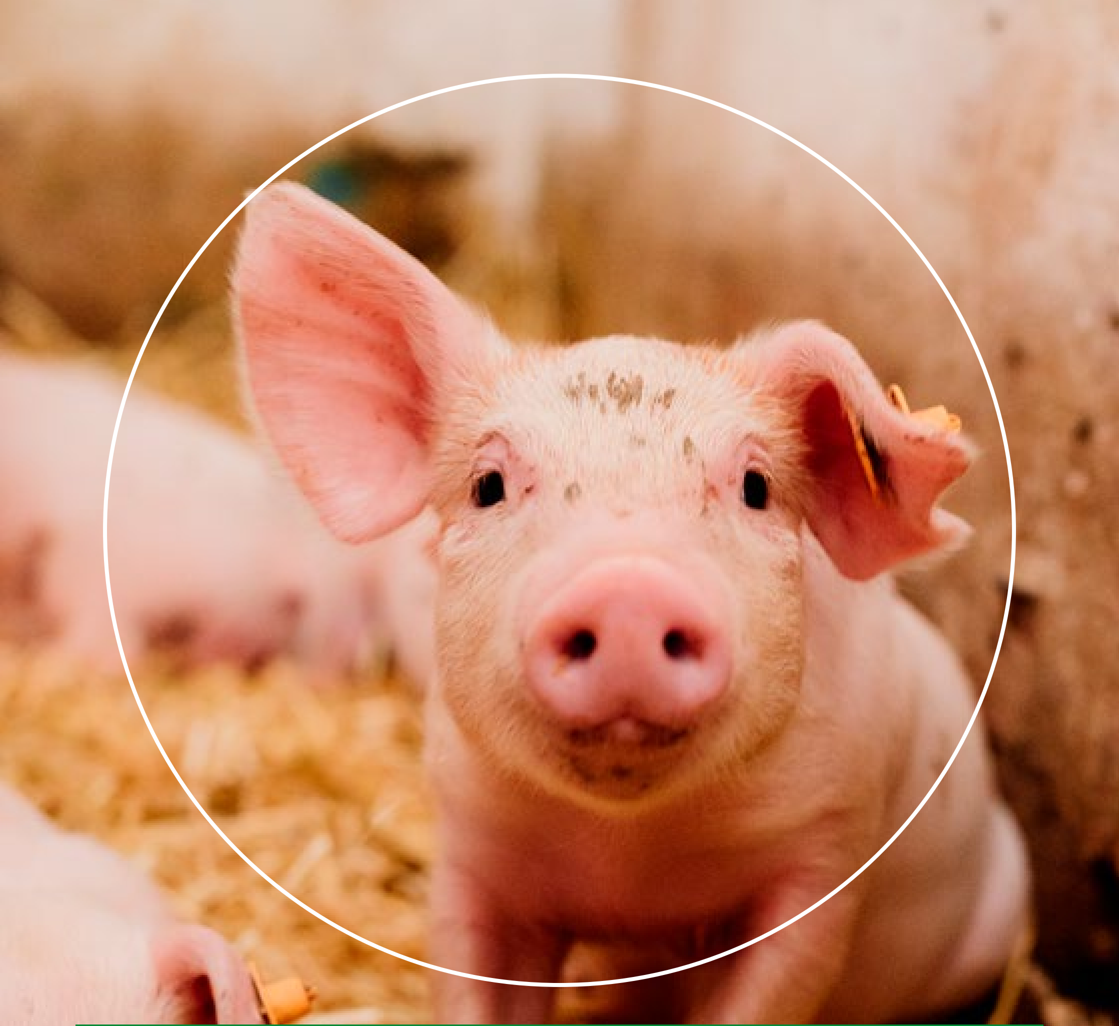

LSR method capturing impact on variability

Practical guidelines

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Illustration

A pig feeding experiment was designed to compare a standard and a precision feeding method during the grower and finisher period for pigs with either a low or high by weight at birth.

The model to analyse daily body weight included day in the experiment as a covariate and birth weight and feeding method as two class effects with two levels each, along with other class effects to correct for systematic variation between pigs.

The daily body weight recordings were analysed using an unbalanced ANOVA method in GenStat.

Table 1 Effect of feeding method and birth weight class on body weight of finisher pigs

LSR	Standard feeding	Precision feeding	Margin
High birth weight	+8.60	+3.56	+5.31
Low birth weight	-6.33	-4.31	-5.01
Margin	+0.64	-0.64	

The residual variance was 38.21 kg2. The residuals from the above analysis were transformed using this residual variance.

Table 2 Estimated means of LSR of body weight of finisher pigs by feeding method and birth weight class

LSR	Standard feeding	Precision feeding	Margin
High birth weight	3.44	3.47	3.46
Low birth weight	4.68	3.36	3.82
Margin	4.10	3.41	

The interaction between feeding method and birth weight class was significant for both body weight and LSR of body weight ($P<0.001$).

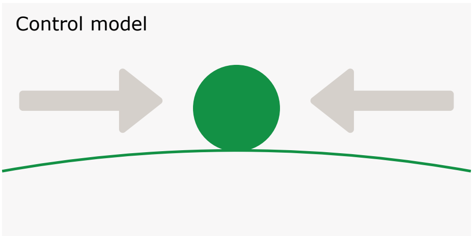
The conclusion would be that standard feeding allows the high-birth-weight pigs to maximise their growth rate, but low-birth-weight pigs vary considerably in growth rate. The precision feeding method reduces the variation between birth weight classes and within the low-birth-weight class.

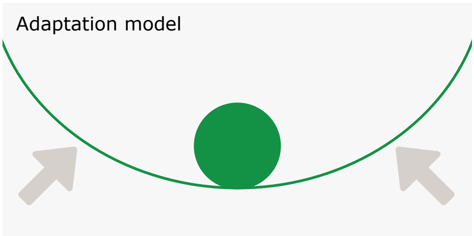
In a standardised experiment in which only pigs with an above-average birth weight were used, the conclusion would have been to prefer the standard feeding method. Adding low birth weight as a noise factor to the experiment revealed that in practice, standard feeding may lead to a lower uniformity compared to precision feeding.

Background

In livestock farming we aim for stable health and welfare of animals. One way to achieve this is to protect animals from disease and discomfort as much as possible. The living environment of animals is controlled to a high extent. In such a system, animals are highly dependent on successful protection and timely intervention of farm workers in case protection fails. This is the Control model.

An alternative way is to prepare animals for disease and dynamic conditions that regularly occur in their living environment. They will adapt to stressors and minimise the impact. This is the Adaptation model.





Both insufficient protection and inadequate adaptation lead to more variation in health, welfare and performance. The challenge is to identify what induces and what reduces this variation. Resilient farming systems show minimal increase in variation in dynamic conditions. The LSR method involves experimental designs that generate sufficient variation and provides a tool to analyse it for more resilient farming systems.

Application

Examples of applications are:

- A product works well in a test environment but is variable in practical conditions, for example feeding a high level of lysin to high or normal health pigs.
- Identify management practices that give a reasonable & stable performance of livestock, for example type of bedding in cubicles of dairy cows.
- Identify settings of equipment that minimise variation in its function, for example a sorting gate or a sow feeding station.
- Identify a feed level that minimises variation in performance, such as milk production, as a proxy for animal health.

Experimental designs

Scientific experiments are generally designed to minimise residual variation in order to test contrasts between treatments. Optimisation experiments, however, should be done in conditions that reflect practice. It means that it is better to add noise factors to the experimental design. A noise factor is a dynamic condition in practice, which is added to the experimental design in two or three levels, for example moisture content of litter or room temperature. Alternatives to applying noise factors are to do the study on a range of commercial farms or to analyse field data.

Analysis tool

The LSR method (Linearised Squared Residuals) is an evaluation of the residuals of the statistical analysis of means of treatments and conditions. It is a method to analyse variation in addition to analysing means. The residuals are stored, transformed and analysed as a trait with the same model as the analysis of means.

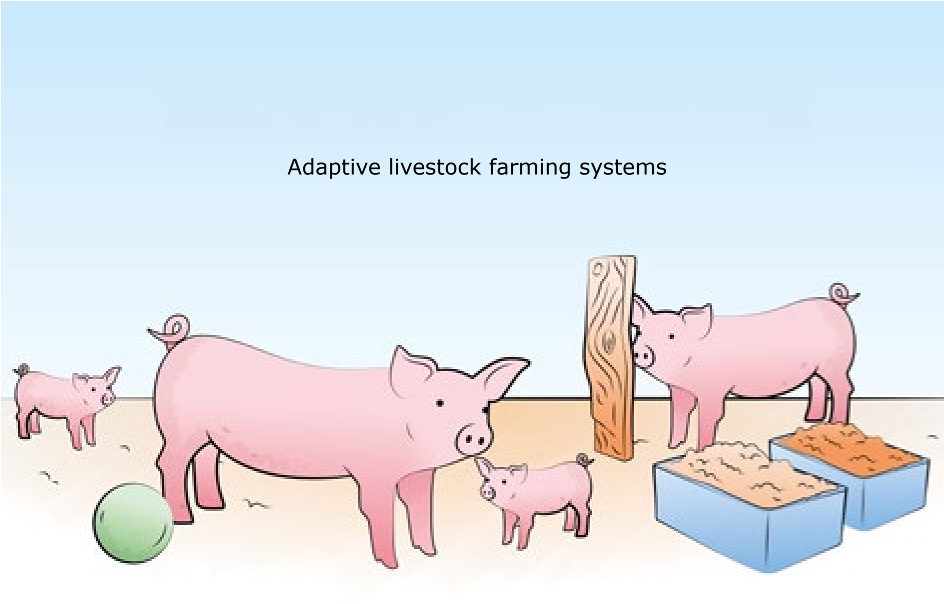
The first step is to define an appropriate model for observed performance to estimate treatment effects while correcting for any other systematic differences between observations. The statistical method can be ANOVA, unbalanced ANOVA or generalised linear regression, depending on the data structure.

The second step is to transform the residual (e) of a record into the LSR using

$$LSR = \log(VarE) + \left(\frac{e^2 - VarE}{VarE} \right)$$

VarE is the residual variance (or ANOVA mean square error) from the analysis of means.

The third step is to analyse LSR with the same model and method as the original observations. If LSR is approximately normally distributed, the F-tests of ANOVA or the t-test of comparing level means may be used to determine whether treatments and conditions really impact on


Adaptive livestock farming systems

Interpretation

The LSR method gives insight into the impact of different treatments on variation in performance. If the experiment is standardised to a large extent, there may not be much variation to analyse. Any results of the LSR method may not be meaningful in that case.

If a level of treatment or condition has significantly higher LSR than other levels, it may reduce the resilience of animals by affecting the ability to cope with this environment. In such a case, a histogram of observed performance will likely be skewed towards levels that are indicative of poor health, welfare or performance.

A treatment may *appear* to increase variation, if in an unbalanced design, relatively many records were collected in more dynamic conditions. The LSR method allows to correct for such an unbalanced design and estimate the impact on variation across the levels of other effects in the model.

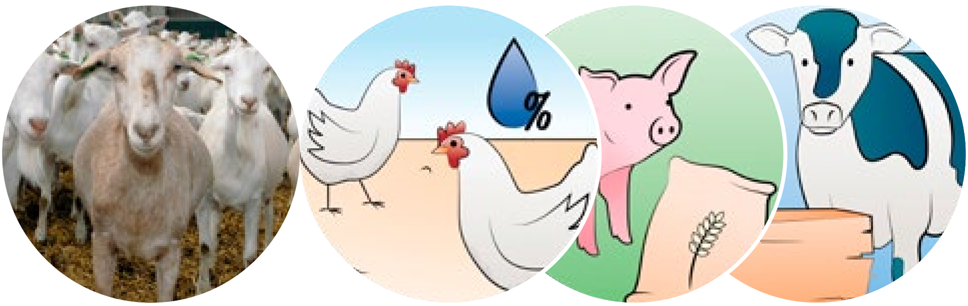
Treatments that do not have increased variation in a more dynamic environment may be considered not to affect resilience of animals.

Correct use

The LSR method to quantify the impact of a treatment on variability is particularly relevant if data were collected either in commercial practice or in experiments in which the main sources of variation in commercial practice were added as noise factors. Treatments that make animals more dependent on good management can only be identified as such if they were evaluated in dynamic environments.

Even in highly controlled conditions, there will be a residual variance and the LSR method may show small, but significant contrasts. From earlier analyses, it appeared that such significant differences are not repeatable and do not reflect differences in practice.

If used correctly, the LSR method contributes to livestock farming in which we support animals to adapt to dynamic conditions where possible and protect them where necessary.



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