A dynamic programming model for optimising the timing of replacement of sows

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Introduction

Approximately half of sows are removed from the stock each year. Early culling of sows is an important economic and animal welfare problem. It is associated with genetic traits of sows and animal welfare issues such as the prevalence of animal diseases, inappropriate feeding, stress and housing environment - issues which can reduce also piglet growth and increase their mortality.

Rational producer can decide to replace the least productive sows after having evaluated their genetic and phenotypic traits. However, animal's performance is unknown *a priori* for both the current sow and gilts which may replace it. This uncertainty carries a cost and it can impact the timing of replacement considerably.

Our goal is to estimate how information about the piglet yield contributes to the timing of replacement, and how improvements in the animal's genetic traits impact the replacement pattern and return on capital invested in the facility.

Model

We use a recursive stochastic dynamic programming model to appraise genetic traits in the sow. The model maximises return on sow space unit by optimising the voluntary replacement policy. The state variables are parity number and litter size. The transition equations are parameterized with data about 12197 sows born in 2002. Statistical market price data are also used. Litter size and involuntary culling rate (exogenous shocks such as disease) can be represented by:

$$\textit{Litter size}_{Parity+1} = \textit{Litter size}_{Parity} + f(\textit{Litter size, Parity, Farm effect, Breed, Genotype, other factors}) + \textit{random term (i.i.d.)},$$

$$\textit{Probability of involuntary culling} = f(\textit{Parity}, \Delta(\textit{Litter size}), \Delta(\textit{Mortality}), \textit{Breed, Genotype, Price vector, other factors}),$$

where $\Delta(.)$ is the difference between *observed value* and *expected value* of variable inside the parenthesis[1]. *Litter size* equation is estimated with OLS whereas the probability of involuntary culling is estimated in a binary response model (probit). Data from experiments conducted at MTT parameterize piglet performance.

Results & Discussion

The optimal replacement rule responds inelastically and the value function elastically to changes in prices. The sow's genetic ability to repeatedly produce a large number of live piglets and the ability to stay in the herd increase the value of sow place (Fig.1). Involuntary culling of primiparous sows particularly contributes to the overall replacement cost and infertility and leg disorders are the most important stated reasons to cull the sow.

Small litter, high piglet mortality, the sow's age (parity number) and poor genetic index significantly ($p<0.05$) impact the decision to cull the sow. Piglet price also contributes to replacement decision, whereas feed price is less important. Incentives for voluntary replacement increase rapidly only after the 6th farrowing, because the optimal replacement policy is driven by involuntary replacements and uncertainty about future piglet yield (Fig. 2).

***Fig. 1.* Estimated benefits from improved genetics (the magnitude of change is given in parenthesis; * denotes a change which is equal to the genetic standard deviation of the measure).**

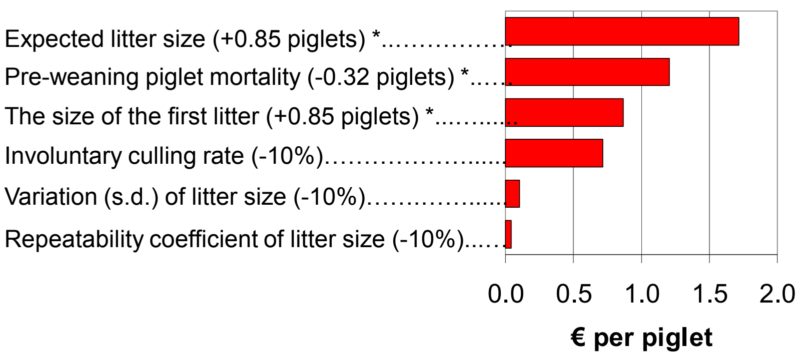
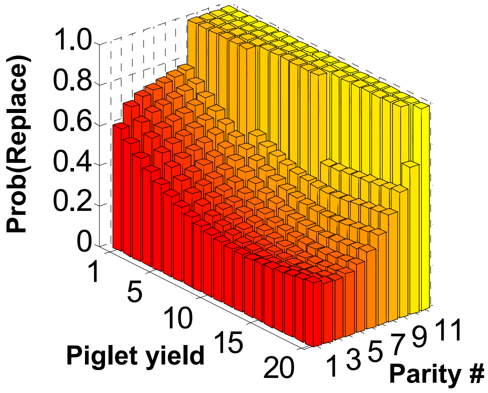


***Fig. 2.* Replacement policy conditional on piglet yield and parity number.**



Conclusion

Information about piglet yield in current parity has little value when used to forecast the next litter, because the repeatability of high and low piglet yield in successive farrowings is low. This reduces the benefits from early replacement of poorly productive sows. Durable animal investments require that animal breeding programmes, housing and management practices pay attention to yield, piglet mortality and other performance measures in early parities. Future research should examine returns on investments in animal-friendly production technologies.

1) e.g.Kristensen, A.R. & Søllestedt, T.A. (2004). A sow replacement model using Bayesian updating in a three-level hierarchic Markov process: II. Optimization model. *Livestock Production Science* **87**, 25-36.

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