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Agreement of dairy cattle replacement policies by two models: Optimization and Simulation

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Introduction

The ability of farmers making right decisions at the right times determines the success of a dairy enterprise. Maximizing total farm's profit has been recognized as the overall goal of most dairy farms. Replacement decisions have been studied as an important factor, among other factors, affecting farm's profitability. Historically, dynamic programming (**DP**) has been used to find optimal replacement policy in dairy cattle. Recently, Markov chain simulation (**MC**) model was modified to find suboptimal replacement strategies.

Objectives

- Systematically compare the replacement decision policies with DP and MC models
- Comparing the effect of optimal replacement policies on the herd structure and net revenue

Materials & Methods

Shared Modeling Specifications

- Cow states: Lactation number (l=1-10), month in milk (m=1-20) and month in pregnancy (p=0-9)
- Transition probabilities: Pregnancy, abortion, and involuntary culling

Modeling Differences

- Control mechanism in MC is transition probabilities
- Extra control on selecting optimal action

DP Model

- Objective function: Maximizing net present value (**NPV**) from the present and its potential replacement with a 1-mo stage length
- Keep and replace values calculated at each decision stage
- Retention pay-off (**RPO**) of a cow was calculated by subtracting the replace from the keep value

MC Model

- NPV of a cow and its replacement were calculated by aggregating all economic values at each stage from the start of simulation until model reached steady state
- After finding NPV the cow value was estimated by following equation:

Cow Value (CV) = NPV Cow – NPV Replacement – (Replacement Cost – Salvage Value – Calf Value)

Shared Models Parameters

- Milk production curves, live body weight, dry matter intake, involuntary culling, reproduction and all economic parameters

Model Comparison

- Ranking of animals based on RPO and CV using spearman's rank correlation

Post Optimality analysis

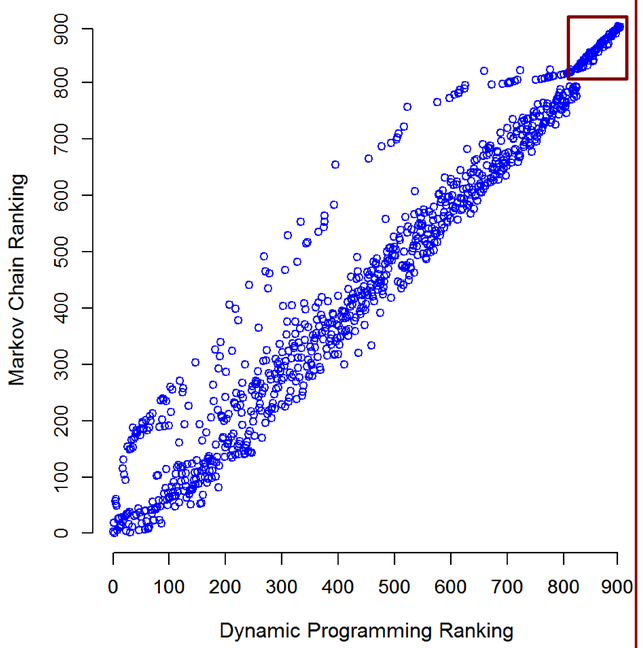
- Basic Markov chain model was used to simulate the herd structure and dynamics and to quantify the effect of using obtained decisions on the herd net revenue

Sensitivity Analysis

- Effect of 20% changes in milk production level and heifer price on RPO and CV

Results

Spearman's correlation of 1,000 possible states between two models was 95% (df =898, p-value < 0.0001)

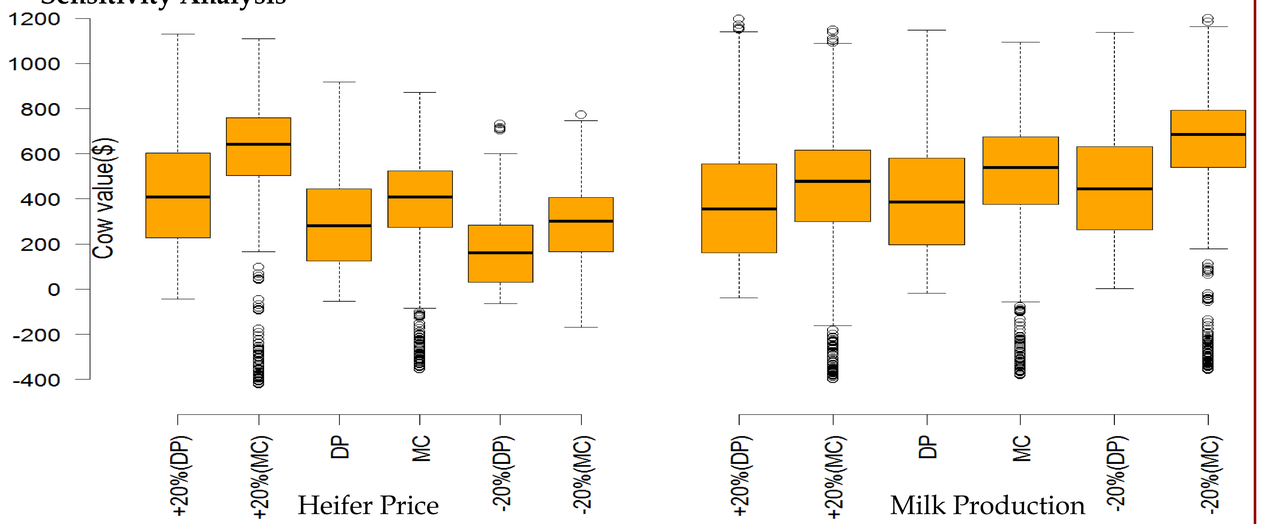


Post optimality analysis

Scenario	Economic Parameters (US$/cow/yr)						Herd structure and dynamics						
	Net Rev.	Milk sales	Feed cost	Calf sales	Cull cost	Rep. Cost	Par. 1 (%)	Par. 2 (%)	Par. 3 (%)	Par. >= 4 (%)	DIM (d)	Pregnant (%)	Lact. (%)
MC[1]	1,584	3,266	-1,402	63	-274	-69	34.38	25.4	16.69	23.2	138	60.8	81.22
MC + DP[2]	1,590	3,263	-1,401	63	-265	-69	34.84	25.26	16.59	23.04	141	60.53	81.48
MC + Sub[3]	1,590	3,279	-1,400	63	-280	-71	36.28	26.27	16.46	20.99	135	60.6	81.23

[1] Basic Markov chain simulation [2] Markov chain simulation with the optimal decisions from dynamic programming [3] Markov chain simulation with sub-optimal decisions from Markov chain

Sensitivity Analysis



Conclusion

- The effect of applying obtained decisions based on two models resulted in similar herd economics and dynamics between two models
- Strong founded correlation between ranking of dairy cows based on the cow value using two models suggests that suboptimal decisions based on Markov chain could be a good alternative to dynamic programming model.
- From the programming perspective, MC model could be solved as a parallel program, which would reduce the computational time considerably

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References

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