Optimally Achieving Milk Bulk Tank Somatic Cell Count Thresholds

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The Problem

- High levels of Somatic Cell Count (SCC) in milk reduces shelf life of milk and reduces yield of manufactured dairy products such as cheese
- As a result farmers are penalized for high SCC or receive a premium for low SCC in the milk they deliver
- Thus farmers often sequentially cull the highest SCC cows to meet the bulk tank SCC threshold, but in the process some high value cows may be culled

What is a Somatic Cell?

- White blood cells known as leukocytes constitute the majority of somatic cells
- The number of somatic cells increases in response to pathogenic bacteria in the mammary gland
- SCC is quantified as cells per ml. of milk
- Cows with SCC less than 200,000 scc/mL are not likely infected with major pathogens.
- Herds with bulk tank SCC above 200,000 scc/mL have varying degrees of subclinical mastitis present.

Study Objective

- To help farmers make optimal decisions attaining somatic cell count (SCC) bulk tank thresholds
- Our approach is to specify the problem as maximize herd milk NPV subject to meeting bulk tank SCC thresholds
- The level of SCC is determined by taking a sample of milk from the bulk tank when the milk is collected from the farm, but all cows contribute to the SCC loading
- Thus this is essentially a blending problem
- Data are used from two New York dairy farms

Model

The mathematical programming model is specified as:

$$\max \sum_{i=1}^{n}\sum_{j=1}^{2} NPVcow_{(i)} * cow_{(ij)}$$

subject to:

$$(1)\ \sum_{i=1}^{n}\sum_{j=1}^{2} cow_{(ij)} + cow_{(ij)} = 1$$

$$(2)\ \sum_{i=1}^{n} Yield\ cow_{(i1)} = Total\ milk$$

$$(3)\ \sum_{i=1}^{n} SCC\ cow_{(i1)} = Total\ SCC$$

$$(4)\ \sum_{i=1}^{n} cow_{(i1)} \geq .33 * \sum_{i=1}^{n}\sum_{j=1}^{2} cow_{(ij)}$$

$$(5)\ \frac{Total\ SCC}{Total\ milk} \leq K_1$$

with:

$$cow_{(ij)} = \begin{cases} cow_{(i1)}\ if\ retained\ (\mathrm{j} = 1) \\ cow_{(i2)}\ if\ culled\ (\mathrm{j} = 2) \end{cases}$$

$NPVcow_{(i)}$ = Net Present Value (dollars) of $cow_{(i)}$

K_1 = somatic cell count (SCC) threshold.

Results from optimizing profit and meeting somatic cell count (SCC) threshold of 200,000 scc/mL with upper culling bound of 33% of total herd, Dairy A – 1/23/2014 test date[1]

	Pre-decision herd[2]	Post-decision cows retained[3]	Post-decision cows culled[4]
Cow Value (dollars)[5]	313.61	692.07	-455.05
	(793.96)	(620.95)	(495.78)
Production (1000s mL)	40.94	42.39	37.98
	(13.03)	(12.45)	(13.71)
Total Tank SCC (1000s) Concentration	10,365.76	8,443.35	14,270.19
	(33,078.26)	(21,355.31)	(48,795.11)
Total Tank SCC/mL	253,181 scc/ml	199,151 scc/ml	199,151 scc/ml
Cows	391	262	129

[1]Optimized using binary linear optimization.
[2] Pre-decision statistics before culling for profit and SCC, mean and standard deviation.
[3]Post-decision statistics after culling for profit and SCC, mean and standard deviation for retained cows.
[4]Post-decision statistics after culling for profit and SCC, mean and standard deviation for culled cows.
[5]Values derived from Dairy Comp 305 software.

Results from optimizing profit and meeting somatic cell count (SCC) threshold of 400,000 scc/mL with upper culling bound of 33% of total herd, Dairy B – 10/11/2007 test date[1]

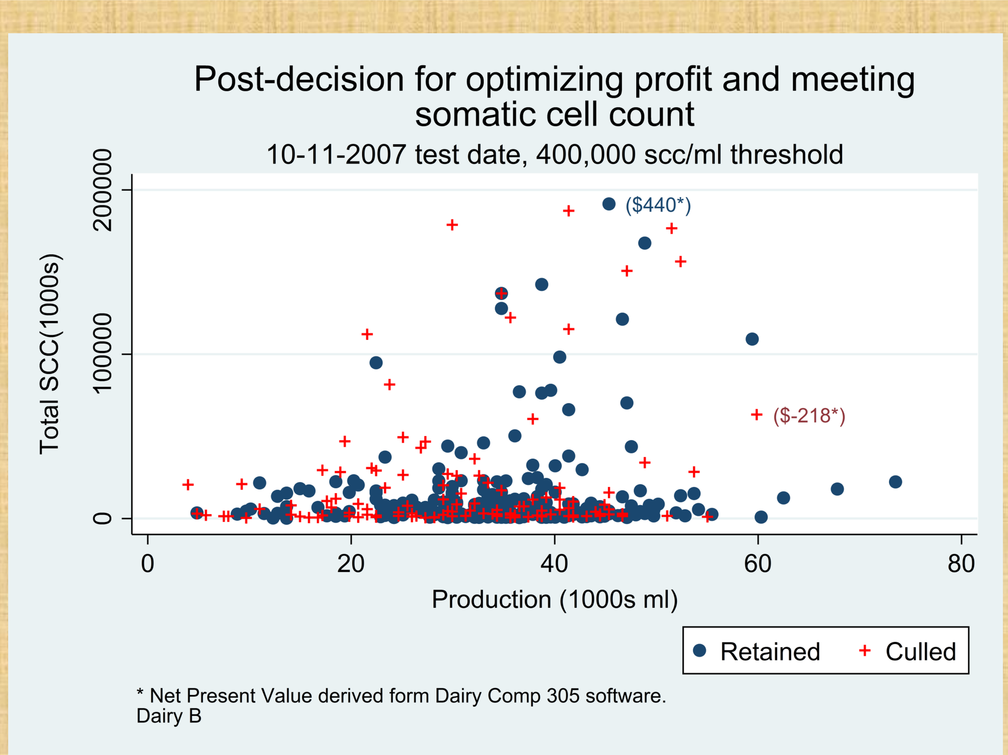
	Pre-decision herd[2]	Post-decision cows retained[3]	Post-decision cows culled[4]
Cow Value (dollars)[5]	111.94	503.55	-687.73
	(777.71)	(608.33)	(361.60)
Production (1000s mL)	33.59	34.79	31.15
	(11.06)	(10.52)	(11.77)
Total Tank SCC (1000s) Concentration	16,292.03	13,888.16	21,200.76
	(32,156.85)	(27,256.94)	(40,045.89)
Total Tank SCC/mL	484,958 scc/ml	399,195 scc/ml	399,195 scc/ml
Cows	362	243	119

[1]Optimized using binary linear optimization.
[2]Pre-decision statistics before culling for profit and SCC, mean and standard deviation.
[3]Post-decision statistics after culling for profit and SCC, mean and standard deviation for retained cows.
[4]Post-decision statistics after culling for profit and SCC, mean and standard deviation for culled cows.
[5]Values derived from Dairy Comp 305 software.

Results from naïve and mathematical optimization culling meeting somatic cell count (SCC) threshold with upper culling bound of 33% of total herd

	Dairy A – 200,000 scc/mL	Dairy B – 200,000 scc/mL
Original SCC (1000s/mL)	253.59	484.96
Mathematically Optimized Culling NPV[1]	$181,324.00	$122,363.00
Naïve Culling NPV[2]	$180,597.00	$117.664.00
Increased Profit from Optimal Culling	$727.00	$4,699.00

[1]Optimized using binary linear optimization.
[2]Cows culled naively (first, high SCC cows to reach threshold, second lowest value cows while still meeting threshold) until herd size equal to herd size under mathematically optimized model.



Conclusions

- NPV from optimization is greater than NPV from naively culling cows beginning with the highest SCC cow
- Increase in NPV might be only a few percentages but the model can be incorporated into current dairy data software where NPV and SCC per cow is currently collected.

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