The New Economics of Livestock Production Management

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Abstract

The importance of heterogeneity of animal attributes in livestock production is assessed. Preliminary results indicate that variance and skew measures of attributes may be becoming more important over time.

Keywords: livestock economics, herd management, livestock marketing

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Recent decades experienced a rapid development of carcass merit and lean value payment systems for market hogs. Twenty years ago the swine industry was characterized by live weight pricing and spot markets. Now, integration is much more common, and, for most independent producers, animals are sold under a grid-based pricing system that provides rewards for being close to targets for carcass weight and leanness. Our hypothesis is that as grid-pricing systems shift over time, the relative importance of moments of the distribution of performance measures beyond the mean, particularly the variance and skew, are becoming more important.

Grid-pricing systems are in the form of discounts (and premiums) for deviations from a target range of carcass weight (referred to as weight hereafter) and leanness. An important aspect of these grid-pricing systems is that they are step functions. Thus, in analyzing management decisions affecting animal growth and leanness, approaches based on the first-order conditions will often fail because the net revenue-maximizing optimum may lie at an end point of the grid in one or more dimensions where revenues are non-differentiable. It is fairly straightforward to adapt the analysis to cope with this. However, some researchers (e.g., Boys et al. 2007) indicate that the analysis of animal management should focus on the herd rather than individuals.

In analyzing the economic management of livestock production, the herd can be modeled via either a discrete or a continuous distribution. In the discrete case, the discontinuities in the revenue function as a function of weight and leanness for an individual animal result in discontinuities in the herd-level revenue function. However, if the herd is modeled as a continuous distribution (clearly an approximation) then the discontinuities are removed via integration across the distribution of animals. The resulting herd-level revenue function may still fail to be differentiable, but will generally be continuous.

Growth varies across animals for a variety of reasons. Despite the fact that many producers take pains to ensure their pigs have uniform genetics and most environmental factors (temperature, humidity, etc.) and treatments (diets, pen space, etc.) are similar for all animals within the group, individual animals express different growth curves. This can be due to differences in birth weight, social interactions and health challenges. For example, Schinckel and Craig [2002] found that measures of skew in animal performance were positively correlated with the extent of the presence of disease in the herd. These challenges result in individual animals that, once they begin to lag in the growth process, can fall further and further behind their group mates. The result is that these “tail-enders” skew the distribution of performance measures, and they often receive substantial discounts when sold.

For purposes of illustrating our point, we focus on the decision of when to market the barn. (Thus, we abstract from the common practice of marketing the herd in truckload batches that is addressed in Boys et al. [2007].) In the absence of grid pricing, the optimum marketing date is determined by the maximum of net returns per unit of time (Dillon and Anderson 1990). This concept extends directly to the herd level in the absence of grid pricing, with the optimum timing of marketing being coincident with the maximum of net returns per unit of time averaged across the herd. Thus, it is sufficient to focus on the mean in the absence of grid pricing and when the variance and skew are irrelevant. This optimization criterion is still correct in the presence of grid pricing, but because the levels of discounts will vary depending upon where each animal falls in the joint carcass weight/leanness distribution, the higher order moments of the distribution will make a difference to average profits.

To test our hypothesis, the mean, variance, and skew for carcass weight and leanness are fit to hog growth data over time. The parameters of triangular distributions for carcass weight and leanness are calculated to match the first three moments of these distributions as functions of time. Average profit per unit of time will be calculated by integrating profit per unit of time across the distributions of carcass weight and leanness, taking into account the varying levels of discounts (and premiums). The optimal marketing date will be calculated as the time at which average profit per unit of time is maximized. (Due to the lack of differentiability and potential non-convexity of the average revenue function, the tools of Calculus are not appropriate, and the optimum is performed by brute force, comparing the average profit levels at 0.1-day time intervals.) The arc elasticities of the marketing date with respect to the mean, variance, and skew of the distributions of animal-performance measures will be calculated for two alternative grids from a single packer at different points in time, and the magnitudes of the arc elasticities of marketing date will be compared. We hypothesize that these elasticities will be larger for the more recent grid.

If our hypotheses are supported by this analysis, they have important implications for applied research in animal production: lending support to the idea that analysis at the herd level is important, providing impetus for the development of precision livestock management, and suggesting livestock production management strategies that focus on treating animals that appear to be lagging behind relative to their peers in terms of growth. Also, the nature of inter-individual variation in performance, as evidenced by non-normal distribution of weight among other measures, provides insight into the herd's state of wellbeing, and its welfare status (Curtis, 2007).

Hog Data and the Distribution

This study uses a trial consisting of 188 gilts raised under conditions that approximate typical production husbandry. The animals were obtained at approximately 50 pounds and monitored throughout the growth period. Each hog's carcass weight and percent lean were recorded at 161, 180, and 199 days of growth. This growth period corresponds to the finishing phase for most production operations. Using these data points, the mean, variance, and skew at the herd level are calculated for hot carcass weight and percent lean on each of these three days. Quadratic functions of time for each of these three moments were fit to the three observations in order to model the change of the moments over time. These curves provide estimates of the first three moments of the marginal distributions of carcass weight and leanness at any point in time over the range from 161 to 199 days. (See figures 1 and 2.)

In order to obtain a continuous revenue function for this heterogeneous herd analysis, a continuous distribution is needed. In this project, a triangular distribution – the most common simple continuous distribution capable of reflecting skew - is chosen. A triangular distribution is often used when there is a limited amount of data available for analysis and no clear understanding of the true distribution is available (Ross, 2006). A triangular distribution can be described by specifying the minimum point in its support (a), the maximum support point (b), and the mode of the distribution (c). The mean, variance, and skew of the triangular distribution are calculated as follows:

(1)
$$\begin{aligned} \text{mean} &= \int_a^c x g_1(x)dx + \int_c^b x g_2(x)dx, \\ \text{variance} &= \int_a^c (x-\mu)^2 g_1(x)dx + \int_c^b (x-\mu)^2 g_2(x)dx, \text{ and} \\ \text{skew} &= \int_a^c (x-\mu)^3 g_1(x)dx + \int_c^b (x-\mu)^3 g_2(x)dx \end{aligned}$$

where μ = mean, $g_1(x) = 2(x-a)/[(b-a)(c-a)]$, and $g_2(x) = 2(b-x)/[(b-a)(b-c)]$. Alternatively, given the mean, variance, and skew measures, the system of moment relationships (1) can be solved for the parameters of the triangular distribution, a, b, and c. Because we have expressed these moments as functions of time, we effectively obtain the parameters of the triangular distributions as functions of time. This gives us a family of triangular distributions that changes over time to reflect the heterogeneous growth of the herd. (See figures 3 and 4.)

Modeling Herd-level Profits

In the typical livestock-production analysis, the producer makes a shipping decision based on the performance of the mean of the animals in a heterogeneous herd. For a renewal process in which one batch of animals is replaced by the next, as is common in the pork-production industry, the strategy is to send animals to market on the day in which the average daily profit for the cycle is maximized (Dillon, 1990). The following profit equation illustrates the model:

(2) $$\max_t \ \pi(t,w,l) = \frac{1}{t+\delta}\left[w(t)\left(P - d(w(t),l(t)) - V(t) - F\right)\right]$$

where

t	=	the total number of days the herd resides in the facility,
δ	=	the time to prepare and repopulate the facility,
$w(t)$	=	hot carcass weight as a function of time,
$l(t)$	=	carcass lean as a function of time,
P	=	the base hot carcass weight price in dollars per pound,
$d(w,l)$	=	the step function that reflects the discounts/premia from the processor's grid as a function of carcass weight and percent lean,
V(t)	=	variable cost (feed, housing, labor, etc.) as a function of time, and
F	=	the fixed cost per animal (feeder pig, vaccination, etc.).

While this is the typical approach to analysis, revenues for the producer are based on the actual weight for each animal, and thus the variability of carcass weight and leanness, which is ignored in the objective above, has important impacts on producer profits. The reason is that the discount function, $d(w,l)$, is nonlinear, and thus average (across animals) profit per unit of time is not the same as profit per unit of time for the average animal.

Herd-Level Profits

A more theoretically consistent model of the objective for the herd-level livestock management problem is based on the average (across the animals in the herd) profit per unit of time. Because the discount function is nonlinear and animals are heterogenous with respect to their growth in carcass weight and development of lean tissue, higher order moments of the distributions of these animal attributes may have an impact on optimal production management decisions. For the analysis presented here, we focus on the timing of marketing. The expected profit for a continuous distribution of hogs can be found from the following formulation:

(3)
$$\begin{aligned}\Pi = &\int_{a_l}^{c_l}\left[\int_{a_w}^{c_w}\pi(t,w,l)g_1^w(w)g_1^l(l)\,dw + \int_{c_w}^{b_w}\pi(t,w,l)g_2^w(w)g_1^l(l)\,dw\right]dl \\ &+\int_{c_l}^{b_l}\left[\int_{a_w}^{c_w}\pi(t,w,l)g_1^w(w)g_2^l(l)\,dw + \int_{c_w}^{b_w}\pi(t,w,l)g_2^w(w)g_2^l(l)\,dw\right]dl\end{aligned}$$

where:

a_i = minimum of the triangular distribution ($i = w$ for carcass weight, l for leanness)

b_i = maximum of the triangular distribution ($i = w$ for carcass weight, l for leanness)

c_i = mode of the triangular distribution ($i = w$ for carcass weight, l for leanness)

$g_1^i()$ = the triangular distribution from the minimum to the mode for attribute i

$g_2^i()$ = the triangular distribution from the mode to the maximum for attribute *i*

This setup allows for the packer's grid to affect expected profit, and thus the optimal marketing time, through the higher-order moments present in the distributions of the attributes. The question at hand is whether these higher-order moments are becoming more or less important over time.

Production Data and System

This analysis assumes an all-in/all-out production system with one group of hogs being replaced by another over time. This is the predominant manner of scheduling production cycles and thus marketing hogs in the U.S. Since all pigs are sent to the packer at the same time, the barn is idle for preparation for and restocking with a new herd. It is assumed for this study that 7 days are necessary for this restocking process. The growth curves and attribute distributions are developed for a herd of gilts, and - because of the short time period for the grow/finish stage of production - discounting to reflect the time value of money is not reflected. (It is a straightforward modification of our setup to include this type of discounting.)

Costs

Feeder pig costs: The aforementioned profit function includes variable and fixed costs. Feeder pig replacement price is assumed to be $40 per pig, reflecting the high quality of genetics of the hogs used for development of the growth curves. The AMS estimated 50-54% lean value feeder pigs on a 50-pound basis is assumed to range from $27.00-$50.00 (Agricultural Marketing Service, 2008). Other fixed costs are omitted here, but should be considered for a more comprehensive analysis.

Feed costs: Feed represents a large cost associated with finishing hogs. Feed costs were developed from the recorded cumulative feed intake (CFI) assumed for each hog during the experiment. A CFI mean for each day (161, 180, 199) was calculated and a quadratic function was fit to these three points. Given this function, average CFI at any point in time can be calculated. The amount of feed assumed in the profit calculations is cumulative from the time that the 50-pound feeder pig is placed on feed.

In developing the per-pound price for feed, a swine diet decision aid designed around a standard corn-SBM diet was used. This diet formulation is based on the apparent digestible lysine level for amino acids and includes the possibility of inclusion for numerous synthetic amino acids in the diet. Nutrient requirements for the decision aid were taken from the Nutrient Requirements for Swine (NRC, 1998). The cost-minimizing formulation is shown in Table 1. Using a corn price of $5.20 per bushel and a SBM price of $340 per ton, the cost per pound of feed is calculated at $0.10 per pound. It is recognized that the volatility of ingredient prices will influence the profit levels, but this factor is ignored in the present analysis.

Daily costs: In conjunction with the other costs, there exist numerous costs that impact profit in pork production. Veterinary expenses, bedding, marketing, interest, and fuel costs are among the many relevant costs. These variable costs are calculated on a hundredweight basis by numerous extension and government agencies and producer organizations. Using the hog-production costs from ERS, the daily costs of all of the other production inputs was recently estimated to be $0.12 per day (Economic Research Service, 2006).

Pricing Grids

Pork processors use pricing grids to create incentives for producers to deliver hogs in a certain carcass weight and leanness range. These grids give discounts and premiums based on the attributes of the individual animals delivered to the plant. The grids have an associated base payment level to which the discounts and premiums are applied. There exist two ways most processors impose discounts. The first is a function of the carcass weight of the animal delivered to the plant exclusively. The second grid provides payments based on the percentage of lean tissue in addition to the carcass weight.

Our study employs two grid systems developed by Tyson Foods (Springdale, AR) used in their procurement operations. These grids are labeled “Old” and “New.” The Old grid was in place for some time before February 4, 2008; the New grid was instituted on that date. Tables 2 and 3 display the payment schedules provided to producers. Table 2 shows the payments based solely on carcass weight. Table 3 includes additional discounts based on the combination of the carcass weight and percent lean. A base price of $55 per hundredweight of carcass weight is used for the present analysis.

As shown in Table 2, the new grid increased the penalties for delivering lightweight hogs to the processor, while no incentives were provided for heavier hogs. Table 3 highlights the main changes in the shaded areas of the table. These changes show an additional incentive for slightly heavier hogs when leanness is above 52%.

Results

For each grid, the optimal marketing time for the herd is calculated. Under the Old grid system, the optimum time was 172.0 days of age, and the average level of profit is $9.20 per hog. Under the New grid system, the optimal marketing point is at 187.2 days of age, and the average profit level is $9.40 per hog. This shift towards shipping date that is over 15 days later reflects the incentive under the new grid to deliver heavier (relatively lean) hogs to the processor. While the profit per hog is slightly higher, the 15 additional days in the barn greatly reduces the number of hogs capable of being marketed by a producer on an annual basis.

Elasticities: *Old Grid*

In order to estimate the impact of the moments of the attribute distributions on the marketing decision, each attributes' mean, variance and skew are increased by 1% in turn, and the percentage change in the optimal marketing day is observed, yielding an arc elasticity estimate of the response. An increase of 1% in the mean of the distribution of either hot carcass weight or percent lean decreases the optimal marketing time by about 0.1% and 0.2%, respectively (see Table 4). This is the expected result for hot carcass weight because the increase in the mean results in the hogs reaching the no-discount range of the grid sooner.

An increase of 1% for the variance of the distributions of hot carcass weight and leanness yields about a 0.2% increase in the optimal marketing time for hot carcass weight, but no discernable effect for percent lean (given the 0.1-day increments used for optimizing marketing time). An increase of 1% for the skew of the distributions of hot carcass weight and leanness yields no discernable effect for hot carcass weight but a decrease of about 0.06% for leanness. In analyzing the impact of changes in percent lean, it should be understood that the skew for the distribution is negative across the entire period. Thus, an increase in skew by 1% makes the distribution more negatively skewed. Understanding the cause and effect of this relationship will require more detailed analysis of the source of penalties and discounts.

Elasticities: *New Grid*

An increase of 1% in the mean of the distribution of either hot carcass weight or percent lean with the New grid decreases the optimal marketing time by about 0.2%, which is again the expected result for hot carcass weight. An increase of 1% for the variance of the distributions of hot carcass weight and leanness yields about a 0.1% increase in the optimal marketing time for hot carcass weight and a decrease of about 0.1% for percent lean. An increase of 1% for the skew of the distributions of hot carcass weight and leanness yields about a 0.1% decrease in optimal marketing time for both hot carcass weight and leanness.

Elasticities Compared – Old and New Grids

Taking the signs of the arc elasticities that were measured to be zero as ambiguous, the pattern of changes in the optimal market weights with respect to the moments of the distributions of attributes are consistent across the Old and New grids. In terms of magnitudes, these elasticities are large in three of four cases under the New grid relative to the Old grid, lending support to our hypothesis that the higher moments of the distributions of carcass attributes are becoming more important over time.

Conclusions

This study uses a heterogeneous-herd-management approach to evaluate the importance of higher-order (than the mean) moments in determining the optimal strategy for a decision of central importance in swine production – the optimal time to turn the barn. The analysis was applied to two recently available carcass-merit pricing grids used by a major hog packer, and found that, in three out of four cases, the higher-order (variance and skew) statistics of the distribution of carcass merit variables became more important with the institution of a New grid, lending support to the hypothesis that these statistics are becoming more important over time. Additional work is needed to refine the elasticity estimates and test the hypothesis with additional grids from other points in time and other packers to further validate our hypothesis.

If further support for this hypothesis were established, it would suggest that future efforts in livestock-production management may do well to focus on strategies for managing the higher moments of the attribute distributions – e. g., inter-individual variation in performance. This may pave the way for more precise agricultural management in the livestock sector, such as animal-specific medication, refined sorting strategies, and behavioral- and environmental-management techniques that minimize inter-individual variation in performance.

References

Boys, K., N. Li, P.V. Preckel, A.P. Schinckel, and K.A. Foster, 2007. "Economic Replacement of a Heterogeneous Herd," Am. J. of Agr. Econ., 89:24-35.

Curtis, S. E. 2007. "Performance indicates animal state of being: A Cinderella axiom?" Prof. Anim. Scient. 23:573.-583.

Dillon, J.L., and J.R. Anderson. 1990. *The Analysis of Response in Crop and Livestock Production, 3rd Ed*. New York, NY: Pergamon Press.

National Research Council (NRC). 1998. Nutrient Requirements for Swine., 10th Revised Edition. National Academic Press, Washington DC, USA.

Ross, Sheldon. 2006. *A First Course in Probability, 7th Ed*. Upper Saddle River, NJ: Pearson-Prentice Hall Press

Schinckel, A. P. and B. A. Craig. 2002. "Evaluation of Alternative Nonlinear Mixed Effects Models of Swine Growth," Prof. An. Sci., 81:219-226.

Tyson Procurement Program Announcement. 2007. Tyson Fresh Meats, Inc. Dakota Dunes, SD.

U.S. Department of Agriculture, Department of Ag Market News. *National Direct Feeder Pig Report: Week Ending April* 11. Des Moines, Iowa. Bruce Thomas, Marketing Reporter www.ams.usda.gov/LSMarketNews, accessed April 2008.

U.S. Department of Agriculture, Economic Research Service, *Cost and Return Estimates*. www.ers.usda.gov/Data/Costsand Returns/testpick.htm, accessed April 2008.

Table 1. Cost Minimizing Diet

Ingredient	Amount
Corn	84.82%
Soybean Meal	13.19%
Lysine HCL	0.15%
Limestone	0.97%
DiCalciumPhosphate	0.72%
Vitamin premix	0.13%
DL Methionine	0.00%
Grease	0.00%
Lthreonine	0.02%
Ltryptophan	0.00%
Metabolizable Energy (Kcal/lb)	1517.73456
Crude Protein	13.44%
Lysine	0.60%
MethionineCystine	0.40%
Threonine	0.38%
Tryptophan	0.10%
Calcium	0.60%
Phosphorus	0.46%
Available Phosphorus	0.19%
Crude Fiber	2.40%
Isoleucine	0.50%
Valine	0.43%
Vitamin Premix	0.13%
Crude Fat	3.70%

Table 2. Tyson Carcass Grid

WEIGHT RANGE				**OLD**	**NEW**	**OLD**	**NEW**
LIVE WGT (APPROX.)		HOT CARCASS		LIVE WEIGHT DISCOUNT	LIVE WEIGHT DISCOUNT	DRESS WEIGHT DISCOUNTS*	DRESS WEIGHT DISCOUNTS*
UNDER-	189	UNDER-	139	$9.00	$10.00	$12.25	$13.61
190-	199	140-	146	$6.00	$7.00	$8.16	$9.52
200-	209	147-	155	$4.00	$5.00	$5.41	$6.76
210-	220	156-	163	$2.50	$3.00	$3.37	$4.05
221-	230	164-	171	$0.50	$1.00	$0.67	$1.35
231-	240	172-	178	$0.00	$0.00	$0.00	$0.00
241-	250	179-	186	$0.00	$0.00	$0.00	$0.00
251-	260	187-	194	$0.00	$0.00	$0.00	$0.00
261-	270	195-	202	$0.00	$0.00	$0.00	$0.00
271-	280	203-	209	$0.00	$0.00	$0.00	$0.00
281-	290	210-	218	$0.50	$0.50	$0.67	$0.67
291-	300	219-	225	$1.00	$1.00	$1.33	$1.33
301-	310	226-	233	$2.00	$2.00	$2.67	$2.67
311-	320	234-	240	$3.50	$3.50	$4.67	$4.67
321-	330	241-	248	$5.25	$5.25	$7.00	$7.00
331-	340	249-	255	$7.00	$7.00	$9.33	$9.33
341-	350	256-	263	$8.00	$8.00	$10.67	$10.67
351-	360	264-	271	$10.00	$10.00	$13.29	$13.29
361>	UP	272>	UP	$11.00	$11.00	$14.62	$14.62

Table 3. Tyson Lean Grid

New Grade Premium Schedule (effective February 4, 2008)

Approx. Live Wt.	HCW Range	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60
under 209	under 155	(7.50)	(6.00)	(4.00)	(3.00)	(2.00)	(1.00)	-	1.00	2.50	3.00	3.00	3.00	3.00	3.00	3.00	3.00
210-220	156-163	(7.50)	(6.00)	(4.00)	(3.00)	(2.00)	(1.00)	-	1.00	2.50	4.00	4.00	4.00	4.00	4.50	4.50	4.50
221-230	164-171	(7.50)	(6.00)	(4.00)	(3.00)	(2.00)	-	-	2.50	3.00	4.00	4.50	4.50	4.50	4.50	4.50	4.50
231-240	172-178	(7.50)	(6.00)	(4.00)	(3.00)	(2.00)	-	-	2.50	3.50	4.00	4.50	5.00	5.00	4.50	4.50	4.50
241-250	179-186	(7.50)	(6.00)	(4.00)	(3.00)	(2.00)	-	-	2.50	3.50	4.50	5.50	6.00	6.00	6.00	5.50	5.50
251-260	187-194	(7.50)	(6.00)	(4.00)	(3.00)	(1.00)	-	-	3.00	4.00	5.00	5.50	6.00	6.50	7.00	7.00	7.50
261-270	195-202	(7.50)	(6.00)	(4.00)	(3.00)	(1.00)	-	-	3.00	4.50	5.50	6.00	6.50	7.00	7.00	7.50	7.50
271-280	203-209	(7.50)	(6.00)	(4.00)	(3.00)	(1.00)	-	-	4.00	5.00	6.50	6.50	7.00	7.00	7.00	7.50	7.50
281-290	210-218	(7.50)	(6.00)	(4.00)	(3.00)	(1.00)	-	-	4.00	5.50	7.00	7.00	7.50	7.50	7.50	7.50	7.50
291-300	219-225	(7.50)	(6.00)	(4.00)	(3.00)	(1.00)	1.00	2.00	4.00	5.50	7.00	8.00	8.50	8.50	8.50	8.50	8.50
301-310	226-233	(7.50)	(6.00)	(4.00)	(3.00)	(1.00)	1.00	2.00	3.50	5.50	8.00	8.50	8.50	8.50	8.50	8.50	8.50
311-320	234-240	(7.50)	(6.00)	(4.00)	(3.00)	(1.00)	1.00	2.00	3.50	5.50	8.00	8.50	8.50	8.50	8.50	8.50	8.50
321-330	241-248	(7.50)	(6.00)	(4.00)	(3.00)	(1.00)	1.00	2.50	4.00	6.00	8.00	8.50	8.50	8.50	8.50	8.50	8.50
331-340	249-255	(7.50)	(6.00)	(4.00)	(3.00)	(1.00)	1.00	2.50	4.00	6.00	8.00	8.50	8.50	8.50	8.50	8.50	8.50
341-up	256-up	(7.50)	(6.00)	(4.00)	(3.00)	(1.00)	1.00	2.50	4.00	6.00	8.00	10.00	10.00	10.00	10.00	10.00	10.00

Current Grade Premium Schedule

Approx. Live Wt.	HCW Range	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60
under 209	under 155	(7.50)	(6.00)	(4.00)	(3.00)	(2.00)	(1.00)	-	1.00	2.50	3.00	3.00	3.00	3.00	3.00	3.00	3.00
210-220	156-163	(7.50)	(6.00)	(4.00)	(3.00)	(2.00)	(1.00)	-	1.00	2.50	4.00	5.00	5.00	5.00	5.00	5.00	5.00
221-230	164-171	(7.50)	(6.00)	(4.00)	(3.00)	(2.00)	-	-	2.50	4.00	5.00	5.50	5.50	5.50	5.50	5.50	5.50
231-240	172-178	(7.50)	(6.00)	(4.00)	(3.00)	(2.00)	-	-	2.50	4.00	5.00	5.50	5.50	5.50	5.50	5.50	5.50
241-250	179-186	(7.50)	(6.00)	(4.00)	(3.00)	(2.00)	-	-	2.50	4.00	5.50	6.50	6.50	6.50	6.50	6.50	6.50
251-260	187-194	(7.50)	(6.00)	(4.00)	(3.00)	(1.00)	-	-	2.50	4.00	5.50	7.50	7.50	7.50	7.50	7.50	7.50
261-270	195-202	(7.50)	(6.00)	(4.00)	(3.00)	(1.00)	-	-	2.50	5.00	6.50	7.50	7.50	7.50	7.50	7.50	7.50
271-280	203-209	(7.50)	(6.00)	(4.00)	(3.00)	(1.00)	-	-	3.50	5.50	7.50	7.50	7.50	7.50	7.50	7.50	7.50
281-290	210-218	(7.50)	(6.00)	(4.00)	(3.00)	(1.00)	-	-	3.50	5.50	7.50	7.50	7.50	7.50	7.50	7.50	7.50
291-300	219-225	(7.50)	(6.00)	(4.00)	(3.00)	(1.00)	1.00	2.00	3.50	5.50	8.00	8.50	8.50	8.50	8.50	8.50	8.50
301-310	226-233	(7.50)	(6.00)	(4.00)	(3.00)	(1.00)	1.00	2.00	3.50	5.50	8.00	8.50	8.50	8.50	8.50	8.50	8.50
311-320	234-240	(7.50)	(6.00)	(4.00)	(3.00)	(1.00)	1.00	2.00	3.50	5.50	8.00	8.50	8.50	8.50	8.50	8.50	8.50
321-330	241-248	(7.50)	(6.00)	(4.00)	(3.00)	(1.00)	1.00	2.50	4.00	6.00	8.00	8.50	8.50	8.50	8.50	8.50	8.50
331-340	249-255	(7.50)	(6.00)	(4.00)	(3.00)	(1.00)	1.00	2.50	4.00	6.00	8.00	8.50	8.50	8.50	8.50	8.50	8.50
341-up	256-up	(7.50)	(6.00)	(4.00)	(3.00)	(1.00)	1.00	2.50	4.00	6.00	8.00	10.00	10.00	10.00	10.00	10.00	10.00

Table 4. Elasticities of Marketing Date with Respect to Moments

Moment	Hot Carcass	Percent Lean
Old Grid		
Mean	-0.116	-0.174
Variance	0.174	0.000
Skew	0.000	-0.058
New Grid		
Mean	-0.107	-0.107
Variance	0.053	-0.107
Skew	-0.107	-0.107

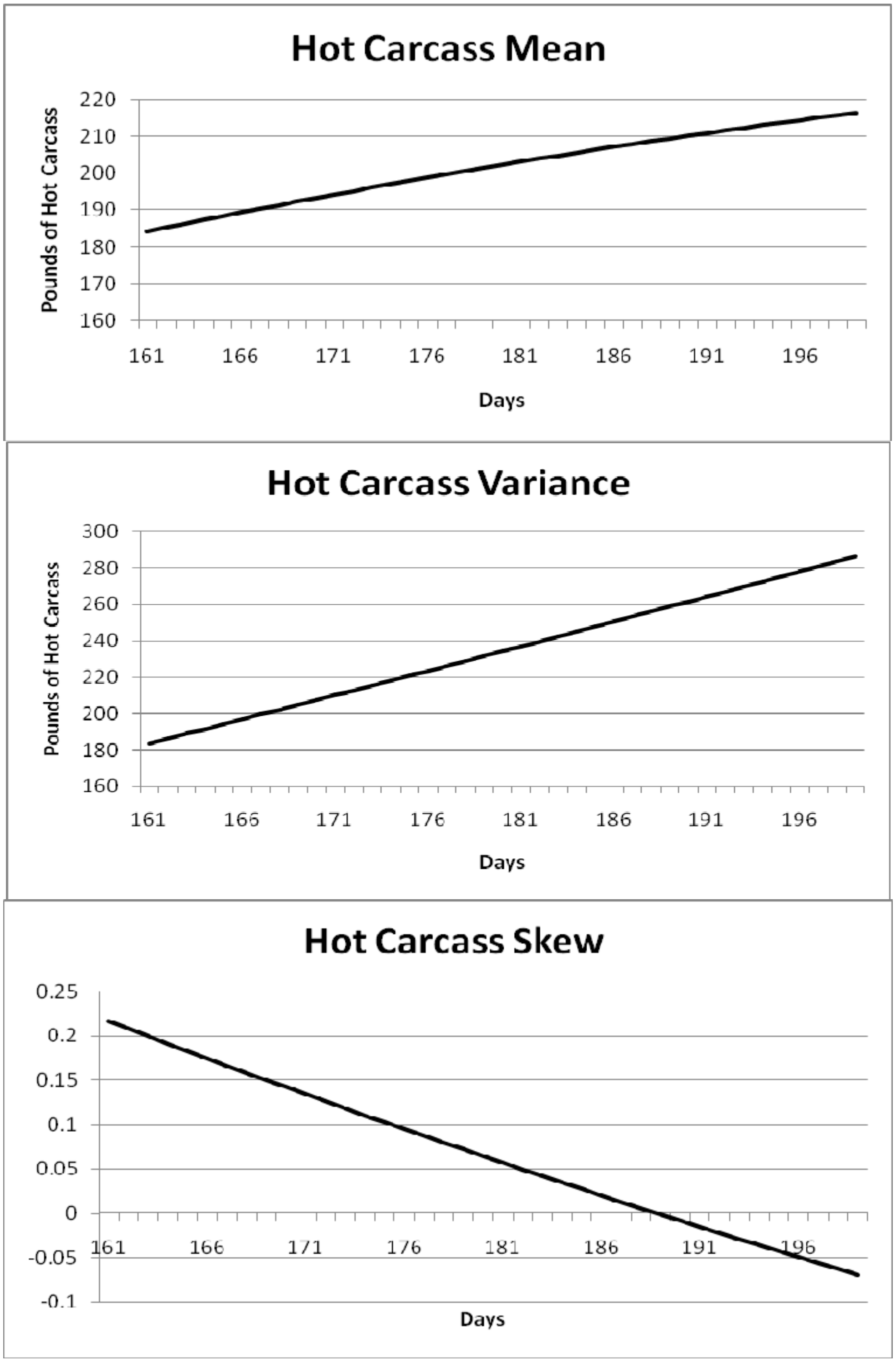

Figure 1. Evolution of Moments of Carcass Weight over Time

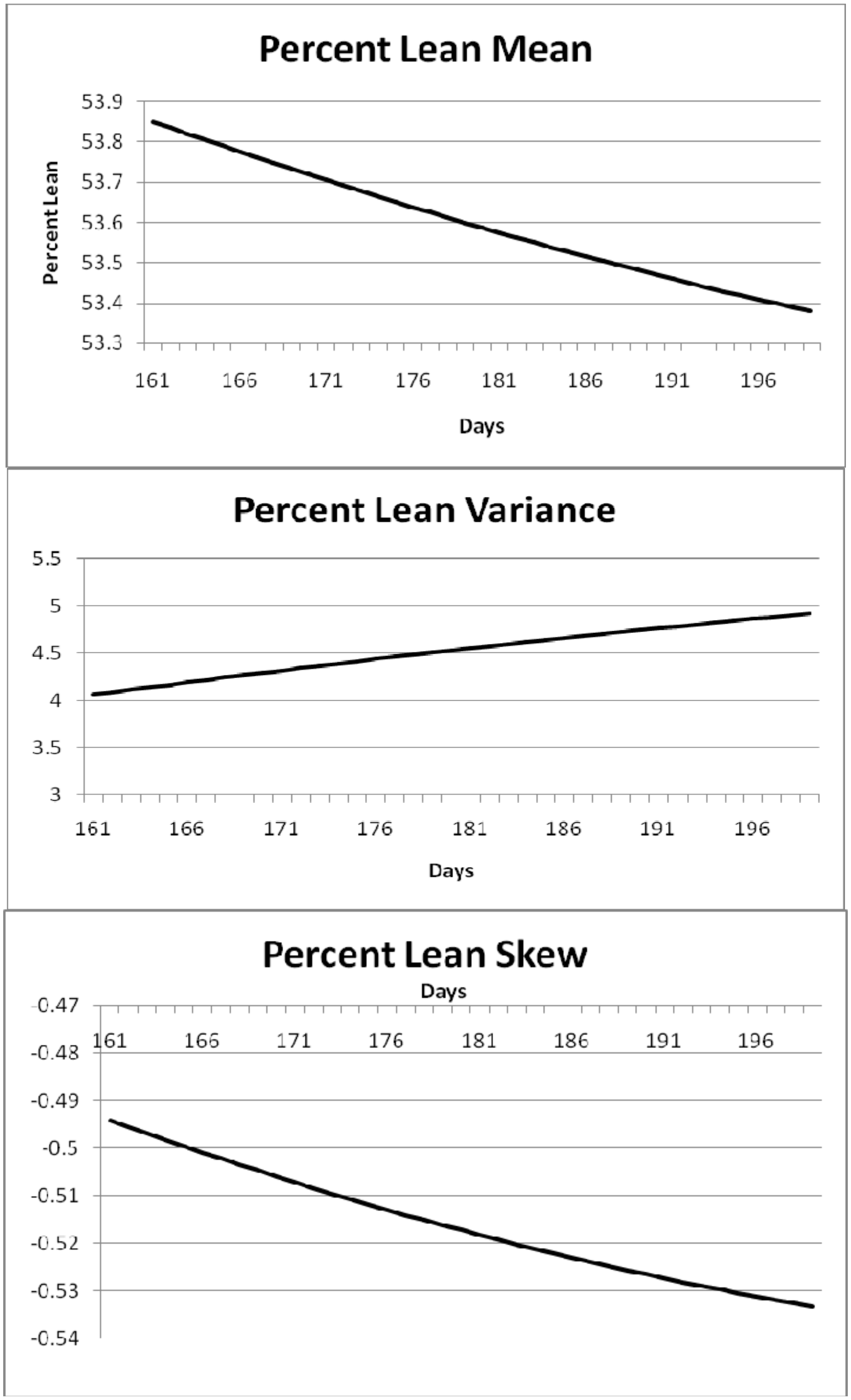

Figure 2. Evolution of Moments of Leanness over Time

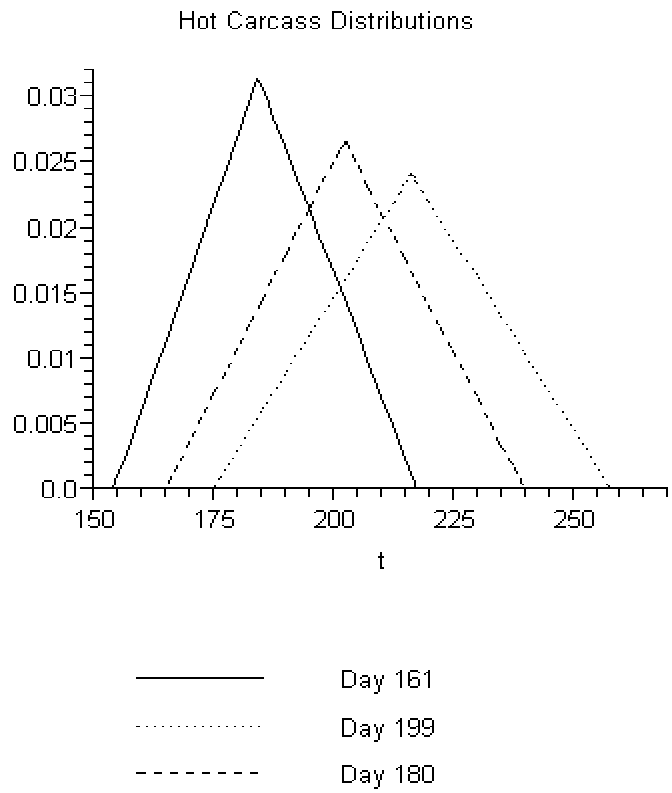

Figure 3. Evolution of the Herd-level Distribution of Carcass Weight over Time

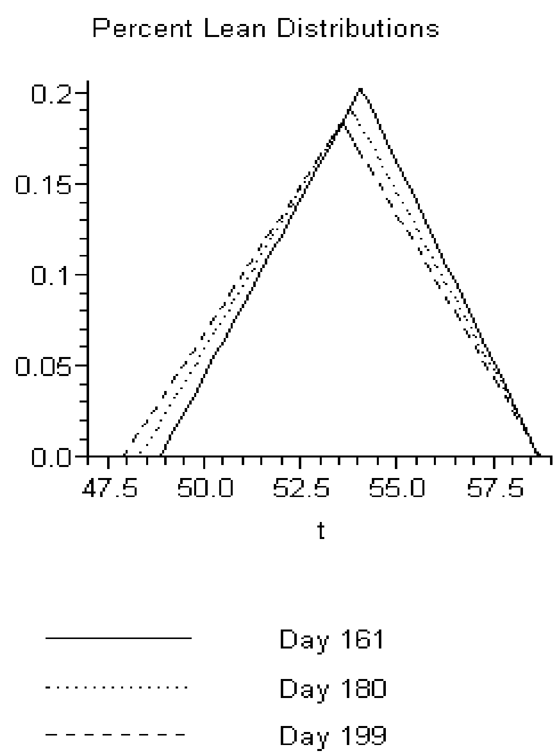

Figure 4. Evolution of the Herd-level Distribution of Percent Lean over Time