United States Department of Agriculture

Before The Secretary of Agriculture

In re: [Docket No. 23-J-0067; AMS-DA-23-0031]

Milk in the Northeast and Other Marketing Areas

Hearing beginning August 23, 2023

Opposition Testimony In Association with Topic 4: Base Class I Skim Milk Price

Testimony Presented By:

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Over the previous two weeks, several assertions have been recurringly invoked in support of Proposal 13, or in opposition to other proposals on the topic #4 – Base Class I Skim Milk Price. These assertions, paraphrased as I understood them to mean, are the following:

1. "Average-of" pricing regime is not necessary to facilitate hedging because Class I can be hedged under "higher-of" pricing approach using swaps.
2. U.S. Generally Accepted Accounting Principles (GAAP) require correlation coefficient to be between 0.8 and 1.25 for risk management activities to be recognized as hedging for accounting purposes.
3. "Higher-of" pricing regime would not 'detract' from risk management vs "average-of" pricing regime.
4. "Average-of" pricing regime caused depooling in recent years.

In this rebuttal testimony, I am presenting my preliminary analysis of these arguments. Further and more thorough analysis will be included in Edge's post-hearing brief.

Assertion #1: "Average-of" pricing regime is not necessary to facilitate hedging because Class I can be hedged under "higher-of" pricing approach using swaps.

Rebuttal

It was stated by a National Milk Producers Federation (NMPF) expert witness that Over-The-Counter (OTC) contracts would suffice for hedging if Base Class I Skim Milk Price were to be set to the higher of Advanced Class III Skim Milk Price and Advanced Class IV Skim Milk Price. Over the last few days, I reached out to OTC providers and brokers with deep understanding of the OTC market. I asked them to 'give me a quote', assuming that we are back in the higher-of pricing regime. The cost they quoted me was $0.30/cwt. Let me illustrate what that means. For example, let's imagine a Class I handler wanted to lock in the Class I Skim Milk Price. In this example, expected prices for Class III Skim Price and Class IV Skim Milk Price, implied from milk and butter futures prices, are respectively $14.00 and $13.00, then the OTC provider may offer a swap at $14.30 – the higher of two futures prices plus $0.30/cwt. That is akin to buying a futures contract that settles on the higher-of Advanced Class III Skim Price and Advanced Class IV Skim Price, except that the buyer does not need to post margin calls if prices decline. The difference between the higher-of the two expected prices and the swap price is the cost of hedging that must be absorbed by Class I handler. Expected profit margin is reduced by $0.30/cwt. If the Class I handler has a profit margin that is small relative to the swap premium, they would simply not be able to hedge – even if hedging instruments are technically available.

Under the average-of approach, Class I handler does not need to go to the swap dealer. They can hedge using the CME futures directly. Brokerage commissions vary from $5 to $30 per contract per transaction. Contract size is 200,000 lbs or 2,000 cwt. If the handler needs two contracts to create an average-of hedge, and closes the futures position (rather than waiting for contracts to expire), the cost, at the high end, would be 2 x $60 per 400,000 lbs of milk. That translates to 3 cents per cwt ($0.03/cwt). The cost is 10 times lower than under OTC. Occasionally, Class I handlers may still want to buy a swap rather than take a futures position, as that helps avoid margin calls in case of large price swings. But the cost of those swaps may go up to 10 cents per cwt ($0.10/cwt), which is still 3 times cheaper than the swap cost under higher-of regime.

Assertion #2: U.S. Generally Accepted Accounting Principles (GAAP) require correlation coefficient to be between 0.8 and 1.25 for risk management activities to be recognized as hedging for accounting purposes.

Rebuttal

The issue of the correlation coefficient may appear technical to dairy producers or policymakers, but it is important to understand what numbers 80% and 125% within GAAP really mean so we can properly evaluate hedge effectiveness of alternative policy proposals noticed for this hearing.

Correlation coefficient is defined as follows:

$$\rho = \frac{cov(x, y)}{\sigma(x)\sigma(y)}$$

where x and y are some stochastic variables, such as prices. If x and y tend to "move together", then covariance between them, $cov(x, y)$, will be positive and high, and correlation coefficient will be positive and high. In the extreme case, if x and y are exactly the same, then $cov(x, y) = \sigma^2(x)$, in that case, the correlation coefficient is equal to:

$$\rho = \frac{\sigma^2(x)}{\sigma(x)\sigma(x)} = 1$$

It is not mathematically possible for correlation be higher than 1, or lower than -1.

As for the GAAP, the numbers cited, 80% to 125% do not refer to the correlation coefficient. Accounting standards are focused on the extent to which changes in cash flows of the hedging instrument offset changes in the cash flows of the hedged item. For example, if Class I skim price is projected to be $18.00/cwt based on current futures prices, and the actual value turns out to be $21.00/cwt, then the change in the hedged item is $3.00/cwt. Using a 'dollar-offset method', an evaluation would be made to assess if the hedging instrument would result in hedging gains equal to 80% to 125% of $3.00/cwt, i.e. $2.40/cwt to $3.75/cwt.

Assertion #3: "Higher-of" pricing regime would not 'detract' from risk management vs "average-of" pricing regime.

Rebuttal

There are three reasons why hedging Class I Milk Price may not result in hedging gains that perfectly offset unexpected increases in Class I Milk Price:

1) **"Mover" Risk:** If hedging with Class III or Class IV futures, and Class I Skim Milk Price is based on the higher-of Class III Skim Milk Price and Class IV Skim Milk Price (whether Advanced or final), there is a "mover" risk, i.e. the risk that the hedge will be based on the 'wrong' contract. For example, at the time when the hedge is initiated, Class III futures price is higher than the Class IV futures price. However, published Class IV Skim Milk Price is higher than Class III Skim Milk Price.
2) **"Advanced Prices" Risk:** If Class I Milk Price is based on Advanced prices calculated using surveys of commodity prices during the middle two weeks of the prior month, then it is likely that the full-month average skim milk prices (for the month during which two-week averages are calculated) will not be equal to the two-week average prices.
3) **Bid-Ask Spread / Risk Premium**: Even if advanced prices are not used in pricing, and a Base Class I Milk futures contract is introduced by the Chicago Mercantile Exchange Group, it is still possible that the futures price may contain upward bias, i.e. that Class I Milk futures price is not an unbiased expectation of AMS-published Base Class I Milk price. If the arbitrage between Base Class I Milk futures contract and Class III and IV milk futures is costly, then arbitragers and market makers will impose a wide spread between the price at which they are willing to sell such Base Class I Milk futures and the price at

which they are willing to buy it. The transacted price will be higher than the expected price, and the hedging gains will be lower than the unexpected change to the Base Class I Milk Price, thus reducing hedge effectiveness.

Most proposals noticed for this hearing suffer from at least one of these three sources of hedging ineffectiveness. The summary is provided in the table below.

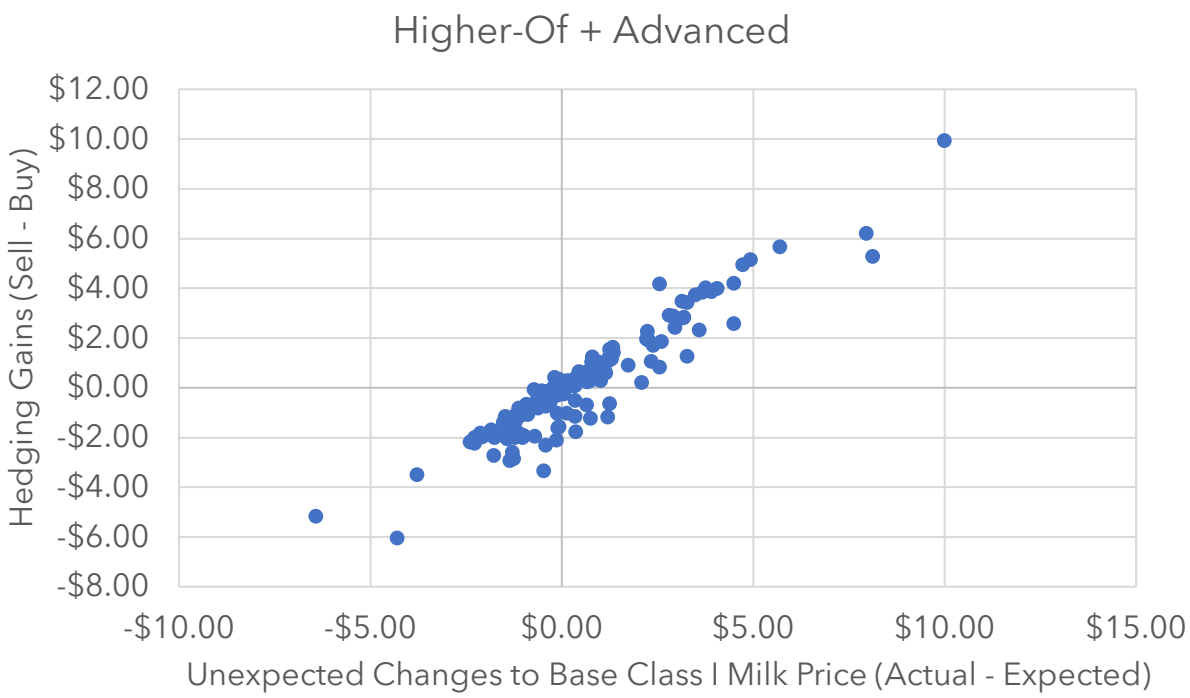
Proposal #No	Eliminates Mover Risk?	Eliminates Advanced Prices Risk?	Eliminates Bias / Risk Premium?
Proposal #13 by NMPF	**No**	**No**	**Yes**
Proposal #14 by IDFA	**Yes**	**No**	**Yes**
Proposal #15 by MIG	**Yes**	**No**	**Yes**
Proposal #16 by Edge	**Yes**	**Yes**	**Yes**
Proposal #17 by Edge	**Depends on CME**	**Yes**	**No**
Proposal #18 by AFBF	**Depends on CME**	**Yes**	**No**

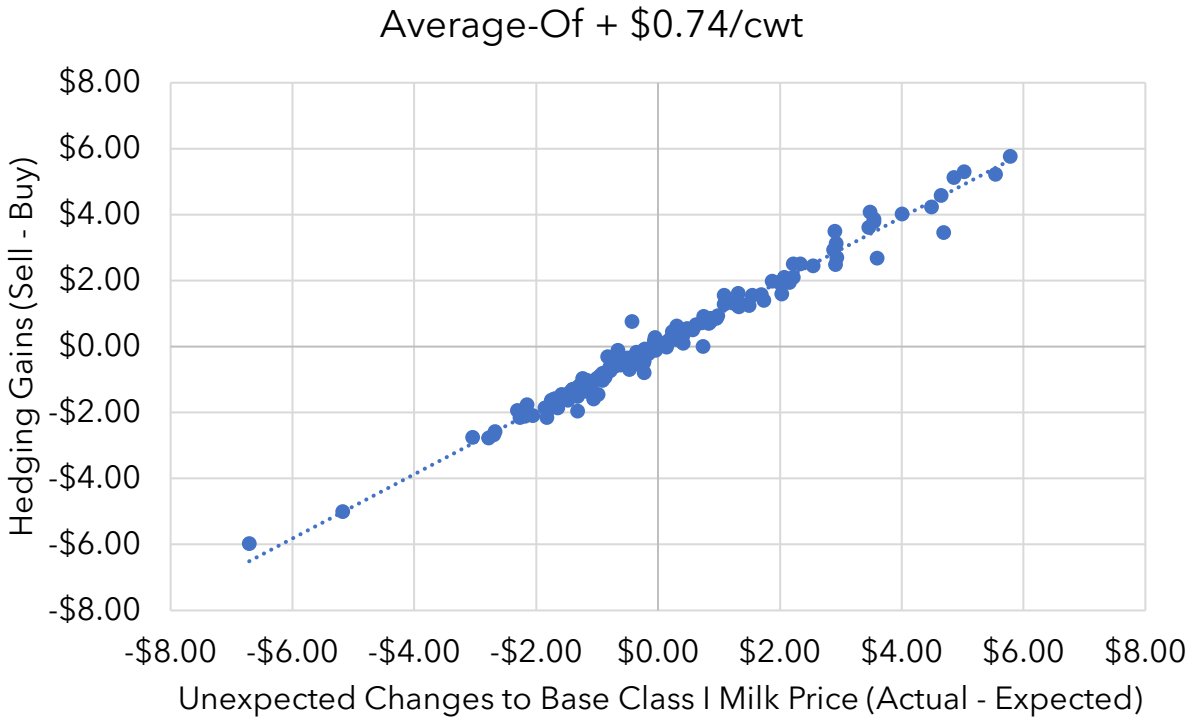
Due to its design, and the fact that futures contracts are cash-settled, proposal #16 will fully eliminate basis risk and quantitative analysis is redundant. Proposals #17 and #18 cannot be quantitatively analyzed using historical data as information on bid/ask spread on Class I futures contract is unknown. As for proposals #14 and #15, as long as the hedging horizon is shorter than the lag at which the adjuster is recalibrated, their hedging effectiveness from the Class I handler perspective, will equal the hedging effectiveness of the current pricing regime (average-of + $0.74/cwt).

Therefore, in this testimony it is sufficient to compare hedging effectiveness under "higher-of" and under the current pricing regime – "average-of" + $0.74/cwt.

To assess the relative effectiveness of hedging under higher-of vs average-of, I built a hedging program under each regime, with the methodology described below. The full calculation is included in the enclosed Excel spreadsheet (Edge-15A). The conclusions are:

1) Residual basis risk (measured as a standard deviation of the sum of unexpected changes in Base Class I Milk Price and hedging gains) under "higher-of" is $0.75/cwt, vs. only $0.27/cwt under "average of". In other words, basis risk is nearly three times as large under the higher-of than under the average-of regime.
2) "Mover" risk is substantial under "higher-of" regime. From January 2011 through June 2023, over 150 months, the actual mover class was different than the expected mover class in 49 months, or 32.6% of the time. To illustrate the "mover" effect consider the scattergrams that relate the unexpected changes to the Base Class I Milk Price to hedging gains under a program designed to offset such unexpected changes.





If the hedging program eliminates the basis risk, then all the dots would fall perfectly on the 45-degree line. In the 'higher-of' regime, close to a third of the dots are substantially removed from the 45-degree line. In most of these cases, the unexpected changes in the Base Class I Milk Price were accompanied by the unexpected change in the 'mover' class. In the average-of regime, the

dots are much closer to the 45-degree line, but the relationship is not perfect, due to the "Advanced Price" risk.

3) Hedging under the average-of method would clearly meet effectiveness standards required for hedge accounting status. A hedging program with futures contracts, under higher-of pricing regime, would have major difficulties achieving such status.
4) "Advanced Prices" risk remains substantial under the "average-of" regime. The number of months in which hedging gains do not fall in the range of 80% to 125% of changes in Class I Milk Price is reduced by 25% under "average-of" vs. "higher-of" regime, due to the elimination of the "Mover" risk. Nevertheless, it is still the case that in 42 out of 150 months, the hedging gains fall outside that range. It is important to note however that the "dollar-offset" method produces uninformative measurements when the change in the hedged item is very small. If we restrict the sample to months in which the change (either positive or negative) in the Base Class I Price was higher than $0.375/cwt, then under average-of regime, hedges fall in the 80% to 125% range in 102 out of 123 months, or 83% of the time.

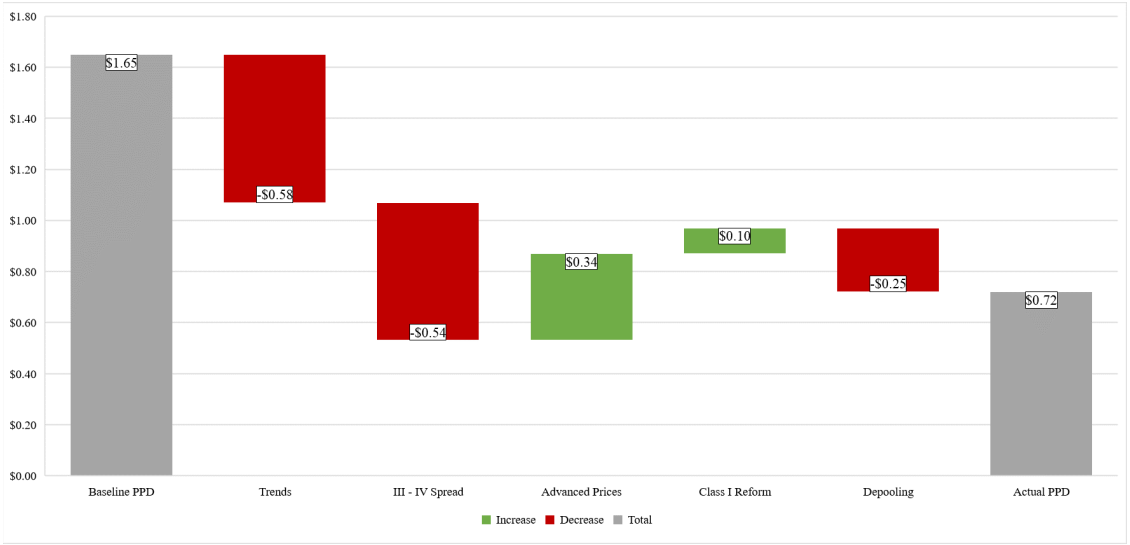
The conclusions decisively disprove the assertion that "higher-of" would not 'detract' from hedging Class I Milk input costs.

Assertion #4: "Average-of" pricing regime caused depooling in recent years.

Rebuttal

Prof. Christopher Wolf and I developed a methodology for decomposing Producer Price Differentials, and have published that manuscript in the Journal of Dairy Sciences (Exhibit-76, Edge-2). I will use that methodology to do a walk-through of the PPDs for FMMO #33 (Mideast) from March through December 2020.

March 2020



In March 2020, announced prices are lower than advanced prices. Lockdowns start in the second half of the month and are not yet fully reflected in monthly milk prices.

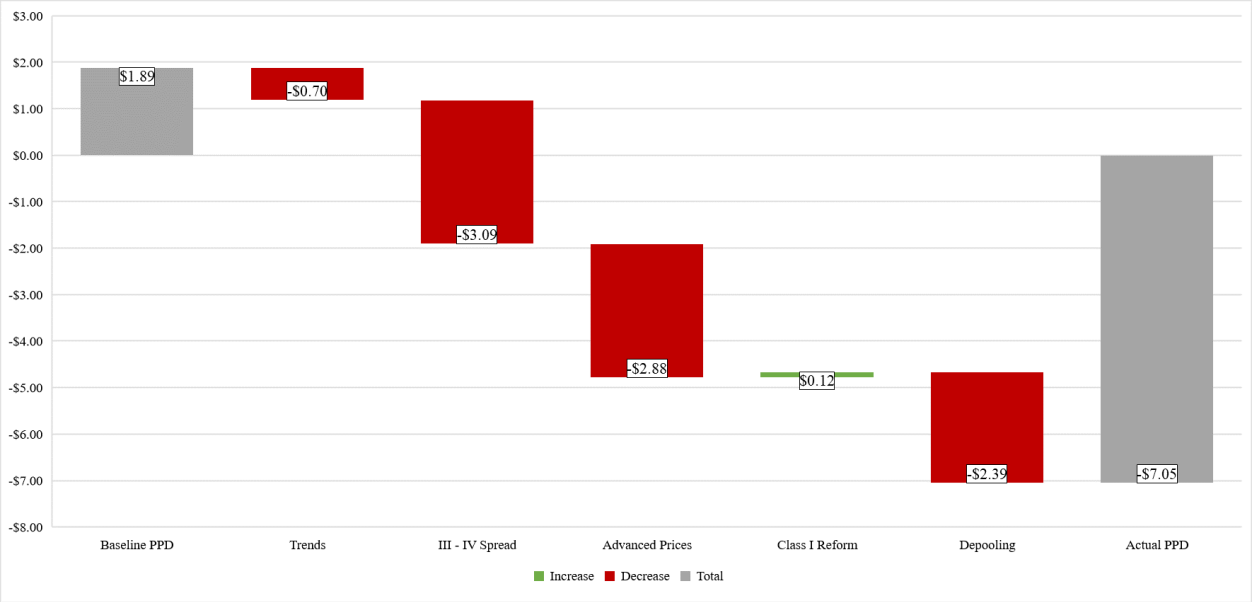
April 2020

The country is relatively locked down. Milk prices subside dramatically. Advanced Prices, measured in mid-March are higher than full-month April prices and lift PPD up by $0.91/cwt.

May 2020

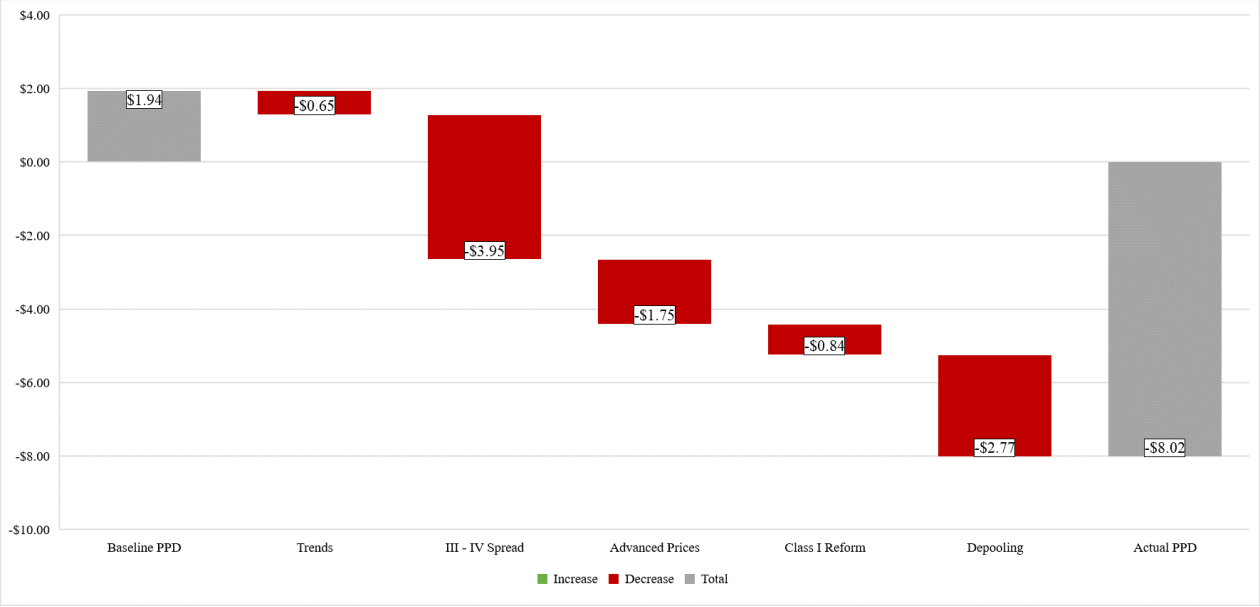
Prices continue to fall. Advanced prices continue to offer some PPD support. PPD is +$0.59/cwt.

June 2020



Farmers to Families Food Box program kicks into effect. Cheese prices skyrocket. Class III-IV spread expands. Advanced prices are much lower than announced prices and contribute to negative PPD. Advanced Class III and Class IV skim milk prices in May 2020 were not far apart, so Class I reform contributes $0.12/cwt towards mitigating the negative PPD. Depooling is pervasive. PPD is -$7.05/cwt.

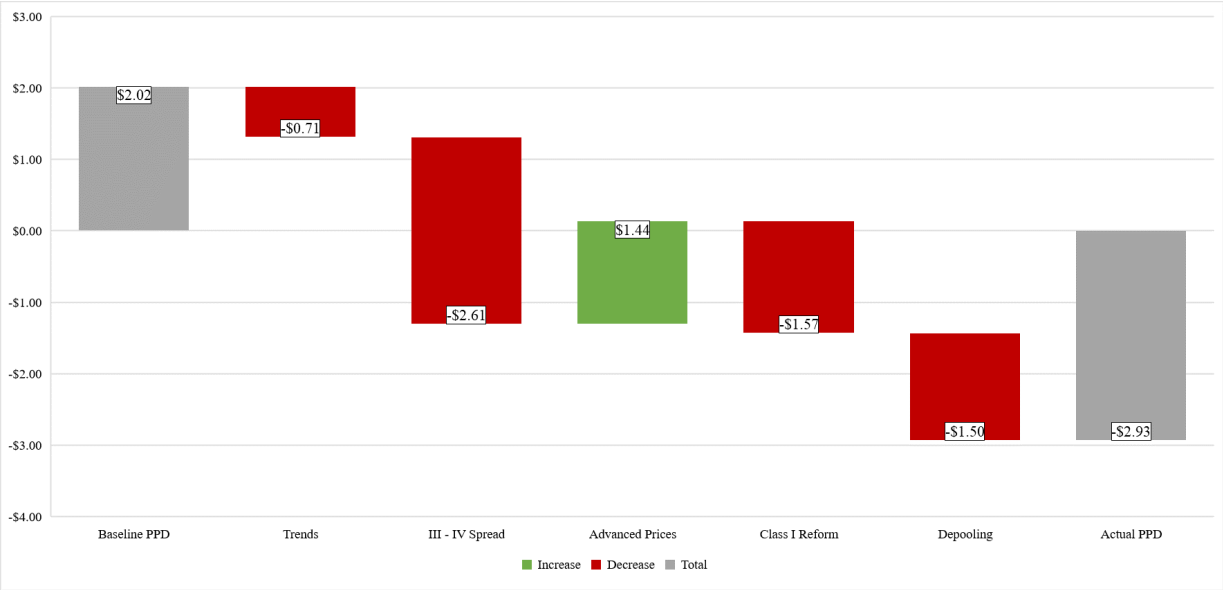
July 2020



The spread between Class III and Class IV continues to be the dominant factor causing negative PPDs. Advanced prices contribute another -$1.75/cwt. Even if there was no depooling, and no Class I reform, PPD in the Mideast order would have been lower than -$4.00/cwt. At that level,

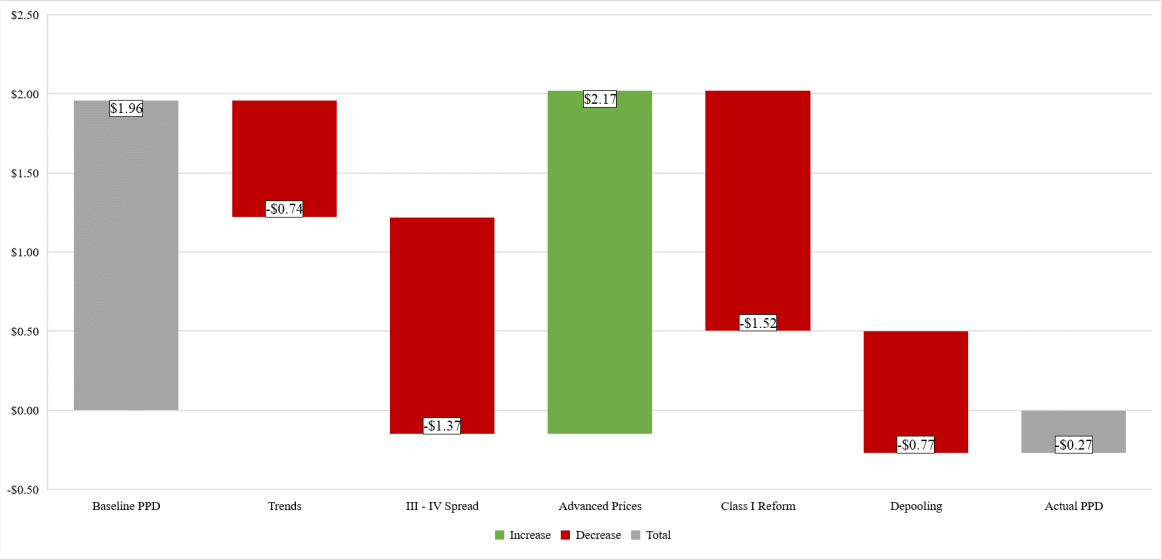
depooling would be pervasive even in the absence of the Class I reform. Class I reform contributed -$0.84/cwt to negative PPDs, but it is highly questionable how much incremental impact that had on the amount depooled.

August 2020

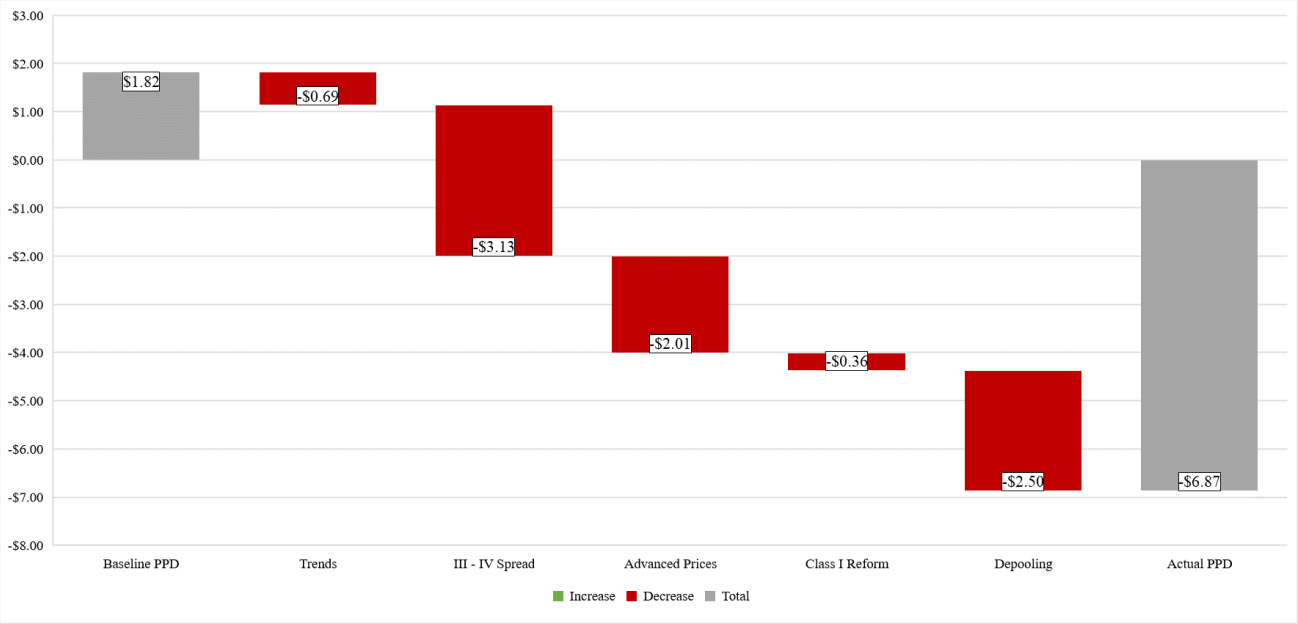


Full-month prices drop, advanced prices contribute +$1.44/cwt to PPD. In the absence of depooling and Class I reform, PPD might have been just slightly higher than zero. However, large spread between Class III and IV persists, and Class I reform pushes the PPD back in the negative territory. If there is any month in 2020 where one could reasonably question whether Class I reform deepened the depooling, it would be August 2020. However, data from the PPD report reveals that more milk was pooled in August than in July 2020. Class III milk pooled increased from 72,047,123 to 140,207,844 lbs. Negative PPD is likely deepened – not through depooling as labeled on the chart above, but by the increase in pooled Class II milk, from 318,125,699 lbs in July to 416,164,395 lbs in August.

September 2020

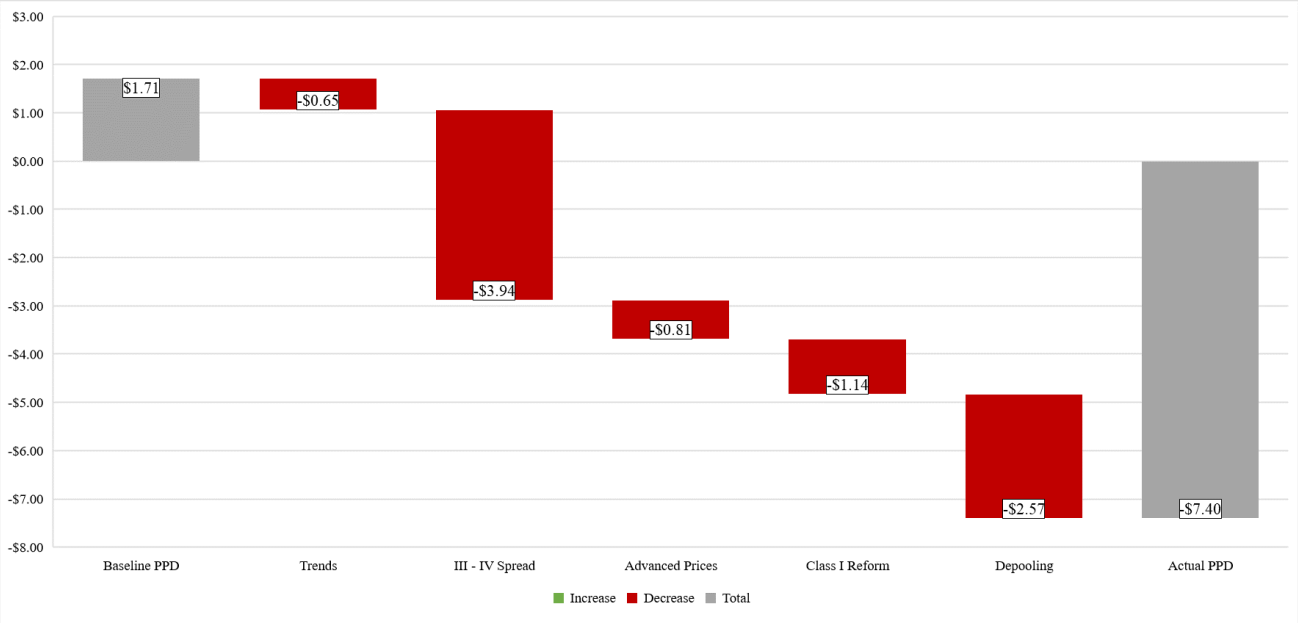


October 2020



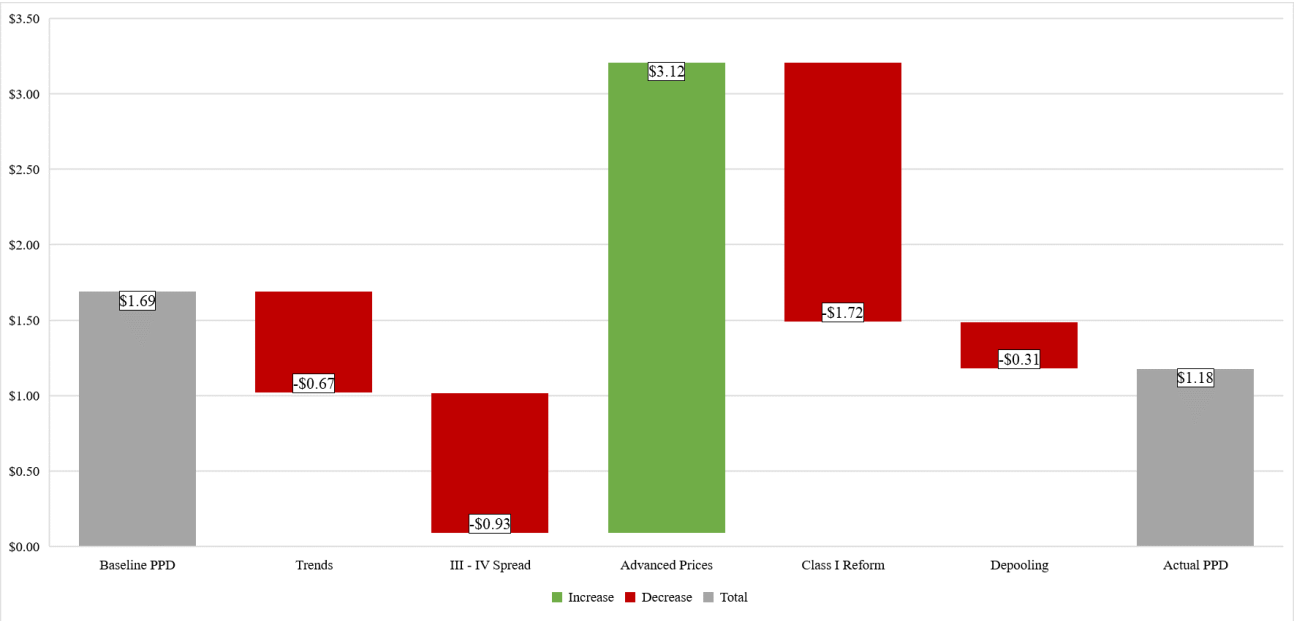
Another round of government purchases, and another rally in Class III milk price. PPD is negative, -$6.87/cwt with Class I reform likely not contributing much to depooling.

November 2020



November 2020 PPD is -$7.40/cwt. Without Class I reform and depooling, it would still be nearly -$4.00/cwt, which implies that most if not all of depooling would have happened anyway.

December 2020



Another large price drop, which compresses the spread between Class III and IV. Class I reform contributes -$1.72/cwt to PPD, but PPD remains positive at +$1.18/cwt. Class III pooled pounds increase from 93,062,503 lbs in November to 260,657,016 lbs in December.

These decomposition charts confirm the conclusions from the Exhibit #76, the Bozic and Wolf 2022 paper. The primary driver of depooling in 2020 was the large spread between Class III and Class IV milk prices. The second most important factor was advanced prices. Class I reform did make PPD more negative in some months, but the PPD would be at historically negative levels anyway, even if Class I was priced using "higher-of" approach. The assertion that Class I reform *caused* depooling is disproven by this analysis.

Appendix I – Hedge Effectiveness Excel Workbook Walkthrough

Tab: Futures

- Contains all end-of-day futures prices for Class III and Class IV Milk Futures for contract months January 2010 through August 2025, as observed on trading days January 31, 2008, through September 25, 2023.
- The data is extracted from the Understanding Data & Markets (UDM) data service maintained by Bozic LLC. The data is cloud-connected and can be refreshed (updated) by users who hold a UDM license.

Tab: Calendar

- Contains dates on which the AMS report *Announcement of Advanced Prices and Pricing Factors* was or will be published between December 23, 1999, and November 20, 2024.
- The data is extracted from the Understanding Data & Markets (UDM) data service maintained by Bozic LLC. The data is cloud-connected and can be refreshed (updated) by users who hold a UDM license.
- These dates are used to determine the date on which hedge positions are closed.

Tab: AMS

- Contains actual advanced and announced prices from January 2000 through October 2023 as published by AMS.
- The data is extracted from the Understanding Data & Markets (UDM) data service maintained by Bozic LLC. The data is cloud-connected and can be refreshed (updated) by users who hold a UDM license.

Tab: Analysis

- Develops hedging programs under "higher-of" and "average-of" pricing regime.
- Develops expected Base Class I Price.
- Compares unexpected changes to Base Class I Price with hedging gains to assess hedging effectiveness.

To assess the relative effectiveness of hedging under higher-of vs average-of, I built a hedging program under each regime, with the methodology contained in the tab "Analysis" described below.

Step #1: Decide on the hedging horizon.

For this exercise, the hedging horizon is 120 days. The date when hedge is initiated is the latest trade date that is more than 90 calendar days before the start of the month that is prior to the month when milk will be hedged. For example, for milk that will be sold during the month of June 2023, [B155], the prior month starts on May 1, 2023 [C155]. The last trading date that is more than 90

calendar days before May 1, 2023, was January 30, 2023. The hedge is initiated on January 30, 2023 [D155].

Step #2: Observe futures prices on the hedge initiation date.

For milk that will be sold during June 2023, we will use May 2023 futures contracts, as the advanced price is published during May 2023. On January 30, 2023, Class III Milk futures for May 2023 [E155] closed at $18.49/cwt, and Class IV Milk futures [F155] for May 2023 closed at $18.30/cwt. Butter futures for May 2023 [G155] closed at $2.4275/lb.

Step #3: Calculate futures-implied expected Base Class I Milk under Higher-Of Regime

#3.1. From butter futures, we calculate futures-implied butterfat price:

$$Expected\ butterfat\ price\ =\ (Butter\ Futures - 0.1715)\ *\ 1.211$$

On January 30, 2023, the expected butterfat price [H155] for May 2023 was $2.7320/lb.

#3.2. We calculate expected Class III skim milk price and Class IV skim milk price for May 2023:

$$Expected\ Class\ III\ Skim\ Milk\ Price = (Class\ III\ Milk\ Futures - 3.5\ *\ Expected\ Butterfat\ Price)\ /\ 0.965$$

On January 30, 2023, expected Class III skim milk price [I155] for May 2023 was $9.25/cwt. Using similar calculations, the expected Class IV skim milk price [J155] for May 2023 was $9.05/cwt.

#3.3. We calculate expected Base Class I Skim Milk Price [K155] under higher-of regime as the higher of expected Class III Skim Milk Price and expected Class IV Skim milk price. This approach ignores nonlinearity in the max() operator, but in my assessment such simplification does not lead to misleading conclusions. On January 30, 2023, expected Base Class I Skim Milk Price for June 2023 was $9.25/cwt.

#3.4. We calculate expected Base Class I Price:

$$Base\ Class\ I\ Price = 3.5\ x\ Expected\ Butterfat\ Price + 0.965\ x\ Expected\ Class\ I\ Skim\ Milk\ Price$$

For June 2023, the expected Base Class I Price based on information known on January 30, 2023 was $18.49/cwt.

Step 4. Observe futures prices on the hedge close date.

We assume that the handler will unwind their hedge position on the date when the advanced prices are published. For June 2023, advanced prices were published on May 17, 2023 [N155]. On May 17, 2023, Class III futures for June 2023 [O155] was $16.19/cwt and Class IV futures for June 2023 [P155] was $18.10/cwt.

Step 5. Determine hedging gains under higher-of regime

#5.1. A critical decision a handler must make under higher-of regime is which futures contract to use – Class III or Class IV milk futures. In this exercise, I choose the contract that had the higher futures milk price on the date when the hedge was initiated. For May 2023 contract month, on January 30, 2023 Class III milk futures was higher than Class IV milk futures, so Class III milk futures contract would have been used for hedging Class I milk price exposure [R155].

#5.2. For the contract chosen for hedging, we observe the hedge open [S155] and hedge close [T155] price. For May 2023 contract, Class III milk futures price on hedge open was $18.49 as determined in Step #2, and the price on the hedge close date was $16.19/cwt as determined in Step #4.

#5.3 Hedging gains are always determined by taking the difference between the price at which the contract is sold and the price at which the contract was bought. To protect against price increase, Class I handler would buy a futures contract at hedge initiation and sell it on the hedge close date. For May 2023 contract, hedging gains were -$2.30/cwt, i.e. the hedger lost $2.30/cwt on their hedge position [U155].

Step 6. Determine Base Class I Milk Price under Higher-Of Regime

#6.1. From USDA published reports, I collect actual Advanced Class III Skim Milk Price [W155] and Advanced Class IV Skim Milk Price [X155]. Those prices were $7.17/cwt and $8.78/cwt respectively.

#6.2. The higher-of-based Base Class I Skim Milk Price is calculated as the higher-of Advanced Class III Skim Milk Price and Advanced Class IV Skim Milk Price. For June 2023, that price would have been $8.78/cwt [Y155].

#6.3. Advanced butterfat price for June 2023 was collected from USDA published reports. For June 2023, that price is $2.7412/lb [Z155].

#6.4. Base Class I Milk Price is calculated as:

$$\begin{aligned} &Base\ Class\ I\ Milk\ Price \\ &\quad = 3.5\ x\ Advanced\ Butterfat\ Price \\ &\quad + 0.965\ x\ Base\ Class\ I\ Skim\ Milk\ Price \end{aligned}$$

For June 2023, under higher-of regime, Base Class I Milk Price would have been $18.07 [AA115].

Step 7. Determine change in hedged item (Base Class I Milk Price).

I define the shock as the *unexpected* change in Base Class I Milk Price. This is calculated as the difference between actual Base Class I Milk Price and expected Base Class I Milk Price as determined in Step #3.4. Actual Base Class I Milk Price for June 2023 (under higher-of regime) would have been $18.07 as determined in #6.4, and projected or expected Base Class I Milk Price, as calculated in step #3.4 was $18.4949/cwt. The shock to Base Class I Milk Price was $18.07/cwt - $18.49/cwt = -$0.42/cwt.

For this month, the hedge was not effective. Class I handler's cash costs were $0.42 lower than expected, but their hedging losses were $2.42/cwt.

Why did the hedge not perform well?

At the time when the hedge was initiated, the expected mover contract was Class III. However, Class III milk dropped faster and further than Class IV. Higher-of regime limited the shock to Base Class I skim price to the difference between the futures-implied Class III skim price for May 2023, as observed on January 30, and actual advanced Class IV skim as published by USDA. From January 2011 through June 2023, over 150 months, the actual mover class was different than the expected mover class in 49 months, or 32.6% of the time. The hedge placed in the manner described above would be outside the 80-125% range 37% of the time.

Analysis under average-of + $0.74

We will keep the hedging horizon (Step #1) the same as in the previous analysis. Futures prices are also the same (Step #2).

Step 8. Calculate futures-implied expected Base Class I Milk under Average-Of Regime

I use the futures-implied expected Class III Skim Milk Price and expected Class IV Skim Milk Price as calculated in the step #3.2.

#8.1. Futures-Implied Base Class I Skim Milk Price is then calculated as:

$$Expected\ Base\ Class\ I\ Skim\ Milk\ Price = (Expected\ Class\ III\ Skim\ Milk\ Price + Expected\ Class\ IV\ Skim\ Milk\ Price)/2 + \$0.74$$

On January 30, 2023, the expected Class III skim milk price [I155] for May 2023 was $9.25/cwt and expected Class IV skim milk price [J155] for May 2023 was $9.05/cwt. Therefore, the expected Base Class I Skim Milk Price under average-of regime is $9.89/cwt.

#8.2. Futures-implied Base Class I Milk Price is calculated using the formula described in the step #3.4. On January 30, 2023, expected butterfat price [H155] for May 2023 was $2.7320/lb, and expected Base Class I Skim Milk Price under average-of regime is $9.89/cwt. Expected base Class I Price [AJ155] is $19.11/cwt.

Step 9. Determine hedging gains under average-of regime

To hedge Class I price exposure, the handler buys an equal number of Class III milk futures and Class IV milk futures, such that the total volume of milk hedged under all contracts equals the total raw milk expected to be purchased.

#9.1. Hedging gains on Class III milk contracts is calculated as the difference between Class III futures price on the hedge close date [O155] and Class III futures price on the hedge open date [E155], and the result is then divided by 2. For the May 2023 contract, Class III milk futures price on the hedge close date was $16.19/cwt and the price on the hedge open was $18.49. Hedging gains [AK155] are -$1.15/cwt

#9.2. Hedging gains on Class IV milk contracts is calculated as the difference between Class IV futures price on the hedge close date [P155] and Class IV futures price on the hedge open date [F155], and the result is then divided by 2. For the May 2023 contract, Class IV milk futures price on the hedge close date was $18.10/cwt and price on the hedge open date was $18.30/cwt. Hedging gains [AL155] are -$0.10/cwt.

#9.3. Total hedging gains [AM155] are the sum of hedging gains on Class III and Class IV positions. For the May 2023 contract, total hedging gains are -$1.25/cwt.

Step 10. Determine Base Class I Milk Price under Average-Of Regime

#10.1. As described in step #6.1. Advanced Class III Skim Milk Price [W155] and Advanced Class IV Skim Milk Price [X155] for June 2023 were $7.17/cwt and $8.78/cwt respectively.

#10.2. The average-of-based Base Class I Skim Milk Price is calculated as the average-of Advanced Class III Skim Milk Price and Advanced Class IV Skim Milk Price, plus $0.74/cwt, rounded to two decimal points. For June 2023, that price was $8.72/cwt [AN155].

#10.3. As described in step #6.3, advanced butterfat price for June 2023 was $2.7412/lb [Z155].

#10.4. Base Class I Milk Price is calculated as:

$$\begin{aligned} &Base\ Class\ I\ Milk\ Price \\ &\quad = 3.5\ x\ Advanced\ Butterfat\ Price \\ &\quad + 0.965\ x\ Base\ Class\ I\ Skim\ Milk\ Price \end{aligned}$$

For June 2023, under average-of regime, Base Class I Milk Price was $18.01 [AO155].

Step 11. Determine change in hedged item (Base Class I Milk Price).

As a reminder, the shock is defined as the *unexpected* change in Base Class I Milk Price. This is calculated as the difference between actual Base Class I Milk Price (#10.4) and expected Base Class I Milk Price as determined in Step #8.2. Actual Base Class I Milk Price for June 2023 (under average-of regime) was $18.01 as determined in #10.4, and projected or expected Base Class I Milk Price, as calculated in step #8.2 was $19.11/cwt. The shock to Base Class I Milk Price was $18.01/cwt - $19.11/cwt = -$1.10/cwt.

For this month, the hedge was effective. Class I handler's cash costs were $1.10 lower than expected, and their hedging losses were -$1.25/cwt. The ratio of hedging losses to cash gains is $1.25/$1.10 = 113.6%, which falls within the 80-125% range.

Standard deviation of shocks to the Base Class I Milk Price suggests how difficult it is to predict Base Class I Milk Price. Under higher-of regime, standard deviation is $2.21/cwt, and variance is $4.89. Under average-of regime, standard deviation of shocks to the Base Class I Milk Price is $1.98/cwt and variance is $3.92.

We can define a *basis risk* as the difference between hedging gain and shocks to hedged item. When hedging gain is exactly equal to the shock to the hedged item, then the hedging error is zero.

When hedging is highly effective, standard deviation of basis risk will be near zero. One way to evaluate hedging effectiveness is to calculate as:

$$Hedge\ Effectiveness = 1 - Variance\ of\ Basis\ Risk\ /\ Variance\ of\ Shocks\ to\ Hedged\ Item.$$

For hedging under the higher-of regime, the hedge effectiveness [AB158] is 88%. In contrast, for hedging under the average-of regime, hedge effectiveness [AP158] is 98%.