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Practitioner's Abstract

The number of U.S. fed cattle marketed through a value based or grid marketing system is increasing dramatically. Most grids reward Choice or better quality grades and some pay premiums for red meat yield. The Choice-Select (C-S) price spread increased 55 percent, over $3/cwt between 1989-91 and 1999-01. However, there is a cost associated with pursuing these carcass premiums. This paper examines these trade-offs both in the feedlot and in a retained ownership scenario. Correlations between carcass and performance traits resulted in economic tradeoffs that change across input costs and quality grade premiums and discounts. Feedlot profitability was largely determined by marbling, carcass weight, and feed efficiency. Carcass weight was most important at a low C-S spread. However, at average C-S spread and higher, marbling became the largest determinate of feedlot profits, and its importance increased with the C-S spread. Carcass weight and feed efficiency influence on feedlot profitability declined at higher C-S spreads. Rib-eye area was the fourth most important variable and declined in importance as marbling increased in importance. There is some indication that cows with lower feed costs also produce the most profitable calf for the feedlot, and vice-versa. The data suggests that cow size and marling score are negatively correlated. The current trend toward wider C-S spreads and rewarding higher quality grading cattle places greater emphasis on marbling ability of calves. These correlations and results suggest that higher marbling is associated with lower cost cows to maintain.

Keywords: beef quality, yield grade, quality grade, price grid

Introduction

The number of U.S. fed cattle marketed through a value based or grid marketing system is increasing dramatically. Most of these grids reward Choice or better quality grades, with some grids also paying premiums for red meat yield. Similar to trends in the pork industry, beef producers are responding to price signals by adjusting feeding and/or breeding practices to receive higher grid premiums. However, few producers are asking about the cost of achieving a premium in terms of reduced animal efficiency and performance. Yet animal genetics and management decisions that are known to alter quality and yield grades also influence production efficiency. Furthermore, some carcass traits are thought to be antagonistic with performance traits. Thus there is a trade-off between traits that influence costs and those that influence revenue that are not fully apparent when selling on average prices.

An additional complication affecting the transmission of cost and price signals through the beef value chain is that cattle typically have multiple owners with different objectives. Cowherds desire a cow that efficiently produces a live healthy calf on a yearly interval. Feedlots seek feeder cattle that grow rapidly and efficiently and that produce a carcass that receives a premium or at least is not discounted severely. Both segments wish to generate a profit, but it may come at the expense of the other segment of the beef value chain. While supply and demand for feeder cattle will influence how cowherds and feedlots share potential returns, not fully understanding the relationship between cost and revenue traits and management in the two sectors may limit the size of available profits or inadvertently shift costs from one sector to the next.

The objectives of this research are two-fold. First, quantify the relative profit contribution in feedlots comparing carcass premiums and feedlot performance. And second, compare feedlot profitability to cow characteristics and maintenance costs to determine if the least cost cow produces the most profitable feedlot steer. We then evaluate these profit contribution relationships over a range of input and output prices.

The results of this analysis will allow cowherds that retain ownership of their calves to evaluate beef systems' profits and determine how best to manage their resources. Feedlots will better understand the trade-off between production costs and fed cattle price premiums, and how to better evaluate the purchase price of feeder cattle that excel in one or both attributes. Likewise, cowherds that sell calves can determine the relationship between cowherd productivity and maintenance costs versus higher revenues generated from producing calves with characteristics favored by feedlots. As market participants improve their understanding of this relationship, appropriate price signals are more readily passed through the beef value chain.

Relevant Literature

Previous studies indicated that price variables (fed and feeder cattle and corn) significantly outweighed production variables (feed efficiency and average daily gain) in explaining profit differences between pens of cattle (Lawrence, Wang, and Loy 1999; Langemeier, Schroeder, and Mintert 1992; Schroeder et al. 1993, Mark, Schroeder, and Jones 2000). The largest single impact on profit was fed cattle selling price. Grid marketing is used by packers to better relay market demand to producers by rewarding better grading cattle and discounting poorer quality cattle (Ward and Lee). As a result, value differences within a pen or even a truckload of fed cattle can often exceed $350 per head (Strohbehn). Thus the variable with the greatest influence on profits has become more inconsistent.

In a grid marketing system, hot carcass weight, quality grades and yield grades each play a major role in establishing the net carcass value of animals coming out of the feedlot (Trenkle). Variation in carcass value in grid pricing depends heavily on discounted characteristics such as Select and Standard carcasses, Yield Grade 4-5 carcasses, light and heavy carcasses, and non-conforming or "out" carcasses (Ward and Lee, Trenkle). Producers using a grid-based system will be forced to improve both the genetics they bring in to their feedlots and the management practices they use to avoid any discounts and to capture all the available premiums (Ward and Lee). Feuz found that variability of revenue increased with grid marketing compared with live or carcass pricing. While weight was the largest source of variation in revenue, Feuz found that marbling difference may account for about 25 percent of the variation, depending on time period and grid. Fat thickness and ribeye area accounted for less than three percent of the variation in revenue. While of lesser importance on profit variability than selling price, feed efficiency and average daily gain still impact feeding costs and thus profits, and are correlated with carcass traits.

Beef cowherds producing calves for the feeding sector are also concerned with feed cost. Fifty to seventy percent of the total cost of maintaining a beef cow is feed cost (Miller, Knipe, and Strohbehn), but with proper feed management, producers can achieve a targeted body condition score (BCS) that will maximize cow/calf profitability. BCS of cows at parturition are related to calf birth weights, interval from calving to the onset of estrus, and pregnancy rates (Spitzer et al). The preferred BCS range at calving is 4,5,6 on a 1-9 scale (Spitzer et al). Cow size and milk production impact feed requirements; a larger cow requires additional feed to maintain her in the optimal BCS range. However, birth weight is positively correlated to cow size and weaning weight is influenced by milk production. A cowherd marketing pounds of weaned calf must weigh calf and cull cow income against the cost of maintaining a larger cow. How does the equation change if the cowherd owner retains ownership of the calf through the feedlot and markets the finished steer on a grid? Does the least cost cow produce the most profitable calf for the feedlot?

Data

The Tri-County Steer Carcass Futurity Program in southwest Iowa has provided an opportunity for cowherds to learn more about how their cattle perform in the feedlot and on the rail for more than 20 years. Cowherds retain ownership of their calves in a central feedlot where the calves are sorted into commercial sized feeding groups by sex, weight, and expected marketing date. Iowa State University Extension coordinates the Futurity Program and is responsible for collection and analysis of animal, feeding, and carcass data. Upon arrival at the feedlot, individual animal data on weight, hip height, and condition score are recorded. Individual weights, disposition score, and health treatments are recorded throughout the feeding period; at slaughter, full carcass data is collected. In addition to feedlot data, some herds provide detailed cow and calf information, i.e., birth date and weight, cow and sire breed, cow age, cow weight and condition score at weaning.

In addition to providing valuable information to producers participating in the Futurity Program, numerous research trials have also been conducted in conjunction with the program. The Tri-County Steer Carcass Futurity database has detailed data on over 3,000 head of cattle spanning 12 years. These data were sorted for the variables required for this analysis. Heifers represented a small part of the total data set and were excluded from the study to avoid a sex effect. A total of 1147 feeder steers from over 50 producers marketed between 1996 and 1999 were used in this study (Table 1). These cattle were fed in 6 or 7 feedlots following similar nutrition and management procedures. The analysis of cowherd costs and feedlot performance narrowed the database further. Most participants only place a few steers from their herd in the centralized feedlot test, possibly leading to sampling bias. This analysis focused on 5 herds that put most or all of their steer calves into the Futurity Program each year and provided sufficient data on their cows.

Table 1. Summary of Steer Carcass Data.

Year	Head	Weight	% Choice	YG	FE	ADG
1999	453	1166	67	2.72	6.66	3.21
1998	231	1155	68	2.44	7.20	2.96
1997	188	1108	65	2.64	6.22	3.10
1996	275	1175	44	2.59	6.38	3.16

Input and output prices were standardized across years and marketing periods to identify profit differences due to efficiency and carcass traits. Feed prices were standardized for the cost per pound of feed delivered to the cattle. Feeder cattle were priced using a base price with a fixed price slide (Prevatt). The base feeder price used was calculated using data from Medium #1 Steer Calves in Oklahoma City, from 1995-1999 and was $72.17/cwt for a 550 lb steer calf. The spread between weight categories was calculated using the same data. Fed cattle were valued using a representative grid system with premiums and discounts reflecting conditions in early 2002 (Table 2). The carcass base price used was $103.51, which reflects the average price over the four-year period.

Methods

A significant driver of premiums and discounts in most marketing grids is the Choice-Select price spread. This analysis evaluated the results over a range of Choice – Select spreads to determine how sensitive the results were to these carcass premiums.

Net return (NR) per head is defined as the difference between total revenue (TR) and total costs (TC). Equation 1 is the net revenue for the $_i$th animal.

Eq. 1 $NR_i = TR_i - TC_i$

Total revenue was calculated for each animal using actual carcass weight, a standardized base price and the representative marketing grid. The grid in Table 2 pays premiums and discounts based on quality grade and yield grade, and pays discounts on out-of-range carcasses. Later the grid premiums and discounts will be changed to determine the sensitivity of the results to grid parameters.

Table 2. Base Grid Used for Calculating Final Carcass Value.

Base Price	$103.51		
Quality Grade Adjustments	Adjustment	Carcass Weight Adjustments	Adjustment
Prime	$7.00	Under 500 lbs	($35.00)
CAB (Ch+ and Ch^o)	$3.00	500-599 lbs	($10.00)
NonBlack (Ch+ and Ch^o)	$2.00	550 - 950 lbs	$0
Select ($ off of Choice)	($12.00)	951 - 999 lbs	($10.00)
NoRoll ($ off of Select)	($2.00)	1000 lbs and up	($35.00)
Standard ($ off of Choice)	($20.00)		
Off Grades ($ off of Choice)	($35.00)		
Yield Grade 1	$5.00	Yield Grade	($1.00)
Yield Grade 2A	$3.50	Yield Grade 4	($15.00)
Yield Grade 2B	$2.50	Yield Grade 5	($25.00)
Yield Grad 3A	$0.00		

Hot carcass weight (HCW) is measured at the plant on each animal. Quality grade is determined in the plant by an USDA grader based on the carcass being in the acceptable range for youthfulness and lean color and on the degree of marbling. Since all of these steers were of comparable age (13-15 months), and dark cutters were not included in the dataset[1], marbling is the determinant of quality grade. Marbling score (MAR) is the measure of marbling and was called to either the nearest one-third or one-tenth of a quality grade by the USDA Grader. These scores are on a scale with 1000 equal to low Choice and 1300 equal to low Prime.

In most commercial applications the USDA grader will determine the yield grade based on visual appraisal. However, these yield grade data were calculated from measured data collected by trained employees of the Tri-County Steer Carcass Futurity Program. Fat cover (FC) and rib eye area (REA) are measured in inches and square inches, respectively, in the plant ahead of the grading station. Kidney, pelvic and heart (KPH) is a percentage estimated by the USDA Grader. Yield grade (YG) reflects the lean meat yield of the carcass and is calculated from HCW, Fat Cover (FC), Rib Eye Area (REA), and percent kidney, pelvic, and heart fat (KPH) (Equation 2). The lower the YG the leaner the carcass and the higher the lean meat yield.

Eq. 2 $$YG = 2.5 + (2.5 * FC) + (.2 * KPH) + (0.0038 * HCW) - (.32 * REA)$$

Total cost per head is the sum of each animal's feed cost, yardage charge, feeder animal cost, and interest on the feeder and half the feed cost. Feed cost is based on standardized feed prices, total gain, and feed efficiency (FE). In this analysis FE is calculated for each animal using pen level feed disappearance and individual animal gain (collected at the beginning and end of feeding period) and carcass yield grade. The yield grade measurements quantify the percent bone, lean, and fat in the carcass. Using this information, the Net Energy System was used to prorate total pen feed consumption across the individual animals based on the amount and composition of gain (lean or fat). As a result the FE variable explicitly incorporates average daily gain (Perry and Fox).

While an identity for NR can be calculated, our goal is to evaluate the tradeoffs between correlated variables that impact revenue and costs. For example, FC and MAR are positively correlated (Table 3). Higher FC results in higher yield grades (a price negative) and poorer FE (a cost negative) to put on the external fat, but a higher MAR results in a higher quality grade and potentially higher premiums. A dummy variable was included for the year with 1996 as the base year. Thus, NR is regressed on independent variables hypothesized to impact revenue and costs (equation 3). The results are evaluated over a range of discounts and premiums and feed prices.

Eq.3 $$NR_i = f(FE_i, HCW_i, FC_i, REA_i, KPH_i, MAR_i, D_{Year})$$

It is expected that FE, FC, and KPH will be inversely related to profits. The remaining variables are expected to have a positive effect on net returns.

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[1] Dark cutters occur in 1-3% of the cattle slaughtered and are severely discounted. The condition is linked to stress before slaughter, but scientists do not agree on a predictable cause. Because it is not believed to be caused by genetics dark cutter carcasses were removed from the analysis.

Table 3. Correlation Matrix.						
	FE	HCW	Fat Cover	REA	% KPH	MAR
FE	1.00					
HCW	0.22	1.00				
Fat Cover	0.34	0.07	1.00			
REA	-0.22	0.51	-0.27	1.00		
% KPH	0.25	0.23	0.40	0.02	1.00	
Marbling	0.12	0.08	0.34	-0.17	0.20	1.00

The importance of each variable included in the model was ranked using standardized regression coefficients. Studies using this methodology to answer similar questions have traditionally used coefficients of separate determination (Lawrence, Wang, and Loy 1999; Langemeier, Schroeder, and Mintert 1992; Schroeder et al. 1993). However, in a study ranking factors explaining variability in cattle feeding profits, Mark, Schroeder, and Jones (2000) used standardized coefficients, pointing out that coefficients of separate determination is not constrained to be greater than zero and negative numbers are difficult to interpret. Standardized coefficients are calculated by scaling ordinary least squares coefficient estimates by the ratio of the standard deviation of the relevant independent variable to the standard deviation of the dependent variable (Pindyck and Rubinfeld 1998). This calculation converts ordinary least squares estimates to unit-free coefficients whose absolute magnitudes are directly comparable, revealing the relative impact of the independent variables on the dependent variable. Simply put, this technique reveals how many standard deviations the dependent variable is expected to change in response to a standard deviation change in each respective independent variable (Mark et al. 2000).

Results

As was discussed above there are both positive and negative correlations between economically important variables when cattle are sold on a value based marketing system. The results of the initial regression equation are shown in Table 4. The adjusted r-square is .64 and all but one of the hypothesized variables was highly significant and had the expected sign. KPH was positive rather the expected negative, but was not significant. Of the year variables, only 1999 was significant and it was positive.

The variables influencing net returns are is different units and have differing levels of variability. Table 5 represents the mean and standard deviation of all the variables used in the regression. Table 6 reports the standardized betas across four different Choice- Select price spreads. Feuz reported that HCW was the largest source of revenue variability and, to a lesser extent, marbling played a role. These results indicated MAR, HCW, FE, and REA greatly impacted net returns per head. Fat cover and KPH had a smaller impact. Also note that MAR became increasingly important at higher Choice-Select discounts, while FE, HCW, and REA decreased in importance.

Table 4. Regression Results for Model Estimating Influence of Carcass Characteristic and Year on Net Return.

Variable	Coefficient	Standard Error	t-Stat	P-value
Intercept	-608.00	23.24	-26.16	0.00
Feed Efficiency	-23.05	2.18	-10.55	0.00
Hot Carcass Weight	0.35	0.02	14.36	0.00
Fat Cover Inches	-37.51	10.11	-3.71	0.00
Rib Eye Area	8.95	1.21	7.40	0.00
% KPH	1.35	2.59	0.52	0.60
Marbling	0.45	0.01	30.99	0.00
1997	4.73	3.50	1.35	0.18
1998	-4.95	3.89	-1.27	0.20
1999	6.90	2.77	2.49	0.01
R^2	0.64	**Observations**	1147	

Table 5. Mean and Standard Deviation for Regression Variables.

	Net Return	FE	HCW	Fat Cover	REA	% KPH	Marbling
Mean	$32.31	6.63	705	0.37	12.2	2.15	1004
Std. Dev.	58.0	0.69	59.7	0.13	1.17	0.46	80.1

Table 6. Standardized Betas for Regression Variables by Choice - Select Spread.

	Std Dev	**Standardized Coefficients (%)**					
Choice-Select	**Net Return**	**FE**	**HCW**	**Fat**	**REA**	**KPH**	**Marbling**
$ (4.00)	$50.36	-38.7	49.3	-9.3	22.4	2.0	43.3
$ (8.00)	$52.61	-35.6	44.4	-8.2	19.7	1.8	54.7
$(12.00)	$58.00	-31.8	38.5	-7.2	15.3	1.8	61.7
$(16.00)	$65.77	-26.3	31.1	-5.3	12.9	1.1	65.1

While the effect of changing the price spreads between Choice and Select grade carcasses resulted in MAR having a greater influence on NR, the effect of changing feed costs had a lesser impact. Table 7 shows the effect of a 10 percent change in feed costs. The standardized beta for MAR was relatively unchanged whereas other variables showed modest, non-linear changes. For example, HCW coefficient increased 6.6 percent at lower peed prices and decreased 10.7 percent at higher prices.

Table 7. Standardized Betas by Feed Cost at $12 Choice-Select Spread.

	Std. Dev.	Independent Variables (%)					
	Return	FE	HCW	Fat Cover	REA	KPH	Marbling
Feed Cost -10%	58.24	-29.06	41.05	-5.91	14.81	0.84	61.54
Actual	58.00	-31.80	38.50	-7.20	15.30	1.80	61.70
Feed Cost +10%	57.95	-32.78	34.39	-7.37	17.84	2.01	61.71

Retained ownership

The prior discussion focused on economics of biological trade-offs in the feedlots, but what about over the life of the animal? More specifically, does the least cost cow to feed produce the most profitable steer in the feedlot? For this analysis, five herds were selected that put all or nearly all of their steer calves in the Futurity each fall. Focusing on their five herds reduces the selection bias that may result from herds sending only their best calves to the Futurity. Table 8 shows the correlations between cow traits and feedlot and carcass traits for the 267 head in this subset. First, notice that most cow and feedlot traits are lowly correlated, .17 or less. Second, the traits are negatively correlated with the exception of cow weight, cow feed cost, and feedlot feed efficiency. However, a higher FE (pounds of feed per pound of gain) is a negative on profit. Marbling score, determined to be important in feedlot profitability, is negatively correlated with cow weight and stored feed cost[2] for the cow, suggesting that a smaller cow that is cheaper to feed also has offspring with a higher marbling score. This result should not be surprising, and is consistence with British (Angus specifically) cattle generally believed to marble better and weigh less than continental breeds.

Table 8. Correlation Matrix of Performance, Carcass, and Beef Cow Traits.

	Cow Age	Cow Wt	Stored FC	Cow BCS
Cow Age	1.00			
Cow Weight	0.39	1.00		
Stored Feed Cost	0.36	0.94	1.00	
Cow BCS	0.14	0.30	-0.05	1.00
Cow Frame Score	0.21	0.26	0.30	-0.04
Marbling Score	-0.02	-0.16	-0.14	-0.07
Average Daily Gain	-0.12	-0.06	-0.05	-0.04
Feed Efficiency	-0.11	0.11	0.14	-0.07

The 267 steers from five herds were sorted into two groups (Low and High) by estimated cow stored feed costs (Table 9). The average of the two groups differed by $20 per cow. Interestingly, the low cost cow group had the higher feedlot return. The average feedlot return for steers from these cow groups differed by $6.50 to nearly $9.00 per head depending on the Choice – Select spread. Statistically, neither cow cost nor feedlot return was significantly different across groups, but the lower cost cow group produced calves with generally higher feedlot returns.

[2] The original Tri-County Steer Carcass Futurity data included cow weight, frame score, and BCS. Cow weights were adjusted to a BCS of 5 by adding (subtracting) 80 pounds for each condition score below (above) 5. The average weight of cows with an actual BCS of 5 was used as a baseline and that average weight (1213 pounds) was converted to a metabolic equivalent weight by raising it to the 0.75 power. The cows were indexed by dividing their adjusted weight by the average metabolic weight. Estimated feed cost was determined by multiplying their index value by the feed costs of the average BCS 5 cow feed costs. Feed costs and quantities were based on Iowa State University Estimated Livestock Budgets, from 1995-1998.

Table 9. Average Feedlot Net Return for Various Choice – Select Spreads and Cow Stored Feed Costs Sorted by Cow Feed Cost.

		Feedlot Returns by C-S Spread		
Cow cost	Cow cost	$4	$8	$12
Low	$ 148.50	$ 48.46	$ 41.36	$ 32.93
High	$ 168.43	$ 41.97	$ 33.03	$ 24.07
Average	$ 158.43	$ 45.23	$ 37.21	$ 28.52

Table 10 takes this analysis a step further. The contingency table compares where the number of steers from Low or High cow costs group placed in the Low and High feedlot profitability group. Ranking the variables from lowest to highest and dividing the data into two equal size groups determined the classifications. Seventy-four of 134 steers from Low cost cows produced High return steers in the feedlot, compared with 60 that were Low return Steers. High cost cows produced more Low return steers than High return steers.

Table 10. Number of Steers With Low, and High Feedlot Returns by Cow Stored Feed Cost.

	$4 Spread		$8 Spread		$12 Spread		
Cow cost	Low	High	Low	High	Low	High	Total
Low	66	68	62	72	60	74	134
High	68	65	72	61	73	60	133
Total	134	133	134	133	133	134	267

While the averages across the groups are not statistically different, this small sample suggests that some cows are better than others in that they are cheaper to feed and their offspring are more valuable in the feedlot. Note from Tables 8 and 9 that at small Choice-Select spreads the difference in feedlot profits and the number of High return calves from Low cost cows decreases relative to a wider Choice-Select spread. As the industry has trended toward a wider Choice-Select spread, it has also favored a lower cost cow to maintain.

The results also raise more questions that deserve further analysis. Are the Low cost/High return calves from a single herd or do they occur across all the herds? What are the other characteristics of the Low cost/High return cow and of the High Cost/Low Return cow, so that she may be recognized at culling time? Over time, does the cow or offspring change categories? Secondly, it would be important to gather more herd information as this analysis only includes cows that placed a steer calf in the feedlot. It excludes cows that didn't have a calf or that had a longer calving interval.

Conclusion

Biological correlations are import factors to consider when cattle producers evaluate grid marketing. The positive and negative correlations between carcass traits and carcass and performance traits result in economic tradeoffs that change across input costs and quality grade premiums and discounts. The long-run trend in the U.S. beef industry is having fewer cattle grade Choice and more grade Select. At lower Choice-Select spreads, MAR is of lesser importance and FE, HCW, and REA are of greater importance. Technologies such as aggressive implant strategies or cross breeding programs that emphasize continental breeds produce larger, leaner, faster, and more efficient growth. The Choice-Select boxed beef price spreads increased 55 percent, over $3/cwt between 1989-91 and 1999-01. This recent emphasis on quality grade premiums suggests that marbling score will be of more interest in the future. Yet, as producers search for the holy grail of marbling, they must keep in mind the cost associated with achieving it.

There is some indication that low costs cows, defined by estimated feed costs, also produce the most profitable calf for the feedlot. The data also suggests that cow size (positively related to feed cost) and marling score are negatively correlated. A greater portion of feedlots' net returns are explained by marbling score as the Choice-Select spread widens. The current trend to rewarding higher quality grading cattle will have the added benefit of reduced cow cost.

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