Sponsors

University of Minnesota
College of Veterinary Medicine

College of Agricultural, Food and Environmental Sciences

Extension Service

Swine Center

Editors

W. Christopher Scruton
Stephen Claas

Layout

David Brown

Logo Design

Ruth Cronje, and Jan Swanson;
based on the original design by Dr. Robert Dunlop

Cover Design

Shawn Welch

Configuring a pig production system to manage variability

Bill Greenley, MS
Swine Graphics Enterprises, LP, Webster City, Iowa

Introduction

Variability in the processes that make up the pig production chain is unavoidable. Traditionally, only means of the measurements of process throughputs are considered when production systems are configured to those measures. As actual pig flow surges and ebbs, pigs are stuffed through the production pipeline and processes are starved out, respectively. During a surge in pig flow, the pigs in the pipeline ahead of the surge are prematurely forced to the next stage, resulting in younger wean-ages, earlier transfer from nursery to finisher, and/or lighter market weights.

To configure and manage a pig production system around the unavoidable process variation, protective capacity of facilities must be built in. Additionally, excess pig flow at the beginning of the production chain must be planned to reduce the frequency of process starve-outs. With both of these design goals, traditional process efficiency measurements will be compromised.

This paper will examine strategies for placement and sizing of protective capacity and pig flow as well as the impact of these on performance measurements. Alternative system performance measurements will be discussed that more directly connect to bottom-line enhancing decisions.

Discussion

A pork production chain can be minimally thought of as two interacting sub-systems. At the end is the nursery/finisher system to grow out weaned pigs to market weight. These weaned pigs are produced by a reproduction subsystem. In some enterprises, this reproduction system is preceded by a multiplication sub-system that produces replacement gilts. The weaned pig deliverable between the reproduction and nursery/finisher sub-systems is a point of conflict in a couple ways. One is the rate (both mean and variation) at which weaned pigs are generated and the other is the wean-age profile of each batch. The batch-to-batch variation of wean-age profiles is also significant. Main and Dritz, et al. published a series of papers in 2002 on the effect of wean-age on subsequent nursery/finisher performance. Younger weaned pigs are penalized in nursery/finisher growth and need additional time to achieve market weights equal to older weaned pigs. The additional time penalty required for this growth is nearly double the number of days of their wean-age reduction. Therefore the economic impact of the wean-age profile must be considered in configuring adequate nursery/finisher capacity.

In **Table 1** we see a typical finisher group as it approaches market weight. In this scenario, a group is stratified into

Table 1: Typical finisher group as it approaches market weight, stratified into seven semi-loads for marketing.

Finisher days	Avg Wgt	Revenue	Loads reaching target wt	Incr. rev	Incr. feed	Incr. CM	Load weight [Load no. (CV[A])] 1 (7%)	2 (6%)	3 (5%)	4 (4%)	5 (5%)	6 (6%)	7 (7%)
100	226	$146,682	0	-			271	254	237	222	210	200	189
105	234	$154,333	0	$7650	$3581	$4069	282	264	246	230	218	207	196
110	243	$161,296	1	$6964	$3581	$3382	290	274	256	239	226	215	203
115	250	$167,172	1	$5876	$3070	$2806	290	285	265	247	234	222	210
120	257	$172,316	2	$5144	$3070	$2074	290	290	274	256	242	230	217
125	262	$176,598	2	$4281	$2558	$1723	290	290	284	265	250	237	224
130	268	$180,855	3	$4257	$2558	$1699	290	290	290	273	258	244	231
135	273	$183,876	3	$3020	$2047	$974	290	290	290	282	266	252	238
140	277	$186,782	4	$2907	$2047	$860	290	290	290	290	274	259	245
145	280	$189,068	4	$2286	$1535	$751	290	290	290	290	282	267	252
150	284	$190,965	5	$1897	$1535	$362	290	290	290	290	290	274	259
155	285	$192,368	5	$1403	$1023	$380	290	290	290	290	290	282	266
160	287	$193,491	6	$1123	$1023	$100	290	290	290	290	290	289	273

[A]Overall group weight CV, 11%.

seven semi-loads for marketing. We use the following assumptions, which are typical for a Midwest pork production enterprise:

- F/G (heavies), 3.8
- Ration cost, $0.072 per lb feed (final stage)
- Gain/week, 11 lb
- Final ADG, 1.70
- Feeder pig in-weight, 50 lb
- Final stage feed cost per pig per week, $3.01
- Meat base, $70.00
- Head/group, 1190
- Mean lean, 55%
- CV lean, 5%
- Yield, 76%

Loads are best-effort sorts (not perfect) to transport the heaviest pigs. A load is sold when its average weight reaches a target market weight. The target market weight is chosen such that any incremental contribution margin (incremental revenue minus incremental expense) of additional gain is negligible and such that selling lighter would forgo opportunity for incremental contribution margin. In this particular illustration, an interval in the finisher of less than 110 days for these 50 pound average feeder pigs would not allow even a single top load to reach this 290 pound target market weight. As the time interval in the finisher increases, more and more loads are able to reach the target market weight and the group's incremental contribution margin (CM) grows. At the extreme, only one final load remains and little incremental contribution margin can be captured with more time. (Typically individual load averages are not known in this manner for the pigs at group closeout as they are simply gate-cut onto trucks rather than sorted by weights.)

Indeed, this view suggests an approach for configuring nursery/finisher capacity. Having enough capacity to allow groups to have 125 versus 120 days, for example, will capture, approximately, an additional $1723 in contribution margin. The annual cost of the required additional nursery/finisher capacity can be compared with this $1723/group additional contribution margin it enables. Additional capacity and/or equivalent intervention can and should be added up to the point of insufficient incremental revenue to warrant the incremental expense.

A younger wean-age profile for a group can be assessed using this table as age effectively shifts the time interval in the finisher. In other words, a wean-age profile of X days younger will have the same effect as nearly 2*X less days in the finisher. Alternatively, if the wean-age profile is simply broader rather than uniformly younger, then the top loads may well be unaffected and the lighter loads alone would bare the time penalty.

We can assess the financial health of a reproduction and nursery/finisher system (hereafter known as "pyramid" for brevity sake) by looking at Pyramid Contribution Margin (PCM):

$$\text{PCM} = \left(\sum_{i=1}^{N} CM_i - OtherDirectCosts\right)$$

where CM_i denotes the contribution margin of group i. To be sure, CM is not the same for each group. Surges and ebbs in pig flow will cause the number of days available to a group in a nursery/finisher to decrease or increase, respectively. Surges and ebbs in the number of litters farrowing will similarly decrease or increase the wean-age profiles of weaned pigs. These two dynamics affect the CM of groups about to close or groups being placed. As the reproduction subsystem increases, the number N equals groups produced per year; then CM_i will decrease unless some intervention occurs in the form of more nursery/finisher capacity or treatment(s) that accelerate growth. Remember that as N increases, the wean-age profile of weaned pigs is typically decreasing overall which exacerbates the decreases in CM_i. Furthermore, increasing N almost certainly increases other direct costs related to sow feed and replacement gilt costs. The obvious question is the following: Did the above total annual contribution margin improve with an increase in N? By definition other expenses are fixed and are the same for various values of N and are, therefore, not relevant to this analysis. An example of a non-direct cost is overhead expense.

In multi-pyramid enterprises, this can be replicated up the system by substituting in the above equation PCM for CM with other direct costs referring to system-wide direct costs such as multiplication sub-systems, boar studs, trucking sub-systems, etc. Some enterprises may even have intermediate levels if pyramids are clustered.

In general here we are decomposing profit into the simple formula:

$$\text{Profit} = \text{Margin} - \text{Overhead}$$

To enable analysis we are stratifying margin into levels with an individual group of nursery/finisher pigs at the lowest level. To a certain extent we can even decompose margin to the load level. What we are *not* doing here is allocating expenses.

Revisiting **Table 1** we should note that the spread between these seven loads is based on the overall weight distribution within the group. In this particular example, the coefficient of variation (CV) is about 11%. Obviously, as this distribution changes, so too does the time at which each load will reach target market weight. Top loads may

Production

go earlier or later but will not impact the group's CM much as long as the interval is less than the group's overall time in the facility. Bottom loads will be lighter or heavier when the clock runs out for this group in the facility. It should be noted that pulling a top load can impact the remaining pig growth by freeing up pen space. This has been investigated before and must be tempered with the brief re-socialization period that hinders the growth of remaining pigs. Clearly if sacrificing a little CM on the top load increases the CMs of the remaining loads, then it is the prudent strategy.

From a modeling perspective, we should observe that, given some input and assumption parameters that define the quantity (weight X percent lean distribution) and base price, we can apply a packer's grid to compute the load revenues. Furthermore, given F/G and ration cost data, we can determine the target market weight, incremental feed expense, and thereby incremental CM. As discussed before, the wean-age profile of a group impacts the weight distribution of the group. Last but not least is the number of days allotted to the group before it must vacate the finisher.

The above group-CM model must now be spliced onto a reproduction model whose output is a stream of weaned pig batches, each with a wean-age profile. The frequency of these batches and the varying time interval between them clearly impacts the input parameters of the group CM model. Therefore, sow farm sizing and management strategies with their respective cost differences can be assessed by evaluating this resulting output stream of weaned pigs and the nursery/finisher's capability to process them into CM. Using these spliced models, we can value the tradeoffs involved in sow herd and facility sizing, including relative gestation and farrowing capacity. Farrowing capacity and the strategies for its use coupled with the number of litters being pushed through it (enabled by the gestation capacity and sow herd load) play out in the wean-age profiles and the output stream of weaned pig batches.

The next model to splice is the replacement gilt subsystem to determine its optimum size so that the reproduction system is not starved out so often that weaned pig output is compromised. As process variation manifests itself in sow culling and mortality, there is dynamic demand pulling on an incoming stream of replacement gilts.

Intuitively one can begin to sense the damage done by traditional industry efficiency measurements. In general, any efficiency measurement that tries to assess use of a resource, such as facility usage, will drive management behavior to reduce the amount of that resource to the point that it frequently constrains the system's ability to generate contribution margin. In the context of efficiency measurements, even occasional excess is evil. However, as we have discussed here, occasional excess capacity is necessary to protect the nursery/finisher subsystem's ability to generate CM and the reproduction subsystem's ability to generate a stable output stream of weaned pigs that don't exhibit frequent young wean-age profiles. We might label these planned capacity excesses "system buffers" or "protective capacity."

Conclusion

Evaluating the profitability of a pig production system should only be done in full recognition of the variation that occurs in pig flow and within batches of pigs. The traditional use of simple means ignores variation and, therefore, results in bogus models of reality and flawed decisions where alternative management decisions are evaluated.