

Stochastic evaluation of reproductive performance under farms' variable conditions



THE UNIVERSITY
of
WISCONSIN
MADISON



A.S. Kalantari and V.E. Cabrera

Department of Dairy Science

University of Wisconsin Madison



Introduction:

- Reproductive performance affects profitability of farms
- There are many biological and management factors that also affect farm's profitability
- Therefore, different farms with the same reproductive performance could have different economic outcomes.



Introduction:

- Markov chain could be used to quantify the effect of various reproductive performances and interaction with other factors
- **Limitation:** This method produces deterministic results and produces expected value from the input parameters



Objectives:

- Introducing stochastic elements into a Markov chain simulation model.**
- Evaluating the economic impact of reproductive performance under farms' variable conditions.**



M & M:

- ✓ A dairy herd was modeled using Markov chain simulation with 21-d stage length
- ✓ Cows were described based on DIM, DIP and parity
- ✓ Uncertainty was introduced one by one (stepwise refinement) into the Markov chain model



M & M:

➤ Different ways to introduce randomness:

- **Fitting Polynomial Regression model:**

- Involuntary Culling
- Abortion



- **Using Distributions:**

- Normal Distribution: Milk production
- Triangular Distribution:
 - 21-d Pregnancy rate



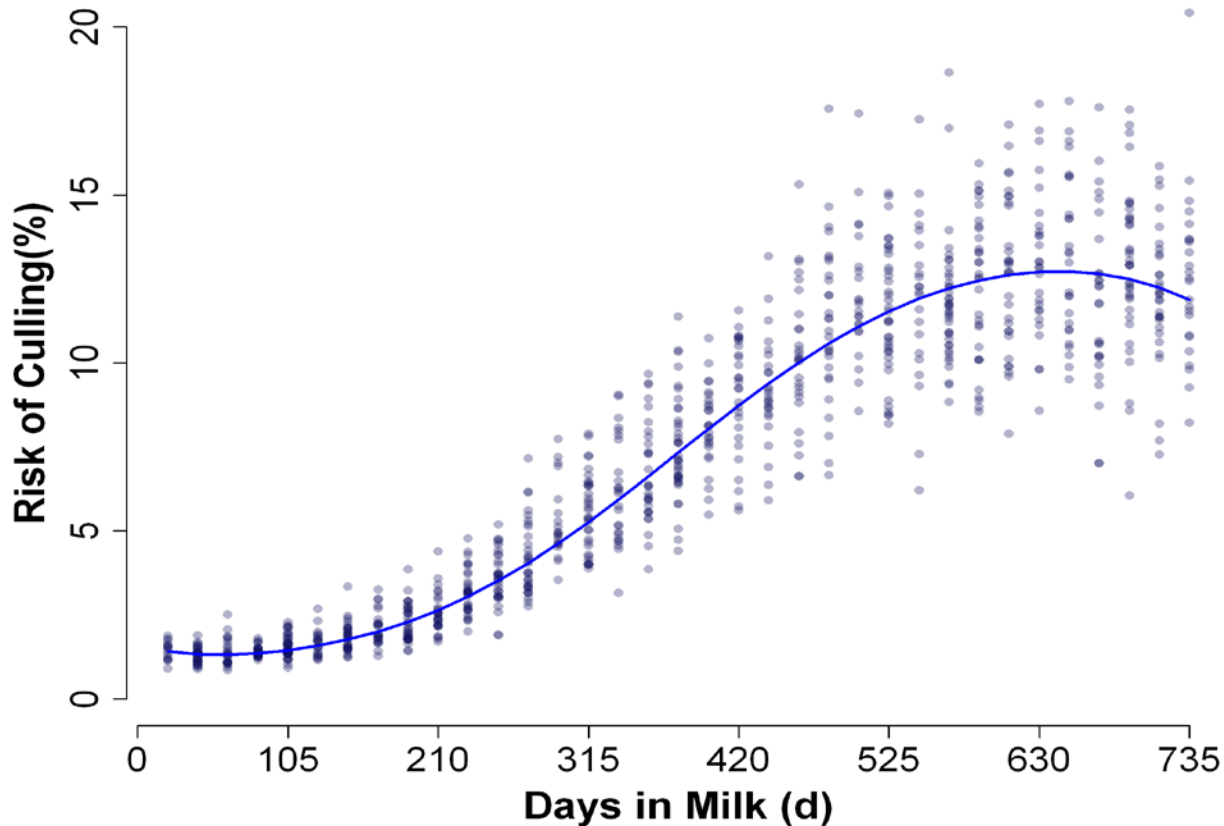


M & M:

➤ 5th order Polynomial Regression (Binomial Family)

white noise ($\sim N(0, \text{sd}(\text{predicted residual}))$)

- Example for second lactation cows

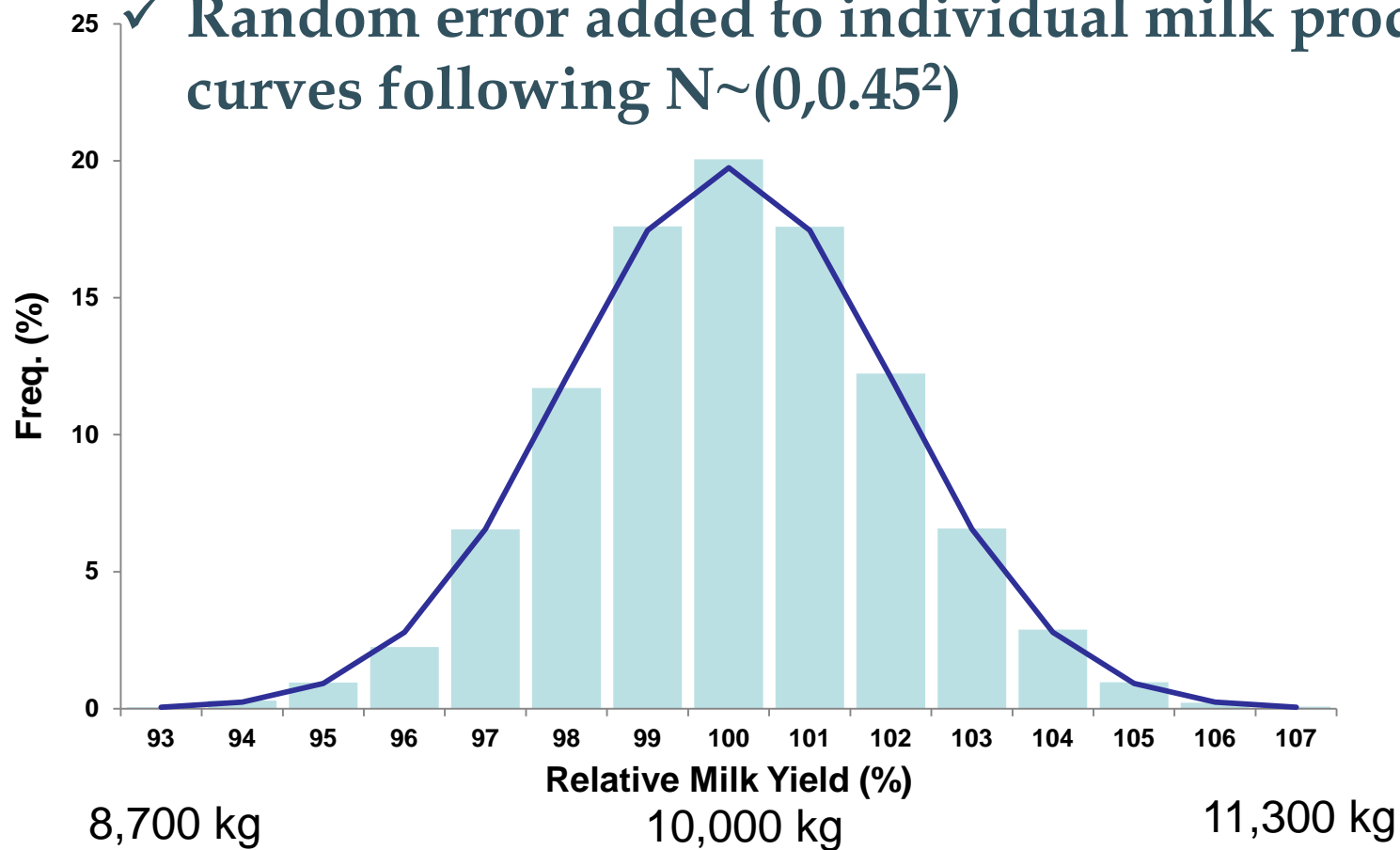




M & M:

✓ 15 milk classes with respect to the average milk production of 10,000 kg/yr (estimated using MilkBot® model)

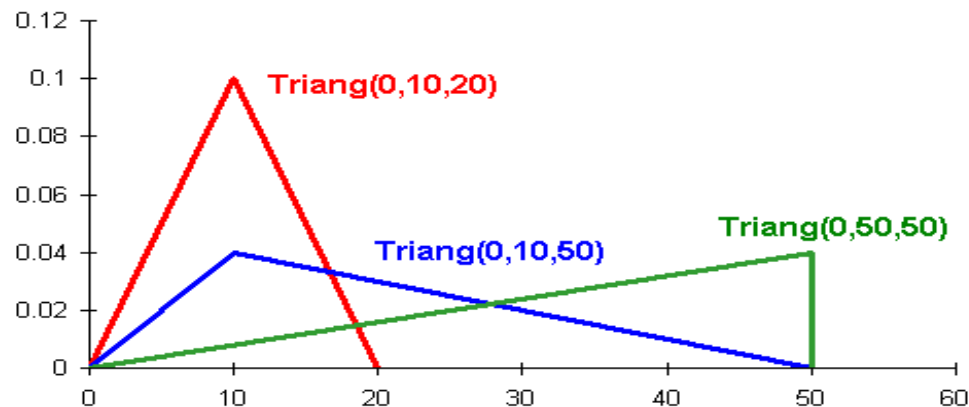
✓ Random error added to individual milk production curves following $N\sim(0,0.45^2)$





M & M:

- ✓ Reproductive performance was modeled using 21-d PR
- ✓ Triangular distribution to include the variation between and within lactations
- ✓ Average of 15% 21-d PR was used as the mode and 5% below and above this average as the Max and Min of the distribution





Results:

Herd economics after introducing randomness (Expected Value(\$/cow/yr) \pm SD based on 10,000 rep.)

Run	Net Return	Milk Sales	Feed Costs	Calf Sales	Culling Costs	Rep. Costs
NR	2372	3400	-794	65	-161	-138
I	± 3.24	± 1.25	± 0.25	± 0.02	± 2.66	± 0.08
I+A	± 3.24	± 1.25	± 0.25	± 1.06	± 2.66	± 0.08
I+P	± 4.41	± 1.62	± 0.37	± 0.54	± 2.72	± 1.43
I+A+P	± 4.42	± 1.61	± 0.38	± 0.54	± 2.72	± 1.44
I+A+P+M	± 56.9	± 65.3	± 6.97	± 0.58	± 3.36	± 1.51

NR = No randomness (Expected Value)

I+A = Inv. culling + Abortion

I+A+P = Inv. Culling + Abortion + Pregnancy rate

I = Inv. Culling

I+P = Inv. Culling + Pregnancy rate

I+A+P +M= Inv. Culling + Abortion + Pregnancy rate + Milk prod. level



Results:

Herd structure after introducing randomness (Expected value \pm SD based on 10,000 rep.)

Run	Parity 1 (%)	Parity 2 (%)	Parity \geq 3 (%)	Total leaving (%)	21-d PR(%)
NR	35.7	24.9	16.3	40.4	15
I	± 0.28	± 0.16	± 0.12	± 0.59	± 0
I+A	± 0.28	± 0.16	± 0.12	± 0.59	± 0.7
I+P	± 0.55	± 0.32	± 0.25	± 0.88	± 0.7
I+A+P	± 0.55	± 0.32	± 0.25	± 0.88	± 0.7
I+A+P+M	± 0.56	± 0.32	± 0.25	± 1.18	± 0.7

NR = No randomness (Expected value)

I+A = Inv. culling + Abortion

I+A+P = Inv. Culling + Abortion + Pregnancy rate

I = Inv. Culling

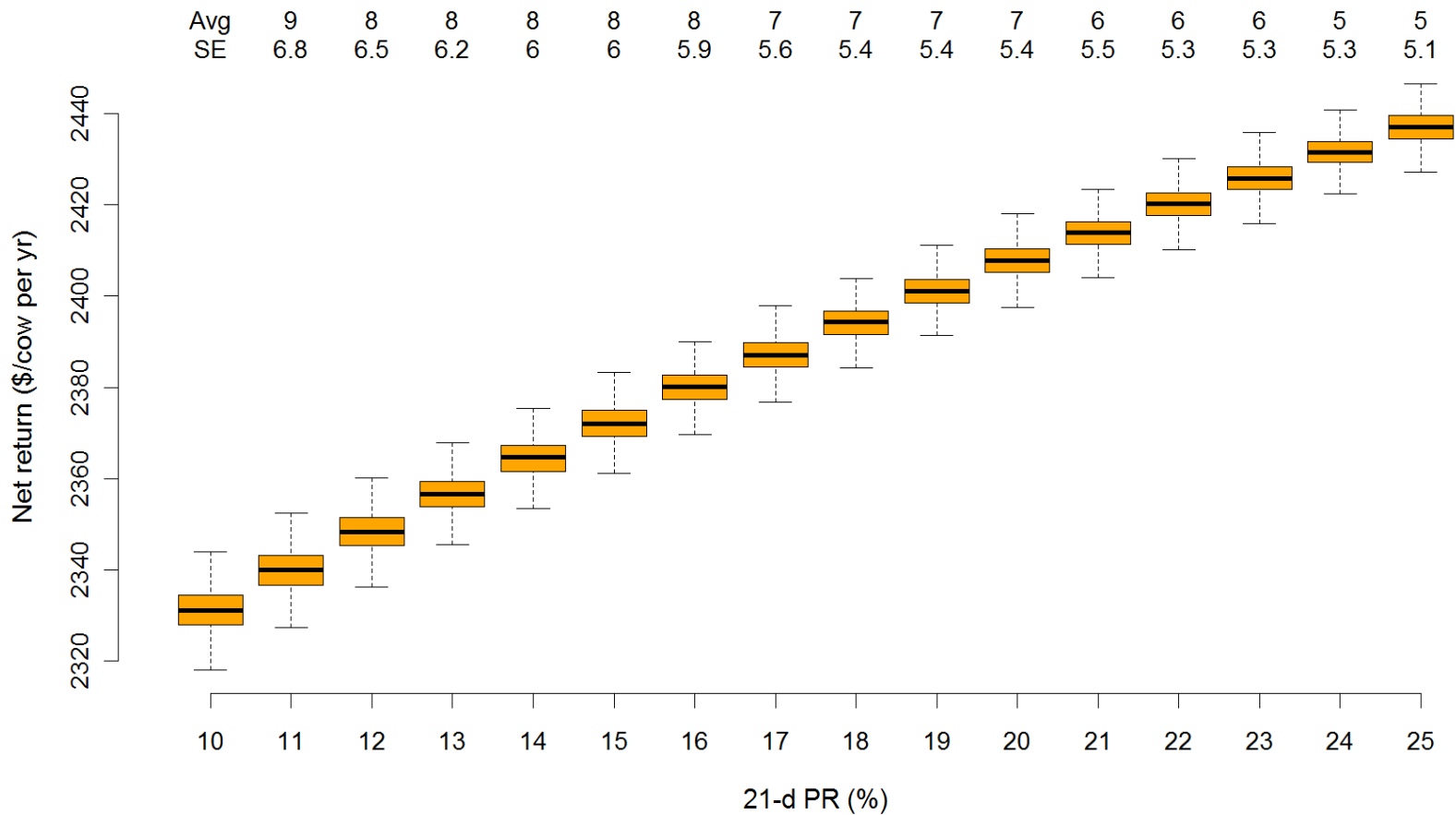
I+P = Inv. Culling + Pregnancy rate

I+A+P +M= Inv. Culling + Abortion + Pregnancy rate + Milk prod. level



Results:

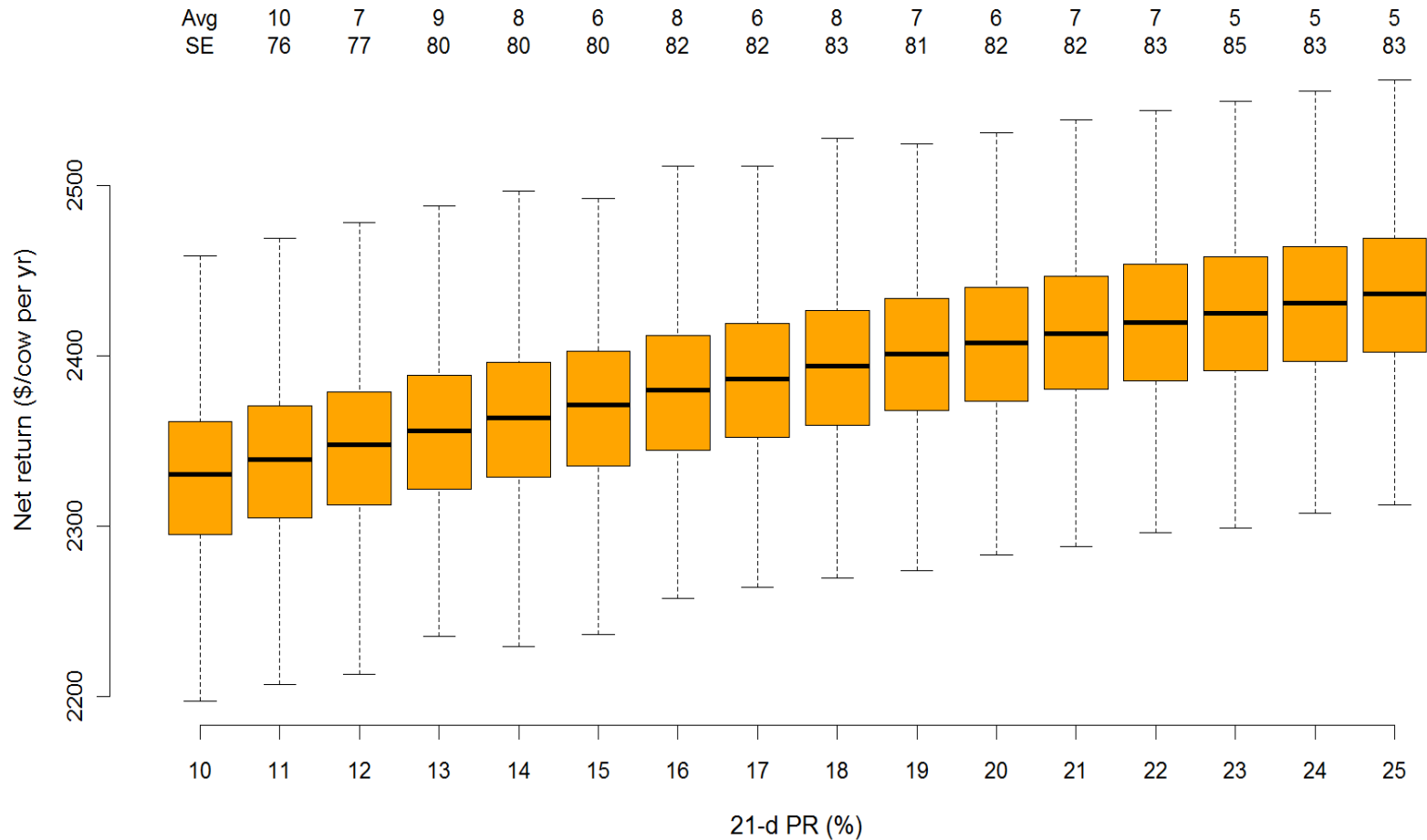
- Net return variation without a variation in Milk production, 2,000 Rep.





Results:

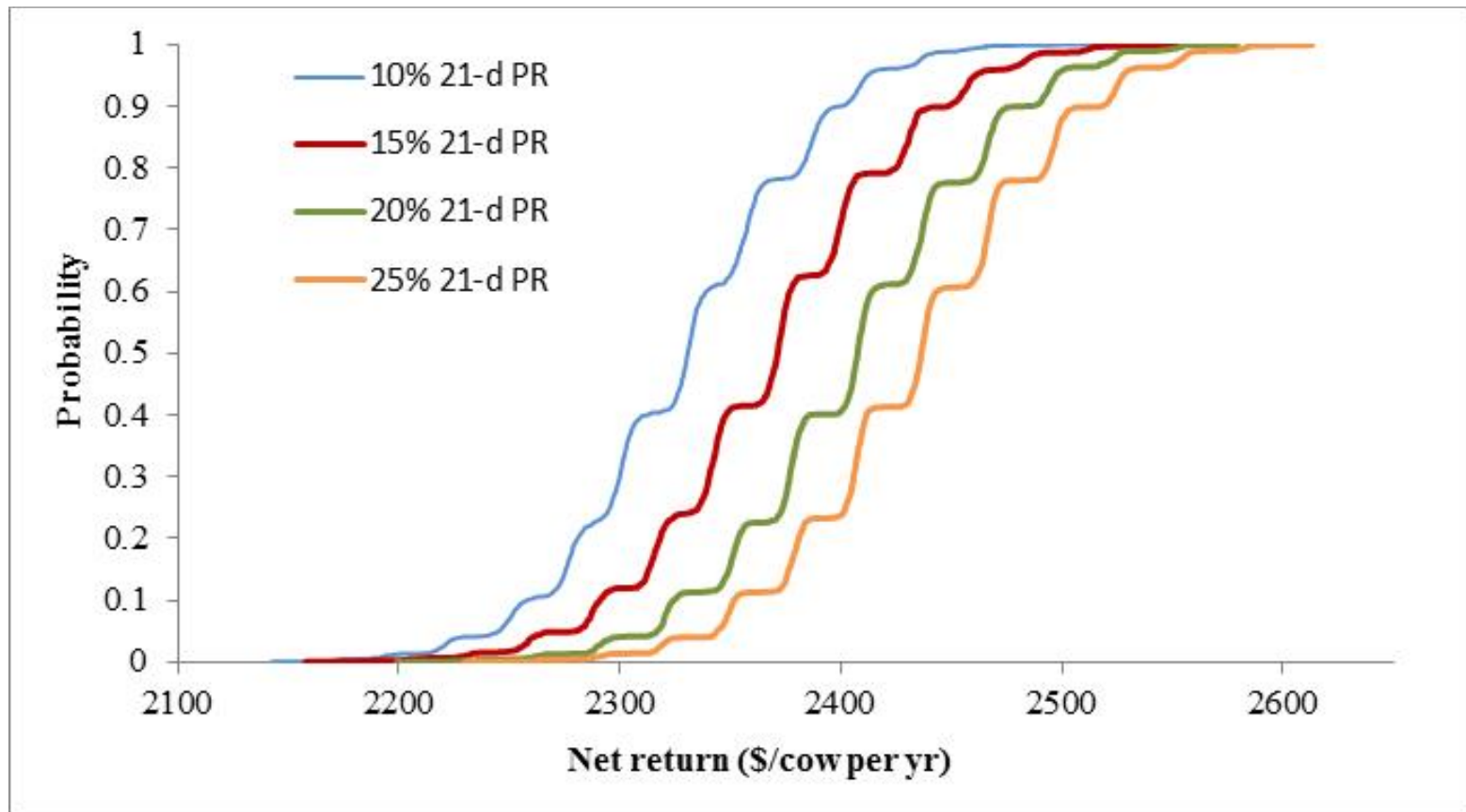
Net return variation with Milk production variation, 2,000 Rep.





Results:

Cumulative density functions for four 21-d PR performances when all parameters are random





Conclusion:

- Net return without any stochastic element resembled the expected value calculated from the original Markov chain model.
- The model was able to capture the inherent variability within and between herds
- As expected, gain of increasing 21-d PR followed the law of diminishing net returns



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App.

Variables name	Average value	Source
Input herd variables		
Herd turnover %/yr	35	De Vries et al. (2010)
Milk production level kg/yr	10,000	DHI benchmark ² (2013)
Dry period d	60	DHI benchmark ² (2013)
Last day to breed a cow d	294	Giordano et al. (2012)
Milk threshold kg/cow per d	23	Giordano et al. (2012)
Pregnancy loss %/lactation	8.2	De Vries (2006)
Pregnancy rate %/yr	14.6	DHI benchmark ² (2013)
Mortality ³ %/yr	20	Pinedo et al. (2010)
Economic variables		
Replacement cost, \$/cow	1,300	
Reproductive cost \$/service	20	
Carcass value, \$/kg	0.38	
Calf value, \$/calf	100	Cabrera (2012)
Milk price, \$/kg	0.35	
Feed price for lactating cow, \$/kg	0.22	
Feed price for dry cows, \$/kg	0.18	