UPPER MIDWEST MARKETING AREA

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

2019

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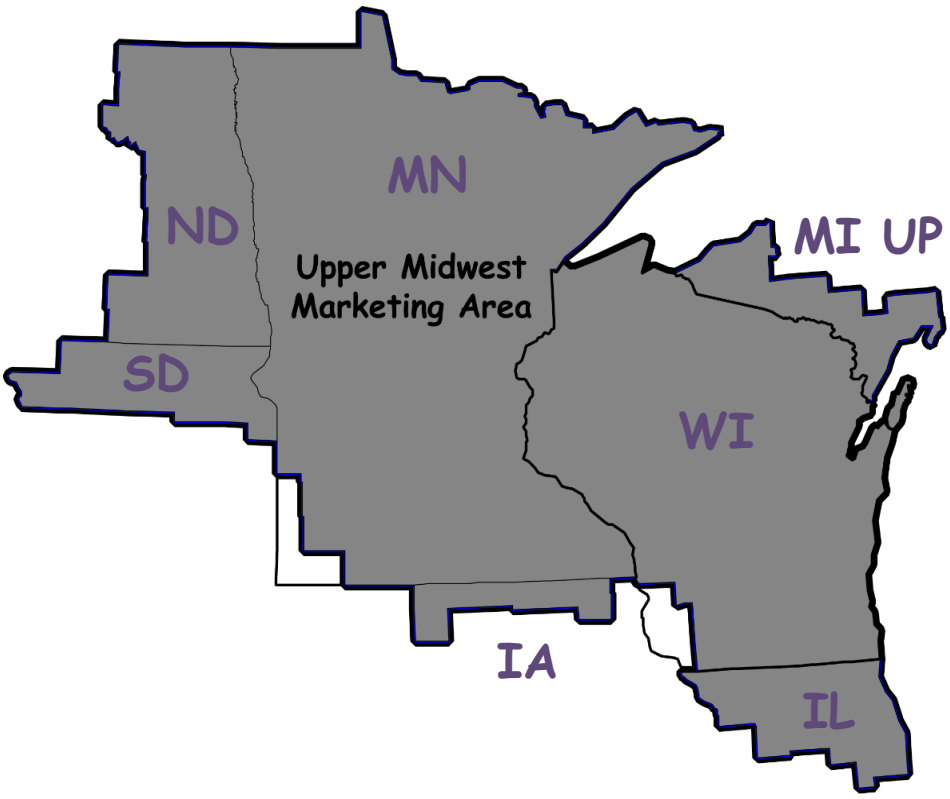

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2019

Corey Freije [1]

Introduction

This study analyzes the component levels and values comprising milk production for Federal Order 30 for 2019. The payroll data for producers who were associated with the Upper Midwest Marketing Order were examined. On average, 10,840 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 producer milk pooled on other orders and milk historically associated with the order but not pooled in some months because of class price relationships. The result is a difference between the number of producers and milk production reported in this study and the number of producers and milk 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 in this analysis, total monthly milk marketed, component pounds, and somatic cell count (SCC) from payrolls submitted to the Market Administrator's office are aggregated to the farm level.

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

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 varies somewhat.

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 states in 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 2019, average component levels by size of producer marketings were also examined.

This paper also looks at SCC data for the period 2007 to 2019. The analysis seeks to identify and quantify a possible trend in decreasing SCC. The trend component must also be separated from the cyclical component endemic to SCC.

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, the 'spring flush' and the winter drop in production, also leads 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 the winter months. Other solids tests show little variation, but usually peak in the spring or summer months.

Monthly weighted average component levels and SCC for 2019 are summarized in Table 1. Seasonal changes in component levels for 2019 appeared to be relatively normal. Beginning in February, butterfat and protein tests tapered off during the summer to low points in July, then rose to peak levels in November. Other solids tests generally increased slightly through June and then declined 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 2019 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

2019

Month	Butterfat	Protein	Other Solids	SNF	SCC
	- % -	- % -	- % -	- % -	- 1,000 -
January	4.04	3.20	5.76	8.96	166
February	4.06	3.22	5.74	8.96	177
March	4.02	3.20	5.74	8.94	177
April	3.93	3.14	5.77	8.92	172
May	3.89	3.10	5.80	8.90	173
June	3.82	3.05	5.80	8.85	179
July	3.77	3.00	5.79	8.79	202
August	3.81	3.05	5.77	8.82	202
September	3.91	3.11	5.78	8.89	188
October	4.03	3.21	5.76	8.97	178
November	4.12	3.28	5.73	9.01	166
December	4.07	3.24	5.73	8.98	169
Total	**3.96**	**3.15**	**5.77**	**8.91**	**179**
Minimum	3.77	3.00	5.73	8.79	166
Maximum	4.12	3.28	5.80	9.01	202

Several miscellaneous annual statistics are summarized in Table 2. For the year, the simple averages for protein, other solids, and SNF were lower than the weighted averages for the respective components, indicating that larger producers tended to have higher levels of these components than smaller producers. The simple average SCC of 240,000 was higher than the weighted average of 179,000, indicating that larger producers on average tended to have lower SCC than their smaller counterparts. Moreover, the median SCC level of 160,000 was also lower than the simple average, indicating that the distribution of SCC levels for the market was skewed toward higher levels.

During 2019, butterfat levels dropped from 4.04% in January to 3.77% in July, and then rose to 4.12% for November. Protein and SNF showed the same seasonal patterns during the year, bottoming out in July and peaking in November. Other solids levels ranged from a high of 5.80% in the summer months and a low of 5.73% in November and December. The seasonal high SCC of 202,000 was reached in July followed by a low of 166,000 in November, a change of 36,000 during the year. The standard deviation for butterfat, protein and SNF was 0.34, 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)

2019

Component	Weighted Average	Simple Average	Weighted Standard Deviation	Weighted Median	Minimum	Maximum
	- % -	- % -	- % -	- % -	- % -	- % -
Butterfat	3.96	3.96	0.34	3.90	1.95	8.25
Protein	3.15	3.13	0.19	3.12	1.54	5.09
Other Solids	5.77	5.70	0.07	5.77	3.01	7.77
SNF	8.92	8.83	0.19	8.90	4.65	11.06
SCC (per 1,000)	179	240	88	160	16	3,663

As just discussed, and as seen in Table 2, the weighted average for SCC is below the simple average. Historically, this relationship was also true for butterfat and protein. In the past, this relationship indicated that milk production, other solids, and solids-not-fat tests were directly related, while butterfat, protein, and SCC were inversely related to production levels.

The period from 2012 to 2019 has seen higher protein levels and overall higher component levels in the largest production group, as seen in Table 5a for 2019. The more numerous smaller dairies have tests more likely equal to the simple average, while the fewer larger dairies have tests 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 of 2019. 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 at the farm level in the data (see Table 2) was fairly wide. Monthly average individual producer butterfat levels in the data were as low as 1.95% and as high as 8.25%; protein levels ranged from 1.54% to 5.09%; other solids levels ranged from 3.01% to 7.77%; SNF levels ranged from 4.65% to 11.06%; and SCC ranged from 16,000 to 3,663,000.

However, during the year, the component tests and SCC levels in most producer milk were within one standard deviation of the weighted average [2]. The ranges of component levels within one standard deviation of the weighted average were: 3.61% to 4.30% for butterfat; 2.96% to 3.34% for protein; 5.69% to 5.84% for other solids; 8.73% to 9.10% for SNF; and 92,000 to 267,000 for SCC. Approximately three-quarters of the observed component levels and SCC in the 2019 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 2019 were divided into ten percentiles, ten groups with the same number of producers, based on average monthly production. The monthly average component tests by group are shown in Table 3a, while the range of average monthly production and total production by group are shown in Table 3b.

[2] By definition, for a *normal distribution*, approximately 68 percent of observations are within one standard deviation of the weighted average.

Table 3a

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

2019

Percentile Group	Number of Producers	Butterfat	Protein	Other Solids	SNF	SCC
		- % -	- % -	- % -	- % -	- 1,000 -
1	844	4.03	3.14	5.60	8.75	299
2	845	4.00	3.13	5.65	8.77	286
3	844	3.98	3.13	5.67	8.80	271
4	845	3.96	3.12	5.69	8.82	261
5	844	3.95	3.13	5.72	8.84	228
6	845	3.94	3.12	5.72	8.84	228
7	845	3.93	3.13	5.74	8.86	211
8	844	3.93	3.14	5.75	8.88	199
9	845	3.91	3.12	5.76	8.89	181
10	844	3.97	3.16	5.78	8.95	159
Total	**8,445**	**3.96**	**3.15**	**5.77**	**8.92**	**178**

Table 3b

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

2019

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	22,942	1,518	34,731	232,361,588	0.57	0.57
2	44,786	34,762	54,730	454,130,710	1.11	1.68
3	64,983	54,753	74,952	658,148,249	1.61	3.29
4	85,667	74,960	96,544	868,661,886	2.13	5.42
5	108,739	96,587	122,134	1,101,304,445	2.69	8.11
6	138,841	122,181	158,220	1,407,844,677	3.44	11.55
7	187,322	158,270	226,739	1,899,446,767	4.65	16.20
8	288,496	226,757	368,919	2,921,889,357	7.15	23.35
9	549,463	369,066	843,280	5,571,550,211	13.63	36.98
10	2,543,362	844,705	21,332,809	25,759,169,244	63.02	100.00
Market Total	**403,340**	**1,518**	**21,332,809**	**40,874,507,134**		

A more detailed look at the relationship between producer size and component levels shows that larger producers tend to have lower butterfat tests and SCC than do smaller producers. The producers averaging 22,942 pounds per month in Group 1 had an average butterfat test of 4.03%, while producers averaging 2,543,362 pounds in Group 10 had a 3.97% butterfat test. The butterfat test declined steadily from a weighted average of 4.03% for the smallest group to a weighted average of 3.91% for Group 9.

The SCC declined steadily from an average of 299,000 for producers averaging 22,942 pounds per month, to an average of 159,000 for producers averaging 2,543,362 pounds per month, a difference in the SCC of 140,000.

Protein tests also declined from the smaller producers to the larger producers, but to a smaller extent than for butterfat. Protein fell from 3.14% for producers in Group 1 averaging 22,942 pounds per month to 3.12% for producers in Groups 4, 6, and 9, but rising to 3.16% for producers averaging 2,543,362 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 5.78% for the largest group, while SNF tests increased steadily from 8.75% to 8.95% 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 10 percent of producers supply less than 1 percent of the milk, while the largest 10 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 403,340 pounds.

Variations in Component Levels and SCC Within the Marketing Area

Milk component levels and SCC were examined (see Table 4 on Page 9) for the seven states that have counties within the Upper Midwest Marketing Area (see Figure 1 on Page 8). 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 seven states that are wholly or partially located within the Upper Midwest Marketing Area, South Dakota had the highest weighted average butterfat, protein, and SNF tests.

South Dakota, North Dakota, and Iowa had the highest weighted average other solids test. Wisconsin had the lowest weighted average SCC and the Michigan UP had the highest.

Figure 1

Upper Midwest Marketing Area

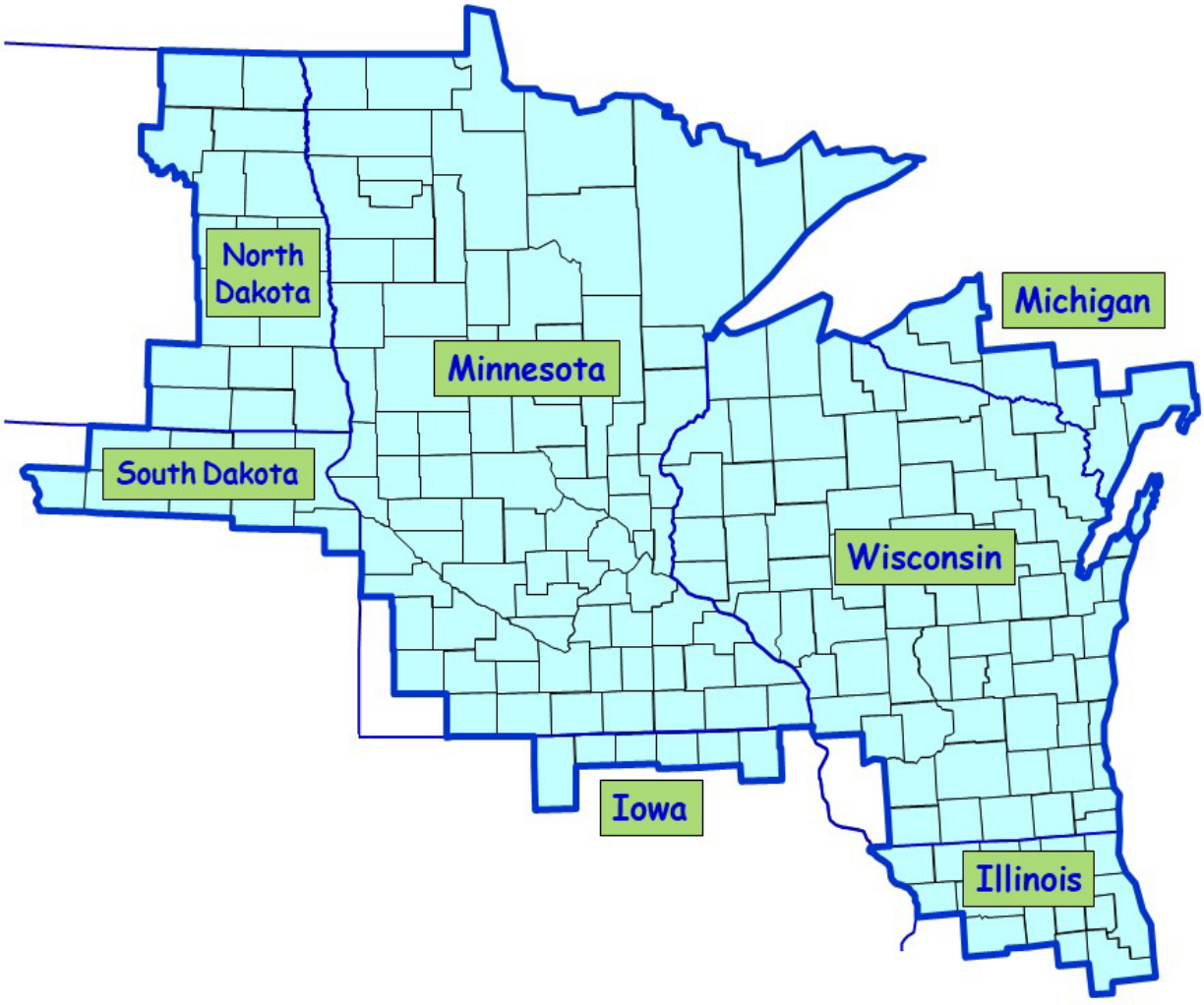


Table 4

Weighted Average Component Levels and SCC by State

2019

State	Butterfat	Protein	Other Solids	SNF	SCC
	- % -	- % -	- % -	- % -	- 1,000 -
Illinois	3.91	3.14	5.75	8.89	198
Iowa	3.97	3.18	5.78	8.96	194
Michigan UP	4.01	3.12	5.76	8.89	229
Minnesota	4.05	3.21	5.76	8.97	185
North Dakota	3.89	3.18	5.78	8.96	202
South Dakota	4.27	3.30	5.78	9.08	187
Wisconsin	3.89	3.11	5.76	8.88	174
Market Total	**3.96**	**3.15**	**5.77**	**8.92**	**179**
Minimum	3.89	3.11	5.75	8.88	174
Maximum	4.27	3.30	5.78	9.08	229

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 also indicates the average monthly production for the largest range is twice as much as the second largest size range.

Table 5b shows that the largest size category produces 21.6% of total production.

Table 5a
Weighted Average Components by Size Range of Monthly Average Producer Milk
All Producers -- 2019

Size Range Categories *(Pounds)*	Monthly Average Pounds	Butterfat	Protein	Other Solids	SNF	SCC
		- % -	- % -	- % -	- % -	- 1,000 -
Up to 49,999	27,583	4.01	3.14	5.63	8.77	292
50,000 to 99,999	74,050	3.97	3.13	5.69	8.81	264
100,000 to 249,999	154,034	3.93	3.13	5.73	8.86	219
250,000 to 399,999	313,651	3.92	3.14	5.75	8.89	200
400,000 to 599,999	487,717	3.91	3.12	5.76	8.89	186
600,000 to 999,999	768,391	3.89	3.12	5.77	8.89	173
1,000,000 to 1,499,999	1,217,980	3.89	3.11	5.78	8.89	165
1,500,000 to 2,499,999	1,911,331	3.91	3.12	5.79	8.91	157
2,500,000 to 4,999,999	3,381,257	3.95	3.16	5.79	8.95	158
5,000,000 or more	8,227,088	4.07	3.22	5.78	9.00	156
Average	**362,104**	**3.96**	**3.15**	**5.77**	**8.92**	**179**

Table 5b
Monthly Average Producer Milk by Producer Size Range
All Producers -- 2019

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	30,594	23	49,997	1.79	1.79
50,000 to 99,999	30,302	50,000	99,996	4.77	6.56
100,000 to 249,999	36,607	100,000	249,999	11.97	18.53
250,000 to 399,999	10,859	250,002	399,977	7.23	25.76
400,000 to 599,999	6,360	400,089	599,992	6.59	32.35
600,000 to 999,999	5,482	600,025	999,906	8.94	41.29
1,000,000 to 1,499,999	3,393	1,000,014	1,499,784	8.77	50.06
1,500,000 to 2,499,999	2,991	1,500,079	2,497,220	12.14	62.20
2,500,000 to 4,999,999	2,254	2,500,340	4,994,340	16.18	78.38
5,000,000 or more	1,238	5,000,530	23,245,550	21.62	100.00
Total	**130,080**				

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 2019. 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 $18.66 per cwt. for the market for 2019. The value was $9.92 for butterfat, $7.52 for protein, and $1.07 for other solids. The SCC adjustment for the year amounted to $0.15 per cwt.

Table 6

Component Values in Producer Milk

2019

	Component				
	Butterfat	Protein	Other Solids	Somatic Cell Count	Total Value
Value (per cwt.)	$9.92	$7.52	$1.07	$0.15	**$18.66**
Percentage	53.2	40.3	5.7	0.8	**100.0%**

Categorized by size range of delivery in Table 7, average values of producer milk ranged from a low of $18.41 per cwt. for monthly producer milk deliveries of between 100,000 and 249,999 pounds, to a high of $19.22 per cwt. for monthly producer milk deliveries of 5 million pounds 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 $18.63 for the smallest producers to $18.41 for those producing between 100,000 and 249,999 pounds a month, then rose for the larger producers, except for the 1,000,000 to 1,499,999 producers. Historically, this relationship between value per cwt. and production has been inversely related with the producers in the 5 million pounds 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

2019

Size Range Categories (Pounds)	Aggregated Component Values * (Dollars)	Producer Milk (Pounds)	Weighted Average Value ($/cwt.)
Up to 49,999	157,252,288.33	843,870,144	18.63
50,000 to 99,999	414,551,970.51	2,243,854,741	18.47
100,000 to 249,999	1,038,321,963.15	5,638,717,082	18.41
250,000 to 399,999	629,060,668.36	3,405,933,395	18.47
400,000 to 599,999	572,519,124.84	3,101,880,035	18.46
600,000 to 999,999	775,864,390.54	4,212,317,537	18.42
1,000,000 to 1,499,999	761,013,481.28	4,132,605,595	18.41
1,500,000 to 2,499,999	1,058,496,383.61	5,716,790,492	18.52
2,500,000 to 4,999,999	1,424,580,973.33	7,621,353,020	18.69
5,000,000 or more	1,957,638,068.51	10,185,134,684	19.22
Total	**8,789,299,312.45**	**47,102,456,725**	**$18.66**

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

Component Value in 2019

Table 8 contains the component prices announced by Federal orders for 2019. Table 7 indicates the overall component value for each size category using Table 8 prices and the 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 93.5%, while other solids and the somatic cell value contribute just 6.5%.

Table 8

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

2019

Month	Butterfat Price	Protein Price	Other Solids Price	Somatic Cell Adjustment Rate
	Dollars per Pound			*Dollars per cwt. per 1,000 SCC*
January	2.4981	1.1927	0.2898	0.00069
February	2.5345	1.1776	0.2631	0.00070
March	2.5461	1.6303	0.2200	0.00077
April	2.5375	1.9890	0.1990	0.00082
May	2.5718	2.1159	0.1847	0.00085
June	2.6579	2.0046	0.1702	0.00085
July	2.6858	2.4032	0.1689	0.00091
August	2.6574	2.4453	0.1730	0.00091
September	2.4982	2.8633	0.1758	0.00095
October	2.4031	3.1700	0.1447	0.00098
November	2.3195	3.9118	0.1112	0.00109
December	2.1952	3.6515	0.1341	0.00103
Simple Average	**2.5088**	**2.3796**	**0.1862**	**0.00088**

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 United States 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 2007 to 2019.

Table 9

Weighted Average Somatic Cell Count in Milk

2007 to 2019

Year	Weighted Average Somatic Cell Count	Weighted Standard Deviation
	-1,000-	-1,000-
2007	288	137
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

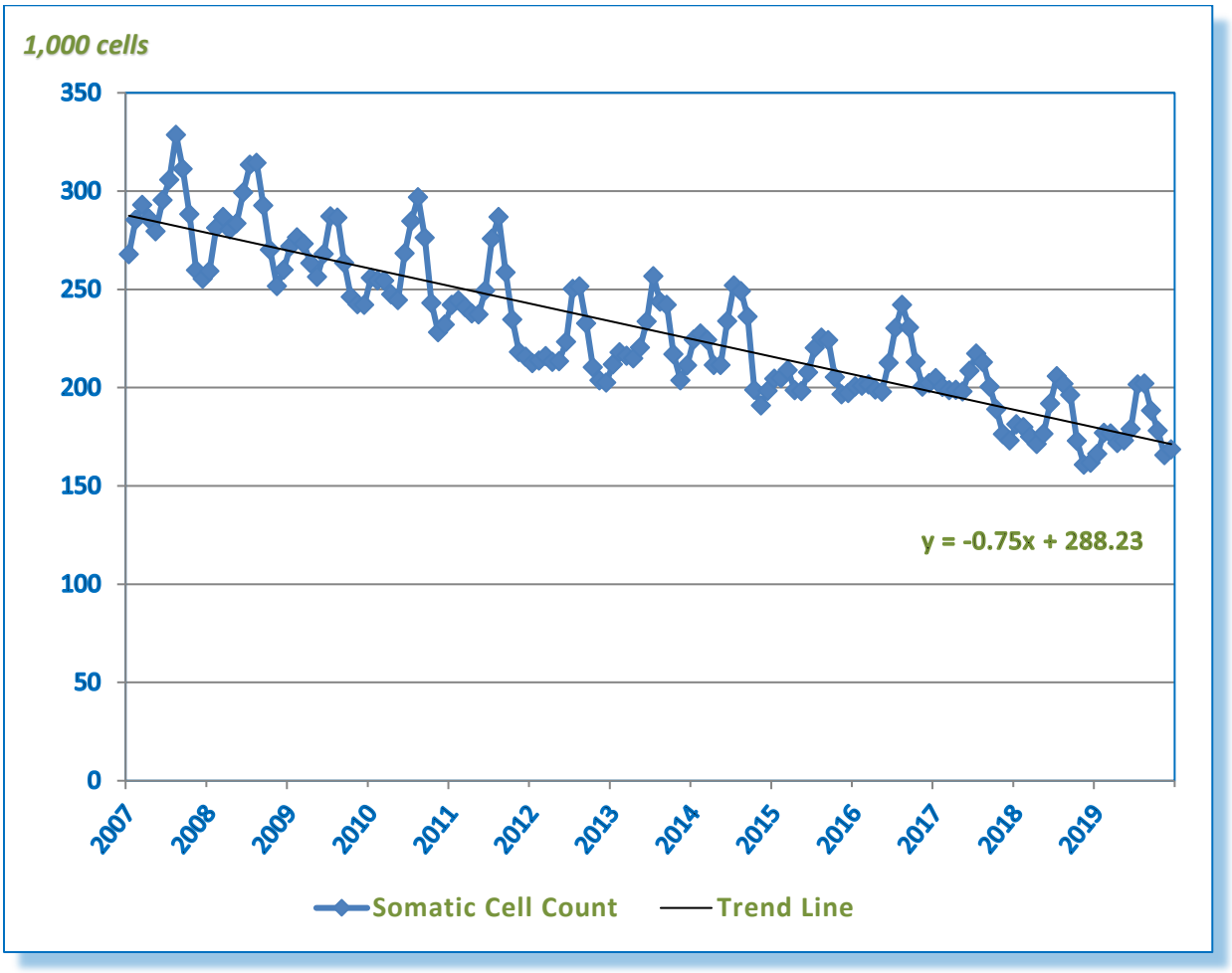
Figure 2 indicates that in addition to a downward sloped trend line, the effect of the trend is greater than the normal seasonal shifts in monthly SCC. The herd milk from producers in recent years has a seasonal high SCC, usually in mid or late summer, that no longer

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 -0.75 times the average. So after a hundred observations, or months, the average cell count falls by 75,000 cells per milliliter from January 2007 to December 2019.

Figure 2

Weighted Average Somatic Cell Count by Month

2007 to 2019



Summary

The producer payroll data for Federal Order 30 is characterized by seasonality, roughly normal distributions, and a pronounced skewness in the number of producers by size. Seasonally, SCC increases 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 market 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 the 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 total milk, while the largest producers, those over 1.5 million pounds monthly, produced half of all the milk. The monthly average pounds of milk marketed were 362,104 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 2007 through 2019. 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 $18.66 per cwt. for the market. Butterfat and protein contribute most of the milk's value, with other solids and SCC contributing just 6.5% of the total value.

#