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Economic analysis of pig space: Comparison of production system impacts

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Abstract

This study evaluates the economic impact of changing pig space allotments in a pig production system. Increasing concerns regarding the health and well-being of meat animals raised in confinement facilities have resulted in consideration of increasing the space allotment for animals. A survey was conducted to determine pig space allotments currently in use by the industry. Pig space allocations per pig currently in use averaged 7.19 square feet for confinement facilities and 11.57 square feed for hoop systems. A simulation model was developed to use in evaluating economic impacts of increasing pig space allotments above those currently in use. Space restrictions result in two key economic impacts: 1) an under utilization of the existing confinement production asset base, and 2) a resulting impact on potential marketing practices.

Three major results emerged. First, restricting pig space has significant negative financial consequences for existing commercial confinement swine production systems. Secondly, marketing weight and timing mitigation strategies can be a short-term solution when compared to restricting flows into the finishing phase of production, but are clearly inferior to the longer range solution of adding finishing barns to existing production systems to accommodate the pigs. Reducing pig flows into the finishing phase through reduced size of the breeding herd results in underutilizing the most expensive capital assets (farrowing) and therefore, is the least preferred strategy as it had the most negative impact on return on equity. Additionally, reducing pig flow in the finishing facility through selling weaner pigs, while superior to reduced size of breeding herd, is inferior to most scenarios where all pigs remained in the production system. It was also shown that because of changing weight and animal composition in marketing strategy scenarios that the pricing grid of the packer to which the producers market has a substantial impact on the consequences of marketing lighter pigs to meet pig space restrictions. Therefore, impacts will not be uniform across the industry. The simulations show that regardless of mitigation strategies adopted by existing swine producers there will be substantial and negative financial implications ranging from a 10 percent to a 97 percent reduction in return on equity. Therefore, adoption of space restrictions should be carefully considered in concert with any potential economic benefits which might occur, namely consumer willingness to pay for pigs raised in larger spaced facilities. As food chains consider imposing the space requirements on suppliers, they must recognize that the producers affected must be able to pass on some of the cost to downstream processors, retailers and ultimately consumers.

Introduction

The efficient utilization of facility space for swine production has been a key economic and production issue since the introduction of confinement production facilities. Current animal welfare concerns related to stocking density of pigs in confinement facilities add new dimensions to the issue. Given the fixed nature of a facility, it's clear that to minimize average total costs, pigs should be stocked as densely as economically possible into the facility. The goal would be to maximize pounds of pork without experiencing an adverse impact on feed efficiency. Research suggests marginal costs increase as stocking densities increase due to reduced growth performance of finishing pigs (e.g., Brumm 2004). Edwards et al. (1988) showed that for the British market, the most economical allocation of pen floor space was less than the space needed for optimal performance with about 6 square feet of floor space required for the best economic performance versus 7.5 square feet for best pig performance for a grow finish facility that sold a 198 pound pig. Powell and Brumm (1992), considered the optimum stocking density at alternative cost and price scenarios and similar to Edwards determined that the minimum cost for producing a pound of pork was 4.2 square feet for growing (40-120 lb BW) and 6.0 square feet for finishing space (120-250 lb BW).

The economic studies are in sharp contrast with the research on the effects of space allocation on pig performance. Recently, a National Pork Board (NPB) working group examined the issue of space allocation in grow-finish facilities (Gonyou et al., 2004). The basis of this study was an examination of published literature on the effect of floor space allocation on performance from initiation of an experiment until final weight (235 lb BW or greater). Floor space was expressed by the following equation:

$A = k * BW^{0.667}$

Where A is the space allocation in square meters and BW is the *final* body weight in kilograms (Petherick, 1983). In most applications, BW and A are observed variables and k is a constant calculated based on the final or heaviest weight reported. Gonyou et al., (2004) concluded that at coefficients (k) of 0.034 or greater, further increases in space allocation do not result in any further increases in daily gain or daily feed intake. At space allocations below the critical k value, they predict that for each three percent reduction in space, there is a one percent degradation in daily gain and daily feed intake. There was no relationship between space allocation and feed conversion efficiency. Powell and Brumm used an end weight of pigs of 250 lbs, so the recommended k-value by Gonyou et al. would translate to 8.73 sq ft per pig, clearly beyond the economically optimal level considered by Powell and Brumm of 6 sq ft per pig. With current marketing weights averaging 269 pounds (AMS, USDA) the Gonyou recommendation of space allocation which results in no decrease in daily gain due to space allocation restrictions translates into 8.80 sq ft per pig.

Objective

The objective is to provide an analysis of the economic impact of pig space. Alternative pig marketing strategies which can be used to adopt to changing pig space requirements are also evaluated.

Previous economic studies have described the economically optimal stocking densities. However, none of the studies evaluate what the economic impact of restricting space allocation decisions might be on the optimal *production* level (defined as the point where final stocking density has no adverse impact on average daily gain). This is an important consideration as pork customers increasingly consider space requirements as a proxy for animal welfare. They may also consider space requirements as being consistent with optimal animal performance. Hence, rather than selecting a grow-finish space allocation or pig flow based on cost of production or profit considerations, this study develops a simulation model for the economic impacts of space allocation decisions based on animal welfare considerations using best individual pig performance as an estimate of pig welfare. Prior economic studies also only consider the optimal solution at the finishing stage of production. This ignores the fact that in modern production systems pig flow or stocking bottlenecks at one stage in production manifest themselves in upstream and downstream stages as well. The simulation model developed in this analysis takes into account the effects not only on finishing, but also incorporates effects on farrowing by incorporating pig flows between stages of production from farrowing to finishing. The simulation also accounts for the implications on asset utilization and return on equity which are return to capital measures. This approach seems appropriate given that potential stocking density changes in response to animal welfare and/or consumer demand will dramatically affect the existing assets in the industry. Finally, alternative processor grid payment schedules are included as changing pig space requirements may affect both pig weights and lean composition.

Materials and methods

Survey of pig space

To establish a technical baseline for finished pig stocking practices in the U.S. swine industry, a survey of industry participants was conducted. The survey had two main objectives: (1) to determine current industry practices for stocking finishing barns and (2) to establish current marketing practices regarding timing and market hog weights. Participants included swine producers, academics engaged in swine research, and allied industry personnel such as veterinarians and other animal health and nutrition professionals. Participants were also selected so that the survey results represent participants geographically dispersed throughout the U.S. swine industry. The survey instrument is available from the authors upon request. Respondents were contacted by telephone and responses were recorded. Forty respondents were originally contacted by telephone and thirty-six provided usable responses to the telephone survey for a response rate of ninety percent. **Table 1** summarizes the results of the survey. The detailed results of the survey are available from the authors upon request. The responses of industry and university respondents were almost identical. Although not shown, variations in values across regions are not significant, suggesting that stocking rates in finishing facilities are relatively consistent nationally. Thus, the aggregated results are used in the analysis.

The most important summary value is that the average confinement pig space allotment in use in the industry is projected to be 7.19 square feet per pig. This compares to the equivalent production optimum figure computed by Gonyou et al. (2004) of 8.73 square feet per pig at 269 lb BW. This disparity is consistent with previous economic studies which clearly suggested that optimal individual pig performance was not equivalent to optimal economic performance. Current pig stocking practices seem to reflect this notion.

The telephone survey also included the same questions in regard to hoop facilities. However, the response was limited and there is no evidence from Gonyou et al (2004) or others to suggest an appropriate k value for use in a model. Further, hoops represent a small portion of the total US production and would require constructing a pig flow and economic simulation model to account for several key

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Table 1: Survey summary results for US industry pig spacing

Item	Mean	Std. Dev.	Coeff. of Var.
Confinement Response (n=36)			
Confinement Pig Space (sq ft/hd)	7.19	0.29	3.99%
Pen Size (sq ft)			
Small Pen (sq ft)	195.83	37.87	19.34%
Large Pen (sq ft)	1,761.52	1,561.14	88.62%
Average Pen (sq ft)	219.64	83.96	38.23%
Pigs per Pen (hd)			
Small Pen (hd)	26.04	3.72	14.27%
Large Pen (hd)	222.93	203.20	91.15%
Average Pen (hd)	29.70	11.13	37.47%
Percent Confinement Small Pen	87.03	7.94	9.12%
Percent Confinement Large Pen	15.03	15.39	102.43%
Pig Marketing Characteristics			
Barns Topped (percent)	90.06	10.62	11.79%
Total Sale Duration for Topped (days)	24.76	5.50	22.21%
Percent of Barns Dumped	10.29	10.84	105.35%
Average Sale Weight First Group (lb)	265.21	12.07	4.55%
Percent Sold First Group	18.85	8.99	47.66%
Average Sale Weight All Pigs (lb)	260.24	9.86	3.79%
Hoop Facility Response (n=12)			
Hoop Pig Space (sq ft/hd)	11.57	1.44	12.42%
Pen Size (sq ft)			
Small Pen (sq ft)	2654.29	1491.61	56.20%
Large Pen (sq ft)	3080.00	1633.25	53.03%
Average Pen (sq ft)	2541.11	1324.82	52.14%
Pigs per Pen (hd)			
Small Pen (hd)	219.80	93.11	42.36%
Large Pen (hd)	251.94	112.54	44.67%
Average Pen (hd)	203.86	86.79	42.58%
Percent Confinement Small Pen	100	0	0
Percent Confinement Large Pen	0	0	0
Pig Marketing Characteristics			
Barns Topped (percent)	94.36	5.05	5.35%
Total Sale Duration for Topped (days)	25.36	6.30	24.83%
Percent of Barns Dumped	5.64	5.05	89.51%
Average Sale Weight First Group (lb)	248.50	36.06	14.51%
Percent Sold First Group	14.50	5.99	41.28%
Average Sale Weight All Pigs (lb)	256.50	9.44	3.68%

differences compared to confinement facilities. Never-the-less the results on stocking practices of hoop facilities show that pigs are substantially less densely stocked with an average of 11.57 square feet per pig (**Table 1**). This result may prove useful for providing insight to industry practices for use in future research.

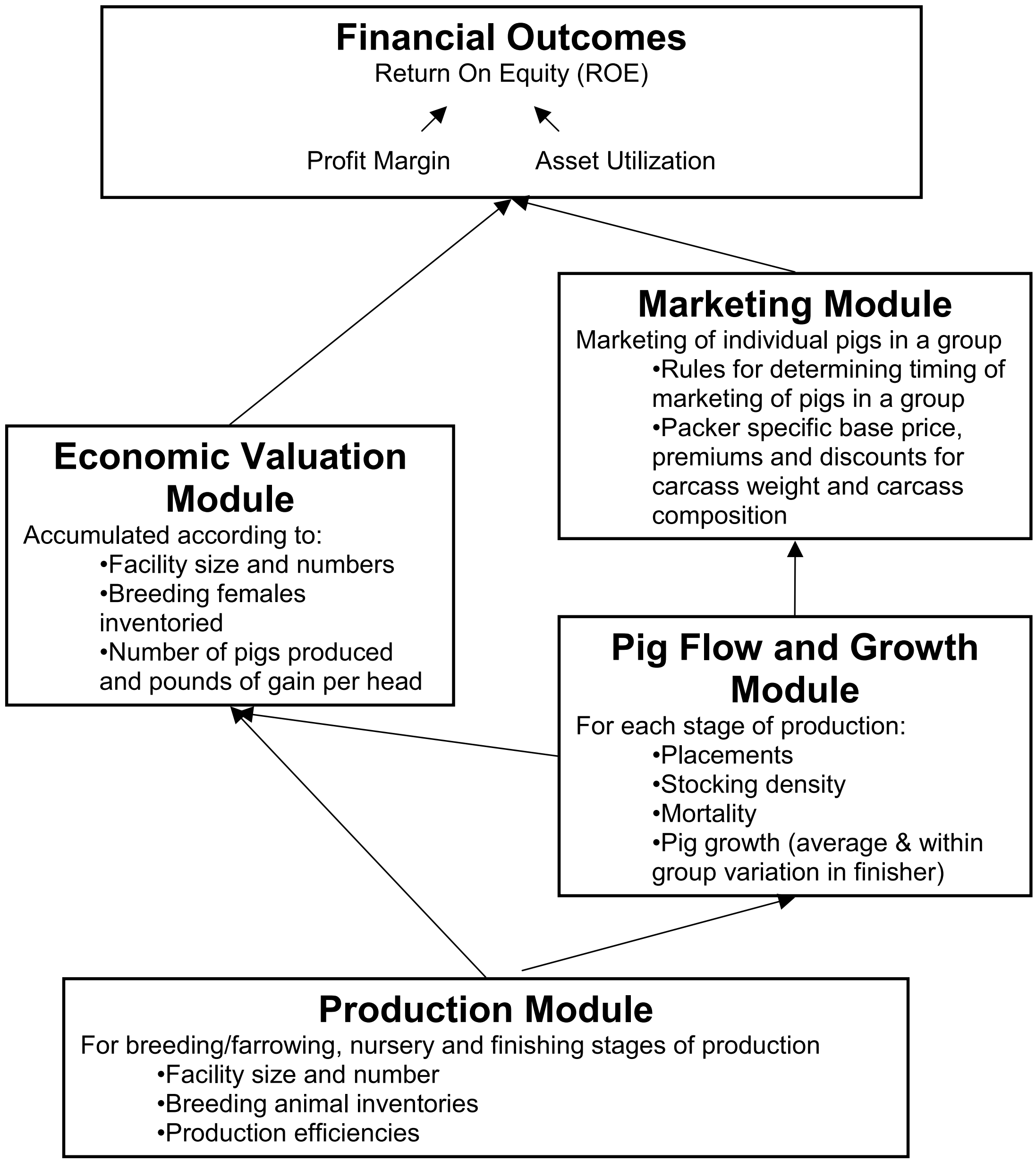
Another key result relates to marketing strategies of pigs if increased pig space allotments become incorporated into production practices. Slightly more than 10 percent of all confinement barns are 'dumped' (**Table 1**). This means that all pigs in the barn are marketed at the same time. The implication of this is that if the number of pigs in a pen does not change from current production practices with the imposition of space constraints, then pigs will need to be marketed at substantially lighter weights resulting in large reductions in pork prices received from packers based on current payment grids. However, 90 percent of respondents suggested that it was common practice to 'top' pens. This means that the heaviest hogs are sorted from the pen and marketed, while the lighter pigs remain in the pen for a period of time to gain additional weight. This process was reported by respondents to typically continue for on average 25 days after the first pigs were sold. Of those 'topping' the barn about 19 percent of the pigs were sold in the first sale group. The parameters from the survey form the baseline assumptions for stocking density and marketing practices for use in the simulation. The survey further showed that about 87 percent of facilities are small pen facilities.

Financial model of pig space

Three approaches were identified for evaluating the economic impacts of alternative swine space requirements: a partial budgeting approach, an optimization approach and a complete financial model approach. The partial budgeting approach was viewed as inadequate because partial budgeting does not typically account for changing asset values and utilization rates. It also does not lend itself to following and evaluating pig flows. Optimization approaches such as linear programming were considered, but while this approach would illustrate optimal stocking to maximize an objective such as profits, it would be quite complex to include capital asset issues. As a result, a complete financial simulation model is developed that incorporated three stages of production (farrowing, nursery and finishing), a model of pig flows through this system, a model of marketing methods, and finally an incorporation of the Dupont Model of Return on Equity to help evaluate asset utilization rates and other issue of capital costs. The complete model is available in Microsoft Excel spreadsheet format. Due to extensive use of macros, it is necessary to use version 2002 or higher of Excel to maintain compatibility.

Figure 1 provides a schematic representation of the economic model. The model is best represented as a configuration of sub-modules within the pork production system. The basis of the model is the technical aspects of

Figure 1: Schematic of economic model of pig space



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production at each stage of the pig production process. The production stages are linked by the module of pig flow and growth by which pigs move between stages of production. The technical relationships of pig production and flows are assigned values by incorporation into the financial accounting module (assets, liabilities and costs) to assign economic values to the production process. The fourth major module is the marketing module which is critical for accounting for the differences in marketing finished pigs as a result of changing pig space requirements. Finally, these modules combine to provide economic outcomes of profit, asset utilization and return on equity which are the variables that concisely illustrate potential impacts of pig space.

Scenarios of pig space requirements

The primary basis for the economic impacts of pig space is the difference between the allometric value of maximum pig space (k-value) suggested by Gonyou et al. and the k-value in use by the industry as reflected in this study's survey. According to Gonyou et al., production performance begins to suffer when the k-value is less than .0336 (the lower the k-value the less allometric space is available per pig). However, the survey results suggest that current industry practice yields a k-value of 0.028 when pigs are fed to an average sale weight of all pigs in the pen of approximately 256 pounds. With 90% of the US industry topping pens and selling pigs from a finishing facility for 24.8 days on average, the critical weight for space allocation is considerably less. That is, after the heaviest pigs are removed in the first cut (topping) the k-value for the remaining pigs will be greater since the average weight (BW) of pigs remaining declines and the area available to each pig in the pen (A) increases. If a space requirement mandating a minimum k-value = 0.0336 were to be implemented, the question is would current topping practices be sufficient to maintain space requirements?

To increase the k-value, producers have two basic alternatives (1) to maintain the same number of pigs in the entire system, but market some or all pigs at lighter weights or (2) reduce the initial stocking rates of the finishing facility. Neither scenario is particularly appealing; marketing at lighter weights is likely to result in significant price discounts based on current packer grids. In addition, it has implications for increased costs of sorting and transportation which are related to how the producer manages the marketings (in the extreme case dumping the barn at very light weights to marketing pigs in truckload, or partial truckload intervals as the target k-value (0.0336) is reached). Production efficiency such as feed efficiency can also be impacted. Placing fewer pigs in a barn at the start of the finishing phase requires that additional finishing space be allocated if it is assumed that the farrowing and nursery phases are operated as before the finishing pig space restrictions. Hence, there is the potential for increased capital costs of additional finishing pig space. Two other alternatives are to reduce the breeding herd and hence, the number of pigs weaned per year, or selling weaned pigs while maintaining the same level of finishing space thereby underutilizing the breeding herd assets relative to current stocking levels. The summary of scenarios analyzed is in **Table 2**. The key difference between the two scenarios is that for the adjustment to hog marketing scenarios the target k-value dictates marketings, while in the adjustment to stocking density scenarios, the k-value determines initial stocking densities in the finishing phase based on target market weights of hogs.

The baseline of financial performance includes critical assumptions regarding size of the facilities, the growth rates of animals, nutritional requirements, marketing weights, and other economic factors. The system modeled is typical of a large scale three stage farrow-nursery-finish confinement production system. The values on key variables approximate industry averages for these types of facilities. **Table 3** provides a summary of key baseline assumptions of the simulated production system. Many of the variables can be adjusted within the model to provide different baseline starting scenarios. However, in most cases, the model is linear in results, so that approximations can be made simply by proportionally increas-

Table 2: Scenarios for analysis of economic impacts of pig space restrictions

Market Pigs Early When Target k-value is Reached	Reduce Finisher Stocking Density by Wean Pig Sales or Reducing Breeding Herd
a. Incrementally market minimum number of pigs to maintain k-value. Dump barns when target k-value reached.	a. Meet expected finisher pig space restriction by selling excess weaned pigs in market.
b. Market pigs at target k-value but market in large enough group to fill truck.	b. Meet expected finisher space restriction by reducing breeding herd inventory.
c. Repeat a-c for two packer grids to simulate impacts of changing market weights in different packer payment grids.	c. Construct additional finishing space to accommodate pigs through finish.
d. Repeat a-c for large pens and small pens.	d. Repeat a-c for large and small pens.

Table 3: Baseline assumptions on key variables impacting results of pig space allocation

Variable	Value
Average Breeding Female Inventory (hd)	2600
Total Weaned Pigs Per Year (hd/yr)	56,777
Weaned Pigs Transferred to Nursery (hd/yr)	55,926
Total Pigs Transferred Out of Nursery (hd/yr)	54,248
Total Standard Finisher Pigs Sold (hd/yr)	52,892
Target Average Market Weight (lbs/hd)	265
Space Per Pig at Sale of First Pig (sq ft/hd)	7.17
Finishing Barns Required	17
Market hogs per Barn (hd)	1,007
Base Live Price For Market Hog ($/cwt)	$38.00
Weighted Average Market Hog Daily Gain (lbs/d)	1.75
Total Feed Costs Per Hundredweight Pigs Marketed ($/cwt)	$22.30
Total Assets ($)	$8,944,126

Table 4: Finisher diet assumptions

	Cost ($/Ton)	Expected ADG (lb)	Expected Feed Conversion (feed/gain)	Days on Diet	Avg Consumption per Pig per Day (lb)	Ending Weight (lb)
Finisher Diet 1	150.00	1.55	2.10	21	3.26	86
Finisher Diet 2	131.50	1.74	2.48	30	4.29	138
Finisher Diet 3	123.49	1.91	3.05	31	5.83	198
Finisher Diet 4	109.49	1.75	3.73	39	6.52	266

ing or decreasing results based on these underlying assumptions.

As pig space restrictions are implemented, pigs may be sold sooner so that the feed intake and feed costs will be particularly affected by the marketing set of scenarios. **Table 4** represents the finishing diets of the pigs and the assumed performance implications for the scenarios. By altering growth rates through time it was possible to estimate the impacts of marketing timing decisions and to model the growth of pigs remaining in the facility.

In addition to the values of key variables, several key assumptions or modeling approaches were taken to accomplish the objectives of this research. These are mainly in regard to the finishing phase of production where the primary impact from market hog space requirements occurs. The initial assumption is that the pigs are marketed as they approach a target market weight. As the survey results indicate, pigs are generally marketed over a 3-4 week period from most finishing facilities. This is obviously a result of inherent variation in finished pig weights within a pen. Hence, "topping" pens is a critical part of marketings and in these scenarios the pigs which have reached target market weights are removed from pens, the remaining pigs grow until the second sale of target weight pigs is made and so on. Topping pens is also a key strategy of the restricted pig space scenarios except that rather than beginning to top the pens when the largest pigs reach sale weights, pens are topped when the k-value restriction is met. As indicated above, this is well before target market weights are met.

To effectively model this situation required the ability to model the with-in pen variation of finishing pig weights, growth rates, lean composition and feed consumption of remaining pigs. To estimate the distribution of closeout weights in a pen, data from University of Nebraska closeouts from three research trials where pens of pigs were dumped was used to test for the best probability distribution fit. In all cases, the normal distribution fit was found to be statistically valid, and not different from other closely related probability distributions. Therefore, the distribution of weights of pigs within the pen is modeled as a normal distribution. Although the final market weights of the trial pigs differed across trials, the coefficient of variation for pig weight ranged from 7.9% to 9.5%. For the trial which most closely approximated the assumed baseline starting weight (260 pounds), the coefficient of variation was 9.5%, which is used for the baseline in our simulations. However, this coefficient of variation was applied at the seventh week of the finishing stage so that as weights increase over the remaining weeks and with the variance or standard deviation constant, the coefficient of variation at the finished pig weights is lower, which is probably not realistic. However, the marginal value of more precisely modeling growth was determined to be not worth the substantial additional complication to the model. To model the topping of pens, variation is in-

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troduced by modeling individual pigs beginning at the seventh week in the finisher (16 weeks of age). The average weight in the baseline at seven weeks is 138 pounds. A normal distribution of weights, with a coefficient of variation of 9.5 percent and average weight of 138 pounds, is generated for each pen (the number of pigs per pen varies due to modeling both small pens and large pens). From this point on growth rates are applied uniformly across pigs. Marketings are simulated by pulling the heaviest pigs from each pen, for example, when a target k-value is met. Alternative rules for determining the timing of marketings are modeled. For example, to meet a target k-value for one scenario it is assumed that one pig was pulled from each pen when the target was violated. For a barn with an assumed 38 pens, this means marketing 38 pigs (one from each pen). However, 38 pigs sold are much less than a truckload and would likely not be cost effective. The model can also simulate pulling, for example, four pigs per pen once the target k-value is met, thus allowing for the possibility of marketing in increments to suit other cost or management objectives.

As noted earlier, the scenarios also include the impacts of marketing at different weights based on alternate packer payment grids. Marketing at different rates can also affect carcass composition of animals. Of the two packer grids modeled (Tyson and Hormel), Tyson uses the AUS (Animal Ultrasound Systems, Ithaca, NY) measure of lean in their payment grid, while Hormel uses a measure of last rib backfat. To model the changing carcass composition a lean percent equation and backfat equation, each as a function of bodyweight, are included to model quality premiums or discounts. Thus, as the sale weight of pigs change in response to changes in k-value, the price received is affected not only by sort loss due to weight, but also by the carcass composition of the pigs marketed.

Simulations and results

Economic simulations are conducted for each of the scenarios as described in **Table 2**. Tables 5 through 8 show the results of these scenarios. However, as results are interpreted, it's important to recall that the pig weights are modeled as a stochastic or variable process. Therefore, each distribution of weights calculated for a pen is only one representation of many possible outcomes and a new outcome occurs every time a new random number generator for pig weights is run. Hence, any given set of weights may be sampled anywhere in the distribution including the extreme tails of the normal distribution. To avoid sampling only extreme values the random number generator was used to sample ten times from the distribution. Essentially, this is a limited Monte Carlo simulation approach. By sampling from the distribution of weights ten times, a range of values within a normal distribution with the mean and variance described above is created. The ten iterations are too small to generate a statistically significant number of iterations, but are intended primarily to avoid obtaining point estimates that are potentially drawn from the tail of a distribution. The reason for not running more simulations is that the complexity of the excel program created required ten hours to run the set of scenarios provided with only the ten simulations. Given that nearly all base parameters are 'best-estimate' values, adding additional simulations gives the impression of precision when in fact the base parameters are simple averages. Each of the scenarios identified in **Table 2** were run for two packers and for two pen sizes (large pen facilities and small pen facilities) to illustrate the impacts of differing grid pricing systems and production facility types on the outcomes of the alternative scenarios. For brevity the reported values in **Tables 5-8** are averages of the ten interations. However, the ranges of estimates are available in the complete spreadsheet model and are available from the authors.

Scenario set 1: Marketing pigs when target k-value is violated

The first three scenarios provided in each table examine the effects of marketing pigs from the finishing facility when a target k-value is violated. When the target k-value is violated, a predetermined number of pigs per pen were marketed to relieve the space constraint. Other pigs remain in the pen for one more week, at which time the space requirement is reevaluated. This weekly "decision" continues until the average weight of all pigs remaining equals or exceeds the target market weight at which point all pigs in the barn are marketed. Pigs are also marketed when the average weight of the heaviest cut of pigs, defined as one truckload of 165 pigs, equals or exceeds the target market weight. Clearly, marketing one pig per pen from a thirty-eight pen facility is likely not cost efficient from a sorting and transportation cost perspective. While the cost of sorting and transportation are not explicitly accounted for, the model was created so that more than the minimum number of pigs can be marketed to meet the space constraint when the k-value is met. In other words, rather than pulling just one pig per pen, the decision could be made to pull enough pigs from each pen to fill a full truck. The implication of pulling more pigs is that when the space constraint is initially violated, more pigs must be marketed at lighter weights. Therefore, lower sorting and transportation costs are exchanged for higher sort and carcass quality discounts.

To illustrate the effects of changing the rule of the number of pigs marketed at a marketing pull, the first three scenarios vary the number of pigs marketed per pen. For the Tyson pricing grid and small pen facilities (**Table 5**), as the number of pigs marketed per pen increases, the average market weight becomes lighter (258 lbs for one pig compared to 255 for three pigs). This does not appear

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to be a dramatic change in average weights of pigs marketed when compared to the baseline value of 262 pounds. However, this does not adequately show the distribution of pig weights. Using the example of pulling two pigs from the pen when the target k-value is met, the average week of the first marketing pull (i.e., the week at which the k-value constraint is initially violated) is week 11 in the finisher. The average weight of the two pigs pulled from the pen to relieve the k-value constraint is only 219 pounds. Therefore, with the k-constraint, 38 pens multiplied by two pigs per pen or 76 pigs are marketed at 219 pounds in week eleven. The next sale occurs in week 13 (compared to week 12 when a single pig per pen was marketed) at an average weight of 239 pounds. The next time the k-value is violated is in week 15 and now the two pigs sold per pen weigh an average of 261 pounds. The remaining approximately 725 remaining pigs in the barn are marketed at the target weight of 265 pounds. This illustration is precisely why the model was constructed as it is. The average barn sale weights (257 pounds) mask the issue that over 200 pigs were marketed at sub-optimal (with respect to current market pricing grids, and even performance efficiency) weights. The complete number of head marketed and weights of the pigs sold during each week are provided in Appendix A. The tables in Appendix A are numbered 5A through 8A to correspond with the summary results of Tables 5-8. The economic impact of selling light weight pigs is best illustrated by the percent change in return on equity from the baseline. Selling even one pig per pen at each sales interval to meet the k-value restriction results in over a 20% decline in return on equity (**Table 5**), from 14.57 percent to 11.58 percent. Selling more pigs at each increment to reduce transport costs, meaning more pigs are sold at lighter weights, decreases the return on equity from the baseline by as much as 50 percent.

For all of the scenarios where pigs are marketed early to meet space restrictions the key impact is on changing market values received for the animals. In addition, packer grids are not standardized in terms of optimal weight ranges, carcass quality or price discount breaks, therefore using the same marketing strategies with different packer grids will also affect the results. To illustrate, it's useful to compare the first three scenarios in **Table 5** to the first three scenarios in **Table 7**. In **Table 5**, the pigs are marketed under Tyson's price matrix, while in **Table 7** the pigs are marketed under Hormel's price grid. The same assumptions regarding k-value restrictions, feed efficiencies, lean growth performance and market timing (i.e., how many pigs to pull when k-value restriction is violated) are held for both price grids. The only change in **Table 7** is the pigs are marketed under Hormel's grid. As with Tyson's price grid the costs associated with marketing pigs early to meet pig space requirements for producers marketing under Hormel's grid are significant, reducing ROE from between 42 percent (17.19 percent ROE to 9.94% ROE) for marketing one pig per pen when the target k-value is violated, to 98 percent for marketing four pigs per pen when the pig space constraint is reached. This result is expected considering the narrower sort criteria employed in Hormel's grid. The point of this discussion is not to debate the merits of alternative grids, but to note that pig space restrictions, and marketing strategies utilized in the current commercial swine production model will affect the economic performance of all production systems negatively, but the effects will depend on where and how pigs are marketed. In fact, the same base live price of $38/cwt. is used under each pricing grid. Typically the base prices used by Tyson and Hormel will differ so that the values as calculated are not accurate representations of which packer may pay the highest net price.

Similar results and comparisons emerge for the case of large pens examined in Tables 6 and 8. The only major change in assumption is the base level of stocking density as indicated by the survey. A more thorough assessment would require including large pen versus small pen facility investment cost and potential differences in pig production performance between the two systems. Readers are encouraged to examine Tables 5-8 more carefully to examine impacts on market prices, production costs, feed costs and other key variables which may fit their particular situation more closely.

Scenario set 2: Reducing stocking density by selling wean pigs or reducing breeding female inventory.

The first three scenarios only consider manipulating marketings and all upstream processes of production (farrowing, wean, nursery) are unchanged. The fourth and fifth scenarios lower the initial stocking density of finishers so that market hogs may be sold at target market weights without violating space requirements thereby avoiding the marketing discounts associated with scenarios 1, 2 and 3. To accomplish this, the fourth scenario (**Table 5** to begin with) is constructed so that the k-value is met at the ending target finish weight for all pigs. The way to accomplish this is to sell excess weaned pigs at the outset so that all pigs going into the barn exit the barn at the target weight. Note that this does not necessarily imply "dumping" the barn all at once. Weight variations still exist within the pen and if necessary pigs are marketed at their target weight. In this scenario the finishing pig marketing decision is not determined by a space restriction – that has been avoided by marketing the appropriate number of weaned pigs at the outset. The space restriction determines the number of weaned pigs to market. As shown in **Table 5** under the sell wean pigs scenario, this strategy results in a 39 percent reduction in ROE compared to baseline, and for the case of Hormel's grid, only a 24 percent reduction is projected (**Table 7**).

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Table 5 (part 1): Scenarios with Tyson grid, small pen assumptions

Scenario	Baseline	Market 1 pig at target k-value	Market 2 pigs at target k-value	Market 4 pigs at target k-value (truck-load)	Sell Wean Pigs to meet target k-value	Reduce Breeding Inventory to meet target k-value	Construct Finishing Space to meet target k-value
Return on Equity	14.57%	11.58%	10.53%	7.40%	8.88%	1.21%	13.19%
Net Profit Margin	6.74%	5.41%	4.94%	3.52%	4.25%	0.59%	6.86%
Asset Turnover	0.88	0.87	0.86	0.85	0.81	0.78	0.84
Leverage Ratio	2.46	2.47	2.47	2.47	2.57	2.61	2.29
Percent Change in ROE from Baseline		-20.55%	-27.73%	-49.20%	-39.06%	-91.70%	-9.47%
Undepreciated Value of Assets Per Cwt Sold ($/cwt, live)	$46.67	$47.31	$47.45	$47.83	$52.66	$52.49	$48.79
Average Market Price Received ($/cwt, live)	$40.94	$40.98	$40.91	$40.66	$42.83	$40.92	$40.89
Average Cost of Production ($/cwt, live)	$38.18	$38.76	$38.89	$39.23	$41.01	$40.68	$38.08
Total Feed Costs ($/cwt, live)	$21.89	$22.23	$22.30	$22.50	$22.12	$21.77	$21.72
Total Non-Feed Costs ($/cwt live)	$17.76	$18.03	$18.09	$18.25	$20.60	$20.37	$17.83
Cull Breeding Animal Income ($/cwt live)	($1.47)	($1.50)	($1.50)	($1.51)	($1.71)	($1.46)	($1.46)
Average Profits ($/cwt, live)	$2.76	$2.22	$2.02	$1.43	$1.82	$0.24	$2.81
Change in Average Profits From Baseline ($/cwt, live)		($0.54)	($0.74)	($1.33)	($0.94)	($2.52)	$0.05
Breeding Female Inventory	2,600	2,600	2,600	2,600	2,600	2,212	2,600
Wean Pigs Marketed (head)	0	0	0	0	8,350	0	0
Finisher Pigs Marketed per Year	52,349	52,349	52,349	52,349	44,533	44,537	52,349
Average Market Weight of Finisher Pigs Marketed (lbs)	262.4	258.4	257.5	255.3	263.8	263.9	264.5
Total Pounds of Pork Marketed per Year (Mil lbs)		13.5	13.5	13.4	11.7	11.8	13.8
Total Economic Loss From Pig Space Restrictions ($1000s)		(73.30)	(99.19)	(177.54)	(110.64)	(296.09)	6.36

Table 5 (part 2): Scenarios with Tyson grid, small pen assumptions

Scenario	**Baseline**	**Market 1 pig at target k-value**	**Market 2 pigs at target k-value**	**Market 4 pigs at target k-value (truck-load)**	**Sell Wean Pigs to meet target k-value**	**Reduce Breeding Inventory to meet target k-value**	**Construct Finishing Space to meet target k-value**
Barn Tie-up, Pigs in barn Plus Cleanup (weeks / turn)	16.2	16.5	16.6	16.6	16.2	16.2	16.3
Average Turns per Year in Finishers	3.23	3.17	3.15	3.15	3.23	3.23	3.21
Average Pig Density at Placement (sq ft / pig)	7.02	7.02	7.02	7.02	8.25	8.25	8.25
Average Pig Density at First Marketing Cut (sq ft / pig)	7.19	7.19	7.19	7.19	8.45	8.45	8.45
Average Finisher Mortality (% of pigs placed)	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%
Average number of pigs transferred from nursery per week	1,043	1,043	1,043	1,043	887	888	1,043
Pigs Placed per Finishing Barn	1,032	1,032	1,032	1,032	878	878	1,032
Number of Finishing Barns Needed To Accommodate Pig Flow	17	17	17	17	17	17	20
Number of Finishing Barns Available	17	17	17	17	17	17	20
Target k-value	0	0.0336	0.0336	0.0336	0	0	0
Number of pigs marketed per pen	0	1	2	4	0	0	0

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Table 6 (part 1): Scenarios with Tyson grid, large pen assumptions

Scenario	**Baseline**	**Market 1 pig at target k-value**	**Market 2 pigs at target k-value**	**Market 4 pigs at target k-value (truck-load)**	**Sell Wean Pigs to meet target k-value**	**Reduce Breeding Inventory to meet target k-value**	**Construct Finishing Space to meet target k-value**
Return on Equity	15.34%	12.63%	10.91%	8.08%	9.04%	1.64%	12.92%
Net Profit Margin	7.08%	5.89%	5.11%	3.83%	4.32%	0.80%	6.73%
Asset Turnover	0.88	0.87	0.86	0.85	0.81	0.78	0.84
Leverage Ratio	2.46	2.47	2.47	2.47	2.57	2.61	2.29
Percent Change in ROE from Baseline		-13.34%	-25.14%	-44.56%	-37.97%	-88.71%	-11.33%
Undepreciated Value of Assets Per Cwt Sold ($/cwt, live)	$46.45	$47.04	$47.40	$47.76	$52.56	$52.30	$48.80
Average Market Price Received ($/cwt, live)	$40.87	$40.92	$40.94	$40.74	$42.77	$40.83	$40.84
Average Cost of Production ($/cwt, live)	$37.98	$38.51	$38.85	$39.18	$40.92	$40.51	$38.09
Total Feed Costs ($/cwt, live)	$21.78	$22.08	$22.28	$22.46	$22.07	$21.68	$21.73
Total Non-Feed Costs ($/cwt live)	$17.67	$17.92	$18.07	$18.22	$20.56	$20.29	$17.83
Cull Breeding Animal Income ($/cwt live)	($1.47)	($1.49)	($1.50)	($1.51)	($1.71)	($1.46)	($1.46)
Average Profits ($/cwt, live)	$2.89	$2.41	$2.09	$1.56	$1.85	$0.33	$2.75
Change in Average Profits From Baseline ($/cwt, live)		($0.35)	($0.67)	($1.20)	($0.91)	($2.43)	($0.01)
Breeding Female Inventory	2,600	2,600	2,600	2,600	2,600	2,212	2,600
Wean Pigs Marketed (head)	0	0	0	0	8,350	0	0
Finisher Pigs Marketed per Year	52,349	52,349	52,349	52,349	44,533	44,537	52,349
Average Market Weight of Finisher Pigs Marketed (lbs)	263.8	260.1	257.8	255.6	264.4	265.0	264.4
Total Pounds of Pork Marketed per Year (Mil lbs)		13.6	13.5	13.4	11.8	11.8	13.8
Total Economic Loss From Pig Space Restrictions ($1000s)		(47.90)	(90.03)	(160.74)	(107.39)	(287.03)	(1.56)

Table 6 (part 2): Scenarios with Tyson grid, large pen assumptions

Scenario	Baseline	Market 1 pig at target k-value	Market 2 pigs at target k-value	Market 4 pigs at target k-value (truck-load)	Sell Wean Pigs to meet target k-value	Reduce Breeding Inventory to meet target k-value	Construct Finishing Space to meet target k-value
Barn Tie-up, Pigs in barn Plus Cleanup (weeks / turn)	16.4	16.6	16.6	16.6	16.3	16.4	16.3
Average Turns per Year in Finishers	3.19	3.15	3.15	3.15	3.21	3.19	3.21
Average Pig Density at Placement (sq ft / pig)	7.02	7.02	7.02	7.02	8.25	8.25	8.25
Average Pig Density at First Marketing Cut (sq ft / pig)	7.19	7.19	7.19	7.19	8.45	8.45	8.45
Average Finisher Mortality (% of pigs placed)	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%
Average number of pigs transferred from nursery per week	1,043	1,043	1,043	1,043	887	888	1,043
Pigs Placed per Finishing Barn	1,032	1,032	1,032	1,032	878	878	1,032
Number of Finishing Barns Needed To Accommodate Pig Flow	17	17	17	17	17	17	20
Number of Finishing Barns Available	17	17	17	17	17	17	20
Target k-value	0	0.0336	0.0336	0.0336	0	0	0
Number of pigs marketed per pen	0	10	20	40	0	0	0

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Table 7 (part 1): Scenarios with Hormel grid, small pen assumptions

Scenario	Baseline	Market 1 pig at target k-value	Market 2 pigs at target k-value	Market 4 pigs at target k-value (truck-load)	Sell Wean Pigs to meet target k-value	Reduce Breeding Inventory to meet target k-value	Construct Finishing Space to meet target k-value
Return on Equity	17.19%	9.94%	7.65%	0.36%	11.07%	4.31%	14.40%
Net Profit Margin	7.86%	4.69%	3.64%	0.18%	5.24%	2.08%	7.44%
Asset Turnover	0.89	0.86	0.85	0.82	0.82	0.79	0.84
Leverage Ratio	2.46	2.47	2.47	2.47	2.57	2.61	2.29
Percent Change in ROE from Baseline	17.92%	-31.77%	-47.51%	-97.53%	-24.04%	-70.44%	-1.18%
Undepreciated Value of Assets Per Cwt Sold ($/cwt, live)	$46.58	$47.22	$47.38	$47.81	$52.60	$52.24	$48.96
Average Market Price Received ($/cwt, live)	$41.34	$40.58	$40.29	$39.29	$43.23	$41.32	$41.30
Average Cost of Production ($/cwt, live)	$38.09	$38.68	$38.83	$39.22	$40.96	$40.46	$38.23
Total Feed Costs ($/cwt, live)	$21.84	$22.18	$22.26	$22.49	$22.09	$21.65	$21.80
Total Non-Feed Costs ($/cwt live)	$17.72	$17.99	$18.06	$18.24	$20.58	$20.26	$17.89
Cull Breeding Animal Income ($/cwt live)	($1.47)	($1.49)	($1.50)	($1.51)	($1.71)	($1.46)	($1.47)
Average Profits ($/cwt, live)	$3.25	$1.90	$1.47	$0.07	$2.26	$0.86	$3.07
Change in Average Profits From Baseline ($/cwt, live)		($0.86)	($1.29)	($2.69)	($0.50)	($1.90)	$0.31
Breeding Female Inventory	2,600	2,600	2,600	2,600	2,600	2,212	2,600
Wean Pigs Marketed (head)	0	0	0	0	8,350	0	0
Finisher Pigs Marketed per Year	52,349	52,349	52,349	52,349	44,533	44,537	52,349
Average Market Weight of Finisher Pigs Marketed (lbs)	263.0	258.9	257.9	255.3	264.2	265.3	263.4
Total Pounds of Pork Marketed per Year (Mil lbs)		13.6	13.5	13.4	11.8	11.8	13.8
Total Economic Loss From Pig Space Restrictions ($1000s)		(116.31)	(174.60)	(359.67)	(58.29)	(224.39)	42.84

Table 7 (part 2): Scenarios with Hormel grid, small pen assumptions

Scenario	**Baseline**	**Market 1 pig at target k-value**	**Market 2 pigs at target k-value**	**Market 4 pigs at target k-value (truck-load)**	**Sell Wean Pigs to meet target k-value**	**Reduce Breeding Inventory to meet target k-value**	**Construct Finishing Space to meet target k-value**
Barn Tie-up, Pigs in barn Plus Cleanup (weeks / turn)	16.3	16.6	16.6	16.6	16.3	16.5	16.1
Average Turns per Year in Finishers	3.21	3.15	3.15	3.15	3.21	3.17	3.25
Average Pig Density at Placement (sq ft / pig)	7.02	7.02	7.02	7.02	8.25	8.25	8.25
Average Pig Density at First Marketing Cut (sq ft / pig)	7.19	7.19	7.19	7.19	8.45	8.45	8.45
Average Finisher Mortality (% of pigs placed)	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%
Average number of pigs transferred from nursery per week	1,043	1,043	1,043	1,043	887	888	1,043
Pigs Placed per Finishing Barn	1,032	1,032	1,032	1,032	878	878	1,032
Number of Finishing Barns Needed To Accommodate Pig Flow	17	17	17	17	17	17	20
Number of Finishing Barns Available	17	17	17	17	17	17	20
Target k-value	0	0.0336	0.0336	0.0336	0	0	0
Number of pigs marketed per pen	0	1	2	4	0	0	0

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Table 8 (part 1): Scenarios with Hormel grid, large pen assumptions

Scenario	Baseline	Market 1 pig at target k-value	Market 2 pigs at target k-value	Market 4 pigs at target k-value (truck-load)	Sell Wean Pigs to meet target k-value	Reduce Breeding Inventory to meet target k-value	Construct Finishing Space to meet target k-value
Return on Equity	15.24%	11.20%	8.42%	1.08%	11.61%	2.41%	14.68%
Net Profit Margin	7.02%	5.25%	3.97%	0.50%	5.49%	1.17%	7.57%
Asset Turnover	0.88	0.86	0.85	0.82	0.82	0.78	0.84
Leverage Ratio	2.47	2.47	2.47	2.47	2.57	2.61	2.29
Percent Change in ROE from Baseline	4.59%	-23.16%	-42.26%	-92.62%	-20.32%	-83.46%	0.70%
Undepreciated Value of Assets Per Cwt Sold ($/cwt, live)	$46.93	$47.10	$47.53	$47.88	$52.47	$52.66	$48.89
Average Market Price Received ($/cwt, live)	$41.31	$40.71	$40.57	$39.49	$43.22	$41.31	$41.30
Average Cost of Production ($/cwt, live)	$38.41	$38.58	$38.96	$39.28	$40.85	$40.82	$38.17
Total Feed Costs ($/cwt, live)	$22.03	$22.12	$22.34	$22.53	$22.03	$21.85	$21.77
Total Non-Feed Costs ($/cwt live)	$17.87	$17.94	$18.12	$18.27	$20.52	$20.45	$17.87
Cull Breeding Animal Income ($/cwt live)	($1.48)	($1.49)	($1.50)	($1.52)	($1.70)	($1.47)	($1.46)
Average Profits ($/cwt, live)	$2.90	$2.14	$1.62	$0.21	$2.37	$0.48	$3.13
Change in Average Profits From Baseline ($/cwt, live)		($0.62)	($1.14)	($2.55)	($0.39)	($2.28)	$0.37
Breeding Female Inventory	2,600	2,600	2,600	2,600	2,600	2,212	2,600
Wean Pigs Marketed (head)	0	0	0	0	8,350	0	0
Finisher Pigs Marketed per Year	52,349	52,349	52,349	52,349	44,533	44,537	52,349
Average Market Weight of Finisher Pigs Marketed (lbs)	260.7	259.6	257.1	254.9	264.9	262.9	263.8
Total Pounds of Pork Marketed per Year (Mil lbs)		13.6	13.5	13.3	11.8	11.7	13.8
Total Economic Loss From Pig Space Restrictions ($1000s)		(84.60)	(153.98)	(340.68)	(45.88)	(266.65)	50.56

Table 8 (part 2): Scenarios with Hormel grid, large pen assumptions

Scenario	Baseline	Market 1 pig at target k-value	Market 2 pigs at target k-value	Market 4 pigs at target k-value (truck-load)	Sell Wean Pigs to meet target k-value	Reduce Breeding Inventory to meet target k-value	Construct Finishing Space to meet target k-value
Barn Tie-up, Pigs in barn Plus Cleanup (weeks / turn)	16.6	16.6	16.3	16.5	16.4	16.0	16.2
Average Turns per Year in Finishers	3.15	3.15	3.21	3.17	3.19	3.27	3.23
Average Pig Density at Placement (sq ft / pig)	7.02	7.02	7.02	7.02	8.25	8.25	8.25
Average Pig Density at First Marketing Cut (sq ft / pig)	7.19	7.19	7.19	7.19	8.45	8.45	8.45
Average Finisher Mortality (% of pigs placed)	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%
Average number of pigs transferred from nursery per week	1,043	1,043	1,043	1,043	887	888	1,043
Pigs Placed per Finishing Barn	1,032	1,032	1,032	1,032	878	878	1,032
Number of Finishing Barns Needed To Accommodate Pig Flow	17	17	17	17	17	16	20
Number of Finishing Barns Available	17	17	17	17	17	17	20
Target k-value	0	0.0336	0.0336	0.0336	0	0	0
Number of pigs marketed per pen	0	10	20	40	0	0	0

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This clearly illustrates that given space requirements a producer's strategy may very well depend on the packer where they sell their pigs. For Hormel, it is important to market pigs at the target weight and adjust number of pigs to the facility capacity. The economic impact of marketing lightweight pigs is more dramatic than for the Tyson grid. The average market price received is higher than the baseline and higher than the upcoming scenario for reduced breeding herd. This is because the sale price of weaned pigs is averaged into the market price value.

The fifth scenario falls in the same general category of mitigation strategy in that pig numbers are reduced at the beginning of the production stage. However, in this scenario reduced number of pigs is accomplished by reducing the size of the entire breeding herd inventory. In this case, the clear impact is on reduced asset utilization efficiency, as asset turnover drops by eleven percent compared to the baseline. As a result this strategy is clearly inferior to all other strategies when marketing under Tyson's current price grid. However, for the simulations using Hormel's current price grid, marketing four pigs for each sale strategy is inferior because of the deep sort loss discounts. This scenario has tangential insights in considering the analogous effects of an increase in sow space requirements. The economic impacts of restricting sow space (i.e., having fewer breeding females in current systems) would have impacts even greater than restrictions in finishing pig space mitigated through other strategies described in this report.

Constructing additional finishing space

The final scenario developed considers the construction of additional finishing space to accommodate the increased space requirements. This is a compromise between scenarios 1-3 (early marketing of market hogs) and scenarios 4-5 (reduced number of market hogs). In this case finishing space is built to allow for all pigs produced to be finished to target market weights. Although this seems like an extreme scenario, it actually is the best scenario over-all. It comes the closest to the baseline scenario results. This is due to the fact that the investment cost is amortized over the life of the facilities versus incurring the costs of reduced marketings, or light pig marketings, every production turn of the facilities. Also, meeting the space requirements for a 2600 sow base unit requires that a modest addition of 3 finishing barns be added to the base of 17 finishing barns.

Conclusions

Increasing concerns regarding the health and well-being of meat animals raised in confinement facilities have resulted in consideration of increasing the space allotment for animals. Recent research suggests that the appropriate measure for pig space is an allometric based measure referred to as a k-value. Additional research reported suggests that the k-value at which pig production performance peaks is k = 0.336. This report sought to first document whether this k-value was restrictive compared to current industry conventions for pig space allotment. This was accomplished by conducting a survey requesting information on stocking densities in the grow-finish phase of production and associated swine marketing practices. Key results suggest that the industry norm is to allow substantially less pig space than suggested by the hypothesized k-value of recent research by Gonyou et al.

The space restrictions implied result in two key economic impacts: (1) an underutilization of the existing confinement production asset base, and (2) a resulting impact on potential marketing practices. Therefore, it's clear that pork produces will find it necessary to adopt mitigation strategies in response to more restrictive pig space allocation requirements. This paper developed a financial economic model based on pig flows from farrowing through marketing and allowed for examination of alterative marketing practices and facilities management practices to mitigate the economic impacts through operation management. This model was used to simulate scenarios broadly categorized as managing finished pig marketings without altering upstream assets (marketing strategies), or alternatively managing upstream pig flows (weaned pig marketings), asset utilization (reduce breeding herd), or building more finishing capacity. Three major results emerged. First, restricting pig space has significant negative financial consequences for existing commercial confinement swine production systems. Secondly, marketing weight and timing mitigation strategies can be a short-term solution when compared to restricting flows into the finishing phase of production, but are clearly inferior to the longer range solution of adding finishing barns to existing production systems to accommodate the pigs. Reducing pig flows into the finishing phase through reduced size of the breeding herd results in underutilizing the most expensive capital assets (farrowing) and therefore, is the least preferred strategy as it had the most negative impact on return on equity. Additionally, reducing pig flow in the finishing facility through selling weaner pigs, while superior to reduced size of breeding herd, is inferior to most scenarios where all pigs remained in the production system. It was also shown that because of changing weight and animal composition in marketing strategy scenarios that the pricing grid of the packer to which the producer market has a substantial impact on the consequences of marketing lighter pigs to meet pig space restrictions. Therefore, impacts will not be uniform across the industry.

In a policy context, the simulations show that regardless of mitigation strategies adopted by existing swine producers there will be substantial and negative financial implications ranging from a 10 percent to a 97 percent reduction in return on equity. Therefore, adoption of space restrictions should be carefully considered in concert with any potential economic benefits which might occur, namely consumer willingness to pay for pigs raised in larger spaced facilities. As food chains consider imposing the space requirements on suppliers, they must recognize that the producers affected must be able to pass on some of the cost to downstream processors, retailers and ultimately consumers. Naturally, this will occur through market forces as producers leave the pork industry and market prices of pork increase from lower production levels. However, even this will not occur if the same or stronger restrictions are not placed on international suppliers of pork to the U.S.. This case would clearly undermine efforts aimed at animal welfare entirely and must be considered in the broader policy of space requirements for finished animals.

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References

Brumm, M.C. 2004. "The Effect of Space Allocation on Barrow and Gilt Performance." *J. Anim. Sci*. 82:2460-2466.

Edwards, S.A., et al. 1988. "Effect of Floor Area Allowance on performance of Growing Pigs Kept on Fully slatted Floors." *Animal Production*. 46:453-459.

Gonyou, H.W., J. Deen, J.J. McGlone, P.L. Sundberg, M. Brumm, H. Spoolder, J. Kliebenstein, B. Buhr, and A.K. Johnson. 2004. "Developing a Model to Determine Floor Space Requirments for Pigs." *J. Anim. Sci* 82: in press.

Petherick, J.C. 1983. A biological basis for the design of space in livestock housing. In: S.H. Baxter, M.R. Baxter and J.S. SC. MacCormack (Ed.) *Farm Animal Housing and Welfare*. Pp 103-120. Martinus Nijoff Publisher, Boston.

Powell, T.A. and M.C. Brumm. 1992. "Economics of Allocation for Grower-Finisher Hogs." *J. of Farm Managers and Rural Appraisers*. 56(1):67-72.