Feasibility of Hedging Milk Input Costs for a Dairy Processor: A Case Study

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This case study evaluates milk input price-risk management strategies for a processor of refrigerated dairy products. The firm perceives price risk both when milk costs are over budget and when budgets are too conservative. Price-forecasting models produced mean absolute percentage errors of sic to nine percent. In a 2000–2008 simulation, hedging with Class III milk futures reduced the variance of budget deviations by only 31 percent, while hedging with call options produced a similar cost profile with more predictable cash-flow requirements. Recommendations include using the price-forecasting models to improve budgeting accuracy but delaying the launch of a hedging program.

The firm on which this case study was based is a processor of refrigerated dairy products. Each month the firm purchases approximately 70,000 cwt of milk for processing facilities in New York and California. A custom blend of 3.25-percent milkfat Class II milk is purchased in New York, with "Class II" denoting milk used in soft products such as ice cream, yogurt, cottage cheese, cream cheese, etc. In California's classified pricing system, the analogous category is Class 4a milk with 3.25 percent milkfat. Milk is the firm's primary material input, and since mid-2007 it has accounted for nine to 12 percent of the firm's revenue, up from historical levels of five to ten percent (see Figure 1). High milk costs are expected to continue for the foreseeable future, according to Chicago Mercantile Exchange (CME) futures prices. As of August 21, 2008, Class III milk futures prices exceed $17/cwt for all but one delivery month through July, 2009 (Levitt 2008). In contrast, the average Class III milk price was only $12–$13/cwt before 2007.

A second concern shown in Figure 1 is high volatility in milk prices, both in unit values and as a share of revenue. The firm perceives price risk both when milk costs exceed budgeted levels and when milk costs are much lower than budgeted. In the case of overly conservative budgeting, the risk stems from lost opportunities to use funds for other purposes.

Ideally, a price-risk-management plan would allow the firm to avoid spikes in milk input costs and produce a smooth, predictable milk cost profile over time. Price forecasting can improve the predictability of costs. Hedging with futures or options can reduce cost variability and may avoid some cost increases. Since neither forecasting nor hedging are fully effective, the purpose of this analysis was to determine if such tools are effective enough to justify devoting scarce resources to price-risk management.

The specific objectives of the analysis were to:

1. Develop price-forecasting models for Class II milk with 3.25 percent milkfat at the New York and California facilities, four months in advance;
2. Estimate the risk-minimizing hedge ratio applicable to the firm (i.e., how many futures contracts are needed to hedge a given spot-market purchase);
3. Estimate the degree to which hedging with Class III milk futures will reduce total variation and unexpected price variation, and estimate the impact of hedging on average cost and worst-case outcomes;
4. Repeat Objective (3), replacing futures hedges with options hedges;
5. Estimate funds needed to maintain futures margin accounts, and to purchase options; and
6. Synthesize the results to aid decision making.

Background Information

The firm's price-risk-management alternatives were constrained. In the short-run, its ability to pass on commodity price increases to its customers was limited. Similarly, it was not feasible to forward-contract with its milk input suppliers to obtain a smoother, more predictable cost profile. Remaining alternatives include hedging with exchange-traded futures and with options. The firm is a natural

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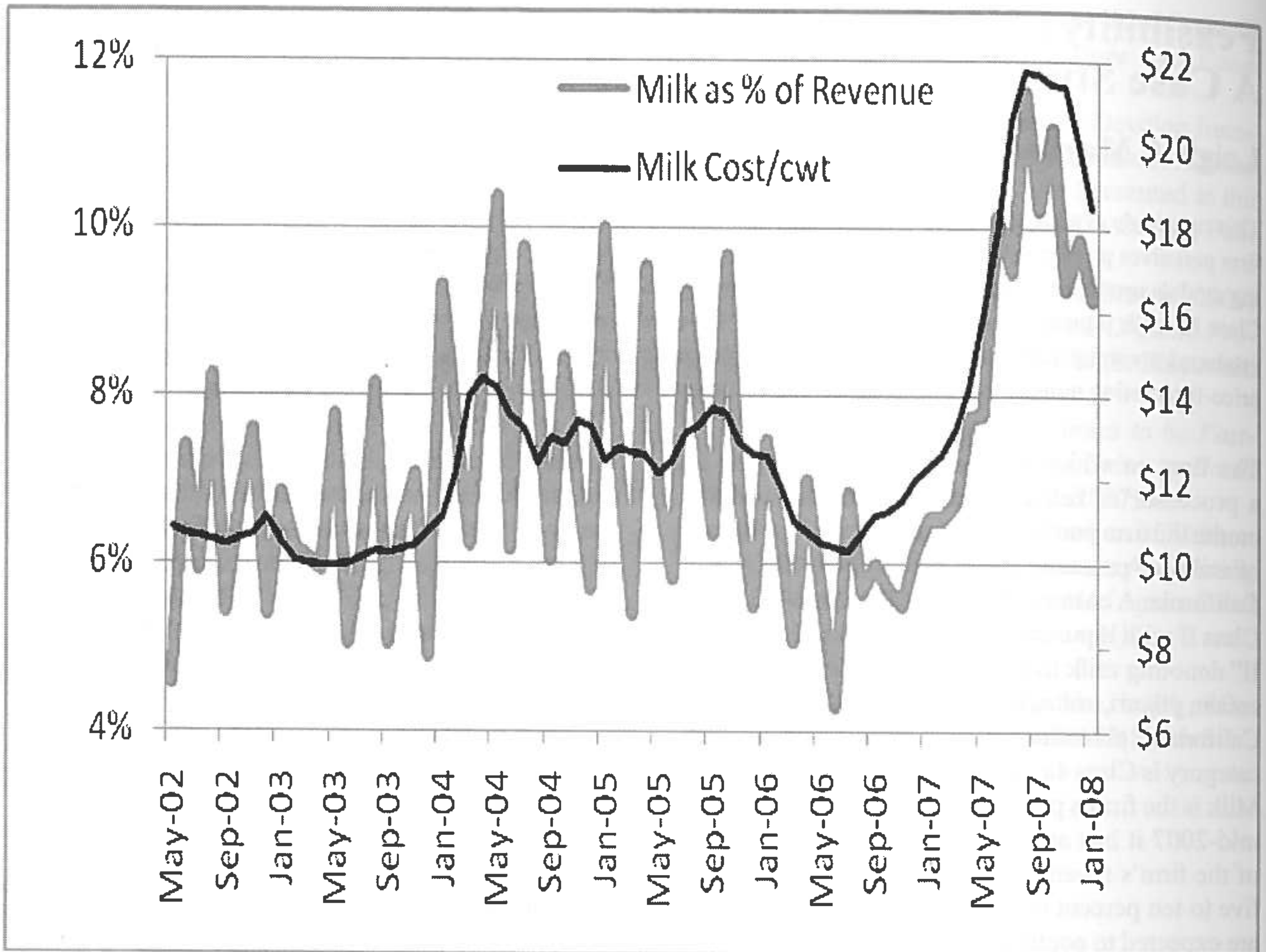

Figure 1. Milk Cost as a Share of Firm Revenue: Rising and Volatile.

long hedger in the milk market, implying that its risk-management objective is to protect against unexpected milk input cost increases. The most straightforward ways to implement long hedges are either to buy futures contracts or to buy call options that give the holder the right, but not the obligation, to buy futures.

The dairy-futures complex offered by the CME Group includes Class III milk (used in cheese processing), Class IV milk (used in butter and non-fat dry milk processing), dry whey, non-fat dry milk (abbreviated as NFDM), and butter contracts. Ideally, the firm would hedge with Class IV milk futures or options, because Class IV prices are 98 percent correlated with Class II prices. Unfortunately, Class IV futures and options are too thinly traded to be a practical hedging tool, as are the NFDM and butter futures contracts. Hedgers often have difficulty filling orders promptly in thin markets, and may have to offer price concessions to entice traders to take the other side of a futures or options transaction. On August 21, 2008, Class IV futures trading volume was zero, while 2,604 Class III milk futures contracts and 635 Class III milk options were traded (Levitt 2008). Class III milk prices are 79 percent correlated with Class II prices, and offer the best feasible alternative.

Hedging with futures contracts versus options offers greater liquidity and locks in a price subject to basis risk. Basis risk occurs from unexpected changes in the difference between Class III prices and the firm's 3.25 percent Class II and Class 4a prices. The main disadvantage of hedging with futures versus options is the unpredictable magnitude of margin calls if milk futures prices fall. When opening a Class III futures position, an initial margin of \$1,000–\$1,300 per contract must be deposited. If the futures position accumulates paper losses while it is open, additional deposits equal to those paper losses will be demanded. Although all margin deposits are returned after the futures position is closed, it can be hard to plan cash-flow needs.

Milk Price Forecasts

Price forecasts are useful for budgeting and strategic planning, and can therefore be a risk-management tool in their own right. In the context of this study, forecasts were also required to identify which price changes were unexpected, and therefore indicative of price risk. Futures prices often are assumed to be among the most accurate price forecasts. The USDA issues long-term, annual dairy-price forecasts, but annual forecasts may be of limited value for the firm. Dairy economists at universities (e.g., Ken Bailey at Penn State, Bob Cropp at the University of Wisconsin, Cam Thraen at Ohio State, etc.) provide monthly outlook reports and/or forecasts. Private consulting firms such as Downes-O'Neill, Jerry Dryer, and Blimling and Associates provide fee-based price-forecasting services. These forecasters are often modest about their forecasts' performance, and none appears to be consistently superior to others (Plourd 2008). Even futures prices are not consistently superior forecasts in the dairy markets.

In the case of the firm's 3.25 percent Class II milk (Class 4a in California), there are no publicly available forecasts. Throughout this analysis, a forecasting and hedging horizon of four months was used because futures market liquidity declines for delivery months more than four months in the future, making it more time-consuming and costly to fill hedging orders. Most of the data used in the analysis were collected from the University of Wisconsin "Understanding Dairy Markets" website (http://future.aae.wisc.edu/) maintained by Brian Gould. The January 2000 Federal Milk Marketing Order pricing reform introduced major changes in dairy-pricing policy, so only data since January 2000 were used.

Straightforward forecasting alternatives should be considered before using more time-consuming approaches. A simple, reasonable alternative might be called the "average-basis forecast." For example, if it were May, the September 3.25 percent Class II price forecast would be:

(1) *Sept. 3.25 percent Class II forecast = Sept. Class IV futures price as of May + average Sept. basis,*

where basis = 3.25 percent Class II price–Class IV price.

The firm's 3.25-percent Class II and 3.25 percent Class 4a prices are 97 percent and 99 percent correlated with Class IV prices, respectively. Although very little Class IV futures trading occurs, futures prices remain available and should be a useful component of a Class II or Class 4a forecast. Using monthly prices from January 2000 to February 2008, the average 3.25 percent Class II basis and the average 3.25 percent Class 4a basis for each month of the year were calculated, then added to the appropriate Class IV futures price four months prior to expiration.

Figure 2 shows that this average-basis forecast often follows the actual price with a long lag. The average absolute error was \$1.05/cwt for 3.25 percent Class II prices and \$1.15/cwt for 3.25 percent Class 4a prices. The average absolute percentage errors were 8.0 percent and 9.4 percent, respectively, and the worst errors were \$5.04/cwt and \$4.65/cwt, respectively. There appeared to be room for improvement, and this motivated a more time-consuming forecasting approach based on regression analysis.

Regression-Based Forecasting Approach

The firm's milk prices in New York and California can be expressed as functions of butter and NFDM prices. These functions fluctuate with changes in the federal and California milk-pricing formulas, as shown in Table 1. Thus estimating Class II and Class 4a milk prices as composities of NFDM and butter price forecasts allows one to avoid misattributing the impact of pricing-formula changes to other price determinants.

In the case of the 3.25 percent Class II price, the relevant NFDM price is the advanced NFDM price

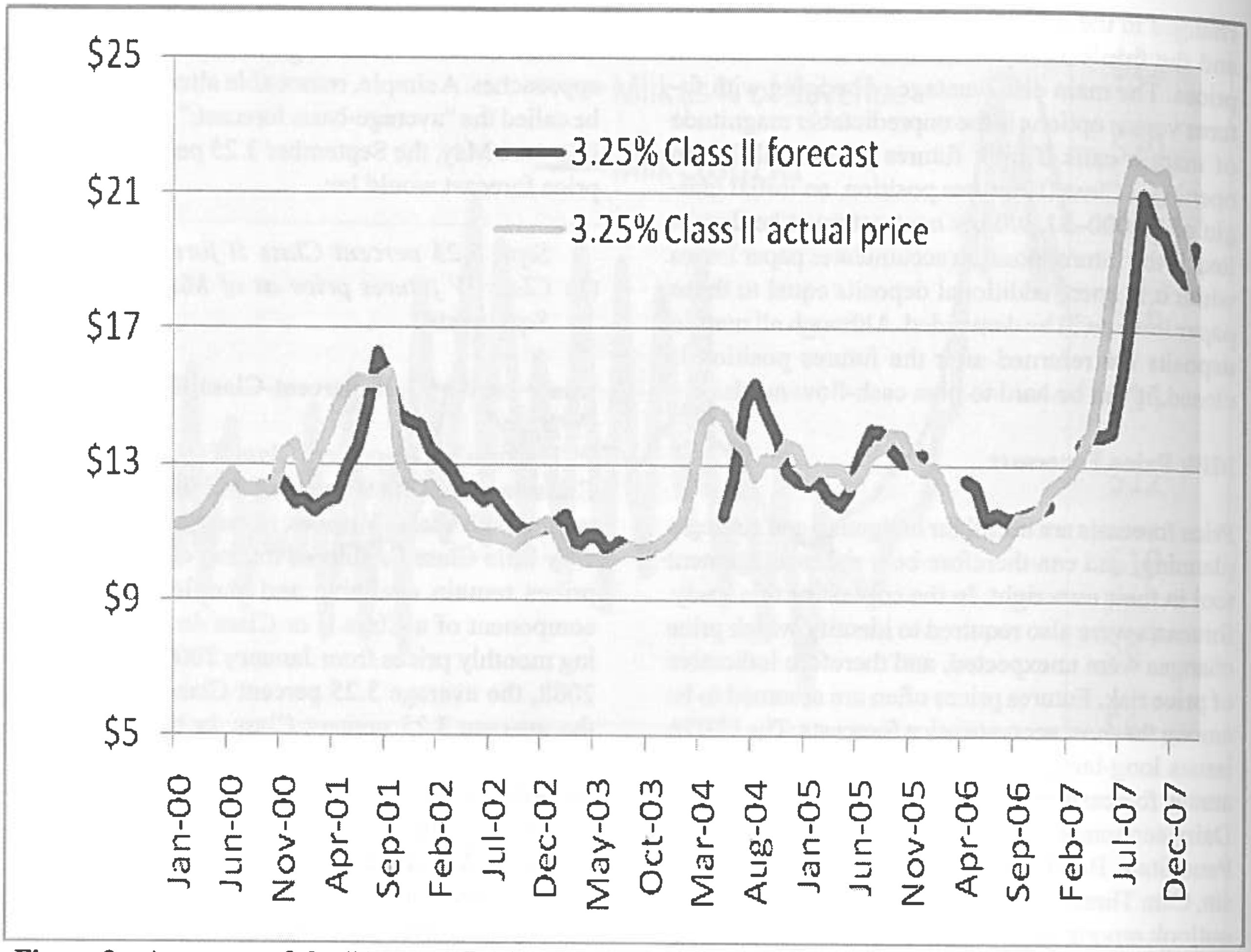

Figure 2a. Accuracy of the "Average Basis Forecast" for 3.25 percent Class II Milk.

Note: Gaps in the forecast series are due to missing historical Class IV futures data.

used in the Federal Milk Marketing Order price formulas. The advanced NFDM price is the volume-weighted two-week average NFDM price from the National Agricultural Statistics Service (NASS) survey. For example, the advanced NFDM price for May 2008 was the volume-weighted average from the weeks ending April 5 and April 12. The relevant butter price in the 3.25 percent Class II formula is a four-week volume-weighted NASS average. For example, the May 2008 butter price was the average from weeks ending May 3, May 10, May 17, and May 24, and was announced on May 30. In the case of the 3.25 percent Class 4a price, the relevant NFDM price is the monthly average price received by California processors for Grade A and Extra Grade nonfat powder, while the relevant butter price is the monthly average Chicago Mercantile Exchange (CME) spot price for Grade AA butter.

Factors at the farm level, processor level, and retail/export level all are expected to influence NFDM and butter prices. In general, farm-level supply depends on farm output prices, farm input prices, technology, and capital stocks. Processors' demand for farm-level inputs and supply of manufactured outputs both depend on processed-commodity output prices, farm-level and other processing input prices, and processed inventories in storage. Retail and export demand depends on

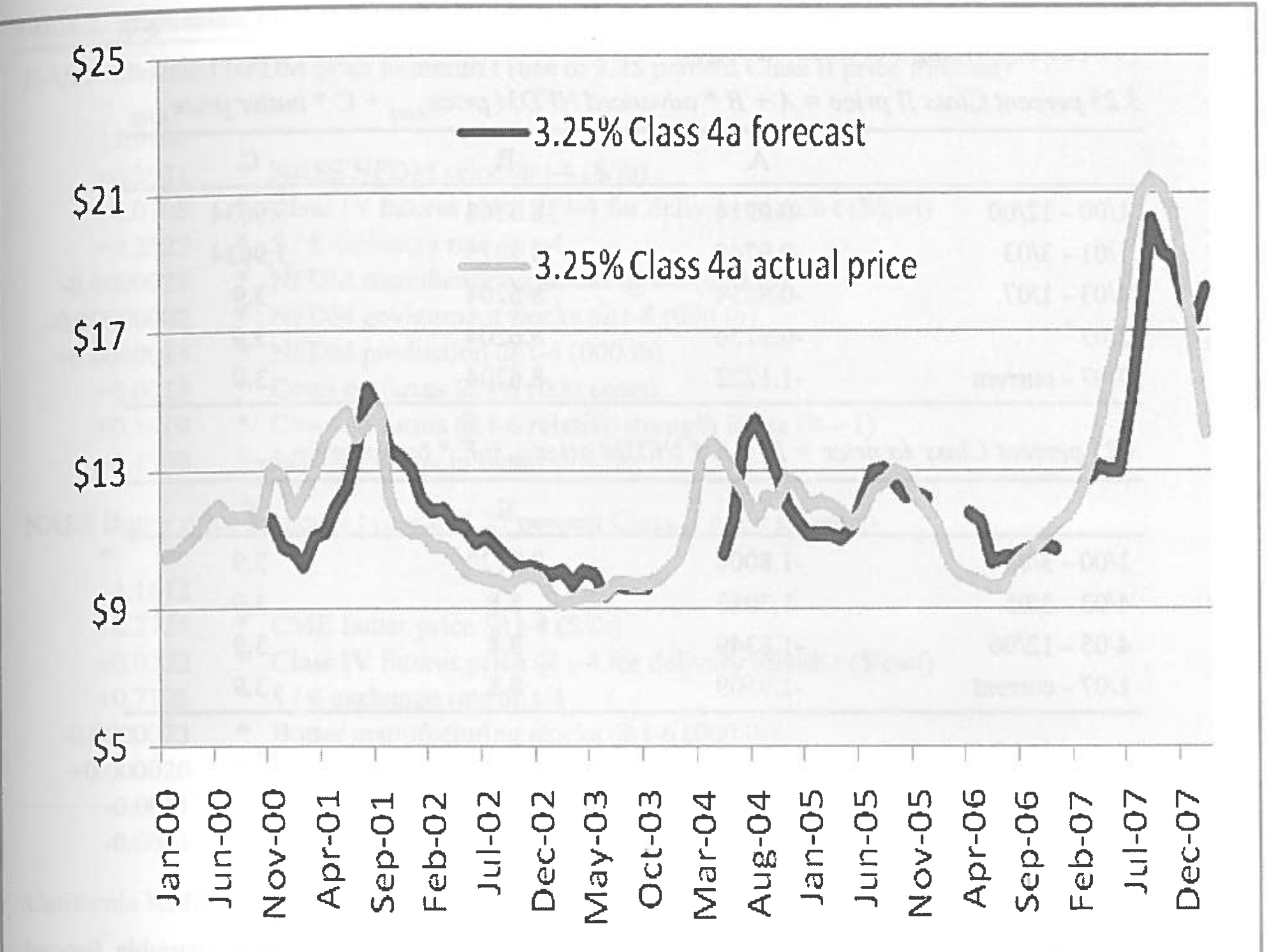

Figure 2b. Accuracy of the "Average Basis Forecast" for 3.25 percent Class 4a Milk.

Note: Gaps in the forecast series are due to missing historical Class IV futures data.

the commodity's own price, prices of substitutes and complements, consumer income, exchange rates, and seasonality. This multi-level demand and supply structure is useful as a mental map, but a reduced-form, price-dependent regression equation is appropriate for forecast estimation.

Early in the forecast-development process, data on a wide range of potential price determinants were gathered, extending even to such variables as temperature in Tulare County, California's leading milk-producing region. The next stage was to identify a concise set of variables that consistently had the greatest impact on NFDM and butter prices. Often, a good forecasting model is not the most detailed one but rather one that strikes a balance between detail and robustness to changing market conditions. The timing of data availability is another consideration in model design. For example, current prices and exchange rates are available almost immediately, but production, stocks, and export figures only appear after delays of up to four months. In other words, the data used in month t-4 to forecast the price in month *t* came from market activity during the interval t-8 to t-4. Opportunities to obtain some data on a more timely basis appear feasible and will be incorporated into future improvements.

Regressions were estimated on 77 monthly observations from September 2000 to February

Table 1. Class II and Class 4a Milk Prices Expressed as Functions of Commodity Prices and Pricing Formula Changes.

*3.25 percent Class II price = A + B * advanced NFDM price$_{NASS}$ + C * butter price$_{NASS}$*

	A	B	C
1/00 - 12/00	-0.9214	8.5368	3.9634
1/01 - 3/03	-0.9748	8.7075	3.9634
4/03 - 1/07	-0.9554	8.6204	3.9
2/07	-0.9756	8.6204	3.9
3/07 - current	-1.1222	8.6204	3.9

*3.25 percent Class 4a price = D + E * NFDM price$_{CA}$ + F * butter price$_{CME}$*

	D	E	F
1/00 - 3/03	-1.8004	8.7120	3.9
4/03 - 3/05	-1.7053	8.8	3.9
4/05 - 12/06	-1.8349	8.8	3.9
1/07 - current	-1.9509	8.8	3.9

2008. Several observations were lost due to missing data on deferred Class IV futures prices. Out-of-sample forecast criteria would normally be desired, but given the low number of observations and the unusual market conditions during the final months of the study period, the entire sample was used in estimating the forecast regressions. Out-of-sample testing is becoming more feasible as post-reform data accumulate.

Table 2 contains NFDM and butter price forecasting models applicable to Class II and Class 4a milk prices, presented in a format appropriate for the stakeholder audience. In all but a few cases, estimated parameters were statistically signficant at a 0.10 level or better. Adjusted R-squared values ranged from 0.60 for CME butter prices to 0.91 for NASS NFDM prices.

Two items in Table 2 warrant clarification. First, one variable is a "relative strength index" of cow numbers. This variable measures the ratio of monthly cow-number increases divided by the absolute value of all monthly cow-number changes during a four-month period from t-9 to t-6. In other words, it measures the strength of upward momentum in a variable. Second, the final variable in the list is a 0/1 variable referring to the "butter/powder tilt." The tilt describes the relative levels of support prices at which the Commodity Credit Corporation will purchase butter and NFDM. A change in the tilt was announced on May 31, 2001 which favored butter production by raising the butter support price by \$0.1999/lb while lowering the NFDM support price by \$0.1032/lb. The California NFDM and CME butter price models were very similar to their federal counterparts, with adjusted R-squared values of 0.87 and 0.60, respectively.

Combining the NFDM and butter price forecasts from Table 2 with the appropriate conversion formulas in Table 1 produces 3.25 percent Class II and 3.25 percent Class 4a milk forecasts. The forecasts' in-sample accuracy is shown visually in Figure 3. As with the simpler "average-basis" forecasting approach, one can see substantial lags as the forecast fails to anticipate price movements. Table 3, however, shows that the regression-based forecasts outperform the average-basis approach by wide margins in every diagnostic category.

Table 2. Regression Models Supporting Class II and Class 4a Milk Price Forecasts.

NASS Advanced NFDM price in month t (use in 3.25 percent Class II price forecast) =

-11.9100		
+0.3531	*	NASS NFDM price @ t-4 ($/lb)
+0.0708	*	Class IV futures price @ t-4 for delivery month t ($/cwt)
+0.2522	*	$ / € exchange rate @ t-4
-0.0000023	*	NFDM manufacturing stocks @ t-6 (000 lb)
-0.00000002	*	NFDM government stocks @ t-8 (000 lb)
+0.0000014	*	NFDM production @ t-6 (000 lb)
+0.0013	*	Cows on farms @ t-6 (000 cows)
+0.1419	*	Cows on farms @ t-6 relative strength index (0 – 1)
+0.1309	*	5/2001 change in butter/powder tilt (0/1)

NASS Butter price in month t (use in 3.25 percent Class II price forecast) =

1.1612		
+0.2724	*	CME butter price @ t-4 ($/lb)
+0.0272	*	Class IV futures price @ t-4 for delivery month t ($/cwt)
+0.7105	*	$ / € exchange rate @ t-4
-0.0000023	*	Butter manufacturing stocks @ t-6 (000 lb)
+0.000026	*	Butter government stocks @ t-8 (000 lb)
-0.0011	*	Heifer price @ t-4 ($/cwt)
-0.0041	*	Butter commercial disappearance @ t-7 (000,000 lb)

California NFDM price in month t (use in 3.25 percent Class 4a price forecast) =

-11.1869		
+0.1725	*	NASS NFDM price @ t-4 ($/lb)
+0.0744	*	Class IV futures price @ t-4 for delivery month t ($/cwt)
+0.1860	*	$ / € exchange rate @ t-4
-0.0000031	*	NFDM manufacturing stocks @ t-6 (000 lb)
-0.00000008	*	NFDM government stocks @ t-8 (000 lb)
+0.0000022	*	NFDM production @ t-6 (000 lb)
+0.0012	*	Cows on farms @ t-6 (000 cows)
+0.1362	*	Cows on farms @ t-6 relative strength index (0 – 1)
+0.1914	*	5/2001 change in butter/powder tilt (0/1)

CME Butter price in month t (use in 3.25 percent Class 4a price forecast) =

1.2736		
+0.2437	*	CME butter price @ t-4 ($/lb)
+0.0288	*	Class IV futures price @ t-4 for delivery month t ($/cwt)
+0.7104	*	$ / € exchange rate @ t-4
-0.0000023	*	Butter manufacturing stocks @ t-6 (000 lb)
+0.000021	*	Butter government stocks @ t-8 (000 lb)
-0.0012	*	Heifer price @ t-4 ($/cwt)
-0.0044	*	Butter commercial disappearance @ t-7 (000,000 lb)

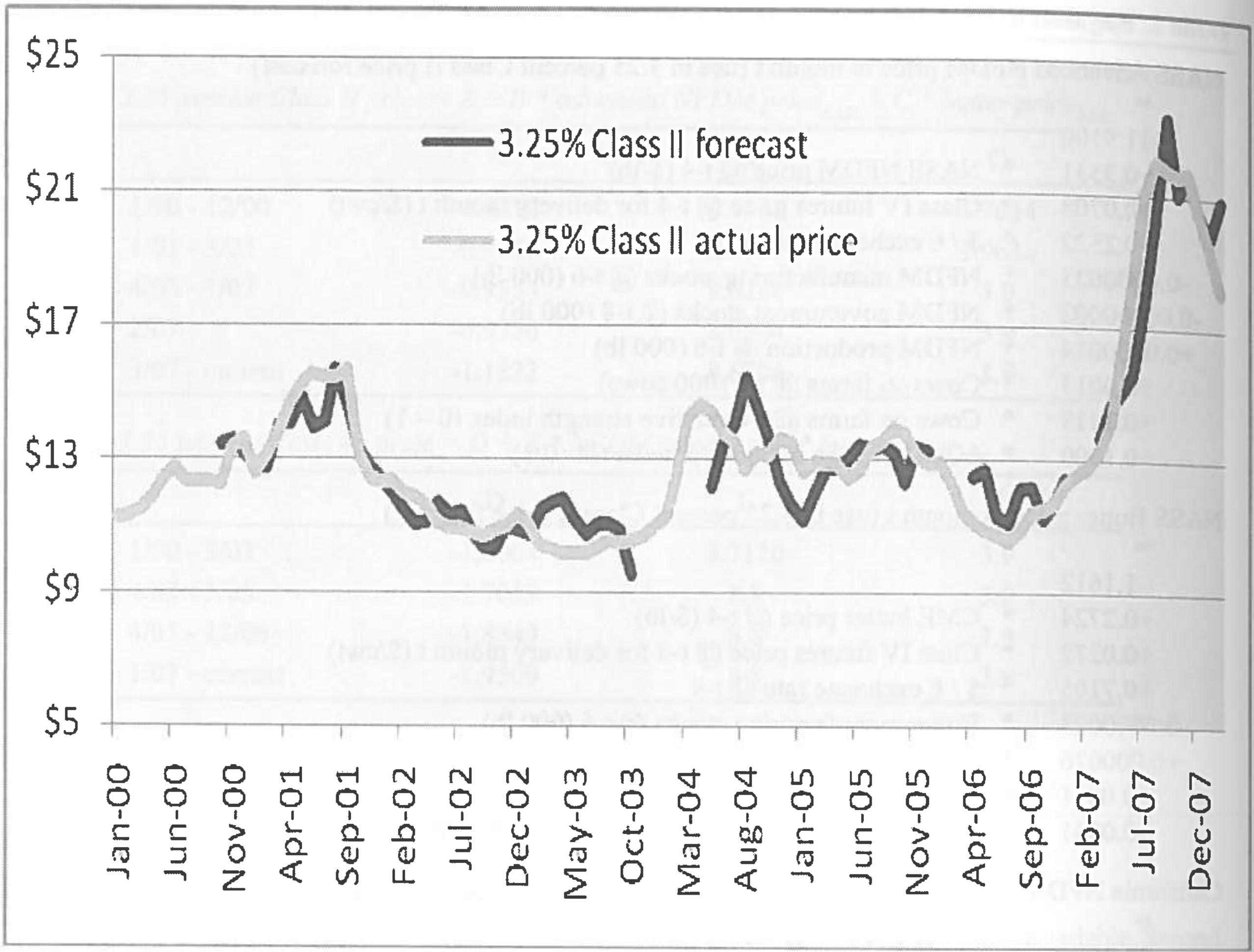

Figure 3a. Accuracy of "Regression-Based Forecasts" for 3.25 percent Class II Milk.

Note: Gaps in the forecast series are due to missing historical Class IV futures data.

Table 3. Regression-Based Forecasts Are More Accurate than the "Average-Basis" Approach.

	Regression-based forecasts		"Average basis" forecasts	
	3.25 percent Class II	3.25 percent Class 4a	3.25 percent Class II	3.25 percent Class 4a
Average error	$0.00	$0.01	$0.17	$0.12
Average absolute error	$0.79	$0.82	$1.05	$1.15
Median absolute error	$0.55	$0.54	$0.79	$0.96
Average absolute percent error	6.0 percent	6.7 percent	8.0 percent	9.4 percent
Maximum absolute error	$3.28	$3.06	$5.04	$4.65

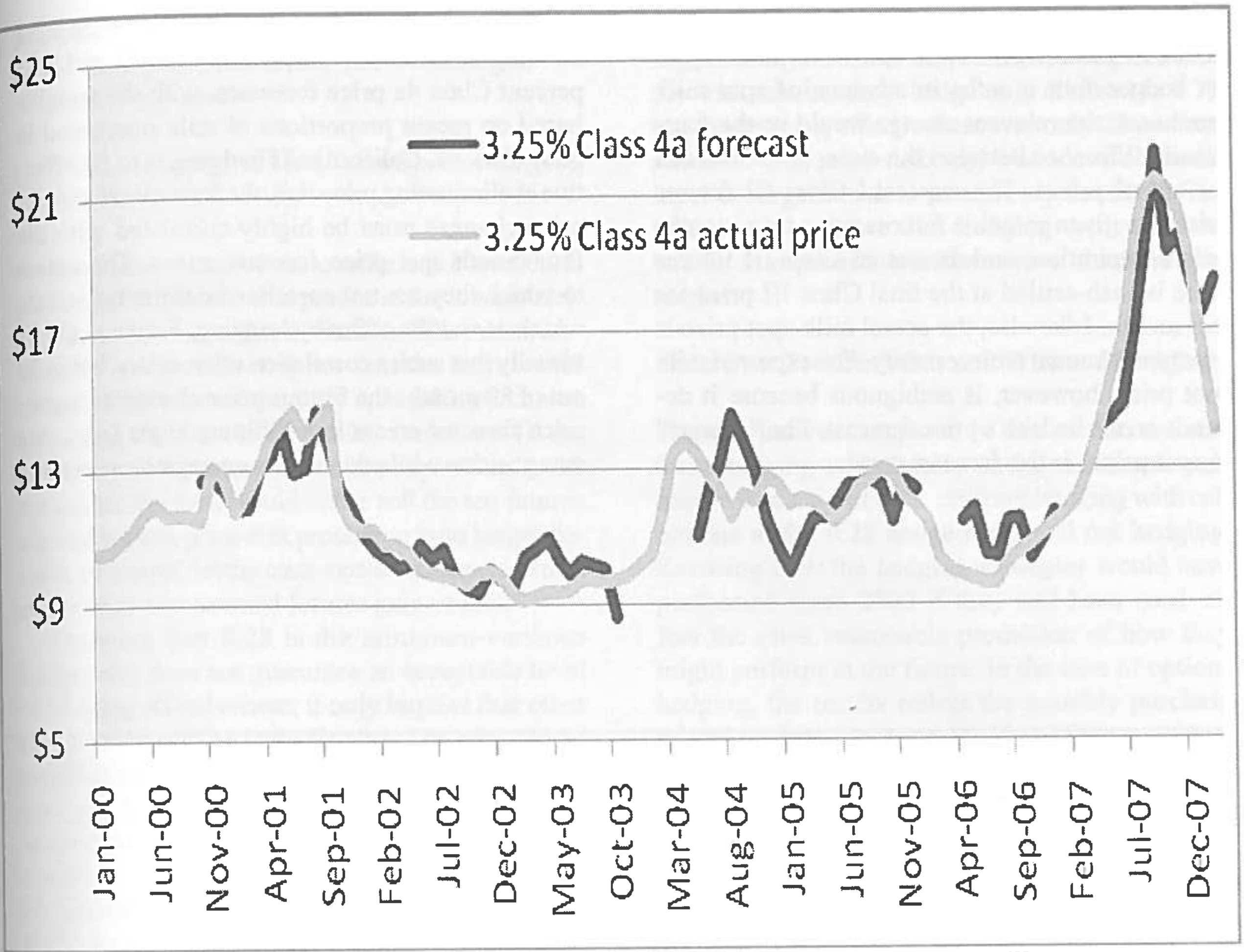

Figure 3b. Accuracy of "Regression-Based Forecasts" for 3.25 percent Class 4a Milk.

Note: Gaps in the forecast series are due to missing historical Class IV futures data.

Designing acceptable price forecasts was important not just for budgeting purposes but also to determine whether hedging in Class III futures or options markets can eliminate a sufficient portion of price risk. Price risk stems from unexpected price changes, i.e., forecast errors, which now are available for use in the next stage of the analysis.

Risk-Minimizing Hedge Ratios

A hedge ratio defines how many futures contracts are needed to hedge a given quantity of commodity purchased on the spot market. For example, if the firm's 3.25 percent Class II spot price rises by $0.40/cwt for every $1.00/cwt increase in the Class III futures price, then the risk-minimizing hedge ratio would be 0.4. The most straightforward way to estimate a minimum-variance hedge ratio is to regress spot-price changes on futures price changes. The resulting coefficient on futures price changes can be interpreted as the minimum-variance hedge ratio. This approach is appropriate when spot and futures prices follow a random walk (Myers and Thompson 1989), conditions that were confirmed using Augmented Dickey-Fuller tests. The adjusted R-squared also approximates the percentage of price risk that can be avoided by hedging (Stoll and Whaley 1993, p. 56).

But what exactly constitutes a "change" in spot prices or futures prices? If one were planning to set hedges four months in advance of spot milk purchases, the relevant change would be the four-month difference between the expected prices and the actual prices. The expected Class III futures price is a given month's futures price four months before expiration, and the actual Class III futures price is cash-settled at the final Class III price for that month. Likewise, the actual milk spot price is eventually known with certainty. The expected milk spot price, however, is ambiguous because it depends on the hedger's price forecast. The "change" in spot prices is the forecast error.

The expected milk spot price was treated as a 70/30 weighted sum of 3.25 percent Class II and 3.25 percent Class 4a price forecasts, with the weights based on recent proportions of milk purchased in New York vs. California. If hedging is to be effective at eliminating price risk, the four-month futures price changes must be highly correlated with the four-month spot-price forecast errors. The extent to which they are not correlated defines basis risk, which cannot be offset by hedging. Figure 4 shows visually that such a correlation often exists, but in 30 out of 89 months the futures price change and spot-price forecast errors had different signs (e.g., one was positive while the other was negative). In other

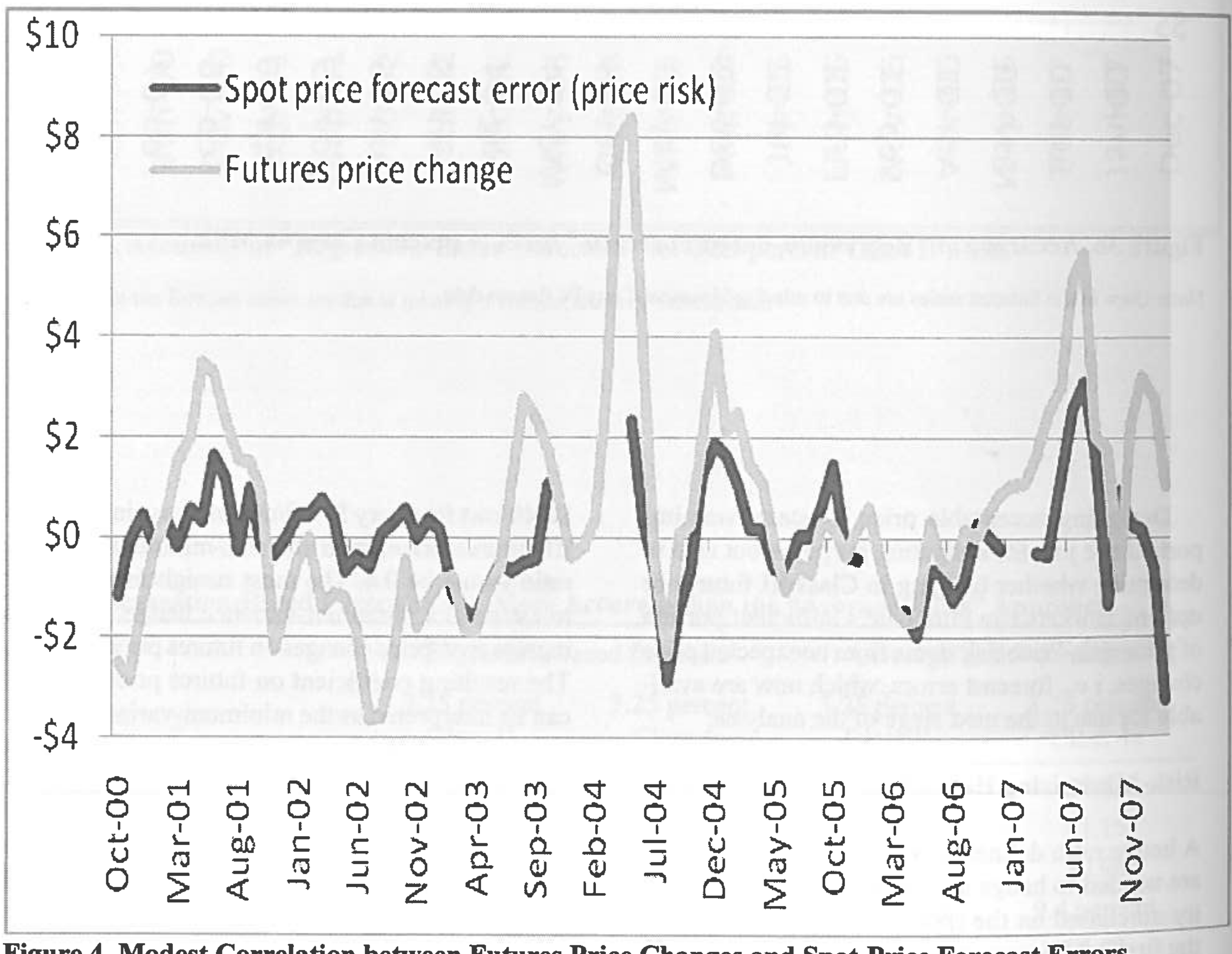

Figure 4. Modest Correlation between Futures Price Changes and Spot-Price Forecast Errors.

words, one-third of the time, hedging would have accentuated price risk rather than offsetting it.

In the regression

$$Forecast\ error_t = a + h^*(Futures\ price\ changes)_t + e_t, \quad (2)$$

the estimated value of the coefficient h was 0.28, and is the hedge ratio that produces the lowest variance in milk-cost budget deviations. This minimum-variance hedge ratio implies that the firm would hedge 70,000 cwt of monthly spot milk purchases by buying 70,000 / 2,000 * 0.28 ≈ ten Class III futures contracts four months before expiration. To lift the hedge, the firm would either sell the ten futures contracts when price-risk protection is no longer desired, or simply let the cash-settled contracts expire and realize any accrued futures gain or loss.

Knowing that 0.28 is the minimum-variance hedge ratio does not guarantee an acceptable level of hedging effectiveness; it only implies that other hedge ratios will be less effective. The adjusted R^2 measure of hedging effectiveness in this application was 31 percent, which is not especially high. In contrast, a similar analysis at the farm level produced milk-hedging effectiveness values exceeding 50 percent for most parts of the country (Maynard, Wolf, and Gearhardt 2005). In some other commodities, especially grains, hedging effectiveness is typically very high.

As a forecast becomes increasingly accurate, there will be smaller forecast errors and therefore less price risk available for hedging to eliminate. For example, when the analysis was repeated using forecast errors from the simpler but inferior "average-basis" forecasting approach, the hedging effectiveness was 47 percent.

This interdependence between the forecast accuracy and hedging effectiveness prompted questions about what exactly the firm perceives as price risk. The response was consistent with the textbook definition of price risk as forecast errors. Underestimating the true price was viewed as causing "budget risk," while over-estimating the true price causes "opportunity risk." Using this perspective, hedging and more accurate forecasting can both be tools for reducing price risk.

Another perspective might treat price risk simply as variation in milk input costs, net of hedging outcomes. This is equivalent to using an unchanging forecast such as a recent five-year average. Repeating the analysis under this definition of price risk, the "risk-minimizing" hedge ratio climbed to 0.73, but the hedging effectiveness was only 27 percent. Alternatively, price risk might be viewed as milk input costs greater than an arbitrary threshold. The next section shows that hedging typically was unable to cap costs at a lower level than the spot market.

Milk Cost Profiles With and Without Hedging

The alternatives compared in this section are uniform hedging with futures at the minimum-variance hedge ratio of 0.28, uniform hedging with call options at the 0.28 hedge ratio, and not hedging. Knowing how the hedging strategies would have performed since 2000 if they had been used offers the most reasonable prediction of how they might perform in the future. In the case of options hedging, the results reflect the monthly purchase of call options that were \$0.50–\$0.75/cwt "out of the money," (i.e., given the June Class III futures price of \$16.30/cwt on February 6th, the June Class III call option with a \$17.00/cwt strike price would be used in the option-hedging simulation).

Figure 5 shows that uniform hedging would have had a modest impact on the milk cost profile during the last eight years. Hedging would have helped contain cost increases by \$0.31/cwt on average during 2001, \$0.63/cwt during 2004, and \$0.67/cwt during 2007. Table 4 shows that hedging would have modestly reduced the overall variability of milk costs, as measured by standard deviation and coefficient of variation. Uniform hedging would not have noticeably reduced the maximum costs encountered during the 2000–2008 period. The table indicates a slightly lower average cost when hedging was used, mainly due to large hedging gains in 2004 and 2007, but this is not a typical outcome from hedging.

Cash-Flow Considerations

Hedging with futures requires maintaining a margin account, with sufficient reserves to meet potentially unlimited margin calls. Hedging with options, however, only requires the up-front payment of the option premium. Under the uniform hedging strategy evaluated here, most futures positions lost money at some point during the four-month hedge duration,

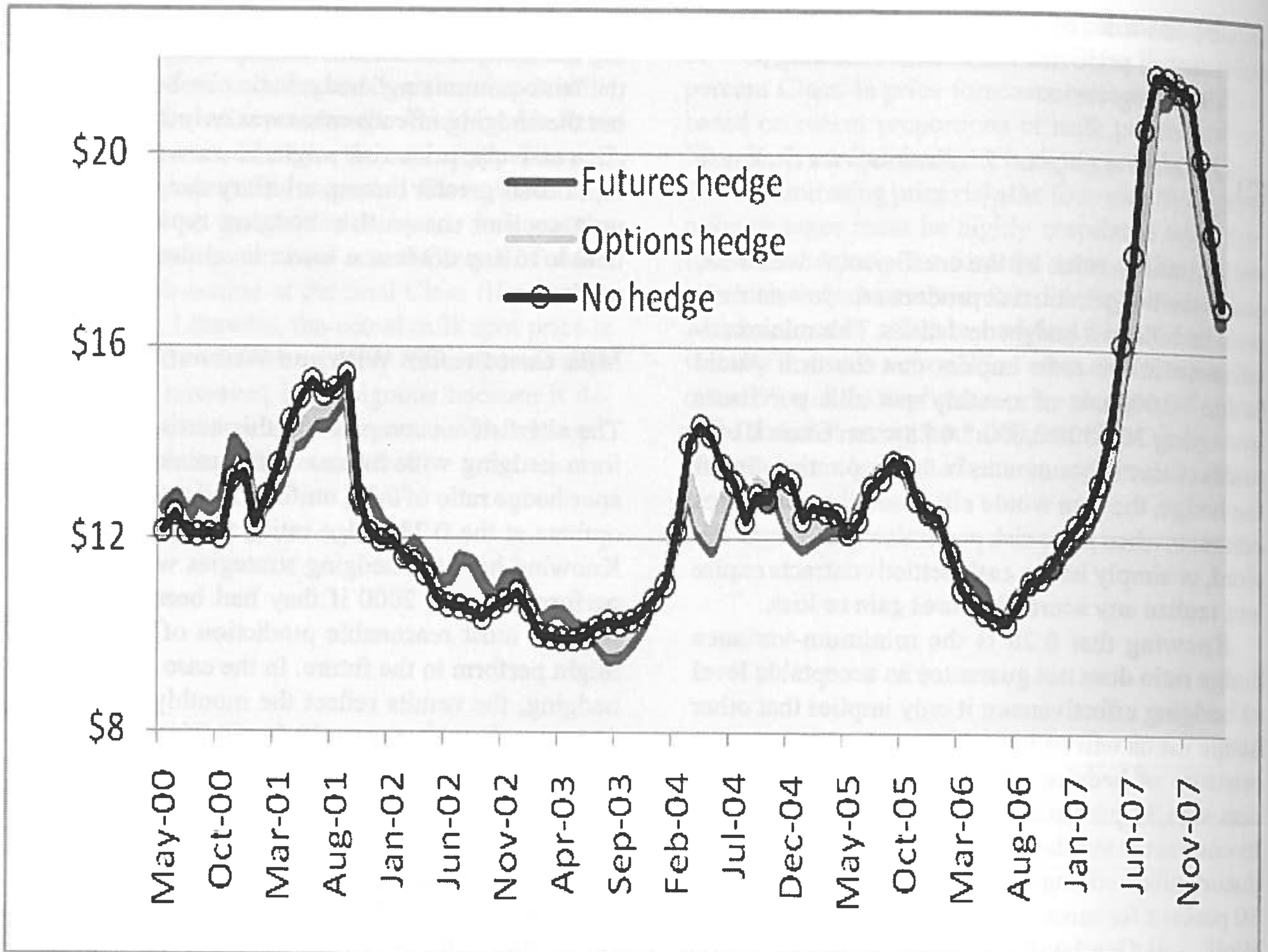

Figure 5. Net Milk Cost with Uniform Futures Hedging, Options Hedging, and No Hedging.

Table 4. Uniform Hedging Would Have Only Slightly Reduced Cost Variation in 2000–2008.

	Futures hedge	Options hedge	No hedge
Average cost ($/cwt)	$ 12.77	$ 12.78	$ 12.89
Standard deviation	$ 2.53	$ 2.64	$ 2.79
Coefficient of variation (std. dev. / average)	20 percent	21 percent	22 percent
Lowest cost	$ 9.49	$ 9.78	$ 9.91
Highest cost	$ 21.74	$ 21.66	$ 21.74

even when they later expired with a gain. Figures 6 and 7 provide two ways to visualize the magnitude of these paper losses.

Currently, hedgers must post an initial margin of $1,300 for each Class III futures contract, and any subsequent paper losses must be matched with additional margin deposits. Using the paper losses accumulated on any given day from 2000–2008, and bearing in mind that up to four hedges of ten futures contracts each might be in place on a given day, Figure 8 shows the funds devoted to meeting margin requirements. Bear in mind that all margin deposits are returned when a hedge is lifted, but they tie up funds that could be used elsewhere.

The options evaluated in this analysis were $0.50–$0.75/cwt out-of-the-money, which offer moderate protection against rising milk costs for a moderate premium cost. Figure 9 shows the funds needed to maintain hedges of ten options per delivery month, with up to four delivery months being hedged simultaneously. An option premium is an expenditure that is recovered, partially or fully, if the option expires in-the-money. Figure 9 isolates the expenditure component of the options-hedging strategy, which is considerably more stable than the futures-margin deposit profile in Figure 8. Overall, the option premium expenditures were more than offset by option gains during the 2000–2008 period, producing net negative cash flow only through April 2001 and during the first half of 2003.

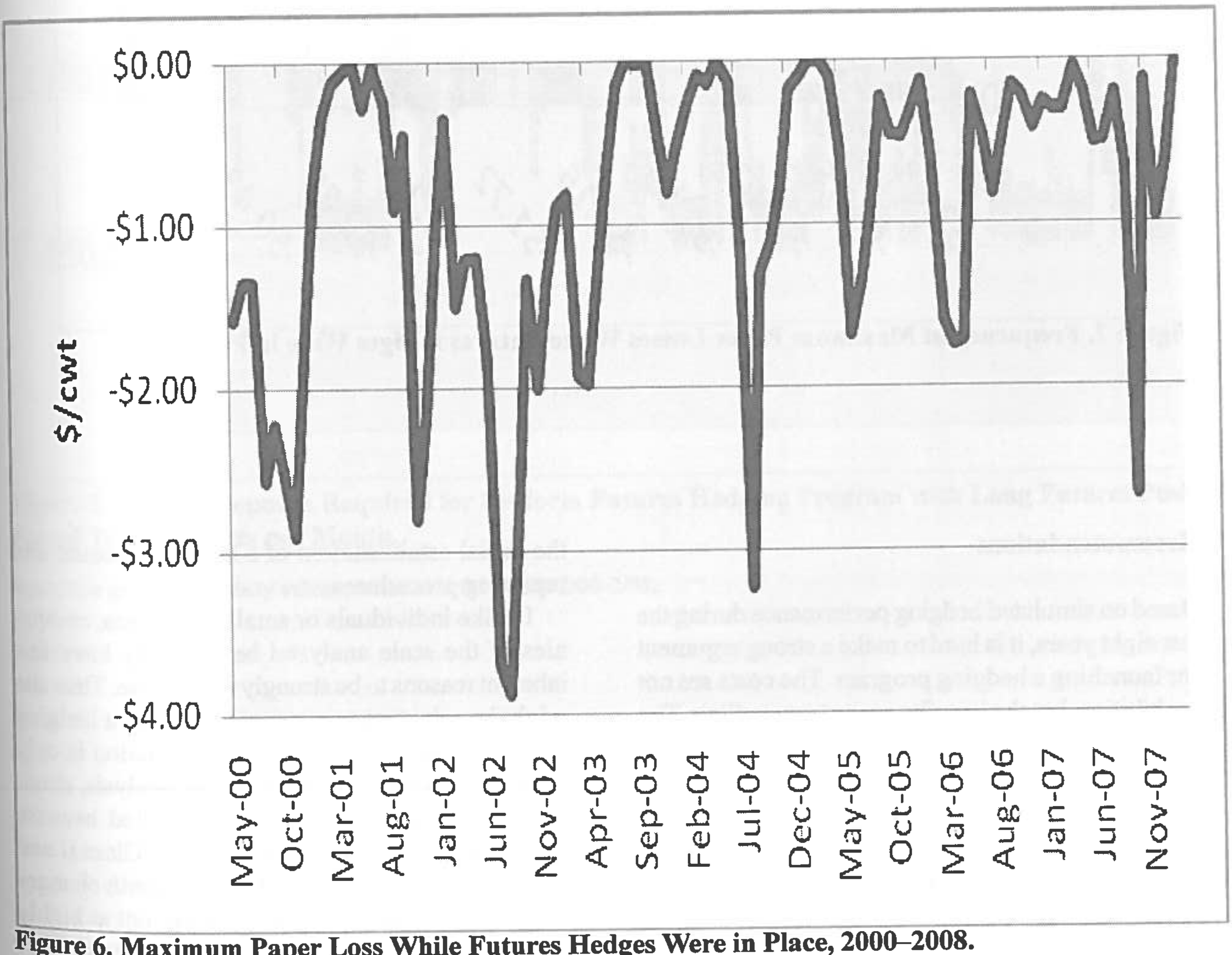

Figure 6. Maximum Paper Loss While Futures Hedges Were in Place, 2000–2008.

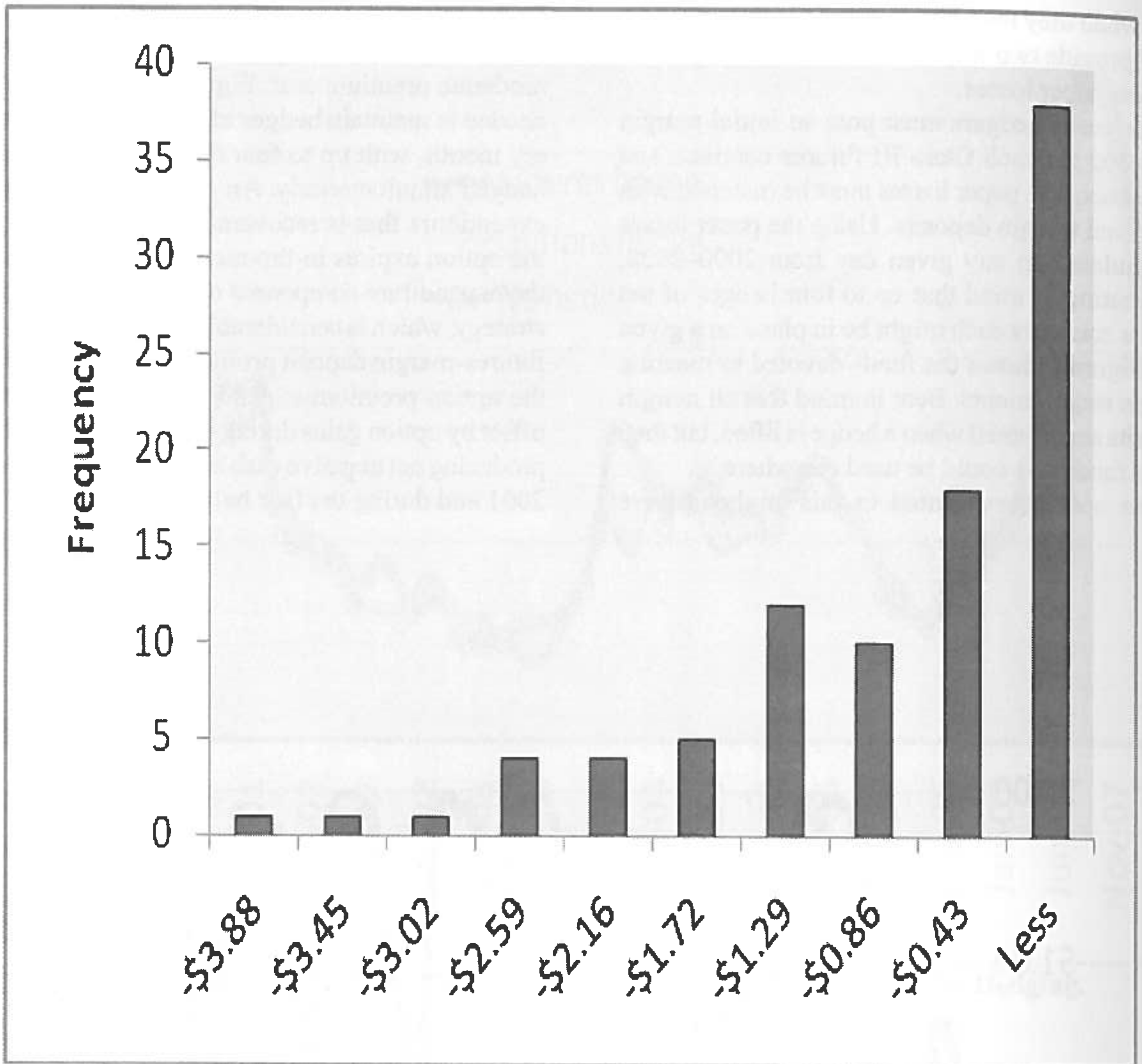

Figure 7. Frequency of Maximum Paper Losses While Futures Hedges Were in Place.

Recommendations

Based on simulated hedging performance during the last eight years, it is hard to make a strong argument for launching a hedging program. The costs are not prohibitive, but the benefits are not compelling. The benefits are a modest reduction in unforeseen cost volatility, with equally modest impact on the net milk cost profile. The financial costs include the opportunity cost of committing $50,000–$250,000 to margin deposits or option-premium expenditures. Personnel and management costs of administering a hedging program are not likely to be high after the initial establishment of a hedging account and reporting procedures.

Unlike individuals or small businesses, companies of the scale analyzed here usually have few inherent reasons to be strongly risk-averse. Thus one might be reluctant to suggest launching a hedging program when the expected risk reduction is only weak or moderate. Before doing the analysis, stronger hedging effectiveness was expected because of the 79 percent correlation between Class II and Class III prices. However, the four-month changes in spot prices and futures prices were not as highly correlated (about 56 percent), and it is these changes

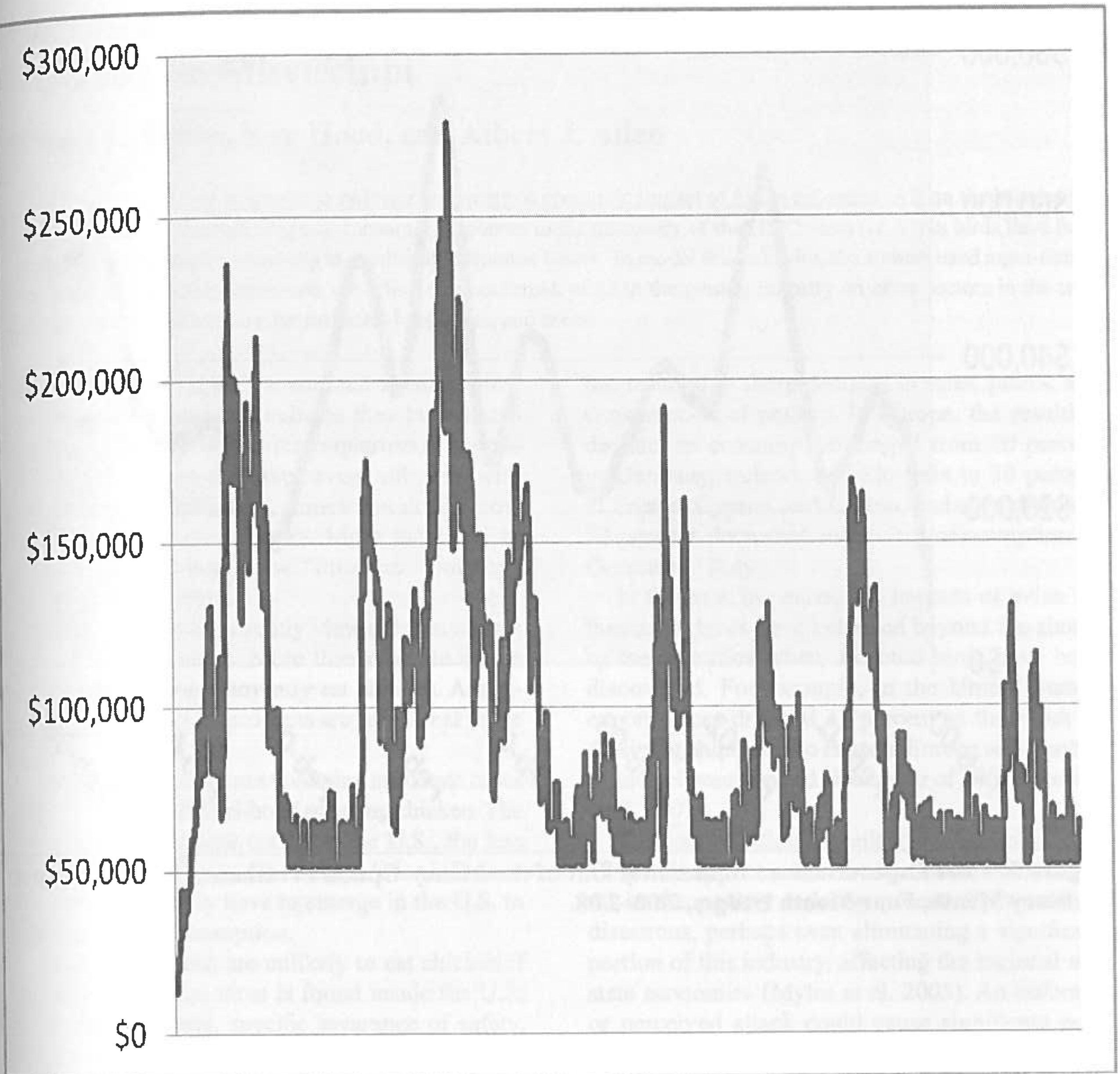

Figure 8. Margin Deposits Required for Uniform Futures Hedging Program with Long Futures Position of Ten Contracts per Month.

Note: This graph shows daily values plotted over the period 2/00–2/08.

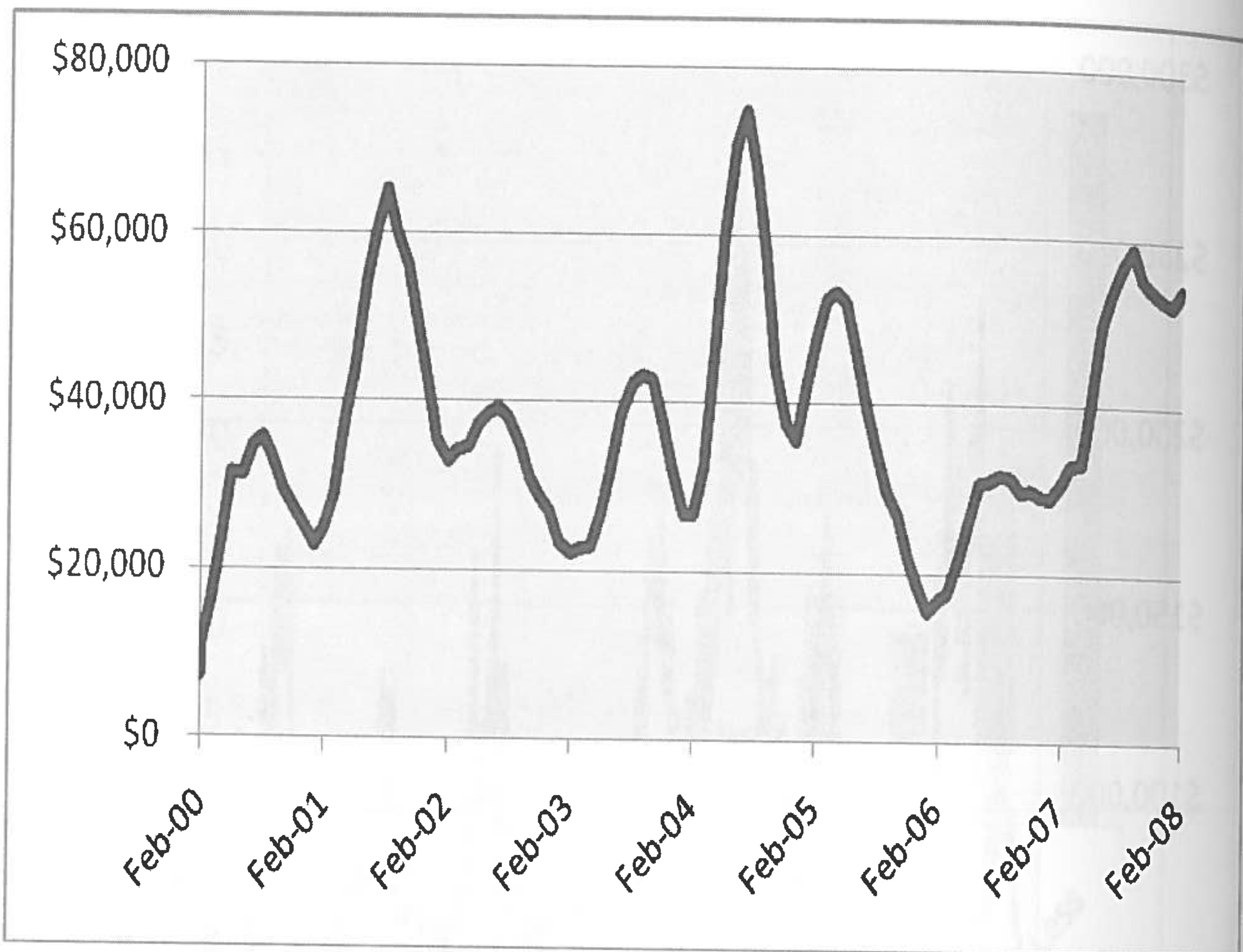

Figure 9. Total Expenditure on Moderately Out-of-the-Money Option Premiums, Ten Options per Delivery Month, Four-Month Hedges, 2/00–2/08.

that determine hedging effectiveness. Identifying the four-month spot price changes (i.e., forecast errors) was a major goal of the analysis, and is in itself a useful price-risk-management tool.

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