Survival analysis to study replacement strategy of Dutch dairy farmers over 10 years with varying agricultural policies

AUTHORS

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SUMMARY

Voluntary replacement of dairy cattle is associated with various production, reproduction and health performance factors. Moreover, agricultural policy may affect the replacement strategy of farmers and the longevity of dairy cows. We present a unique 10-year longitudinal study on survival of all commercially producing dairy cows in the Netherlands. This big data study shows that performance factors drive replacement, regardless of varying agricultural policy schemes that influence herd size.

ABSTRACT

Replacement of underperforming dairy cows by suitable heifers is a fundamental part of dairy farm management. Changes in agricultural policy such as milk-quota abolishment impact herd size and might influence replacement policy of dairy farmers. The aim of this study was to analyze the survival of dairy cows on commercial Dutch dairy farms in response to policy changes.

To study the policy effects, parametric survival analysis with left truncated survival time was applied. The event was defined when an animal was sent to slaughter, exported or sold alive to another farm. An Accelerated Failure Time (AFT) model was used. Survival time per animal was split in right censored intervals of weeks between test days of the Milk Production Registration (MPR). The MPR data included5,289,957 milk producing cows from 14,618 commercial dairy herds between 2009 and 2019. For such a big database analysis, a high-performance computing solution was needed.

Time-varying factors of individual cows such as parity, relative milk production level, high somatic cell count (SCC), abnormal fat-protein-ratio, and rolling average of inseminations per parity (INS) were included in the analysis. The periods corresponding to changes in national agricultural policy were milk-quota era (MQ, 2009-2013), post milk-quota abolishment era (PMQ, 2014-2016) and start of phosphate regulation era (PH, 2017-2019), which were included as factors in the model. Estimates from the AFT model were time ratios between factor levels on a logarithmic scale.

Based on the data, the total replacement events (10^3) varied between 245-519 in MQ, 199-262 in PMQ and 297-327 in PH period. The mean survival age for the cows was 441 weeks overall. Results of the AFT model showed that parity and INS were collinear with survival age of cows and hence their association to replacement was complex to interpret. This issue was partially resolved by refitting the AFT model on parity level as age-like factor, which made the other variables more difficult to interpret. In general, in all versions of the AFT model, relative milk production level had a positive effect on survival time whereas abnormal fat-protein ratio and high SCC had a negative effect (refer Figure 1). Farmers react to policy changes with decreased (PMQ) or increased (PH) culling rates. However, the animal-level performance factors remained similarly important in the 3 policy periods (results not shown).

Modelling effects of policy changes on individual animal survival was more complex than anticipated, due to left- and right-censoring, the event definition, time-varying covariates and the size of the database. Agricultural policy changes were modelled in three fixed periods, precluding assessment of the variation in response time of farmers who might anticipate changes in policy differently, with varying response times before or after the new policy. Based on our results, we theorize that due to the policy changes, the criteria for replacement remain the same, but farmers become more or less selective.

In conclusion, the survival age of cows was influenced by the agricultural policy changes, the associated factors remained almost stable and the total productive lifetime decreased.

Figure 1. Accelerated Failure Time model for survival of Dutch dairy cows

Factors [±]	Survival time (weeks and days)
Intercept	**253 weeks and 2 days**
Relative Milk Production level	
below average	ref level
above average	286 weeks and 2 days
Somatic cell count (number/ kg milk)	
≤200,000	ref level
200,000 < SCC ≤ 600,000	240 weeks and 4 days
600,000 < SCC ≤ 1,000,000	233 weeks and 4 days
> 1,000,000	219 weeks and 1 day
Fat-Protein ratio > 1.5 (in first 100days lactation)	
frequency ≤ 10%	ref level
10% < frequency ≤ 50%	267 weeks and 2 days
frequency > 50%	268 weeks and 5 days
Fat-Protein ratio < 0.9 (in first 100days lactation)	
frequency ≤ 10%	ref level
10% < frequency ≤ 50%	252 weeks 6 days
frequency > 50%	245 weeks and 1 day
Policy period factor	
milk-quota era (MQ)	ref level
post-milk-quota era (PMQ)	252 weeks and 6 days
phosphate regulation era (PH)	241 weeks and 5 days
Scale †	**68 weeks and 3 days**

Time Ratios [ˇ] (with 95% CI)

[±] Corrected for Parity and rolling average of Inseminations. Note: Interaction effects not displayed in the figure

[ˇ]Time ratios are on log scale. $e^{\log(t)}$ = time to event in weeks.

[†] Scale is the scale parameter/ Std Deviation of underlying log-normal distribution