

Show Me the Money—Optimizing Production

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■ What is Optimization?

The Oxford English Dictionary defines optimization as, *the action or process of making the best of something*, and that best point is the *optimum* (pl. optima). Challenges arise in the interpretations of *best* and *something*. *Best* could denote superior quality, maximal output, least variation, or a measure of profit. *Something* could refer to local or generalized optima. In the big picture, optimization occurs at the level of the system; localized optimization, alternatively, can result in *suboptimization* at the level of the system—the condition that occurs when a system’s individual components fail to work together to achieve maximum performance. System optimization, therefore, requires achievement of a balance of *competing objectives*, that is, resolving the conflicts between local optima.

Different processes have different types of optima (Xu et al, 2004). *Nominal-The-Better* (NTB) optima occur with the minimum deviance from target, such as the weekly production of weaned pigs to fill a system. *Larger-The-Better* (LTB) optima occur when response is maximized, such as the weaning weight of those pigs. And *Smaller-The-Better* (STB) optima occur when response is minimized, such as the combination of culls, deads and lightweight pigs from finishing production.

■ Approaches to Competing Objectives

As with other industries, pork producers have looked to improve their performance with improvements in quality, but quality has different meanings for different people in different areas. The transcendent definition refers to a non-specific excellence—i.e., a “good” weaned pig. The product-based

definition quantifies product attributes—i.e., a healthy, fast-growing weaned pig. The user-based definition refers to fitness for intended use—i.e., a defect-free weaned gilt of specified genetics that has 14 evenly-spaced teats and will be suitable as a replacement female. The value-based definition describes return for the price—i.e., the weaned pig produced at the least cost, or the weaned pig produced at the most profit. A manufacturing-based definition refers to conformance to specifications—i.e., a pig >8 lbs and >15 days of age at weaning. And the broad definition of quality describes the ability to meet or exceed customer requirements—i.e., the correct number of weaned pigs meeting the specified requirements delivered to the nursery at the specified time. (Evans and Lindsay, 2005)

Such differences in the interpretation of quality allude to the challenges of system optimization. Priorities differ among different segments of production and different functions within an operation. Some objectives may be easier to balance than others, i.e., biosecurity risks versus trucking costs. Other competing objectives are more difficult to weigh, i.e., is it better to keep the system filled with pigs even if it means placing substandard piglets? And with an imperfect system, is it better to focus on least cost or strive for most profit? In the absence of a universal definition of quality throughout a system, how can system-wide optimization be achieved?

■ Working within Limitations

A true or full optimization is a worthwhile goal and yet virtually impossible under current circumstances. We are limited by the measurements that we can and do make of swine production. We are limited by the analytic capabilities to address the wide variation and nonlinearity of the relationship of inputs and outcomes on the farm.

We must identify the full range of the challenge and then choose those factors that are most likely to affect the outcome. This can be done subjectively, but is often limited, in large enterprises, by the lack of knowledge of the full system. For instance, we can bring together different managers, but they are often specialized in areas such as the sow unit, the feed mill or grow finish barns. Most have been trained to create a local optimum in their specific area, and to essentially neglect other concerns.

Moreover, nonlinear relationships between inputs and outputs are rarely assessed correctly if left as a subjective concern. The relationship between inputs and outcome characteristics must be quantified to allow a good optimal result to be identified.

■ Finding a balance with Quality Management

The concept of *Quality Management* has evolved over the last several decades. The core principles of Quality Management, as adopted by the International Organization of Standards are described below.

Principle 1 Customer focus: All processes have customers—recipients of a product or process. Internal customers receive products and services within the system; external customers receive the system’s end product(s). Meeting internal and external customer requirements is essential to the efficiency of a system.

Principle 2 Leadership: Leadership within a system establishes consistency of purpose and allows the greater operation to reach optimization.

Principle 3 Involvement of people: Employees at all levels of organization are capable of valuable observations, input and insight. Flexibility, adaptability and openness to “better” methods are essential to improvement.

Principle 4 Process approach: Formal, consistent procedures and processes help to reduce variation within a system.

Principle 5 System approach to management: Only a system-wide approach that balances competing objectives will be able to achieve long-term optimization.

Principle 6 Continual improvement: Operations not striving to improve are prone to “regression to the mean.”

Principle 7 Factual approach to decision making: Measurements and statistics are essential for establishing improvement.

Principle 8 Mutually beneficial supplier relationships: Input suppliers recognize their inherent interest in delivery quality product and services that meet their customer expectations.

*Adapted from the revised ISO 9000:2000,
source: <http://www.iso.org/iso/en/iso9000-14000/understand/qmp.html>*

■ General Approaches on Swine Farms

We would argue that there have been three general assaults on quality management in swine farming over the last number of years. They include:

- **Expansion of size and localization of responsibility.** This is illustrated by the reliance on bonus systems that focuses on local optima for productivity. Little communication is evident between phases of production and input suppliers so that cost minimization is much more of a decision-making emphasis than quality improvement.
- **Lack of measurement for factual assessment of quality.** It is surprising that it took so long for the swine industry to recognize that a low weaning age was a function of a local optimization rather than a system optimization. When lower weaning age pigs are tracked through the production system it has often been found that the savings within the sow unit are matched and exceeded by additional costs in the production system.
- **A lack of management accounting.** Improvements in quality are not assessed through standard financial accounting methodologies. Financial accounting is biased towards assessing historic costs and their manipulation. Management accounting assesses potential improvements, particularly in system-level approaches to quality. Management accounting is done by managers, not accountants and these skills need to be developed in swine production.

There's a general reluctance to admit to the high level of complexity of pig production. There are very few manufacturing processes that involve such a broad range of inputs with variable quality and interactions with outcomes. Given this high level of complexity, the swine industry is particularly reluctant to invest in production monitoring methods, as well as analytic protocols. Optimization of production processes requires adequate investment in records, people and methodological skills. When such resources are available, the opportunities for improvement in swine production rise to a new threshold.

■ An Example: Weaned Pig Characteristics and the Nursery

In production flow, the nursery is a customer [either internal or external] of the sow farm. The success of a group of nursery pigs is dependent on both the quality of animals placed and conditions experienced during the phase. And the quality of animals placed is dictated by the conditions in the sow unit.

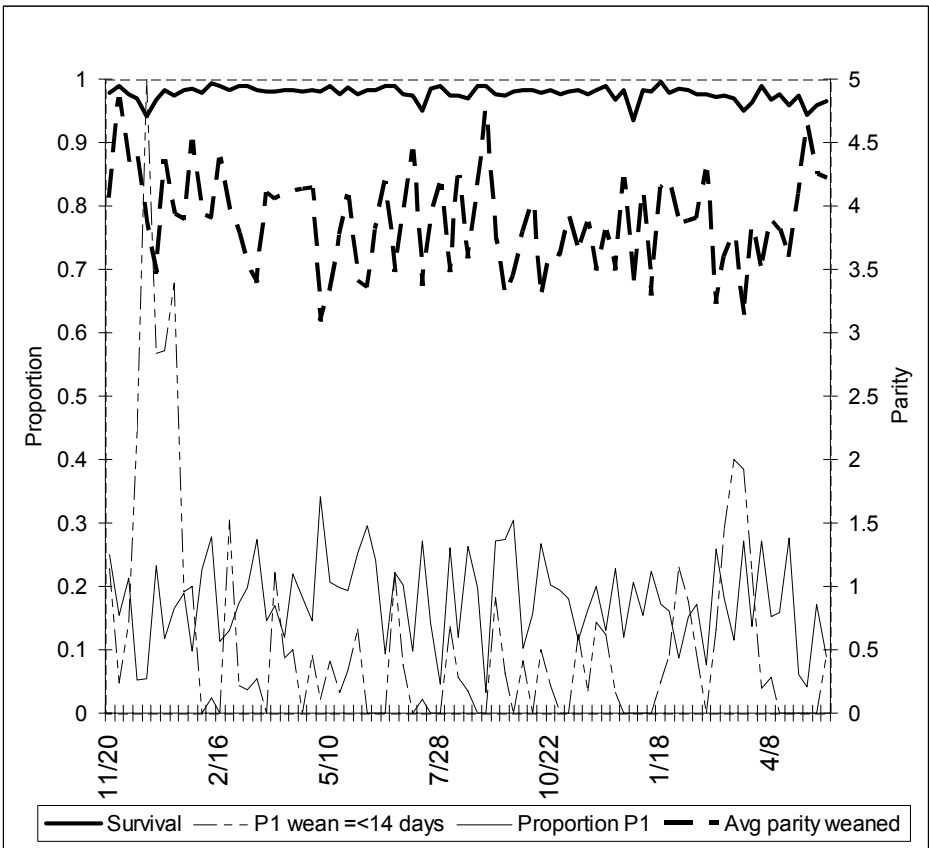


Figure 1: Group survivability and weaned sow characteristics by placement date for a single-sourced nursery.

Characteristics of both the piglets weaned and the group as a whole will impact the growth and mortality of progeny in the nursery (Larriestra et al, 2006). At the individual pig level, they showed that factors at entry into the nursery such as weight, age, parity of the dam, and gender are all involved in predicting survivability and quality of pig at exit from the nursery. These risk

factors can be expressed through individual failures such as failure to thrive or as group level failures such as epidemics of disease. The existence of epidemics illustrates that the existence of a poor quality pig within a population may not only have an effect on itself, it appears to have an effect upon the quality and well-being of the performance of other pigs within the population. These two effects are often called atomistic and ecologic effects and most should be considered when evaluating the potential benefits of improvement of quality of inputs.

A simple initial analysis is illustrated in **Figure 1**. One of the characteristics of input quality in swine farms is its instability. It is a very limited use to speak about average weaning age without examining the variation of weaning age. There are systematic pressures that create seasonality in weaning age and thus weaning weight in many systems. For instance, seasonal infertility can result in increased weaning ages. The rebound of sows bred after seasonal infertility often forces weaning ages down.

For this system, the predictors of group success (as defined by survivability of progeny in the nursery) included older average parity at weaning, fewer parity 1 sows weaned at 14 days or less, and groups placed January-February (Figure 1). Such correlations between weaned pig quality and subsequent performance are not uncommon, but are often not assessed.

An Example: Sow Unit Output

Sow unit output is treated in a number of different manners. The most common historic method has been to treat the number of pigs as a larger the better optima, with the output restricted by other qualities such as weight and age. Usually the restrictions are characterized by the average weight and age for a cohort of pigs leaving the unit at the same time.

This oversimplifies the effect of output on the overall system for two reasons. The first is that the qualities of number, weight and age of pigs do not have a linear relationship with the requirements of downstage production. The second is that these factors are not independent and not only should the variance be addressed, but also the covariance. In addition, we must focus on the interventions that have an effect on the outcome. In this case, the number and type of sows bred in a week's cohort, along with the choice of weaning age are the main manipulables.

The problem with the sow unit is that optimization should include an examination of variation of output. Demand is actually, completely static and defined by the capacity of the nursery. Producing pigs beyond the capacity of the next stage results in low value sales or overcrowding. Underproduction results in poor utilization of facilities and/or compensatory actions such as the

reduction of weaning age or the mixing of sources to meet the requirements to fill the nursery facility.

We must do more analyses of contributing factors to the underproduction or overproduction of piglets within one system. Variation, in this case, is actually not classic variation. It is not variation from a mean, but from a target, modeled best by techniques such as minimization of total absolute deviations. When we have looked at this, the farrowing rate has consistently been the top contributor to variation. This is in addition to the number of sows bred and the litter size. For instance, producers seem to be surprised year after year by seasonal infertility. Seasonal infertility may be addressed by compensatory mechanisms, such as increasing the number of sows available within the herd. However, improving the consistency of the variable at fault is a more direct methodology. **Figure 2** shows an analysis of farrowing rate based on the number of matings in this graphic can be seen that the single mated sows have seasonal infertility, rather than the population as a whole.

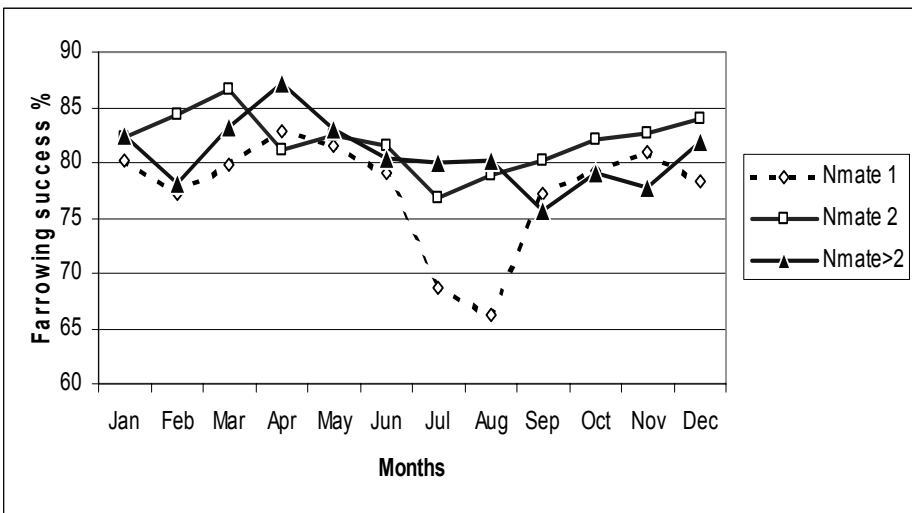


Figure 2: Comparison of farrowing rates based on number of matings within a service

The input, in this sample, is the number of matings. The number of matings in turn affects the farrowing rate, the farrowing rate affects the number of piglets weaned and the utilization of nurseries. The farrowing rate also rebounds so that there is an excess of piglets after this, affecting the quality of pigs weaned and subsequent survival and growth rates. There are more linkages in pig production than we often think.

■ Summary

There is a technique in quality management called the “Five Why’s”. When there is a problem, there should be not only one why but a set of at least five why's linking the system together. These sequences are difficult to do but highly advantageous when solved. For instance pigs die in the nursery because of *H. parasuis*. They die of the disease because they were weaned too light. They were too light because they were too young. They were too young because too many sows farrowed. Too many sows farrowed because there were an excess number of sows rebred with a subsequent high farrowing rate. These were returns because of seasonal infertility. Seasonal infertility occurred because of a low farrowing rate caused, at least in part, by single matings during the summer. And so we can go on.

Optimization of the system is recognizing the links and emphasizing them as common responsibilities. It is something that we are starting to do, but the opportunities are endless.

■ References

- Evans, J.R., Lindsay, W.M. (2005) Introduction to Quality. *In The Management and Control of Quality, Sixth ed.* Thomson Southwestern, Mason, Ohio, pp. 12-14.
- Larriestra, A.J., Wattanaphansak, S., Neumann, E.J., Bradford, J., Morrison, R.B., Deen, J. (2006) Pig characteristics associated with mortality and light exit weight for the nursery phase. *Can Vet J.* 47:560-566.
- Xu, K., Lin, D.K.J., Tang, L.C., Xie, M. (2004) Multiresponse systems optimization using a goal attainment approach. *IIE Transactions* 36:433-445.