Applied Economic Perspectives and Policy (2013) volume 35, number 3, pp. 550–564.
doi:10.1093/aepp/ppt017
Advance Access publication on 24 July 2013.

Submitted Article

Road Block to Risk Management — Investigating Class I Milk Cross-Hedging Opportunities

John Newton* and Cameron S. Thraen

John Newton is a PhD candidate and Cameron Thraen is associate professor at the Department of Agricultural, Environmental and Development Economics, The Ohio State University.
*Correspondence may be sent to: newton.276@osu.edu.

Submitted 17 August 2012; accepted 20 May 2013.

Abstract *This study examines the risk management opportunities for fluid milk market participants in the United States through the use of milk futures contracts. We estimate the nature of basis risk from 2002–2011 using modern time-series and econometric techniques. The results of this investigation reveal that at sufficient hedging intervals, using class III manufacturing milk futures contracts to cross-hedge fluid milk has the ability to reduce risk and provide revenue stability to market participants. When used in conjunction with milk futures, prediction algorithms for the closing basis facilitate more direct management of fluid milk price risk.*

Key words: Dairy policy, Generalized hedge ratio, Generalized autoRegressive conditional heteroskedasticity, Hedge fluid milk, Basis risk.

JEL codes: Q13, Q14, Q18.

Over 200 billion pounds of milk is produced in the United States per year, of which approximately one-third flows into packaged fluid milk products (class I beverage milk), and two-thirds flows into soft and hard manufactured products. Farm cash receipts from the sales of raw milk into the beverage and manufactured dairy product sectors represents well over $40 billion dollars (USDA NASS 2012). In recent years, due to increased price variability, operating a business in the dairy sector has become increasingly risky (Thraen 2011). Complicating the risk in the beverage milk sector is the perishable nature of fluid milk, which prevents self-insurance through inventory holdings. Meanwhile, milk and dairy products have been priced and regulated by the USDA for more than 70 years. One of the central issues for industry participants servicing the beverage milk sector and managing price risk is the nature of USDA regulations in relation to milk priced through forward or futures contracts.[1]

[1]*Industry participants in the fluid milk sector may include agricultural bargaining and marketing cooperatives, fluid milk processors, end-users, and farmers.*

The USDA regulates milk and dairy product prices using Federal Milk Marketing Orders (FMMOs), which help to ensure that dairy farmers receive a minimum cash price for their milk through revenue pooling and end-product price formulas. The FMMO minimum prices must be paid to producers delivering milk to a FMMO-regulated plant; FMMO-regulated plants include beverage milk processors and cooperative-owned non-fluid manufacturing plants. However, all manufacturing plants may forward contract with producers and are not subject to minimum price enforcement. Regulated manufacturing plants must account for the FMMO pool based on the classified value of their milk utilization, but this does not prevent payments below the FMMO minimum if producers are under forward contracts. Due to this technicality, FMMOs minimum price provisions primarily apply to class I beverage milk processors, and prohibit risk management through forward contracts.

Since the Chicago Mercantile Exchange (CME) does not offer a futures contract for fluid milk, the most common method of protecting against class I price variability is to cross-hedge by using CME manufacturing milk futures contracts. A cross-hedge involves taking a position in an asset with similar price movements as the hedged asset, and helps to reduce the financial risk associated with the cash market position (Anderson and Danthine 1981). Cross-hedging is generally thought to be effective provided basis risk is minimal and less than price risk (basis is the difference between the cash and futures market price). This is not always the case with class I milk, since cross-hedging is subject to periods of excessive basis risk because existing milk futures contracts cannot replicate the price dynamics inherent in the FMMO class I end-product pricing formula. Exposure to basis risk results in financial gains or losses, makes it difficult to construct marketing plans, and may discourage future cross-hedging endeavors. Consequently, federal milk pricing provisions inhibit the ability to shift or manage the price risk for approximately 44 billion pounds of milk produced and sold in beverage form in the United States each year (USDA AMS 2012).

Early analyses of dairy risk management using dairy futures contracts include Fortenbery et al. (1997) and Anderson et al. (1999). Fortenbery et al. found a strong relationship between the futures market and the cash price that together support hedging as a risk management strategy. Anderson et al. noted that the success of the hedging strategy is contingent on the predictability of the closing basis. More recent work by Maynard and Bamba (2004), and Maynard et al. (2005) found that the length of the hedge was a successful component of eliminating the cash price risk in mailbox milk prices, and that hedging using futures markets can eliminate 50-60% of the cash price variation when using deferred milk delivery contracts. This early literature, however, only characterized the effectiveness of hedging the cash price risk associated with the mailbox milk price. The mailbox price represents the net pay price received by dairy farmers for milk and includes fluid and manufacturing milk prices, premiums, and authorized deductions.[2] The mailbox milk price does not fully capture the cash price risk realized by fluid market participants. Zylstra et al. (2004) recognized the basis exposure associated with shorting class I milk using milk futures, and concluded that

[2]*FMMO language §1000.73 of the Code of Federal Regulations allows for minimum price deductions authorized in writing. Common deduction in the industry include transportation fees, advertising and promotion fees, and loan fees.*

federal milk pricing provisions lead to volatility in the closing basis and prevented hedgers from locking in a minimum price. Given the recent price volatility in class I milk markets, there is a need to examine how federal milk price provisions impact the effectiveness of different risk management strategies from a short and long position.

The research approach employed in this paper uses time series and regression techniques to determine the nature of the basis and effectiveness of price risk management tools from 2002–2011. First, the nature of the basis risk that arises when cross-hedging class I milk is explored. This work expands the effort of Zylstra et al. (2004) to measure the basis from a long- and short-hedge position using multiple cross-hedging instruments. After identifying the relationship between the underlying asset and the cross-hedged asset, the performance of cross-hedging techniques using the generalized optimal hedge ratio are measured (Myers and Thompson 1989). Then, a comparison of first- and second-moments of the net milk price under the various cross-hedging strategies form the basis for conclusions about the effectiveness of class I cross-hedging using CME manufacturing milk futures. Finally, given the limited success of CME milk futures under various cross-hedging strategies, public and private market risk management solutions are considered.

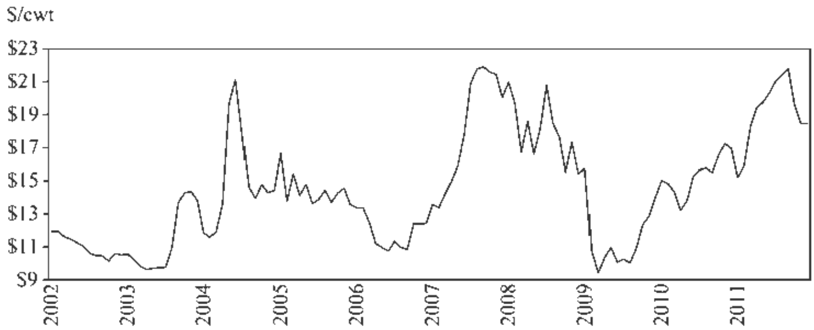
These results have implications in hedge accounting, since the Financial Accounting Standards Board (FASB) requires a hedging instrument to have a correlation of 0.80 to 1.25 for it to be used in risk-management activities (Deloitte 2011; FASB 1998). The contributions of this work relative to prior literature are that: (i) it extends the characterization of the milk hedging basis to include alternative cross-hedging strategies; (ii) it uses empirical data to estimate optimal hedge ratios; (iii) it demonstrates at sufficient hedging intervals that the use of manufacturing milk futures to cross-hedge fluid milk have the ability to reduce risk and provide revenue stability to market participants; and (iv) it confirms that even when accounting for all relevant conditioning information, basis exposure limits the potential risk reduction.

Beverage Milk Pricing

Approximately 66% of the milk marketed by dairy farmers across the nation is priced through FMMOs (USDA AMS 2012). These marketing orders provide a complex set of regulations designed to facilitate the orderly marketing of milk by announcing a minimum cash price to be received by dairy farmers for their pooled milk. For more than 70 years FMMO minimum price protection has remained virtually unchanged. A minor change in the 2008 Farm Bill allowed producers to voluntarily circumvent minimum pricing provisions using forward price contracts for milk deliveries into manufacturing classes only (classes II, III, and IV).[3] However, these privileges were not extended to milk marketed for fluid use. Fluid milk processors remain subject to minimum price enforcement on milk used to produce class I beverage products.

[3]*The Dairy Forward Pricing Program in the 2008 Farm Bill allowed forward contracting in manufacturing milk with termination on September 30, 2012. The 2008 Farm Bill can be found online at: http://www.usda.gov/documents/Bill_6124.pdf. In proposed 2012 Farm Bill language the Dairy Forward Pricing Program was extended to 2017 with contracts allowable until 2020. This language was not passed into law.*

Figure 1 Class I mover milk price, 2002–2011, in $/cwt



These FMMO pricing provisions, while providing for a minimum price, also leave the beverage milk industry vulnerable to significant volatility in their cash price. For example, the class I mover price of milk, a measure of the milk price paid by beverage milk processors, dropped by 37% in 2009 to $11.48 per hundredweight (cwt.), and then rebounded 67% to $19.13 per cwt in 2011 (see Figure 1).

The industry first responded to the need for risk management tools in 1993 when the Coffee, Sugar and Cocoa Exchange (CSCE) launched futures contracts for cheddar cheese and non-fat dry milk; the idea was that the correlation between commodity prices and raw milk prices would facilitate dairy industry participants' hedging activity (Fortenbery et al. 1997). The lack of trading activity by fluid market participants led the CSCE and the CME to petition the Commodity Futures Trading Commission to begin trading a futures contract in Grade A milk in 1995. By 1996, cash-settled Grade A milk futures were introduced on both the CSCE and the CME. The Grade A milk contract was effective for buyers and sellers of class I milk because it was cash settled to the USDA announced price used to price beverage milk (Fortenbery et al. 1997; Jesse and Cropp 1997).

In 2000 the ease to which fluid market participants could engage in hedging activities stopped when end-product pricing formulas for each of the four classes of milk were introduced (Maynard et al. 2005). The price classifications are: class I for beverage milk; class II for soft dairy products such as ice cream and yogurt; class III for cheese; and class IV for butter and powder.[4] The methodology for determining the fluid milk price also changed dramatically. The fluid milk price was no longer based on a lagged manufacturing price as it had been from 1968 to 2000; instead, the price was the higher of two separate advanced pricing factors (referred to as the class I mover).[5] Allowing the class I mover to alternate among the highest valued manufacturing classes of milk each month increases the minimum price received by dairy farmers marketing milk through FMMOs (over the ten-year period analyzed, the higher-of mechanism added $0.38 per cwt to the class I price). In response to milk price reform, the CME discontinued Grade A milk futures and began offering futures contracts for manufacturing milk only (class III and class IV). This shift in pricing policies complicated hedging incentives and basis calculations (Maynard et al. 2005).

[4]*For a more detailed exposition on FMMO classified pricing see Thraen (2006) or visit: www.ams.usda.gov/dairy.*
[5]*For a history of milk pricing and policy, see Manchester and Blayney (2001).*

The FMMO pricing provisions are formula-based and use weighted average Agricultural Marketing Service (AMS) commodity prices for cheese, butter, nonfat dry milk, and whey to price milk in each class.[6] The milk prices of interest for this analysis are the advanced class I mover, advanced class III and IV prices, and the final class III and IV prices.[7] The class III formula price is based on wholesale prices of cheese, butter, and whey. The class IV formula price is based on wholesale prices for butter and nonfat dry milk. The class I mover price is used to price milk purchased in the following month and is the maximum of the class III and class IV advanced prices. The class I price paid by processors includes a fixed-location differential and a negotiated over-order premium.[8] The only difference between the advanced and final prices is that the advanced price is calculated using the weighted average of two weeks of AMS data, and the final price is calculated using the weighted average of at least four weeks of AMS data. Advanced prices are announced on or before the 23rd of the previous month, while final prices are announced on or before the 5th of the following month (see table 1).

The CME does not list a class I mover milk contract; instead, it offers futures and options contracts on class III and class IV milk.[9] With these contracts it is difficult to directly manage class I price risk because the contracts give rise to the temporal and index effects on basis that are attributable to the FMMO class I fluid milk pricing formula. The temporal effect is the result of a 1-2 week difference between the announcement of the class I mover price and the expiration date of the underlying CME futures contract. The index effect is the result of the class I price being derived from the maximum of the class III and class IV advanced pricing factors each month. The magnitudes of the temporal and index effects vary, depending on which CME futures contract is used as the cross-hedging instrument. The sum of the index and temporal effects equals the basis risk. Zylstra et al. (2004) recognized that these effects lead to volatility in the closing basis, thus preventing class I hedgers from locking in a minimum price.

Cross-Hedging Class I Milk

Both buyers and sellers of fluid milk would like to manage price risk through forward price contracts; however, unlike their manufacturing counterparts there is no opportunity to forward contract because FMMOs enforce minimum pricing provisions on class I beverage milk. Prices below the minimum price, even if agreed upon in a forward contract, undermine the regulatory provisions of FMMOs and are not permitted. Fluid market participants can go to over-the-counter swap markets to lay off their risk; however, concerns about capital requirements, FMMO minimum price enforcement, counter-party risk, the lack of margin accounts, and no regulatory oversight all make over-the-counter swaps a less than ideal risk management platform.

Since the class I milk price is announced using data from the prior month, and no class I futures exist, the overlap in AMS survey price and sales data

[6] *USDA price formulas can be found online at www.ams.usda.gov/dairy.*

[7] *CME futures contracts settle to the final USDA announced class III and IV milk prices.*

[8] *The only source of variation in the price is the class I mover and the over-order premium. The class I location differential is fixed, so it is a predictable addition to the basis, and the over-order premium is negotiable between a producer and processor.*

[9] *The CME also offers spot, futures and options contracts on cheese, butter, non-fat dry milk, whey, and international skim milk powder.*

Table 1 Sample Release Dates for Federal Milk Order Prices

Month	Class Price	Announcement Date	Survey Prices Used
Dec. 2011	Advance CL III & IV	Nov. 18, 2011	11/5, 11/12
Nov. 2011	Final CL III & IV	Dec. 2, 2011	11/5, 11/12, 11/19, 11/26
Dec .2011	Final CL III & IV	Dec. 30, 2011	12/3, 12/10, 12/17, 12/24

between the advance and final prices (e.g., 11/5 and 11/12 in table 1) allow a trader to use CME class III and class IV futures contracts for the delivery month prior to the month that fluid milk is purchased to form a cross-hedge. However, this method exposes the trade to the temporal and index basis effects.

For example, to hedge the risk associated with purchasing class I fluid milk in December, the trader must use either a November class III futures contract, class IV futures contract, or some combination of the two. The trader must use the November futures contracts because the December class I price will be derived from the highest of the class III or class IV advanced pricing factors calculated using November wholesale commodity price data. Following this method, consider a plant manager who wants to cross-hedge the July 2007 class I milk price in April 2007 (three months prior to milk being received). In April the manager goes long using the June 2007 class IV futures contract at $14.00 per cwt (excluding transaction costs).[10] On June 22, 2007 when the July class I mover price is announced, the manager liquidates the futures position at a market price of $19.80 per cwt. The return from hedging has netted the manager $5.80 per cwt. However, the bottling plant must account to the FMMO pool the class I value of $20.91 per cwt.[11] So even though the CME contract netted $5.80, the basis of $1.11 ($20.91 - $19.80) made the effective cash price $15.11 per cwt compared to the cross-hedged position of $14.00. Thus, rather than locking in $14.00 milk, the actual price was $15.11. For a fluid milk processor, cross-hedging 25 million pounds of milk on the basis of $1.11 per cwt represents an unexpected expense of $277,500 (absent any naïve basis forecast).

For the present analysis, basis is defined as the difference between the spot price and the futures price of the hedging instrument (classes III and IV) at the time of contract liquidation ($b_t^i = s_t - f_t^i$, for $i =$ III, IV). Basis is calculated for 120 USDA price announcement dates between 2002-2011. For a fluid market participant, the uncertainty associated with imperfect fluid milk hedging is embodied by the basis and its lack of convergence. The importance of basis and motivation for managing price variability differs among industry participants. A food service provider may wish to manage beverage milk price risk to support price stability for product offerings that utilize fluid milk as an input. A retailer may seek to manage beverage milk price risk to facilitate promotional campaigns. For a producer of raw milk, managing the output price of milk provides the ability to manage the farm income stream and protect an operating margin over feed costs. Finally, for a processor the motivation may not be immediately intuitive, since most processors pass through price variations to their customers. However, for a

[10] *Transaction costs represent costs associated with participating in the commodity exchange market and may include brokerage fees, search, and information costs.*

[11] *Regulated class I buyers of milk must account a FMMO pool to the difference between the use value of the milk at the plant and the market-weighted average blend price.*

processor competing with a cooperative for the supply of raw milk, the ability to offer price protection is of paramount importance. Cooperatives are not bound by FMMO minimum prices and can offer forward pricing to its member producers for 100% of their milk. Meanwhile, a processor buying milk from a non-cooperative member producer may only offer price protection equivalent to the amount of milk utilized in various manufacturing classes (e.g., a processor with 85% class I utilization can offer forward prices on only 15% of the milk received at the plant). The inability to offer 100% price protection to its suppliers puts bottlers at a competitive disadvantage with cooperatives when procuring supplies of raw milk from producers. The ability of a processor to finance cross-hedging services for a supplier using CME futures (mimicking a hedge line of credit) could be viable if basis converged to a predictable level and costs associated with futures markets were acceptable minimum price deductions.

Accepting basis risk is not straightforward since class III and class IV futures prices often alternate back and forth as to which is the highest in a given month. These fluctuations make it difficult to formulate an efficient hedging strategy that minimizes basis.[12] In the following section the effect of the milk pricing provisions under different risk management strategies will be illustrated.

Measuring Basis

To analyze the basis associated with class I cross-hedging, four scenarios were estimated between January 2002-December 2011: (i) *ex post* analysis using the contract underlying the class I mover (*ex post* basis); (ii) using the class III contract as the hedging instrument (class III basis); (iii) using the class IV contract as the hedging instrument (class IV basis); and (iv) using the highest valued contract 90 days prior to the class I price announcement as the hedging instrument ($f^{\max}$).[13,14,15,16]

The strategy using the highest valued contract 90 days to maturity has a foundation in the literature.[17] Maynard et al. (2005) found that longer hedging intervals could eliminate up to 60% of the cash price risk, and 90 days provides the potential for significant changes in the futures contract value, thereby providing hedging opportunities to the trader.

Volatility in the closing basis for each of the hedging strategies is demonstrated in figure 2.[18] As demonstrated, the *ex post* basis showed the least amount of variation, followed by the 90-day basis, then the class III basis,

[12] *Over the last decade the class III price has served as the mover 61% of the time, while the class IV price has served as the mover 39% of the time.*

[13] *The* ex post *basis is calculated after all uncertainty has been resolved, so it represents the minimum possible basis.*

[14] *All basis measurements were calculated at 3.5% butterfat to correspond with USDA announced prices.*

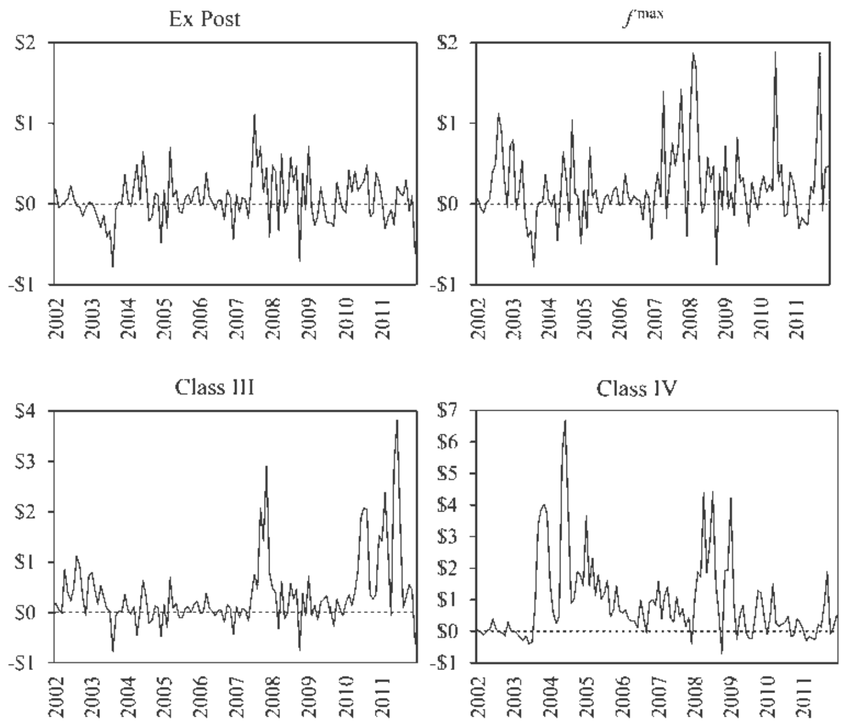
[15] *Where applicable for months when the futures contract did not have a reported value within 90 days of expiration, the price from trading day closest to 90 days was used.*

[16] *A combination of class III and class IV milk futures did not significantly reduce variation in the basis and was not considered for this analysis.*

[17] *Mean prediction errors in class III futures of 2.7% and 14.20% at 30 and 90 days to maturity were identified in: Bozic, M., and R. Fortenbery. 2011. Volatility Dynamics in Non-Storable Commodities: A Case of Class III Milk Futures. University of Wisconsin-Madison, unpublished work posted online.*

[18] *The basis measurements assume that a contract holder will liquidate the contract prior to expiration on the date the class I price is announced.*

Figure 2 Closing basis, 2002–2011, in $/cwt



Note: Figure headings identify the applicable basis associated with the cross-hedging strategy.

Table 2 Basis Descriptive Statistics ($/cwt), 2002–2011

Parameter	Spot	Ex Post	Class III	Class IV	f^{max}
μ	14.576	0.060	0.380	0.926	0.229
	(Temporal Effect)	0.060	0.013	-0.082	-0.007
	(Index Effect)	0.000	0.367	1.008	0.236
σ^2	12.262	0.089	0.531	1.713	0.237
Min	9.43	-0.78	-0.78	-0.72	-0.78
Max	21.91	1.11	3.84	6.68	1.89

while the class IV basis showed the most volatility. The volatility and wide range between the minimum and maximum values demonstrated in table 2 highlight the basis risk when cross-hedging (i.e., the June 2011 class III basis was $3.84).

When using the CME contract that corresponds with the class I mover, the temporal effect averaged $0.06 per cwt from 2002-2011. Under this scenario the index effect is equal to zero since the hedging instrument is identified *ex post*. The biggest source of basis risk is driven by incorrect estimates on which class price will drive the mover (index effect). As an example, when the class III contract was always used as the hedging instrument, the index effect averaged $0.367 per cwt, and the temporal effect averaged $0.013 per cwt. When the class IV contract was always used as the hedging instrument, the index effect averaged $1.008 per cwt, and the temporal effect averaged -\$0.082. Using the highest valued manufacturing contract, the index effect averaged \$0.236 and the temporal effect averaged -\$0.007.

In all scenarios the basis is less variable than the cash price. Cash market participants trade price risk for basis risk, which is consistent with the basis risk inherent in other commodities such as livestock (e.g., Purcell and Hudson 1985). When comparing the different hedging strategies, not including *ex post*, the 90-day strategy of cross-hedging class I milk using the highest-valued manufacturing contract resulted in the lowest basis mean and variance. A low basis mean and variance are not the only measure of success. To provide risk management opportunities, the futures contract must also consistently reduce exposure to unexpected volatility in cash prices.

Hedge Ratio and Effectiveness

The data have thus far demonstrated that due to the different aspects of the underlying asset and cross-hedged asset, there exists a significant amount of financial risk attributable to basis. As a result, a class I milk trader may not want to cross-hedge 100% of their cash exposure. To minimize the risk of cross-hedging, the trader may identify and use a hedge ratio, which is the proportion of spot positions that should be covered by futures market positions $\delta = n_{t-j}/q_{t-j}$, where n_{t-j} is the size of the futures market position and q_{t-j} is the size of the cash market position when the hedge is placed. Given this definition, the hedge ratio δ is identified in the following representation of the net milk price, $s_t - \delta(f_t - f_{t-j})$. To obtain δ and account for the presence of conditional information available at the time a hedging decision is made, Myers and Thompson (1989) suggest estimating a generalized optimal hedge ratio.[19]

The generalized optimal hedge ratio for this analysis is obtained using an augmented reduced form model of the spot price with the change in the futures price over the life of the hedge ($\Delta f_t = f_t - f_{t-j}$) as the augmenting variable, and the highest-valued manufacturing contract ($f_{t-j}^{\max}$) and one-period lagged basis for class III and class IV as the relevant conditioning information.[20] Hedging intervals, j, of 30 and 90 days were used to compute the generalized optimal hedge ratios. This method imposes the restriction that milk futures markets are unbiased. To ensure the hedge ratio model was not misspecified, an augmented Dickey-Fuller test for a unit root was performed on the class I mover. The null hypotheses that the class I mover is non-stationary and that it possesses a unit root were rejected.

Results of the OLS analyses in table 3 indicate that hedging intervals of 90 days have optimal hedge ratios that are not statistically different from one, indicating compliance with FASB guidelines. A hedge ratio of one is no different than a naïve hedge ratio. Another important implication from this result is the net milk price, defined as $s_t - \delta(f_t - f_{t-j})$, is equal to the locked-in futures price plus the basis ($b_t + f_{t-j}$), even when conditioning on the basis in the hedge ratio estimation. Thus, when hedge ratios of one are

[19] *We investigated both a time-varying optimal hedge ratio (Myers 1991) and a dynamic minimum variance hedge ratio (Lence, Kimle, and Hayenga 1993), and confirm only negligible differences in hedging effectiveness relative to the constant generalized optimal hedge ratio.*

[20] *We investigated whether other lagged futures prices should be included as conditioning information in the OLS estimator and found that lagged class III and class IV futures prices were statistically insignificant.*

Table 3 Estimated Generalized Optimal Hedge Ratios

Model		Generalized Optimal Hedge Ratio $\hat{\delta}$ j = 30/t = 119	j = 90/t = 40
(1)	$s_t = \delta\Delta f_t^{III} + X_{t-j}\alpha + \varepsilon_t$	0.624* (0.065)	0.956*# (0.058)
(2)	$s_t = \delta\Delta f_t^{IV} + X_{t-j}\alpha + \varepsilon_t$	0.422* (0.081)	0.972*# (0.132)
(3)	$s_t = \delta\Delta f_t^{max} + X_{t-j}\alpha + \varepsilon_t$	0.731* (0.061)	0.943*# (0.049)

*Note: Standard error in parentheses; *p-value < 0.001, #not statistically different from $\delta = 1$.*

Table 4 Class I Cross-hedge Evaluations Using Generalized Hedge Ratios, 2002–2011 in $/cwt

	Mean	Variance	Mean	Variance
Cross-Hedge Evaluation	**j = 30**		**J = 90**	
No Hedge	14.58 (0%)	12.26 (0%)	14.58 (0%)	12.26 (0%)
Class III	14.49* (-0.6%)	11.29 (-8.0%)	14.38 (-1.4%)	8.05# (-34.3%)
Class IV	14.57 (-0.1%)	11.86 (-3.3%)	14.50 (-0.5%)	9.89# (-19.4%)
f^{max}	14.58 (0.0%)	11.72 (-4.4%)	14.54 (-0.2%)	9.28# (-24.4%)

*Note: *Statistically significant first moment returns using student's t-test; #Results of Levene's test indicate statistically different variances from the non-hedged position.*

employed to cross-hedge, class I milk traders remain subject to volatile closing basis that prevents them from managing 100% of the cash price exposure.

As the hedging interval decreases, changes in the class III and class IV milk futures contracts have significantly less explanatory power for determining the cash price, thus lowering the optimal hedge ratio. Optimal hedge ratios for class III, class IV, and f^{max} decrease by 35%, 57%, and 22%, respectively, when the hedging interval is reduced to 30 days. This is consistent with Maynard et al. (2005), who found that longer hedging intervals were more effective at reducing cash price risk in mailbox milk prices. Futures contracts with a 30-day hedging interval fail to satisfy FASB thresholds, while longer intervals meet these criteria and demonstrate that the offset in risk is not accidental. The inadequacy of cross-hedging using smaller hedging windows can be attributed to the deterministic nature of end-product price formulas, which allow uncertainty in the futures contract settlement price to be resolved as the weekly AMS price series is updated (e.g., table 1).

For quantitative evidence of the hedge effectiveness, the first- and second-moment of the net milk price (using estimated generalized hedge ratios) were computed for each of the hedging strategies using a 30-day and 90-day hedging interval (table 4). Over the 10-year period analyzed, cross-hedging using CME milk futures at 30-days and 90-days reduced the net milk price and sample variance compared to not hedging at all.

When comparing the various hedging strategies, the pure-strategy class III using a 90-day interval performed the best and was able to reduce the cash price variance by 34.3% compared to not hedging. At 30-day hedging intervals, the reduction in the cash price variance was less than 10% regardless of the CME contract employed. It is important to test that the reductions in the variance at 90-day hedging intervals are statistically significant. Results of Levene's test (1960) indicated that we could reject the null hypothesis of equal variances among the hedged positions and the non-hedged position. At 30-day intervals we could not reject the null hypothesis of equal variances.

While a reduction in the price variance is of value to traders, fluid milk market participants may also assess performance based on the returns from hedging. When comparing the net milk price absent hedging to the net price under various hedging strategies it is initially evident that at 90-days, cross-hedging reduces the net milk price and increases first-moment returns (a benefit for the milk buyer). However, statistical tests of significance indicate that first-moment profits are in fact no different from zero for most of the hedging strategies. Combining the statistical tests of significance for the mean and variance, we conclude that hedging the fluid milk price using CME futures can reduce price volatility at significant hedging intervals and positive first-moment returns do not exist for the long hedger. More importantly, we see that when using longer hedging intervals the basis still provides barriers to direct cash price management.

Is Basis Predictable?

Given that basis is defined as the spot price minus the futures settlement price $s_t - f_t$, it is apparent that at longer hedging intervals when the hedge ratio is equal to one, the net milk price is equal to $f_{t-j} + b_t$. With a hedge ratio that is no different than one, basis exposure in the net milk price limits the ability of class I market participants to directly manage their cash price risk. If this basis risk can be reduced to some predictable level with some reliability, then the futures market may provide more direct risk management opportunities for cash market participants. Naïve basis estimations and forecasts of the basis using time series techniques were used to evaluate the implications of basis predictability on the success of the hedging strategy.

Based on an augmented Dickey-Fuller test for a unit root, the null hypotheses that the class III and class IV basis noise processes are non-stationary and possess a unit root are rejected.[21] The first 50 lags of the autocorrelation function (ACF) were examined in both the residuals and squared residuals for class III and class IV basis, and revealed significant autocorrelation in the first lag. Since the squared residuals measure the second-order moment, the results indicate that the conditional variance may exhibit time-varying conditional heteroscedasticity.

To allow for volatility clustering in the basis, the class III and class IV basis were used to estimate the parameters of an AR(1)-GARCH(1,1) model where autoregressive terms represent the conditional mean. This approach is consistent with Dehn (2000), Moledina et al. (2002), and Swaray (2002), all of whom used the generalized autoRegressive conditional heteroskedasticity (GARCH) framework to model commodity price volatility.

Based on the results of the estimated GARCH models, the relationships in table 5 are suggested for the class III and class IV basis. Both models show

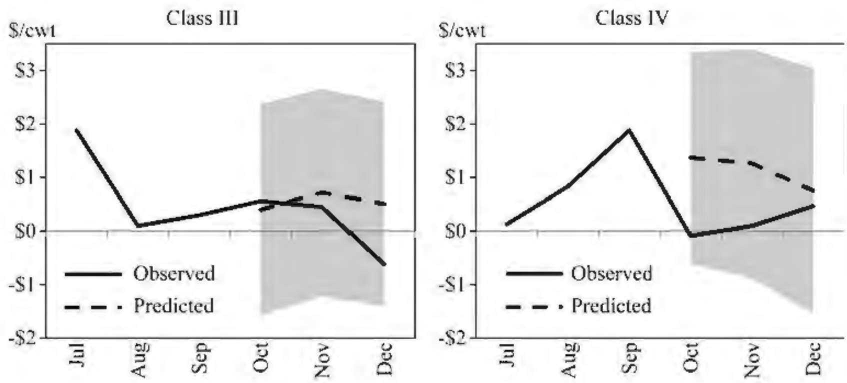
[21] *The data was decomposed to remove the trend cycle and seasonal factors using a moving-average filter and seasonal residuals of the smoothed data.*

Table 5 GARCH Model Parameter Estimates

Parameters	Class III	Class IV
c	-0.048 (0.050)	-0.114 (0.050)
AR(1)	0.532** (0.097)	0.731** (0.097)
α_0	0.027 (0.016)	0.028 (0.016)
ARCH(1)	0.189* (0.078)	0.462** (0.078)
GARCH(1)	0.749** (0.085)	0.673** (0.085)
Ljung-Box Test	40.41	32.95

*Note: Standard error in parentheses, p-value: *< 0.05, **< 0.001.*

Figure 3 Observed and predicted values of the basis



Note: Solid lines represent the observed basis, dotted lines represent the conditional expectation, and shaded regions indicate confidence intervals.

statistically significant coefficients on the autoregressive and GARCH coefficients. The ACF plot of the squared residuals shows some signs of autocorrelation remaining, and the p-value from a Ljung-Box test indicates that the null hypothesis of no autocorrelation left in the residuals can be rejected. Given these results, we conclude that the GARCH model is reasonably successful in modeling the serial correlation structure in the conditional mean and conditional variance.

Next the basis was forecast for three months following the traditional iterative approach for model prediction. The three months forecast for the basis correspond to the length of the hedging interval identified in the previous section. The GARCH model forecasts of the basis were compared to naïve forecasts of the basis using a 12-month rolling average. Results indicate that the model was reasonably successful in predicting the class III basis in nearby months, with a mean-square-prediction-error (MSPE) of $0.46 per cwt. Using the 12-month rolling average class III basis as the forecast resulted in a MSPE of $1.82 per cwt, which is nearly 3 times less accurate than the GARCH specification. The GARCH prediction results of the class IV basis were even less accurate, with a MSPE of $1.18 per cwt. The forecast from the GARCH model performed notably worse than the 12-month rolling average forecast, which had a MSPE of $0.06 per cwt. The performance of the GARCH models in forecasting the basis shows the class III basis may to some extent be predictable over short time horizons, whereas using lagged observations of the basis and volatility has little predictive power for class IV basis. These results provide evidence that when combined with longer hedging intervals, GARCH prediction models of the class III basis may improve the ability of traders to manage the cash price risk by updating price expectations conditional on historical basis.

Our findings support the reevaluation by hedge accounting firms of acceptable cross-hedge instruments to include class III futures. However, the MSPE demonstrates that the basis still results in a considerable amount of risk exposure for the trader, even when using an appropriate basis-forecasting technique. The basis exposure can be addressed through policy or market-based solutions that more closely align the class I price with derivative instruments.

Policy Implications

The results of this study have implications in the policy and private market arena. To facilitate risk management, a number of solutions are available, including: to allow adjustments related to the use of forward or futures contracts as a minimum price deduction; alternative price provisions; to introduce a class I mover derivative instrument.

As the forward contract markets develop in manufacturing milk classes, it could become a customary adjustment to settle up on contracts relative to minimum prices; these adjustments would constitute an authorized deduction. This may be worth USDA consideration in the context of fluid market transactions. The USDA could also alter the FMMO interpretations on minimum price adjustments to allow for deductions related to forward contracting and margin calls on futures market transactions. Class I milk under forward contracts, or managed via futures, would be exempt from FMMO minimum pricing provisions, thus providing farms, processors, and retailers with the ability to more directly manage their price risk.

Producers and cooperatives, with the help of the USDA, could also consider fixing or eliminating the higher-of component in milk pricing. For example, eliminating the higher-of component could result in a class I milk price equal to the class III plus a fixed higher-of value and the location adjustment. Eliminating or fixing the higher-of mechanism as a constant would remove index basis effects. Additionally, the USDA could consider alternative price discovery methods such as using CME settlement prices or lagged manufacturing pricing as the price discovery method for class I milk. Prices based on CME settlement prices or one-month lagged manufacturing prices would allow for the class I mover and the underlying CME contract to converge in price, thereby eliminating basis risk.[22]

Introducing a cash-settled class I mover contract on the CME represents a private market solution. This product would settle on the higher-of class III and class IV and would completely eliminate both the temporal and index effects. However, changes in commodity prices would sharply change the price of a mover contract and may have implications on the price of the option premium. This concern, and concerns over liquidity in milk futures

[22]*Depending on the changes to FMMOs, amendments would require an industry request to the Secretary of Agriculture, and, if granted, a FMMO rulemaking process. This would not be the case with authorized deductions in writing, as those deductions are part of the 1937 Agricultural Marketing and Agreement Act, and are determined by the FMMO offices independently.*

markets may be warranted, as a class I mover contract would compete with class III and IV contracts for speculative traders who act as market makers.

These proposed policy initiatives provide solutions to volatile milk prices and help to facilitate risk management on behalf of fluid market participants. None of the proposed solutions violate the integrity of the FMMO program. In fact, voluntary programs such as forward contracting or new price discovery methods would provide avenues for producer and processor profitability.

Conclusion

This study has examined the risk management opportunities for class I cash market participants through the use of CME milk futures contracts. The study considered a variety of futures price cross-hedging scenarios using class III and class IV milk futures contracts. Results suggest that although CME milk futures contracts cannot account for the advance and higher-of dynamics inherent in the FMMO class I milk price, using the class III contract to cross-hedge class I milk may prove effective in reducing risk. The class IV futures contract has inconsequential effects on reducing the cash price variance, and techniques to forecast the expected basis perform poorly compared to observed levels. The basis exposure prevents class III and IV milk futures contracts from directly managing the milk price and limits potential risk reduction and revenue stability for fluid market participants. Removing these road blocks to risk management would provide avenues for farm, processor, and retailer profitability in an increasing volatile market.

Funding

Funding support provided by the Ohio Agricultural Research and Development Center and the Agricultural Marketing Service, U.S. Department of Agriculture.

References

Anderson, D., D. McCorkle, and R. Schwart, Jr. 1999. Hedging Milk With BFP Futures and Options. Texas Agricultural Extension Service, Texas A&M University.

Anderson, R., and J.P. Danthine. 1981. Cross Hedging. *Journal of Political Economy* 89(6): 1182–1197.

Bollerslev, T. 1986. Generalized Autoregressive Conditional Heteroskedasticity. *Journal of Econometrics* 31: 307–327.

Dehn, J. 2000. Commodity Price Uncertainty in Developing Countries. Centre for the Study of African Economics, Department of Economics, University of Oxford.

Deloitte. 2011. *Hedge Accounting Adapting to Change*. Deloitte and Touche Exposure Draft on Hedge Accounting.

Financial Accounting Standards Board. 1998. *Accounting for Derivative Instruments and Hedging Activities*. Financial Accounting Standards No. 133.

Fortenbery, R., R. Cropp, and H. Zapata. 1997. Analysis of Expected Price Dynamics Between Fluid Milk Contracts and Cash Prices for Fluid Milk. Agricultural and Applied Economics Paper No. 407, University of Wisconsin.

Jesse, E., and R. Cropp. 1997. The Basic Formula Price Futures Contract: A New Dairy Industry Risk Management Tool. Marketing and Policy Briefing Paper No. 56, University of Wisconsin.

Lence, S., K. Kimle, and H. Hayenga. 1993. A Dynamic Minimum Variance Hedge. *American Journal of Agricultural Economics* 75: 1063–1071.

Levene, H. 1960. Robust Tests for Equality of Variances. In *Contributions to Probability and Statistics: Essays in Honor of Harold Hotelling*. ed. Ingram Olkin, 278–93, Palo Alto, CA: Stanford University Press.

Manchester, A., and D. Blayney. 2001. Milk Pricing in the United States. Washington, DC: U.S. Department of Agriculture, Economic Research Service Bulletin 761.

Maynard, L., and I. Bamba. 2004. Hedging-effectiveness of Milk Futures Using Value-at-risk Procedures. Paper presented at the annual meetings of NCR-134, Applied Commodity Price Analysis, Forecasting, and Market Risk Management, St. Louis MO.

Maynard, L., C. Wolf, and M. Gearhardt. 2005. Can Futures and Options Markets Hold the Milk Price Safety Net? Policy Conflicts and Market Failures in Dairy Hedging. *Applied Economics Perspectives and Policy* 27: 273–286.

Moledina, A., and T. Roe. 2002. Reexamining the Measurement of Commodity Price Volatility and the Welfare Consequences of Eliminating Volatility. Working Paper, Economic Development Center, University of Minnesota.

Myers, R.J. 1991. Estimating Time-varying Optimal Hedge Ratios on Futures Markets. *Journal of Futures Markets* 20: 73–87.

Myers, R.J., and S.R. Thompson. 1989. Generalized Optimal Hedge Ratio Estimation. *American Journal of Agricultural Economics* 71: 858–868.

Purcell, W., and M. Hudson. 1985. The Economic Roles and Implications of Trade in Livestock Futures. Washington, DC: The American Enterprise Institute for Public Policy Research.

Swaray, R. 2002. Volatility of Primary Commodity Prices: Some Evidence from Agricultural Exports in Sub-Saharan Africa. Discussion Paper in Economics, The University of York.

Thraen, C. 2006. From Dairy Product to Milk Check: A Primer on Current Federal Order Pricing. Agricultural, Environmental and Development Economics Extension Paper, The Ohio State University.

——. 2011. Highly Variable Prices or Excessive Volatility? An Extension Dairy Economist's Perspective. Paper presented at the annual meetings of NCCC-134, Applied Commodity Price Analysis, Forecasting, and Market Risk Management, St. Louis MO.

U.S. Department of Agriculture, Agricultural Marketing Service. 2012. Federal Milk Order Market Statistics. Available online at: www.ams.usda.gov/dairy

U.S. National Agricultural Statistics Service. 2012. Agricultural Statistics. Available online at: www.nass.usda.gov.

Zylstra, M., R. Kilmer, and S. Uryasev. 2004. Hedging Class I Milk: The Acceleration and Mover Effect. Proceedings of the American Agricultural Economics Association, Denver, CO.