UPPER MIDWEST MARKETING AREA

ANALYSIS OF COMPONENT LEVELS AND SOMATIC CELL COUNT IN INDIVIDUAL HERD MILK AT THE FARM LEVEL
2018

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I. INTRODUCTION

This study analyzes the component levels and values comprising milk production for Federal Order 30 for 2018. The payroll data for producers who were associated with the Upper Midwest Marketing Order were examined. On average, 11,142 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.

II. 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

[1] The author, Dr. Corey Freije, is an Agricultural Economist with the Market Administrator's Office, Minneapolis, Minnesota. Assisting Dr. Freije was Rachel M. Benecke of the Upper Midwest Market Administrator's office.

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 2018, average component levels by size of producer marketings were also examined.

This paper also looks at somatic cell count data for the period 2006 to 2018. 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.

III. SEASONAL VARIATION IN MILK COMPONENT LEVELS AND SOMATIC CELL COUNT

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 2018 are summarized in Table 1. Seasonal changes in component levels for 2018 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 November. 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 2018 also appeared to be typical, with higher levels in the summer and lower levels in the fall and winter.

Table 1

Weighted Average Levels of Selected Components and Somatic Cell Count in Milk, by Month

2018

Month	Butterfat Test	Protein Test	Other Solids Test	Solids-Not-Fat Test	Somatic Cell Count
	- % -	- % -	- % -	- % -	- 1,000 -
January	4.03	3.21	5.73	8.94	181
February	4.00	3.19	5.74	8.92	180
March	3.96	3.16	5.74	8.91	175
April	3.97	3.16	5.75	8.90	171
May	3.85	3.06	5.77	8.83	177
June	3.77	3.01	5.79	8.80	192
July	3.75	3.00	5.79	8.79	206
August	3.79	3.04	5.79	8.83	202
September	3.87	3.11	5.78	8.89	196
October	4.04	3.21	5.78	8.99	173
November	4.09	3.24	5.76	9.01	161
December	4.06	3.20	5.77	8.97	162
Minimum	3.75	3.00	5.73	8.79	161
Maximum	4.09	3.24	5.79	9.01	206
Annual Average	3.93	3.13	5.77	8.90	182

Several miscellaneous annual statistics, in addition to weighted averages, are summarized in Table 2. For the year, the simple average butterfat level was higher than the weighted average, indicating that smaller producers (in terms of monthly milk deliveries) tend to have higher levels of butterfat than their larger counterparts. Conversely, 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 182,000, indicating that larger producers on average tended to have lower SCC than their smaller counterparts. Moreover, the median SCC level of 162,000 was also lower than the simple average, indicating that the distribution of SCC levels for the market was skewed toward higher levels. During 2018, butterfat levels dropped from 4.03% in January to 3.75% in July, and then rose to 4.09% 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 5.79% in the summer months and a low of 5.73% in January. The seasonal high SCC of 206,000 was reached in July followed by a low of 161,000 in November, a change of 45,000 during the year. The standard deviation for butterfat, protein and SNF was 0.33, 0.18 and 0.18 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) of Milk:
Weighted Average, Simple Average, Weighted Standard Deviation,
Weighted Median, Minimum, and Maximum**

2018

Component	Weighted Average	Simple Average	Weighted Standard Deviation	Weighted Median	Minimum	Maximum
	- % -	- % -	- % -	- % -	- % -	- % -
Butterfat	3.93	3.94	0.33	3.88	2.49	6.93
Protein	3.13	3.12	0.18	3.11	0.32	4.85
Other Solids	5.77	5.70	0.08	5.77	3.13	9.91
SNF	8.90	8.83	0.18	8.88	5.46	13.10
SCC (1,000's)	182	240	89	162	9	2,000

As just discussed, and seen in Table 2, the weighted averages for butterfat and SCC lie below the simple average. Historically, this relationship was also true for protein. In the

past, this relationship has indicated that milk production, other solids and solids-not-fat tests, were directly related. While butterfat, protein, and somatic cell counts were inversely related to production levels. The period from 2012 to 2018 has seen higher protein levels and overall higher component levels in the largest production group, as seen in Tables 5a and 5b for 2018. The more numerous smaller dairies have tests more likely equal to the simple average and the fewer larger dairies more likely equal 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 2.49% and as high as 6.93%; protein levels ranged from 0.32% to 4.85%; other solids levels ranged from 3.13% to 9.91%; SNF levels ranged from 5.46% to 13.10%; and SCC ranged from 9,000 to 2,000,000.

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: 3.60% to 4.26% for butterfat; 2.95% to 3.31% for protein; 5.69% to 5.85% for other solids; 8.71% to 9.08% for SNF; and 92,000 to 271,000 for SCC. Approximately three-quarters of the observed component levels and SCC in the 2018 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 2018 were divided into ten percentiles, ten groups with the same number of producers, based on average monthly production. The monthly average production and component

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

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 Component Tests by Monthly Average Producer Milk Production

Producers with Production in Each Month of 2018

Percentile	Number of Producers	Butterfat Test - % -	Protein Test - % -	Other Solids Test - % -	Solids-Not-Fat Test - % -	Somatic Cell Count - 1,000 -
1	990	4.01	3.13	5.61	8.74	292
2	990	3.98	3.12	5.65	8.78	286
3	991	3.95	3.12	5.67	8.79	278
4	990	3.93	3.11	5.69	8.81	261
5	990	3.92	3.11	5.72	8.83	235
6	990	3.92	3.12	5.72	8.84	232
7	991	3.91	3.11	5.73	8.85	219
8	990	3.91	3.12	5.75	8.87	197
9	990	3.88	3.11	5.76	8.87	183
10	990	3.94	3.14	5.79	8.93	160
Total or Average	9,902	3.93	3.13	5.77	8.90	180

Table 3b

Monthly Average Producer Milk by Producer Size

Producers with Production in Each Month of 2018

Percentile	Monthly Average Pounds	Minimum Monthly Average Pounds	Maximum Monthly Average Pounds	Total Pounds	Percent of Total Pounds	Cumulative Percent of Total
1	23,921	2,983	35,326	284,184,769	0.66	0.66
2	44,667	35,336	53,949	530,639,255	1.23	1.88
3	63,413	53,980	72,984	754,102,330	1.74	3.63
4	83,250	72,996	94,325	989,015,158	2.29	5.92
5	105,813	94,349	118,740	1,257,058,891	2.91	8.83
6	134,010	118,743	151,819	1,592,044,377	3.68	12.51
7	177,360	151,956	210,090	2,109,159,314	4.88	17.39
8	265,669	210,102	336,385	3,156,153,439	7.30	24.69
9	494,479	337,161	755,251	5,874,406,728	13.59	38.28
10	2,245,979	755,288	21,035,664	26,682,233,259	61.72	100.00
Total or Average	363,807			43,228,997,520		

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 23,921 pounds per month in group 1 had an average butterfat test of 4.01%, while producers averaging 2,245,979 pounds in group 10 had a 3.94% average butterfat test. The butterfat test declined steadily from a weighted average of 4.01% for the smallest group to a weighted average of 3.88% for group 8. The SCC declined steadily from an average of 292,000 for producers averaging 23,921 pounds per month, to an average of 160,000 for producers averaging 2,245,979 pounds per month, a difference in the SCC of 132,000.

Protein tests also declined from the smaller producers to the larger producers, but to a smaller extent than for butterfat. Protein fell from 3.13% for producers in group 1 averaging 23,921 pounds per month to 3.11% for producers in groups 4, 5, 7 and 9, but rising to 3.14% for producers averaging 2,245,979 pounds in group 10.

Other solids and SNF tests steadily increased as average monthly production increased. Other solids tests increased from 5.61% for the second smallest group to 5.79% for the largest group, while SNF tests increased steadily from 8.74% 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 363,807 pounds.

IV. VARIATIONS IN MILK COMPONENT LEVELS AND SOMATIC CELL COUNTS 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. South Dakota, North Dakota and Iowa had the highest weighted average other solids test. Wisconsin had the lowest weighted average SCC and North Dakota had the highest.

Table 4

Weighted Average Components Levels and Somatic Cell Count in Milk by State

2018

State	Butterfat Test	Protein Test	Other Solids Test	Solids-Not-Fat Test	Somatic Cell Count
	- % -	- % -	- % -	- % -	- 1,000 -
Illinois	3.95	3.13	5.75	8.88	208
Iowa	3.97	3.16	5.78	8.94	198
Michigan U.P.	3.94	3.13	5.75	8.88	188
Minnesota	3.97	3.16	5.77	8.93	190
North Dakota	3.85	3.14	5.78	8.92	209
South Dakota	4.23	3.27	5.78	9.05	185
Wisconsin	3.89	3.11	5.76	8.87	175
Market	3.93	3.13	5.77	8.90	182
Minimum	3.85	3.11	5.75	8.87	175
Maximum	4.23	3.27	5.78	9.05	209

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 5b indicates the average monthly production for the largest range is twice as much as the second largest size range. Table 5b also shows that the largest size category produces 19.12% of total production.

Table 5a

Weighted Average Component Tests by Monthly Average Producer Milk Production

All Producers 2018

Size Categories (Pounds)	Monthly Average Pounds	Butterfat Test - % -	Protein Test - % -	Other Solids Test - % -	Solids-Not-Fat Test - % -	Somatic Cell Count - 1,000 -
Up to 49,999	30,513	4.01	3.14	5.62	8.77	294
50,000 to 99,999	74,024	3.95	3.12	5.69	8.80	266
100,000 to 249,999	153,834	3.91	3.12	5.73	8.84	223
250,000 to 399,999	312,111	3.91	3.13	5.75	8.88	198
400,000 to 599,999	486,909	3.89	3.11	5.76	8.87	188
600,000 to 999,999	773,373	3.88	3.11	5.78	8.88	172
1,000,000 to 1,499,999	1,214,461	3.89	3.10	5.78	8.88	160
1,500,000 to 2,499,999	1,915,645	3.89	3.11	5.79	8.90	156
2,500,000 to 4,999,999	3,349,534	3.93	3.14	5.79	8.93	159
5,000,000 or more	8,002,191	4.02	3.19	5.79	8.98	158
Average	346,816	3.93	3.13	5.77	8.90	182

Table 5b

Monthly Average Producer Milk by Producer Size

All Producers 2018

Size Categories (Pounds)	Number of Observations	Minimum Monthly Average Pounds	Maximum Monthly Average Pounds	Percent of Total Pounds	Cumulative Percent of Total
Up to 49,999	27,002	100	49,996	1.78	1.78
50,000 to 99,999	32,768	50,002	99,995	5.23	7.01
100,000 to 249,999	40,659	100,000	249,989	13.49	20.50
250,000 to 399,999	11,292	250,003	399,973	7.60	28.10
400,000 to 599,999	6,711	400,028	599,999	7.05	35.14
600,000 to 999,999	5,708	600,037	999,789	9.52	44.66
1,000,000 to 1,499,999	3,390	1,000,014	1,499,951	8.88	53.54
1,500,000 to 2,499,999	2,985	1,500,004	2,499,914	12.33	65.88
2,500,000 to 4,999,999	2,077	2,500,139	4,998,485	15.00	80.88
5,000,000 or more	1,108	5,003,580	22,833,000	19.12	100.00
Total	133,700				

V. 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 2018. 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.

In Table 6 for 2018, the cumulative value of butterfat, protein, other solids, with an adjustment for SCC, averaged $16.06 per cwt. for the market. The value of each component was $9.92 for butterfat, $5.16 for protein, and $0.85 for other solids. The SCC adjustment for the year amounted to $0.13 per cwt.

Categorized by size range of delivery in Table 7, average values of producer milk ranged from a low of $15.90 per cwt. for monthly producer milk deliveries of between 400,000 and 1,000,000 pounds, to a high of $16.44 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 $16.17 for the smallest producers to $15.90 for those producing between 400,000 and 1,000,000 pounds a month, then rose for the larger 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 Part III of this paper.

Component Value

Table 8 contains the component prices announced by Federal orders for 2018. 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 nearly 94%, while other solids and the somatic cell value contribute just 6.07%.

Table 6

Breakdown of Component Values of Producer Milk Deliveries

2018

	Component				
	Butterfat	Protein	Other Solids	Somatic Cell Count	Total Value
Value ($/cwt.)	$9.92	$5.16	$0.85	$0.13	$16.06
Percentage	61.78%	32.14%	5.26%	0.81%	100.00%

Table 7

Aggregated Component Values by Size Range of Monthly Producer Milk Deliveries

2018

Size Categories (Pounds)	Aggregated Component Values* ($)	Producer Milk (Pounds)	Weighted Average Value ($/cwt.)
Up to 49,999	133,225,600.72	823,914,970	16.17
50,000 to 99,999	387,887,505.14	2,425,605,947	15.99
100,000 to 249,999	996,684,467.44	6,254,738,385	15.93
250,000 to 399,999	563,464,971.93	3,524,355,630	15.99
400,000 to 599,999	519,695,846.23	3,267,647,501	15.90
600,000 to 999,999	701,749,102.56	4,414,414,493	15.90
1,000,000 to 1,499,999	655,779,497.79	4,117,021,211	15.93
1,500,000 to 2,499,999	911,753,544.81	5,718,200,113	15.94
2,500,000 to 4,999,999	1,120,826,206.94	6,956,982,699	16.11
5,000,000 or more	1,457,488,336.18	8,866,427,324	16.44
Total	7,448,555,079.73	46,369,308,273	16.06

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

Table 8

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

2018

Month	Butterfat Price	Protein Price	Other Solids Price	Somatic Cell Adjustment Rate
	($/Pound)			($/cwt. per 1,000 SCC)
January	2.4531	1.6612	0.0787	0.00076
February	2.3490	1.6265	0.0550	0.00074
March	2.4273	1.8066	0.0556	0.00078
April	2.5113	1.7810	0.0619	0.00079
May	2.6239	1.8609	0.0742	0.00082
June	2.6692	1.7478	0.1128	0.00081
July	2.5287	1.4827	0.1422	0.00074
August	2.6009	1.6245	0.1741	0.00078
September	2.5442	2.0029	0.2098	0.00083
October	2.5551	1.7185	0.2553	0.00078
November	2.5385	1.3419	0.2714	0.00072
December	2.5080	1.1417	0.2775	0.00069
Simple Average	2.5258	1.6497	0.1474	0.00077

VI. 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 2006 to 2018.

Chart 1 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 -0.7291 times the average. So after a hundred observations, or months, the average cell count falls by 72.91 1,000s of cells per milliliter from January 2006 to December 2018.

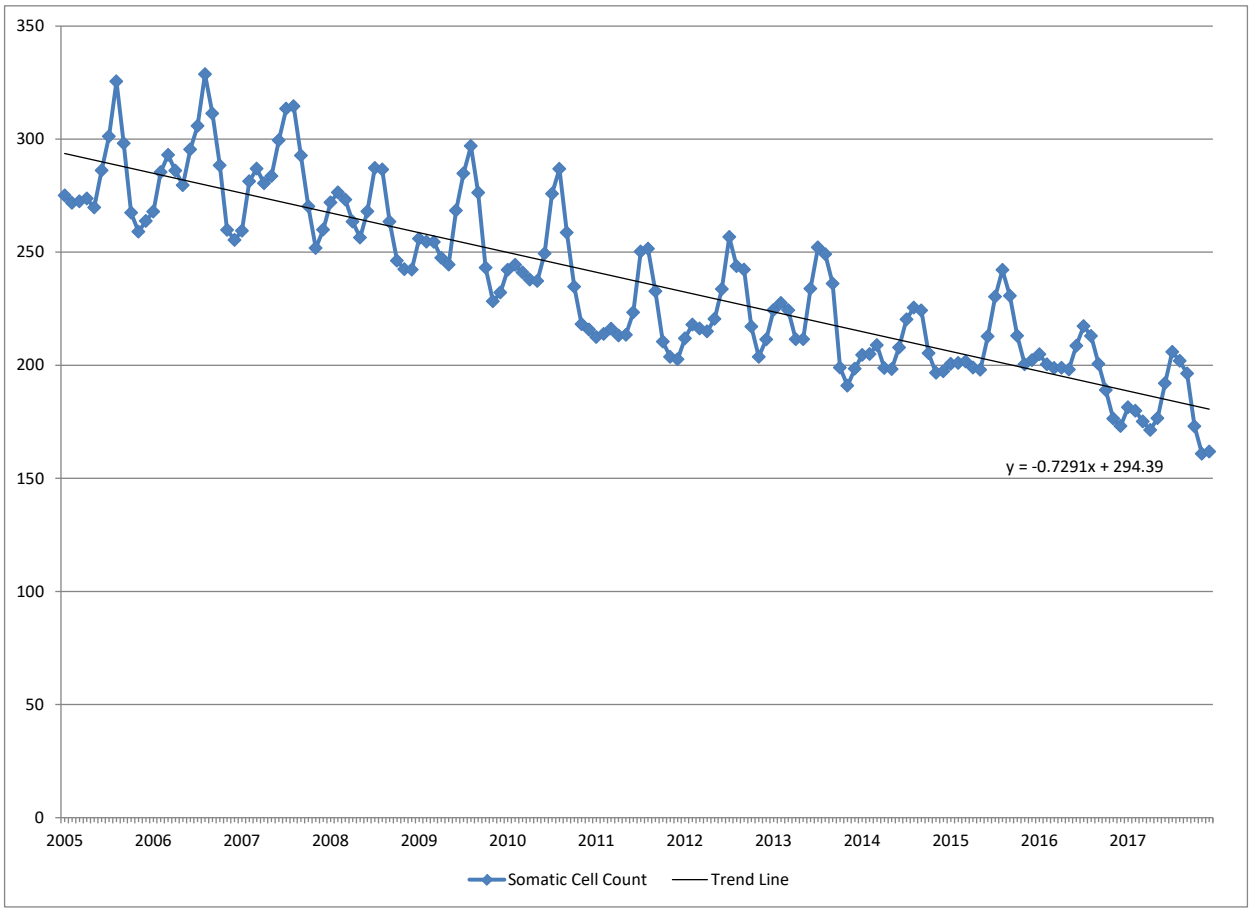
Table 9

Weighted Average Somatic Cell Count in Milk
2006 - 2018

Year	Weighted Average Somatic Cell Count	Weighted Standard Deviation
	-1,000-	-1,000-
2006	280	133
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

Chart 1

Weighted Average Somatic Cell Count by Month, 2006 to 2018



VII. 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 3 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 346,816 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 2006 through 2018. 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 $16.06 per cwt. for the market. Butterfat and protein contribute most of the milk's value with other solids and SCC contributing just 6.07% of the total value.