Section VI – Rating Methodology

Introduction

This paper explores the extension of a Livestock Gross Margin (LGM) insurance product for dairy cattle. LGM products are currently available to hog producers in Iowa and cattle producers in 20 states. The construction of the LGM for Dairy Cattle insurance product follows the methods of existing LGM products. LGM for Dairy Cattle is designed to protect dairy producers from adverse price changes for their outputs and inputs. The rating methodology for LGM for Dairy Cattle is almost identical to that for LGM for Swine and LGM for Cattle (Hart, Babcock, and Hayes). However, there are two major differences between LGM for Dairy Cattle and the companion products. One is that the dairy industry is supported by a government program that sets a support price for milk. The rating structure for LGM for Dairy Cattle must explicitly account for the effects of the price support program on dairy prices. The other is that feed rations in the dairy industry are highly variable across the country. For LGM for Swine and LGM for Cattle, a fixed production plan with constant feed rations is assumed. Given the wide diversity in feeding patterns across dairy farms, constant feed rations simply do not make sense. Thus, LGM for Dairy Cattle is constructed to allow producers to set the feed component of the product to match their current feeding practices.

Following the structure of LGM for Cattle, LGM for Dairy Cattle is set on a dollar deductible and incorporates average regional basis information to allow the computed gross margins to more closely mimic local price behavior. To avoid time conflicts with the other LGM products, the price discovery and sales closing dates for LGM for Dairy Cattle are set to be two business days earlier than are currently used for LGM for Cattle and LGM for Swine. These date changes should ease the time constraint problem of reviewing and offering the three LGM products within one 16-hour period each month. The date changes do not affect the rating structure.

Most of the techniques used to evaluate the proposed product are the same as those currently being used to rate LGM for Swine and LGM for Cattle. The technique employed to impose the correlation structure on the random variables underlying the analysis is transparent since the only manipulation to the original data is a re-sorting of the data. Thus, the technique preserves the original distributional structure of each data series while changing the relationships among the series.

Contract Design

The contract design will parallel the LGM for Cattle and LGM for Swine design. The LGM for Dairy Cattle product is a gross margin insurance product, with gross margin being defined as the difference between output revenues and input costs. This type of insurance product is known as an Asian Basket Option, where the indemnity will equal the difference (if positive) between the value (here, the actual gross margin) of an asset portfolio and a set strike value (the insured gross margin). Price risks reflected in the futures markets for Class III milk, corn, and soybean meal are covered by the product. There are twelve sales periods, one in each month. The insurance period covers ten months and is separated from the sales period by one month. For example, an LGM for Dairy Cattle insurance policy sold at the end of January would cover the marketing months of March through December. At signup, producers would be required to provide information on the number of hundredweight of milk they intend to market in each calendar month, the amount of corn (or corn equivalent) and protein meal (proxied by soybean meal) they expect to feed each month, the state in which their dairy operation is located, and the dollar deductible for the policy.

Prices for the milk are based on the futures prices for Class III milk on the Chicago Mercantile Exchange (CME). Prices for feed are based on the futures prices for corn and soybean meal from the Chicago Board of Trade (CBOT). Basis is incorporated for milk and corn in the insurable prices by adding an average historical basis pattern to the futures prices. Under the given structure, indemnities would not be known until the end of the insurance period, unless the marketing plan does not include any marketings during the latter part of the contract. Given that gross margins could be negative, we have deviated from the common practice of having producers choose a percentage deductible in favor of a dollar deductible. The dollar deductible is applied to each of the monthly per hundredweight insurable gross margins.

The insurance policy is constructed to minimize any moral hazard problems. Under the policy framework, producers provide expected per month target marketings and per month target feed figures at signup. These monhtly target marketings and target feed figures are also used to calculate actual revenues and actual feed costs. That is, they do not change over the insurance period even if actual production and actual feed use deviate from these target levels. Insurance prices are set by the futures markets and the average basis patterns. In this way, producers can not affect the policy parameters that trigger indemnities.

There is only one production type for LGM for Dairy Cattle. Feed costs are based on input from the producer and once the producer has chosen the feed rations, the rations are held fixed during the insurance period. Thus, once the producer signs up for LGM for Dairy Cattle coverage, the feed rations are constants, as they are for the other LGM products. Unexpected changes in costs due to changes in feed rations from their expected levels are not covered by the LGM for Dairy Cattle product. All the prices for milk, corn, and soybean meal are aligned to the same month. The price alignment is chosen because the feed utilized within a given month is a direct input for the milk produced in that month. The calculated revenues from marketing milk in month *t* is given by

$$X_t*MilkP_t - Y_t*(2000/56)*CornP_t - Z_t*SoyMealP_t \quad (1)$$

where X is the number of hundredweight of milk marketed, MilkP is the average price of the relevant Class III milk futures contract plus the average regional basis for milk for the month, Y is the number of tons of corn or corn equivalent fed for the month, CornP is the average price of the relevant corn futures contract plus the average regional basis for corn for the month, Z is the number of tons of protein meal fed for the month, and SoyMealP is the average price of the relevant soybean meal futures contract. The soybean meal price is not basis adjusted because cash price data for the soybean meal market is limited. The corn price is multiplied by the ratio 2,000/56 to put the price on a dollars per ton of corn basis. One bushel of corn equals 56 pounds. There are also restrictions on the number of hundredweight of milk marketed and the number of tons of corn and protein meal fed. The number of hundredweight of milk marketed must be greater than zero in a month for a producer to enter any feed tonnage. Also, the number of tons of corn and protein meal fed are restricted to be within set bounds. For corn, the number of tons must be between zero and 0.0335 tons per hundredweight of milk. For protein meal, the number of tons must be between zero and 0.00775 tons per hundredweight of milk. These upper limits on feed use (lower limits on feed efficiency) allow producers to adjust feed rations to closely match their feeding situations without allowing producers to turn the LGM for Dairy Cattle policy into a feed-cost-only policy.

The insurance product has the standard indemnity stream of the form

$$\max[0, \text{gross margin guarantee - actual gross margin}] \quad (2)$$

where the gross margin guarantee is based on prices at the time the insurance is purchased, and the actual gross margin represents the gross margins calculated at the end of the insurance period. Both the gross margin guarantee and the actual gross margin are based on futures prices and average basis patterns. The gross margin guarantee is also based on the dollar deductible and projected prices formed from the average futures prices for the various futures over the three trading days prior to the last two trading days for the sales month.

For example, for March 2006, the price discovery and sales closing dates would fall in the week of March 27. Because all the days between March 27 and March 31 are business days, the three-day period for the average futures prices for LGM for Dairy Cattle would be March 27-29, with March 30-31 being the last two trading days for the sales month. The sales closing date would be March 29, the end of the price discovery period. Prices for non-contract months are set at the average price of surrounding futures contracts. For example, the projected corn price for April is the average of the projected corn prices for March and May. This is only a concern for the corn and soybean meal prices because Class III milk futures are traded in each calendar month.

Actual gross margins are based on the actual average futures settlement prices in the closing month of the contracts and average basis patterns. For contract months, the average price is taken from the settlement prices of the three trading days prior to the last trading day for the contract. For non-contract months, we follow the same formula as in setting the gross margin guarantees. For example, the April corn price is the average of the corn prices established for March and May.

Basis Patterns

To determine the basis patterns, we examined price data from the National Agricultural Statistics Service (NASS). The NASS price data are state-level estimates of the price received by producers. NASS provides monthly milk price estimates for 20 states and monthly corn price estimates for 18 states in the latest version of the annual edition of "Agricultural Prices." The milk prices are subdivided into prices for three categories: Milk, Sold at Plants, Eligible for Fluid Market; Milk, Sold at Plants, Manufacturing Grade; and Milk, Sold at Plants, All. For the basis analysis, the NASS all milk price is aligned with the Class III milk futures price. To calculate the basis for the states and commodities available from NASS, we subtracted the commodity's futures prices, as determined for the actual gross margins for the insurance product, from the NASS all milk price. Thus, the basis also takes the LGM for Dairy Cattle price-setting rules into account. Tables 1 and 2 show the average monthly basis patterns for milk and corn for these states over the last five years of NASS data (Jan. 2000 to Dec. 2004).

For most of the states and commodities where NASS does not provide monthly price data, it does provide annual price data. For this product, we have targeted coverage for the contiguous 48 states. Annual milk price data are available for the 48 states. Annual corn price data are available in 41 of the 48 states; Connecticut, Maine, Massachusetts, Nevada, New Hampshire, Rhode Island, and Vermont are not represented. To extend basis patterns across all states and commodities, a representative state for each state with no monthly price data from the states with monthly price data is chosen. The average annual price difference between the representative state and the state with no reported monthly price data is computed and the basis pattern in each month is adjusted by this difference. For example, monthly corn prices are not reported for Wyoming, so Wyoming's corn basis pattern is represented using Colorado's corn basis pattern. The basis pattern for Wyoming is adjusted by adding 8 cents per bushel (the five-year average difference between NASS annual corn prices for Wyoming and Colorado) to each monthly basis number for Colorado. Tables 3 and 4 present information on the representative state choices and the average annual price differences for milk and corn, respectively. For corn in Nevada and the New England states, the representative state basis pattern is applied without adjustment. Tables 5 and 6 present the basis information used in the LGM for Dairy Cattle calculations for milk and corn, respectively. Note that the basis adjustments do not transfer basis risk; this risk remains with the producer.

Premium Determination

To determine the actuarially fair premium for LGM for Dairy Cattle, Monte Carlo simulations are performed, based on closed-form probability density functions for the milk, corn, and soybean meal prices. All futures prices are assumed to follow lognormal distributions, where the standard deviations of prices are derived from the implied volatilities from options markets. Because the prices used in the insurance product are average prices, we face the issue that the sum (or, in our case, the average) of lognormal random variables is not lognormal and, in fact, has no closed-form probability density function.

Two analytical approximations have been employed in recent literature, using either a lognormal or inverse gamma distribution, to represent the required distribution. Turnbull and Wakeman (1991) and Levy (1992) have supported the use of a lognormal distribution as a good approximation. However, the lognormal approximation fares less well as volatilities increase (Levy 1997). Levy found that the lognormal approximation fits well for volatilities in the 10 percent to 30 percent range. At 50 percent volatility, the lognormal approximation showed a slight overcharge (roughly 1 percent). For this analysis, the lognormal approximation is employed for all the price distributions. For the basis patterns, we use the historical averages from the last five years, by calendar month. For the Monte Carlo analysis, we can have up to 24 random variables from the various combinations of milk, corn, and soybean meal futures prices. For the example given in this paper, there are 24 random variables: twelve milk futures prices, five corn futures prices, and seven soybean meal futures prices.

For the price distributions, given the lognormality assumption, we only require estimates of the mean and standard deviation to define the distributions. In all cases, the mean price is defined as the three-day average price over the price discovery period. For the standard deviation of the price, we have computed the annualized implied volatility from "at-the-money" options over the same three days. The implied volatilities are computed under a modified version of the Black-Scholes model. The modifications are to account for options on futures and for the American variety of the options. An Excel add-in, available from FIS Limited at http://www.fis-group.com/finmodls.htm, was used for the volatility computations. We de-annualize the volatility by multiplying by the square root of the time remaining until the futures contract is settled. The standard deviation of the price is then simply the product of the de-annualized volatility and the mean price.

The existence of the dairy price support program can and does have an effect on the milk price distributions we utilize. The Federal dairy price support program is designed to support milk prices above a certain target level. The program involves the sale of milk products by dairy processors to the Commodity Credit Corporation (CCC) and because the sale of these products involves additional processing, the effective price support level as it translates into a Class III milk price is not transparent.

Integration with Existing Federal Dairy Programs

There are three aspects of the current federal milk program that might influence a producer's decisions as to whether and at what level to purchase LGM for Dairy Cattle. One aspect has an influence on the rate structure of LGM for Dairy Cattle and one has a possible implication on the futures market used to generate expected and actual prices.

The Milk Income Loss Contract Program (MILC) pays dairy producers monthly when the Boston Class I milk price falls below $16.94 per cwt. Payment rates are determined by multiplying a positive difference by 34 percent. Payments are issued to individual producers up to a maximum of 2.4 million pounds of milk produced and marketed per fiscal year. See Chite (2005) or Bailey (2005) for a full description of this program.

The MILC program essentially acts in a manner that is similar to the countercyclical payments that are available to grain producers. That is, payments rise whenever milk prices fall. Payments are limited to 2.4 million pounds per farm operation or the milk equivalent of approximately 100 cows. The MILC program was scheduled to terminate September 30, 2005, but was reauthorized on February 2, 2006. This program will likely reduce the level of producer demand in LGM for Dairy Cattle among smaller producers, especially those who forward contract for grain. However, the program only compensates producers for 34% of the price reduction so it is an imperfect substitute for LGM.

The price of milk at the farm level is determined by a Federal Milk Marketing Order "pool" price, which is the weighted average of four prices with weights given by the proportion of milk delivered in a Milk Marketing Order to each of four classes of milk: Class I (fluid milk), Class II (ice cream and soft products), Class III (cheese), and Class IV (Butter and Powder). The formulas that explain how the class prices are determined are shown below.

Class I[a]:

Class I Price = (Class I skim milk price x 0.965) + (Class I butterfat price x 3.5).

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[a] Note: Milk prices are per 100 pounds, or hundredweight (cwt.), rounded to the nearest cent. Component prices are per pound, rounded to nearest one-hundredth cent. Cheese, dry whey, butter, and nonfat dry milk prices are weighted monthly averages of weekly NASS survey prices, rounded to the nearest one-hundredth cent.

Class I Skim Milk Price = Higher of advanced Class III or IV skim milk pricing factors + applicable Class I differential.

Class I Butterfat Price = Advanced butterfat pricing factor + (applicable Class I differential divided by 100).

Class II:

Class II Price = (Class II skim milk price x 0.965) + (Class II butterfat price x 3.5).

Class II Skim Milk Price = Advanced Class IV skim milk pricing factor + $0.70.

Class II Butterfat Price = Butterfat price + $0.007.

Class II Nonfat Solids Price = Class II skim milk price/9.

Class III:

Class III Price = (Class III skim milk price x 0.965) + (Butterfat price x 3.5).

Class III Skim Milk Price = (Protein price x 3.1) + (Other solids price x 5.9).

Class III Protein Price = [(Cheese price – 0.165) x 1.383] + ({[(Cheese price – 0.165) x 1.572] - Butterfat price x 0.9} x 1.17).

Class III Other Solids Price = (Dry whey price – 0.159) x 1.03.

Class III Butterfat Price = (Butter price – 0.115) x 1.20.

Class IV:

Class IV Price = (Class IV skim milk price x 0.965) + (Butterfat price x 3.5).

Class IV Skim Milk Price = Nonfat solids price x 9.

Class IV Nonfat Solids Price = (Nonfat dry milk price - 0.14) x 0.99.

Class IV Butterfat Price = See Class III.

Dairy producers are paid the Class III value of the milk sold and a producer price differential for the remaining value of milk in the marketing pool. As can be seen from the formulas presented above, the price of milk in each class is determined by NASS prices for cheese, butter, nonfat dry milk, and dry whey. The prices of those components are based on NASS surveys.

The producer price differential for Class I milk is used to increase price for milk that is produced away from the traditional milk-producing regions in the upper Midwest. It is thought that an additional incentive is need to induce producers, in say Florida, to produce fresh milk for the Florida market.

As shown by the formulas, the Class I price of milk is determined by the higher of the advanced Class III or Class IV skim price, which is called the price mover for Class I milk. This represents the manufacturing value of milk. The pricing structure described above means that the Class I mover will sometimes depend on the Class III price (dry whey, butter and cheese) and may at other times depend on Class IV (nonfat dry powder and butter). LGM for Dairy Cattle uses the Class III futures price because it has been the price mover since milk futures markets have been in operation. The farm greater amount of liquidity in the Class II contract compared to the Class IV futures contract reflects the fact that the Class II price is the most relevant price for dairy farmers. Thus, the fixed basis adjustments that are used in LGM for Dairy Cattle to determine the margin guarantee and indemnity will not be influenced by changes in this price mover. However, it is possible that an increase in butter and powder prices relative to cheese might create much more interest in the Class IV futures contracts and a reduction in liquidity in the Class III futures prices. If this were to happen, the relative amount of contract liquidity might change to favor the Class IV price. If this occurs, we would then move to plan on basing the product on the Class IV price. We do not anticipate an immediate reduction in liquidity in the Class III futures, and we should have a minimum of a year to make this change.

The Dairy Price Support Program (DPSP) allows dairy processors to sell surplus quantities of butter, cheese, or nonfat dry milk to the Commodity Credit Corporation (CCC) at prices linked to the support price of milk. Because the DPSP program provides a floor for these commodity prices, it places a floor on the manufacturing price of milk. The support price for milk has been at $9.90 per cwt for milk testing 3.67 percent milk fat since August 15, 1999. That price is linked to CCC purchase prices for butter, nonfat dry milk, and cheese. Historic data on this support program are provided in Table 7 (Chite 2005).

The DPSP has some important implications for both the rating and success of this product. First, it essentially puts a floor price on the price of Class III milk. This means that whenever futures traders expect this price to be binding, they will build it into their expectations about futures prices and options prices. Therefore, the rating method we have proposed first checks to see if the milk price distribution we use contains possible price outcomes below this support price. When these price outcomes are observed, we acknowledge that the true price distribution (the distribution used by traders) is truncated at a price that is influenced by the support price program and we then solve for the expected price level and volatility of this truncated distribution. This means that our rates will fully incorporate the existence of the program and therefore we do not expect the existence of this program to reduce producer interest in LGM. The real issue that arises from consideration of the DPSP is that we do not know precisely where the price truncation point lies.

Figure 1 shows the historical price pattern from the nearby Class III milk futures from January 1996 to March 2005. As can be seen from Figure 1, the Class III milk futures has on occasion gone below the $9.90 price specified in the dairy price support program. The lowest price observed during this twenty year period was $8.57 in November 2000. The reason why the price fell below support levels is that dairy processors must have chosen to sell cheese, butter, and nonfat dry powder to private buyers at a price less than the CCC would have paid. The most

straightforward explanation of why processors would do this is that they felt that the price received from private buyers net of transaction costs must have been greater than the net price they could have received from the CCC. That is, when market prices are a small amount below

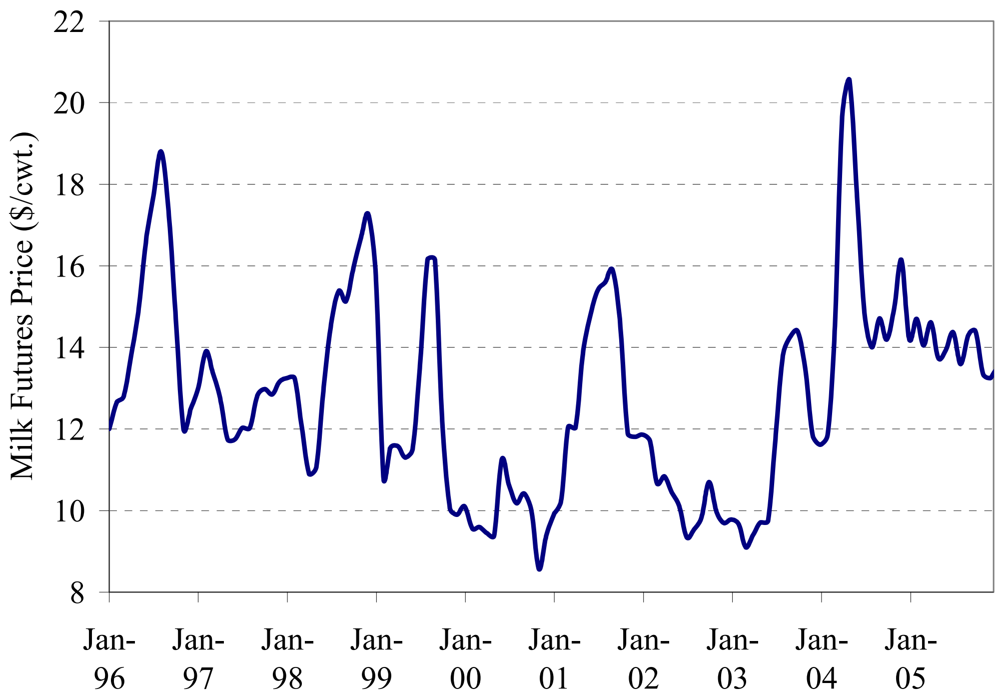

Figure 1. Historical Class III milk futures prices

support levels, there must exist some additional costs that accrue to sell product to the government. So long as the price penalty to selling to the private sector is less than this additional cost, then processors will choose to sell privately. NASS reported prices can therefore fall below support levels.

Eventually, however, if the price gap becomes large enough, processors will choose to sell to CCC. It is at this price point, rather than the nominal support level, that we should choose our truncation point for LGM for Dairy Cattle rating. Based on Figure 1, we use a truncation point of $8.50.

If futures markets traders are aware of a program that puts a floor price on the commodity, they will incorporate this information in their pricing decisions. This creates a technical problem for us because we plan to use the prices of futures and options to rate the LGM for Dairy Cattle product. To see why the dairy price support program could create a problem for the LGM for Dairy Cattle product, examine Figures 2 and 3.

Figure 2 shows a milk futures price distribution that is consistent with a futures price of $14.00/cwt. and an implied volatility of 10 percent. As can be seen from this distribution, there is almost a zero possibility that the price will fall below the recorded minimum price of $8.57/cwt. This market situation means that we can use the futures price as the mean price and use Black's formula and options premia to solve for the volatility. We could then generate a lognormal price distribution with this mean and volatility for use in the Monte Carlo rating methodology.

One can easily surmise, however, that a lower futures price would increase the probability that lognormal price deviates would fall below $8.57/cwt. Figure 3 shows the situation if the mean of the lognormal distribution is $10.00/cwt, the volatility is 10 percent, and the price distribution is truncated at $8.50/cwt. to show the impact of a price floor. This truncation

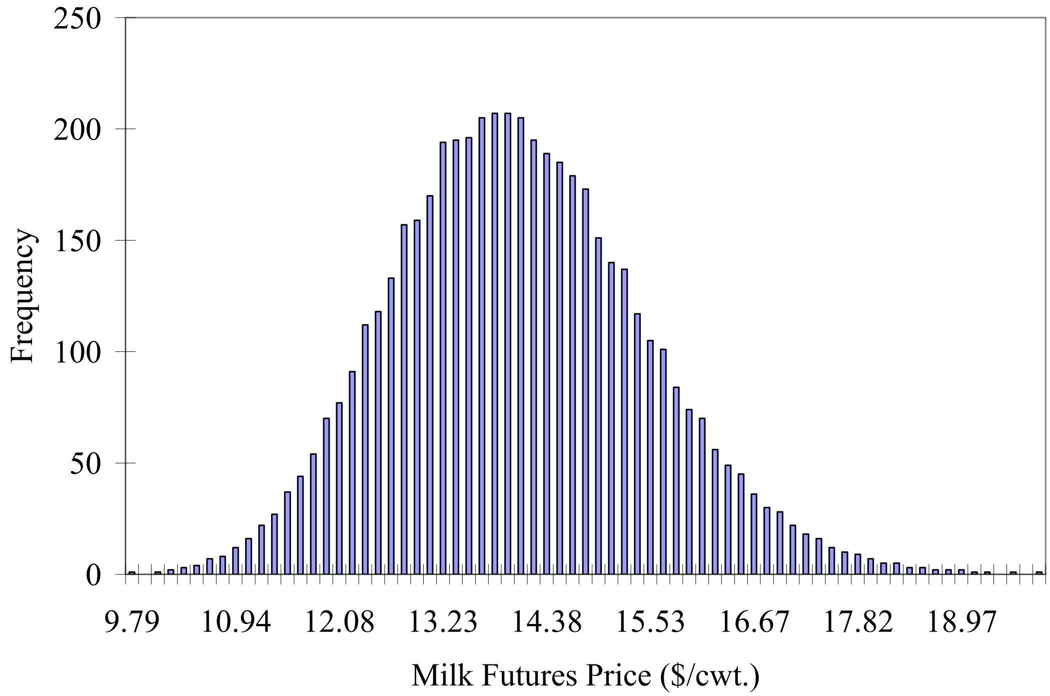

Figure 2. Milk futures price distribution with a mean of $14/cwt and a volatility of 10 percent

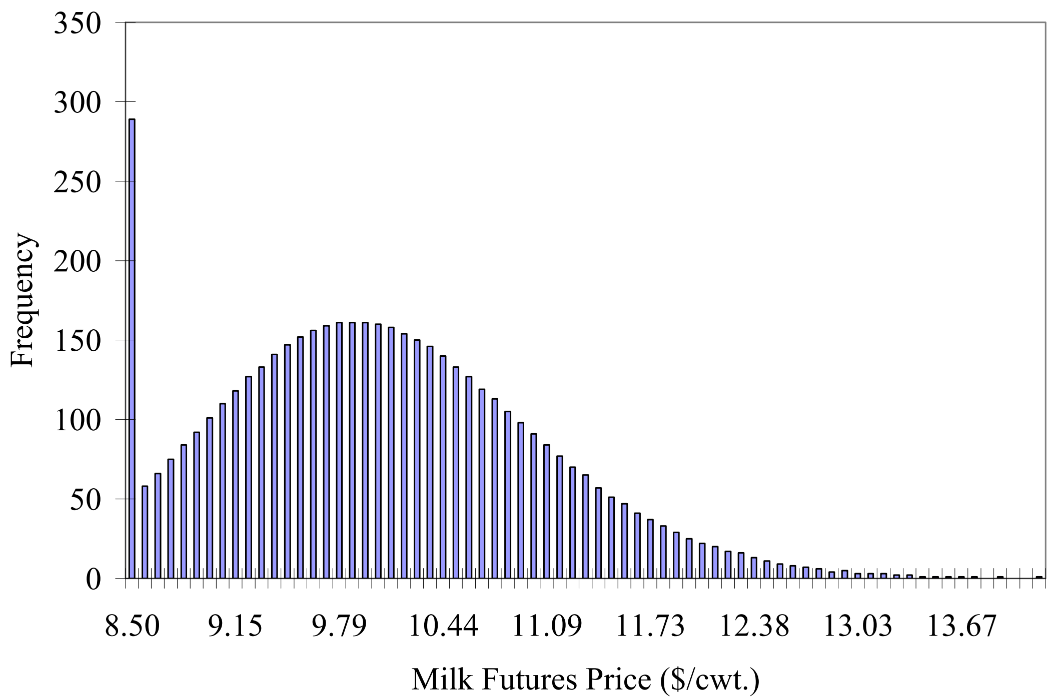

Figure 3. Milk futures price distribution with a mean of $10/cwt and a volatility of 10 percent

increases the mean from \$10.00/cwt. to \$10.07/cwt. and it reduces the volatility to 9.6 percent. If traders have Figure 3 in mind when pricing futures and options and we incorrectly use market-based futures and options premia to generate a non-truncated lognormal distribution, we will introduce an error into the rating exercise. Thus, we need a procedure that allows us to generate a truncated distribution from market data when traders realize that the price distribution is truncated.

The procedure we use is motivated by two conditions that will hold even in a market with a price floor. The first condition is that the futures market will always trade at the expected value of the price distribution, even when the distribution is truncated. To see why this condition must hold, assume the futures price traded at \$10/cwt. even though the expected value of the distribution was \$10.07/cwt. Then, traders would profit from buying the undervalued futures at \$10/cwt. and plan on selling these same futures at maturity at an expected average price of \$10.07/cwt., and this would violate the efficient market hypothesis.

The second condition is called put-call parity and is driven by arbitrage (see page 328 of Hull 2006). Consider the following portfolios of puts and calls both with the same strike price and time to expiration. Portfolio A consists of a call on the futures as well as an amount of cash equal to the current value of the strike price at maturity. Portfolio B consists of a put option on the futures, a long futures contract, plus an amount of cash equal to the current value of the futures contract.

The cash amount in Portfolio A can be invested at the risk free-rate and will grow to equal the strike price at maturity. If the closing futures price is greater than this amount, the call option will be exercised and the value of the portfolio will equal the futures price. If the futures price at maturity is below the strike price, the call will not be exercised and the portfolio will be worth the strike price. This means that the value of Portfolio A at maturity is the maximum of the futures price or the strike price.

In Portfolio B, the cash position will increase in value to equal the initial futures price. The put option provides a payoff (if any) equal to the strike price minus the maturity futures price, and the futures position will have a profit or loss equal to the difference between the futures price at maturity and the original futures prices. Adding these three values up, we find that the value of option B at maturity is also equal to the maximum of the futures price at maturity and the strike price.

Both portfolios are worth the same amount at maturity regardless of what happens to the futures price and therefore they must be worth the same amount today. This relationship provides an arbitrage-based relationship between put values and call values that is true regardless of the shape of the price distribution. This relationship states that the value of a call plus the current value of the strike price (Portfolio A), must equal the value of the put plus the current value of the initial futures price (Portfolio B excluding the futures position, which is worth zero). When we consider at-the-money options, this relationship simplifies to the put value equals the call value (P = C).

This put-call parity relationship is important because it helps us understand what happens as the futures price approaches the truncation point. For example, suppose the futures market is currently trading at $9/cwt. and that the truncation point is at $8.50/cwt.. It is clear that the futures market cannot fall much further, which means that the fair value of an at-the-money put will be low. But the value of an at-the-money call must equal the put value, which means that the value of a call will also be low. In both puts and calls, the implied volatilities will fall as the futures price falls to the truncation point.

To get an intuitive understanding of how these two conditions come together to allow us to generate the truncated distribution, consider the special case of a futures price that is at the truncation point. This means that the market cannot fall and therefore the fair value of the put will be zero. But put-call parity also indicates that the call value will be zero, which means that the market has no upside potential. The only way for the futures market (the expected value of the truncated distribution) to trade at this extreme level is that the market participants are completely confident that the floor price constraint will be binding. In other words, market fundamentals are so bearish that there is a 100 percent chance that the floor price will be the actual price. In this extreme situation, the implied volatility will be zero.

For any given truncation point, we have two pieces of information, the current futures price and the implied volatility from either the put or the call. We also have two unknowns, the mean and volatility of the truncated distribution. We can solve for the two unknown parameters to obtain the truncated distribution.

As mentioned earlier, the lowest observed futures price was $8.57/cwt.. We have chosen a floor price of $8.50. We do this because there is no guarantee that we will not see futures prices that are slightly below $8.57/cwt. in the future. Also, we have examined futures and options price data for the March 2003 time period when milk futures fell below the $9.90/cwt. support price and found the price data were consistent with an $8.50/cwt. floor price. (See the Excel spreadsheet, "Example of Milk Futures and Options below Support.xls," for the futures and options data for the March 2003 time period and an example of the calculation of the truncated lognormal distribution, which is included as an electronic attachment to this submission.) The mean and volatility of the truncated distribution are obtained by a grid search over the mean and standard deviation of an untruncated lognormal distribution. For each grid search point (the grid is in one cent increments for both the mean and standard deviation), we compute the expected price (the futures price) and options premia associated with that point as:

$$\text{Expected Price} = \frac{1}{5000}\sum_{i=1}^{5000} \max\left(P_i, 8.50\right)$$

$$\text{Put Options Premium} = \frac{1}{5000}\sum_{i=1}^{5000} \max\left[0, \text{Strike Price} - \max\left(P_i, 8.50\right)\right]$$

$$\text{Call Options Premium} = \frac{1}{5000}\sum_{i=1}^{5000} \max\left[0, \max\left(P_i, 8.50\right) - \text{Strike Price}\right]$$

where P_i is a price draw of the untruncated lognormal distribution and Strike Price is the strike price nearest to the observed futures price.

Thus, if in the course of simulating milk futures prices for LGM for Dairy Cattle we find that some of the simulated milk prices fall below $8.50/cwt., we will implement a truncated lognormal distribution for the milk prices with a truncation point at $8.50/cwt.. The mean and volatility of the truncated lognormal distribution will be set to recover the value of nearby put and call options and the futures price as the distribution mean. Also, if the milk futures price were to fall below $8.50/cwt. during the price discovery periods for either the expected gross margins or the actual gross margins, LGM for Dairy Cattle price formulas will use a price of $8.50/cwt. for that day. However, should the support price be changed, the truncation point in milk price distributions will need to be adjusted. Our proposal is to maintain the difference between the support price and the truncation point at $1.40/cwt. of milk if the support price is adjusted.

In implementing the Monte Carlo procedure, it is very important that the methods incorporate the correlation among the random variables. To induce the desired correlation, we follow the procedure outlined by Iman and Conover (1982) and have implemented the variance reduction method in the procedure. The procedure takes independent draws from the various marginal distributions (the price distributions) and re-sorts them to obtain the desired levels of correlation. The procedure preserves the marginal distributions because the original draws are not changed (just rearranged). The correlations required by the procedure are the rank correlations among the variables.

The Iman and Conover procedure has four attractive properties. First, the procedure works well with any distribution function. Most correlation techniques are directed at standard distribution functions and cannot be used with other distribution functions. Second, the mathematics behind the procedure is not extremely complex. Cholesky factorization and inversion of matrices are the most exotic steps in the procedure. Third, the procedure can be used under any sampling scheme. Fourth, the marginal distributions of interest are maintained throughout the procedure. The moments of the marginal distributions are not affected by the procedure.

In the Iman and Conover procedure, the only manipulation of the original draws from the marginal distributions is to re-sort the draws on the basis of the ranks of numbers in the columns from a transformed "score" matrix. The score matrix is the same size as the matrix of the draws from the marginal distributions. The score matrix consists of columns of independent permutations of any set of numbers. Iman and Conover suggest using ranks, random normal deviates, and van der Waerden scores ($\Phi^{-1}(i / N+1)$ where Φ^{-1} is the inverse of the standard normal distribution function, N is the number of draws, and i = 1, ..., N are possible scores. For their analysis, Iman and Conover used van der Waerden scores. We follow this convention in our analysis.

Let **X** represent the score matrix, **R** represent the actual Spearman's rank correlation of the columns of the score matrix, and **T** represent the target rank correlation matrix that is desired in the analysis. For **R**, a positive definite and symmetric matrix, there exists a matrix **S** such that **T** = **SRS'** (where **S'** is the transpose of **S**). Since both **R** and **T** are positive definite and symmetric matrices, there exist lower triangular matrices **U** and **V** such that
R = **UU'** and **T** = **VV'**, so **VV'** =**T** = **SRS'**= **SUU'S'**. This implies that **S** = $\mathbf{VU}^{-1}$ (where $\mathbf{U}^{-1}$ is the inverse of **U**). The columns of the transformation **XS'** have a rank correlation matrix that approaches the target rank correlation matrix **T**. When the original draws from the marginal distributions are sorted to match ranks with the data in the columns of **XS'**, then the rank

correlation matrix of the sorted draws is equal to the rank correlation matrix of **XS'**. Thus, the rank correlation matrix of the sorted draws approaches the target rank correlation matrix **T**.

For our analysis, we have set up a dairy farm in Iowa that markets production equally throughout the year. The farm markets 1,560 hundredweight of milk each month and feeds 20.5 tons of corn and 6 tons of soybean meal each month. This example is derived from the 24,000 pounds of milk per cow example on page 24 of "Livestock Enterprise Budgets for Iowa – 2005," an Iowa State University Extension publication. For the rest of this rating document, we will concentrate on this example dairy operation. However, the rating for other dairy operations directly parallels the work shown here. The futures prices used in the analysis are the actual values for the relevant markets over the three trading days prior to the last two trading days of January 2006. A summary of the distributional assumption underlying the analysis is given in Table 8. Table 9 presents the example feed inputs and insurable gross margins.

The Monte Carlo analysis consists of 5,000 draws from the distributions outlined above. The draws for each variable are done independently from each other. The target correlation matrices are based on the historical rank correlations among corn and soybean meal futures prices from 1978 to 2005 and Class III milk futures from 1998 to 2005. The difference between the expected and actual price levels for each commodity was calculated for each contract year, taking the expected and actual prices as defined in the contract details section. Rank correlations of these price deviates were then calculated. Given the short panel of milk futures prices, the rank correlations involving milk futures were noisy and resulted in non-positive definite correlation matrices. Figure 4 through Figure 6 show the rank correlations involving milk as a function of the difference in time between contract months. Negative time differences occur when the corn or soybean meal futures contract month is before the milk futures contract month. Based on Figures 5 and 6, we have set the milk-corn and milk-soybean meal rank correlations equal to zero in all cases. For the rank correlations for milk futures shown in Figure 4, we estimated a regression relating the rank correlations to the contract month time difference, restricting the intercept to one (as must be the case since the rank correlation of a series with itself has to be one). The regression estimates and line are also shown in Figure 4. For the milk-milk rank correlations, we used the projections from this regression to set the rank correlations. These changes created positive definite rank correlation matrices with which we could proceed. Appendix Table 1 shows the milk-milk rank correlation matrix for all months. Appendix Tables

2 through 13 show the rank correlation matrices for corn and soybean meal for each month. Again, the rank correlations between milk and the feed commodities are set to zero. The Iman and Conover technique is applied to impose the target rank correlation matrix. In the terminology above for this example, **X** is a 5,000 by 22 matrix and **R**, **T**, **S**, **U**, and **V** are 22 by 22 matrices.

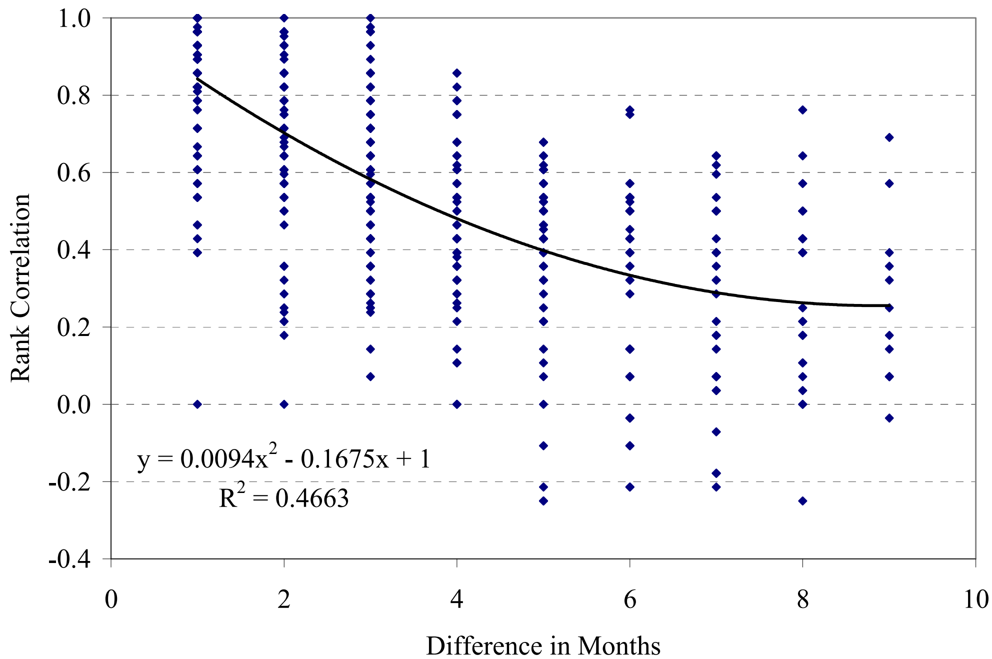

Figure 4. Milk futures price deviation rank correlations

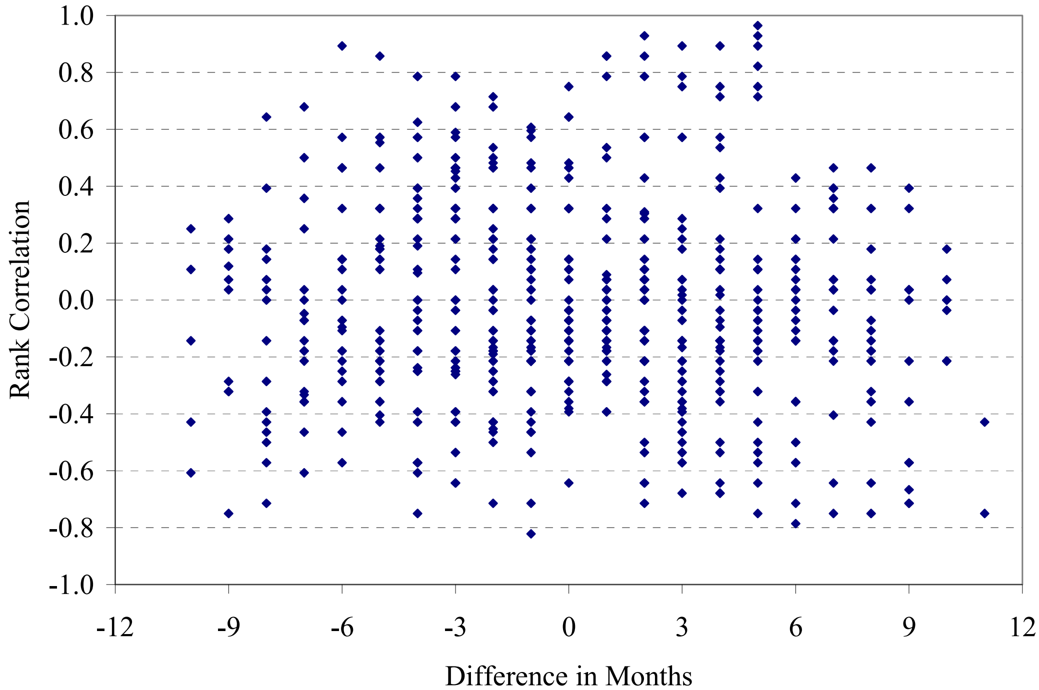

Figure 5. Milk-corn futures price deviation rank correlations

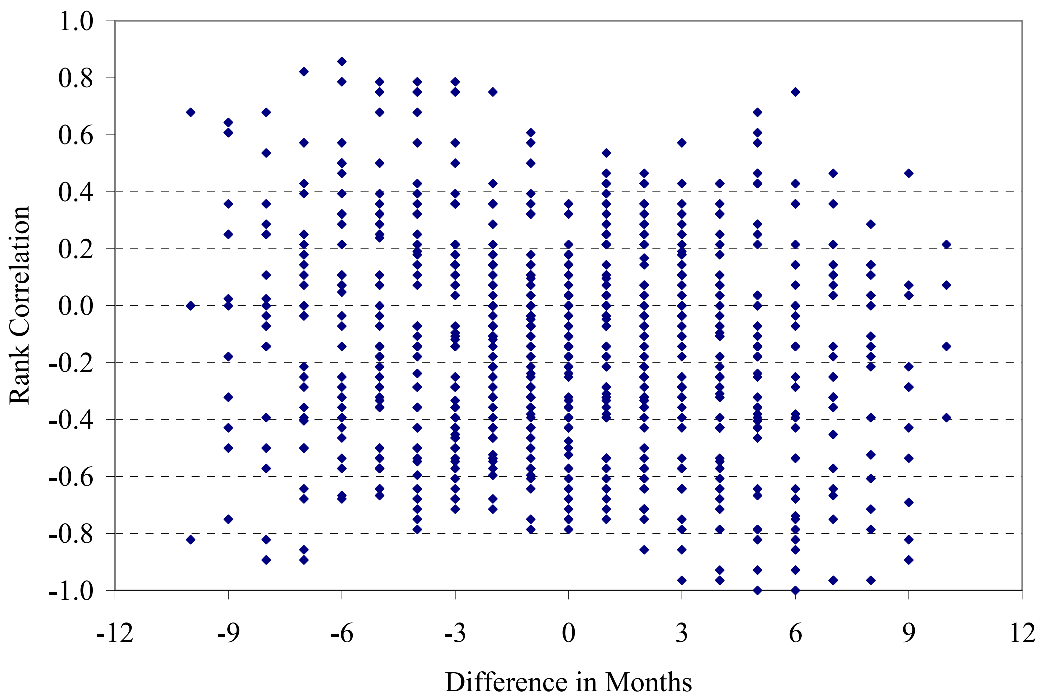

Figure 6. Milk-soybean meal futures price deviation rank correlations

Results

The actual gross margins are calculated for each of the 5,000 draws. Indemnities are then calculated. Premiums are set at the actuarially fair level with a 3 percent reserve load. Figure 9 shows the per hundredweight premiums for the LGM for Dairy Cattle policy for dollar deductibles from zero to $1.00 per head. The premium graph displays a typical pattern for insurance premiums (or options prices). We do not compute premium rates because the gross margins (both expected and actual) can be zero or negative, thus making premium rates per dollar of gross margin an ineffective or incorrect way to state premium values.

For a zero dollar deductible, the per-hundredweight premium is $0.34. The premium falls below $0.10/cwt. for a $0.70 deductible. With a $1 deductible, the per-hundredweight premium is $0.04. The basis adjustment has no impact on the premium levels because the same basis adjustments are applied to both the expected and actual prices that make up the gross margins. We have checked to ensure this is the case. The premium graph for LGM for Dairy Cattle with

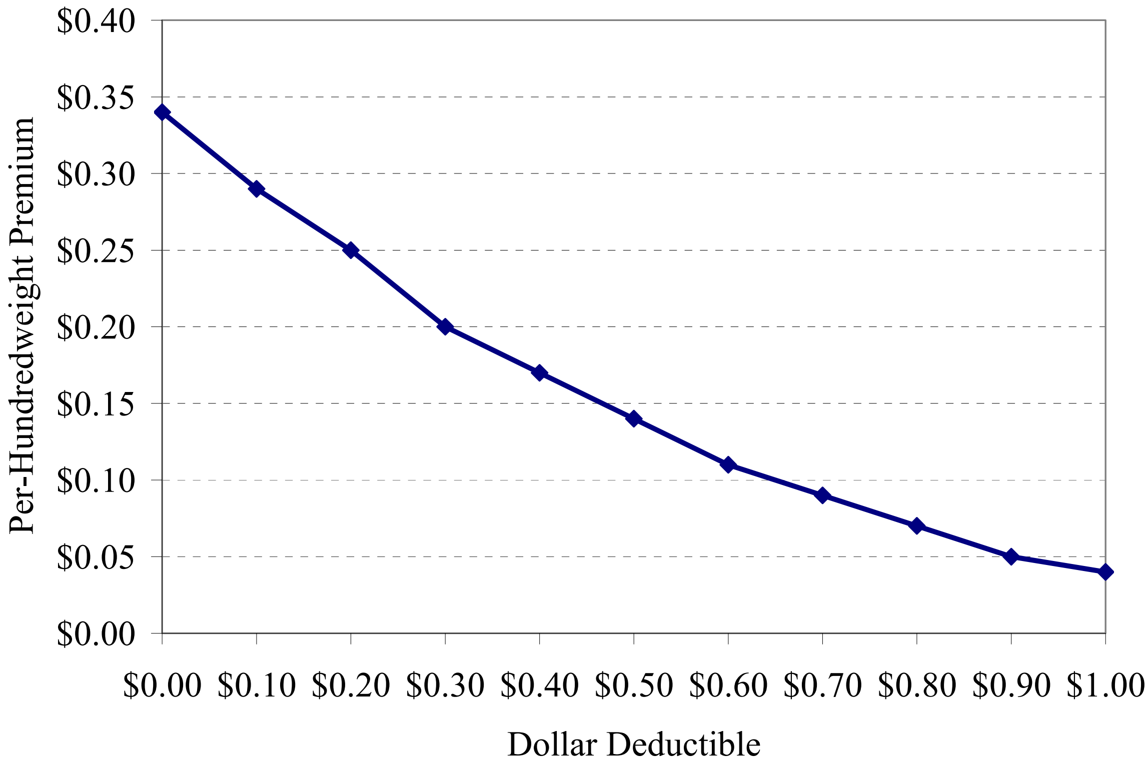

Figure 7. Per hundredweight premiums for LGM for Dairy Cattle at given dollar deductibles

no price basis adjustments looks exactly the same as Figure 7. Basis patterns are included to adjust insurance prices and gross margins to local levels. Basis risk (the changing of the basis patterns) is not covered by this policy.

Historical Analysis

To see how LGM for Dairy Cattle would have performed in the past, we calculated the expected gross margins, actual gross margins, and indemnities if the product had been offered to dairy producers each January from 1998 to 2005. Table 10 shows the expected gross margins by month. The average expected gross margin was $10.54/cwt. The minimum expected gross margin occurred during March 2003 and was $8.22/cwt. The maximum expected gross margin was $13.00/cwt for March 2005. Table 11 contains the actual gross margins by month. These actual gross margins display more variability, ranging from $7.32/cwt. for March 2003 to $17.93 for May 2004. The average actual gross margin was $11.04/cwt.

Table 12 shows the per hundredweight indemnities from LGM for Dairy Cattle at the $0, $0.20, $0.40, $0.60, $0.80, and $1 deductible levels. Given the short panel, indemnities would have been paid in two out of eight years for all coverage levels. The average per hundredweight indemnity would have been $0.50 at $0 deductible, $0.43 at $0.60 deductible, and $0.39 at $1 deductible. The short panel shows the typical loss nature of margin products, several years of zero indemnities mixed with a few years of large losses.

One might conclude that premiums for LGM for Dairy Cattle would be inadequate to cover losses because the historical losses are greater than the current-estimated premiums. But premiums for LGM for Dairy Cattle reflect current, not historical, estimates of market price volatility and they will respond to changes in this volatility, as shown next.

Effects of Increased Volatility

During the last several years, livestock markets have experienced great swings in price volatility. To investigate the effects of volatilities on the proposed insurance product, we estimated premiums with the distributional parameters set to reflect a doubling of the price volatilities. The rank correlation tables are the same for this analysis as before. Table 13 shows the insurance prices and volatilities for this scenario. Figure 8 shows the per hundredweight premiums at dollar deductibles from $0 to $1. The doubling of volatilities has a dramatic effect on premium levels. At $0 deductible, the premium increases 100 percent, to $0.68. The dollar increase in premium levels drops as the deductible is raised, but the percentage increase in premium levels rises. At $0.50 deductible and given the doubled volatilities, the premium is $0.44. This is a 214 percent increase over the original premium. This result shows that the futures price volatilities are major drivers of the premium levels.

Concluding Remarks

Currently, there are two federally supported livestock insurance products, LRP and LGM. LRP insures against output price declines. LGM insures against gross margin declines from either output price declines or feed cost increases. Both products were originally piloted for Iowa hog producers. LRP has been expanded to several states and to fed and feeder cattle producers. This research supports the extension of an LGM-style insurance product to dairy producers in the lower 48 states. The product has the potential to provide these producers a new and useful risk management tool.

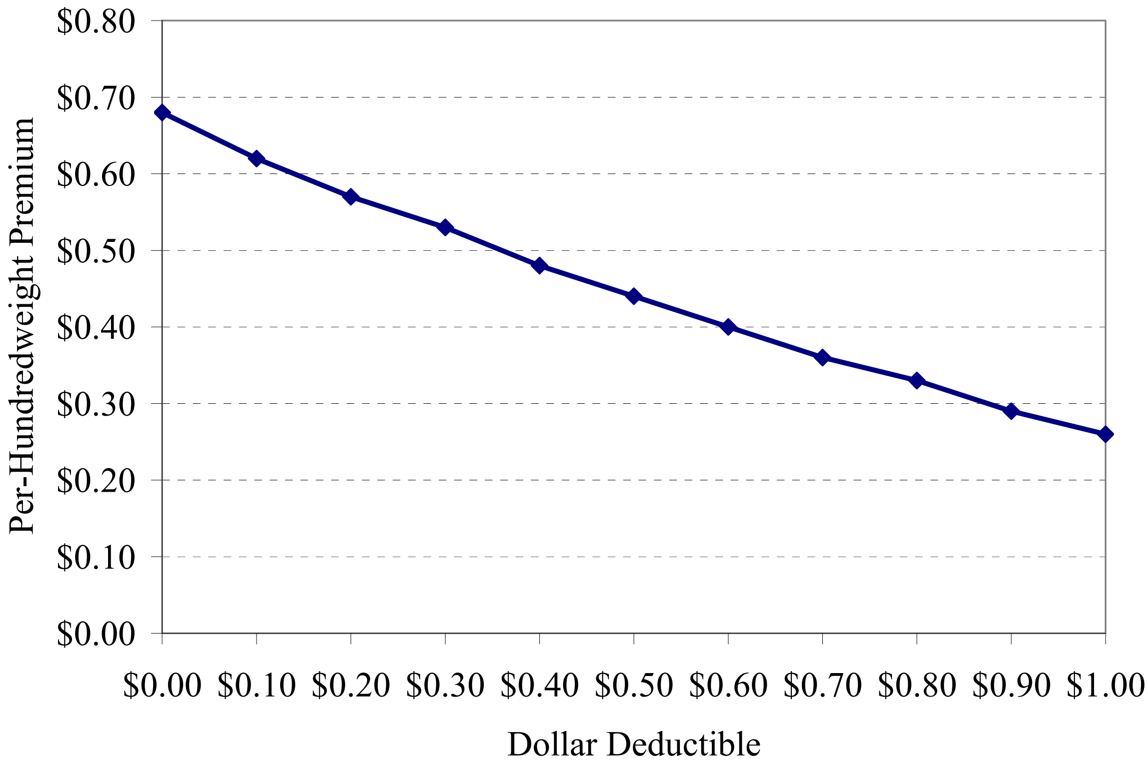

Figure 8. Per hundredweight premiums for LGM for Dairy Cattle with doubled price volatilities

The product is structured to insure against price risks in the markets for milk, corn, and soybean meal. The insurable prices, set by average prices from the futures market over a price discovery period, are adjusted to a local level by accounting for the average basis (cash price less futures price) pattern for the state and commodity. Basis risk is not covered by the product because the same basis pattern is applied to both the insurable and realized futures prices. Monte Carlo analysis is used to develop fair premiums at various coverage levels. A historical correlation structure is imposed on the simulated price data using a method proposed by Iman and Conover that maintains the marginal distributions of the variables. The product is further tailored to match the dairy operation insured by allowing producers to choose the number of hundredweight of milk insured, along with the amount of feed also covered by the product. Government intervention in the dairy market is also taken into account by the rating methodology. The dairy price support program provides a price floor to milk, truncating the lognormal price distribution.

Historical analysis is carried out to examine how the product would have performed had it been offered. The product is shown to perform as intended, paying indemnities in years of extreme price volatility. Sensitivity analysis is also performed to determine the effect of volatility levels on the fair premiums. Premium levels increase as the level of price volatility is increased.

References

Bailey, Ken. "Dairy Programs Face Difficult Future." Staff Paper #373. Department of Agricultural Economics and Rural Sociology, Pennsylvania State University. March 2005.

Chite, Ralph M. "Dairy Policy Isssues." CRS Issue Brief for Congress. Congressional Research Service. Updated January 7, 2005. Available at http://kohl.senate.gov/milc.pdf.

Ellis, Shane, William Edwards, and John Lawrence. "Livestock Enterprise Budgets for Iowa—2005." Iowa State University Extension Publication FM 1815. February 2005.

Hart, C. E., B. A. Babcock, and D. J. Hayes. "Livestock Revenue Insurance." *Journal of Futures Markets* 21(2001):553-80.

Hull, J. C. *Options, Futures, and Other Derivatives*. Prentice Hall, 2006.

Iman, R. L., and W. J. Conover. "A Distribution-Free Approach to Inducing Rank Correlation Among Input Variables." *Communication in Statistics: Simulation and Computation* 11(1982):311-34.

Levy, E. "Asian Options." *Exotic Options: The State of the Art*. L. Clewlow and C. Strickland (eds.) Chapter 4. London: International Thomson Business Press, 1997.

Levy, E. "Pricing European Average Rate Currency Options." *Journal of International Money and Finance* 11(1992):474-91.

Turnbull, S. M., and L. M. Wakeman. "A Quick Algorithm for Pricing European Average Options." *Journal of Financial and Quantitative Analysis* 26(1991):377-89.

Table 1. Basis patterns for milk using monthly NASS prices

State	January	February	March	April	May	June	July	August	September	October	November	December
							($ per cwt.)					
Arizona	1.60	1.49	1.35	0.78	0.88	1.24	1.17	0.96	0.92	1.12	1.81	1.48
California	0.94	0.89	0.97	0.42	0.03	0.31	0.12	0.25	0.19	-0.04	1.06	0.77
Florida	5.10	4.83	4.41	3.56	4.34	5.22	4.69	4.14	4.36	4.90	5.93	5.02
Iowa	1.96	1.95	1.83	1.28	1.18	1.28	1.15	0.96	1.26	1.68	2.31	2.04
Idaho	0.78	0.85	1.01	0.54	-0.08	-0.06	-0.01	-0.10	0.06	-0.12	0.89	0.66
Illinois	1.96	1.93	1.75	1.10	0.86	1.26	1.01	0.72	1.16	1.66	1.97	1.90
Indiana	2.88	2.43	2.27	1.34	1.72	2.24	2.03	1.64	1.58	2.16	3.33	2.56
Kentucky	3.20	3.03	2.85	1.90	2.28	2.84	2.85	2.34	2.34	2.54	3.69	3.02
Michigan	2.46	2.27	2.07	1.50	1.48	1.72	1.53	1.26	1.34	1.72	2.43	2.08
Minnesota	1.96	1.91	2.01	1.70	1.36	1.34	1.21	1.30	1.52	1.70	2.27	2.00
Missouri	2.46	1.95	1.63	0.90	0.96	1.58	1.57	1.14	1.70	1.90	2.63	2.04
New Mexico	2.04	1.79	1.61	0.84	0.58	0.98	0.83	0.60	0.80	1.08	2.09	1.66
New York	2.84	2.71	2.65	1.82	1.96	2.26	1.97	1.70	1.82	2.16	3.13	2.74
Ohio	2.56	2.45	2.45	1.42	1.50	1.84	1.75	1.26	1.58	2.00	2.93	2.62
Pennsylvania	3.62	3.55	3.47	2.56	2.60	3.16	2.81	2.40	2.66	3.12	4.21	3.68
Texas	3.06	2.85	2.65	1.70	1.62	2.12	2.03	1.82	2.04	2.20	3.05	2.70
Virginia	4.32	4.01	3.79	2.74	2.92	3.24	3.75	3.04	3.06	3.40	4.57	3.66
Vermont	2.88	2.95	2.87	1.92	1.94	2.36	1.95	1.74	1.92	2.30	3.37	2.82
Washington	2.26	2.11	2.05	1.42	1.28	1.58	1.31	0.96	0.96	1.28	2.17	1.80
Wisconsin	2.02	1.99	1.99	1.66	1.34	1.30	1.15	1.16	1.42	1.78	2.29	2.10

Table 2. Basis patterns for corn using monthly NASS prices

State	January	February	March	April	May	June	July	August	September	October	November	December
						($ per bushel)						
Colorado	-0.03	-0.05	-0.06	-0.03	-0.02	0.07	0.21	0.10	0.12	0.05	0.05	0.06
Illinois	-0.10	-0.08	-0.09	-0.09	-0.07	-0.06	-0.06	-0.11	-0.15	-0.15	-0.12	0.00
Indiana	-0.06	-0.04	-0.05	-0.03	-0.01	-0.05	-0.03	-0.03	-0.14	-0.23	-0.18	-0.03
Iowa	-0.23	-0.20	-0.21	-0.20	-0.21	-0.18	-0.18	-0.25	-0.25	-0.24	-0.21	-0.14
Kansas	-0.04	-0.05	-0.07	-0.04	-0.08	-0.02	0.01	-0.07	-0.08	0.03	0.06	0.02
Kentucky	0.07	0.13	0.07	0.06	0.10	0.17	0.14	0.03	-0.05	-0.10	0.00	0.11
Michigan	-0.14	-0.13	-0.11	-0.12	-0.13	-0.10	-0.07	-0.10	-0.14	-0.21	-0.22	-0.16
Minnesota	-0.29	-0.31	-0.31	-0.28	-0.29	-0.23	-0.21	-0.28	-0.32	-0.30	-0.28	-0.22
Missouri	-0.05	-0.02	-0.03	-0.01	-0.06	0.04	-0.02	-0.07	-0.17	-0.23	-0.17	-0.08
Nebraska	-0.16	-0.16	-0.17	-0.16	-0.16	-0.11	-0.11	-0.16	-0.19	-0.15	-0.13	-0.09
North Carolina	0.35	0.38	0.38	0.36	0.39	0.35	0.51	0.30	0.10	0.14	0.20	0.35
North Dakota	-0.40	-0.34	-0.32	-0.28	-0.29	-0.18	-0.17	-0.21	-0.24	-0.27	-0.30	-0.29
Ohio	-0.04	-0.03	-0.05	-0.05	-0.04	0.00	0.02	-0.04	-0.12	-0.18	-0.15	-0.04
Pennsylvania	0.37	0.38	0.37	0.40	0.44	0.49	0.51	0.42	0.29	0.10	0.18	0.26
South Dakota	-0.34	-0.30	-0.33	-0.28	-0.30	-0.23	-0.29	-0.30	-0.37	-0.39	-0.40	-0.30
Tennessee	0.09	0.04	0.13	0.17	0.16	0.23	0.28	0.00	-0.12	-0.10	0.25	0.23
Texas	0.17	0.13	0.17	-0.46	0.08	0.19	0.11	0.04	0.19	0.26	0.25	0.23
Wisconsin	-0.21	-0.20	-0.22	-0.19	-0.20	-0.10	-0.07	-0.15	-0.16	-0.18	-0.17	-0.13

Table 3. Representative states for basis and average annual price adjustments for milk

State	Representative State	Price	Rep. State Price	Difference
			($ per cwt.)	
Alabama	Florida	15.42	16.64	-1.22
Arizona	Arizona	13.20	13.20	0.00
Arkansas	Missouri	14.60	13.66	0.94
California	California	12.50	12.50	0.00
Colorado	New Mexico	13.34	13.24	0.10
Connecticut	New York	14.86	14.32	0.54
Delaware	Pennsylvania	14.64	15.14	-0.50
Florida	Florida	16.64	16.64	0.00
Georgia	Florida	14.44	16.64	-2.20
Idaho	Idaho	12.38	12.38	0.00
Illinois	Illinois	13.40	13.40	0.00
Indiana	Indiana	14.18	14.18	0.00
Iowa	Iowa	13.52	13.52	0.00
Kansas	Missouri	13.04	13.66	-0.62
Kentucky	Kentucky	14.72	14.72	0.00
Louisiana	Texas	14.48	14.28	0.20
Maine	Vermont	15.14	14.44	0.70
Maryland	Pennsylvania	14.64	15.14	-0.50
Massachusetts	Vermont	14.94	14.44	0.50
Michigan	Michigan	13.82	13.82	0.00
Minnesota	Minnesota	13.70	13.70	0.00
Mississippi	Florida	14.60	16.64	-2.04
Missouri	Missouri	13.66	13.66	0.00
Montana	Idaho	13.62	12.38	1.24
Nebraska	Iowa	13.60	13.52	0.08
Nevada	California	12.16	12.50	-0.34
New Hampshire	Vermont	14.94	14.44	0.50
New Jersey	Pennsylvania	14.26	15.14	-0.88
New Mexico	New Mexico	13.24	13.24	0.00
New York	New York	14.32	14.32	0.00
North Carolina	Virginia	15.38	15.62	-0.24
North Dakota	Minnesota	13.16	13.70	-0.54
Ohio	Ohio	14.02	14.02	0.00
Oklahoma	Texas	14.84	14.28	0.56
Oregon	Washington	13.86	13.56	0.30
Pennsylvania	Pennsylvania	15.14	15.14	0.00
Rhode Island	New York	15.02	14.32	0.70
South Carolina	Virginia	15.02	15.62	-0.60
South Dakota	Minnesota	14.12	13.70	0.42
Tennessee	Kentucky	14.66	14.72	-0.06
Texas	Texas	14.28	14.28	0.00
Utah	Arizona	13.10	13.20	-0.10
Vermont	Vermont	14.44	14.44	0.00
Virginia	Virginia	15.62	15.62	0.00
Washington	Washington	13.56	13.56	0.00
West Virginia	Pennsylvania	14.22	15.14	-0.92
Wisconsin	Wisconsin	13.70	13.70	0.00
Wyoming	Idaho	12.88	12.38	0.50

Table 4. Representative states for basis and average annual price adjustments for corn

State	Representative State	Price	Rep. State Price	Difference
			($ per bu.)	
Alabama	Tennessee	2.40	2.21	0.19
Arizona	Colorado	3.04	2.28	0.76
Arkansas	Missouri	2.20	2.11	0.09
California	Colorado	2.68	2.28	0.40
Colorado	Colorado	2.28	2.28	0.00
Connecticut	Pennsylvania	#N/A	2.47	0.00
Delaware	Pennsylvania	2.40	2.47	-0.07
Florida	North Carolina	2.38	2.46	-0.08
Georgia	North Carolina	2.35	2.46	-0.11
Idaho	Colorado	2.80	2.28	0.52
Illinois	Illinois	2.14	2.14	0.00
Indiana	Indiana	2.11	2.11	0.00
Iowa	Iowa	2.03	2.03	0.00
Kansas	Kansas	2.23	2.23	0.00
Kentucky	Kentucky	2.26	2.26	0.00
Louisiana	Texas	2.24	2.44	-0.20
Maine	Pennsylvania	#N/A	2.47	0.00
Maryland	Pennsylvania	2.40	2.47	-0.07
Massachusetts	Pennsylvania	#N/A	2.47	0.00
Michigan	Michigan	2.08	2.08	0.00
Minnesota	Minnesota	1.99	1.99	0.00
Mississippi	Tennessee	2.18	2.21	-0.03
Missouri	Missouri	2.11	2.11	0.00
Montana	North Dakota	2.20	1.97	0.23
Nebraska	Nebraska	2.10	2.10	0.00
Nevada	Colorado	#N/A	2.28	0.00
New Hampshire	Pennsylvania	#N/A	2.47	0.00
New Jersey	Pennsylvania	2.37	2.47	-0.10
New Mexico	Colorado	2.61	2.28	0.33
New York	Pennsylvania	2.59	2.47	0.12
North Carolina	North Carolina	2.46	2.46	0.00
North Dakota	North Dakota	1.97	1.97	0.00
Ohio	Ohio	2.14	2.14	0.00
Oklahoma	Kansas	2.35	2.23	0.12
Oregon	Colorado	2.72	2.28	0.44
Pennsylvania	Pennsylvania	2.47	2.47	0.00
Rhode Island	Pennsylvania	#N/A	2.47	0.00
South Carolina	North Carolina	2.41	2.46	-0.05
South Dakota	South Dakota	1.89	1.89	0.00
Tennessee	Tennessee	2.21	2.21	0.00
Texas	Texas	2.44	2.44	0.00
Utah	Colorado	2.86	2.28	0.58
Vermont	Pennsylvania	#N/A	2.47	0.00
Virginia	North Carolina	2.33	2.46	-0.13
Washington	Colorado	2.77	2.28	0.49
West Virginia	Pennsylvania	2.41	2.47	-0.06
Wisconsin	Wisconsin	2.08	2.08	0.00
Wyoming	Colorado	2.36	2.28	0.08

Table 5. Basis patterns for milk for LGM for Dairy Cattle ($/cwt.)

State	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
Alabama	3.88	3.61	3.19	2.34	3.12	4.00	3.47	2.92	3.14	3.68	4.71	3.80
Arizona	1.60	1.49	1.35	0.78	0.88	1.24	1.17	0.96	0.92	1.12	1.81	1.48
Arkansas	3.40	2.89	2.57	1.84	1.90	2.52	2.51	2.08	2.64	2.84	3.57	2.98
California	0.94	0.89	0.97	0.42	0.03	0.31	0.12	0.25	0.19	-0.04	1.06	0.77
Colorado	2.14	1.89	1.71	0.94	0.68	1.08	0.93	0.70	0.90	1.18	2.19	1.76
Connecticut	3.38	3.25	3.19	2.36	2.50	2.80	2.51	2.24	2.36	2.70	3.67	3.28
Delaware	3.12	3.05	2.97	2.06	2.10	2.66	2.31	1.90	2.16	2.62	3.71	3.18
Florida	5.10	4.83	4.41	3.56	4.34	5.22	4.69	4.14	4.36	4.90	5.93	5.02
Georgia	2.90	2.63	2.21	1.36	2.14	3.02	2.49	1.94	2.16	2.70	3.73	2.82
Idaho	0.78	0.85	1.01	0.54	-0.08	-0.06	-0.01	-0.10	0.06	-0.12	0.89	0.66
Illinois	1.96	1.93	1.75	1.10	0.86	1.26	1.01	0.72	1.16	1.66	1.97	1.90
Indiana	2.88	2.43	2.27	1.34	1.72	2.24	2.03	1.64	1.58	2.16	3.33	2.56
Iowa	1.96	1.95	1.83	1.28	1.18	1.28	1.15	0.96	1.26	1.68	2.31	2.04
Kansas	1.84	1.33	1.01	0.28	0.34	0.96	0.95	0.52	1.08	1.28	2.01	1.42
Kentucky	3.20	3.03	2.85	1.90	2.28	2.84	2.85	2.34	2.34	2.54	3.69	3.02
Louisiana	3.26	3.05	2.85	1.90	1.82	2.32	2.23	2.02	2.24	2.40	3.25	2.90
Maine	3.58	3.65	3.57	2.62	2.64	3.06	2.65	2.44	2.62	3.00	4.07	3.52
Maryland	3.12	3.05	2.97	2.06	2.10	2.66	2.31	1.90	2.16	2.62	3.71	3.18
Massachusetts	3.38	3.45	3.37	2.42	2.44	2.86	2.45	2.24	2.42	2.80	3.87	3.32
Michigan	2.46	2.27	2.07	1.50	1.48	1.72	1.53	1.26	1.34	1.72	2.43	2.08
Minnesota	1.96	1.91	2.01	1.70	1.36	1.34	1.21	1.30	1.52	1.70	2.27	2.00
Mississippi	3.06	2.79	2.37	1.52	2.30	3.18	2.65	2.10	2.32	2.86	3.89	2.98
Missouri	2.46	1.95	1.63	0.90	0.96	1.58	1.57	1.14	1.70	1.90	2.63	2.04
Montana	2.02	2.09	2.25	1.78	1.16	1.18	1.23	1.14	1.30	1.12	2.13	1.90
Nebraska	2.04	2.03	1.91	1.36	1.26	1.36	1.23	1.04	1.34	1.76	2.39	2.12
Nevada	0.60	0.55	0.63	0.08	-0.31	-0.03	-0.22	-0.09	-0.15	-0.38	0.72	0.43
New Hampshire	3.38	3.45	3.37	2.42	2.44	2.86	2.45	2.24	2.42	2.80	3.87	3.32
New Jersey	2.74	2.67	2.59	1.68	1.72	2.28	1.93	1.52	1.78	2.24	3.33	2.80
New Mexico	2.04	1.79	1.61	0.84	0.58	0.98	0.83	0.60	0.80	1.08	2.09	1.66
New York	2.84	2.71	2.65	1.82	1.96	2.26	1.97	1.70	1.82	2.16	3.13	2.74
North Carolina	4.08	3.77	3.55	2.50	2.68	3.00	3.51	2.80	2.82	3.16	4.33	3.42
North Dakota	1.42	1.37	1.47	1.16	0.82	0.80	0.67	0.76	0.98	1.16	1.73	1.46
Ohio	2.56	2.45	2.45	1.42	1.50	1.84	1.75	1.26	1.58	2.00	2.93	2.62
Oklahoma	3.62	3.41	3.21	2.26	2.18	2.68	2.59	2.38	2.60	2.76	3.61	3.26
Oregon	2.56	2.41	2.35	1.72	1.58	1.88	1.61	1.26	1.26	1.58	2.47	2.10
Pennsylvania	3.62	3.55	3.47	2.56	2.60	3.16	2.81	2.40	2.66	3.12	4.21	3.68
Rhode Island	3.54	3.41	3.35	2.52	2.66	2.96	2.67	2.40	2.52	2.86	3.83	3.44
South Carolina	3.72	3.41	3.19	2.14	2.32	2.64	3.15	2.44	2.46	2.80	3.97	3.06
South Dakota	2.38	2.33	2.43	2.12	1.78	1.76	1.63	1.72	1.94	2.12	2.69	2.42
Tennessee	3.14	2.97	2.79	1.84	2.22	2.78	2.79	2.28	2.28	2.48	3.63	2.96
Texas	3.06	2.85	2.65	1.70	1.62	2.12	2.03	1.82	2.04	2.20	3.05	2.70
Utah	1.50	1.39	1.25	0.68	0.78	1.14	1.07	0.86	0.82	1.02	1.71	1.38
Vermont	2.88	2.95	2.87	1.92	1.94	2.36	1.95	1.74	1.92	2.30	3.37	2.82
Virginia	4.32	4.01	3.79	2.74	2.92	3.24	3.75	3.04	3.06	3.40	4.57	3.66
Washington	2.26	2.11	2.05	1.42	1.28	1.58	1.31	0.96	0.96	1.28	2.17	1.80
West Virginia	2.70	2.63	2.55	1.64	1.68	2.24	1.89	1.48	1.74	2.20	3.29	2.76
Wisconsin	2.02	1.99	1.99	1.66	1.34	1.30	1.15	1.16	1.42	1.78	2.29	2.10
Wyoming	1.28	1.35	1.51	1.04	0.42	0.44	0.49	0.40	0.56	0.38	1.39	1.16

Table 6. Basis patterns for corn for LGM for Dairy Cattle ($/bu.)

State	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
Alabama	0.28	0.23	0.32	0.36	0.35	0.42	0.47	0.19	0.07	0.09	0.44	0.42
Arizona	0.73	0.71	0.70	0.73	0.74	0.83	0.97	0.86	0.88	0.81	0.81	0.82
Arkansas	0.04	0.07	0.06	0.08	0.03	0.13	0.07	0.02	-0.08	-0.14	-0.08	0.01
California	0.37	0.35	0.34	0.37	0.38	0.47	0.61	0.50	0.52	0.45	0.45	0.46
Colorado	-0.03	-0.05	-0.06	-0.03	-0.02	0.07	0.21	0.10	0.12	0.05	0.05	0.06
Connecticut	0.37	0.38	0.37	0.40	0.44	0.49	0.51	0.42	0.29	0.10	0.18	0.26
Delaware	0.30	0.31	0.30	0.33	0.37	0.42	0.44	0.35	0.22	0.03	0.11	0.19
Florida	0.27	0.30	0.30	0.28	0.31	0.27	0.43	0.22	0.02	0.06	0.12	0.27
Georgia	0.24	0.27	0.27	0.25	0.28	0.24	0.40	0.19	-0.01	0.03	0.09	0.24
Idaho	0.49	0.47	0.46	0.49	0.50	0.59	0.73	0.62	0.64	0.57	0.57	0.58
Illinois	-0.10	-0.08	-0.09	-0.09	-0.07	-0.06	-0.06	-0.11	-0.15	-0.15	-0.12	0.00
Indiana	-0.06	-0.04	-0.05	-0.03	-0.01	-0.05	-0.03	-0.03	-0.14	-0.23	-0.18	-0.03
Iowa	-0.23	-0.20	-0.21	-0.20	-0.21	-0.18	-0.18	-0.25	-0.25	-0.24	-0.21	-0.14
Kansas	-0.04	-0.05	-0.07	-0.04	-0.08	-0.02	0.01	-0.07	-0.08	0.03	0.06	0.02
Kentucky	0.07	0.13	0.07	0.06	0.10	0.17	0.14	0.03	-0.05	-0.10	0.00	0.11
Louisiana	-0.03	-0.07	-0.03	-0.66	-0.12	-0.01	-0.09	-0.16	-0.01	0.06	0.05	0.03
Maine	0.37	0.38	0.37	0.40	0.44	0.49	0.51	0.42	0.29	0.10	0.18	0.26
Maryland	0.30	0.31	0.30	0.33	0.37	0.42	0.44	0.35	0.22	0.03	0.11	0.19
Massachusetts	0.37	0.38	0.37	0.40	0.44	0.49	0.51	0.42	0.29	0.10	0.18	0.26
Michigan	-0.14	-0.13	-0.11	-0.12	-0.13	-0.10	-0.07	-0.10	-0.14	-0.21	-0.22	-0.16
Minnesota	-0.29	-0.31	-0.31	-0.28	-0.29	-0.23	-0.21	-0.28	-0.32	-0.30	-0.28	-0.22
Mississippi	0.06	0.01	0.10	0.14	0.13	0.20	0.25	-0.03	-0.15	-0.13	0.22	0.20
Missouri	-0.05	-0.02	-0.03	-0.01	-0.06	0.04	-0.02	-0.07	-0.17	-0.23	-0.17	-0.08
Montana	-0.17	-0.11	-0.09	-0.05	-0.06	0.05	0.06	0.02	-0.01	-0.04	-0.07	-0.06
Nebraska	-0.16	-0.16	-0.17	-0.16	-0.16	-0.11	-0.11	-0.16	-0.19	-0.15	-0.13	-0.09
Nevada	-0.03	-0.05	-0.06	-0.03	-0.02	0.07	0.21	0.10	0.12	0.05	0.05	0.06
New Hampshire	0.37	0.38	0.37	0.40	0.44	0.49	0.51	0.42	0.29	0.10	0.18	0.26
New Jersey	0.27	0.28	0.27	0.30	0.34	0.39	0.41	0.32	0.19	0.00	0.08	0.16
New Mexico	0.30	0.28	0.27	0.30	0.31	0.40	0.54	0.43	0.45	0.38	0.38	0.39
New York	0.49	0.50	0.49	0.52	0.56	0.61	0.63	0.54	0.41	0.22	0.30	0.38
North Carolina	0.35	0.38	0.38	0.36	0.39	0.35	0.51	0.30	0.10	0.14	0.20	0.35
North Dakota	-0.40	-0.34	-0.32	-0.28	-0.29	-0.18	-0.17	-0.21	-0.24	-0.27	-0.30	-0.29
Ohio	-0.04	-0.03	-0.05	-0.05	-0.04	0.00	0.02	-0.04	-0.12	-0.18	-0.15	-0.04
Oklahoma	0.08	0.07	0.05	0.08	0.04	0.10	0.13	0.05	0.04	0.15	0.18	0.14
Oregon	0.41	0.39	0.38	0.41	0.42	0.51	0.65	0.54	0.56	0.49	0.49	0.50
Pennsylvania	0.37	0.38	0.37	0.40	0.44	0.49	0.51	0.42	0.29	0.10	0.18	0.26
Rhode Island	0.37	0.38	0.37	0.40	0.44	0.49	0.51	0.42	0.29	0.10	0.18	0.26
South Carolina	0.30	0.33	0.33	0.31	0.34	0.30	0.46	0.25	0.05	0.09	0.15	0.30
South Dakota	-0.34	-0.30	-0.33	-0.28	-0.30	-0.23	-0.29	-0.30	-0.37	-0.39	-0.40	-0.30
Tennessee	0.09	0.04	0.13	0.17	0.16	0.23	0.28	0.00	-0.12	-0.10	0.25	0.23
Texas	0.17	0.13	0.17	-0.46	0.08	0.19	0.11	0.04	0.19	0.26	0.25	0.23
Utah	0.55	0.53	0.52	0.55	0.56	0.65	0.79	0.68	0.70	0.63	0.63	0.64
Vermont	0.37	0.38	0.37	0.40	0.44	0.49	0.51	0.42	0.29	0.10	0.18	0.26
Virginia	0.22	0.25	0.25	0.23	0.26	0.22	0.38	0.17	-0.03	0.01	0.07	0.22
Washington	0.46	0.44	0.43	0.46	0.47	0.56	0.70	0.59	0.61	0.54	0.54	0.55
West Virginia	0.31	0.32	0.31	0.34	0.38	0.43	0.45	0.36	0.23	0.04	0.12	0.20
Wisconsin	-0.21	-0.20	-0.22	-0.19	-0.20	-0.10	-0.07	-0.15	-0.16	-0.18	-0.17	-0.13
Wyoming	0.05	0.03	0.02	0.05	0.06	0.15	0.29	0.18	0.20	0.13	0.13	0.14

Table 7. Historical milk support prices

Marketing Year	CCC Support Price
	($ per cwt.)
1980-81	13.10
1981-82	13.10 to 13.49
1982-83	13.10
1983-84	12.60 to 13.10
1984-85	11.60 to 12.60
1985-86	11.60
1986-87	11.35 to 11.60
1987-88	10.60 to 11.10
1988-89	10.60 to 11.10
1989-90	10.10 to 10.60
1990-91	10.10
1991-92	10.10
1992-93	10.10
1993-94	10.10
1994-95	10.10
1995-96	10.10 to 10.35
1996-97	10.20
1997-98	10.05 to 10.20
1998-99	9.90 to 10.05
1999-2000	9.90
2000-01	9.90
2001-02	9.90
2002-03	9.90
2003-04	9.90

Table 8. Insurance prices and volatilities for the January 2006 example

Commodity	Futures Month	Price	Volatility
		($/cwt.)	(percent)
Milk	March	12.21	4
	April	12.22	5
	May	12.34	6
	June	12.49	7
	July	12.69	8
	August	12.98	9
	September	13.12	9
	October	12.94	10
	November	12.80	10
	December	12.62	11
		($/bu.)	
Corn	March	2.17	8
	May	2.27	12
	July	2.36	17
	September	2.43	22
	December	2.53	23
		($/ton)	
Soybean Meal	March	181.70	8
	May	183.23	13
	July	185.90	16
	August	187.07	18
	September	187.93	19
	October	187.53	21
	December	189.47	21

Table 9. Insurable gross margins

Insurance Month	Expected Gross Margin
	($$/cwt.)
March	12.42
April	11.85
May	11.85
June	12.06
July	12.10
August	12.21
September	12.63
October	12.86
November	13.31
December	12.81

Table 10. Historical expected gross margins

Year	March	April	May	June	July	August	Sept.	Oct.	Nov.	Dec.
					($/cwt.)					
1998	10.33	9.92	9.91	9.89	10.24	10.66	10.89	10.85	10.84	10.84
1999	10.40	10.52	10.18	10.23	10.65	10.99	11.20	11.44	11.43	11.41
2000	8.65	8.80	9.28	9.86	10.66	10.96	11.04	10.98	10.56	10.23
2001	8.62	8.67	8.82	9.41	10.11	10.23	10.24	10.22	9.75	9.60
2002	10.14	10.26	10.26	10.83	11.60	11.70	11.77	11.16	10.74	10.47
2003	8.22	8.42	8.78	9.39	10.03	10.67	11.02	10.53	10.36	10.09
2004	9.55	9.85	10.04	10.47	11.21	11.61	11.99	11.25	10.48	10.18
2005	13.00	12.36	12.12	11.89	12.31	12.37	12.45	11.80	11.22	10.99

Table 11. Historical actual gross margins

Year	March	April	May	June	July	August	Sept.	Oct.	Nov.	Dec.
					($/cwt.)					
1998	10.92	10.17	9.40	11.15	12.81	13.78	13.78	14.49	15.33	15.74
1999	9.93	10.03	9.77	10.04	12.29	14.36	14.65	10.31	8.52	8.74
2000	7.83	7.68	7.56	7.85	9.14	8.76	9.28	8.49	6.96	7.68
2001	9.78	10.46	12.29	13.40	13.68	13.85	14.22	12.91	9.75	10.21
2002	9.09	9.28	9.23	8.45	7.58	7.66	7.81	8.81	8.00	7.98
2003	7.32	7.53	7.71	7.86	9.96	12.01	12.37	12.42	11.47	9.75
2004	11.91	17.06	17.93	15.20	12.49	12.21	13.05	12.62	13.38	14.67
2005	12.34	12.92	12.03	12.14	12.45	11.78	12.64	12.80	11.75	11.77

Table 12. Historical per cwt. indemnities at various dollar deductibles given equal marketings

	Dollar Deductible					
Year	0	0.2	0.4	0.6	0.8	1
			($ per cwt.)			
1998	0.00	0.00	0.00	0.00	0.00	0.00
1999	0.00	0.00	0.00	0.00	0.00	0.00
2000	1.98	1.78	1.58	1.38	1.18	0.98
2001	0.00	0.00	0.00	0.00	0.00	0.00
2002	2.50	2.30	2.10	1.90	1.70	1.50
2003	0.00	0.00	0.00	0.00	0.00	0.00
2004	0.00	0.00	0.00	0.00	0.00	0.00
2005	0.00	0.00	0.00	0.00	0.00	0.00
Average	0.50	0.48	0.45	0.43	0.41	0.39

Table 13. Insurance prices and volatilities for doubled volatility example

Commodity	Futures Month	Price	Volatility
		($ per hundredweight)	(percent)
Milk	March	12.21	8
	April	12.22	10
	May	12.34	12
	June	12.49	14
	July	12.69	16
	August	12.98	18
	September	13.12	18
	October	12.94	20
	November	12.80	20
	December	12.62	22
		($ per bushel)	
Corn	March	2.17	16
	May	2.27	24
	July	2.36	34
	September	2.43	44
	December	2.53	46
		($ per ton)	
Soybean Meal	March	181.70	16
	May	183.23	26
	July	185.90	32
	August	187.07	36
	September	187.93	38
	October	187.53	42
	December	189.47	42

Appendix Table 1. Rank correlation matrix for milk futures

	Month 1	Month 2	Month 3	Month 4	Month 5	Month 6	Month 7	Month 8	Month 9	Month 10
Month 1	1.0000	0.8419	0.7026	0.5821	0.4804	0.3975	0.3334	0.2881	0.2616	0.2539
Month 2	0.8419	1.0000	0.8419	0.7026	0.5821	0.4804	0.3975	0.3334	0.2881	0.2616
Month 3	0.7026	0.8419	1.0000	0.8419	0.7026	0.5821	0.4804	0.3975	0.3334	0.2881
Month 4	0.5821	0.7026	0.8419	1.0000	0.8419	0.7026	0.5821	0.4804	0.3975	0.3334
Month 5	0.4804	0.5821	0.7026	0.8419	1.0000	0.8419	0.7026	0.5821	0.4804	0.3975
Month 6	0.3975	0.4804	0.5821	0.7026	0.8419	1.0000	0.8419	0.7026	0.5821	0.4804
Month 7	0.3334	0.3975	0.4804	0.5821	0.7026	0.8419	1.0000	0.8419	0.7026	0.5821
Month 8	0.2881	0.3334	0.3975	0.4804	0.5821	0.7026	0.8419	1.0000	0.8419	0.7026
Month 9	0.2616	0.2881	0.3334	0.3975	0.4804	0.5821	0.7026	0.8419	1.0000	0.8419
Month 10	0.2539	0.2616	0.2881	0.3334	0.3975	0.4804	0.5821	0.7026	0.8419	1.0000

Appendix Table 2. Rank correlation matrix for corn and soybean meal for January

January		Corn					SoyMeal						
		March	May	July	September	December	March	May	July	August	September	October	December
Corn	March	1.0000	0.7835	0.4542	0.4438	0.3108	0.2616	0.3690	0.2394	0.3094	0.2473	0.2601	0.2429
	May	0.7835	1.0000	0.5500	0.4682	0.3761	0.2554	0.3682	0.3131	0.3874	0.4067	0.4584	0.5145
	July	0.4542	0.5500	1.0000	0.8724	0.7414	-0.0379	0.1118	0.4882	0.5995	0.5409	0.5453	0.4788
	September	0.4438	0.4682	0.8724	1.0000	0.8507	0.1005	0.2734	0.5911	0.7562	0.7591	0.7350	0.6488
	December	0.3108	0.3761	0.7414	0.8507	1.0000	0.1271	0.2542	0.5675	0.6788	0.7133	0.7424	0.7094
SoyMeal	March	0.2616	0.2554	-0.0379	0.1005	0.1271	1.0000	0.6399	0.2877	0.1463	0.1631	0.1596	0.2601
	May	0.3690	0.3682	0.1118	0.2734	0.2542	0.6399	1.0000	0.5680	0.4394	0.4562	0.3995	0.5394
	July	0.2394	0.3131	0.4882	0.5911	0.5675	0.2877	0.5680	1.0000	0.8030	0.7291	0.6798	0.6842
	August	0.3094	0.3874	0.5995	0.7562	0.6788	0.1463	0.4394	0.8030	1.0000	0.9286	0.8808	0.8103
	September	0.2473	0.4067	0.5409	0.7591	0.7133	0.1631	0.4562	0.7291	0.9286	1.0000	0.9576	0.8892
	October	0.2601	0.4584	0.5453	0.7350	0.7424	0.1596	0.3995	0.6798	0.8808	0.9576	1.0000	0.9227
	December	0.2429	0.5145	0.4788	0.6488	0.7094	0.2601	0.5394	0.6842	0.8103	0.8892	0.9227	1.0000

Appendix Table 3. Rank correlation matrix for corn and soybean meal for February

February		Corn						SoyMeal							
		March	May	July	September	December	March	March	May	July	August	September	October	December	January
Corn	March	1.0000	0.5399	0.2315	0.3414	0.4266	0.3468	0.4783	0.2251	0.1094	0.2537	0.2537	0.3212	0.2897	0.2596
	May	0.5399	1.0000	0.4833	0.4251	0.3601	0.4438	0.2394	0.2655	0.1946	0.3177	0.3966	0.4404	0.5305	0.4961
	July	0.2315	0.4833	1.0000	0.8626	0.7291	0.7305	-0.1527	-0.0281	0.4241	0.5847	0.5837	0.5394	0.4744	0.4355
	September	0.3414	0.4251	0.8626	1.0000	0.8783	0.8586	-0.0227	0.1813	0.5103	0.7606	0.8113	0.7438	0.6655	0.6320
	December	0.4266	0.3601	0.7291	0.8783	1.0000	0.9227	0.0581	0.1660	0.4828	0.6567	0.7241	0.7675	0.6842	0.6197
	March	0.3468	0.4438	0.7305	0.8586	0.9227	1.0000	-0.0084	0.2424	0.4424	0.6227	0.7064	0.7310	0.6862	0.6217
SoyMeal	March	0.4783	0.2394	-0.1527	-0.0227	0.0581	-0.0084	1.0000	0.3296	-0.0645	0.0498	-0.0039	0.0453	0.0764	0.0754
	May	0.2251	0.2655	-0.0281	0.1813	0.1660	0.2424	0.3296	1.0000	0.5034	0.3640	0.4089	0.3527	0.4926	0.4438
	July	0.1094	0.1946	0.4241	0.5103	0.4828	0.4424	-0.0645	0.5034	1.0000	0.7296	0.6956	0.6419	0.6793	0.6355
	August	0.2537	0.3177	0.5847	0.7606	0.6567	0.6227	0.0498	0.3640	0.7296	1.0000	0.9241	0.8527	0.7995	0.7379
	September	0.2537	0.3966	0.5837	0.8113	0.7241	0.7064	-0.0039	0.4089	0.6956	0.9241	1.0000	0.9222	0.8759	0.8384
	October	0.3212	0.4404	0.5394	0.7438	0.7675	0.7310	0.0453	0.3527	0.6419	0.8527	0.9222	1.0000	0.9227	0.8931
	December	0.2897	0.5305	0.4744	0.6655	0.6842	0.6862	0.0764	0.4926	0.6793	0.7995	0.8759	0.9227	1.0000	0.9429
	January	0.2596	0.4961	0.4355	0.6320	0.6197	0.6217	0.0754	0.4438	0.6355	0.7379	0.8384	0.8931	0.9429	1.0000

Appendix Table 4. Rank correlation matrix for corn and soybean meal for March

March		Corn					SoyMeal							
		May	July	September	December	March	May	July	August	September	October	December	January	March
Corn	May	1.0000	0.5143	0.4571	0.3951	0.4527	0.1261	0.2931	0.3296	0.4586	0.4399	0.5626	0.5291	0.4296
	July	0.5143	1.0000	0.8567	0.7502	0.7118	0.0448	0.4601	0.6182	0.5773	0.4931	0.4512	0.4241	0.3941
	September	0.4571	0.8567	1.0000	0.8921	0.8542	0.1936	0.5039	0.8005	0.8000	0.7128	0.6714	0.5936	0.5655
	December	0.3951	0.7502	0.8921	1.0000	0.9069	0.1616	0.4739	0.6680	0.7103	0.6857	0.6443	0.5764	0.5296
	March	0.4527	0.7118	0.8542	0.9069	1.0000	0.2517	0.4345	0.6458	0.7069	0.6734	0.6754	0.5823	0.5931
SoyMeal	May	0.1261	0.0448	0.1936	0.1616	0.2517	1.0000	0.5153	0.4222	0.5054	0.3877	0.5296	0.4966	0.4882
	July	0.2931	0.4601	0.5039	0.4739	0.4345	0.5153	1.0000	0.7123	0.6877	0.5941	0.6241	0.5995	0.4985
	August	0.3296	0.6182	0.8005	0.6680	0.6458	0.4222	0.7123	1.0000	0.9305	0.8645	0.7847	0.7187	0.6833
	September	0.4586	0.5773	0.8000	0.7103	0.7069	0.5054	0.6877	0.9305	1.0000	0.9300	0.8857	0.8296	0.7631
	October	0.4399	0.4931	0.7128	0.6857	0.6734	0.3877	0.5941	0.8645	0.9300	1.0000	0.9236	0.8990	0.8325
	December	0.5626	0.4512	0.6714	0.6443	0.6754	0.5296	0.6241	0.7847	0.8857	0.9236	1.0000	0.9547	0.8631
	January	0.5291	0.4241	0.5936	0.5764	0.5823	0.4966	0.5995	0.7187	0.8296	0.8990	0.9547	1.0000	0.9074
	March	0.4296	0.3941	0.5655	0.5296	0.5931	0.4882	0.4985	0.6833	0.7631	0.8325	0.8631	0.9074	1.0000

Appendix Table 5. Rank correlation matrix for corn and soybean meal for April

April		Corn					SoyMeal							
		May	July	September	December	March	May	July	August	September	October	December	January	March
Corn	May	1.0000	0.1581	0.2665	0.1374	0.2182	0.3596	0.2665	0.4453	0.3961	0.4315	0.5143	0.5552	0.5414
	July	0.1581	1.0000	0.7867	0.6256	0.5143	0.0025	0.5163	0.5911	0.5596	0.5182	0.4281	0.4404	0.3365
	September	0.2665	0.7867	1.0000	0.8709	0.7887	0.2049	0.5453	0.7685	0.8005	0.7246	0.6404	0.6089	0.5601
	December	0.1374	0.6256	0.8709	1.0000	0.8729	0.1734	0.5079	0.6187	0.7010	0.7187	0.6601	0.6020	0.5384
	March	0.2182	0.5143	0.7887	0.8729	1.0000	0.1724	0.3562	0.5453	0.6704	0.6409	0.6374	0.5892	0.5793
SoyMeal	May	0.3596	0.0025	0.2049	0.1734	0.1724	1.0000	0.5079	0.3675	0.3754	0.4227	0.5493	0.5039	0.3635
	July	0.2665	0.5163	0.5453	0.5079	0.3562	0.5079	1.0000	0.6916	0.6118	0.6089	0.6123	0.5877	0.4473
	August	0.4453	0.5911	0.7685	0.6187	0.5453	0.3675	0.6916	1.0000	0.9010	0.8404	0.7335	0.7281	0.6788
	September	0.3961	0.5596	0.8005	0.7010	0.6704	0.3754	0.6118	0.9010	1.0000	0.9281	0.8320	0.8286	0.7335
	October	0.4315	0.5182	0.7246	0.7187	0.6409	0.4227	0.6089	0.8404	0.9281	1.0000	0.9000	0.9030	0.8030
	December	0.5143	0.4281	0.6404	0.6601	0.6374	0.5493	0.6123	0.7335	0.8320	0.9000	1.0000	0.9621	0.8305
	January	0.5552	0.4404	0.6089	0.6020	0.5892	0.5039	0.5877	0.7281	0.8286	0.9030	0.9621	1.0000	0.9074
	March	0.5414	0.3365	0.5601	0.5384	0.5793	0.3635	0.4473	0.6788	0.7335	0.8030	0.8305	0.9074	1.0000

Appendix Table 6. Rank correlation matrix for corn and soybean meal for May

May		Corn					SoyMeal							
		July	September	December	March	May	July	August	September	October	December	January	March	May
Corn	July	1.0000	0.7941	0.6498	0.4897	0.3717	0.5246	0.6005	0.4764	0.3803	0.2749	0.2847	0.1778	0.0537
	September	0.7941	1.0000	0.8453	0.7660	0.6387	0.4586	0.7552	0.7468	0.6700	0.5704	0.5399	0.4507	0.3946
	December	0.6498	0.8453	1.0000	0.9118	0.8101	0.4473	0.5704	0.6271	0.6502	0.5670	0.5079	0.3906	0.3015
	March	0.4897	0.7660	0.9118	1.0000	0.9234	0.2596	0.5020	0.6153	0.6074	0.5493	0.4749	0.4281	0.3443
	May	0.3717	0.6387	0.8101	0.9234	1.0000	0.2170	0.4525	0.5096	0.6091	0.5200	0.4702	0.4677	0.3958
SoyMeal	July	0.5246	0.4586	0.4473	0.2596	0.2170	1.0000	0.5665	0.3670	0.4054	0.3433	0.3438	0.3030	0.3143
	August	0.6005	0.7552	0.5704	0.5020	0.4525	0.5665	1.0000	0.8478	0.7542	0.5631	0.5493	0.5276	0.5118
	September	0.4764	0.7468	0.6271	0.6153	0.5096	0.3670	0.8478	1.0000	0.8498	0.7236	0.6867	0.6232	0.6163
	October	0.3803	0.6700	0.6502	0.6074	0.6091	0.4054	0.7542	0.8498	1.0000	0.8463	0.8512	0.7557	0.7064
	December	0.2749	0.5704	0.5670	0.5493	0.5200	0.3433	0.5631	0.7236	0.8463	1.0000	0.9552	0.8084	0.7704
	January	0.2847	0.5399	0.5079	0.4749	0.4702	0.3438	0.5493	0.6867	0.8512	0.9552	1.0000	0.8828	0.8192
	March	0.1778	0.4507	0.3906	0.4281	0.4677	0.3030	0.5276	0.6232	0.7557	0.8084	0.8828	1.0000	0.9379
	May	0.0537	0.3946	0.3015	0.3443	0.3958	0.3143	0.5118	0.6163	0.7064	0.7704	0.8192	0.9379	1.0000

Appendix Table 7. Rank correlation matrix for corn and soybean meal for June

June		Corn					SoyMeal						
		July	September	December	March	May	August	September	October	December	January	March	May
Corn	July	1.0000	0.6591	0.5325	0.3961	0.2892	0.5537	0.4409	0.3030	0.2123	0.2123	0.1369	0.0005
	September	0.6591	1.0000	0.7966	0.7187	0.6108	0.6670	0.7399	0.6429	0.5813	0.5281	0.5167	0.4833
	December	0.5325	0.7966	1.0000	0.9187	0.8522	0.4803	0.6069	0.6512	0.6192	0.5498	0.4813	0.3862
	March	0.3961	0.7187	0.9187	1.0000	0.9315	0.3966	0.5680	0.5655	0.5857	0.4897	0.5010	0.4261
	May	0.2892	0.6108	0.8522	0.9315	1.0000	0.3532	0.4626	0.5305	0.5478	0.4695	0.4985	0.4350
SoyMeal	August	0.5537	0.6670	0.4803	0.3966	0.3532	1.0000	0.8281	0.7099	0.5906	0.5227	0.4379	0.4754
	September	0.4409	0.7399	0.6069	0.5680	0.4626	0.8281	1.0000	0.8744	0.8079	0.7222	0.5818	0.5975
	October	0.3030	0.6429	0.6512	0.5655	0.5305	0.7099	0.8744	1.0000	0.9025	0.8714	0.6990	0.6951
	December	0.2123	0.5813	0.6192	0.5857	0.5478	0.5906	0.8079	0.9025	1.0000	0.9527	0.7961	0.7833
	January	0.2123	0.5281	0.5498	0.4897	0.4695	0.5227	0.7222	0.8714	0.9527	1.0000	0.8675	0.8212
	March	0.1369	0.5167	0.4813	0.5010	0.4985	0.4379	0.5818	0.6990	0.7961	0.8675	1.0000	0.9315
	May	0.0005	0.4833	0.3862	0.4261	0.4350	0.4754	0.5975	0.6951	0.7833	0.8212	0.9315	1.0000

Appendix Table 8. Rank correlation matrix for corn and soybean meal for July

July		Corn					SoyMeal						
		September	December	March	May	July	September	October	December	January	March	May	July
Corn	September	1.0000	0.4995	0.3995	0.2877	0.2276	0.5773	0.4182	0.3571	0.3286	0.2695	0.2970	0.2202
	December	0.4995	1.0000	0.8020	0.6961	0.5158	0.2946	0.4153	0.4783	0.3084	0.1369	0.0778	0.1729
	March	0.3995	0.8020	1.0000	0.8384	0.6143	0.2153	0.2882	0.4611	0.2645	0.2325	0.1872	0.1562
	May	0.2877	0.6961	0.8384	1.0000	0.6305	0.1369	0.3182	0.4044	0.2916	0.2901	0.2852	0.2616
	July	0.2276	0.5158	0.6143	0.6305	1.0000	0.0123	0.0803	0.2379	0.1197	0.0000	0.0153	0.3271
SoyMeal	September	0.5773	0.2946	0.2153	0.1369	0.0123	1.0000	0.8458	0.6778	0.6369	0.3714	0.3522	0.2665
	October	0.4182	0.4153	0.2882	0.3182	0.0803	0.8458	1.0000	0.7941	0.6941	0.4291	0.3611	0.3163
	December	0.3571	0.4783	0.4611	0.4044	0.2379	0.6778	0.7941	1.0000	0.8921	0.6813	0.5764	0.4793
	January	0.3286	0.3084	0.2645	0.2916	0.1197	0.6369	0.6941	0.8921	1.0000	0.8000	0.7374	0.6005
	March	0.2695	0.1369	0.2325	0.2901	0.0000	0.3714	0.4291	0.6813	0.8000	1.0000	0.8975	0.6049
	May	0.2970	0.0778	0.1872	0.2852	0.0153	0.3522	0.3611	0.5764	0.7374	0.8975	1.0000	0.6961
	July	0.2202	0.1729	0.1562	0.2616	0.3271	0.2665	0.3163	0.4793	0.6005	0.6049	0.6961	1.0000

Appendix Table 9. Rank correlation matrix for corn and soybean meal for August

August		Corn					SoyMeal					
		September	December	March	May	July	October	December	January	March	May	July
Corn	September	1.0000	0.3791	0.3273	0.4047	0.1599	0.2411	0.3352	0.3377	0.3500	0.4190	0.2687
	December	0.3791	1.0000	0.9074	0.7680	0.6020	0.5581	0.6074	0.4232	0.2158	0.0926	0.2478
	March	0.3273	0.9074	1.0000	0.8739	0.6389	0.4887	0.6118	0.4552	0.3424	0.2261	0.2473
	May	0.4047	0.7680	0.8739	1.0000	0.6177	0.5232	0.5296	0.4192	0.3522	0.2941	0.3133
	July	0.1599	0.6020	0.6389	0.6177	1.0000	0.2192	0.3010	0.1202	0.0739	0.0325	0.3325
SoyMeal	October	0.2411	0.5581	0.4887	0.5232	0.2192	1.0000	0.6675	0.5675	0.2980	0.2330	0.3773
	December	0.3352	0.6074	0.6118	0.5296	0.3010	0.6675	1.0000	0.8946	0.5818	0.5187	0.4404
	January	0.3377	0.4232	0.4552	0.4192	0.1202	0.5675	0.8946	1.0000	0.7296	0.6847	0.5256
	March	0.3500	0.2158	0.3424	0.3522	0.0739	0.2980	0.5818	0.7296	1.0000	0.9044	0.6882
	May	0.4190	0.0926	0.2261	0.2941	0.0325	0.2330	0.5187	0.6847	0.9044	1.0000	0.7064
	July	0.2687	0.2478	0.2473	0.3133	0.3325	0.3773	0.4404	0.5256	0.6882	0.7064	1.0000

Appendix Table 10. Rank correlation matrix for corn and soybean meal for September

September		Corn					SoyMeal						
		December	March	May	July	September	October	December	January	March	May	July	August
Corn	December	1.0000	0.8101	0.6010	0.4946	0.2409	0.3995	0.5350	0.3438	0.2488	0.0517	0.1734	0.2714
	March	0.8101	1.0000	0.8091	0.5889	0.4081	0.3874	0.6135	0.4303	0.4244	0.3062	0.3057	0.3372
	May	0.6010	0.8091	1.0000	0.6094	0.4813	0.4034	0.4133	0.2818	0.3798	0.3635	0.3778	0.4005
	July	0.4946	0.5889	0.6094	1.0000	0.7961	0.1177	0.4118	0.2064	0.1448	0.1049	0.4300	0.5374
	September	0.2409	0.4081	0.4813	0.7961	1.0000	-0.1581	0.1901	0.0448	0.0911	0.1926	0.4591	0.6099
SoyMeal	October	0.3995	0.3874	0.4034	0.1177	-0.1581	1.0000	0.4291	0.2877	0.1951	-0.0005	0.0414	-0.0478
	December	0.5350	0.6135	0.4133	0.4118	0.1901	0.4291	1.0000	0.8645	0.5522	0.4118	0.4409	0.4064
	January	0.3438	0.4303	0.2818	0.2064	0.0448	0.2877	0.8645	1.0000	0.7291	0.6315	0.5872	0.4975
	March	0.2488	0.4244	0.3798	0.1448	0.0911	0.1951	0.5522	0.7291	1.0000	0.8803	0.7015	0.6138
	May	0.0517	0.3062	0.3635	0.1049	0.1926	-0.0005	0.4118	0.6315	0.8803	1.0000	0.7591	0.6586
	July	0.1734	0.3057	0.3778	0.4300	0.4591	0.0414	0.4409	0.5872	0.7015	0.7591	1.0000	0.8778
	August	0.2714	0.3372	0.4005	0.5374	0.6099	-0.0478	0.4064	0.4975	0.6138	0.6586	0.8778	1.0000

Appendix Table 11. Rank correlation matrix for corn and soybean meal for October

October		Corn					SoyMeal						
		December	March	May	July	September	December	January	March	May	July	August	September
Corn	December	1.0000	0.6709	0.4734	0.4148	0.4079	0.3739	0.3734	0.3557	0.2059	0.3818	0.4537	0.3448
	March	0.6709	1.0000	0.8059	0.5532	0.4695	0.3739	0.3192	0.5192	0.4606	0.3675	0.3665	0.3690
	May	0.4734	0.8059	1.0000	0.6192	0.5527	0.1970	0.1394	0.4256	0.4429	0.4049	0.4138	0.4897
	July	0.4148	0.5532	0.6192	1.0000	0.8429	0.2862	0.1256	0.1030	0.1069	0.3941	0.5084	0.4631
	September	0.4079	0.4695	0.5527	0.8429	1.0000	0.3094	0.1089	0.1197	0.2015	0.4660	0.6384	0.7059
SoyMeal	December	0.3739	0.3739	0.1970	0.2862	0.3094	1.0000	0.7714	0.4414	0.3611	0.3557	0.5355	0.4768
	January	0.3734	0.3192	0.1394	0.1256	0.1089	0.7714	1.0000	0.6719	0.5946	0.5606	0.5877	0.4335
	March	0.3557	0.5192	0.4256	0.1030	0.1197	0.4414	0.6719	1.0000	0.8897	0.6729	0.5596	0.4650
	May	0.2059	0.4606	0.4429	0.1069	0.2015	0.3611	0.5946	0.8897	1.0000	0.7714	0.6291	0.5680
	July	0.3818	0.3675	0.4049	0.3941	0.4660	0.3557	0.5606	0.6729	0.7714	1.0000	0.8557	0.7202
	August	0.4537	0.3665	0.4138	0.5084	0.6384	0.5355	0.5877	0.5596	0.6291	0.8557	1.0000	0.8749
	September	0.3448	0.3690	0.4897	0.4631	0.7059	0.4768	0.4335	0.4650	0.5680	0.7202	0.8749	1.0000

Appendix Table 12. Rank correlation matrix for corn and soybean meal for November

November		Corn						SoyMeal						
		December	March	May	July	September	December	January	March	May	July	August	September	October
Corn	December	1.0000	0.4749	0.2695	0.0852	0.1128	0.0052	0.4512	0.4345	0.2414	0.2330	0.1557	0.1488	0.0734
	March	0.4749	1.0000	0.8094	0.4148	0.3744	0.2776	0.3256	0.5527	0.4635	0.3030	0.2754	0.3049	0.2700
	May	0.2695	0.8094	1.0000	0.4862	0.4532	0.3963	0.2847	0.5207	0.4877	0.3961	0.4138	0.4714	0.5192
	July	0.0852	0.4148	0.4862	1.0000	0.8345	0.6800	0.0419	0.0788	0.1276	0.4512	0.5355	0.4951	0.4887
	September	0.1128	0.3744	0.4532	0.8345	1.0000	0.8860	-0.0138	0.0749	0.2000	0.4596	0.6182	0.7010	0.6911
	December	0.0052	0.2776	0.3963	0.6800	0.8860	1.0000	-0.0397	0.0919	0.2249	0.4342	0.5874	0.7185	0.7495
SoyMeal	January	0.4512	0.3256	0.2847	0.0419	-0.0138	-0.0397	1.0000	0.7645	0.6394	0.5212	0.4571	0.3232	0.2000
	March	0.4345	0.5527	0.5207	0.0788	0.0749	0.0919	0.7645	1.0000	0.8709	0.6271	0.5025	0.3980	0.3389
	May	0.2414	0.4635	0.4877	0.1276	0.2000	0.2249	0.6394	0.8709	1.0000	0.7468	0.6025	0.5542	0.4946
	July	0.2330	0.3030	0.3961	0.4512	0.4596	0.4342	0.5212	0.6271	0.7468	1.0000	0.8517	0.7296	0.6788
	August	0.1557	0.2754	0.4138	0.5355	0.6182	0.5874	0.4571	0.5025	0.6025	0.8517	1.0000	0.9123	0.8488
	September	0.1488	0.3049	0.4714	0.4951	0.7010	0.7185	0.3232	0.3980	0.5542	0.7296	0.9123	1.0000	0.9552
	October	0.0734	0.2700	0.5192	0.4887	0.6911	0.7495	0.2000	0.3389	0.4946	0.6788	0.8488	0.9552	1.0000

Appendix Table 13. Rank correlation matrix for corn and soybean meal for December

December		Corn					SoyMeal							
		March	May	July	September	December	January	March	May	July	August	September	October	December
Corn	March	1.0000	0.8049	0.4906	0.4374	0.3399	0.0591	0.4350	0.5241	0.3453	0.2788	0.3128	0.2916	0.3527
	May	0.8049	1.0000	0.4980	0.4631	0.4187	0.0901	0.4010	0.4877	0.3670	0.3606	0.4384	0.4675	0.5089
	July	0.4906	0.4980	1.0000	0.8286	0.6685	0.0222	0.0611	0.1571	0.4246	0.5419	0.4729	0.4202	0.4177
	September	0.4374	0.4631	0.8286	1.0000	0.8547	0.0310	0.1379	0.2892	0.5542	0.7251	0.7365	0.6956	0.6443
	December	0.3399	0.4187	0.6685	0.8547	1.0000	0.0852	0.2010	0.3059	0.4837	0.6690	0.7404	0.7488	0.7222
SoyMeal	January	0.0591	0.0901	0.0222	0.0310	0.0852	1.0000	0.5547	0.4970	0.3340	0.3236	0.2897	0.1453	0.2635
	March	0.4350	0.4010	0.0611	0.1379	0.2010	0.5547	1.0000	0.8537	0.6207	0.4655	0.4153	0.3458	0.5128
	May	0.5241	0.4877	0.1571	0.2892	0.3059	0.4970	0.8537	1.0000	0.7128	0.5473	0.5212	0.4576	0.6365
	July	0.3453	0.3670	0.4246	0.5542	0.4837	0.3340	0.6207	0.7128	1.0000	0.8167	0.7059	0.6522	0.6985
	August	0.2788	0.3606	0.5419	0.7251	0.6690	0.3236	0.4655	0.5473	0.8167	1.0000	0.9271	0.8522	0.8424
	September	0.3128	0.4384	0.4729	0.7365	0.7404	0.2897	0.4153	0.5212	0.7059	0.9271	1.0000	0.9448	0.9069
	October	0.2916	0.4675	0.4202	0.6956	0.7488	0.1453	0.3458	0.4576	0.6522	0.8522	0.9448	1.0000	0.9335
	December	0.3527	0.5089	0.4177	0.6443	0.7222	0.2635	0.5128	0.6365	0.6985	0.8424	0.9069	0.9335	1.0000