Stochastic evaluation of reproductive performance under farms' variable conditions

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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:

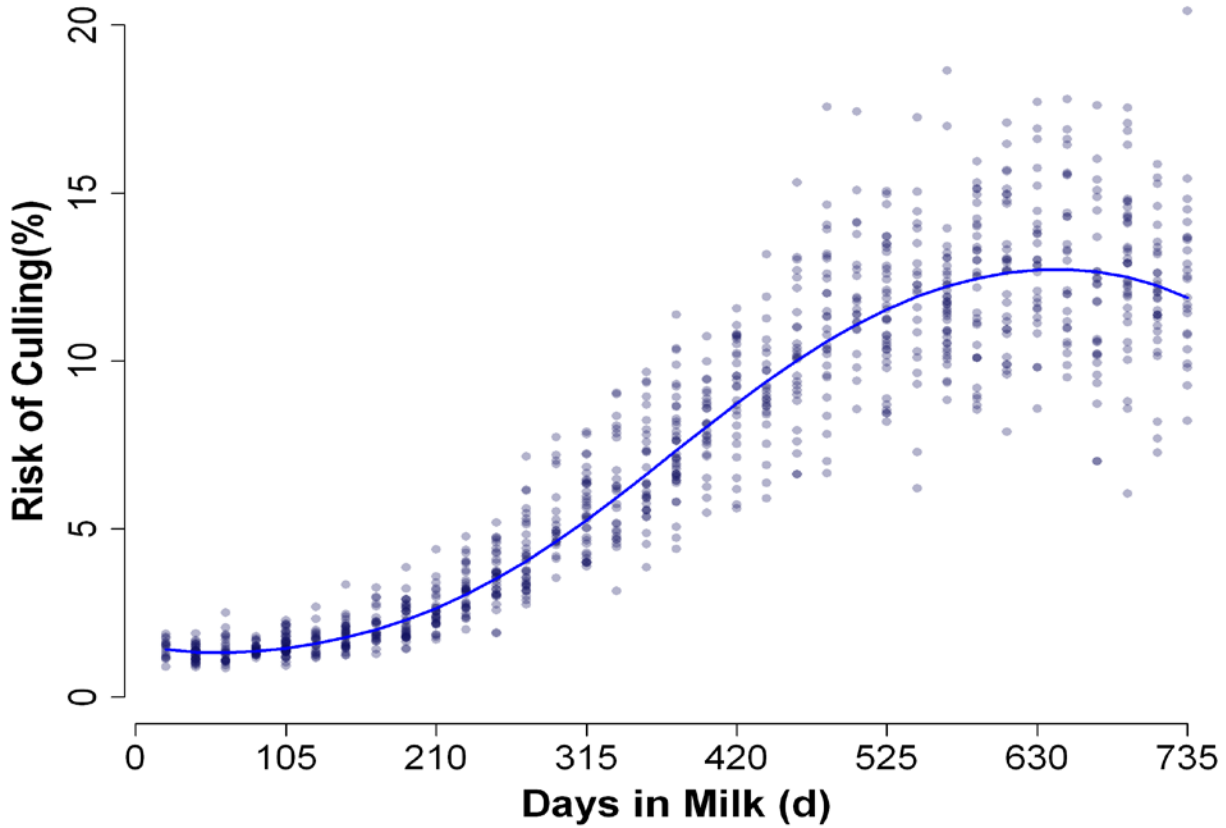
- Different ways to introduce randomness:
  - Fitting Polynomial Regression model:
    - Involuntary Culling
    - Abortion
  - Using Distributions:
    - Normal Distribution: Milk production
    - Triangular Distribution:
      - 21-d Pregnancy rate

M & M:

- 5th order Polynomial Regression (Binomial Family)

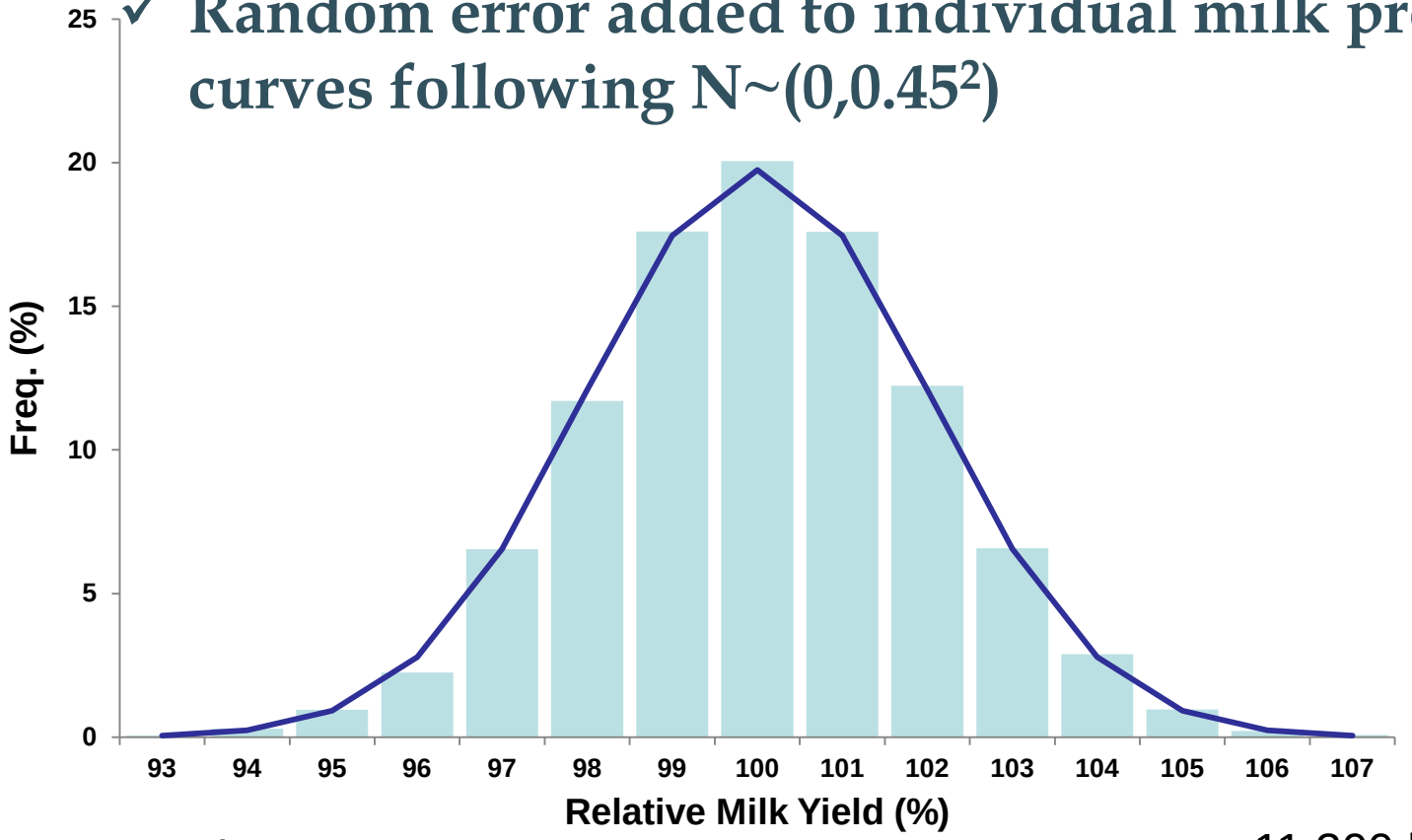
white noise (~N(0,sd(predicted residual))

  - Example for second lactation cows



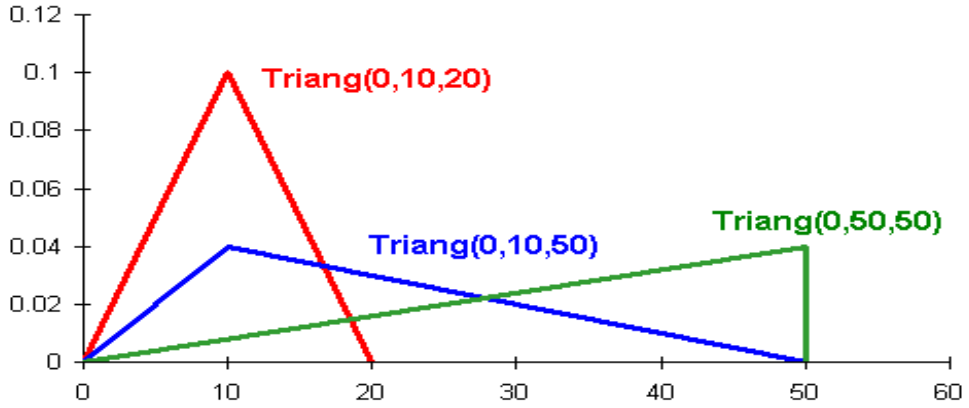
M & M:

- ✓ 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) ± 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 = Inv. Culling

I+A =Inv. culling + Abortion

I+P = Inv. Culling + Pregnancy rate

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

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

Results:

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

Run	Parity 1 (%)	Parity 2 (%)	Parity >= 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

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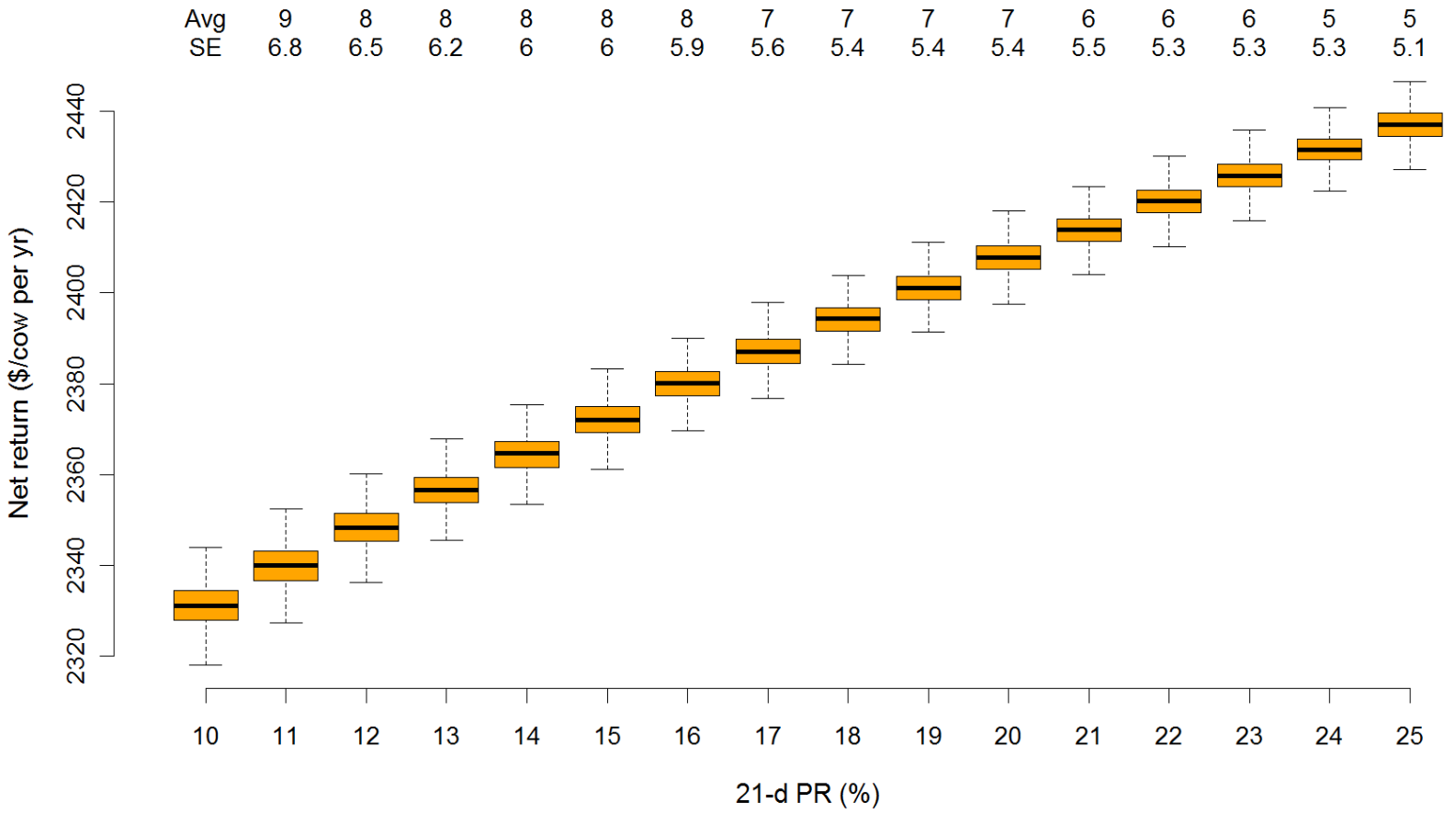
I+A+P +M= Inv. Culling + Abortion + Pregnancy rate + Milk prod. level

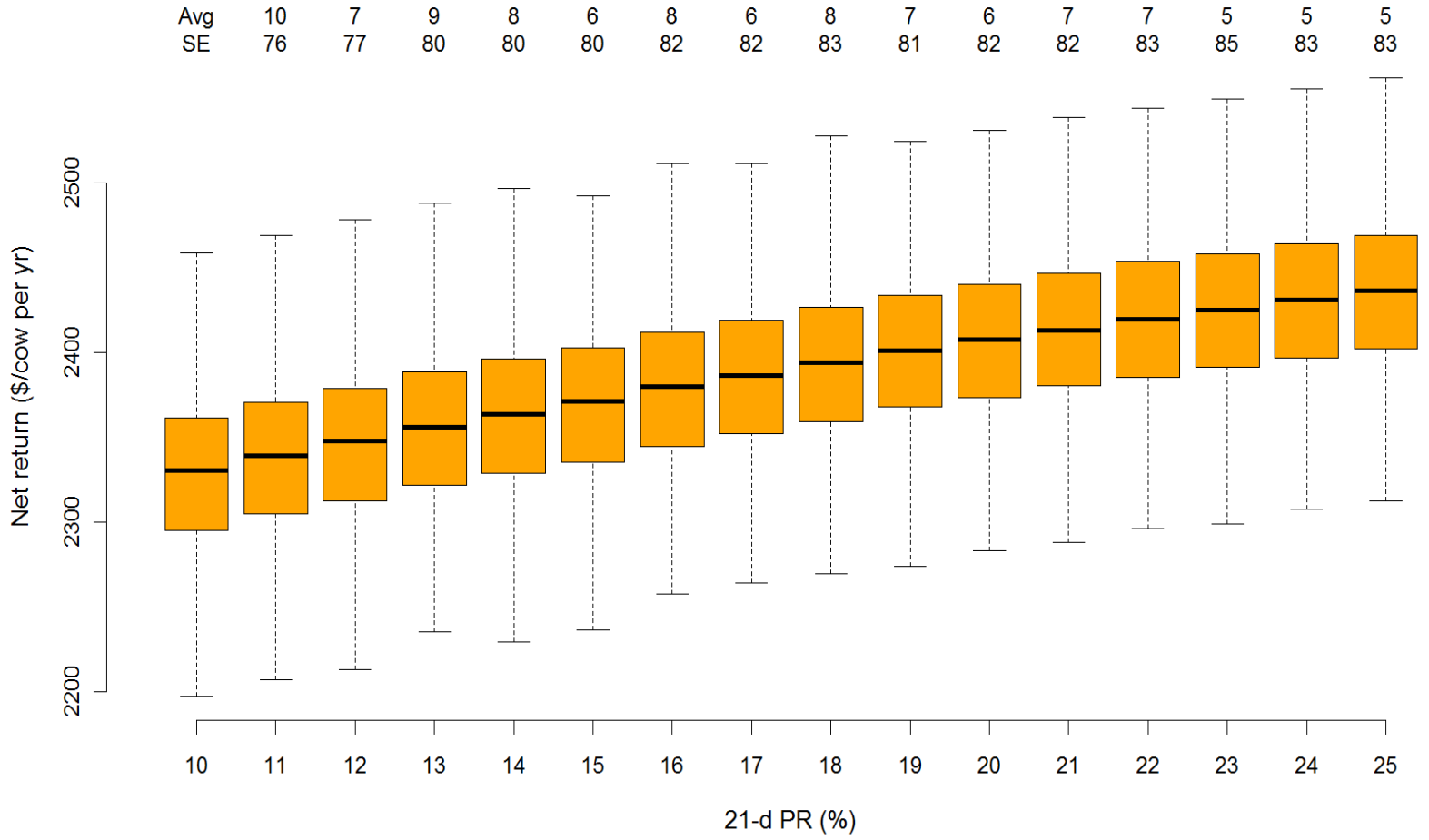
Results:

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



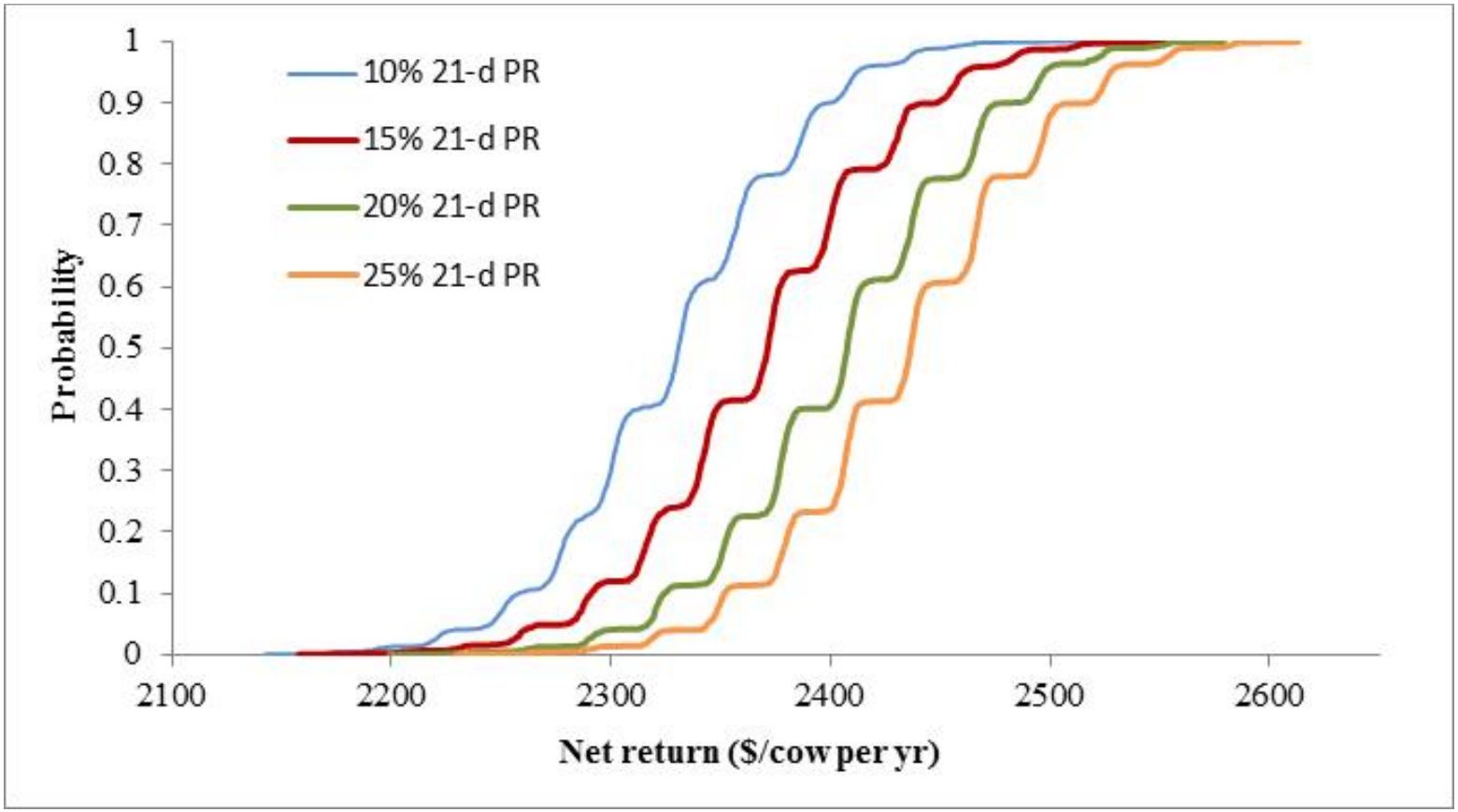
Results:

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**	