Option Valuation and Speculative Interest in a MPP-Dairy Margin Futures Contract

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Introduction

As an alternative to dairy farm revenue and commodity price support programs the Agricultural Act of 2014 (H.R. 2642 2014) created the Margin Protection Program for dairy producers (MPP-Dairy) as the new dairy farm safety net program. MPP-Dairy is a voluntary program, run by the USDA Farm Service Agency, which makes payments when the national average income-over-feed-cost margin index falls below a farmer-selected coverage level.[1] Different coverage options reflect a producer's ability to indemnify different margin levels (from $4 to $8 per hundredweight) and different coverage percentages of the farm's milk production (from 25% to 90%). In short, MPP-Dairy functions as a USDA sponsored put option, and is a financial loss management program which provides assistance to dairy farmers when the national measure of farm income falls below a farmer-selected threshold. By functioning similar to an option contract Wolf et al. (2013) found that MPP-Dairy was a substitute to existing risk management products and has the potential to reduce liquidity in private risk markets. Wolf et al. proposed the introduction of a futures contract based on the MPP-Dairy index to address the liquidity concerns. A futures contract based on the MPP-Dairy index would allow dairy farmers to monetize the implicit subsidy in MPP-Dairy by writing put options against their USDA backed coverage levels. Such a strategy would result in the riskless capitalization of farm program subsidies, but may also increase private market liquidity and allow for expanded coverage at fair market prices.

This article extends the research of Wolf et al. (2013), and uses empirical futures market data from 2008 to 2013 to derive monthly futures prices of an MPP-Dairy derivative instrument at different months to maturity. Then, using expectations of milk and feed prices derived using at-the-money futures and options prices, bi-monthly expected MPP-Dairy indemnifications are estimated for each of the MPP-Dairy coverage options, i.e., strike prices, for each month from 2008 to 2013. The payment expectations are then used to evaluate the potential benefits under different risk environments to determine if, and under what conditions, a commercially traded or over-the-counter margin contract could increase market liquidity.

Conceptual Framework

MPP-Dairy is an option-style program designed to pay an indemnity to a participating farm when the difference between the national average all-milk price and the formula-derived estimate of total herd feed costs falls below a farmer-selected coverage level. Coverage levels are available from $4 to $8 per hundredweight in 50¢ increments. The MPP-Dairy margin index is given by

the following formula: $M = p_{AMP} - \left(1.0728 \times p_C + 0.00735 \times p_{SBM} + 0.0137 \times p_H\right)$ where p_{AMP} is the USDA National Agricultural Statistics Service (NASS) announced all-milk price per hundredweight, p_C is the USDA NASS announced corn price per bushel, p_{SBM} is the USDA Agricultural Marketing Service announced central-Illinois high protein soybean meal price per ton, and p_H is the USDA NASS announced alfalfa hay price per ton.[2] Figure 1 illustrates the MPP-Dairy margin from 2000 to 2013. To determine how much is paid to a participating dairy operation MPP-Dairy margins are evaluated on consecutive two-month intervals such that up to six payments are possible each calendar year.[3] If the MPP-Dairy margin does not fall below the farmer-selected threshold for the consecutive two-month period it expires worthless and a farmer loses only the premium and administrative fees paid.

[Insert Figure 1 About Here]

In order to participate in MPP-Dairy, dairy operations must annually pay an administrative fee of $100. The administrative fee provides dairy producers with the base catastrophic coverage of $4 and 90%. Additional margin protection on levels above $4 per hundredweight can be selected by participating dairy farmers at supplementary costs with premium rates depending on the farm's covered production. The premiums are structured at a lower level for the first four million pounds of covered production and are higher for milk covered in excess of four million pounds.[4] The premium rates are fixed for the life of the Farm Bill, but premium discounts of 25% are specified for the 2014 and 2015 calendar years for all but the $8 level. Table 1 includes the premium rates and coverage levels available under MPP-Dairy.

[Insert Table 1 About Here]

Participating dairy operations may choose each year what level of margin protection to purchase for the calendar year. Margin protection is available from $4 to $8 per hundredweight in 50¢ increments and enrolled producers may receive coverage on 25% to 90% of their milk production history in 5% increments. The production history is to be determined at sign-up in the first year of the program and is defined as the highest level of annual milk production during the 2011, 2012, or 2013 calendar years. In subsequent years a farm's production history will be updated by USDA to reflect only the increase in national average milk production. Individual milk production growth above the national average will not be reflected in the updated production history.

Following Nelson and Loehman (1987); Coble et al. (1997); Just, Calvin, and Quiggin (1999); and Esuola et al. (2007) the MPP-Dairy payment is specified in terms of a fixed amount of bi-monthly milk production, $\overline{q}$, and is defined as one-sixth of the covered production history such that $\overline{q} = \theta Q_{\max(2011,2012,2013)} / 6$ where θ is the coverage percentage and $Q_{\max(2011,2012,2013)}$ is the farm's production history. Given a guaranteed coverage level, C, an MPP-Dairy indemnification is equal to $\overline{q}\left[\max(C - M_T, 0) - R\right]$ where $M_T \geq 0$ is the bi-monthly average of the MPP-Dairy

index and R is the premium rate. Thus, dairy farmer profit for a two-month period depends on whether the MPP-Dairy margin index is above or below the coverage level, and may be written as: $\pi = p_M q - c(q) + \overline{q}\left[\max(C - M_T, 0) - R\right]$ where q is actual milk production, p_M is the farm-level milk price, $c(q)$ represents the cost function, and $p_M q - c(q)$ represents a traditional single output profit function.

A key feature of MPP-Dairy is that while the premium rates differ depending on a number of choice variables in the contract design, the rates are fixed at predetermined levels explicitly written into the 2014 Farm Bill and do not change to reflect the anticipated risk environment. Since the premium rates do not adjust to reflect the anticipated risk environment, during the annual registration period it's possible to for MPP-Dairy coverage options to have non-negative expected benefits based on anticipated risk in milk and feed markets, i.e., $E_t\left(\overline{q}\left[\max(C - M_T, 0) - R\right]\right) \geq 0$. Newton, Thraen, and Bozic (2013a, 2013b) provided a methodology to evaluate the actuarial soundness of MPP-Dairy using publically available information from Chicago Mercantile Exchange Class III milk, Class IV milk, corn, and soybean meal futures contracts. Thus, the presence of a commercially traded or over-the-counter margin contract as proposed by Wolf et al. (2013), and as highlighted in Table 2, would allow dairy producers to evaluate the fair market price of MPP-Dairy coverage strike prices compared to the fixed USDA premium rates.

When the fair market price is greater than the USDA premium dairy farmers may monetize the implicit subsidy in MPP-Dairy by writing put options against their USDA-backed coverage levels. Under such a scenario the dairy farmer profit would depend on the returns from MPP-Dairy along with the put option payoff, and may be written as $\pi = p_M q - c(q) + \overline{q}\left[\max(C - M_T, 0) - R\right] + nS\left[\min(M_T - C, 0) + \gamma\right]$ where n is the number of option contracts written, S is the contract size, and γ is the option premium. With positive expected benefits from MPP-Dairy the fair market option premium should exceed the cost of the USDA-backed equivalent contract such that $\gamma = \delta + R$, where δ is the implicit subsidy attributable to the fixed premium rate R. Substituting for γ in the dairy farmers profit function results in $\pi = p_M q - c(q) + nS\gamma - \overline{q}R + \overline{q}\left[\max(C - M_T, 0)\right] + nS\left[\min(M_T - C, 0)\right]$. As a result, if a dairy farmer establishes a hedge ratio equal to the covered milk production, i.e., $nS = \overline{q}$, then profit is given by $\pi = p_M q - c(q) + \overline{q}\delta$ and would allow for the riskless capitalization of implicit MPP-Dairy subsidies. Additionally, it would be possible for a dairy farmer to write an option at a strike price lower than the MPP-Dairy coverage option, or trade at a lower hedge ratio, in order to partially monetize the subsidy while holding some of the risk in the MPP-Dairy position. Whether or not a dairy farmer fully, or partially, monetizes the implied subsidy depends on the farmer's risk preferences.[5]

It may not be possible to always monetize the subsidy in MPP-Dairy. When expected benefits are negative $E_t\left(\overline{q}\left[\max(C-M_T,0)-R\right]\right)<0$ the implied subsidy is negative such that $\gamma = R-\delta$. However, this condition reveals that the fair market price for the option would be below the USDA premium. As a result, a dairy farmer may purchase equivalent MPP-Dairy coverage at lower prices if a MPP-Dairy futures or options contract were offered on a private exchange or over-the-counter. Under such a scenario, a participating dairy farmer could elect the free catastrophic MPP-Dairy coverage $(R=0)$ and then purchase greater protection from private risk markets. The dairy farmer would get equivalent MPP-Dairy coverage at lower costs and profit may be written as $\pi = p_M q - c(q) + \overline{q}\left[\max(4-M_T,0)\right] + nS\left[\max(C-M_T,0)-\gamma\right]$. Thus, when expected MPP-Dairy benefits are both positive and negative, at least conceptually, private market liquidity could be enhanced with the introduction of futures and options contracts based on the MPP-Dairy index.

[Insert Table 2 About Here]

The benefit to the dairy farmer in writing the put option is the removal of risk from the MPP-Dairy position. However, by writing the put option the dairy farmers foregoes any additional benefits if the final MPP-Dairy payment exceeds the fair option premium. When anticipated margins are favorable the benefit to the dairy farmer in buying the put option is the fair market price should be less than the USDA premium for equivalent coverage. On the other side of the position the purchaser of the put option assumes the risk in the MPP-Dairy contract. If margins deteriorate beyond the expected margin at the purchase date the purchaser of the put option collects the foregone benefits given up by the option writer. A purchaser of this put option may include speculative hedgers, dairy farmers seeking to purchase MPP-Dairy coverage beyond their covered production, or milk processing facilities offering similar coverage options to their dairy farmer suppliers. For example, a dairy farm operation with milk production growth rates greater than the national average, and unable to purchase USDA-backed coverage on 100% of the farm milk marketed, could use the put option to offset the uncovered milk production. The purchasing and writing of the put options would increase liquidity in private risk markets.

Methodology

The MPP-Dairy guarantee is specified in terms of the USDA announced prices. However, none of the four government reported prices are used to settle any futures contract. As a consequence, futures prices for USDA all-milk, corn, soybean meal, and alfalfa hay cannot be directly observed to derive an MPP-Dairy futures contract price. In order to derive expected values for the USDA announced prices, estimators of the USDA prices were defined as $p_{tk} = X_{tk}\beta + \varepsilon_{tk}$ at time t for each of the k = all-milk, corn, soybean meal, and alfalfa hay USDA commodity prices. The conditioning information, X_{tk}, includes a matrix of CME futures prices and lagged USDA

prices observed at time *t*. Table 3 includes the OLS estimates used to derive the USDA announced prices and MPP-Dairy margin price using data from 2001 to 2013.[6]

[Table 3 about here]

The estimates of USDA prices at time *t* were then used in the MPP-Dairy margin index formula to approximate the asset price of the MPP-Dairy margin contract such that $E_t(M_T) = E_t\left[\, p_{T,AMP} - \left(1.0728 \times p_{T,C} + 0.00735 \times p_{T,SBM} + 0.0137 \times p_{T,H}\right)\right]$. The MPP-Dairy margin futures contract prices were estimated for each consecutive two-month period for the first six nearby contracts (12 months). This calculation was performed monthly from 2008 to 2013 in order to generate a vector of asset prices associated with each bi-monthly contract at different months to maturity.

Next, following Newton, Thraen, and Bozic (2013a, 2013b) MPP-Dairy benefits were simulated for each bi-monthly period. To model the dependence structure among the milk and feed price variables the marginal distributions are coupled into a multivariate probability distribution function using Spearman's rank correlation coefficients and the procedure developed by Iman and Conover (1982). Mildenhall (2006) demonstrated that the Iman-Conover procedure is equivalent to using a Gaussian copula. Thus by defining $F_{III}, F_{IV}, F_C, F_{SBM}$ as marginal distributions of the futures prices (denoted by f) for class III milk, class IV milk, corn, and soybean meal, respectively, it then follows that the dependence structure among the milk and feed futures price distributions can be modeled as $G\left(f_{III}, f_{IV}, f_C, f_{SBM}\right) = C\left(F_{III}(f_{III}),...,F_{SBM}(f_{SBM})\right)$. The function $C(\cdot)$ is a copula that couples together the marginal distributions of futures prices in such way that it fully contains the dependence structure reflected in the joint distribution function. The purpose of the copula is to account for the correlation of price shocks in the milk and feed variables and the impact these shocks may have on the IOFC margin.

A simplifying assumption regarding the correlation structure is that each correlation coefficient is dependent only on the time-to-maturity horizon for each futures price pair. This nearby-based approach is flexible enough to allow correlation coefficients to depend not just on distance between contract months, but also time to maturity. At the same time, this modification greatly simplifies the estimation burden compared to estimating month specific correlation matrices. The multivariate distribution function has 36 degrees of freedom consisting of 12 nearby class III and class IV futures, five nearby corn contracts, and seven nearby soybean meal contracts. Thus for the Monte-Carlo experiment we have 5,000 draws from 36 marginal distributions. For months in which Chicago Mercantile Exchange (CME) contracts do not trade a weighted average of nearby months is used to extrapolate the prices. This transformation provides a matrix of 5000×48 correlated milk and feed prices. Bozic et al. (2014) use a similar process to model the overall dependence structure for livestock insurance products. This final matrix of 12-month MPP-Dairy margins was used to estimate the expected indemnifications during each bi-monthly period. The expected indemnity at each of the MPP-Dairy strike prices represents an approximation of the

fair market premium value for a MPP-Dairy replicator contract. Finally, comparisons of the fair option premium to the MPP-Dairy premium were used to form the basis for conclusions on the financial incentive for dairy farmers to monetize the implicit subsidy in MPP-Dairy or purchase the fair market equivalent MPP-Dairy contract.

Results

The analysis illustrates that market uncertainty is resolved as the MPP-Dairy contract approaches expiration, Figure 2. At distant hedging horizons the range in asset price deviations from the final MPP-Dairy announced margin ranges $12.00 per hundredweight. At more nearby expiration dates the range in asset price deviations from the MPP-Dairy announced price is approximately $4 per hundredweight. Thus, when the MPP-Dairy margin is anticipated to be below MPP-Dairy coverage levels it's possible for a dairy farmer to write a put option against the USDA-backed MPP-Dairy position and monetize the implicit subsidy. When the MPP-Dairy margin futures price is above the USDA coverage options the fair market premium on the option may be below the USDA premium rates.

[Insert Figure 2 About Here]

As demonstrated in Table 4 the opportunity to monetize the subsidy persisted for prolonged periods. That is, the potential to monetize the subsidy was available to a dairy producer for several months prior to expiry. For example, in Figure 3, the July-August 2009 MPP-Dairy option premium remained above the MPP-Dairy premium from 10 months to maturity until expiration. However, Table 4 and Figure 4 also reveal that MPP-Dairy futures and options contracts could prove to be cheaper alternatives than the USDA backed program when conditions in milk and feed markets indicate favorable margins. For example, in November 2008, the fair market option premium for July-August 2009 $8 strike price was only $0.88 per hundredweight. As the contract approached expiration, however, the option premium increased significantly. By July 2009, the option premium, with two months remaining until expiration, was $5.23 per hundredweight, Figures 3 and 4. This expected benefit of $5.23 was $3.87 per hundredweight greater than the maximum MPP-Dairy premium charged by USDA. Thus, the risk free return for a dairy operator liquidating the July-August 2009 position to monetize the subsidy would have ranged from $3.87 to $4.76 per hundredweight (depending on the premium paid). While the final MPP-Dairy margin was $3.58 per hundredweight, with a $4.52 indemnification, the dairy farmer would have received an immediate, and risk free, benefit by liquidating the position. Additionally, for farm seeking to purchase coverage beyond their MPP-Dairy coverage constraints the market risk in milk and feed markets in November 2008 warranted a much lower premium for the $8 strike price. By July the premium for an $8 strike price was nearly six times as expensive as a result of the riskier milk and feed price environment.

[Insert Figure 3 About Here]

[Insert Figure 4 About Here]

[Insert Table 4 About Here]

This example demonstrates the consequences and benefits of the fixed premium structure. First, when the anticipated risk in milk and feed market is high the MPP-Dairy premium is too low, and in the presence of an MPP-Dairy replicator contract, opportunities may exist for dairy farmers to monetize the subsidy. When the anticipated risk in milk and feed market is low the MPP-Dairy premium is too expensive and may result in dairy farmers purchasing less protection in the absence of a MPP-Dairy replicator contract. In either event, these results suggest that a MPP-Dairy futures and options contract may provide opportunities for private risk markets to capitalize on MPP-Dairy deficiencies. By providing either monetization incentives, or lower priced coverage options, a MPP-Dairy replicator contract may increase liquidity in private risk markets.

Summary

The 2014 Farm Bill created MPP-Dairy. MPP-Dairy is a voluntary safety net program and functions similar to an option contract. Dairy farmers may self-select individual strike prices settled against a national MPP-Dairy margin index. A dairy farmer will receive a payment from MPP-Dairy when the bi-monthly margin index falls below the farmer-selected MPP-Dairy strike price. If the margin does not fall below the strike price during the bi-monthly period the farmer's position expires worthless and a farmer loses only the premium paid.

By functioning similar to an option contract MPP-Dairy acts as a substitute to the current suite of risk management products, i.e., futures, options, and forward contracts, and has the potential to reduce market liquidity. Private risk markets may replicate the MPP-Dairy margin index in an effort to increase dairy market liquidity. This article has demonstrated that a futures or over-the-counter contract based on the MPP-Dairy index would allow dairy farmers to fully or partially monetize the implicit subsidy in MPP-Dairy by writing put options against their USDA backed coverage levels. Such innovations in the over-the-counter market are already occurring with "return-over-feed" margins at identical strike prices to MPP-Dairy. The presence of futures or over-the-counter instruments allows for the riskless capitalization of farm program subsidies. When margins are favorable, the presence of a MPP-Dairy replicator contract would allow for dairy farmers to purchase coverage at prices below the USDA premium rates. In either scenario, the monetization of subsidies, or the ability to purchase MPP-Dairy equivalent coverage at lower prices, is made possible because MPP-Dairy premiums are fixed for the life of the Farm Bill and do not reflect the risk environment during the annual registration period. As a result, this article demonstrates that no matter the price conditions, a MPP-Dairy replicator contract could provide opportunities to increase liquidity in private risk markets and bring back traders initially lost to MPP-Dairy.

[1] The income-over-feed-cost margin is defined as the difference between the national average all-milk price and a formula-derived estimate of feed costs comprised of corn, alfalfa hay, and soybean meal.

[2] The MPP-Dairy margin formula was derived through collaboration with animal scientists and includes the costs of feeding milking cows, hospital cows, dry cows, and replacement heifers. The fixed coefficients in the feed ration calculation are based on a generic cost of feeding dairy cows.
[3] Consecutive two-month periods are defined as January-February, March-April, …, November-December.
[4] Using average milk production of 21,806 lbs. per cow per year the 4 million pound cap represents a 183 cow dairy.
[5] A risk averse farmer may prefer the risk free return, while a risk loving farmer may prefer to hold the MPP-Dairy position.
[6] Results of Durbin-Watson test statistics indicated the presence of positive serial correlation in the error terms for the OLS models for milk, soybeans, and soybean meal. Since correlated error terms do not bias the coefficient estimates, and the OLS models are used only to transform the simulated CME price to USDA prices, corrections for autocorrelation in the standard errors or models of the noise process were not pursued.

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Table 1. MPP-Dairy Premiums in Dollars per Hundredweight

MPP-Dairy Coverage Level	First 4 Million Pounds Covered (2014-2015)	First Four Million Pounds Covered (2016+)	Coverage in Excess of 4 Million Pounds
$4.00	No Cost	No Cost	No Cost
$4.50	$0.008	$0.010	$0.020
$5.00	$0.019	$0.025	$0.040
$5.50	$0.030	$0.040	$0.100
$6.00	$0.041	$0.055	$0.155
$6.50	$0.068	$0.090	$0.290
$7.00	$0.163	$0.217	$0.830
$7.50	$0.225	$0.300	$1.060
$8.00	$0.475	$0.475	$1.360

Table 2. Contract Specification for MPP-Dairy Futures and Options

MPP-Dairy Margin Futures

Contract Size	2,000 cwt of Grade A Milk (~ 90 metric tons)
Price Quotation	MPP-Dairy Margin
Pricing Unit	Cents per hundredweight (cwt.)
Tick Size (minimum fluctuation)	$0.01 per cwt (=$20.00 per contract)
Daily Price Limits	$0.75 per cwt above or below the previous day's settlement price.
Last Trade Date/Time	Trading shall terminate on the business day immediately preceding the day on which the USDA announces the Actual Dairy Producer Margin.
Contract Months	February, April, June, August, October, December
Settlement Procedure	There shall be no delivery of milk in settlement of this contract. All contracts open as of the termination of trading shall be cash settled based on the average USDA Actual Dairy Producer Margin for the particular Consecutive 2-month Period (e.g. Jan-Feb average Actual Dairy Producer Margin is the settlement margin for the February contract, etc), as first released.

MPP-Dairy Margin Options

Contract Size	One MPP-Dairy Margin Futures contract
Pricing Unit	Cents per hundredweight (cwt.)
Tick Size (minimum fluctuation)	$0.01 per cwt (=$20.00 per contract)
Daily Price Limits	None
Last Trade Date/Time	Trading shall terminate on the business day immediately preceding the day on which the USDA announces the Actual Dairy Producer Margin.
Contract Months	February, April, June, August, October, December
Strike Price Intervals	All Contract Months: $4.00 to $8.00 per cwt in $.50 intervals.
Exercise Procedure	American Style

Table 3. OLS estimators of USDA announced prices

	AMP_t	CP_t	SBM_t	HAY_t
Intercept	1.84**	0.19**	-1.29	9.28**
f_t^{III}	0.40**			
f_t^{IV}	0.24**			
$\max(f_{t-1}^{III}, f_{t-1}^{IV})$	0.33**			
f_t^{Corn}		0.88**		5.06**
f_t^{SBM}			1.01**	-0.04*
Hay $Price_{t-1}$				0.87**
R^2	0.99	0.97	0.98	0.97
Durbin-Watson	0.72	2.18	1.40	2.20

*Note: *p-value <0.10, **p-value < 0.05*

Table 4. Frequency Bi-Monthly MPP-Dairy Option Premium Was Above USDA MPP-Dairy Premium Rates

MPP-Dairy Coverage Level	Frequency Bi-Monthly Contracts With Put Premium At or Above Tier 1 Premium	Frequency Bi-Monthly Contracts With Put Premium At or Above Tier 2 Premium
$4.00	100%	100%
$4.50	22%	17%
$5.00	27%	22%
$5.50	34%	24%
$6.00	45%	31%
$6.50	51%	32%
$7.00	51%	22%
$7.50	57%	25%
$8.00	62%	29%
Breakout for $8.00 Coverage (N=66 Annual)		
2009	92%	50%
2010	30%	0%
2011	53%	23%
2012	97%	62%
2013	73%	49%

Note: Evaluated on a monthly basis for first six nearby contracts.

Figure 1. MPP-Dairy Margin, 2000 – June 2014

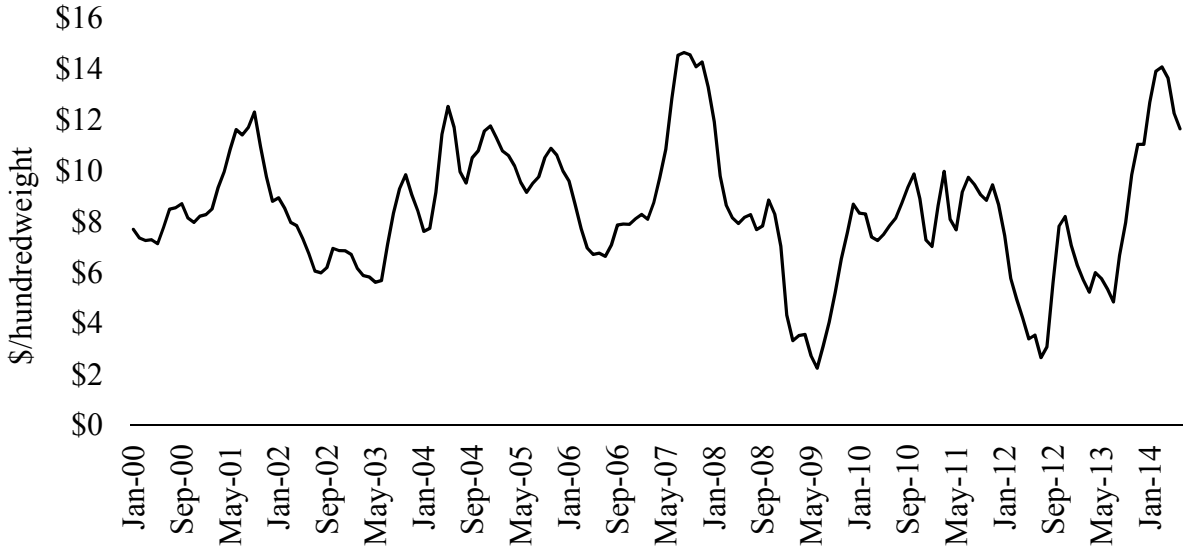

Figure 2. Asset Price Deviations from MPP-Dairy Final Margin

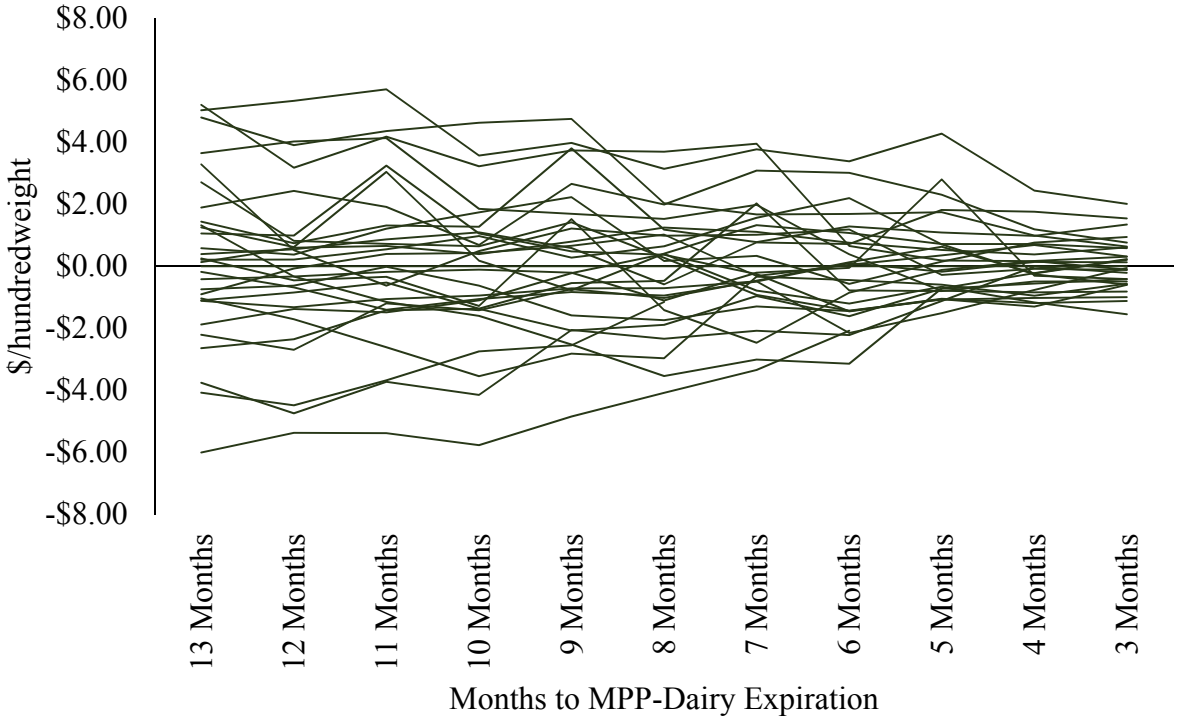

Figure 3. Expected MPP-Dairy Indemnification for July-August 2009, $8 MPP-Dairy Coverage Level Strike Price

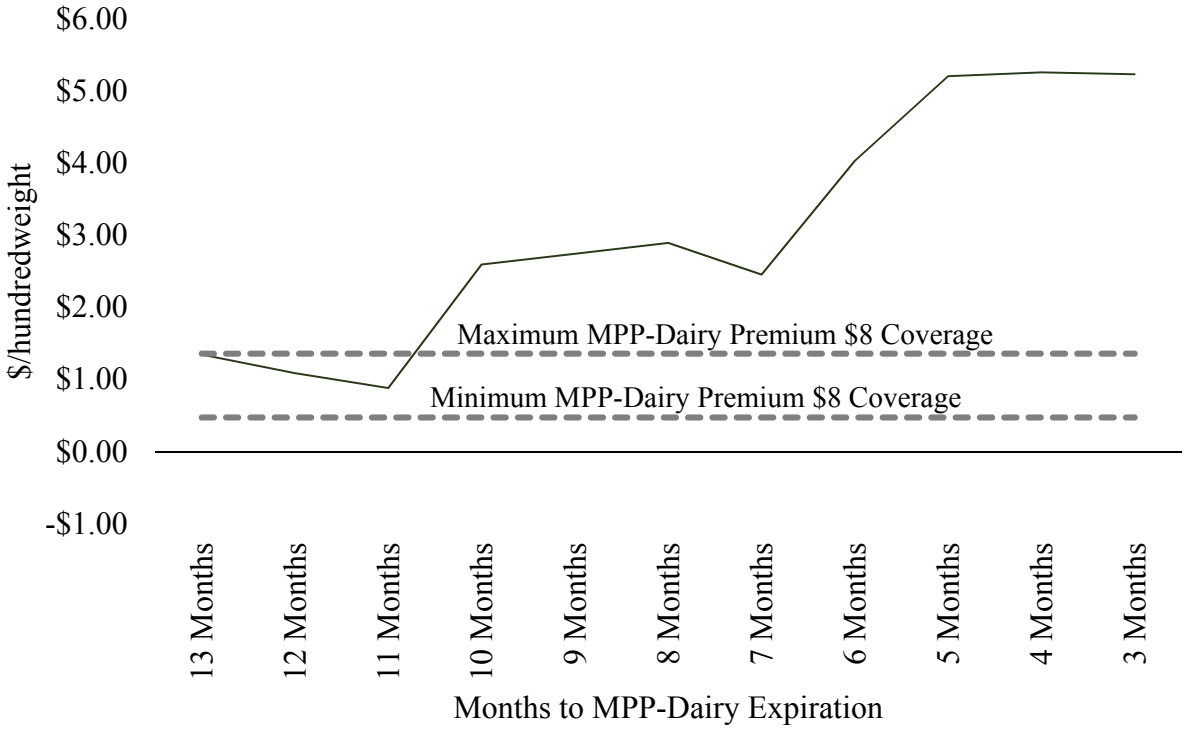

Figure 4. Expected MPP-Dairy Indemnification at Various Months to Expiry, $8 MPP-Dairy Coverage Level Strike Price