Journal of Agribusiness 27, 1/2 (Spring/Fall 2009): 1−15

Cross-Hedging Distillers Dried Grains Using Corn and Soybean Meal Futures Contracts

Adam J. Brinker, Joe L. Parcell, Kevin C. Dhuyvetter, and Jason R. V. Franken

Ethanol mandates have led to an increase in the production of distillers dried grains (DDGs), a co-product of ethanol production that is incorporated into livestock rations. As with most competitive industries, there is some level of price risk in handling DDGs, and there is no DDG futures contract available for managing price risk. Commonly, DDGs are hedged using only corn futures. Our results suggest that cross-hedge risk may be reduced by including soybean meal futures in an encompassing cross-hedge strategy. Further, we also conclude soybean meal futures currently may be slightly more effective at reducing risk than in the past.

Key Words: cross-hedge, distillers dried grains, ethanol, price risk

Ethanol mandates and high fuel prices have led to an increase in the number of ethanol plants in the United States in recent years. U.S. ethanol production increased from less than 200 million gallons in 1980 to over 9 billion gallons in 2008. Over this same time period, corn used for ethanol production increased from less than 100 million bushels to 4.5 billion bushels [U.S. Department of Agriculture/Economic Research Service (USDA/ERS), 2009]. In turn, this has led to an increase in the production of distillers dried grains (DDGs) as a co-product of corn ethanol production. One bushel of corn (56 lbs.) yields approximately 2.8 gallons of ethanol and 17 pounds of DDGs in the process of ethanol production (American Coalition for Ethanol, 2007). Thus, estimated 2008 DDG production was 23 million metric tons. DDG production steadily increased from 1999 to 2008, and is expected to continue increasing over the next several years due to renewable fuels mandates (Renewable Fuels Association, 2007).

As with most competitive industries, there is some level of price risk in handling DDGs, and no DDG futures contract is available for managing the price risk of this co-product. Ethanol plants, as well as users of DDGs, may find cross-hedging DDGs with corn or soybean meal (SBM) futures as an effective means of managing price risk.

Adam J. Brinker is a field sales trainee for Pioneer Hi-Bred International, Inc., and former M.S. graduate research assistant, Department of Agricultural Economics, University of Missouri; Joe L. Parcell is associate professor, Department of Agricultural Economics, University of Missouri; Kevin C. Dhuyvetter is professor, Department of Agricultural Economics, Kansas State University; and Jason R. V. Franken is post-doctoral fellow, Department of Agricultural Economics, University of Missouri.

Although DDGs in the United States are primarily composed of the product left over from corn ethanol production, DDGs and corn are not perfect substitutes. The protein content of corn, SBM, and DDGs varies considerably at 8%–10.9%, 48%, and 27%–28%, respectively (Distillers Grains Technology Council, 2007; Shurson et al., 2003). Thus, a combination of corn and SBM contracts may provide better risk abatement in hedging DDGs than corn futures alone.

DDGs generated by ethanol production are predominantly fed in ruminant animal diets, comprising up to 20% in the daily diets of cattle. DDG price risk management is important, as feed costs are the primary expenditure for livestock operations. Since DDGs can be substituted for either grain corn or SBM (Powers et al., 1995), the hedging weight between corn and SBM futures is unclear.[1] The objective of this study is to determine the appropriate hedge ratio of corn or SBM futures as an effective means of managing the DDG price risk.

Following the hedging research of Brorsen, Buck, and Koontz (1998), and Franken and Parcell (2003), weekly DDG cash price time series for four export locations from January 1990 through April 2009, and three ethanol plant locations from January 2004 through April 2009 are regressed on corn and SBM futures prices.[2] In-sample forecasted errors from estimated hedging relationships are used in the procedure presented by Sanders and Manfredo (2004) to estimate weighted hedging values between corn and SBM futures and DDG cash price. The procedure employs the encompassing principle to determine if a particular contract "encompasses" the risk-reduction properties of an alternative contract or if a composite hedge using both contracts would more effectively minimize residual basis risk (Sanders and Manfredo, p. 34). They illustrate their framework with empirical application to wheat futures contracts offered at competing exchanges, multiple cross-hedging alternatives, and proposed versus existing futures contracts. The advantage of this approach over others (e.g., Anderson and Danthine, 1981) is that it permits testing the statistical significance of the differences in the effectiveness of alternative hedging mechanisms.

Though several measures of hedging effectiveness have been proposed [Pennings and Meulenberg (1997) list frequently used measures], the concept has not changed dramatically since Ederington's (1979) initial use of the correlation coefficient to measure the relationship between changes in cash and futures prices (Sanders and Manfredo, 2004). Myers and Thompson (1989) suggest that conditioning hedging rules on all available information (e.g., past prices) improves upon the effectiveness

---

[1] In particular, flexibility in the use of these alternative inputs in diets may reduce the need for hedging, but this effect is limited by the degree of substitutability.

[2] Due to the limited availability of long time series of DDG cash prices, results for nearly 20 years of DDG prices at Atlanta, Boston, Buffalo, and Chicago are compared with results for shorter price series at Atchinson, KS, Clarence, NY (delivered to Springfield, MO), and Muscatine, IA, which are more representative of interior ethanol plants and regions of livestock production. Furthermore, while export prices may reflect inconsistent quality due to the apparent variation in DDG quality indicated by price differences across ethanol plants, prices at any individual plant should reflect relatively more consistent quality.

of unconditional hedges. However, conclusions about the hedging performance of futures markets vary little with the chosen measure of hedging effectiveness (Floros and Vougas, 2006).

A particular futures contract may more effectively mitigate risk than futures contracts for the same commodity at alternative exchanges. Leuthold and Kim (2000) found the CBOT's electronic exchange, Project A, a superior overnight hedging alternative to the Tokyo Grain Exchange (TGE) contract in mitigating corn spot price risk. Yet, thin trade of the promising, but illiquid, electronic contract may render the hedging alternative unviable for large grain merchants.

This study investigates effectiveness of using corn and SBM futures, or some combination thereof, in cross-hedging DDG price risk across multiple time horizons. The empirical procedures are laid out in the section below, followed by a description of the data. Next, the results are presented. The study concludes with a discussion of our findings and their implications.

Empirical Model

The empirical model follows from Sanders and Manfredo (2004), except that cash and futures prices are not first differenced. For the current analysis, statistical tests conducted for the presence of nonstationarity indicated no need to take the first differences. In addition, scouring the data indicated many similar DDG prices in the sequence. Therefore, the analysis is performed using levels as opposed to changes which would result in numerous observations with values of zero. Furthermore, Myers and Thompson (1989) found only a marginally improved hedge coefficient by employing first differences.

As noted by Leuthold, Junkus, and Cordier (1989), ex post minimum variance hedge ratios are usually estimated with ordinary least squares regression as:

(1) $$\Delta CP_t = \alpha + \beta \Delta FP_t + e_t ,$$

where CP_t and FP_t are cash price and futures price, respectively. In equation (1), α is the trend in cash prices, β is the ex post minimum variance hedge ratio, Δ represents changes in price, and e_t is the residual basis risk.

If there are two competing contracts that can be used to hedge a cash transaction, a standard minimum variance regression can be utilized to determine the hedging effectiveness of the two different contracts. Equation (1a) represents the original contract, and equation (1b) represents the alternative contract:

(1a) $$CP_t = \alpha_0 + \beta_0 FP_t^0 + e_{0,t} ,$$

or

(1b) $$CP_t = \alpha_1 + \beta_1 FP_t^1 + e_{1,t} .$$

The fitted values for the competing hedging contracts are represented by y_0 and y_1 for equations (1a) and (1b), respectively. The dependent variable is denoted by y in place of CP_t. The fitted and actual dependent variables can be plugged into equation (2) (Maddala, 1992, p. 516):

$$y - y_0 = \Phi + \lambda(y_1 - y_0) + v, \tag{2}$$

where $y - y_0$ represents the residual basis or spread risk of the first model, while $y_1 - y_0$ represents the difference in fitted values of the two models. This study is not examining a conventional basis, but rather the spread in the case of a cross-hedge. In this case, if λ is not found to be statistically different from zero, then the second model has no more explanatory power than the first. Therefore, if $\lambda = 0$, the new contract does not provide a reduced basis or spread risk above the original contract. Following Granger and Newbold (1986), by adding λy to equation (2), we obtain:

$$y - y_0 = \Phi + \lambda\left[(y - y_0) - (y - y_1)\right] + v, \tag{2a}$$

where $y - y_0$ is the residual basis risk for the original contract and $y - y_1$ is the residual basis risk for the new contract. Given the above, the error terms from equations (1a) and (1b) can be substituted for basis risks $y - y_0$ and $y - y_1$ in equation (2a), respectively, yielding:

$$e_{0,t} = \Phi + \lambda\left[(e_{0,t} - e_{1,t})\right] + v_t. \tag{2b}$$

Equation (2b) is similar to the regression test for forecast encompassing used by Harvey, Leybourne, and Newbold (1998). In this equation, λ is the weight to be placed on the new model and $(1 - \lambda)$ is the weight to be placed on the original model's forecast which minimizes the mean squared forecast error. The null hypothesis that the preferred model "encompasses" the new model is tested, and the following are the alternative results:

- $\lambda = 0$: All hedging should be in the encompassing futures market.
- $0 < \lambda < 1$: A combination of hedging should be done in each market with λ as the weight assigned to the new futures contract.
- $\lambda = 1$: All hedging should be done in the competing futures market.

As shown by Maddala (1992, p. 516), the λ that best reduces the error or risk can be illustrated as:

$$\lambda = \frac{\sigma_{e_0}^2 \rho_{e_0 e_1}}{\sigma_{e_0}^2 + \sigma_{e_1}^2 - 2\rho_{e_0 e_1}\sigma_{e_0}\sigma_{e_1}}, \tag{3a}$$

where σ^2, σ, and ρ, respectively, represent the variance, standard deviation, and correlation associated with basis risk for the original and new models. Maddala also shows:

$$\text{(3b)} \qquad \lambda \geq 0 \quad \text{iff} \quad \frac{\sigma_{e_0}}{\sigma_{e_1}} \geq \rho_{e_0 e_1}$$

and

$$\text{(3c)} \qquad \lambda < 0 \quad \text{iff} \quad \frac{\sigma_{e_0}}{\sigma_{e_1}} < \rho_{e_0 e_1}.$$

The λ in equations (3b) and (3c) shows the ability of the new futures contract to reduce the residual basis risk associated with the original futures contract.

Previous studies (e.g., Sanders and Manfredo, 2004) compare two different markets to determine the hedging effectiveness of each. This study will determine the cross-hedge ratio of corn and SBM futures contracts as an effective hedge for DDGs in four markets in different parts of the United States.

The conventional practice of hedging corn in the corn futures markets is to use one 5,000 bushel contract for each 5,000 bushels of corn to be hedged. However, since DDGs are a substitute for corn or SBM, the one-to-one ratio may be inappropriate, and a cross-hedge ratio is necessary to determine the size of the futures position to take. Following the work of Buhr (1996) and Schroeder and Mintert (1988), the relationship between cash prices for DDGs and corn or SBM futures prices is estimated using SHAZAM 9.0 to determine the cross-hedge ratio (β) in equation (1):

$$\text{(4)} \qquad \textit{DDG Cash Price} = \beta_{0,Corn} + \beta_{1,Corn}(\textit{Corn Futures Price})$$

and

$$\text{(5)} \qquad \textit{DDG Cash Price} = \beta_{0,SBM} + \beta_{1,SBM}(\textit{Soybean Meal Futures Price}),$$

where ($\beta_{0,Corn}$ and $\beta_{0,SBM}$) are the intercepts or expected basis and ($\beta_{1,Corn}$ and $\beta_{1,SBM}$) are the hedge ratios. The corn and soybean meal futures prices are for the nearby months. While not specified in equations (4) and (5), contract dummy variables were used to account for contract bias that might exist in the data. These variables control for any variations across contract months, and possibly reflect seasonality in the associated commodities. Lagged error terms are also included to correct for autocorrelation (Brorsen, Buck, and Koontz, 1998). Unlike prior research, the estimated cross-hedge coefficients here are not time variant. Specifically, we do not evaluate alternative hedging horizons for each contract futures month offered. We justify non-time-varying hedge ratios because, in practice, merchandiser and procurement managers prefer the use of a seemingly simple rule-of-thumb cross-hedge relationship.

Historical weekly average CBOT corn and SBM closing prices were pulled for the time period from January 1990 through April 2009 using Commodity Research Bureau information. Weekly DDG prices for four export locations—Atlanta, GA; Boston, MA; Buffalo, NY; and Chicago, IL—were collected for the same time period from the Ingredient Market Report of *Feedstuffs* magazine (see footnote 2). For comparison, the analysis was also performed using three shorter price series which may be more representative of prices faced by livestock operations. Longer time series of interior locations were unavailable. Weekly prices quoted in Clarence, NY (FOB Springfield, MO); Atchinson, KS; and Muscatine, IA, were obtained from University of Missouri Extension's Agricultural Electronic Bulletin Board (AgEbb) for January 2004 through April 2009.

A total of 1,009 observations were used in estimation of each of the four models using *Feedstuffs* data, and 276 observations were used in the analysis of AgEbb data. Corn futures prices were converted to dollars/ton. For the January 1990–April 2009 period, the mean corn futures price was $96.63/ton with a standard deviation of $29.98/ton, and the mean SBM futures price was $200.35/ton with a standard deviation of $50.50/ton. Mean DDG prices for Atlanta, Boston, Buffalo, and Chicago were $140.28/ton, $143.52/ton, $127.32/ton, and $108.43/ton, respectively, with standard deviations of $25.88/ton, $23.05/ton, $22.95/ton, and $24.67/ton. For the shorter period (January 2004–April 2009), the mean corn futures price was $118.67/ton with a standard deviation of $44.87/ton, and the mean SBM futures price was $239.38/ton with a standard deviation of $68.58/ton. Mean DDG prices for Atchinson, Clarence, and Muscatine were $116.98/ton, $129.26/ton, and 129.62/ton, respectively, with standard deviations of $29.39/ton, $30.78/ton, and $40.78/ton. By comparison, the Atlanta price averaged $151.81 with a standard deviation of $35.15/ton over the same period. Clearly, the level and volatility of prices became higher in the more recent time period.

Correlations of corn futures, SBM futures, and DDG prices are presented in table 1 for both periods of analysis. Of the export locations, Atlanta has the highest correlation with corn and SBM futures in the full sample (0.85 and 0.81, respectively), while the other export locations are slightly less correlated. Across export locations, correlation with corn and SBM futures is higher in the shorter, more recent time period, suggesting these prices may be becoming more closely tied. In general, the Atlanta price series moves more similarly to the Chicago series than the Boston and Buffalo series, which are also similar to each other. DDG price movements at interior locations also more closely mirror movements in the Atlanta and Chicago price series.

Equations (4) and (5) utilize the cross-hedge ratios ($\beta_{1,Corn}$ and $\beta_{1,SBM}$) to determine the approximate tons of DDGs to hedge:

$$\text{(6)} \qquad \textit{Cash DDG Quantity Hedged} = \frac{\textit{Futures Contract Quantity}}{\beta_1}.$$

Table 1. Correlation Among Corn Futures, SBM Futures, and DDG Price Series

Description	Corn Futures	SBM Futures	Atlanta, GA	Boston, MA	Buffalo, NY	Chicago, IL	Atchinson, KS	Clarence, NY [a]	Muscatine, IA
Corn Futures	1.00	0.84	0.92	0.86	0.82	0.92	0.91	0.88	0.93
SBM Futures	0.83	1.00	0.86	0.87	0.84	0.85	0.88	0.80	0.89
Atlanta, GA	0.85	0.81	1.00	0.90	0.90	0.97	0.95	0.94	0.94
Boston, MA	0.68	0.71	0.88	1.00	0.88	0.91	0.89	0.84	0.87
Buffalo, NY	0.67	0.72	0.89	0.92	1.00	0.91	0.93	0.84	0.86
Chicago, IL	0.73	0.69	0.92	0.91	0.91	1.00	0.96	0.93	0.93
Atchinson, KS	—	—	—	—	—	—	1.00	0.91	0.94
Clarence, NY [a]	—	—	—	—	—	—	—	1.00	0.91
Muscatine, IA	—	—	—	—	—	—	—	—	1.00

Note: n = 1,009 for lower off-diagonal full sample from January 1990 through April 2009, and n = 276 for upper off-diagonal sample from January 2004 through April 2009.

[a] FOB Springfield, MO.

The *Futures Contract Quantity* is the bushel (ton) amount per corn or soybean meal futures contract, and the *Cash DDG Quantity Hedged* is tons of ethanol hedged per futures contract. For example, a 5,000 bushel (140 ton) corn futures contract would appropriately cross-hedge 140 tons of DDGs if the cross-hedge ratio ($\beta_{1,Corn}$) is determined to be 1.0. Similarly, if the cross-hedge ratio was estimated to be 0.8, the appropriate number of tons of DDGs to cross-hedge against one corn futures contract is 175 tons (= 140 tons/0.8).

In practice, however, DDG merchandiser and procurement persons are more likely interested in how many futures contracts are needed per portion of DDGs produced during a particular time period. Rearranging equation (6), we obtain:

$$(7) \qquad \textit{Futures Contracts Quantity} = \textit{Cash DDG Quantity Hedged} \times \beta_1 .$$

Suppose the cross-hedge ratio for corn futures is 0.80, and a corn futures contract is for 140 tons of corn. Then a merchandiser seeking to hedge 525 tons of DDGs would take a position on three corn futures contracts ($= 525 * 0.80/140$). Equation (7) can be easily specified to account for hedging weights assigned across multiple futures contracts for the cash price of one commodity.

Results

Tables 2–5 show the model results [equations (4) and (5)] for the Atlanta, Boston, Buffalo, and Chicago export markets, respectively. Panel A in each table presents estimated hedge ratios for corn and SBM to be used when hedging DDGs with corn or SBM alone, along with statistical measures for the regression equations.

Table 2. Model Results for Atlanta Market, January 1990–April 2009 (n = 1,009)

PANEL A. Hedging Regressions

Description	Corn	SBM
Estimated Hedge Ratio (β) (Standard Error)	0.77 (0.01)	0.43 (0.37×10^{-2})
R^2	0.97	0.97
Standard Deviation (e_t)	4.47	4.70
Correlation ($\rho e_0 e_1$)	0.71	

PANEL B. Encompassing Regression

Description	Corn	SBM
Estimated Hedging Weight (Standard Error)		0.42 (0.01)

PANEL C. Contracts Required to Hedge

	Weekly DDG Output (tons)			
Contracts Used to Hedge Quantity	1,000	2,000	4,000	6,000
CBOT Corn	3.19	6.38	12.76	19.14
CBOT SBM	1.81	3.61	7.22	10.84

Table 3. Model Results for Boston Market, January 1990–April 2009 (n = 1,009)

PANEL A. Hedging Regressions

Description	Corn	SBM
Estimated Hedge Ratio (β) (Standard Error)	0.57 (0.01)	0.36 (0.35×10^{-2})
R^2	0.97	0.96
Standard Deviation (e_t)	3.82	4.42
Correlation ($\rho e_0 e_1$)	0.78	

PANEL B. Encompassing Regression

Description	Corn	SBM
Estimated Hedging Weight (Standard Error)		0.19 (0.35×10^{-2})

PANEL C. Contracts Required to Hedge

	Weekly DDG Output (tons)			
Contracts Used to Hedge Quantity	1,000	2,000	4,000	6,000
CBOT Corn	3.30	6.60	13.19	19.79
CBOT SBM	0.68	1.37	2.74	4.10

Table 4. Model Results for Buffalo Market, January 1990–April 2009 (*n* = 1,009)

PANEL A. Hedging Regressions		
Description	Corn	SBM
Estimated Hedge Ratio (β) (Standard Error)	0.56 (0.01)	0.35 (0.32×10^{-2})
R^2	0.97	0.97
Standard Deviation (e_t)	3.72	4.11
Correlation ($\rho e_0 e_1$)	0.76	

PANEL B. Encompassing Regression		
Description	Corn	SBM
Estimated Hedging Weight (Standard Error)		0.30 (0.01)

PANEL C. Contracts Required to Hedge				
	Weekly DDG Output (tons)			
Contracts Used to Hedge Quantity	1,000	2,000	4,000	6,000
CBOT Corn	2.80	5.60	11.20	16.80
CBOT SBM	1.05	2.10	4.20	6.30

Table 5. Model Results for Chicago Market, January 1990–April 2009 (*n* = 1,009)

PANEL A. Hedging Regressions		
Description	Corn	SBM
Estimated Hedge Ratio (β) (Standard Error)	0.63 (0.01)	0.36 (0.38×10^{-2})
R^2	0.97	0.96
Standard Deviation (e_t)	4.49	4.78
Correlation ($\rho e_0 e_1$)	0.80	

PANEL B. Encompassing Regression		
Description	Corn	SBM
Estimated Hedging Weight (Standard Error)		0.34 (0.01)

PANEL C. Contracts Required to Hedge				
	Weekly DDG Output (tons)			
Contracts Used to Hedge Quantity	1,000	2,000	4,000	6,000
CBOT Corn	2.97	5.94	11.88	17.82
CBOT SBM	1.22	2.45	4.90	7.34

For Atlanta, the corn hedge ratio is 0.77, which is a ratio of corn-to-DDGs. The SBM hedge ratio is estimated to be 0.43 for SBM-to-DDGs. Estimated SBM hedge ratios for the other three locations are all near 0.35, while greater variation is observed for corn hedge ratios. Corn and SBM hedge ratios vary by 0.21 and 0.08, respectively, across the four locations.

Panel B in tables 2–5 shows the estimated hedge weight to be placed on SBM, with the standard error reported below. In the case of Atlanta with the hedging weight of 0.42, about 40% of the hedging weight would be placed on the SBM hedge ratio and almost 60% would be placed on the corn hedge ratio (1 − 0.42). The estimated hedging weights on SBM vary considerably across locations with a difference of 0.23 between Atlanta and Boston. Such large differences across locations may reflect differences in DDG quality across regions or perhaps differences in pricing due to the export locations' proximity to markets where DDGs are in higher demand.

Panel C of the tables shows the number of CBOT contracts to hedge per given value of DDGs produced in a week. Weekly production of 1,000, 2,000, 4,000, and 6,000 tons of DDGs corresponds approximately to ethanol plants producing 17, 34, 69, and 103 million gallons per year (MGY). The number of corn contracts to hedge against 1,000 tons of DDGs in Atlanta is determined by multiplying the DDG quantity hedged (1,000) by the corn hedge ratio (0.77) and by the estimated hedging weight for corn [1 − SBM hedge weight (0.42)] and then dividing by 140 tons of corn per futures contract. Similarly for SBM, the number of futures contracts to hedge against 1,000 tons of DDGs is determined by taking the DDG quantity hedged (1,000) multiplied by the SBM hedge ratio (0.43) and the SBM hedge weight (0.42) divided by 100 tons of SBM per futures contract.

To assess whether similar hedging relationships can be expected in regions where livestock operations are more common, estimates are obtained using three shorter DDG price series for interior locations: Atchinson, KS; Clarence, NY (FOB Springfield, MO); and Muscatine, IA. The results for these locations are compared with results for export locations from January 2004 through April 2009 (table 6). The hedge ratios and hedge weights for export locations in this period are fairly similar to the results for the full sample discussed above. Generally, corn and SBM hedge ratios are slightly lower and SBM hedging weights are slightly higher for the shorter period. Again, there is somewhat more variation across locations in the corn hedge ratio than in the SBM hedge ratio or the SBM hedging weight. The interior locations do not differ systematically from the export locations as a group.

Based on our results, inclusion of SBM futures in the cross-hedge decision effectively reduces hedging risk for the periods examined. The SBM futures contract helps explain variation in the (DDG – corn futures) spread not picked up by the corn futures price. This shows the importance of including the alternative contract of SBM in addition to the corn futures. However, as production expands,

Table 6. Summary of Cross-Hedge Relationships for Interior Markets and for Atlanta, January 2004–April 2009 (weekly)

Description	Atlanta, GA	Boston, MA	Buffalo, NY	Chicago, IL	Atchinson, KS	Clarence, NY [a]	Muscatine, IA
Average DDG Price	151.81	147.26	130.39	110.33	116.98	129.26	129.62
(Standard Deviation)	(35.15)	(25.22)	(25.48)	(30.51)	(29.39)	(30.78)	(40.78)
Hedging Relationship:							
Estimated Corn Hedge Ratio (β)	0.75	0.49	0.47	0.67	0.64	0.65	0.86
(Standard Error)	(0.02)	(0.01)	(0.01)	(0.02)	(0.01)	(0.02)	(0.02)
Estimated SBM Hedge Ratio (β)	0.42	0.31	0.30	0.36	0.36	0.35	0.49
(Standard Error)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Encompassing Regression:							
Estimated SBM Hedging Weight	0.46	0.19	0.42	0.39	0.32	0.52	0.39
(Standard Error)	(0.02)	(0.01)	(0.01)	(0.01)	(0.05)	(0.09)	(0.07)

Note: To conserve space, only the coefficient for the hedging relationship is shown here. Full model results are available from the authors upon request.

[a] FOB Springfield, MO.

the use of DDGs as a substitute in livestock rations is changing. Further, the differences in the results reported for Atlanta over the two samples indicate that hedging weights may be changing as well. Thus, determining whether the relative hedging weight is changing over time may shed light on future hedging practices.

Hedging Weight Changes Over Time

The flexible least squares (FLS) estimator is used to test for cross-hedge parameter stability over time. The FLS estimator detects parameter instability which may indicate possible structural change in the analyzed variable (Tesfatsion and Veitch, 1990; Lutkepohl, 1993; Dorfman and Foster, 1991; Parcell, 2003; Parcell, Mintert, and Plain, 2004; Poray, Foster, and Dorfman, 2000). Graphically depicting how the cross-hedge estimate changes over time can be useful in assessing structural change, and the FLS estimator allows for such a graphical representation. The graphical representation suggests inferences regarding potential structural changes that may cause the cross-hedge estimate to change temporarily or persistently.

A brief description of the FLS estimator is given here. Assume a simple hedging model like the following:

$$CP_t = \beta FP_t + \varepsilon_t , \quad (8)$$

where CP_t is the cash price at time t (t = 1, …, T), FP_t is futures price at time t, and ε_t is a random disturbance term. By allowing the coefficient β to vary over time, the FLS estimator minimizes the loss function derived from (8), which can be specified as:

(9) $$\sum_{t=1}^{T}(CP_t - \beta_t FP_t)^2 + \lambda \sum_{t=1}^{T-1}(\beta_{t+1} - \beta_t)' \mathbf{D}(\beta_{t+1} - \beta_t),$$

where β_t is a $\{T \times 1\}$ vector of time-varying parameter estimates, λ is a value between zero and one $[\lambda \in (0, 1)]$, and **D** is a $\{K \times K\}$ weighting matrix. The first term is the sum of the squared errors. The second term is the sum of the squared parameter variations over time. The matrix **D** is specified as a positive definite diagonal unit matrix with diagonal elements $d_{ii} = 1$. Given the specification of (9), a large λ penalizes parameter variability and a small λ allows for greater parameter variability.

The FLS estimator is used to graphically represent the time path of the SBM cross-hedge weights. Individual FLS parameter estimates do not hold great explanatory power, and hence are not meant to proxy for coefficient estimates. However, changes in the magnitude of the coefficients over the time period specify the impact of structural change, like the potential impacts of increased ethanol production or improvements in DDG quality.

Figure 1 shows the time path of the SBM hedge weight, $\lambda = 1$, for each of the export markets. SBM cross-hedge weights varied substantially from 1990 through 2001, and then somewhat stabilized with increased ethanol (and hence DDG) production mandates until more recently. For each of the price series, there is a slight upward trend in the magnitude of SBM cross-hedge weights, which may reflect the increased substitution of DDGs for SBM in some livestock rations. As relative prices change in response to supply and demand, it may be necessary to adjust cross-hedging relationships accordingly.

Conclusions

Distillers dried grains (DDGs), a co-product of corn ethanol production, have a nutritional (protein) content between that of corn and soybean meal (SBM). Even though DDGs are a derivative product of corn, their nutrient makeup and composition put them in a category for end use that is closely related to SBM. Thus, it makes sense to use a combination of both corn and SBM to hedge against DDGs. Our findings suggest that ethanol plants, as well as users of DDGs, may find cross-hedging DDGs with corn and SBM futures an effective means of managing risk.

Data on four export locations and shorter time series on three interior ethanol plant locations, which may be more representative of prices faced by livestock producers, are used for DDG cash prices in this study. DDG price data for any substantial length of time are difficult to acquire. As DDGs become a more widely used and traded commodity, DDG price data should become more readily available.

As shown by our analysis, depending on location and time period analyzed, between 19% and 46% of the hedging weight for DDGs is placed on SBM with the remainder going to corn. Overall, our results reveal that a combination of both

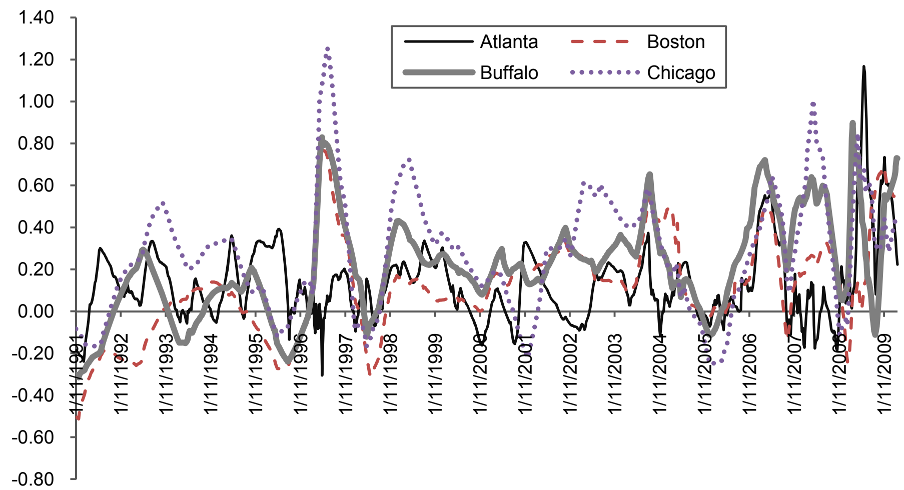

Figure 1. Time path of SBM cross-hedge weight for export locations, 1991–2009, $\lambda = 1$

corn and SBM futures contracts provides a hedge that better reduces the spread risk of cross-hedging DDGs. Generally, the weight placed on SBM is higher for the locations analyzed during the shorter, more recent period, which may suggest an increasing effectiveness of SBM in reducing risk.

The flexible least squares (FLS) estimator offers further insight into the stability of the cross-hedge parameter over time. In this case, a change in magnitude over time indicates structural change, such as increased ethanol production. In general, the SBM hedge weight increased over time, showing an increased substitutability of DDGs in livestock rations.

Many research areas could build on this study. For example, instead of examining only nearby futures contracts for cross-hedging DDG prices, alternative hedging horizons could be explored for better hedging effectiveness.

References

American Coalition for Ethanol. (2007). "Ethanol production." Online. Available at http://www.ethanol.org/index.php?id=38&parentid=8. [Retrieved January 17, 2007.]

Anderson, R., and J. P. Danthine. (1981, December). "Cross hedging." *Journal of Political Economy* 89(6), 1182–1196.

Brorsen, B. W., D. W. Buck, and S. R. Koontz. (1998). "Hedging hard red winter wheat: Kansas City versus Chicago." *Journal of Futures Markets* 18, 449–466.

Buhr, B. L. "Hedging Holstein steers in the live cattle futures market." (1996, January). *Review of Agricultural Economics* 18, 103–114.

Commodity Research Bureau. (2006, December). CD-ROM: Historical weekly average CBOT corn and SBM closing prices, January 1990 through April 2009. CRB, Chicago.

Distillers Grains Technology Council. (2007). "Protein energy content." University of Louisville. Online. Available at http://www.distillersgrains.org/index.html. [Retrieved January 18, 2007.]

Dorfman, J., and K. Foster. (1991, December). "Estimating productivity change with flexible coefficients." *Western Journal of Agricultural Economics* 16(2), 280–290.

Ederington, L. H. (1979, March). "The hedging performance of the new futures markets." *Journal of Finance* 34(1), 157–170.

Floros, C., and D. V. Vougas. (2006, September). "Hedging effectiveness in Greek stock index futures markets, 1999–2001." *International Research Journal of Finance and Economics* 5, 7–18.

Franken, J. R., and J. L. Parcell. (2003, December). "Cash ethanol cross-hedging opportunities." *Journal of Agricultural and Applied Economics* 35, 509–516.

Granger, C. W. J., and P. Newbold. (1986). *Forecasting Economic Time Series*, 2nd edition. New York: Academic Press.

Harvey, D. I., S. J. Leybourne, and P. Newbold. (1998, April). "Tests for forecast encompassing." *Journal of Business and Economic Statistics* 16(2), 254–259.

Ingredient Market Report. (1990–2006). *Feedstuffs*. Various issues.

Leuthold, R. M., J. C. Junkus, and J. E. Cordier. (1989). *The Theory and Practice of Futures Markets.* Lexington, MA: Lexington Books.

Leuthold, R. M., and M.-K. Kim. (2000, Fall). "Managing overnight corn price risks: E*hedging versus Tokyo." *Journal of Agribusiness* 18(3), 275–288.

Lutkepohl, H. (1993). "The source of the U.S. money demand instability." *Empirical Economics* 18, 729–743.

Maddala, M. S. (1992). *Introduction to Econometrics*, 2nd edition. New York: Macmillan.

Myers, R. J., and S. R. Thompson. (1989, November). "Generalized optimal hedge ratio estimation." *American Journal of Agricultural Economics* 71(4), 858–867.

Parcell, J. L. (2003, August). "An empirical analysis of the demand for wholesale pork primals: Seasonality and structural change." *Journal of Agricultural and Resource Economics* 28(2), 335–348.

Parcell, J., J. Mintert, and R. Plain. (2004, December). "An empirical investigation of live-hog demand." *Journal of Agricultural and Applied Economics* 36(3), 773–787.

Pennings, J. M. E., and M. T. G. Meulenberg. (1997, August). "Hedging efficiency: A futures exchange management approach." *Journal of Futures Markets* 17(5), 599–615.

Poray, M., K. A. Foster, and J. H. Dorfman. (2000). "Measuring an almost ideal demand system with generalized flexible least squares." Paper presented at American Agricultural Economics Association annual meetings, Philadelphia. Online. Available at http://agecon.lib.umn.edu/. [Accessed May 2002.]

Powers, W. J., H. H. Van Horn, B. Harris, and C. J. Wilcox. (1995). "Effects of variable sources of distillers dried grains plus solubles on milk yield and composition." *Journal of Dairy Science* 78, 388–396.

Renewable Fuels Association. (2007). "Industry resources: Co-products." Online. Available at http://www.ethanolrfa.org/industry/resources/coproducts/. [Retrieved January 17, 2007.]

Sanders, D. R., and M. R. Manfredo. (2004, April). "Comparing hedging effectiveness: An application of the encompassing principle." *Journal of Agricultural and Resource Economics* 29(1), 31–44.

Schroeder, T. C., and J. Mintert. (1988, December). "Hedging steers and heifers." *Western Journal of Agricultural Economics* 13(2), 316–326.

SHAZAM User's Reference Manual, Version 10.0. (2004). New York: McGraw-Hill.

Shurson J., M. Spiehs, J. Wilson, and M. Whitney. (2003). "Value and use of 'new generation' distiller's dried grains with solubles in swine diets." In *Allech's 19th International Feed Industry Symposium Proceedings.* Department of Animal Science, University of Minnesota, St. Paul.

Tesfatsion, L., and J. Veitch. (1990). "U.S. money demand instability." *Journal of Economic Dynamics and Control* 14, 151–173.

U.S. Department of Agriculture, Economic Research Service. (2009). "Agricultural baseline projections: U.S. crops, 2009–2018." Online. Available at http://www.ers.usda.gov/Briefing/Baseline/crops.htm. [Accessed May 2009.]

University of Missouri Extension. (2009). "Agricultural electronic bulletin board." Online. Available at http://agebb.missouri.edu/dairy/byprod/AllProducts.asp. [Accessed May 2009.]