UPPER MIDWEST MARKETING AREA

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

2020

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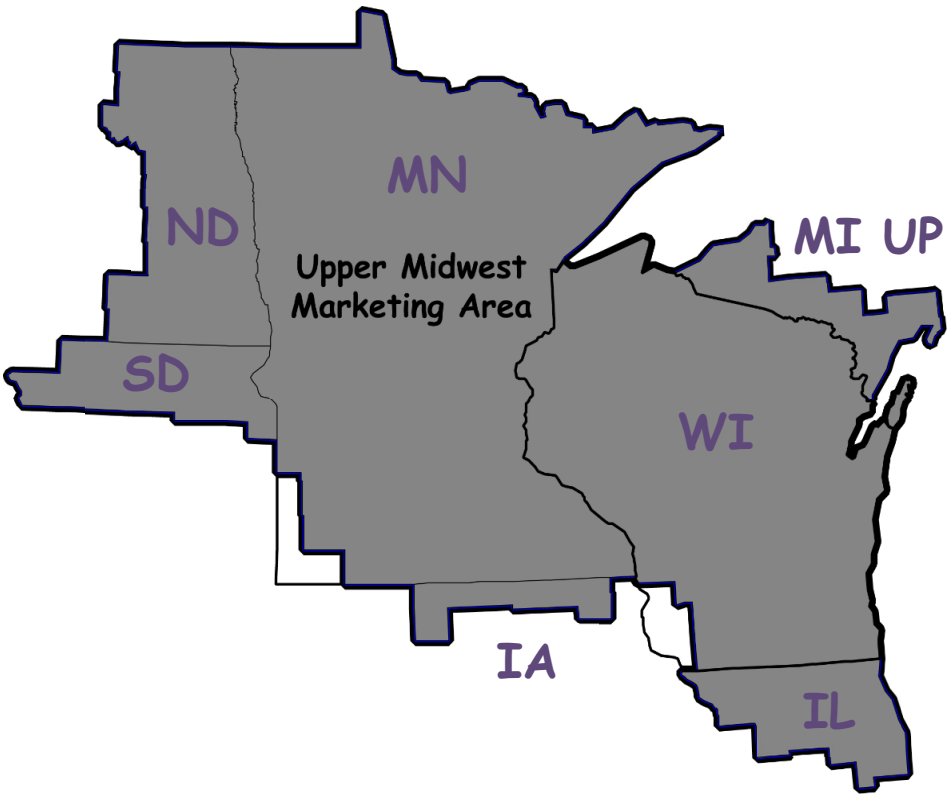

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2020

Corey Freije [1]

Introduction

This study analyzes the component levels and values comprising milk production for Federal Order 30 for 2020. The payroll data for producers who were associated with the Upper Midwest Marketing Order were examined. On average, 9,865 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

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count (SCC) from payrolls submitted to the Market Administrator's office are aggregated 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 2020, average component levels by size of producer marketings were also examined.

This paper also looks at somatic cell count data for the period 2008 to 2020. 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 December. 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 2020 are summarized in Table 1. Seasonal changes in component levels for 2020 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 August and then declined slightly for the remainder of the year.

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 2020 also appeared to be typical, with higher levels in the summer and lower levels in the fall and winter.

Table 1

Weighted Average Components Levels and Somatic Cell Count, by Month

2020

Month	Butterfat	Protein	Other Solids	SNF	SCC
	- % -	- % -	- % -	- % -	- 1,000 -
January	4.03	3.21	5.73	8.95	173
February	4.04	3.22	5.75	8.97	171
March	4.00	3.19	5.76	8.95	171
April	3.98	3.15	5.77	8.93	168
May	3.93	3.12	5.78	8.90	170
June	3.84	3.06	5.78	8.84	183
July	3.80	3.01	5.78	8.79	201
August	3.84	3.06	5.80	8.86	202
September	3.96	3.16	5.78	8.94	190
October	4.11	3.25	5.79	9.04	172
November	4.15	3.26	5.77	9.04	164
December	4.18	3.27	5.78	9.05	165
Total	**3.99**	**3.16**	**5.77**	**8.94**	**178**
Minimum	3.80	3.01	5.73	8.79	164
Maximum	4.18	3.27	5.80	9.05	202

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 averages for the respective components, indicating that larger producers (in terms of monthly milk deliveries) tended to have higher levels of these components than smaller producers. This is the first year this has been true for butterfat, as discussed further on the next page.

The simple average SCC of 232,000 was higher than the weighted average of 178,000, indicating that larger producers on average tended to have lower SCC than their smaller counterparts. Moreover, the median SCC level of 207,000 was also lower than the simple average, indicating that the distribution of SCC levels for the market was skewed toward higher levels.

During 2020, butterfat levels dropped from 4.03% in January to 3.80% in July, and then rose to 4.18% for December. Protein and SNF showed the same seasonal patterns during the year, bottoming out in July and peaking in December. Other solids levels ranged from a high of 5.80% in the summer months and a low of 5.73% in January. The seasonal high SCC of 202,000 was reached in August followed by a low of 164,000 in November, a change of 38,000 during the year. The standard deviation for butterfat, protein and SNF was 0.33, 0.19 and 0.19 percentage points, respectively. Other solids demonstrated the narrowest range of variation with no apparent seasonal pattern.

Table 2

Component Levels and Somatic Cell Count (SCC)

2020

Component	Weighted Average	Simple Average	Weighted Standard Deviation	Weighted Median	Minimum	Maximum
	- % -	- % -	- % -	- % -	- % -	- % -
Butterfat	3.99	3.97	0.33	3.95	0.78	6.55
Protein	3.16	3.14	0.19	3.13	0.01	5.58
Other Solids	5.77	5.71	0.11	5.73	2.46	6.95
SNF	8.94	8.86	0.19	8.86	2.47	12.53
SCC (per 1,000)	178	232	82	207	14	4,307

As just discussed, and seen in Table 2, the weighted average for SCC was below the simple average. Historically, this relationship was also true for protein and butterfat. In the past, this relationship has indicated that milk production, other solids and SNF tests, were directly related, while butterfat and protein test, and the somatic cell count, were inversely related to production levels.

The period from 2012 to 2020 has seen higher protein levels and overall higher component levels in the largest production group, as seen in Tables 5a and 5b for 2020. The more numerous smaller dairies have tests more likely equal to the simple average and the fewer larger dairies more likely equal to the weighted average.

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.

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 0.78% and as high as 6.55%; protein levels ranged from 0.01% to 5.58%; other solids levels ranged from 2.46% to 6.95%; SNF levels ranged from 2.47% to 12.53%; and SCC ranged from 14,000 to 4,307,000. It should be noted here, that some of these extreme test values (e.g. protein of 0.01%) could reflect testing errors, but were used to compute pay prices for at least one producer.

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: 3.66% to 4.32% for butterfat; 2.97% to 3.35% for protein; 5.66% to 5.88% for other solids; 8.75% to 9.13% for SNF; and 96,000 to 260,000 for SCC. Approximately three-quarters of the observed component levels and SCC in the 2020 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 2020 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.

Table 3a

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

2020

Percentile Group	Number of Producers	Butterfat	Protein	Other Solids	SNF	SCC
		- % -	- % -	- % -	- % -	- 1,000 -
1	841	4.03	3.15	5.60	8.76	299
2	840	4.01	3.14	5.66	8.80	281
3	835	4.00	3.15	5.68	8.83	266
4	839	3.97	3.14	5.71	8.84	253
5	840	3.97	3.13	5.73	8.86	228
6	838	3.95	3.13	5.73	8.86	225
7	839	3.95	3.14	5.74	8.88	206
8	841	3.94	3.14	5.76	8.90	199
9	841	3.95	3.14	5.80	8.93	178
10	842	3.94	3.14	5.79	8.93	158
Total	**8,396**	**3.97**	**3.14**	**5.72**	**8.86**	**229**

Table 3b

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

2020

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	23,312	1,751	35,394	235,268,657	0.56	0.56
2	45,518	35,417	55,269	458,822,640	1.09	1.65
3	65,524	55,278	76,228	656,546,312	1.56	3.21
4	87,276	76,240	98,174	878,693,613	2.09	5.30
5	111,004	98,177	125,114	1,118,918,250	2.66	7.96
6	142,676	125,163	163,409	1,434,746,621	3.41	11.37
7	196,827	163,449	239,296	1,981,658,645	4.71	16.08
8	306,273	239,308	396,086	3,090,910,994	7.35	23.43
9	592,139	396,640	906,520	5,975,864,527	14.21	37.64
10	2,595,410	907,321	21,913,228	26,224,024,377	62.36	100.00
Market Total	**417,416**	**1,751**	**21,913,228**	**42,055,454,636**		

A more detailed look at the relationship between producer size and component levels in Table 3a shows that larger producers tend to have lower butterfat tests and SCC than do smaller producers. The producers averaging 23,312 pounds per month in Group 1 had an average butterfat test of 4.03%, while producers averaging 2,595,410 pounds in Group 10 had a 3.94% average butterfat test. The butterfat test declined from a weighted average of 4.03% for the smallest group to a weighted average of 3.94% for Group 8. The SCC declined steadily from an average of 299,000 for producers averaging 23,312 pounds per month, to an average of 158,000 for producers averaging 2,595,410 pounds per month, a difference in the SCC of 141,000.

Protein tests also declined from the smaller producers to the larger producers, but to a smaller extent than for butterfat. Protein fell from 3.15% for producers in Group 1 averaging 23,312 pounds per month to 3.13% for producers in Groups 5 and 6, but rising to 3.14% for producers averaging 2,595,410 pounds in Group 10.

Other solids and SNF tests steadily increased as average monthly production increased. Other solids tests increased from 5.60% for the smallest group to 5.80% for the second largest group, while SNF tests increased steadily from 8.76% to 8.93% 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 417,416 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 test, protein test and SNF test. 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

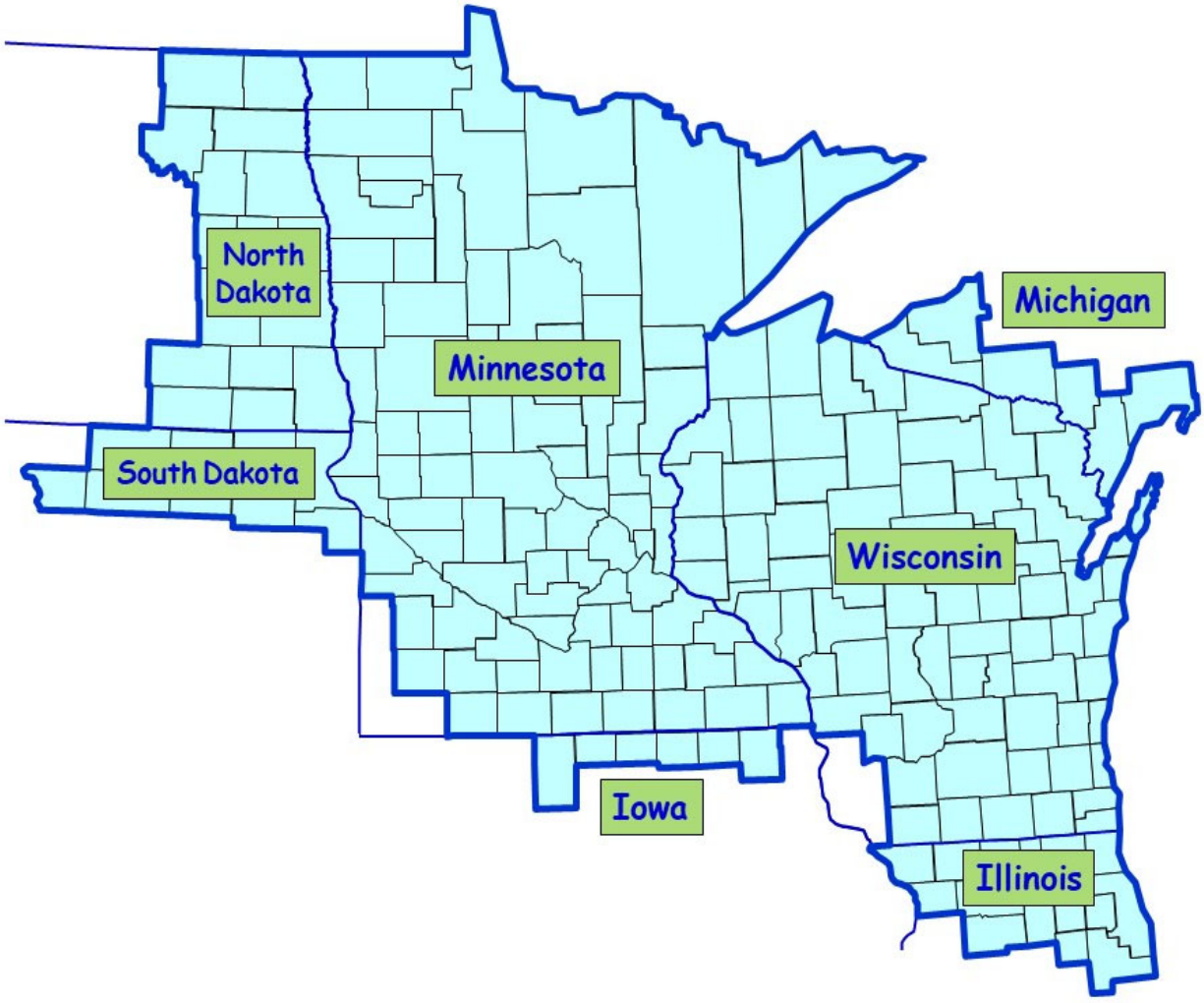


Table 4

Weighted Average Component Levels and SCC by State

2020

State	Butterfat	Protein	Other Solids	SNF	SCC
	- % -	- % -	- % -	- % -	- 1,000 -
Illinois	3.89	3.13	5.77	8.90	201
Iowa	4.03	3.19	5.81	9.00	193
Michigan UP	4.02	3.13	5.74	8.87	237
Minnesota	4.09	3.22	5.76	8.99	186
North Dakota	3.87	3.14	5.78	8.91	200
South Dakota	4.28	3.32	5.79	9.11	193
Wisconsin	3.92	3.12	5.77	8.89	170
Market Total	**3.99**	**3.16**	**5.77**	**8.94**	**178**
Minimum	3.87	3.12	5.74	8.87	170
Maximum	4.28	3.32	5.81	9.11	237

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, and SCC, tend 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. Table 5a indicates the average monthly production for the largest range is more than twice as much as the second largest size range.

Table 5b shows that the largest size category produces 23.58% of total production.

Table 5a
Weighted Average Components by Size Range of Monthly Average Producer Milk
All Producers -- 2020

Size Range Categories *(Pounds)*	Monthly Average Pounds	Butterfat	Protein	Other Solids	SNF	SCC
		- % -	- % -	- % -	- % -	- 1,000 -
Up to 49,999	30,197	4.03	3.16	5.63	8.79	287
50,000 to 99,999	74,308	3.98	3.14	5.70	8.84	260
100,000 to 249,999	155,364	3.95	3.14	5.74	8.87	217
250,000 to 399,999	313,792	3.94	3.14	5.76	8.91	199
400,000 to 599,999	488,801	3.93	3.13	5.77	8.90	184
600,000 to 999,999	768,348	3.92	3.13	5.78	8.91	174
1,000,000 to 1,499,999	1,224,293	3.91	3.12	5.78	8.90	166
1,500,000 to 2,499,999	1,923,988	3.94	3.14	5.79	8.93	154
2,500,000 to 4,999,999	3,374,394	3.98	3.16	5.79	8.96	161
5,000,000 or more	8,703,927	4.12	3.24	5.78	9.02	160
Average	**417,292**	**3.99**	**3.16**	**5.77**	**8.94**	**179**

Table 5b
Monthly Average Producer Milk by Producer Size Range
All Producers -- 2020

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	22,044	50	49,999	1.35	1.35
50,000 to 99,999	27,383	50,004	99,998	4.12	5.47
100,000 to 249,999	35,371	100,000	249,995	11.12	16.59
250,000 to 399,999	10,591	250,008	399,985	6.43	23.32
400,000 to 599,999	6,607	400,026	599,951	6.54	29.86
600,000 to 999,999	5,919	600,029	999,860	9.21	39.06
1,000,000 to 1,499,999	3,652	1,000,007	1,499,897	9.05	48.12
1,500,000 to 2,499,999	3,085	1,500,121	2,498,660	12.02	60.13
2,500,000 to 4,999,999	2,385	2,500,120	4,998,157	16.29	76.42
5,000,000 or more	1,338	5,000,060	36,900,380	23.58	100.00
Total	**118,375**				

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 2020. 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, other solids, with an adjustment for SCC, averaged $19.84 per cwt. for the market for 2020. The value of each component was $6.79 for butterfat, $11.92 for protein, and $0.97 for other solids. The SCC adjustment for the year amounted to $0.16 per cwt.

Table 6

Component Values in Producer Milk

2020

	Component				
	Butterfat	Protein	Other Solids	Somatic Cell Count	Total Value
Value (per cwt.)	$6.79	$11.92	$0.97	$0.16	**$19.84**
Percentage	34.2	60.1	4.9	0.8	**100.0%**

Categorized by size range of delivery in Table 7, average values of producer milk ranged from a low of $19.53 per cwt. for monthly producer milk deliveries in the range of 1,000,000 to 1,499,999 pounds, to a high of $20.43 per cwt. for monthly producer milk deliveries of 5,000,000 or more. In general, the average value of producer milk, per cwt., declines as monthly deliveries increase. Specifically, the average value per cwt. dropped from $19.74 for the smallest producers to $19.61 for those producing between 100,000 and 249,000 pounds a month, then rose for the larger producers, except for two ranges: the 400,000 to 599,999 producers; and the previously mentioned 1,000,000 to 1,499,000 producers. Historically, this relationship between value per cwt. and production has been

inversely related with the producers in the 5 million 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

2020

Size Range Categories (Pounds)	Aggregated Component Values * (Dollars)	Producer Milk (Pounds)	Weighted Average Value ($/cwt.)
Up to 49,999	131,393,998.98	665,672,032	19.74
50,000 to 99,999	399,766,066.04	2,034,770,662	19.65
100,000 to 249,999	1,077,562,512.80	5,495,393,637	19.61
250,000 to 399,999	654,040,103.81	3,323,369,953	19.68
400,000 to 599,999	633,144,751.66	3,229,508,043	19.60
600,000 to 999,999	891,739,095.23	4,547,854,302	19.61
1,000,000 to 1,499,999	873,318,416.23	4,471,119,118	19.53
1,500,000 to 2,499,999	1,165,037,578.61	5,935,501,665	19.63
2,500,000 to 4,999,999	1,595,899,978.42	8,047,929,299	19.83
5,000,000 or more	2,379,057,560.95	11,645,854,236	20.43
Total	**9,800,960,062.73**	**49,396,972,947**	**$19.84**

* Total value of pounds of butterfat, protein, and other solids, adjusted for SCC.

Component Value in 2020

Table 8 contains the component prices announced by Federal orders for 2020. Table 7 indicates the overall component value for each size category using Table 8 prices and Upper Midwest producer data. Given the distribution of larger component test values at smaller sized farms, it is not surprising that the value per cwt. is larger for all but the

largest categories. Table 6 shows the breakdown by component on a cwt. basis for overall milk value. Butterfat and protein contribute the vast majority of the milk's value with 94.3%, while other solids and the somatic cell value contribute just 5.7%.

Table 8

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

2020

Month	Butterfat Price	Protein Price	Other Solids Price	Somatic Cell Adjustment Rate
	Dollars per Pound			*Dollars per cwt. per 1,000 SCC*
January	2.1117	2.9606	0.1417	0.00090
February	1.9813	3.0309	0.1750	0.00089
March	1.9177	2.8424	0.1810	0.00085
April	1.3218	2.4822	0.1793	0.00070
May	1.3756	2.0918	0.1882	0.00065
June	1.8591	4.5349	0.1696	0.00111
July	1.9583	5.6294	0.1492	0.00129
August	1.6275	4.4394	0.1387	0.00105
September	1.5932	3.3935	0.1241	0.00089
October	1.6388	5.0146	0.1534	0.00115
November	1.5553	5.6226	0.1894	0.00123
December	1.5399	3.0282	0.2245	0.00082
Simple Average	**1.7067**	**3.7559**	**0.1678**	**0.00096**

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. This shift has spurred an effort in the US to move the maximum somatic cell count from 750,000 cells

per milliliter to 400,000 cells per milliliter for Grade A milk. The effects of such a move and the question over if there would be an impact at all have been part of the decision-making process. 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 2008 to 2020.

Table 9

Weighted Average Somatic Cell Count in Milk

2008 to 2020

Year	Weighted Average Somatic Cell Count	Weighted Standard Deviation
	-1,000-	-1,000-
2008	283	137
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

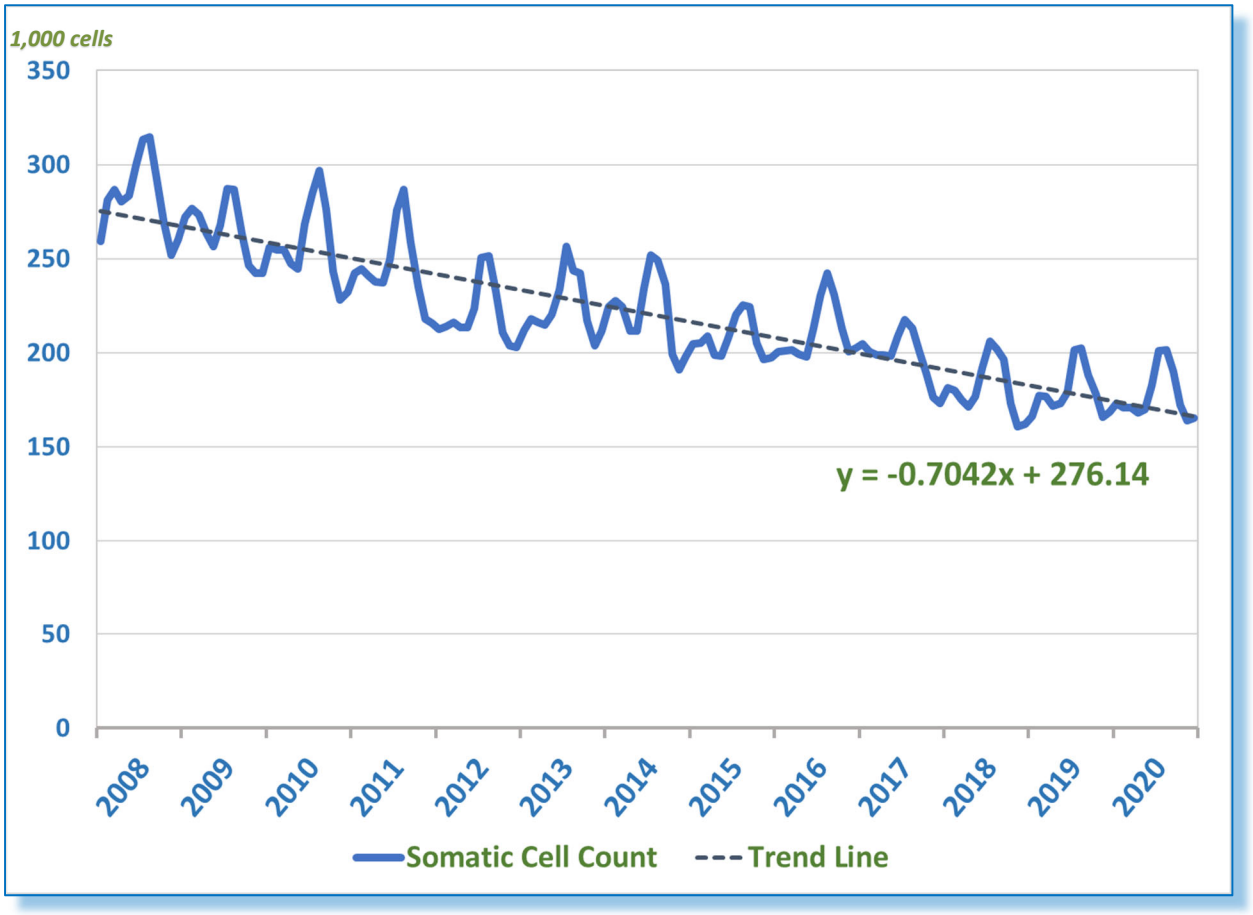
Figure 2 indicates that in addition to a downward sloped trend line, the effect of the trend is greater than the normal seasonal shifts in monthly SCC. The herd milk from producers

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 2008. A trend line fitted to the data shows a downward slope of -0.7042 times the average. So after a hundred observations, or months, the average cell count falls by 70.42 1,000s of cells per milliliter from January 2008 to December 2020.

Figure 2

Weighted Average Somatic Cell Count by Month

2008 to 2020



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. 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, had higher butterfat tests, protein tests, and SCC than larger producers, while larger producers had higher other solids and SNF tests than smaller producers.

The smallest producers marketed less than 2 percent of the milk while the largest producers, those over 2,500,000 pounds, produced more than a third of all the milk. The monthly average pounds of milk marketed were 417,292 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 2008 through 2020. 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 $19.84 per cwt. for the market. Butterfat and protein contribute most of the milk's value at 94.3%, with other solids and SCC contributing just 5.7% of the total value.

#