Optimal Hedging Ratios and Hedging Risk for Grain By-Products

by

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Abstract: Optimal cross hedge ratios are estimated for a number of grain by-products used as livestock feed. Risk associated with these cross hedge ratios is measured to determine if cross hedging reduces grain by-product price risk. Results provide useful risk management guidelines for livestock and dairy producers.

Key Words: by-products, cross hedging, hedge ratio, risk

Introduction

Grain by-products are a valuable and commonly used feed source for livestock and dairy producers. They are widely available, easily transportable, and storable. Grain by-products are often more economical as feed ingredients than the raw commodities from which they are derived. In certain situations, the physical attributes of grain by-products actually make it advantageous to feed them in lieu of unprocessed grains. For example, soybean hulls and corn gluten feed provide energy in the form of highly digestible fiber rather than starch, making them ideal as supplemental feeds for use in a forage based backgrounding/finishing program.

One disadvantage of feeding grain by-products is the difficulty of managing price risk, due to the fact that no futures contracts for grain by-products exist. Since feed is the primary expenditure for livestock and dairy producers, the price risk associated with a certain feed ingredient becomes a major portion of a producer's net income risk. Producers feeding commodities, such as corn, wheat, or soybean meal, can utilize the corresponding futures contracts as a mechanism for transferring price risk between hedgers or between a hedger and a speculator. The producer can hedge a cash market position by taking an equal and opposite position in the futures market, leaving only basis risk, which is generally less variable than an unprotected position in the cash market (Stasko). This is accomplished by hedging these commodities on a one-to-one basis using the appropriate futures contract. For example, the anticipated purchase of 5,000 bushels of number 2, yellow corn in the cash market would be hedged by taking a long position of 5,000 bushels (one contract) of number 2, yellow corn in the futures market.

Sellers of grain by-products and livestock producers purchasing grain by-products face a much more ambiguous procedure for using futures markets to manage price risk. They must use an alternative means of price protection. One alternative is to hedge the anticipated cash market sale or purchase using a futures contract that for which both the by-product and commodity's futures price are highly correlated. This process is known as cross hedging (Leuthold, Junkus, and Cordier). It is not necessarily obvious which futures contract to use when cross-hedging the sale or purchase of a grain by-product, nor is it obvious how much of a given by-product that will effectively transfer the price risk in proportion to the difference in cash price and futures price changes. It is essential that producers who use cross hedging to manage price risk of grain by-products do so properly. A poorly designed cross-hedging strategy can introduce hedging risk into the operation that is equal to or greater than the price risk that it replaced.

The objective of this study is to provide sellers of grain by-products and livestock and dairy producers with information necessary to effectively manage price risk of grain by-products by cross hedging using existing futures contracts. Specifically this study will attempt to identify what reduction of price risk (if any) can be realized from cross hedging corn gluten feed, hominy, and distiller's dried grain using number two yellow corn futures or soybean meal futures. Optimal hedge ratios for each of the aforementioned by-products will be estimated and the effectiveness of this cross hedging relationship at reducing by-product price risk will be assessed. The resulting information will be useful to sellers of by-products and to livestock and dairy producers for whom feed represents one of the most significant costs of production.

Background

Numerous previous analyses have estimated cross-hedge ratios for various commodities; however, previous analyses differ in methodology used to estimate optimal cross hedge ratios and the process to evaluate the cross-hedge ratio. Anderson and Danthine provide a theoretical foundation for cross hedging and state that when cash goods have no obvious futures contract, a cross hedge may be placed by taking a position in a related futures market. They note that the presence of a correlation coefficient between cash and futures prices that is significantly different from zero indicates that a cross hedge is appropriate. In addition to choosing a contract, one must also consider how much of a cash market position can be hedged with a futures market contract for a related commodity.

Witt, Shcroeder, and Hayenga summarized three common approaches to the estimation of optimal hedge ratios: (1) price level models, (2) price change models, and (3) percentage change price models. The factors that ultimately indicate the correct model from among these, they argue, are the objectives of the hedger, the nature of the relationship between cash and futures prices, and whether the hedge is a storage or anticipatory hedge. They conclude that for anticipatory hedges, the price level model is appropriate except in cases where: (1) the cash and futures market price relationship is nonlinear in the levels, (2) the price level equations exhibit strong positive autocorrelation, or (3) first order autocorrelation occurs. The price level model involves using linear regression analysis to determine the relationship between cash and futures market prices. Blake and Catlett use the price level model to determine the most desirable corn futures contract with which to hedge the cash sale of alfalfa hay. The price level model has also been widely used to estimate hedge ratios for cross hedging many types of cattle. Schroeder and Minert use the model to determine the effectiveness of hedging feeder heifers and steers that do not exactly meet the specifications of available cash-settled feeder cattle futures contracts. Elam and Davis use a price level model to evaluate the hedging risk of ratio hedges, which is a hedge in which the commodity can not be hedged on a one to one basis with existing futures market contracts. Buhr employs a very similar methodology to evaluate the hedging of Holstein steers using live cattle futures contracts. Buhr suggests that for nonstorable commodities, such as live cattle, the hedge is anticipatory. In the case of an anticipatory hedge, the current cash price is unattainable and therefore of little interest to a hedger. Buhr goes on to state that a producer hedging in this situation is primarily concerned with ending basis risk. While grain by-products are, for the most part, storable commodities the hedge by a livestock producer relying on by-products as inputs can still be considered anticipatory. Practical matters such as storage capacity and availability of capital make it infeasible to always buy feedstuffs far in advance of their use. Thus, a hedger in this situation would be concerned only with the basis at the time the hedge is to be lifted, that is, on the nearby futures contract.

In addition to the estimation of optimal hedge ratios, previous studies have analyzed the hedging risk associated with cross hedging. According to Buhr, the standard error of the net cash price received about the expected net cash price can be interpreted as hedging risk. This is also the method is used by Elam; Elam and Davis; and Schroeder and Minert. The resulting standard error can be expressed in units that are appropriate to the situation and commodity (Blake and Catlett). This allows intuitive, useful comparisons to be made between unprotected price risk in the cash market and basis risk under a cross-hedging scenario. Defining risk in this manner will provide producers with an indication of the usefulness of cross hedging grain by products.

Data and Methods

Weekly cash prices of corn gluten feed (CGF), hominy, and distiller's dried grain (DDG) on the Chicago market for 1981 through 1998 were collected from *Feedstuffs.* Corn futures prices were obtained from the Chicago Board of Trade (CBOT) over the same time period. Descriptive statistics of the data are shown in Table 1. Weekly average closing prices were used as the nearby futures price. Following practical application, the nearby futures price is defined as the price of the nearest contract month up to and including the last weekly price in the month preceding contract expiration. All simulated hedges are lifted in the last week of the month preceding the contract month in which the hedger has a short or long position. (Elam and Donnell use this method as well)

For the purposes of this paper, a price level model will be used to estimate optimal hedge ratios. Considering objectives of the hedger, this type of hedging can be considered anticipatory. Thus, as indicated by Witt, Shcroeder, and Hayenga, the price level model is theoretically appropriate. With this approach, optimal hedge ratios can be estimated for a feed ingredient as follows:

(1) $$C_{s,\,j} = ß_0 + ß_1 F_{s,\,i} + \varepsilon\ ,$$

where $C_{s,\,j}$ is the cash price of feed ingredient j at time s (i.e., at the time the hedge is set), $ß_0$ is the intercept term, $F_{s,i}$ is the nearby futures price of commodity i at time s, ε is the random error term, and $ß_1$ is the hedge ratio and is defined as the futures contract quantity to be sold divided by the cash quantity. That is,

(2) $$Q_{c,\,i} = \frac{Q_{f,\,j}}{b_1}$$

where $Q_{c,\,i}$ is the amount of feed ingredient i in the cash market to be hedged, $Q_{f,j}$ is the quantity of the futures market position in commodity j, and b_1 is the slope parameter estimated in equation 1. In this manner, b_1 can be used to determine what quantity of position in the futures market is necessary to effectively hedge a given amount of a by-product feed ingredient. The parameters of equation (1) can also be used to calculate the expected price from a ratio hedge that uses $ß_1$ as a hedge ratio (Buhr). Expected price (EP) of the hedge is expressed as:

(3) $$EP = b_o + b_1\ (F_{s,\,i}),$$

where expected price b_o and b_1 are the parameters estimated in equation (1) and $F_{s,\,i}$ is the futures market price of commodity i at the time the hedge is set. Given the ability to accurately predict the basis (i.e., zero basis risk) and a hedge ratio of one, the expected cash price could be known with certainty at the time a hedge is placed. Since this is not realistic, the actual ability to "lock in" prices must be defined. The hedger can establish a price subject to the hedging risk associated with the ratio hedge. The amount that a hedger pays or receives for the by-product plus any losses or gains realized in the futures market, defined as net cash price (NCP), will deviate from EP depending on this risk. The actual NCP of a by-product that has been hedged using a cross hedge will be:

(4) $$NCP = C_{l,\,j} + b_1\,(F_{s,\,i} - F_{l,\,i}),$$

where $C_{l,\,j}$ is the cash price of feed ingredient j at time l (i.e., when the hedge is lifted) and $F_{l,\,i}$ is the futures market price of commodity i at time l. NCP is the cash price of by-product j plus any losses or gains realized in the futures market and represents the amount that the hedger actually pays or receives for the commodity. The amount that NCP deviates from EP will determine the risk of the hedge. As the ability to accurately predict NCP using the EP formula increases, the risk associated with the hedge decreases. This hedging risk can be quantified by the standard error of NCP about EP (Buhr; Schroeder and Mintert). Schroeder and Mintert represent the standard error of NCP as a point forecast about EP as follows:

(5) $$Std\,(NCP - EP) = \sigma_e\left(1 + 1/n + [(F_s - F_m)^2 + \sigma_v^2] / [\Sigma(F_l - F_m)^2]\right)^{1/2},$$

where σ_e is the root-mean square error from the estimation of equation (1), n is the number of observations present in the estimation of equation 1, F_m is the mean of F_l, and σ_v^2 is the standard error of the change in futures prices over the duration of the hedge. All other variables maintain their previous definitions. This equation reveals the ability of the cross hedge to predict the

NCP. Specifically, a hedger's NCP should be within one standard deviation of (EP - NCP) of EP about two-thirds of the time (Elam and Donnell).

Estimation Procedure and Results

Correlation coefficients were calculated for all cash and futures price series to determine the relationship between each of the cash commodity price series and corn futures prices. These coefficients are reported in Table 2. The correlation between these by-product prices and corn futures prices was somewhat lower than some previous cross-hedging studies (Blake and Catlett; Elam and Donnell) suggest it is necessary for a cross hedge to be effective. As a further initial test, basis variability of the by products was compared to by-product price risk. Corn futures prices were converted into dollars per ton and the basis (Cash By-Product Price less Corn Futures Price) risk was also considered. The standard deviation of the basis associated with a by-product was compared to the standard deviation of the price series of that by-product. This comparison is shown in Table 3. For many contracts, the basis risk was noticeably less than the price risk. Since it is the basis that ultimately determines the effectiveness of the cross hedge, it is reasonable to expect that some benefit may be realized from cross hedging these by-products using a corn futures contract. At the very least, a thorough analysis of this cross-hedging relationship appears warranted.

Equation 1 was used to estimate b_o and b_1 for each contract month. The initial estimation was performed using ordinary least squares (OLS). Those estimated equations exhibited first order autocorrelation. Each of the cash and corn price series were examined for a unit root using a Dickey-Fuller test. All of the series were found to be stationary. To correct for autocorrelation, generalized least squares (GLS) was used to estimate the equations. The GLS-estimated hedge ratios (b_1) and average basis terms (b_o) are reported in Table 4. Much information can potentially be gained from the hedge ratio (b_1). For example, when the July corn futures prices are regressed against the May and June cash prices of hominy, an estimated b_1 of 28.48 results. It follows that, on average, a $1.00 per bushel change in corn futures price, *ceteris paribus*, will result in a $28.48 dollars per ton change in hominy prices in the same direction (Elam and Donnell). The hedge ratio (b_1), when entered into equation 2, indicates how many tons of hominy can be hedged with one corn futures contract. The CBOT corn contract size is 5,000 bushels. Considering the amount of by-product that it would hedge, a contract of this size would not be practical for many producers. The Mid-American Exchange corn contract size is 1,000-bushels. In general, these contracts are more likely to suit the needs of producers. Differences between corn futures contract prices on the CBOT and Mid-American Exchange will be negligible. The Mid-American contracts have been used to give practical examples of cross hedging techniques for these very reasons (Blake and Catlett, Elam and Donnell). It should be pointed out that differences in the liquidity of the two markets, which could affect a hedger's ability to execute a desired transaction, are not considered in the examples discussed here. In the case of hominy hedged at the beginning of May using the Mid-American July corn contract, 35.11 tons (1000 bushels / 28.48 bushels per ton) of hominy could be hedged using one contract. Table 5 shows the quantities of by products that could be hedged with each 1,000 bushel Mid-American Exchange corn futures contract.

The parameters estimated in equation 1 were used to simulate hedges over the 18-year period covered by the data. Hedges were uniformly placed two months before the expected date of purchase (i.e., the date the hedge is to be lifted) and lifted in the last week of the month preceding the contract month; no selective criteria were used. For example, a hedge using the

September contract was always set in the first week of July and lifted in the last week of August, regardless of present conditions. This approach was chosen considering that the purpose of this study is to judge the effectiveness of using cross hedging to reduce the by-product price variability (NCP) over time and not to attempt to affect the mean price. The hedges were simulated by entering b_o and b_1, along with the appropriate cash and futures prices into equations 3 and 4 to yield EP and NCP, respectively for each hedge. This process was performed for every contract month in every year resulting in either18 or 19 observations for each contract. Equation 5 was then used to determine the effectiveness of the cross hedge at predicting NCP. The variations of NCP about EP for each contract are shown in Table 6. The standard deviations of the differences between EP and NCP were relatively large for some contracts. For example, the standard deviation of (NCP – EP) based on two-month hedges of CGF using the March corn contract is 17.18. This shows that a producer could expect the NCP to be within ±\$17.18 per ton of the EP about two-thirds of the time (Elam and Donnell). To put the level of variability associated with by product cross hedges into some kind of perspective, table 6 also includes the standard deviation of (NCP – EP) for a straight corn hedge. Clearly, the hedging risk associated with each of the by-products considered here is greater than the same measure of risk for corn hedges.

The variability of by product cross hedges can also be compared to the variability of purchasing the by-products without hedging, which is one of the most common alternatives. To illustrate this case, it is assumed that the expected price for a given by-product prior to its purchase is the cash price at that time. Moreover, if no futures market position is taken, then the NCP will simply be the cash price of the by-product at the time of purchase. These assumptions provide a basis for comparing the standard deviation of (NCP – EP) with no hedge to the standard deviation of (NCP – EP) resulting from the simulated two-month uniform hedges (reported in table 6). The standard deviations of the non-hedging (NCP – EP) series are shown in Table 7. In every contract month for CGF and DDG, the standard deviation of (NCP – EP) is lower without hedging than it is with hedging, indicating that hedging these by-products with corn futures contracts actually increases the hedger's risk. For hominy, results of a hedge are somewhat mixed. Hedging on the May, July, or December corn futures contracts does provide some reduction in risk while hedging on the March or September contract does not.

The possibility of hedging corn gluten feed and distiller's grains using the soybean meal contract was also investigated. These by-products are, unlike corn and hominy, relatively high in protein and so may exhibit some level of substitutability with soybean meal when considered as a feed input. Table 8 reports correlation coefficients between CGF, DDG, and soybean meal futures. Based on these coefficients, CGF appears to be somewhat more closely correlated with soybean meal than with corn futures. The correlation between DDG and soybean meal futures is very similar to the degree of correlation between DDG and corn futures.

Hedge ratios were estimated for each soybean meal contract month using GLS. These hedge ratios are reported in table 9. These hedge ratios were used to simulate two month uniform hedges for DDG and CGF in the same manner as was done using corn futures. The standard deviation of (NCP – EP) for each soybean meal futures contract month is reported in table 10. This table also includes the standard deviation of (NCP – EP) for a non-hedging strategy over the same two-month period). Comparing the figures in table 10 with those in table 6 indicates that CGF can be more effectively hedged using the soybean meal futures contract than using the corn futures contract; however, the level of risk from hedging is still higher than the risk from not hedging. With respect to DDG, corn futures contracts seem to provide more effective hedges. Again, however, the variability of (NCP – EP) is greater with a hedge than without.

Summary and Conclusions

As the use of by-products for livestock feed increases, the need for producers to manage the price risk of these by-products also increases. Cross hedging seems to be a reasonable way to address this need. The underlying theory and mechanics are very well documented and have been proven effective when used for other commodities such as livestock. However, the way in which the price series of CGF, hominy, and DDG behave in relation to the corn futures price series or the soybean meal futures price series makes it difficult to use cross hedging techniques to reduce the price risk associated with each by-product. There would appear to be numerous factors affecting corn and soybean meal futures prices that do not affect by-product prices and vice-versa.

As noted earlier, the by-products evaluated are used almost exclusively as feed ingredients. Therefore, one would expect that the demand for livestock feed would primarily determine the prices for these by-products. It is also important to remember that CGF, hominy, and DDG are all by-products of corn processing operations and are therefore somewhat of a liability to the plants that perform these processing operations. These plants can attempt to capture fair market prices for these by-products but they presumablyhave limited storage capacity and must move some minimum amount of the product over a certain period of time in order to continue operations. Since their incomes depend on these operations, continuing them will take precedence over receiving prices for by-products that truly reflect their market value.

There are many unanswered questions in the area of cross hedging by-products and much opportunity for meaningful research exists. The price discovery of by-products is an area in which many of these questions and much of this potential lie. The reasons that cross hedges fail to perform well in this study should be investigated to determine exactly where the relationship between by-products and commodity futures prices breaks down. Such an investigation is beyond the scope of this paper. Ultimately, futures contracts that can be used to effectively cross hedge by-products that are widely purchased by livestock feeding operations, if there are such contracts, should be identified. Subsequently, the mechanics of executing these cross hedges should be clearly laid out and tested. With these techniques available, producers could chose between traditional grain commodities and by-products based on which alternative is more economical for their respective operations, knowing that there are reliable price risk management methods available for either of the alternatives.

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Table 1. Descriptive Statistics of Variables

	Mean	StDev	C.V.	Min	Max
Corn Gluten Feed ($/ton)	99.02	19.13	19.32%	50.00	145.00
Hominy ($/ton)	87.22	17.82	20.43%	48.00	160.00
Distiller's Grain ($/ton)	125.54	23.07	18.38%	70.00	185.00
Cash Corn ($/bu)	2.60	0.59	22.72%	1.26	5.25
Corn Futures ($/bu)	2.62	0.55	20.84%	1.46	4.95

Note: The C.V. (coefficient of variation) is the standard deviation of each 18-year, weekly price series expressed as a percentage of the mean of that series.

Table 2. Correlation Coefficients for Price Series of By-Products and Corn

	CGF	DDG	Hominy	Corn Futures	Cash Corn
CGF	1.000	0.835	0.595	0.435	0.376
DDG		1.000	0.673	0.624	0.866
Hominy			1.000	0.856	0.576
Corn Futures				1.000	0.967
Cash Corn					1.000

Table 3. Standard Deviation of By-Product Cash Price and Basis Series for Each CBOT Corn Futures Contract Month

	March		May		July		September		November	
	C	B	C	B	C	B	C	B	C	B
CGF	17.79	18.78	19.41	21.16	21.65	20.75	18.89	19.94	17.76	20.05
Hominy	15.03	9.89	19.56	9.58	19.58	7.74	19.40	10.33	17.39	11.21
DDG	22.04	18.37	23.36	19.78	26.82	18.19	23.40	17.89	20.88	17.57

Note: C = By-Product cash price series in $/ton, B = Basis between by-product cash price and nearby corn futures price in $/ton. The by-product price series for each contract month is composed of the weekly by-product cash prices (in dollars per ton) for the two preceding months. The basis series for each contract month is composed of the weekly by-product cash prices (in dollars per ton) minus the corn futures price (in dollars per ton) for the two preceding months.

Table 4. Cross Hedging Relationships between By-Products and CBOT Corn Futures Contracts

	Corn Gluten Feed		Hominy		Distiller's Dried Grain	
	b_0	b_1	b_0	b_1	b_0	b_1
March						
	73.28	11.57	15.68	27.11	74.77	20.83
	(7.31)	(2.12)	(4.33)	(8.12)	(8.12)	(2.18)
May						
	47.74	18.00	-14.68	37.17	68.44	19.60
	(7.99)	(1.94)	(4.53)	(1.47)	(8.46)	(2.36)
July						
	44.98	18.05	10.66	28.48	41.46	29.44
	(8.30)	(1.81)	(3.64)	(1.20)	(8.87)	(2.54)
September						
	39.64	20.44	8.97	30.70	60.17	24.99
	(7.37)	(2.03)	(5.20)	(1.84)	(8.42)	(2.48)
December						
	66.42	12.42	26.66	23.44	82.94	16.52
	(7.72)	(2.26)	(5.21)	(1.84)	(7.56)	(2.41)

Note: The parameters b_0 and b_1 were estimated using equation 1. The numbers in parentheses are the standard errors of the estimates.

Table 5. Tons of By-Product Hedged With a 1,000 Bushel Mid-American Exchange Corn Contract

	March	May	July	September	December
CGF	86.43	55.56	55.40	48.92	80.52
Hominy	36.89	26.90	35.11	32.57	42.66
DDG	48.01	51.02	33.97	40.02	60.53

Table 6. Standard Deviation of Net Cash Price Minus Expected Price For Each Two-Month Uniform Hedge

	March	May	July	September	December
CGF	17.18	19.25	17.87	15.73	16.29
Hominy	8.87	8.59	6.71	10.67	8.67
DDG	17.77	19.36	18.28	16.66	16.79
Corn	2.41	2.72	5.22	3.93	3.15

Note: Hedges were placed two months prior to the beginning of the contract month and lifted in the last week of the month immediately preceding the contract month using no selective criteria.

Table 7. Standard Deviation of Net Cash Price minus Expected Price from Non-Hedging for Each Contract Month ($/ton)

	March	May	July	September	December
CGF	9.49	11.33	11.97	9.33	8.45
Hominy	7.84	10.12	8.02	6.30	11.39
DDG	9.91	10.93	10.25	9.01	10.29
Corn	4.89	10.25	8.70	11.44	9.28

Table 8. Correlation Coefficients for Price Series of Corn Gluten Feed, Distiller's Dried Grain and Soybean Meal Futures

	CGF	DDG	Soybean Meal
CGF	1.000	0.835	0.559
DDG		1.000	0.622
Soybean Meal			1.000

Table 9. Cross Hedging Relationships between Corn Gluten Feed, Distiller's Dried Grain, and Soybean Meal Futures

	Corn Gluten Feed		Distiller's Dried Grain	
	b_0	b_1	b_0	b_1
January				
	37.98	0.35	47.08	0.42
	(9.79)	(0.04)	(10.07)	(0.05)
March				
	48.58	0.30	52.40	0.43
	(7.26)	(0.03)	(8.45)	(0.03)
May				
	42.42	0.30	45.09	0.42
	(7.88)	(0.03)	(8.91)	(0.03)
July				
	48.32	0.25	46.22	0.41
	(8.41)	(0.03)	(11.27)	(0.05)
August				
	38.64	0.28	40.18	0.45
	(10.19)	(0.04)	(12.06)	(0.05)
September				
	43.90	0.27	60.49	0.35
	(7.99)	(0.04)	(9.67)	(0.04)
October				
	42.60	0.29	65.17	0.32
	(9.07)	(0.04)	(9.68)	(0.04)
December				
	45.36	0.29	57.21	0.37
	(7.58)	(0.03)	(7.46)	0.03)

Note: The parameters b_0 and b_1 were estimated using equation 1. The numbers in parentheses are the standard errors of the estimates.

Table 10. Standard Deviation of Net Cash Price minus Expected Price For Two-Month Uniform Hedges

	Corn Gluten Feed		Distiller's Dried Grain	
	Hedge	*No Hedge*	*Hedge*	*No Hedge*
January	14.70	7.22	16.64	7.31
March	14.27	9.49	16.48	9.91
May	18.63	11.33	19.61	10.93
July	16.62	11.97	21.85	10.25
August	16.31	10.04	21.04	9.52
September	15.02	9.33	17.73	9.01
October	16.23	6.65	17.33	7.97
December	15.98	8.45	16.12	10.29

Note: Hedges were placed two months prior to the beginning of the contract month and lifted in the last week of the month immediately preceding the contract month using no selective criteria.