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:

\[
\max \sum_{i=1}^{n} \sum_{j=1}^{n} NPV_{cow(i)} \cdot cow_{ij}
\]

subject to:

1. \( \sum_{i=1}^{n} \sum_{j=1}^{n} cow_{ij} + cow_{ij} = 1 \)
2. \( \sum_{i=1}^{n} Yield_{cow(i)} = Total\ milk \)
3. \( \sum_{i=1}^{n} SCC \cdot cow_{ij} = Total\ SCC \)
4. \( Total\ SCC = \sum_{i=1}^{n} cow_{ij} \)
5. \( Total\ milk = K_t \)

with:

\( cow_{ij} \) if retained (j = 1)
\( cow_{ij} \) if culled (j = 2)

NPV_{cow(i)} = Net Present Value (dollars) of cow_{i}

K_t = somatic cell count (SCC) threshold.

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

<table>
<thead>
<tr>
<th>Cow Value (dollars)(^1)</th>
<th>Pre-decision herd(^2)</th>
<th>Post-decision cows retained(^3)</th>
<th>Post-decision cows culled(^4)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre</td>
<td>Post</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cow Value (dollars)(^1)</td>
<td>(111.94, 503.55)</td>
<td>(687.33)</td>
<td>(361.60)</td>
</tr>
<tr>
<td>Production (1000s mL)</td>
<td>(33.59, 34.79)</td>
<td>(31.15)</td>
<td></td>
</tr>
<tr>
<td>Total Tank SCC (1000s)</td>
<td>(16,292.03, 13,888.16)</td>
<td>(21,200.76)</td>
<td></td>
</tr>
<tr>
<td>Total Tank SCC/mL</td>
<td>(484,958 scc/ml, 399,195 scc/ml)</td>
<td>(399,195 scc/ml)</td>
<td>(399,195 scc/ml)</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>Original SCC (1000s/mL)</th>
<th>Dairy A – 200,000 scc/mL</th>
<th>Dairy B – 200,000 scc/mL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-decision herd(^2)</td>
<td>Post-decision herd(^2)</td>
<td></td>
</tr>
<tr>
<td>Cow Value (dollars)(^1)</td>
<td>(253.59, 484.96)</td>
<td>(253.59, 484.96)</td>
</tr>
<tr>
<td>Mathematically Optimized Culling NPV(^2)</td>
<td>$181,324.00</td>
<td>$122,363.00</td>
</tr>
<tr>
<td>Naive Culling NPV(^2)</td>
<td>$180,597.00</td>
<td>$117,664.00</td>
</tr>
<tr>
<td>Increased Profit from Optimized Culling</td>
<td>$727.00</td>
<td>$4,699.00</td>
</tr>
</tbody>
</table>

Conclusions
- NPV from optimization is greater than NPV from naive 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.