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Comparing different models to cross hedge Distillers Grains in Iowa: Is it necessary to include energy derivatives?

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Comparing different models to cross hedge Distillers Grains in Iowa: Is it necessary to include energy derivatives?

The actual and expected increase of corn based ethanol production in the Midwest has increased the availability of Distillers Grains that are used in the feeding and egg industry as source of protein and energy. Since no future market has existed for this product, no previous studies have found significant results for Iowa and no geographical market integration has been found, the use of corn, soybean meal (SBM) and energy futures contracts is analyzed to hedge Distillers Grains prices in Iowa. Alternative models are estimated and evaluated. Results indicate that there are potential opportunities for cross hedging DDG (Distillers Dried Grain) in Iowa using corn, SBM and energy futures that effectively decrease price risk up to 86% for a 13 week hedge.

Key Words: Cross Hedge, DDG, corn futures, soybean meal, feedingstuff price risk management

Introduction

Distillers Dried Grain (DDG), a byproduct of Corn Ethanol production that has become an important feedstuff in the last decade, represented a one billion dollar market in Iowa in 2008 (Iowa Renewable Fuel Association 2008). Iowa produced in 2008 2.2 billion gallons of ethanol and approximately 6.6 million tons of distillers grains (Iowa Renewable Fuel Association 2008); and it is expected that by 2011 40 million tons dry matter basis of DDG are going to be produced, according to estimations of Center for Agricultural and Rural Development (CARD).

DDG is a source of energy and protein. It can be included in the beef and dairy rations up to 30% to 40%, as a substitute of corn and soybean meal (SBM) without nutritional or carcass quality problems (Tjardes and Wright 2002). The percentage of protein in DDG (25%) is between corn (9%) and SBM (44%), making it a substitute of both products as a source of energy and protein. In 2006, according to a USDA survey 70% of the feed lots in the Midwest were using or considering using distilled grains (USDA 2007). The increase of the availability of DDG in the Midwest, together with record corn prices in 2008, caused the increase of the use of DDG as a feedstuff.

Price risk management in commodities implies the use of futures contracts or derivatives, which in the case of DDG do not exist. An alternative commonly used in the absence of its own futures market is to cross hedge a commodity in other related markets. In this case, considering that DDG is a substitute for corn and SBM in livestock rations, both futures -but no energy derivatives- have been used to estimate optimal cross hedge ratios in previous studies (Coffey, Anderson and Parcell 2000 ; Brinker, Parcell and Dhuyvetter 2007; Van Winlke and Schroeder 2008). Only one study (Van Winlke and Schroeder 2008) has included data for Iowa (from January 2001 through December 2006). This study concluded that distilled grain prices are not strongly cointegrated across locations, have a slow speed of adjustment to other locations' prices and cross-hedging DDG with corn and SBM futures is not viable using recent data (the models for different locations were non significant).

While previous studies estimated one model to cross hedge DDG in many states using corn and SBM futures, this study estimates different models for one state cross hedging also with energy derivatives. The objective of this study is to compare different models' cross-hedging effectiveness of DDG prices using corn, SBM, and energy futures (ethanol, crude oil and natural gas) to minimize the variance of the cash price to buyers and sellers of DDGs in the state of Iowa. The inclusion of energy markets in the cross hedge is based in the sense that DDG is a byproduct of Ethanol and this is an energy market linked to crude oil markets. The inclusion of natural gas as a third energy market is because it is used as an input in the drying of distilled grains.

Typically hedging effectiveness is analyzed by comparing R square of the models, but if the dependent variable is different then other methods such as Information Criteria should be used to rank the models (Akaike Information Criterion (AIC) and Bayesian Information Criterion (BIC)). Also, R squared overestimate hedge effectiveness (Dalhran and Ma). Another criterion used for model selection is to apply the estimated hedge ratios in and out of sample data and then compare the variance of hedging and non hedging errors as a measure of hedging effectiveness. Using this methodology Coffey, Anderson and Parcell (2000) found that the hedge is not effective, in fact it increased price risk. The idea is that if the variance of the net cash price from hedging (price of the DDG's at the time the hedge is lifted plus the profits in the future market) minus the expected price (DDG's price forcasted with the estimated model for the time of the hedge lift at the time of placing the hedge) is lower from hedging (V_h) than non hedging (V_u) then the hedge is effective. The hedge effectiveness, e, can be estimated as $e = (V_u - V_h))/V_u$ (Ederington 1979). If e is positive then the hedge is effective, if it is negative the hedge is increasing the risk and shouldn't be used. The closer is e to one, the more effective is the hedge, and a theoretically perfect hedge is e=1. For the case of out of sample effectiveness it is assumed that the data generating process is the same in both periods (in and out of sample). This implies that the price relations between the futures markets and DDG's is the same in both periods; however, since this is not necessarily true out of sample effectiveness should be expected to be smaller than in sample (Dalhran and Ma).

It has been previously found for other states that both corn and SBM futures have been statistically significant in hedging DDGs, and that the hedge ratio of SBM was diminishing in magnitude until 2005 (Brinker, Parcell and Dhuyvetter 2007). One possible reason for a decreasing impact of SBM is that DDGs inclusion rates might have surpassed protein needs in diets and is now substituting for corn. This study will also evaluate if cross-hedge ratios for corn and SBM Futures are significant or not in the case of Iowa after 2005. In addition to increased DDGs volume since 2005, commodity prices have also reached higher levels and volatility; i.e. in the period 2006-2009 compared to the period 1990-2005 dairy nearby future corn prices increased their mean price, variance and variation coefficient from $ 2.46 , 0.26 and 0.20 to $3.84, 1.27 and 0.29 respectively. Given the increased oscillation in commodity prices after 2005, it is important to determine if the hedge ratios have changed from earlier time periods. Having an updated hedge ratio to manage risk will be of practical use for DGs buyers and sellers in Iowa.

Methodology and data

Multiple methodologies have been used to estimate hedge ratios. For an extended discussion of the implications of some of them see Witt, Shroeder and Hayenga (1987). Ordinary Least Squares Models (OLS) with variables in levels (Van Winlke and Schroeder 2008), in logs (Brown), in first differences and in differences of the length of the hedge (Dahlgran and Ma 2008) have been estimated. Also Generalized Least Squares in levels (Coffey, Anderson and Parcell 2000) and OLS with encompassing forecasting in differences (Sanders and Manfredo 2004), and in levels (Brinker, Parcell and Dhuyvetter 2007). Different reasons are given for the selection of the models on each case, but basically the decision of working with the variables in levels or in first differences is due to the integration order of the time series. Research using data previous to 2005 found that series were stationary (Coffey, Anderson and Parcell 2000; Brinker, Parcell and Dhuyvetter 2007), while research with data that includes information after 2005 found the series integrated of order 1 (Van Winlke and Shroeder). The decision to use the model in differences in the length of the hedge is that while models of first differences may solve the problem on non stationarity, the autocorrelation problem may not. Generalized Lest Squares (GLS) is used to account for autocorrelation (Coffey, Anderson and Parcell 2000) and decrease the variance of the estimator when heteroscedasticity is present, nevertheless the estimator by OLS is still unbiased and can be estimated using a robust estimation to solve this last problem (White 1980).

This paper will evaluate different methodologies to find optimal hedge ratios using two different data set periods. The optimal hedge ratio will be estimated by an Ordinary Least Square (OLS) model on levels (OLS(1) and OLS(2)), on logs (OLS(3)), first differences and differences of the length of the hedge (OLS(6), OLS(7), OLS(8) and OLS(9)); Vector Error Correction (VEC) model on levels (VEC(1) and VEC(2)); and an OLS with encompassing model. The data are weekly DDGs prices ($/per ton) for Iowa from USDA/AMS Corn Belt Feedstuffs Report (SJ_GR225), and weekly nearby Corn ,SBM, Ethanol, Crude Oil and Natural Gas Futures average Monday settlement prices. The two data set periods used are 10/03/06 to 05/27/08 and 10/03/06 to 02/24/09. The reason for the use of two different data set periods is that after 05/27/08 the market was so affected by the stock crisis of 2008 that even when only one more week of data was included in the short dataset the VEC model became not cointegrated, a sign of no long term equilibrium between future prices and DDG's prices during that crisis. Thirty observations after 02/24/09 were used to estimate hedge effectiveness out of sample. Models estimated use the data from 10/03/06 to 05/27/08, unless specified by a * in their names (i.e. OLS(3*)).

The reason to estimate a VEC model was that preliminary tests of the data by the authors after 2005, showed that the series are non-stationary, differing from the results found by Wang and Tomek (2007) that there are no unitary roots for commodity prices. The reason for that difference is that their work includes prices only until 2005. The Johansen test was performed to determine model cointegration, and long term cointegration equations were estimated.

Results

Several studies performed on the series indicated that the series were integrated of order one. Dikey-Fuller test, Augmented Dikey-Fuller test (ADF) and Dikey-Fuller Generalized Least Squares test were performed on the variables, and on the variables on differences. It was not rejected that the variables on levels have unitary roots, while it was rejected that the variables on differences have one, indicating that the variables are integrated of order 1. Cointegration test was performed on DDG, corn future and SBM future prices on levels with 8 lags, for the period ending in 05/27/08, and it was found that the vector error correction model was of rank 1, an indication that there exist a long run equilibrium relationship among the variables (no spur regression) and that the relation is unique (regression coefficients are uniquely determined). When the variable crude oil future price was included, the variables were cointegrated also but the vector error correction model was of rank two indicating the existence of two long run equilibrium relations, thus no VEC was estimated including future oil price. When all energy futures were included the rank was 4, thus no VEC was estimated including all energy futures markets. When the data period was extended to 02/24/09, no cointegration was present among all the variables. Also after adding one more week to the short dataset, no cointegration was present, showing the effect of the chaos of the financial crisis over the commodity markets. Then a set of models were estimated: VEC and OLS in levels, OLS in logs, OLS in first differences and OLS in differences of the length of the hedge. When the period included data after 05/27/08, given the series were non stationary and non cointegrated, models in differences and logs were estimated. A summary of the estimated models is in tables 1, 2 and 3.

Vector Error Correction Model.

Two VEC models where estimated, one with constant and trend (VEC(1)) and other only with constant (table 1). Eight lags were used. The model only with constant had fSBM (SBM futures) non significant, then a restricted model was estimated (VEC(2)). The VEC model with the lowest AIC was the VEC(2) and its hedge effectiveness was similar in and out of sample, varying from 0.33 to 0.73 as hedge horizon increased from 4 to 13 weeks (table 6).

Ordinary Least Square Model on levels.

Given that the series are cointegrated in the short data set, another option is to estimate the model in levels using an OLS(table 1). In this case SBM is significant (OLS(1)), even though the increase in the explanatory power of the model (the increase in R^2) is moderate (only 1.5 percentage points in 81%), and the bias of the hedge ratio caused by not using SBM (OLS(2)) is moderate (0.309 vs the true value is between 0.20 and 0.29 with 95% of confidence). If energy derivatives are included (OLS(2')), ethanol and natural gas futures are individually and jointly non significant (Joint test: Prob > F = 0.3068), then a restricted model is estimated (OLS(2")). In this last model oil future is significant and it increases 4.2 percentage points the explanatory power of the regression compared with only using corn and SBM futures, also is the model on levels with the lowest AIC and BIC. OLS(2”) hedge effectiveness is between 0.43 and 0.68 in sample and 0.69 and 0.82 out of sample. Given series were no cointegrated in the long dataset, no OLS on levels was estimated using that one.

Ordinary Least Square Model on first differences.

A third option is to estimate a model in differences (OLS(5) in table 3, for the short dataset and OLS (5^*) for the long dataset). These models are non significant (Prob > F = 0.9067 and Prob > F = 0.2383, respectively).

Ordinary Least Square on logs.

Following Brown, 1985, a model in logs was estimated for the short (OLS(3) in table 2) and the long data set (OLS(3*) in table 2). In OLS(3) and OLS(3*) the variable lnfgas was non significant, thus a restricted model was estimated in each case (OLS(3') and OLS(3*') respectively). These are the models with the lowest AIC and BIC, and have the highest hedge effectiveness in sample (table 6).

Ordinary Least Square Model on differences of the length of the hedge.

Another approach used was OLS model of the differences of the variables on the period length of the hedge (d-i-fcorn is the ith week difference of future corn). Different horizons were considered (table 3 for unrestricted models and table 4 for restricted ones): 2 (non significant: Prob > F = 0.1164 R-squared = 0.0449), 4(OLS(6) and OLS(6')), 8 (OLS(8)), and 13 weeks (OLS(9) and OLS(9')). OLS(6) have all variables, with the exception of d-4-fcorn, jointly non significant (Prob > F = 0.2676) and OLS(6*) had d-4fcorn and d-4-f oil also jointly non significant (Prob > F = 0.6160), then restricted models were estimated (OLS(6') and OLS (6*') respectively). OLS(8) has d-8-foil and d-8-fgas jointly non significant(Prob > F = 0.4007) and OLS(8*) has d-8-fcorn and d-8-foil non significant (Prob > F = 0.4656), then restricted models were estimated (OLS(8') and OLS(8*') respectively). OLS(9) and OLS(9*) have d-13-fetha and d-13-fgas jointly non significant(Prob > F = 0.8939 and Prob > F = 0.7633 respectively), then restricted model was estimated (OLS(9') and OLS(9*') respectively).

Encompassing Model.

This model was estimated following Sanders and Manfredo (2004) but instead of estimating the model in differences it was estimated in levels as Brinker, Parcell and Dhuyvetter (2007) did. The methodology is to estimate two OLS models of the independent variable against two alternative dependent variables, and if the errors are correlated use the difference between them as a variable to explain the residuals of the first regression (Encompassing Model). The estimated coefficient is the proportion of the amount to hedge that should be hedged using the second independent variable. The Correlation between r1 and r2 was 0.4954. The results of the estimation are in table 5.

Model selection

It is necessary to choose one of all the estimated models to use as a tool to hedge. Given the independent variables in the different models are in logs, levels and differences of different length R square should not be used as a criterion for model performance. AIC and BIC are the criteria that can be used in that case, choosing the model with the lowest values. Another possibility is to select the model that performs best in and out of sample.

According to the AIC and BIC the models that perform the best are OLS(3*') and OLS(3'). When the criterion of hedging effectiveness in sample is used OLS(3*’) and OLS(3’) are again preferred. In these two models hedging effectiveness increases with the length of the hedge, and the levels of effectiveness achieved in sample, especially of 13 week hedges are quite high (above 0.81). Eventhough out of sample the hedging effectiveness is smaller than in sample the level of effectiveness is high, but in this case OLS(3’) outperforms OLS(3*’). It should be noted that these are not the models that performs the best in this out of sample test, but the out of sample represents only one sample so with another out of sample results may change. Given these results, the model that is most promising according to the majority of the criteria used is OLS(3*’).

The information criteria results indicate that model OLS (3*’) provides better hedging than other models considered while if only hedging effectiveness is taken into account, there are also other models that are promising. The model OLS(2”) has the best performance out of sample (and 3rd best performance in sample) for a hedge of 8 weeks, and OLS(1) the second best for the same period out of sample and the best for 13 weeks.

Number of contracts to hedge DDG

All these models, including also OLS(1), were used to calculate the number of future contracts of each commodity necessary to hedge the production of a DDG of an ethanol plant that produces 8,000 tons a week (table 7). In the case of model OLS (3*’) considering current prices are: DDG $ 140, corn $ 4, SBM $ 270, ethanol $ 1.6 and crude oil $ 65, to hedge 8000 tons of DDG 31 future contracts of corn, 17 of soybean meal, 7 of ethanol and -2 of crude oil are necessary. Similar results were found for the model OLS(3') (table5). Both models have the variables in logs, thus to calculate the number of contracts of one future commodity necessary to hedge 8,000 tons of DDG the formula is the following: number of futures contracts of the commodity = [DDG tons to hedge* DDG price/(future price of the commodity *contract size)]*hedge ratio. In the case of corn in OLS (3*’) the formula becomes: [8000*140/(4*5000)]*0.549561=30.77, thus 31 contracts of corn are required to hedge 8,000 tons of DDG. For the case of SBM futures the price is 270 per short ton and the contract size is 100 short tons; for the case of ethanol the price is 1.6 per gallon and the contract size 29,000 gallons; and for the case of crude oil the price is 65 per barrel and the contract size is 1,000 barrels.

In the case of the models in levels (OLS (1), OLS(2") and encompassing) to get the numbers of contracts needed the amount of tons to be hedged is divided by the size of the futures contract in tons times the hedge ratio: (tons to hedge /140)*hedge ratio. As an example in OLS(2") the 16 corn contracts (table 6) are the result of : (8000/140)*0.2817=16.097.

Results are different for OLS(1) and OLS(2"). According to model OLS(1), to hedge 8000 tons of DDG, 14 future contracts of corn and 9 of soybean meal are necessary while according to model OLS(2”) 16 future contracts of corn, 21 of soybean meal and 50 of ethanol are necessary (table 7). One possible explanation is bias on the estimators of OLS(1) due to the omission of a significant variable (ethanol futures).

Hedge effectiveness in the case of models that used differences of the length of the hedge as variables was low, compared to other models. In sample hedge effectiveness was bellow 0.29 in all cases and out of sample below 0.54.

In the case of the Encompassing model to hedge DDG it is necessary a ratio of one SBM contract per 2 fcorn contract (table 7), bigger than the ones found by Brinker, Parcell and Dhuyvetter (2007) that where close of 1 to 4.

Conclusions

It was possible in the absence of a DDG future market[1] to estimate significant models that allow to hedge for a considerable amount of the variability of DDGS prices in Iowa. Corn, sbm and energy futures may be used to hedge DDG in Iowa.

The OLS models in levels and logs present similar R^2 superior to 80%, a significant difference to the results found by the OLS models estimated in Van Winlke and Schroeder (2008), where no significant model was found for Muscatine, IA and 10 different locations in the US. A possible reason for that difference is that the length period used in both studies is different and the market behavior is different in both periods.

Soybean meal is significant in all the models. When ethanol is not included, the hedge ratio of SBM in the model in levels is biased (underestimated), but including ethanol requires writing ethanol contracts, which might not be feasible from a practical point of view for a firm.

In the case of the OLS model in levels, even SBM is a significant variable its effect on the explanation of the price of DDGs is small given the small decrease of the R^2 of the model when it is dropped. Both hedge ratios in OLS(1) are smaller and with smaller standard deviations than previously reported (Coffey, Anderson and Parcell 2000) probably due to a high variability of corn prices during the data period.

The Encompassing Model results show that 80% of the hedging weight should be placed on future corn and only 20% on SBM, a similar result founded by Brinker, Parcell and Dhuyvetter (2007) for the Chicago market. Nevertheless some differences with that study were found: the R^2 of each OLS used for the Encompassing model (OLS(2) and OLS(10)) are close to 20 percentage points higher in this study and the hedge ratio to use for SBM and specially future corn are smaller than in their study: close to 1 for fcorn and 0.47 for SBM compared to .309 for fcorn and .39261 for SBM in this study. These results imply that less contracts are necessary to hedge the same amount of DDGS and that more effectiveness should be observed on average if the future data has similar behavior as the used dataset. Again, the different dataset used in that study, can be the reason for the differences (i.e. data from 1990 to 2005 and stationary series) and can be a sign of their hypothesis about the decrease across time of the participation of SBM in the hedge of DDG's.

Considering the case of a small hedger, the decision of which hedge model to use may take into account transaction costs and indivisibility of future contracts. The simplest and most economical strategy is to hedge only with future corn and SBM using OLS(1), and it should be expected that on average the effectiveness will be 0.77 for a 13 weeks hedge. If better performance is desired, energy derivatives should be included. The best option is to include ethanol and crude oil, using OLS(3*') to achieve an expected effectiveness of 0.86 for the same hedge period.

Ethanol is positively and Crude Oil is negatively correlated with DDG prices: may take opposite position in future markets than in spot DDG for Ethanol and same position for Crude Oil. A possible explanation for it is that the increase in ethanol prices increases less the supply of DDG (due to an increase in ethanol production that has DDG as byproduct) than it increases its demand (due to the price increase generated in the corn market that is a substitute feedstuff for DDG). And the explanation for Crude Oil being significant in hedging DDG even Ethanol is included is that there is an effect on the DDG market that is not though the domino effect on the Ethanol market but a direct effect on Crude Oil on DDG prices, possible due to an increase in transportation costs.

Hedging effectiveness increases with the length of the hedge for almost all models. This result is reasonable given that it is expected that the longer the time period the smaller the noise compared to the fundamentals. The only of the best performance models that is more effective at 8 weeks than at 13 is OLS(2").

Possible extensions of this study may be made in different areas. For example, time variability of the hedge ratios was not considered on this study due to the lack of available longer data series for Iowa, that didn't allow to include seasonal variables.

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Table 1. Regression Models of DDG price (USD/ton) Against Different Regressors.[2 3]

Model	fcorn	fSBM	fetha	foil	fgas	constant	trend	R2
VEC(1)	0.288 (.0603) ***	1.077 (.1804) ***				173.33	2.46	
VEC(2)	0.235 (.0465) ***					21.36		
OLS(1)	0.251 (.0234) ***	0.102 (.0382) ***				-4.023 (5.996)		0.832
OLS(2)	0.309 (.0154) ***					-1.823 (6.246)		0.817
OLS(2')	0.215 (.0568) ***	0.278 (.0623) ***	16.04 (10.57)	-0.472 (.1494) ***	-0.104 (2.071)	-28.75 (14.09) ***		0.864
OLS(2'')	0.282 (.0222) ***	0.243 (.0480) ***		-0.541 (.113)		-9.063 (5.497)		0.859

Table 2. Regression Models of DDG log-price (log (USD/ton)) Against Different Regressors.[2][3]

Model	lfcorn	lfSBM	lfetha	lfoil	lfgas	constant	R2
OLS(3)	0.723 (.1883) ***	0.630 (.146) ***	0.312 (.1554) **	-0.353 (.1034) ***	-0.027 (.1331)	-1.642 (.4945)	0.86
OLS(3’)	0.706 (.1538) ***	0.644 (.1141) ***	0.304 (.1540) *	-0.366 (.0747) ***		-1.613 (.4517)	0.855
OLS(3*)	0.522 (.1637) ***	0.419 (.1123) ***	0.257 (.1332) *	-0.153 (.0469) ***	0.521 (.0910)	-0.272 (.4123)	0.821
OLS(3*’)	0.549 (.1490) ***	0.402 (.1034) ***	0.276 (.1320) **	-0.136 (.0341) ***		-0.325 (.3891)	0.820
OLS(4)	1.082 (.0507) ***					-1.693 (.3052) ***	0.8145

Table 3. OLS Models in Differences of the Length i of the Hedge Period.[3][4]

Model	d-i-fcorn	d-i-fSBM	d-i-fetha	d-i-foil	d-i-fgas	constant	R2
OLS(5) i=1	.0265 (.0289)	.0001 (.0580)	-3.875 (8.015)	-.0787 (.2491)	1.067 (1.142)	1.095 (.7498)	0.01
OLS(5*) i=1	.0023 (.0261)	.0312 (.0392)	-4.931 (7.601)	-.0044 (.1102)	2.888 (1.151) **	.3906 (.5531)	0.06
OLS(6) i=4	.1549 (.0562) ***	-.0114 (.0854)	7.731 (8.136)	-.3388 (.2344)	.3316 (1.356)	3.427 (1.623)	0.18
OLS(6*) i=4	.0335 (.0494)	.0858 (.0566)	9.867 (7.112)	-.1136 (.1269)	2.398 (1.285) *	1.397 (1.199)	0.26
OLS(8) i=8	.1369 (.0494) ***	.2344 (.0861) ***	25.61 (8.242) ***	-.3163 (.2584)	.2632 (2.407)	1.768 (2.724)	0.46
OLS(8*) i=8	.0318 (.0456)	.1842 (.0533)	24.16 (7.247)	-.1222 (.1012)	1.658 (1.333)	1.695 (1.698)	0.51
OLS(9) i=13	.2448 (.0508) ***	.3194 (.0907) ***	1.784 (9.412)	-.5280 (.2642) **	.7101 (2.480)	-1.901 (3.513)	0.68
OLS(9*) i=13	.1996 (.0519) ***	.1577 (.0508) ***	3.718 (9.2203)	-.3243 (.1083) ***	.7213 (1.325)	-0.601 (1.780)	0.69

Table 4. Restricted OLS Models in Differences of the Length i of the Hedge Period.[3] [4]

Model	d-i-fcorn	d-i-fSBM	d-i-fetha	d-i-foil	d-i-fgas	constant	R2
OLS(6') i=4	.1694 (.0446) ***					2.206 (1.238) *	0.14
OLS(6*') i=4		.1022 (.0345) ***	12.17 (5.703) **		2.552 (1.149) **	1.491 (1.217)	0.25
OLS(8') i=8	.1229 (.0419) ***	.2553 (.0846) ***	27.46 (8.226) ***			-.3419 (2.010)	0.45
OLS(8*') i=8		.2111 (.0364) ***	29.77 (6.288) ***			1.583 (1.693)	0.50
OLS(9') i=13	.2619 (.0313) ***	.3067 (.0795) ***		-.4970 (.2073) **		-2.092 (3.457)	0.67
OLS(9*') i=13	.2246 (.0315) ***	.1464 (.0451) ***		-.308 (0.107) ***		-.942 (1.642)	0.69

Table 5. Encompassing Regression Model .[4]

Model	fcorn	fsbm	diffr1-r2	constant	R2
OLS(2)	0.309 (.0154) ***			-1.822 (6.246)	0.817
OLS(10)		0.392 (.0274) ***		25.29 (7.769) ***	0.647
Encompassing (y=r1)			0.202 (.0740) ***	-8.25 e-009 (1.326)	0.0632

Table 6. Measures of Hedging Effectiveness for the Different Estimated Models and Estimated e for Hedges of 4, 8, and 13 Weeks (e4,e8,e13) In and Out of Sample.[4]

Model	R2	AIC	BIC	e4in	e8in	e13in	e4out	e8out	e13out
VEC(1)		23.15	25.4	-0.04	-0.10	-0.18	0.45	0.54	0.64
VEC(2)		15.54	16.5	0.33	0.60	0.73	0.31	0.61	0.71
OLS(1)	0.8317	684.91	694.3	0.30	0.62	0.77	0.53	0.74	0.81
OLS(2)	0.8168	692.28	697.2	0.37	0.66	0.78	0.43	0.73	0.81
OLS(2”)	0.8588	673.6	683.5	0.43	0.72	0.68	0.69	0.82	0.54
OLS(3’)	0.8556	-160.9169	-148.6	0.45	0.75	0.81	0.64	0.67	0.69
OLS(3*’)	0.8205	-219.543	-202.5	0.40	0.76	0.86	0.46	0.58	0.65
OLS(6’)i=4	0.1418	661.4535	666.3	0.07			0.44		
OLS(6*’)i=4	0.2507	973.9888	985.2	0.05			0.32		
OLS(8’)i=8	0.4521	663.6724	673.1		0.17			0.54	
OLS(8*’)i=8	0.5004	994.467	1002.8		0.29			0.45	
OLS(9’)i=13	0.6753	625.6267	634.8			0.08			0.51
OLS(9*’)i=13	0.6917	966.043	976.9			0.10			0.51
Encompassing				0.32	-1.52	0.42	0.49	-1.15	0.14

Table 7. Number of Contracts Required to Hedge 8000 Tons of DDG.

Model	CBOT Corn	CBOT SBM	CBOTETHA	OIL
OLS(1)	14	9		
OLS(2’’)	16	21		-50
OLS(3’)	29	17	6	-3
OLS(3*’)	31	17	7	-2
Encompassing	14	7		

Footnotes

[1] Chicago Mercantile Exchange was expected to begin a contract for DDG on April 26, 2010.

[2] DDG is in levels in the models in levels and in logs in the models in logs. fcorn is the price of the nearby future corn contract in dollars per contract of 5000 bushels (140 tons), fSBM is the price of the nearby future soybean meal contract in dollars per contract of 100 short tons (90.718 tons).

[3] i is the hedge length measured in weeks and d-i-fcorn is the ith week difference of future corn.

[4] * ,** and *** represent significance level at a confidence level or 90, 95 and 99% respectively.