure to price volatility, the prices of the commodities being cross-hedged must be related, so that the respective prices follow in a predictable manner (Graff, et al.). The Detroit spot ethanol and the NYMEX unleaded gasoline futures markets historically have traded in similar patterns, but at different levels (Figure 2).

Most ethanol production is contracted on volume, but the price may be left open ended for future negotiations depending on the preferences of the buyer (Gerhold). Ethanol trades at lower prices than other gasoline oxygenates, and its value is based on octane ratings. Ethanol producers typically contract ethanol from one to six months out. Ethanol price is either set at a flat price, using the average ethanol price at base hubs, or determined by an index based on a historical ethanol-gasoline price spread (Gerhold).

The conventional practice of hedging gasoline in unleaded gasoline futures markets is to use one 42,000 gallon futures contract for each 42,000 gallons of gasoline to be hedged. However, since ethanol is not a perfect substitute for gasoline, cross-hedging in a one-to-one ratio (i.e. hedging 42,000 gallons of ethanol against one 42,000 gallon unleaded gasoline futures contract) may be inappropriate. Discussions with industry persons revealed that cross-hedging in a one-to-one ratio is the general routine followed (Gerhold). This study examines the effectiveness of such one-to-one cross-hedging relationships. Processors, purchasers, and merchandisers of ethanol can use this research to understand the effectiveness of cross-hedging cash ethanol in the unleaded gasoline futures market.

Theoretical Background

The theoretical model used to derive the empirical cross-hedge model follows from Brorsen, Buck, and Koontz, and Leuthold, Junkus, and Gordier. Brorsen, Buck, and Koontz (p. 451) explain that under the assumptions (set forth by Benninga, Eldor, and Zilcha) of, " … (i) the decision maker is not allowed to participate in alternative activities, (ii) no transaction costs, (iii) no production risk, (iv) cash prices are a linear function of futures prices with an independent error term, and (v) futures prices are unbiased," the minimum variance hedge ratios (developed by Johnson) are consistent with utility maximizing hedge ratios. Thus, the minimum variance utility maximization problem can be specified as follows:

(1) $$Max E(U) = X_c E(\tilde{R}_c) + X_f E(\hat{R}_f) - \lambda / 2(X_c^2 \sigma_c^2 + X_f^2 \sigma_f^2 + 2 X_f X_c \sigma_{cf}) ,$$

where $E(U)$ is the expected utility, X_c is the amount of the cash price position, $E(\tilde{R}_c)$ is the expected return on the cash position, X_f is the amount of the futures price position, $E(\tilde{R}_f)$ is the expected return on the futures position, λ is the relative risk aversion coefficient, σ_c^2 is the variance of the cash price change, σ_f^2 is the variance of the futures price change, and σ_{cf} is the covariance between the cash and futures price changes.

The optimal futures position for a given risk aversion level is derived by expressing equation (1) in terms of price changes, differentiating with respect to X_f, rearranging terms, and setting the equation equal to zero (Leuthold, Junkus, and Cordier). The optimal futures position can be expressed as follows:

$$(2) \qquad X_f = \{E(\tilde{F}_1) - F_0)] / \lambda\sigma_f^2\} - [X_c(\sigma_{cf} / \sigma_f^2)] \quad ,$$

where $E(\tilde{F}_1)$ is the expectation at time zero of the futures price at time one, F_0 is the futures price at time zero, and σ_{cf} / σ_f^2 is the cross-hedge relationship.

Empirical analyses to determine cross-hedging ratios have been carried out extensively for agricultural commodities, e.g., Buhr; Graff, et al.; Hayenga and DiPietre; Myers and Thompson; Kahl; Rahman, Turner, and Costa; Schroeder and Mintert. Anderson and Danthine provided a theoretical cross-hedging model from which most empirical analyses are based, and some authors (e.g., Brorsen, Buck, and Koontz) have estimated optimal hedge ratios dependent upon the hedgers' risk aversion level as specified in equation (2). Assuming that the risk aversion level is significantly high, as in enough to deter speculation, the first term in equation (2) becomes zero.[3] Estimating the hedge relationship by specifying the cash and futures price variables as changes in price and incorporating prior information yields the optimal hedge ratio (Myers and Thompson), as follows:[4]

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[3] According to Benninga, et al., risk-averse hedgers wish to reduce risk of income by locking in a margin. Given that the futures market is an unbiased predictor of future spot prices, speculation is not expected to be profitable on average. Note that speculation entails taking on risk above that which cannot be hedged away.

[4] In specifying the empirical model, the data is differenced and prior information included. Thus, while not explicit in the derivation of equation (3), the hedge ratio is considered to be optimal under the assumptions of highly risk-averse hedgers, unbiased futures markets, differenced data, and the inclusion of prior information.

(3) $$\beta^* = \frac{X_f^*}{-X_c} = \frac{\sigma_{cf}}{\sigma_f^2} \ .$$

The more highly correlated the cash price and futures price are, the closer the cross-hedge ratio is to one. The next section describes the process of estimating the ethanol cross-hedge ratio.

Empirical Model

This study uses the empirical methods of Brorsen, Buck, and Koontz to estimate ethanol cross-hedge ratios for alternative hedging horizons. Time-series data, such as the type used to estimate cross-hedge ratios, are likely to exhibit autocorrelation and time-wise heteroskedasticity. A moving average process equal to the length of the cross-hedge horizon may be present (Brorsen, Buck, and Koontz). Thus, autocorrelation is corrected for, in the estimation of the cross-hedge ratio, by approximating the moving average process as an autoregressive process with lags of one and *k*. The k[th] order autoregressive process is incorporated to correct for overlapping time periods between contracts (Brorsen, Buck, and Koontz.). Following the work of Brorsen, Buck, and Koontz for cross-hedging wheat, the relationship between ethanol cash prices and unleaded gasoline futures prices is estimated in changes to determine the cross-hedge ratio (β_l) as follows:

$$\Delta Ethanol\ Cash\ Price_t = \beta_0 + \beta_l\ (\Delta Futures\ Price_t)$$

(4) $$+\ \rho_1\ [\Delta Ethanol\ Cash\ Price_{t\text{-}1} - \beta_0 + \beta_l\ (\Delta Futures\ Price_{t\text{-}1})]$$

$$+\ \rho_k\ [\Delta Ethanol\ Cash\ Price_{t\text{-}k} - \beta_0 + \beta_l\ (\Delta Futures\ Price_{t\text{-}k})]\ ,$$

where Δ *Ethanol Cash Price*$_t$ is the difference in the ethanol cash price over the period *t-k* to *t*; Δ *Futures Price*$_t$ is the difference in the nearby NYMEX unleaded futures price over the period *t-k* to *t*; Δ *Ethanol Cash Price*$_{t-1}$ is the Δ *Ethanol Cash Price*$_t$ lagged one period;

Δ *Futures Price*$_{t-1}$ is the Δ *Futures Price*$_t$ lagged one period; Δ *Ethanol Cash Price*$_{t-k}$ is the Δ *Ethanol Cash Price*$_t$ lagged k periods; Δ *Futures Price*$_{t-k}$ is the Δ *Futures Price*$_t$ lagged k periods; ρ_1 is the first-order autocorrelation parameter; ρ_k is the kth-order autocorrelation parameter; (β_0) is the intercept; and (β_1) is the cross-hedge ratio. Following from the results of Myers and Thompson, specifying the cash and futures price variables as changes in price and incorporating prior information yields the optimal hedge ratio. For this study the cross-hedging horizons analyzed (denoted by Δ) are 1-, 4-, 8-, 12-, 16-, 20-, 24-, and 28-weeks.[5]

Another potential problem, heteroskedasticity in the error terms, may result from the cyclical periods of high and low volatility in the unleaded gasoline futures contract. A generalized autoregressive conditionally heteroskedastic (GARCH) process is implemented to correct for the presence of heteroskedasticity.

Following the methodology of Brorsen, Buck, and Koontz an Estimated Generalized Least Squares (EGLS) process is used to correct for autocorrelation first and heteroskedasticity second, since GARCH parameter estimates are not consistent in the presence of autocorrelation. First, non-linear least squares is used to estimate equation (4). Second, a GARCH (1,1) model is used to derive the residuals of the nonlinear least squares estimate of equation (4). Last, equation (4) is estimated using weighted non-linear least squares. The three-step EGLS process is completed using *SHAZAM* 9.0.[6]

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[5] One reviewer raised the issue of why these time horizons were chosen. Typically, ethanol is forward-contracted in one- to six-month periods (Gerhold), and unleaded gasoline futures contracts are usually offered less than 60 weeks prior to expiration.

[6] Note, adjusting the data and residuals to compensate for the presence of autocorrelation and heteroskedasticity yields parameter estimates similar to the OLS estimated parameters, but with efficient standard errors.

Equation (4) can be rearranged to determine the quantity of cash ethanol to hedge per NYMEX unleaded gasoline futures contract. The cross-hedge relationship from equation (4) is used, in conjunction with the NYMEX contract quantity specification of 42,000 gallons, to determine the approximate gallons of ethanol to hedge. The relationship can be expressed as follows:

(5) $$\textit{Cash Ethanol Quantity Hedged} = \frac{\textit{Futures Contract Quanity}}{\beta_1^*} = \frac{42{,}000 \ \textit{gallons}}{\beta_1^*}.$$

For example, one 42,000 gallon gasoline contract on the NYMEX would be appropriately cross-hedged against 42,000 gallons of ethanol if the cross-hedge ratio (β_1) was determined to be one. Similarly, if the cross-hedge ratio was estimated to be 0.80, then 52,500 gallons of ethanol would be hedged against one NYMEX unleaded gasoline futures contract.

Data

Weekly average price data from January 1, 1989 to November 29, 2001, for NYMEX unleaded gasoline futures contracts and weekly average Detroit spot ethanol prices were compiled. Unleaded gasoline futures contracts are traded for each month of the calendar year, and the delivery location is the New York Harbor. Summary statistics are listed in Table 1. To conserve space we reported only the summary statistics for a nearby month data series.

The NYMEX unleaded gasoline futures contract is rolled forward to the next contract on the first day of the contract expiration month. This method is used, because cash ethanol long hedgers would avoid taking delivery of gasoline during the contract expiration month. Similarly, because the contract specifies a New York Harbor delivery location, many unleaded gasoline long hedgers will exit the market prior to the expiration month. Changes in futures prices over the cross-hedge horizon were computed for the representative contract month for when the hedge is to be lifted. For instance, if the cross-hedge is to be lifted during any week in February 2001, then the change in the futures price over the 1-, 4-, 8-, 12-, 16-, 20-, 24-, and 28-week horizons is in reference to the March 2001 contract. NYMEX unleaded gasoline futures prices were obtained from the Commodity Research Bureau. The Detroit ethanol spot price data were obtained from Kappell.

Results

As previously mentioned, the time-series data used for this study could exhibit statistical issues, i.e., autocorrelation and heteroskedasticity. The EGLS process is used to correct for autocorrelation and heteroskedasticity. After transforming the data for first- and k^{th}-order autocorrelation, an autoregressive conditional heteroskedasticity test of the errors was performed. The Harvey test statistic was used to test the null hypothesis of homoskedasticity. Tests failed to reject the null hypothesis for each cross-hedge horizon[7]. The autocorrelation coefficients, constants, and the estimated cross-hedge relationships from equation (4) are presented in Table 2. The autocorrelation parameter estimates are significant for each of cross-hedge horizons, except the one-week horizon, indicating the strong presence of autocorrelation. This result was as hypothesized.

The *R-squared* statistics reported for the price change models are a measure of hedging effectiveness. Leuthold, Junkus, and Cordier (p. 94) state, " . . . hedging effectiveness refers to

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[7] Summary heteroskedasticity test statistics are available from the authors upon request.

the reduction in variance as a proportion of total variance that results from maintaining a hedged position rather than an unhedged position." The *R-squared* terms become progressively better for further out forecasts. The *R-squared* on the 1-week cross-hedge horizon, however, indicates relatively little hedging effectiveness. Thus, a hedger would be as well off to remain unhedged for a 1-week horizon.

The cross-hedge ratios are generally less than one and are statistically significant at the one percent level. The cross-hedge ratios are not statistically different from one for the 8-, 12-, or 16-week hedge horizons. Thus, a one-to-one hedge ratio is the appropriate hedge ratio for these horizons. Figure 3 graphically depicts the cross-hedge ratios across cross-hedge horizons. The appropriate quantities of ethanol to be hedged against one 42,000 gallon unleaded gasoline futures contract for each cross-hedge horizon are calculated by applying the cross-hedge ratios to equation (5), and are listed in gallons across the bottom of Table 2. The quantity of spot ethanol to hedge declines from the 1-week to the 8-week hedge horizons, remains at 42,000 gallons for the 8-, 12-, and 16-week hedge horizons, and increases steadily beyond.

To cover 100% of production, a 30 million gallon per year ethanol plant requires 619 futures contracts to cover a 4-week routine cross-hedge, 714 futures contracts to cover an 8-, 12-, or 16-week routine cross-hedge, and 509 futures contracts to cover a 24-week routine cross-hedge. Furthermore, the estimates indicate that the US ethanol industry would require somewhere between 25,000 and 41,000 NYMEX unleaded gasoline futures contracts to hedge 100% of production, approximately 1.7 billion gallons in 2001.

Discussion

Cross-hedge relationships between the Detroit spot ethanol price and the NYMEX unleaded gasoline futures price were estimated for this analysis. Using Estimated Generalized Least Squares to account for autocorrelation and heteroskedasticity, cross-hedge ratios for 1-, 4-, 8-, 12-, 16-, 20-, 24-, and 28-week cross-hedge horizons were estimated. The cross-hedge ratios varied from 0.632 for the 28-week hedge horizon, to 1.0 for the 16-week hedge horizon. The measure of hedging effectiveness (R^2) indicated that placing a cross-hedge could substantially mitigate price volatility for the 4-, 8-, 12-, 16-, 20-, 24-, and 28-week cross-hedge horizons.

Two results yield from this analysis. First, cross-hedging in the NYMEX unleaded gasoline futures market can reduce ethanol price uncertainty. Second, the quantity of spot ethanol to cross-hedge with one NYMEX unleaded gasoline futures contract was estimated to be 48,443 gallons, 42,000 gallons, 42,000 gallons, 42,000 gallons, 50,542 gallons, 58,989 gallons, and 66,456 gallons for the 4-, 8-, 12-, 16-, 20-, 24-, and 28-week cross-hedge horizons, respectively. Thus, sometimes it is appropriate to cross-hedge more than 42,000 gallons of ethanol per each 42,000 gallon NYMEX unleaded gasoline futures contract, as opposed to when hedging in a one-to-one ratio.

While this study is limited to one location, the results may be applicable to ethanol prices at other locations. Figure 4 illustrates that Detroit spot, Gulf spot, and Minneapolis terminal ethanol prices follow similar patterns. The correlation coefficients between Detroit spot, and Gulf spot and Minneapolis terminal ethanol prices over the available periods are 0.859 and 0.981, respectively. However, the brevity of available time-series data at other locations prevents further statistical testing to validate the above statement.

While current capacity in the ethanol industry is far too small to sustain an independent ethanol futures contract, this study provides evidence to suggest that the NYMEX unleaded gasoline futures market offers price mitigation opportunities in the absence of a standalone ethanol futures contract.

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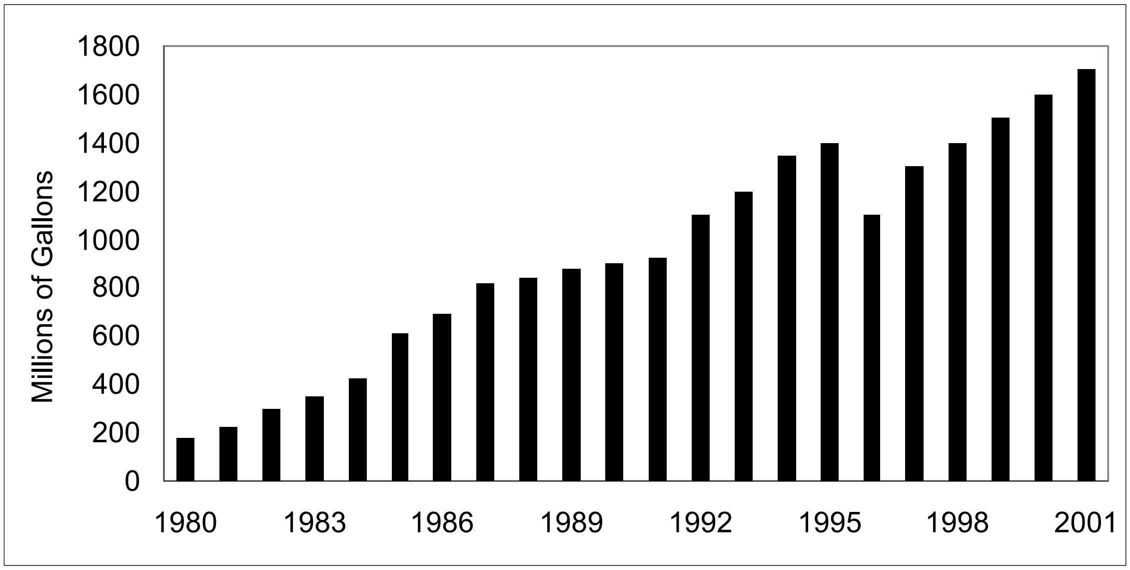
Figure 1. US Annual Fuel Ethanol Production.



Source: Energy Information Administration and Renewable Fuels Association.

Figure 2. Detroit Spot Ethanol Price and Nearby NYMEX Unleaded Gasoline Futures Price.

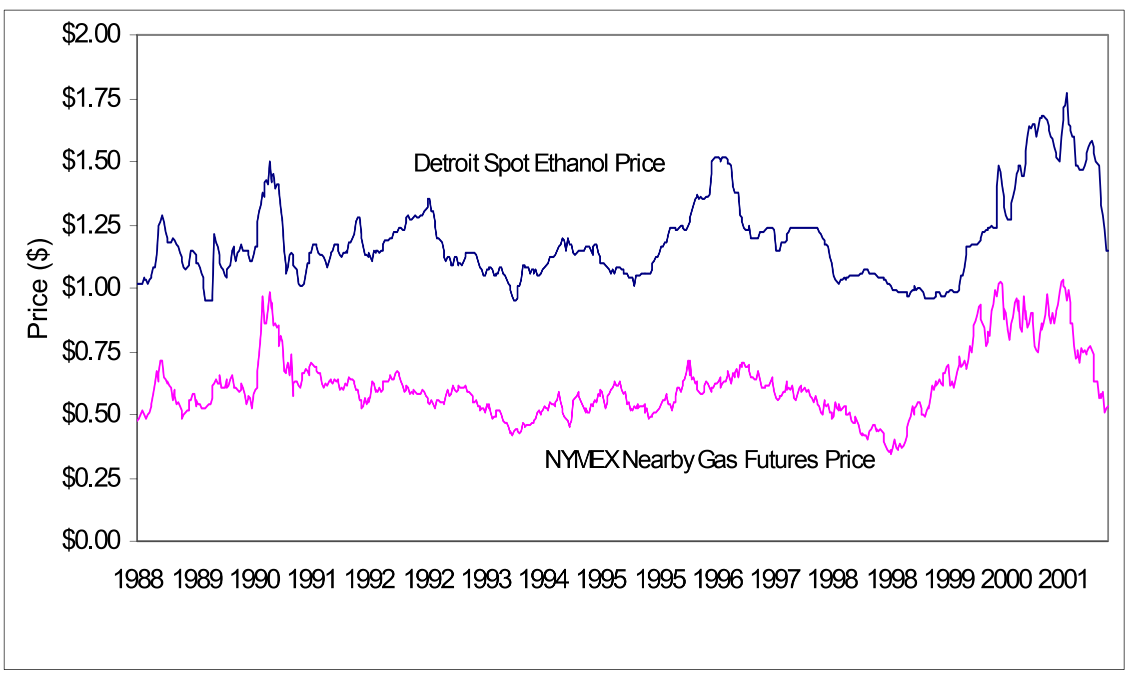
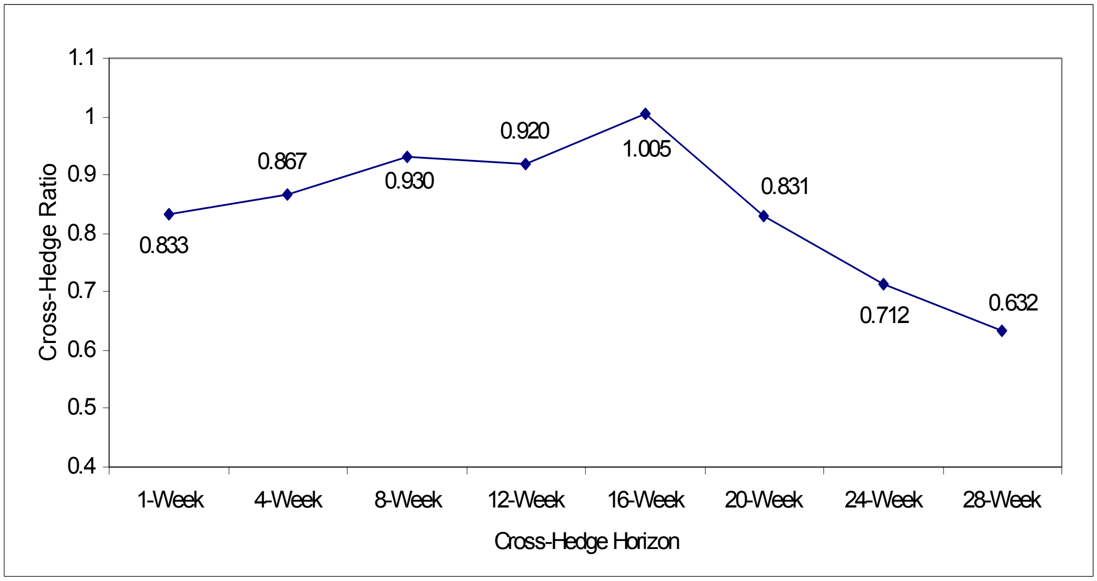


Figure 3. Estimated Cross-Hedge Ratio Over Cross-Hedge Horizons



Note: 8-, 12-, and 16-week cross-hedge relationships are not statistically different from one.

Figure 4. Comparison of Detroit Spot, Gulf Spot, and Minneapolis Terminal Ethanol Prices.

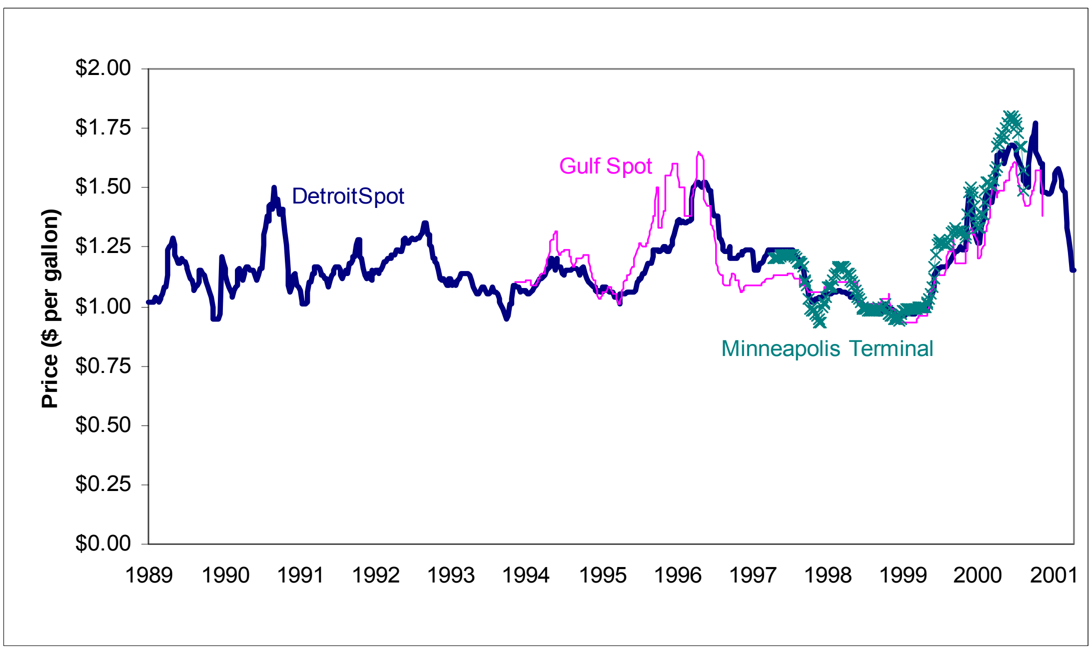


Table 1. Summary Statistics for Variables Used in Estimation of Cross-Hedging Ethanol in Gasoline Futures, Weekly Data between January 1, 1989 and November 29, 2001.

Prices in $/gallon	Avg.	Std Dev	Min.	Max.
Nearby NYMEX unleaded gasoline futures price	$0.60	$0.15	$0.29	$1.14
Detroit spot ethanol price	$1.19	$0.17	$0.95	$1.77

Table 2. Estimated Cross-Hedge Relationships from Equation (4).

Cross-hedge horizon	1-week	4-week	8-week	12-week	16-week	20-week	24-week	28-week
Constant (β_0)	-0.001	-0.002	-0.003	-0.01	-0.027	-0.026	-0.027	-0.049**
	(0.002)	(0.005)	(0.010)	(0.014)	(0.021)	(0.030)	(0.038)	(0.024)
Cross-hedge ratio (β_1)	0.833***	0.867***	0.930***	0.920***	1.005***	0.831***	0.712***	0.632***
	(0.045)	(0.045)	(0.047)	(0.047)	(0.048)	(0.047)	(0.044)	(0.040)
1^{st}-Order autocorrelation (ρ_1)	0.022	0.823***	0.907***	0.943***	0.949***	0.951***	0.960***	0.958***
	(0.039)	(0.025)	(0.019)	(0.016)	(0.014)	(0.013)	(0.011)	(0.010)
k^{th}-Order autocorrelation (ρ_k)	NA	-0.202***	-0.110***	-0.082***	-0.041***	-0.023**	-0.019**	-0.049***
	NA	(0.026)	(0.020)	(0.015)	(0.011)	(0.009)	(0.007)	(0.010)
R-squared (R^2)	0.338	0.786	0.884	0.923	0.945	0.947	0.955	0.961
Number of observations	678	678	678	678	678	678	678	678
H_o: $\beta_1 = 1$ (*p*-value reported)	< 0.01***	< 0.01***	0.135	0.088	0.913	< 0.01***	< 0.01***	<0.01***
Quantity (gallons) of ethanol per 42,000 gallon unleaded gasoline futures contract	50,420	48,443	42,000	42,000	42,000	50,542	58,989	66,456

Note: Standard errors are reported in parentheses below coefficients. Three asterisks (***) and two asterisks (**) indicate statistical significance at the 0.01 and 0.05 levels, respectively. Forty-two thousand gallons of ethanol are hedged with each NYMEX unleaded gasoline futures contract for the 8-, 12-, and 16-week cross-hedge horizons, as the cross-hedge ratios for these horizons were not statistically different from one.