RETURNS TO MARKET TIMING AND SORTING OF FED CATTLE

Stephen R. Koontz, Dana L. Hoag, Jodine L. Walker, and John R. Brethour[*]

This research examines the returns to a cattle feeding operation that sorts animals prior to marketing using ultrasound technology. The returns to sorting are between $11 and $25 per head depending on the number of groups the pens in which cattle can be sorted. Sorting faces declining returns. These returns can also be viewed as the costs imposed by institutional constraints that limit co-mingling of cattle. Through sorting, cattle feeding operations are able to reduce meat quality discounts, increase meat quality premiums, increase beef carcass quality characteristics, more efficiently use feed resources, and increase profits.

Introduction

There are frequent discussions among beef industry participants about the need to improve quality and consistency (Smith et al. 1995 and NCBA). There are also frequent discussions of the need to increase the value added at the farm and ranch level (Cattle Fax). This research contributes to this discussion by measuring economic returns to a cattle feeding organization that sorts animals within pens of fed cattle prior to marketing. The work also examines the inefficiency that is present in the current marketing system due to the institutional constraints that are followed by industry participants.

Beef industry leadership, industry member groups, and the farm popular press have much discussed the decline in beef demand since the early 1980s. Recommendations to address this problem have suggested the need to improve quality, consistency, and convenience characteristics of beef products (Smith et al. 1995 and NCBA). The need to address demand issues and the profitability problems the beef industry faced in the mid-1990s have prompted interest in retained ownership programs, value-added, and value-based marketing (Cattle Fax). Grid pricing systems are also a point of discussion within the value-added and value based marketing systems (Doherty et al. and Dolezal).

The main premise motivating this work is that improving the beef industry likely requires change. Likewise, adding value to a commodity product requires that industry participants do something specific or do something different. Frequently, grid pricing research examines returns

to marketing strategies that do not involve changing production practices or changing the product form (Feuz et al.). It is unlikely that such a simple change in practices will enhance net returns. Such an opportunity would imply the existence of substantial market inefficiencies within the current system that can be easily exploited.

This research looks at the returns to sorting fed cattle prior to marketing. The sorting regime is based on ultrasound technology. Thus, the management change in this case is that the feedlot operation ultrasounds cattle at the feeding stage where cattle typically receive a final growth implant. Based on ultrasound measurements, cattle are sorted into groups that are marketed to optimize returns to weight, yield grade, and quality grade relative to feeding costs. We measure the returns to sorting single pens into different numbers of multiple pens. We are also able to test if cattle feeding operations market cattle optimally given the institutional constraint that sorting or co-mingling of cattle from different pens are not an accepted practice.

In addition to measuring the returns to sorting and testing efficiency of current practices, the results of this work can also be viewed as estimating the costs associated with the current marketing system. Traditional marketing institutions in the fed cattle industry lead to the selling of cattle in pen-level units and in weekly increments. Cattle are not frequently sold when individual animals are at the optimal weight or quality. This practice exacts a cost on the system. We are able to measure this cost. Our tests of efficiency of the marketing practices are within the limits of these current marketing institutions.

The information provided in this research will show the economic potential associated with the adoption of sorting technology. Sorting technology is one method of reducing possible inefficiency in the beef marketing system but it will require the modification of current marketing institutions.

Approach

The general approach taken in this work is to model the results of a sorting technology used by a cattle feeding operation. The sorting technology attempts to move fed cattle based on a marginal cost and marginal return evaluation from heterogenous groups to more profitable marketing windows and more homogenous groups.

This work makes use of the decision support system within Ultrasound Cattle Sorting System (UCSS) technology developed by and reported in Brethour (1989). The main part of the decision support system within the UCSS program is a set of animal growth curves. An ultrasound image of the sagittal plane (shoulder-to-shoulder) over the first and second lumbar vertebrae is captured for each animal on feed approximately 80 days from slaughter. This is the typical re-implant date in a commercial cattle feeding operation. The ultrasound technology measures marbling (intramuscular fat) within the ribeye (longissimus) muscle and backfat (subcutaneous fat). Cattle are also weighed. These measurements are used in three growth curves to predict final slaughter weight, USDA yield grade, and USDA quality grade. Some of these growth curves are published

and are public knowledge and some are proprietary information. (See Brethour 1991, 1994 and 1995.) For discussions and examples of ultrasound research and technology see Faulkner et al., Houghton and Turlington, Perkins et al., Smith et al. 1992, and Whittaker et al.

The UCSS will provide a marketing date to the user based on a projected profit maximum. Profit is projected based on revenue and costs data provided by the user. Revenue data includes the futures price less basis – the price level, premium and discounts for various yield and quality grades. Cost data includes feed costs. The program incorporates declining feed performance for each animal as that animal grows. The price level component of the program is not used in this research. We are only interested in the marginal costs and marginal returns associated with sorting and not total profits. The growth curves and the feed performance assumptions built into UCSS are used in this work to study how the animal composition changes as marketing dates are changed.

A sample of carcass data was collected and used within the UCSS to model changing animal composition. The carcass data represents a sample of the characteristics within the animal population and the UCSS can simulate the growth characteristics as marketing dates change. We are able to modify the characteristics of the animals marketed through different sorting regimes.

Individual animal carcass data were available from the Gelbvieh Alliance. Cattle of any breed can be placed in this alliance. The Gelbvieh Association manages the database and, through the relationship of its personnel with personnel in the Red Meat Division of ConAgra, is responsible for data management and integrity. Cattle in the alliance are marketed in pen-level transactions but data may be collected on individual animals. On a fee basis, participants can have pen-level or individual animal information collected. The data used is the individual animal data. We treat carcass observations as a sample from the population of fed cattle and pen-level transactions as a sample from the population of marketing decisions. Feedlot operations that are known to sort cattle or use ultrasound were removed from the database. The sample includes 7173 animals in 99 pens. Pens in the sample contained 40 to 163 animals.

Carcass data measurements at the time of slaughter are used with the UCSS equations to "backcast" 80 days. Live animal weight, marbling score, and backfat initial measurements are obtained. These measurements simulate the initial reading taken during ultrasound. The backcast measurements are then used in the UCSS to determine carcass characteristics at various marketing dates. We measure changes in carcass characteristics as the marketing date is adjusted.

The UCSS calculates the final carcass characteristics with error. An example observation is shown in Table 1. The software calculates the probability that an individual animal will be in the various yield grade and quality grade categories. However, capturing the measurement error is not possible in the backcast step. The lack of measurement error in the backcast will likely reduce the variability in the data used to calculate the returns to sorting. The impact may overestimate the returns to sorting.

The approach followed in modelling is outlined in Figure 1. Characteristics of every animal in a pen are backcast 80 days. This is the left-arrow in the top of Figure 1. We then examine a number of different marketing scenarios – follow the down-arrow to the different regimes. Minimum returns to ultrasound are determined by examining if the pens in the sample should have been marketed at a different date. This is the top right-arrow in the figure. An example is given where the pen is marketed earlier. Maximum returns to ultrasound and sorting is determined by marketing every individual animal at the optimal date associated with that animal. This is the bottom right-arrow in the figure. Intermediate returns to ultrasound and sorting can be determined by breaking the initial pen structure into a given number of secondary pens where the animals in the secondary pens are then all marketed on the date which is optimal for the pen. The figure illustrates marketing an original pen in two and three secondary groups.

The UCSS software measures animal growth characteristics and also measures feed performance degradation as the animal increases in weight. Fed performance assumptions are discussed below. The optimal marketing date will also depend on premium and discount structure of the grid pricing structure. A grid price structure used is presented in Table 2. The base animal within this grid is USDA Choice, Yield Grade 3, and between 550 and 950 pounds. This is a reasonable typical grid and is the base grid for the work. (See Doherty et al. and Cattle Fax.) The probabilities of the different carcass characteristics in Table 1 are multiplied by the premiums and discounts in Table 2, net of a marginal feed cost, to determine the returns to sorting. There is no base price level so the result, when netted from the premiums or discounts associated with the actual carcass characteristics, is the marginal return to changing the product quality.

The marginal feed cost is determined through the feed performance assumptions. We assume a 6.5 pounds of feed to a one pound of gain ratio. Animals grow 3.2 pounds per day in live weight or 2.3 pounds per day in carcass weight. The feed cost is assumed to be \$0.075 per pound and this is the base for the work. The feed conversion rate is assumed to decline once an animal grows beyond >0.6 inches backfat. This assumption is reasonable may be limiting. However, it is incorporated into the UCSS software and cannot be modified.

To address limitations of assuming a fixed price grid and fixed feed costs, we conduct a sensitivity analysis with different premiums and discounts in the price grid and variable feed costs. Analysis on all the animals, pens, and the maximum return sorting regimes were conducted. The cost of gain was varied between 50, 60, and 70 cents per pound of feed. The USDA Select discount was varied between 0, 5, and 10 dollars per cwt. This captures variation across grids that reward and do not reward marbling. Last, the premium for USDA Yield Grade 1 and 2 carcasses was varied between 0, 5, and 10 dollars per cwt. This capture variation across grids that reward and do not reward red meat yield. The Select discount and the Yield Grade 1 and 2 premiums are the most important elements in a grid.

The three permutations of the three variables create 27 different scenarios. Optimal dates and carcass characteristics for all individual animals were determined for each permutation in the sensitivity analysis. The results will be summarized in a regression.

Results from Sorting Cattle

The minimum economic potential of ultrasound technology is quite limited. The most profitable marketing date is in 84 days. Given that we backcast 80 days and assume that is the re-implant date, the actual marketing was conducted on a day very close to optimal. The reason for the difference between the optimal date based on animal quality and most profitable date for the entire pen is that discounts on animals in pens are greater than premiums. The results show that cattle feeding operations appear to market cattle on profit maximizing date given the institutional constraint of marketing the entire pen at one time. Further, cattle feeders and meatpackers market pens of cattle well given the use of visual identification. The system appears to be efficient within the institutional constraint.

However, while the most profitable marketing date is in 84 days, the average optimal marketing date is 108 days past re-implanting. The difference between the actual and optimal marketing dates reveals inefficiency in the current marketing institution. Sorting technology is able capture some of this inefficiency and improves returns. Table 3 presents the characteristics of the actual carcass data and carcasses at optimal marketing dates. Individual animals sold at optimal dates result in the maximum potential of ultrasound and sorting. The average carcass weight in the actual carcasses was 760 pounds. The average carcass weight for animals optimally sorted increases to 826 pounds. The standard deviation of the sorted cattle is 11.5 pounds or 13% smaller. Carcass weights are more consistent. There are fewer heavyweight outliers but more lightweight outliers. For example, the smallest animal sold in the sorting system had a carcass weight of 292 pounds or a live weight of 520 pounds. This specific animal had relatively large backfat deposition and almost no marbling – a poor yield grade and quality grade. The sorting and optimization program instructs the cattle feeding operation to market this animal as soon as possible given the sorting regime. This animal is an inefficient user of feed.

The average backfat measurement in the actual carcasses was 0.36 inches. The average backfat measurement for animals optimally sorted increases to 0.45 inches. But again, the standard deviation of the sorted cattle is 65% of the nonsorted cattle. Carcass red meat yields are more consistent. There are much fewer poor yield grade cattle. Increases in backfat measurements increase the risk of a poor yield grade penalty, but this change is consistent with increased carcass weights and is not enough to incur the penalty. The sorting and optimization program instructs the cattle feeding operation to grow cattle to heavier weights, and increased marbling, but not to the point where a poor yield grade occurs.

The average marbling score increases and the variation in marbling scores increases as well. Cattle are less consistent in terms of marbling. However, the sorting and optimization program instructs the cattle feeding operation to balance the tradeoff between yield grade and quality

5

grade. Longer feeding periods increase weight and marbling but also increase backfat and decrease the red meat yield. The ultrasound technology is able to find the cattle that will marble without excessive backfat and the sorting system keeps those cattle on feed longer. Cattle which will only marble after deposition of excessive backfat are sold earlier. These poor yielding animals will incur revenue penalties and are inefficient users of feed.

Sorting cattle results in higher average carcass weights, higher average marbling scores and USDA quality grades, and higher average backfat measurements and lower USDA yield grade scores. But the decreased yield grade is not enough in most cases to incur a discount. Sorting also reduces realizations in the lower end of the tail of the weight and yield grade distributions. The minimum economic potential associated with use ultrasound technology is limited because the benefit arises in changing the composition of pens of heterogenous cattle.

Within the constraints of the current marketing system, operations are for the most part underfeeding cattle to avoid penalties. However, within any pen there are cattle that are underfed and cattle that are overfed. This is seen in the average optimal marketing date being 108 days past re-implanting but most profitable date is in 84 days. Further, the average difference between actual and optimal marketing dates, in absolute value, is 32 days. Thus, the average animal is marketed one month away from the optimal date. This illustrates a lumpy output problem given the current institutions used to market fed cattle. Quality could be improved within the industry by more careful management of the individual animals.

Figure 2 presents the returns to various sorting regimes. The maximum return to ultrasound and sorting is $25.50 per head. This involves marketing each animal at that animal's optimal date. This is the maximum return cattle feeding operations could expect from a perfect sorting and value-based marketing plan. Sorting in practice in a feedyard requires that operation to have excess capacity and the ability to co-mingle cattle. There will likely be limitations to the number of secondary pens into which the original pen could be sorted. Figure 2 also presents the results to sorting the original pen into two pens, three, four and five pens. Sorting into two pens returns $11.01 per head, three pens returns $16.88, and four pens returns $19.47 per head. The marginal returns to additional sorts are $11.01, $5.87, and $2.59 per head. Thus, sorting exhibits decreasing marginal returns. Discussions with feedlots that do sort cattle – those operations dropped from the data sample – reveal that estimates of the costs of sorting are approximately $4 to $5 per head. Thus, it appears that sorting should be conducted and pens of cattle should be sorted into three groups at the re-implant stage.

Figure 3 presents the average discount per head as cattle are marketed earlier and later than the optimal marketing date. Clearly, discounts associated with overfeeding are greater than the discounts associated with underfeeding. The probability that cattle carcasses will be Yield Grade 4 or 5 increases with longer feeding periods. Feeding costs also increase as performance deteriorates as animals approach heavier weights. This figure shows the clear asymmetric nature of the premiums and discounts. Meat price discounts associated with overfed cattle are severe

and feeding costs increase. When marketing a pen of cattle, feedlot operators will error to the side of underfeeding to avoid discounts on some of the animals in the pen.

In an effort to improve quality grade and capture Low Choice, Prime, or premiums associated with various certified programs that generally reward High-Choice animals, cattle feeding operations often feed longer. This will not be profitable with large groups of heterogenous cattle or with programs that discount poor yield grade cattle. Figure 4 shows the increase in the probability that an animal will grade Choice or better with longer feeding compared to the probability that an animal will have a yield grade score of 4 or 5. The propensity of animals to be overfed, and discounted, is clear.

Sensitivity Analysis

Table 4 presents the regression summary of the sensitivity analysis. For this analysis, cost of gain was varied between 50, 60, and 70 cents per pound of feed, the Select discount was varied between 0, 5, and 10 dollars per cwt., and the premium for Yield Grade 1 and 2 carcasses were varied between 0, 5, and 10 dollars per cwt. Analysis on all the animals, pens, and the maximum return sorting regimes were conducted.

Regression models are used to explain the variation in the average optimal marketing date, average premiums from sorting, the percent of carcasses grading Choice or better, and the percent of carcasses with yield grade scores of 1 or 2. There are 27 observations for the 27 permutations. These factors are each explained as a function the levels of the changing variable – cost of gain, Select discount, and Yield Grade 1 and 2 premium. Results are presented in terms of the standardized partial regression coefficients. In this form, the results show the percent of variation in the dependent variable explained by variation in the independent variable (Snedecor and Cochran). The three coefficients in each row sum to 100 percent.

The optimal marketing date is most impacted by the variation in the Yield Grade 1 and 2 premium. Cost of gain has the second largest impact. Interestingly, the Select discount has the least impact and yet cattle feeders frequently focus on feeding to capture the Choice premium – or avoid the Select discount.

Premiums from sorting are most impacted by the cost of gain. The tendency is for producers to focus on premiums and discounts in the pricing grid. However, improving meat quality cannot ignore the cost of gain consequences. Alliances may also need to consider this result in construction of pricing grids. Grids will be to vary with feed market conditions to assure adequate supplies of desired animals with desired characteristics.

Both the percent of animals grading Choice or better and Yield Grade 1 or 2 animals are most impacted by the yield grade premium. The Select discount is next in terms of impacting percent of Choice or better while the cost of gain is next impacting the percent of high yielding cattle.

The yield grade premium and the cost of gain have a greater impact of sorting questions than does the Choice premium – or likewise the Select discount.

Returns to sorting across all cattle appear to be more related to costs of gain than grid structures. This result reveals a weakness of practices followed within the industry. Many discussions within the industry of improving product quality do not include an evaluation of the impact on fed costs. Cost considerations remain important in systems that are attempting to improve quality.

However, the grid structure is relatively important in determining the returns to sorting for higher quality cattle. Grid systems and alliances that are attempting to make large improvements in meat quality, through higher marbling or more red meat yield, may need to construct grids that have larger premiums that have been present in past systems.

Conclusions

There appear to be substantial gains to be made from sorting cattle prior to marketing. Sorting returns $11-$25 per head. Industry average returns to cattle feeding are in the range of $10 to $15 per head. This work suggests that the gains to sorting are roughly equivalent to the returns to feeding. This work suggests cattle feeding industry should look closely at the institutions that limit the sorting and co-mingling of fed cattle. Improvements in profitability and meat quality will result if these institutions are changed.

Further, ultrasound technology is not very beneficial unless fed cattle are sorted. The benefits are gained when heterogenous groups of cattle are sorted into more homogeneous groups. Sorting improves feeding and feed use efficiency. Sorting also improves meat quality. But, the current practice of selling cattle based on visual examination appears to be accurate given the pen structure limitations. Pens of fed cattle sold based on visual evaluation are sold at optimal times.

Sorting cattle from one group into two captures 40% of the returns. Sorting into three groups captures 66% of the gains. Thus, sorting exhibits diminishing returns and simple sorting regimes capture most of the benefits.

Returns to sorting across all cattle are more related to costs of gain than meat price grid structures. However, the returns to sorting for higher quality cattle are more related to the grid structure. Future grid systems and alliance may need to consider offering larger premiums. But cattle feeding operations will need to evaluate the marginal changes to performance of cattle in reaching those specifications.

Ultimately, this research reveals that use of ultrasound and sorting holds promise of improving the profitability and efficiency within the beef production system. Further, such changes will improve the quality of the product.

Table 1. Example Information on USDA Quality Grade and USDA Yield Grade Provided by the UCSS for an Individual Animal.

Quality Grade	Prime	Certified[a]	Low Choice	Select	Standard
Probability	0.0%	6.1%	36.4%	55.3%	2.2%

Yield Grade	YG 1	YG 2	YG 3	YG 4
Probability	5.1%	64.4%	28.5%	2.0%

[a] Denotes upper two-thirds of USDA Choice.

Table 2. Dollars Per Hundredweight Premiums and Discounts in the Base Fed Cattle Price Grid.

Quality Grade	Premium/ Discount	Yield Grade	Premium/ Discount	Weight	Premium/ Discount
Prime	$6.00	YG 1	$3.00	<550 lbs	-$20.00
Certified	$4.00	YG 2	$1.50	550-950 lbs	$0
Choice	$0	YG 3	$0	>950 lbs	-$20.00
Select	-$5.00	YG 4 & 5	-$20.00		
Standard	-$12.00				

Table 3. Actual versus Optimal Carcass Measurements.

	Mean	Std Dev	Min	Max
Actual Carcass	760	87.14	450	1056
Optimal Carcass	826	75.67	292	909
Actual Backfat	0.36	0.17	0.04	1.32
Optimal Backfat	0.45	0.11	0.04	0.73
Actual Marbling[a]	Sm 20	0.85	Tr 40	MAb 80
Optimal Marbling	Sm 50	0.93	Tr 40	Ab 30

[a] Abbreviations denote marbling scores of Small, Traces, Moderately Abundant, and Abundant.

Table 4. Percentage of Independent Variable Contribution and R-Squared for Different Marketing Decision Criteria.

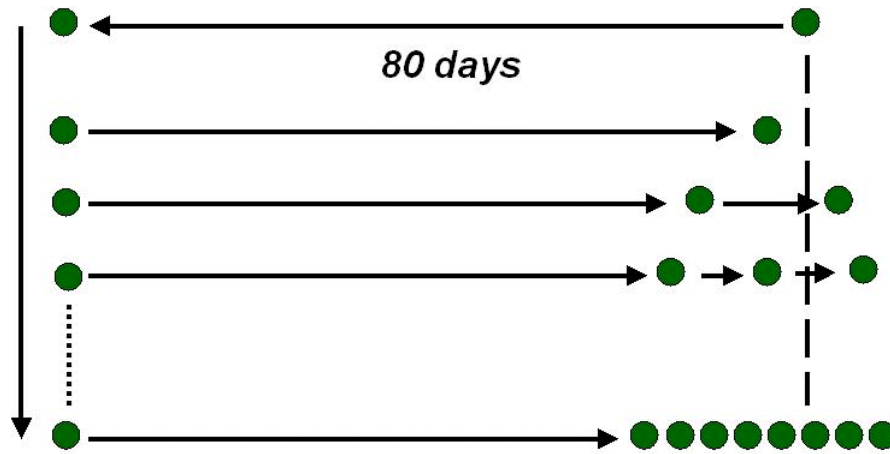| Marketing Decision Criteria	Cost of Gain	Select Discount	YG 1&2 Premium	R-Squared
Optimal Marketing Date	30.46	16.31	53.24	98.5
Premiums from Sorting	53.87	32.45	13.67	93.7
% Carcasses Choice or Better	6.81	34.75	58.44	96.5
% Carcasses YG 1&2	23.44	13.96	62.60	98.9

Figure 1. Modelling and Sorting Approach.

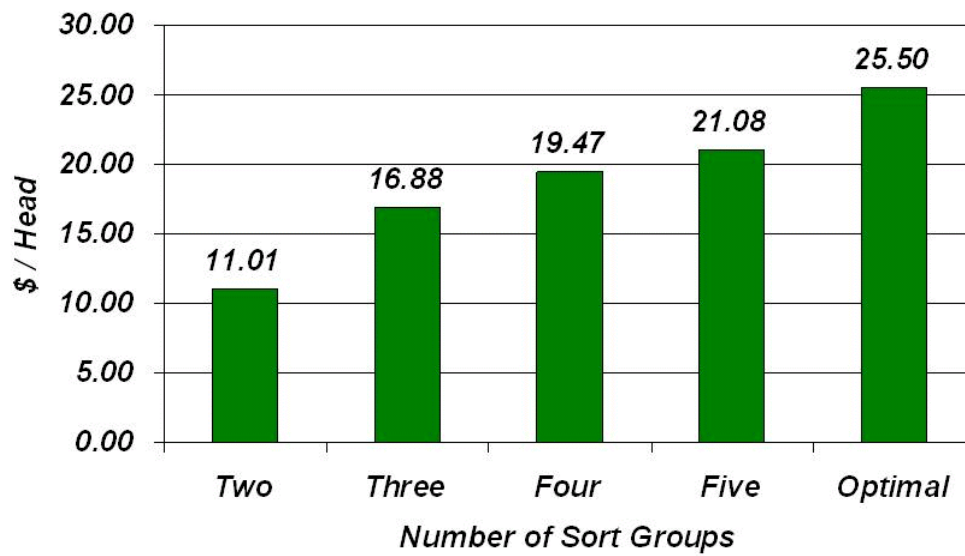Figure 2. Returns to Ultrasound and Sorting.

Figure 3. Dollars per Head Discounts Associated with Marketing Fed Cattle at Various Days Different from the Optimal Date.
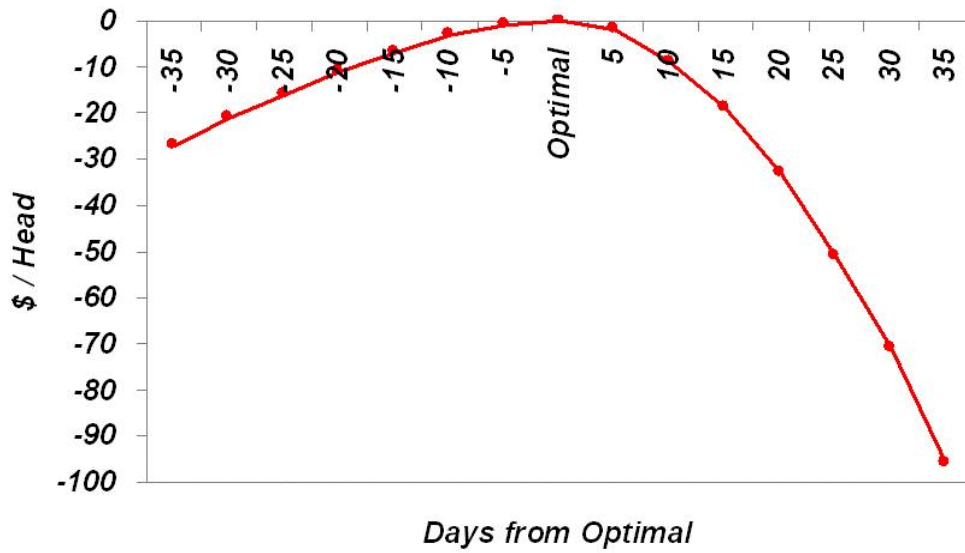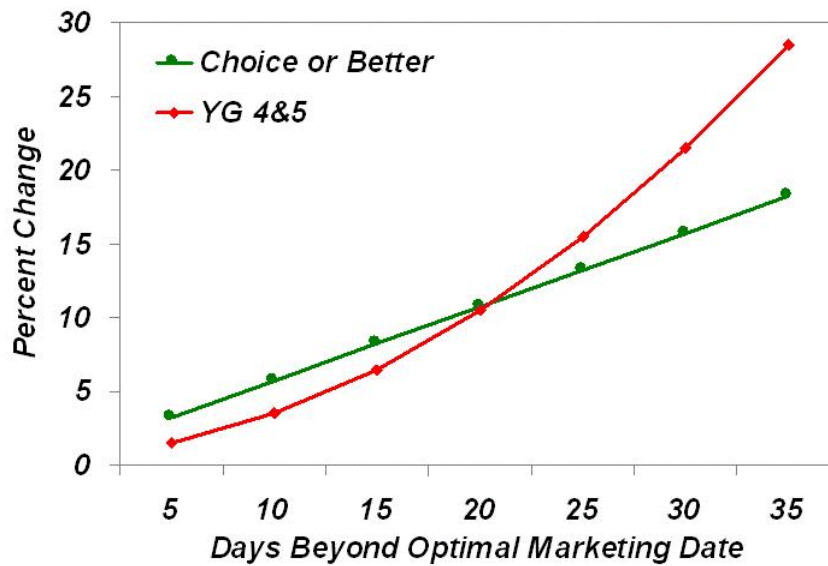

Figure 4. Percent Changes in the Probability of an Animal Grading USDA Choice or Better and Yield Grading 4 or 5 with Additional Days on Feed.

12

References

Brethour, J.R. "Estimating Marbling Score in Live Cattle from Ultrasound Images Using Pattern Recognition and Neural Network Procedures." *Journal of Animal Science* 72(1994): 1425-1432.

Brethour, J.R. *Tracking Marbling Development in Feedlot Steers*. Kansas Agricultural Experiment State Report of Progress No. 731: Kansas State University, 1995.

Brethour, J.R. *Estimating Quality Grade in Cattle with Ultrasound*. Kansas Agricultural Experiment State Report of Progress No. 627: Kansas State University, 1991.

Brethour, J.R. *Using Ultrasound Technology to Increase Cattle Feeding Profits*. Kansas Agricultural Experiment State Report of Progress No. 570: Kansas State University, 1989.

Cattle Fax. *Alternative Marketing Programs*. Englewood, CO, January 1997.

Doherty, R.L., et al. *Developing Benchmarks to Familiarize Cattle Producers with the Benefits and Risks Associated with Grid Pricing: Final Report*. Department of Animal Science, Colorado State University, May 1998.

Dolezal, H.G. "Grid Pricing - The Known and Unknown." Department of Animal Science, Oklahoma State University, 1996.

Faulkner, D.B., D.F. Parret, F.K. McKeith, and L.L. Berger. "Prediction of Fat Cover and Carcass Composition from Live and Carcass Measurements." *Journal of Animal Science* 68(1990): 604-610.

Feuz, D.M., S.W. Fausti, and J.J. Wagner. "Analysis of the Efficiency of Four Marketing Methods for Slaughter Cattle." *Agribusiness* 9(1993): 453-463.

Houghton, P.L., and L.M. Turlington. "Application of Ultrasound for Feeding and Finishing Animals: A Review." *Journal of Animal Science* 70(1992): 930-941.

National Cattlemen's Beef Association. *The War on Fat.* Value Based Marketing Task Force, Englewood, CO, August 1990.

Perkins, T.L., R.D. Green, and K.E. Hamlin. "Evaluation of Ultrasonic Estimate of Carcass Fat Thickness and Longissimus Muscle Area in Beef Cattle." *Journal of Animal Science* 70(1992): 1002-1010.

Smith, G.C., J.W. Savell, H.G. Dolezal, T.G. Field, D.R. Gill, D.B. Griffin, D.S. Hale, J.B. Morgan, S.L. Northcutt, and J.D. Tatum. *Improving the Quality, Consistency, Competitiveness and Market-Share of Beef: Executive Summary*. National Beef Quality Audit. Colorado State University, Oklahoma State University and Texas A&M University, December 1995.

Smith, M.T., J.W. Oltjen, H.G. Dolezal, D.R. Gill, and B.D. Behrens. "Evaluation of Ultrasound for Prediction of Carcass Fat Thickness and Longissimus Muscle Area in Feedlot Steers." *Journal of Animal Science* 70(1992): 29-37.

Snedecor, G.W., and W.C. Cochran. *Statistical Methods*, Seventh Edition. Ames, Iowa: Iowa State University Press, 1980.

Taylor, R.E. *Beef Production and Management Decisions*, Second Edition. New York, New York: Macmillan Publishing Company, 1994.

Whittaker, A.D., B. Park, B.R. Thane, R.K. Miller, and J.W. Savell. "Principles of Ultrasound and Measurement of Intramuscular Fat." *Journal of Animal Science* 70(1992): 942-952.