

UPPER MIDWEST MARKETING AREA

Analysis of Component Levels and Somatic Cell Count in Individual Herd Milk at the Farm Level

2021



Staff Paper 23-02

Prepared by:

Corey Freije

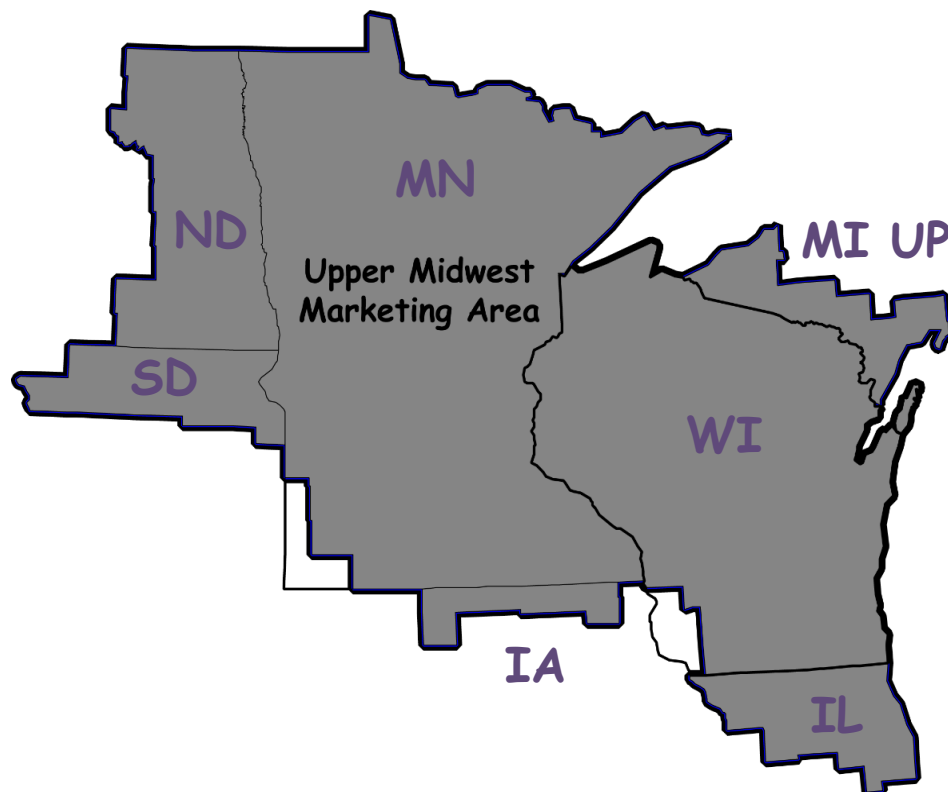
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Analysis of Component Levels and Somatic Cell Count in Individual Herd Milk at the Farm Level

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Corey Freije¹

Introduction

This study analyzes the component levels and values comprising milk production for Federal Order 30 for 2021. The payroll data for producers who were associated with the Upper Midwest Milk Marketing Order were examined. On average, 9,553 dairy producers were associated with the market every month.

The payroll data presented for this study are for those dairy farmers residing in any county in the states comprising Federal Order 30. In Michigan, only dairy farmers in the Upper Peninsula are included. The data are aggregated to the farm level which is consistent with other staff papers done by this office.

Data and Methodology

The data used in this analysis are from monthly payroll records submitted to the Upper Midwest Order. Since handlers generally submit their entire payrolls, the data include not only producer milk pooled on the Upper Midwest, but also may include, in some cases, producer milk pooled on other orders and milk historically associated with the order but not pooled in some months because of class price relationships and prices in other Federal marketing orders. The result is a difference between the number of producers and milk production reported in this study and the number of producers and milk production reported as pooled on the Upper Midwest Order.

Also, there are a number of instances in which there are multiple cases representing producer milk from one farm. These are situations where more than one producer received a share of the milk check, or there is more than one bulk tank on the farm. For individual producers, total monthly milk marketed, component pounds and somatic cell count (SCC) from payrolls submitted to the Market Administrator's office are aggregated

¹ The author, Dr. Corey Freije, is an Agricultural Economist with the Market Administrator's Office, Minneapolis, Minnesota.

to the farm level for this analysis. All producer milk was included in the analysis that follows, unless otherwise noted in the text, figures, or tables.

Other solids, for purposes of Federal milk order pricing, are defined as solids-not-fat (SNF) minus protein. Therefore, other solids consist primarily of lactose and ash. Ash traditionally has been considered a constant in SNF, while lactose does vary somewhat in the SNF.

Many factors such as weather, feed quality and feeding practices, breed of cattle, etc., may impact component levels and relationships among components in milk. No attempt was made to estimate the specific effects of such factors on milk composition. However, average component levels were examined for seasonal or within-year variation. In addition, component levels were examined for the seven primary states that are at least partially within the milk procurement area of the Upper Midwest Order. Since the procurement area stretches from south of Chicago to northwestern North Dakota, state level component and SCC statistics provide a means of reflecting variation in milk composition across a large geographic area. For 2021, average component levels by size of producer marketings were also examined.

This paper also looks at somatic cell count data for the period 2009 to 2021. The analysis seeks to identify and quantify a possible trend in decreasing somatic cell counts. The trend component must also be separated from the cyclical component endemic to somatic cell counts.

The cumulative value of butterfat, protein and other solids, adjusted for SCC, on an annual per cwt. basis, was examined to observe how milk values varied under differing constraints. Monthly Federal order component prices that apply to the Upper Midwest Order were used to calculate milk values for this study.

Seasonal Variation in Milk Component Levels and SCC

While widespread use of artificial insemination, freestall barns, and total mix rations have reduced production swings, seasonality is still present. Seasonal production 'spring flush' and the winter drop in production also lead to seasonal movements in component tests. Butterfat, protein and SNF tests generally have their lowest levels in July and peak in November. Somatic cell counts peak in the warm summer months and reach a low point in November. Other solids tests show little variation but usually peak in the spring or summer months.

Monthly weighted average component levels and SCC for 2021 are summarized in Table 1. Seasonal changes in component levels for 2021 appeared to be relatively normal. Beginning in January, butterfat and protein tests tapered off during the summer to low points in July, then rose to peak levels in December. Other solids tests generally increased slightly through October and then declined slightly for the remainder of the year.

Table 1
Weighted Average Components Levels
and Somatic Cell Count, by Month
2021

Month	Butterfat - % -	Protein - % -	Other Solids - % -	SNF - % -	SCC - 1,000 -
January	4.18	3.26	5.78	9.04	168
February	4.21	3.28	5.78	9.06	176
March	4.13	3.22	5.79	9.01	174
April	4.08	3.20	5.79	8.99	173
May	4.04	3.19	5.78	8.97	174
June	3.94	3.12	5.79	8.91	186
July	3.93	3.10	5.80	8.90	201
August	3.94	3.13	5.80	8.93	205
September	4.02	3.18	5.81	8.99	200
October	4.11	3.23	5.82	9.04	187
November	4.25	3.31	5.80	9.11	172
December	4.26	3.31	5.79	9.10	169
Total	4.09	3.21	5.79	9.00	182
Minimum	3.93	3.10	5.78	8.90	168
Maximum	4.26	3.31	5.82	9.11	205

The seasonality of changes and magnitude of variation in component levels during the year were generally similar to the observed results from previous studies. Seasonal variation in the monthly average SCC in 2021 also appeared to be typical, with higher levels in the summer and lower levels in the fall and winter.

Several miscellaneous annual statistics, in addition to weighted averages, are summarized in Table 2. The simple averages for butterfat, protein, other solids, and SNF were lower than the weighted average, indicating that larger producers (in terms of monthly milk deliveries) tended to have higher levels of these components than smaller producers.

The period from 2012 to 2021 has seen higher protein levels and overall higher component levels in the largest production group, as seen in Tables 5a and 5b for 2021. The more numerous smaller dairies have tests more likely to be around the simple average and the fewer larger dairies are biased toward the weighted average.

Table 2
Component Levels and Somatic Cell Count (SCC)
2021

Component	Weighted Average	Simple Average	Weighted Standard Deviation	Weighted Median	Minimum	Maximum
	- % -	- % -	- % -	- % -	- % -	- % -
Butterfat	4.09	4.03	0.32	4.01	2.13	7.21
Protein	3.21	3.16	0.19	3.15	1.61	4.97
Other Solids	5.79	5.74	0.11	5.75	3.09	6.94
SNF	9.00	8.90	0.30	8.90	4.71	11.43
SCC (per 1,000)	182	232	121	208	21	1,718

The simple average SCC of 232,000 was higher than the weighted average of 182,000, indicating that larger producers on average tended to have lower SCC than their smaller counterparts. Moreover, the median SCC level of 208,000 was also lower than the simple average, indicating that the distribution of SCC levels for the market was skewed toward

higher levels. A more detailed breakdown of that skewness is presented in Tables 3a and 3b. The data for Tables 3a and 3b are from producers for which we have data for all 12 months during the year.

The overall distributions for butterfat, protein, and SNF tests are all approximately normal, with other solids and SCC being skewed. Somatic cell counts are skewed right with a large number of observations at lower levels and fewer large values, meaning that 80% of the farms have a higher SCC than the weighted average SCC. The lower SCC of the larger producers drags down the weighted average.

The range of component levels observed in the data was fairly wide. Monthly average individual producer butterfat levels in the data were as low as 2.13% and as high as 7.21%; protein levels ranged from 1.61% to 4.97%; other solids levels ranged from 3.09% to 6.94%; SNF levels ranged from 4.71% to 11.43%; and SCC ranged from 21,000 to 1,718,000. See Table 2.

However, during the year, the component tests and SCC levels in most producer milk were within one standard deviation of the weighted average. The ranges of component levels within one standard deviation of the weighted average were: 3.77% to 4.41% for butterfat; 3.02% to 3.40% for protein; 5.68% to 5.90% for other solids; 8.70% to 9.30% for SNF; and 61,000 to 303,000 for SCC. Approximately three-quarters of the observed component levels and SCC in the 2021 data were within these ranges.

The differences in the weighted and simple averages and the medians of the component tests warrant a closer look at the relationship between farm size, based on monthly average milk marketed, and milk component levels. Producers with marketings for each month of 2021 were divided into ten percentiles, ten groups with the same number of producers, based on average monthly production. The monthly average production and component tests are shown in Table 3a. The range of average monthly production and total production by group are shown in Table 3b.

A more detailed look at the relationship between producer size and component levels shows that butterfat levels were lowest in the middle groups of producers, but higher for both the smallest and largest size groups. Protein tests showed a similar pattern to that of butterfat. This pattern is different than it generally has been in prior years when the tests dropped as the average size of producer increased.

The SCC declined steadily for producers as they increased in size. Starting with producers of an average of 24,831 pounds per month with an average SCC of 289,000 to producers of an average of 2,879,267 pounds per month with an average SCC of 169,000, a difference in the SCC of 120,000.

Table 3a
Weighted Average Components by Monthly Average Producer Milk
for Producers with Production in Each Month

2021

Percentile Group	Number of Producers	Butterfat	Protein	Other Solids	SNF	SCC
		- % -	- % -	- % -	- % -	- 1,000 -
1	840	4.10	3.19	5.63	8.82	289
2	840	4.06	3.16	5.68	8.84	278
3	840	4.04	3.16	5.71	8.87	261
4	840	4.02	3.15	5.73	8.88	249
5	840	4.00	3.14	5.75	8.89	230
6	840	4.01	3.15	5.76	8.90	218
7	840	4.03	3.16	5.76	8.93	202
8	840	4.02	3.16	5.78	8.94	198
9	840	4.03	3.17	5.82	8.99	179
10	840	4.11	3.23	5.81	9.04	169
Total	8,396	4.08	3.20	5.80	9.00	182

Table 3b
Monthly Average Producer Milk by Producer Size
for Producers with Production in Each Month

2021

Percentile Group	Monthly Average Pounds	Minimum Monthly Average Pounds	Maximum Monthly Average Pounds	Total Pounds	Percentage of Total Pounds	Cumulative Percentage of Total Pounds
1	24,831	368	37,982	250,270,385	0.54	0.54
2	48,848	37,984	59,741	492,343,064	1.06	1.60
3	70,531	59,743	81,861	710,953,744	1.53	3.13
4	93,813	81,866	106,077	945,544,106	2.04	5.17
5	120,011	106,082	135,383	1,209,714,903	2.61	7.78
6	155,315	135,385	179,000	1,565,571,446	3.38	11.16
7	215,933	179,019	262,695	2,176,608,710	4.69	15.85
8	337,108	262,697	439,087	3,398,047,695	7.33	23.18
9	654,757	439,090	997,358	6,599,945,820	14.23	37.42
10	2,879,267	997,603	22,331,020	29,017,255,603	62.58	100.00
Market Total	460,041	368	22,331,020	46,366,255,476		

Protein tests also declined from the smaller producers to the larger producers, but to a smaller extent than for butterfat. Protein fell from 3.19% for producers in Group 1 to 3.14% for producers in Group 5 but rose to 3.23% for producers in Group 10.

Other solids and SNF tests steadily increased as average monthly production increased. Other solids tests increased from 5.63% for the smallest group to 5.82% for the second largest group, while SNF tests increased steadily from 8.82% to 9.04% from the smallest to the largest group.

The data from this group of producers also offer some interesting insight into the structure of the market. For instance, the smallest ten percent of producers supply less than one percent of the milk, while the largest ten percent of producers supply more than 60 percent of the milk in the market. More than 80 percent of producers have monthly production below the monthly average market production of 460,041 pounds.

Variations in Component Levels and SCC Within the Marketing Area

Milk component levels and SCC were examined for the seven states that have counties within the Upper Midwest Marketing Area (see Table 4). Differences in average component levels and SCC between the states were observed. One-way analysis of variance was used to determine that the weighted averages of the states were not equal. In addition, several post hoc paired tests were conducted to determine if any of the individual states' weighted averages were equal. These tests indicated that even though the observed differences between some of the states were relatively small, the differences between the weighted averages were significant.

Of the states that are wholly or partially located in the Upper Midwest Marketing Area, South Dakota had the highest weighted average butterfat, protein, and SNF tests. Iowa had the highest weighted average other solids test. Wisconsin had the lowest weighted average SCC and Michigan UP had the highest.

Figure 1

Upper Midwest Marketing Area

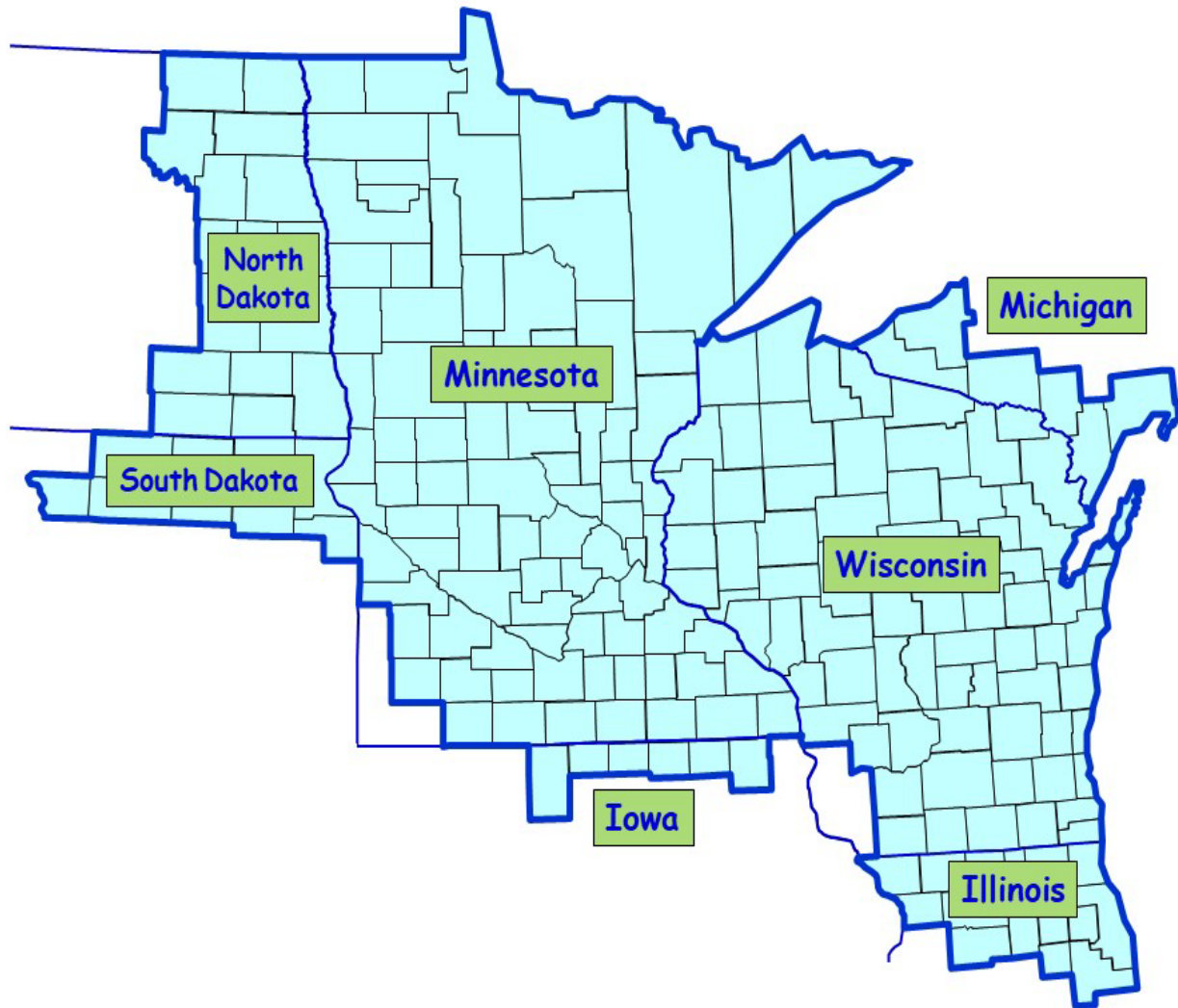


Table 4
Weighted Average Component Levels and SCC by State
2021

State	Butterfat	Protein	Other Solids	SNF	SCC
	- % -	- % -	- % -	- % -	- 1,000 -
Illinois	3.97	3.15	5.78	8.94	198
Iowa	4.16	3.26	5.81	9.06	204
Michigan UP	3.99	3.13	5.77	8.90	231
Minnesota	4.20	3.28	5.78	9.06	194
North Dakota	3.88	3.19	5.79	8.97	184
South Dakota	4.45	3.45	5.81	9.25	192
Wisconsin	4.01	3.16	5.80	8.95	172
Market Total	4.09	3.21	5.79	9.00	182
Minimum	3.88	3.13	5.77	8.90	172
Maximum	4.45	3.45	5.81	9.25	231

Tables 5a and 5b use a scale of production employed by the Upper Midwest Milk Order to illustrate differences present over production ranges from less than 50,000 pounds to over 5,000,000 pounds. Table 5a shows that butterfat and protein tests tend to increase, but SCC tends to decline, as scale increases, though none of the trends are monotonic. The largest scale of production, 5,000,000 pounds or more, has a substantial increase in butterfat and protein tests and a drop in SCC over the next smaller size range. However, patterns in the other size ranges are not very evident. Table 5a indicates the average monthly production for the largest range is more than two and a half times as much as the second largest size range. Table 5b also shows that the largest size category produces 25% of total production.

Table 5a
Weighted Average Components by
Size Range of Monthly Average Producer Milk
All Producers -- 2021

Size Range Categories (Pounds)	Monthly Average Pounds	Butterfat	Protein	Other Solids	SNF	SCC
		- % -	- % -	- % -	- % -	- 1,000 -
Up to 49,999	30,662	4.07	3.18	5.65	8.82	290
50,000 to 99,999	74,270	4.03	3.15	5.71	8.87	262
100,000 to 249,999	155,975	4.01	3.15	5.75	8.90	219
250,000 to 399,999	314,068	4.01	3.16	5.78	8.94	198
400,000 to 599,999	487,920	4.03	3.16	5.79	8.95	188
600,000 to 999,999	766,446	4.01	3.15	5.80	8.95	177
1,000,000 to 1,499,999	1,233,369	4.01	3.15	5.80	8.96	170
1,500,000 to 2,499,999	1,936,577	4.04	3.18	5.81	8.99	158
2,500,000 to 4,999,999	3,450,047	4.07	3.21	5.82	9.03	168
5,000,000 or more	9,018,697	4.26	3.33	5.80	9.13	173
Average	454,694	4.09	3.21	5.79	9.00	182

Table 5b
Monthly Average Producer Milk by Producer Size Range
All Producers -- 2021

Size Range Categories (Pounds)	Number of Observations	Minimum Monthly Average Pounds	Maximum Monthly Average Pounds	Percentage of Total Pounds	Cumulative Percentage of Total
Up to 49,999	19,351	327	49,994	1.14	1.14
50,000 to 99,999	25,168	50,000	99,996	3.59	4.72
100,000 to 249,999	35,481	100,000	249,974	10.62	15.34
250,000 to 399,999	10,699	250,020	399,982	6.45	21.79
400,000 to 599,999	6,702	400,033	599,998	6.27	28.06
600,000 to 999,999	6,250	600,044	999,956	9.19	37.25
1,000,000 to 1,499,999	3,741	1,000,000	1,499,827	8.85	46.11
1,500,000 to 2,499,999	3,258	1,500,340	2,499,909	12.11	58.21
2,500,000 to 4,999,999	2,536	2,500,803	4,997,600	16.79	75.00
5,000,000 or more	1,445	5,003,516	33,930,800	25.00	100.00
Total	114,631				

Component Values Under the Upper Midwest Order

Multiple component pricing on the Upper Midwest Order allows for component levels to be viewed in terms of the value of producer milk given its composition. Milk values, for the purpose of this study, were calculated on an annual basis using monthly Federal order component prices applied to producer milk associated with the Upper Midwest Order during 2021. These values reflect the aggregated value of butterfat, protein and other solids only. These values do not include monthly producer price differentials for the Upper Midwest Order, or premiums and/or deductions that handlers pooling milk under the order may apply to producer pay prices.

As observed in Table 6, the cumulative value of butterfat, protein, and other solids, with an adjustment for SCC, averaged \$19.00 per cwt. for the market for 2021.

Table 6
Component Values in Producer Milk
2021

	Component				Total Value
	Butterfat	Protein	Other Solids	Somatic Cell Count	
Value (per cwt.)	\$7.74	\$8.87	\$2.25	\$0.14	\$19.00
Percentage	40.8	46.7	11.8	0.7	100.0%

Categorized by size range of delivery in Table 7, average values of producer milk ranged from a low of \$18.62 per cwt. for monthly producer milk deliveries of between 50,000 pounds and 100,000 pounds, to a high of \$19.68 per cwt. for monthly producer milk deliveries of 5,000,000 or more. Historically, this relationship between value per cwt. and production has been inversely related with the producers in the 5,000,000 pound or more range having increased value over the next largest category since 2010. These results correspond well to comparisons between simple and weighted average component levels in the section of this paper beginning on the bottom of Page 2.

Table 7
Aggregated Component Values
by Size Range of Monthly Producer Milk
2021

Size Range Categories (Pounds)	Aggregated Component Values *	Producer Milk	Weighted Average Value
	(Dollars)	(Pounds)	(\$/cwt.)
Up to 49,999	125,178,459.80	670,876,086	18.66
50,000 to 99,999	359,467,494.40	1,931,054,100	18.62
100,000 to 249,999	1,045,766,806.73	5,612,471,650	18.63
250,000 to 399,999	638,110,312.52	3,415,387,381	18.68
400,000 to 599,999	616,288,240.84	3,290,990,655	18.73
600,000 to 999,999	902,527,523.62	4,823,862,103	18.71
1,000,000 to 1,499,999	848,296,760.19	4,540,184,606	18.68
1,500,000 to 2,499,999	1,187,589,410.81	6,302,049,853	18.84
2,500,000 to 4,999,999	1,662,042,195.45	8,752,740,928	18.99
5,000,000 or more	2,516,026,778.18	12,782,374,195	19.68
Total	9,901,293,982.55	52,121,991,556	\$19.00
* Total value of pounds of butterfat, protein, and other solids, adjusted for SCC.			

Component Value in 2021

Table 8 contains the component prices announced by Federal orders for 2021. Table 7 indicates the overall component value for each size category using Table 8 prices and Upper Midwest producer data. Table 6 shows the breakdown by component on a per cwt. basis for overall milk value. Butterfat and protein contribute the vast majority of the milk's value with 87.5%, while other solids and the somatic cell value contribute 12.5%.

Table 8
Monthly Component Prices and Somatic Cell Adjustment
Rate for the Upper Midwest Order Producers

2021

Month	Butterfat Price	Protein Price	Other Solids Price	Somatic Cell Adjustment Rate
	<i>Dollars per Pound</i>			<i>Dollars per cwt. per 1,000 SCC</i>
January	1.5541	3.0355	0.2682	0.00083
February	1.4376	2.9816	0.3161	0.00080
March	1.7176	2.6954	0.3652	0.00080
April	1.9496	2.8136	0.4268	0.00086
May	1.9851	3.1307	0.4645	0.00091
June	1.9641	2.5834	0.4579	0.00082
July	1.8996	2.4957	0.4181	0.00080
August	1.8508	2.4582	0.3735	0.00078
September	1.9388	2.6010	0.3445	0.00082
October	1.9414	3.0130	0.3560	0.00088
November	2.1541	2.7536	0.3949	0.00088
December	2.2919	2.5937	0.4532	0.00088
Simple Average	1.8904	2.7630	0.3866	0.00084

Trends in Somatic Cell Counts Under the Upper Midwest Order

In 2009, the European Union shifted to a lower SCC maximum for milk used to produce dairy products in the rest of the world that they imported to their market. The possibility of the tighter restrictions not having a substantial effect rests on the assumption that changes in the dairy industry have led to lower and lower SCC. The data in Table 9 shows that the weighted average SCC on the Upper Midwest Order has fallen over time. In addition, Table 9 indicates that the weighted standard deviation in herd data has also fallen over time. This trend means, in general, that the average has fallen, and the distribution has tightened up around that average from 2009 to 2021.

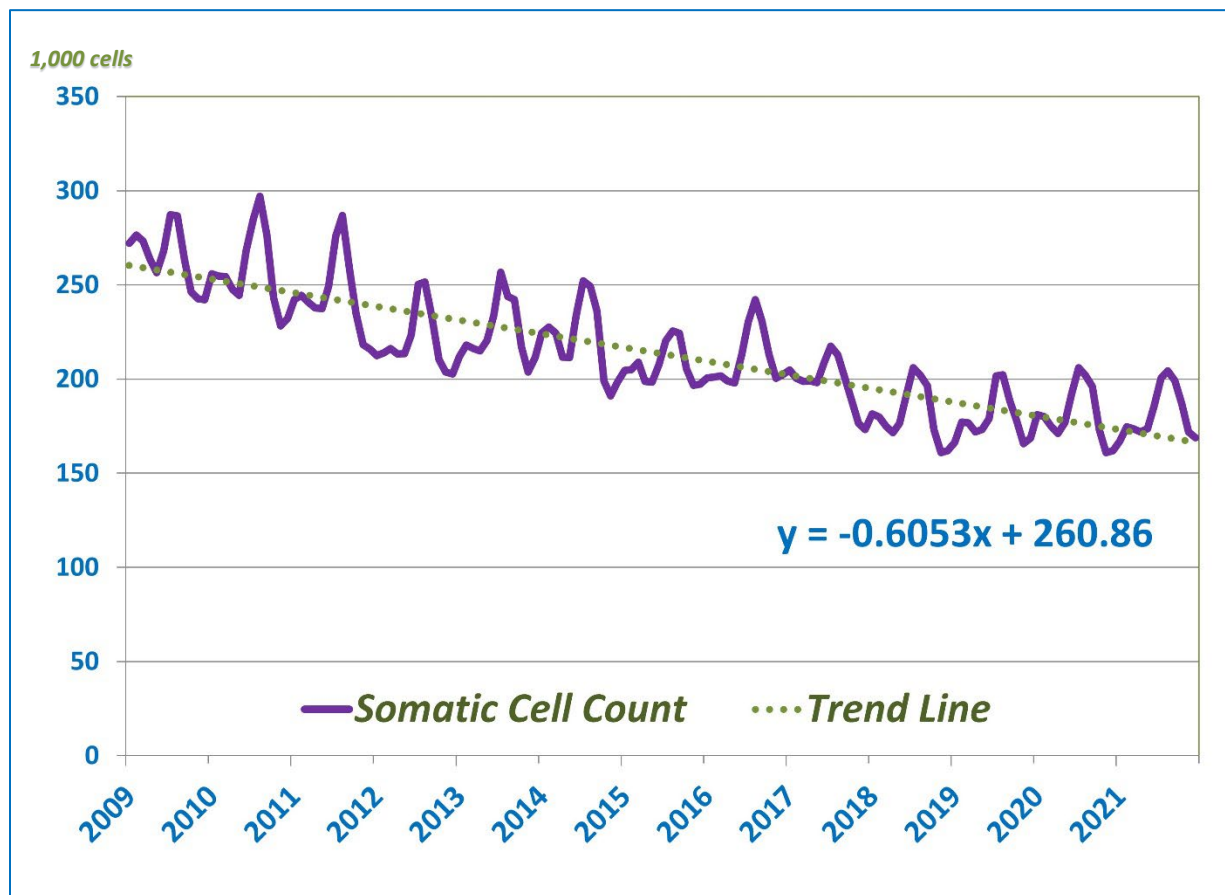
Table 9
Weighted Average Somatic Cell Count in Milk
2009 to 2021

Year	Weighted Average Somatic Cell Count	Weighted Standard Deviation
	-1,000-	-1,000-
2009	265	130
2010	257	123
2011	245	115
2012	220	98
2013	224	100
2014	222	104
2015	208	94
2016	211	98
2017	198	93
2018	182	89
2019	179	88
2020	177	82
2021	182	88

Figure 2 indicates that in addition to a downward sloped trend line, the effect of the trend is greater than the normal seasonal shifts in monthly SCC. The herd milk from producers

in recent years has a seasonal high SCC, usually in mid or late summer, that no longer rises to the winter lows of earlier years. The seasonal highs since 2015 are below the seasonal low for 2009. A trend line fitted to the data shows a downward slope of -0.6053 times the average. So, after a hundred observations, or months, the average cell count falls by 60.53 1,000s of cells per milliliter from January 2009 to December 2021.

Figure 2
Weighted Average Somatic Cell Count by Month
2009 to 2021



Summary

The producer payroll data for Federal Order 30 is characterized by seasonality, roughly normal distributions, and a pronounced skewness in number of producers by size. Seasonally, SCC increase in the summer months as the other tests are decreasing. The SCC are also distributed with a skewness to higher values and a median value lower than the weighted average SCC. The producer data has a large number of farms producing a

relatively small proportion of total milk. The component tests for these small farms have been historically higher including SCC. Historically, as a consequence of this skewness, the cwt. component value of the milk is also higher for smaller farms. A recent break from historical trends is that the largest categories of dairies have higher tests and milk value.

Smaller producers, based on average monthly milk marketed in 2021, still had high butterfat tests, protein tests, but these were no longer the highest tests. They did still have higher SCC values compared to larger producers. Meanwhile, larger producers had higher butterfat tests, protein tests, other solids and SNF tests compared to smaller producers.

The smallest producers marketed less than 2 percent of the milk while the largest producers, those over 1,500,000 pounds, produced more than a third of all the milk. The monthly average pounds of milk marketed were 454,694 pounds, however, over 80 percent of the producers had production below the market average.

Somatic cell counts under the Upper Midwest Order have shown a sustained and substantial downward trend from 2009 through 2021. This trend has coincided with a tightening of the distribution of SCC about the mean.

Under multiple component pricing, the annual weighted average value of butterfat, protein, and other solids, adjusted for SCC, was \$19.00 per cwt. for the market. Butterfat and protein contribute most of the milk's value with other solids and SCC contributing 12.5% of the total value.

#