VALUE ENHANCEMENT MARKETING STRATEGIES FOR CULL BEEF COWS

By

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Submitted to the Faculty of the
Graduate College of
Oklahoma State University
in partial fulfillment of
the requirements for
the Degree of
DOCTOR OF PHILOSOPHY
December, 2012

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ACKNOWLEDGMENTS

I am very thankful to God, the Almighty and the Merciful, for giving me the strength and health to complete this dissertation.

I would like to thank Dr. Kellie Raper, my committee chair, for her continuing support and help. This dissertation would not have been completed without her guidance, patience, direction, and assistance. I would also like to thank others members of my committee, Dr. Francis Epplin, Dr. Derrell Peel, Dr. Jon Biermacher, and Dr. David Lalman for their support and encouragement.

Special thanks to Dr. Francis Epplin, Jean and Patsy Neustadt Chair, Dr. Damona Doye, the interim head of the Agricultural Economics Department, and Dr. Mike Woods, the interim DASNR Vice President, Dean and Director, for their financial support throughout my stay in the Department of Agricultural Economics, without which it would have been very difficult to complete this dissertation. Special thanks also go to Dr. Billy Cook, Senior Vice President and Division Director, at the Samuel Roberts Noble Foundation, Ardmore, for providing me data used in this study.[1]

I would like to thank my parents for their continual support and prayers that help me to succeed in life. I can only pray God to repay the good deed they have done for me. Special thanks go to my brothers and sisters for their prayers and moral support. Finally, to my beloved wife, Halima Abdou Moumouni, for her patience and moral support. This dissertation is dedicated to her to show my gratefulness.

[1]Acknowledgements reflect the views of the author and are not endorsed by committee members or Oklahoma State University.

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CHAPTER 1

INTRODUCTION

This chapter summarizes the importance of cull cows marketing to the overall profitability of cow-calf enterprise. It also highlights the general motivation for this research and finally focuses on objectives for this study.

1.1 The importance of cull cows to the cow-calf enterprise

The sale of cull cows provides a significant source of income to most U.S cow-calf producers. Although cull cows represent 15 percent to 30 percent of annual revenue on a cow-calf operation, cow-calf producers relatively give little attention to this source of revenue and ways to improve it (Feuz 2001, Little et al 1990). Furthermore, Carter and Johnson (2007) argues that dollars are generally left on the table when it comes to marketing cull cows. This is due to the fact that most producers assume that profit can be made on a cow by just selling her calves, but rarely does this happen (Hughes 1995). Therefore, most cow-calf producers traditionally devote their time, effort and money to managing reproductive cows, while cull cows, once identified, are sold immediately in the fall when prices are at or near the seasonal low. However, cow-calf producers may enhance net returns potential by holding their cull cows beyond culling date using alternative management production systems and marketing strategies.

Fuston et al (2003) reported that there are opportunities for producers to add value to cull cows marketing by increasing the weight, improving body conditions and increasing carcass quality and yield. Producers may give little thought to the potential for maximizing the salvage value of these cows, though revenue may be significantly improved by timing cull cow sales to take advantage of seasonally higher prices, and by feeding thin cull cows to improve slaughter grade and weight gain (Feuz 2002). Hughes (1995) also argues that producers can maximize the profitability of a breeding cow by recognizing the salvage value of the cow and viewing cull cows as potential profit center. Feuz (2002) stated that cows are culled from the herd for a variety of reasons including reproductive failure, old age, replacement breeding stock, physical defects and inferior calves. Most cull cows are marketing in the fall, after spring calves are weaned and cows are pregnancy tested and found open. Determining when to cull cows from the herd, understanding factors affecting cull cow value, and the flexibility in the time of the year to market cull cows can have a considerable impact on the profitability of cow-calf enterprises (Feuz 2002). This research primarily focuses on feeding and marketing strategies aimed at enhancing the salvage value of cull cows typically culled from the herd in the fall after weaning calves.

1.2 Motivation for the Study

Cull cows can be viewed as a capital asset at the end of its useful life, but one that potentially has value to another enterprise. Peel and Doye (2004) stated that many cow-calf producers choose to dispose of their cull cows as quickly and easily as possible with relatively little attention given to improve the salvage value of these animals. Feeding cull cows is a viable way to increase profitability of an animal that otherwise has only salvage value. The fact that cull cows have the largest seasonal price swings of all cattle classes widens the marketing window and the opportunity to add value (Peel and Meyer 2002). Peel and Doye (2008) reported that improvement in cull cow management and marketing may increase the value of cull cows by 25 to 45%. Research consistently indicates that the salvage value of cull cows can be enhanced by improving marketing and production practices. For instance, Doye et al

(2004) suggest that it may be beneficial to consider confined feeding of cull cows for 30 to 60 days before marketing if grain is relatively cheap, since feeding cull cows on concentrate feed may significantly enhance their value by means of increased dressing percentage or an increase in quality grade. The decision to sell cull cows at the time of culling versus feeding those cattle for alternative time periods before marketing depends on the seasonality of cow prices, price differences between cull cow slaughter grades and percentage of cull cows in each grade, and the costs of feeding cull cows.

Feuz (2002) reported that cull cow prices generally follow a consistent seasonal pattern. Prices are usually lower in November, December and January while prices are higher in February, March, April and May with summer months prices typically near the average for the figure 1.1. While most cows are culled in the fall due to a spring calving season, there may be potential for profits returned to the producer from feeding the culled cow until the higher prices prevails with seasonal price upswings(Feuz 2006). This seasonal price pattern may offer a financial incentive to provide an alternative period to market cull beef cows compared to the normal time the culled cattle go to market.

Cull cow prices generally vary based on grade, that is, the more desirable the grade, the greater the price received. Cull cow prices generally increase as marketing classification improves with greater premiums for boner grade cattle relative to breakers. Producers can therefore relate cull cow values to the condition of cull cows and evaluate the potential to improve cows by improving body condition (Peel and Doye 2008). Research has shown that feeding cull cows on a high-energy diet for about 60 days can not only significantly increase weight, but may also improve grade and thus price received (Matulis et al 1987, Berger and George 1993).

Body condition scoring is a valuable management tool used to assess and understand the immediate, past and current nutritional needs of beef cattle body condition score (BCS)(Matulis et al 1987). It is also an indication of the energy reserves of a beef animal and plays an important role in beef production and growth performance. Additionally, an important component of any feeding system is to properly monitor BCS. The most commonly used BCS system for beef cows is a scale ranging from 1 to 9, with 1 being severely emaciated and 9 being extremely obese. The body condition of cows at weaning can be useful in determining which cows or heifers need the most attention before calving (Steward 2000). Moreover, research has shown that the easiest and most economical time to improve condition to cows is from weaning to calving, suggesting that open post-weaning has even greater potential to improve condition. Net returns may be significantly increased by feeding thin cull cows to improve slaughter grade and by timing cull cow sales to take advantage of seasonally higher prices.

Previous studies discuss BCS primarily from the perspective of improving it to obtain higher prices. Little et al (1990), in a simulation study of delayed marketing for cull cows, pointed out that cull cows that are open, unsound, injured and simply

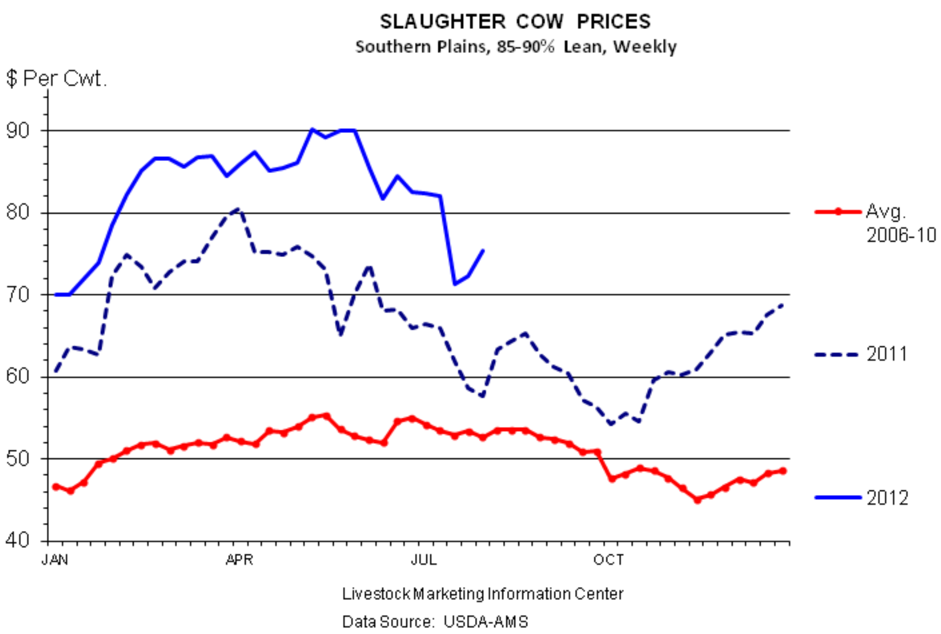

Figure 1.1: 2006- 2011 Seasonal Slaughter cow prices

unhealthy should be sold upon culling, while cull cows that are healthy, sound, and in thin to moderate body condition scores (eg. BCS of 3 to 5) should be retained and fed for alternative periods of time. This suggests that BCS at culling may be a useful decision tool for determining whether to retain cull cows or to market at culling. Cows with lower BCS may be more likely to gain weight substantially over feeding period. Research has indicated that BCS, reproduction, and the profitability of beef cows are positively correlated. Geske (1992) concluded that it is generally desirable to keep the cow at a BCS of 5 to 6 while cows with a BCS of 7 or higher require more feed and without yielding increased production. Thus, alternative timing of cull cow marketing may not only increase net returns that cull cows bring to the cow-calf operation, but it may also increase the number of re-breeding cull cows if a bull is available for use. Nutrition plays a significant role in cow herd reproductive performance. Engelken (1994) suggested a shortterm retention program for open cows offers an opportunity to select thin cows and to use underutilized feed for about 90-150 days to produce value−added product. The value−added may be further improved if these cows can be bull−exposed and marketed as bred cows.

1.3 Objectives

The overall objective of this research is to determine whether alternative management and marketing strategies improve the salvage value of cull cows. Specific objectives of this research include:

1. To determine the viability of two alternative retention and marketing strategies for cull beef cows.

2. To determine the influence of beginning body condition scores on net returns from feeding cull cows in two alternative retention systems.

3. To determine the profitability of marketing cull cows as bred cows relative to

marketing cull cows as slaughter cows.

1.4 Cow Management Systems

A three year experiment conducted at the Samuel Robert Noble Foundation was used to evaluate net returns from retaining spring-calving cull cows in two production systems across five marketing periods. In October each year from 2007 to 2009, cows were culled from a herd of black-hided Angus cows and split in two groups. The herd was comprised of cows four years of age in the initial study. One group of cows was retained in a low-cost dry lot system and fed with rye hay and protein cubes. From mid-October to December, dry lot cows were fed 10% crude protein and then switched to 25% protein for the remainder of the feeding period. In the pasture systems, cows grazed on stockpiled native grass pasture (350 acres) supplemented with hay and cubes only during icy periods. Both groups received mineral supplement. This experiment included in total 162 cows, equally assigned to pasture and dry lot. Specifically, the experiment included 48 cows in year 1, 43 cows in year 2, and 71 cows in year 3. Table 1 shows that the average beginning body condition score (BCS) for cows was 5.5 with scores ranging from 4 to 8.

Data were collected approximately monthly intervals from November through March each year on individual cow weight, estimated USDA grade and dressing percentage. The cost components include feed, pasture, labor, and operating interest. Table 1.2 describes daily feed intake per cow across management systems and years.

Table 1.1: Cull cow BCS distribution and treatment group summary statistics across year and management system

Variables	Characteristics	Average	Year one	Year two	Year three
Mean	BegBCS	5.5	5.4	5.9	5.32
Standard Deviation		0.86	0.72	0.99	0.77
Minimum		4	4	4	4
Maximum		8	6.5	8	7.5
Distribution of Cows					
N		162	48	43	71
Management System					
Pasture		81	24	21	36
Drylot		81	24	22	35

Cube and mineral prices were charged at the rate offered by the local fee d milling company during the feeding period. Rye hay cost is based on tons fed and priced at the purchase price, consistent with prices reported in the Oklahoma Market Report, Oklahoma Department of Agriculture, Food and Forestry for grass hay, east region. Pasture costs are assessed a per acre cash rental rate based on local rates and are within the range reported by Doye and Sahs (2011) for native pasture in the East region of Oklahoma during the study period. Feed cost for each feeding period are converted to a per cow average for individual cows based on management system and number of animals in the pen. Labor is assigned in hours per feeding period for each system at a daily average of 0.17 hours/day in the native grass pasture system and 0.34 hours/day in the dry lot systems and assigned a wage rate consistent with that offered locally for hourly ranch hands during the study period as reported by the Oklahoma Employment Security Commission's Oklahoma Wage Report for years

Table 1.2: Average daily feed, mineral and hay intake per cow and labor requirement per system per day across management system, year, and marketing period as used in the experiment

Years	Marketing Periods	Native Grass Pasture (350 Acres)				Dry lot			
		Feed(lbs/Day)	Mineral(lbs/Day)	Hay (tons/Day)	Labor(hours/day)	Feed (lbs/Day)	Mineral(lbs/Day)	Hay(tons/Day)	Labor(hours/day)
2007/2008	October-November	0.59	0.00	0.00	0.17	1.39	0.00	0.002	0.34
	November-December	0.46	0.11	0.00	0.17	3.05	0.17	0.03	0.34
	December-January	0.75	0.18	0.00	0.17	2.84	0.18	0.03	0.34
	January-February	2.35	0.45	0.00	0.17	3.29	0.45	0.03	0.34
	February-March	1.80	0.34	0.00	0.17	2.52	0.34	0.03	0.34
2008/2009	October-November	0.00	0.13	0.00	0.17	0.00	0.12	0.016	0.34
	November-December	0.00	0.06	0.00	0.17	2.60	0.06	0.01	0.34
	December-January	0.00	0.00	0.00	0.17	5.68	0.08	0.01	0.34
	January-February	0.06	0.06	0.001	0.17	5.68	0.06	0.01	0.34
	February-March	0.21	0.21	0.002	0.17	4.80	0.20	0.01	0.34
2009/2010	October-November	0.11	0.50	0.00	0.17	0.00	0.20	0.02	0.34
	November-December	0.07	0.12	0.0004	0.17	0.40	0.13	0.022	0.34
	December-January	0.27	0.005	0.006	0.17	2.04	0.00	0.022	0.34
	January-February	0.35	0.00	0.002	0.17	2.61	0.00	0.02	0.34
	February-March	0.08	0.04	0.0008	0.17	2.60	0.040	0.02	0.34

in the study period. Operating interest is charged at the annual rate 7.5% on the estimated value of the cow at the initial culling.

This dissertation, consisting of three essays, is organized around five chapters. This chapter introduces the topic and relevant question. The second chapter analyzes alternative retention systems and marketing strategies for cull cows. The third chapter investigates the influence of beginning body condition scores on net returns from feeding cull cows. The fourth chapter discusses profitability of marketing cull cows as bred cows, and finally the fifth chapter reports the overall conclusions.

CHAPTER 2

ALTERNATIVE RETENTION AND MARKETING STRATEGIES FOR CULL COWS

2.1 Introduction

Culling and marketing cull cows in the cow-calf operation can be viewed from both long and short run perspectives. Economists have primarily focused on the long run issues of when and how cows to cull annually from the herd to optimize profitability overtime, especially over a typical cattle cycle (Bentley, Waters and Shumway 1981; Trapp 1986; Frasier and Pfeiffer 1994; Tronstad and Gum 1994). However, limited research has focused on the short run question of when during the year should cull cows be marketed for highest net returns (Yager, Greer, and Burt 1980).

Revenue from cull cows provides a significant source of income to U.S. cow-calf producers. Experience has shown that most producers spend time on feeding and marketing steers, heifers, and reproductive cows. Although cull cows represent 15-30% of a cow-calf herd's annual revenue, producers tend to give cull cow marketing less attention than they give to feeding and marketing steers, heifers, and reproductive cows. This study focuses on the marketing decision and associated management aspects after the decision to cull has been made. The majority of cow-calf producers traditionally cull cows from the herd after weaning in the fall and sell those cows immediately, coinciding with the lowest prices of the year. However, alternative timing of cull cow marketing may represent an opportunity for producers and ranch managers to increase net revenue from cull cows for the cow-calf operation.

This article reports on a three-year study conducted at the The Samuel Roberts

Noble Foundation, Inc. in Ardmore, Oklahoma where spring-calving cows culled from the Foundation's herd were placed into two management programs. One program was essentially a forage-based pasture program while the other was a dry-lot hay and supplement program. Market value of cows was assessed at the time of culling in October and again at five subsequent weigh periods, roughly at one-month intervals from November through March. Results suggest that cow-calf producers and cowherd managers can enhance net returns from cull cows by holding them beyond the low-price period on a low-cost feeding program for about a 90-day period to take advantage of the typical seasonal price increase. The general objective of this paper is to determine how value can be added to cull cows beyond culling.

2.2 Previous Research

Cows are culled for one or more of several reasons, including difficulty rebreeding, old age, genetic improvement from replacement breeding stock, poor health or physical defects, and producing inferior calves. Cow health is a key decision variable when considering retaining cows beyond culling from the production herd. Cows must be healthy enough to continue eating sufficiently to gain weight and to live through the retention period until harvest.

Yager, Greer, and Burt (1980) describe cow culling and marketing as a stochastic dynamic decision process. They argue that after determining whether cow health is adequate to merit retention beyond culling, the two critical variables that inform the manager's decision are expected cow weight and expected price, which together determine cow value. Using a dynamic programming model, they found that holding and feeding spring-calving cows beyond the traditional fall marketing months of November-December could increase expected returns $20-40/head. At the time of the study, that was a 15-20% increase in the cow's value. Even larger returns could be expected, up to $55/head, if cow carcass grade was improved during the feeding period.

Slaughter cow prices exhibit a strong and relatively consistent seasonal pattern (Peel and Meyer 2002). Consistent seasonality occurs in large part due to cow-calf producers' routines of culling and selling spring-calving cows in the fall after weaning calves and pregnancy checking cows, but before winter feeding. Thus, large numbers of cull cows are marketed at about the same time each year (October-November), pushing prices to seasonal lows. Prices then increase through winter and spring months when fewer cows are marketed. This pattern is illustrated in figure 1, which reports a 5-year weekly average for slaughter cow prices in the Southern Plains from 2006-2010, as well as actual weekly prices for 2011 and 2012. The past two production years have seen rapid increases in cow price levels; however, the general pattern of seasonality remains.

Post-culling weight gain by cows depends on several factors, including health, condition, and age of cows at culling. Cows in thin to moderate body condition with body condition scores (BCS) of 3-5 (e.g., 1=extremely thin, 5= moderate, 9=extremely fat) are more likely to gain weight than cows in more fleshy condition (BCS's of 6-8). Sawyer, Mathis, and Davis (2004) found that found that gains also declined as cow age increased.

A second determinant of post-culling weight gain is feeding regimen. The nutritional level of the feeding program matters for two reasons. First, a higher nutritional plane is required for growth (weight gain) beyond the maintenance level of the cow. Second, a higher nutritional plane, typically associated with a higher energy ration, provides a greater opportunity to alter fat color in carcass, improve marbling, and increase carcass grade. Higher energy rations have been shown to improve gains and carcass quality attributes (Matulis et al 1987; Schnell et al 2004). However, higher energy rations mean higher costs (Feuz 2002).

As Yager, Greer, and Burt(1980) noted, it is the combined effect of weight gain and seasonal price increase that provides the opportunity for increased returns from retaining and later marketing of cull cows. An additional opportunity for higher returns exists if the carcass grade of cows harvested can be increased. The limiting factors are physical growth limits of cows and feed and the related costs associated with retaining and feeding those cows.

2.3 Procedure, Data and Models Estimated

Net return for each marketing period is computed as the difference between the marketing period's revenue, revenue if sold at culling and cumulative retention and feeding cost from the culling period to the marketing period. This net return equation can be expressed as follows:

$$\pi_{it} = P_{it}W_{it} - P_{io}W_{io} - Cost_{it} \tag{2.1}$$

where P_{it} is the net return of cow i at marketing period t, W_{it} is the weight of cow i at feeding period t, W_{io} is the weight of cow i at culling, P_{it} is the price per hundredweight at marketing, P_{io} is the price per hundredweight at the culling period, $Cost_{it}$ is the cumulative retention and feeding cost of cow i at feeding period t. Net return in (2.1) is then estimated as a function of feeding system(Pasture or dry-lot) and marketing period(at culling or an alternative period). This equation can be expressed as follows:

$$\pi_{it} = \mu + \sum_{k=1}^{2} \alpha_k \mathrm{system_k} + \sum_{\mathrm{t}=1}^{5} \lambda_\mathrm{t} \mathrm{Period_t} + \sum_{\mathrm{k}=1}^{2} \sum_{\mathrm{t}=1}^{5} (\alpha\gamma)_{\mathrm{kt}} + \nu_\mathrm{t} + \varepsilon_{\mathrm{it}} \tag{2.2}$$

where π_{it} is net return of cow i at period t, system k is k=1 for dry lot and k=2 for pasture, period represents the marketing period, ν_t is the year random effect, and σ_{it} is the randomly distributed error.

Data used in the study comes from a three-year experiment conducted at the Samuel Roberts Noble Foundation. The source herd is a herd of black-hided Angus cows with an average age of six years old in fall 2007. In October of each year (2007, 2008 and 2009), cows were culled and split into two groups. In the dry-lot system, cows were fed rye hay and protein cubes. From mid-October to December, dry-lot cows were fed 10% crude protein and then switched to 25% protein cubes for the remainder of the retention period. Cows retained in the pasture system grazed on stockpiled native grass pasture supplemented with hay and cubes only during icy periods. Both groups received mineral supplement. The experiment included a total of 162 cows, equally assigned to pasture and dry lot. By year, the study included 48 cows in year 1, 43 cows in year 2, and 71 cows in year 3.

Data were collected at approximately monthly intervals from November through March each year on individual cow weight, estimated USDA grade and dressing percentage, and costs, including feed, pasture, labor, and operating interest. USDA grade and dressing percentages were assigned by USDA Agricultural Marketing Service graders at each weigh period. USDA grade and dressing percentage are used in conjunction with the nearest in time weekly Agricultural Marketing Service (AMS) price report to identify a specific price per hundredweight for each cow at each of the five feeding intervals in a culling year. Specifically, prices are taken from AMS price reports KO-LS155 and KO-LS795 for Oklahoma National Stockyards, Oklahoma City. Feed cost data are assigned as a per cow average by marketing interval and by management system. Feed data includes protein range cubes (pounds fed), mineral supplement (pounds fed), and hay (tons fed). Cube and mineral prices are charged at the local market rate during the time period as offered by the local feed milling company. Rye hay cost is based on tons fed and is priced at the purchase price. The most comparable publicly quoted price range is for Grass Hay, East as reported by the Oklahoma Market Report, Oklahoma Department of Agriculture, Food and Forestry. Pasture costs are charged a per acre cash rental rate based on local rates, which are within the range of rates reported by Doye and Sahs (2011) for native pasture in the East region of Oklahoma. For each period, feed costs are calculated on an as fed pen basis by management system and then converted to a per cow average for individual cows. Labor hours are tracked by period for each system and charged at the local hourly rate offered for ranch hands during the study period. This rate is within the wage range for Farming, Fishing, and Forestry as reported by the Oklahoma Employment Security Commission's Oklahoma Wage Report for years in the study period. Operating interest is charged at the annual rate of 7.5% on the estimated value of the cow at the initial culling.

The value of each cow at each potential marketing period is calculated and combined with physical performance data and costs for each cow in each production system to calculate net returns. A mixed model measuring both fixed and random effects as illustrated in equation 2.2 was estimated in SAS using a restricted maximum likelihood (REML) estimation technique and assuming an unstructured covariance matrix.

An alternative measure of net returns can be calculated using a price response function to estimate a monthly price based on a longer history of slaughter cow prices. Both dummy variable and trigonometric models were used to estimate the price response function. The dummy variable model can be expressed as:

$$P_{mgt} = \beta_0 + \sum_{i=1}^{11} \beta_m M_m + \sum_{g=1}^{2} \alpha_g Q_g + \mu_t + \varepsilon_{mgt} \tag{2.3}$$

Similarly, the trigonometric model can be expressed as follows:

$$P_{mgt} = \beta_0 + \beta_1 \mathrm{M} + \sum_{\mathrm{n}=1}^{3} \sum_{\mathrm{T}=4}^{12} [\mathrm{a_n} \cos\left(\frac{2\pi \mathrm{M}}{\mathrm{T}}\right) + \mathrm{b_n} \sin\left(\frac{2\pi \mathrm{M}}{\mathrm{T}}\right)] + \sum_{\mathrm{g}=1}^{2} \alpha_{\mathrm{g}} \mathrm{Q_g} + \mu_{\mathrm{t}} + \varepsilon_{\mathrm{mgt}} \tag{2.4}$$

where P_{mgt} is price in month m for a given quality grade g, T is the frequency, and Q_g is the quality grade of the cull cow. M is intended to capture the seasonal price pattern while Q_g captures any premiums or discounts related to quality grade. Eight years of monthly data from 2003 to 2010 as reported by AMS price reports KO-LS155 and KO-LS795 for Oklahoma National Stockyards, Oklahoma City are used to estimate the price response function, which is then used to assign a price for each cow at each feeding period.

2.4 Results

Two possibilities were considered for the functional form of the price response function as shown in equations 2.3 and 2.4. The chi-square value for the likelihood ratio test is computed as $\chi^2_4 = -5360_U + 5386.7_R = 26.7$, where the trigonometric model (10 parameters) is a restricted fashion of the dummy variable model (14 parameters). Comparing the test value $\chi^2_4 = 26.7$ to the critical chi-square value ($\chi^2_c = 9.48$) concludes that the dummy variable model is more appropriate than the trigonometric model. Coefficient estimates capture the significant seasonality typically present in the slaughter cow market is shown in table 2.1. Relative to the October price, the November coefficient is negative and significant. Price effects for February through September are positive and significant, yield grade coefficients for Boner and breaker are also positive and significantly related to price, relative to a yield grade of lean. The coefficients in table 2.1 are used to estimate price per hundredweight for each cow at each marketing period.

Table 2.1: Estimated slaughter cow price as function of month and quality grade.

Parameters	Independent variables	Estimates	Standard Errors	p-values
β_0	Intercept	41.610	0.5508	< 0.0001
β_1	Jan	1.090	0.7832	0.1644
β_2	Feb	3.599	0.7472	< 0.0001
β_3	Mar	4.146	0.7348	< 0.0001
β_4	Apr	4.619	0.7396	< 0.0001
β_5	May	4.604	0.7196	< 0.0001
β_6	June	3.311	0.7396	< 0.0001
β_7	July	4.600	0.7472	< 0.0001
β_8	Aug	3.634	0.7196	< 0.0001
β_9	Sept	3.808	0.7325	< 0.0001
β_{10}	Nov	-1.669	0.7136	0.0196
β_{11}	Dec	-0.989	0.8326	0.2353
α_1	Breaker	6.308	0.3823	< 0.0001
α_2	Boner	6.740	0.3826	< 0.0001
σ_t^2	Year Random effect	11.144		
σ_ε^2	Variance of error term	23.681		
-2LL	Loglikelihood	5360		

Table 2.2 summarizes descriptive statistics of cull cow physical performance attributes and prices for the three year pooled data. The mean beginning weight at culling is approximately 10 pounds higher for cows assigned to the dry-lot system compared to those assigned to the pasture system. As expected, the mean for average daily gain is also higher for dry-lot cows compared to those in the pasture system. In the pasture system, the mean average daily gain becomes negative beyond 91 days while dry-lot cows maintain a positive mean average daily gain throughout the retention period. Differences in weight gain across systems are contrasted with average cumulative feed cost in figure 2.2. While cows retained in the dry-lot setting have higher gains, on average, than cows retained in the pasture setting, the cumulative feed costs also increase as a much faster pace than for cull cows on pasture.

Table 2.2: Three year pooled summary statistics on key physical and economics attributes of cull cows across management system (n=162)

Marketing Periods	Attribute of cow considered in the study	Pasture(n=81)				Dry lot(n=81)			
		Mean	Standard deviation	Minim	Maxim	Mean	Standard deviation	Minim	Maxim
At Culling (October)	Beginning Weight(lbs/head)	1343.24	150.73	1115	1670	1353.86	165.95	1125	1685
	Beginning dressing percent	49.87	2.2	45	56	50.40	2.26	44	55
	Beginning Revenue($/head)	612.72	117.16	472.50	951.90	653.45	117.80	472.5	884.63
	Beginning price($/ cwt)	46.67	6.81	30	57	46.38	5.76	32.50	55.75
0-35 days(November)	Weight(lbs/head)	1373.52	147.03	1090	1765	1420.00	185.71	1125	1935
	Total gain(lbs/head)	30.28	189.05	-470	520	66.14	145.05	-265	580
	Average daily gain(lbs/day/head)	0.87	0.98	-2.43	4.14	1.89	1.35	-0.81	8.02
	Ending price($/cwt)	37.79	2.13	34.38	43.25	38.55	2.63	36.5	44.63
0-63 days(December)	Weight(lbs/head)	1366.00	117.43	1090	1640	1425.59	124.76	1200	1705
	Total gain(lbs/head)	22.76	37.47	-19	169	71.73	73.45	-15	412
	Average daily gain(lbs/day/head)	0.36	0.95	-0.24	4.29	1.14	1.18	-0.54	5.36
	Ending price($/cwt)	43.90	2.56	39.88	53.25	45.04	2.11	39.88	49.38
0-91 days(January)	Weight(lbs/head)	1346.33	115.39	1065	1625	1420.68	127	1175	1680
	Total gain(lbs/head)	3.09	41.2	-38	154	66.82	89.75	-150	402
	Average daily gain(lbs/day/head)	0.03	0.85	-1.07	3.39	0.73	1.19	-1.35	5.36
	Ending price($/cwt)	47.36	2.58	43.00	55.75	48.56	3.18	43.00	755.52
0-126 days(February)	Weight(lbs/head)	1286.42	110.91	1075	1540	1446.95	130	1200	1705
	Total gain(lbs/head)	-56.82	61.71	-115	149	93.09	91.41	-30	447
	Average daily gain(lbs/day/head)	-0.45	1.13	-3.29	1.11	0.74	1.14	-0.86	5
	Ending price($/cwt)	49.54	2.54	46.75	55.76	50.06	3.69	46.75	55.75
0-155 days(March)	Weight(lbs/head)	1292.83	109.67	1070	1535	1415.76	135.16	1175	1705
	Total gain(lbs/head)	-50.41	66.84	-120	161	61.90	110.01	-100	447
	Average daily gain(lbs/day/head)	-0.33	1.19	-3.64	1.06	0.40	1.07	-3.03	3.33
	Ending price($/cwt)	48.83	1.69	48.00	53.25	49.88	2.67	48	55.75

Table 2.3 reports net return estimates per head across marketing periods for the three year pooled data using actual prices as well as mean net returns by production season and marketing period. Pooled net return estimates for the pasture system are statistically significant at the 90% confidence level or better for each marketing period. At 35 days, however, net returns per head are negative. Pasture system net returns for marketing periods beyond 35 days are all positive. The highest net returns for pasture systems occurred at 126 days beyond culling ($40.76) and followed by 91 days beyond culling ($31.19). This suggests the potential to increase profitability of cull cows by retaining them in a pasture system. In contrast, cows held in the dry-lot exhibit negative net returns per head for all marketing periods, except 126 days beyond culling, which is negative but not statistically different from zero. This implies that selling cull cows immediately after culling would be more profitable than retaining them in a low-cost dry-lot system. A year by year look at net returns suggests large differences across production seasons in the profitability of retaining cull cows beyond the culling period for both the pasture system and the dry-lot system.

Average net returns by production season as estimated with actual prices are also presented in table 2.3. Note that statistical significance of the year by year net returns is not calculated. For cull cows retained on pasture, year 1 (2007/08) was the most profitable year with positive net returns for each of the marketing periods at 63 days and beyond. The first production season in the study also generated the least losses for cows held in the dry-lot system, with positive net returns indicated at 126 and 155 days. Net returns for both systems peaked at 126 days in 2007/08. The second and third years of the study saw less favorable results. In 2008/09, the highest net returns are again reported for the marketing period of 126 days. However, it is the only marketing period with positive average net returns for the pasture system ($22.37/head) and the least negative average net returns for the dry-lot system (-

Table 2.3: Net return to land, owners labor, management and overhead by feeding system, marketing period and year ($/head) using actual prices.

		Days	3-yr Pooled Data		Production Season		
Feeding System	Marketing Periods	Days after Culling	Net Returns($/head)		2007/08	2008/09	2009/10
			Estimate	P-value	Mean	Mean	Mean
Revenue at Culling			599.70		594.86	617.11	606.80
Pasture	November	35	-24.75*	(0.0003[a])	-51.88	-59.50	13.60
	December	63	17.40*	(0.0479)	41.46	-24.80	11.54
	January	91	31.19*	(0.0025)	122.99	-11.01	-20.90
	February	126	40.76*	(0.0029)	171.22	22.37	-74.60
	March	155	25.99*	(0.0308)	157.23	-29.53	-88.73
Revenue at Culling			604.00		570.48	651.72	590.01
Dry lot	November	35	-57.90*	(< .0001)	-57.27	-117.99	-21.00
	December	63	-58.8*	(< .0001)	-76.15	-120.50	-52.79
	January	91	-36.09*	(0.0005)	-2.22	-104.65	-97.76
	February	126	-17.54	(0.1942)	32.79	-68.43	-144.54
	March	155	-59.21*	(< .0001)	8.02	-155.25	-222.34
	-2Loglikelihood		9156.4		2339.7	2372.2	3744.5

[a]Numbers in parentheses are p-values and $*$ denotes statistically significant at $p \leq 0.10$

$68.43/head), implying little potential to add value to cull cows with either system in year 2. The third year of the study saw some improvement. Average net returns in the pasture system were positive for the first two marketing periods, but became negative beyond 63 days. Dry lot average net returns during the third year were again all negative.

Some insight into the differences in results among production seasons can be gained from figure 2.3 to figure 2.4, which illustrate the average price received across marketing periods and across production seasons for cull cows retained in the pasture system and the dry-lot system, respectively. Recall that cows are individually priced based on USDA dressing percentage estimates, weight, and quality grade. Average prices in each production season reached the seasonal low in November, approximately 35 days beyond culling. Years 1 and 2 begin with similar price levels for cull cows. However, prices in year 1 generally rise more rapidly moving into winter than do prices in year 2 and sustain that movement beyond 63 days. Price levels in year 3 begin at a substantially lower level and, beyond 63 days, rise at a slower pace than in the previous two years.

A comparison of net returns between feeding systems and across marketing periods estimated with actual prices is reported in table 2.4. Coefficient estimates in the first component of the table measure the change in average net returns for retaining cull cows in the dry-lot system instead of the pasture system. Results indicate that retention in the dry-lot system generated lower average net returns in each marketing period than did retention in the pasture system. Comparisons of the two systems at each marketing period are negative and statistically significant. The second and third components of table 2.4 measure the change in average net returns across adjacent marketing periods within a feeding system, with the earlier period as the base. A negative sign on net returns indicates that the latter marketing period generates higher net returns than the earlier marketing period, while a positive coefficient indicates that the earlier marketing period generates higher net returns than the later marketing period. In the dry lot system, net returns are maximized at 91 days. Marketing dry lot cull cows at 63 days instead of 91 days would forego \$22.75 per head in net returns (p=0.013). Note that the change in net return for marketing dry-lot cull cows at 91 days rather than 126 days is negative at -\$18.54, but it is not statistically different from zero. Recall that table 2.3 reports positive net returns for every marketing period beyond 35 days for cull cows retained in the pasture system. Additionally, the first component of table 2.3 suggests that the pasture system is superior with respect to net returns at every marketing period. Interestingly, when adjacent marketing periods are compared within the pasture system, there are no statistical differences in net return per head beyond the 63 day marketing period at the 90% confidence level. From a practical standpoint, however, it is of note that marketing cull cows in the pasture system at 63 days rather than marketing at 91 days would forego \$13.78 in net returns per head if measured at the 85% confidence level rather than the 90% level.

Table 2.4: Comparison of changes in net return to land, owners labor, management and overhead between feeding systems and across marketing periods using actual prices.

			3-yr Pooled Data	
Feeding System Comparison	Marketing Periods	Days after Culling	Change Net Returns($/head)	P-value
Revenue at Culling			599.70	
Dry lot to pasture	November	35	-33.14*	(0.0006[a])
	December	63	-76.25*	($<$ .0001)
	January	91	-67.28*	($<$ .0001)
	February	126	-58.30*	(0.0026)
	March	155	-85.21*	($<$ .0001)
Revenue at Culling			604.00	
Dry lot system	Nov.-Dec.	35-63	0.93	(0.8900)
	Dec.-Jan.	63-91	-22.75*	(0.0131)
	Jan.-Feb.	91-126	-18.547	(0.1023)
	Feb.-March	126-155	41.67*	(0.0003)
Pasture system	Nov.-Dec.	35-63	-42.16*	($<$ .0001)
	Dec.-Jan.	63-91	-13.78	(0.1305)
	Jan.-Feb.	91-126	-9.57	(0.3979)
	Feb.-March	126-155	14.76	(0.1918)
	-2Loglikelihood		8764.8	

[a]Numbers in parentheses are p-values and $*$ denotes statistically significant at p $\leq$ 0.10

The results above give a snapshot of the potential for net returns from retaining cull cows beyond the culling period for the three years in the study. An examination of net returns using the price response function gives a longer term perspective on the potential for net returns from retaining cull cows beyond the culling period. When net returns are estimated using the price response function, the model yields results similar to those when actual price is used. Retention of cull cows in the pasture system generates positive and significant net returns above revenue at culling in each of the five alternate marketing periods as shown in table 2.5. The highest level of net returns ($61.80/head) is realized at 155 days (February) with the second highest returns at 91 days ($49.22/head). Table 2.5 also reports that net returns for cows in the dry-lot system are all negative and statistically significant or slightly positive but not statistically different from zero, suggesting little or no potential for increasing the salvage value of cull cows with this system.

Table 2.5: Net return to land, owners labor, management and overhead by feeding system, and marketing period ($/head) using estimated prices.

Feeding system	Marketing period	Days after Culling	Net Returns ($/head)	
			Estimate	P-value
Revenue at Culling			599.70	
Pasture	November	35	13.58*	(0.0019[a])
	December	63	33.52*	(< .0001)
	January	91	49.22*	(< .0001)
	February	126	41.22*	(0.0002)
	March	155	61.8*	(< .0001)
Revenue at Culling			604.00	
Dry lot	November	35	-15.62*	(0.0004)
	December	63	-35.12*	(< .0001)
	January	91	-20.92*	(0.0143)
	February	126	70.54	(0.9612)
	March	155	-25.37*	(0.0195)

[a]Numbers in parentheses are p-values and $*$ denotes statistically significant at $p \leq 0.10$

When net returns are compared at the same marketing interval across feeding systems (see table 2.6), the pasture system is preferred in every case. A comparison of net returns across adjacent marketing periods would suggest the optimal marketing period for cull cows held in the pasture system is 91 days. Though the potential for net returns is higher at 155 days, the risk of holding the cows for an additional 60 days should be considered in that marketing decision.

2.5 Conclusions and Implications

The salvage value of cull cows represents a significant component of annual revenue for cow-calf revenue. Given the consistency and magnitude of price seasonality in cull cow markets, it is useful to examine the possibility of retaining cull cows beyond culling for delayed marketing. This study investigates the impact of the timing of marketing and feeding systems on net returns from cull cows. Specifically, it examines the profitability of selling cull cows immediately after being culled from the herd versus retaining them on pasture or in a low-cost dry-lot system for alternative periods of time.

Key factors in the profitability of retaining fall cull cows beyond culling for delayed marketing are retention cost (including feed, labor, and other costs), weight gain, and the seasonal price movement. Results showed that cull cows in both systems initially gained a significant amount of weight. Beyond the first period, cows retained in the pasture system began losing weight on average while the dry lot cows continued to gain, albeit slowly, until 126 days beyond culling. Average retention cost per cow for the low-cost dry-lot system was more than double that of the average retention cost per cow for the pasture system for the first marketing period and increased at a faster pace throughout the study (figures 2.3 and 2.4). In the case of the low-cost dry-lot system, weight gains by cull cows coupled with the seasonal upswings in price in late winter and early spring were not enough to overcome the relatively higher cost of

Table 2.6: Comparison of changes in net return to land, owners labor, management and overhead between feeding systems and across marketing periods using estimated prices.

			3-yr Pooled Data	
Feeding System Comparison	Marketing Periods	Days after Culling	Change Net Returns($/head)	P-value
Dry lot to pasture	November	35	-29.20*	($<$ .0001)
	December	63	-68.64*	($<$ .0001)
	January	91	-70.13*	($<$ .0001)
	February	126	-41.35*	(0.0087[a])
	March	155	-87.17*	($<$ .0001)
Dry lot system	Nov.-Dec.	35-63	19.50*	(0.0047)
	Dec.-Jan.	63-91	-14.21*	(0.0280)
	Jan.-Feb.	91-126	-21.45*	(0.0141)
	Feb.-March	126-155	25.90*	(0.0037)
Pasture system	Nov.-Dec.	35-63	-19.94*	(0.0038)
	Dec.-Jan.	63-91	-15.70*	(0.0153)
	Jan.-Feb.	91-126	7.33	(0.3976)
	Feb.-March	126-155	-19.90*	(0.0248)

[a]Numbers in parentheses are p-values and $*$ denotes statistically significant at $p \leq 0.10$

retention as compared to the dry-lot system. Although cull cows retained on pasture ultimately weighed less at marketing than at culling, the possibility of positive net returns existed because of the lower retention cost and the seasonal upswing in prices during late winter and early spring. Put simply, the gains from the seasonal price upswing on average were high enough at 63 days or beyond to compensate for the minimal (average) weight loss in pasture system cull cows, given the low retention cost, while the seasonal upswing in price coupled with weight gain was not enough to compensate for the high cost of retaining cows in the dry-lot system. Overall, the outcome of the study indicates that retaining cull cows beyond fall culling for delayed marketing during periods of typically higher prices can generate positive net returns above marketing immediately at culling, but that the retention cost relative to potential weight gain is an important factor for producers to consider.

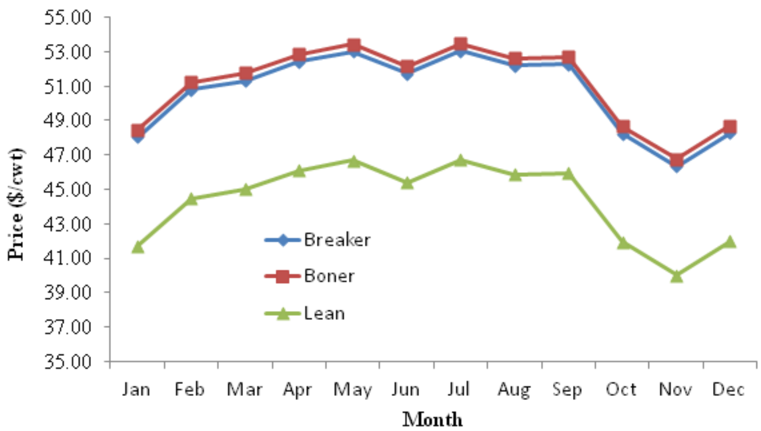

Figure 2.1: Slaughter cow price response as a function of month and quality grade

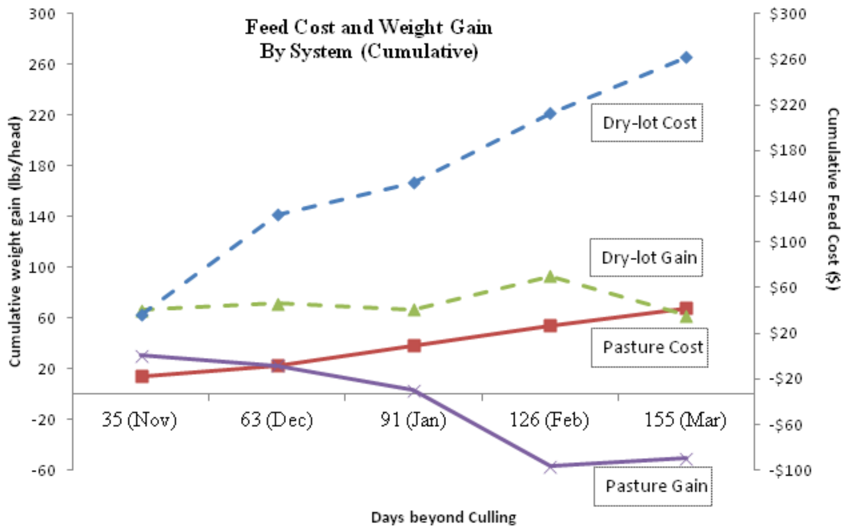

Figure 2.2: Cumulative average feed cost and cumulative average weight gain by cull cow retention system.

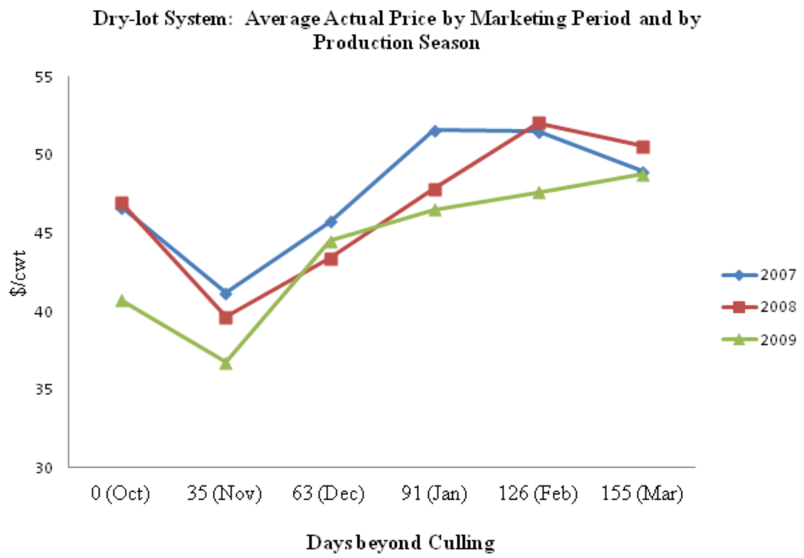

Figure 2.3: Average actual price ($/cwt) across marketing periods and production seasons for cows retained in the dry-lot system.

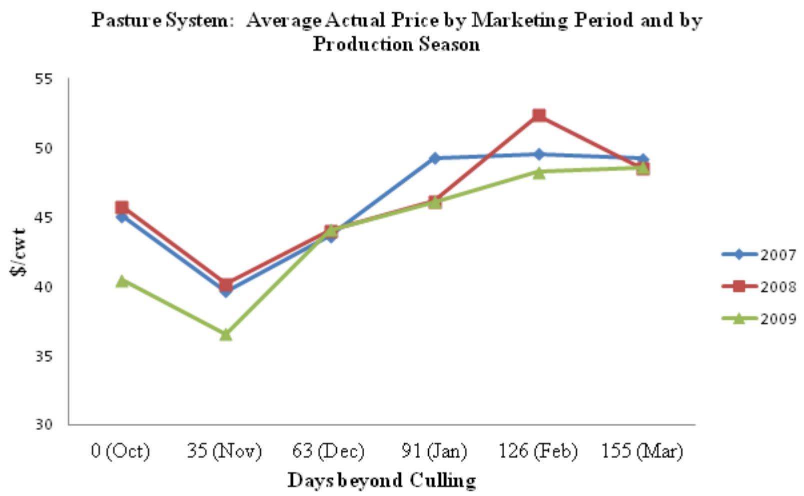

Figure 2.4: Average actual price ($/cwt) across marketing periods and production seasons for cows retained in the pasture system.

CHAPTER 3

NET RETURNS FROM FEEDING CULL COWS: THE INFLUENCE OF BEGINNING BODY CONDITION SCORES

3.1 Introduction

Anecdotal evidence suggests that cow-calf producers usually leave money on the table when it comes to marketing cull cows. Studies such as Blevins (2009) have shown that 15 to 30 percent of cow-calf producers' profit is earned from marketing cull cows. Carter and Johnson (2007) stated that in a typical year, increasing the net income from sales of cull cows by even ten percent results in nearly doubling ranch profit margins. Increasing a cow's salvage value as a capital asset at the end of its useful life to the ranch then becomes a key management issue that deserves more attention.

Cow-calf producers tend to devote high energy to producing and marketing steers and heifers, but give less attention to marketing cull cows. Cows are typically culled from the herd in the fall after weaning calves and sold immediately when cow markets are at the seasonal low price. The most common reason that cows are removed from the herd is that they failed to become pregnant during the most recent breeding cycle. Strohbehn and Sellers (2002) suggested that retaining and feeding sound, healthy cow with thin to moderate beginning body condition scores (BCS) would significantly increase the overall profitability of cull cows[1]. The seasonal price pattern in slaughter

[1]Body condition scores (BCS) are a visual estimate of the external fat carried out by a cow. It is often used by producers, extension personnel and researchers. Scores are assigned from 1 (emaciated and carrying virtually not fat) to 9 (excessively fat. Wagner et al (1988) pointed out

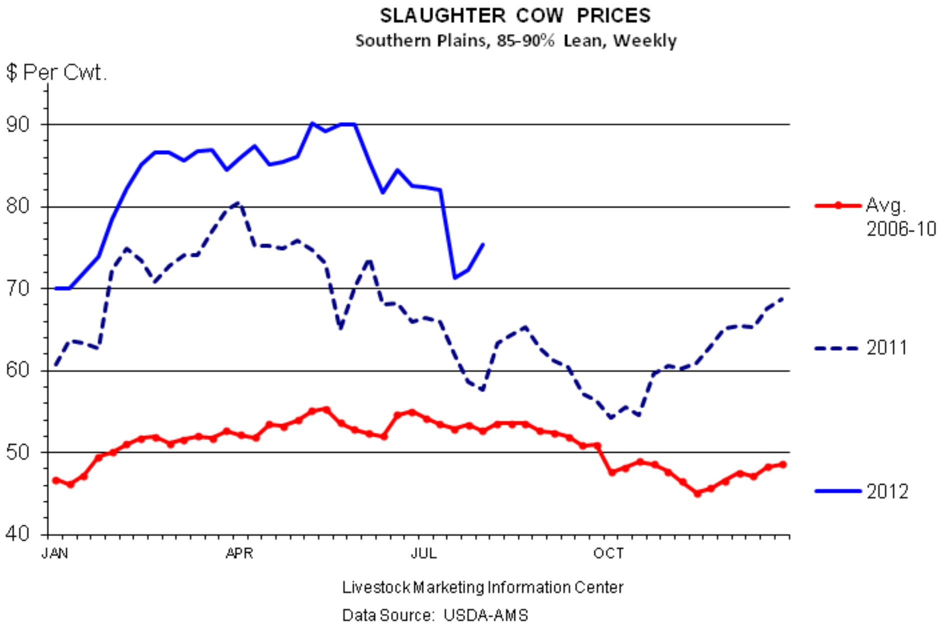

Figure 3.1: Five year weekly average slaughter cow prices, Southern Plains, 85-90% Lean, 2006-2011.

cows has the widest extreme from seasonal low to seasonal high of any class of cattle, offering producers an opportunity to add 10 to nearly 25 percent to the price for cull cows from the seasonal low to the following spring (Peel and Doye 2008). Figure 3.1 shown above illustrates this seasonal movement for the past ten years. In addition to seasonal price increases, cow-calf producers must also consider resource cost and availability, not the least of which include management capacity, feeds, labor and pasture or holding facilities, when deciding whether to retain and feed cull cows or to market them immediately when culled from the herd. In certain situations, feeding cull cows may actually increase the efficiency of underutilized labor resources and low quality forage (Peel and Doye 2008). In other cases, the opportunity cost may outweigh the benefit.

Blevins (2009) contends that managed marketing of cull cows has the potential to

that BCS information may be used to adjust feeding strategies for reproductive performance or feeding efficiency.

increase overall profitability of the cow-calf herd. Roeber et al (2001) indicated that beef producers could increase returns from cull cows by as much as $70 per head or more when quality defects, health, and condition of cull cows are well managed and marketed in a timely manner. Amadou et al (2009) found positive net returns for retaining cull cows beyond fall culling on native grass for 90 to 120 days. This practice takes advantage of the normal seasonal pattern in cull cow prices at a relatively low feed cost.

Some studies have suggested that, in addition to capturing additional value from the seasonal price upswing, retaining cows culled from the breeding herd in a short-term feeding system with a specified forage or concentrate ration may allow producers to increase pounds sold along with slaughter quality grade of the animal (Feuz 2006, Wright 2005). Peel and Doye (2008) concluded a relationship exists between ending BCS, marketing classification, and estimated dressing percentage. That is, the body condition score at marketing can be an indicator of other characteristics that impact the price per pound received. Apple (1999) found that cows with higher BCS scores at slaughter (7 to 8) had the highest gross and net carcass values while cows with lower BCS scores (2 to 3) at slaughter had less value. Schnell et al (2004) pointed out that improvement in the quality and consistency of beef products obtained through feeding a high concentrate diet could enhance the salvage value of cull beef cows. Carter and Johnson (2007) stated that cows with higher ending BCS and heavier weight optimize economic returns by having both a higher carcass value and a higher live value. However, Wright (2005) contends that the value added to cull cows from this practice depends on feed costs and availability as well as on final cow carcass quality and days on feed. The studies mentioned here are focused on the ending BCS at marketing and do not account for the cost to the cow-calf producer of holding and feeding cull cows to obtain a higher ending BCS.

According to Feuz (1992), a one point increase in BCS requires 60 to 80 pounds of gain, depending on the frame of individual cow. Encinias and Lardy (2000) recommend a BCS of > 4 at weaning and 5 at calving for mature cows in order to maximize breeding potential. Cows that end the weaning season with a relatively low BCS (e.g leaner) should be more feed efficient in a retention setting. That is, a greater percentage of feed should go to weight gain rather than to weight maintenance for these animals. Thus, the cost of gain will likely be less for cows with lower initial BCS, enhancing the opportunity for a positive net return from retaining cull cows for a period rather than marketing them immediately at culling.

While many have suggested that BCS at marketing plays a role in determining value and that BCS is a useful tool when making culling decisions, there is little information on the influence of beginning BCS on net returns from feeding cull cows. The objective of this research is to determine the influence of body condition score at culling on net returns from retaining cull cows in a pasture system or a low-cost dry lot system for a period of time beyond the culling date. We hypothesize that cull cows with lower beginning BCS will have higher net returns from feeding in a retention setting than cows with higher beginning BCS.

3.2 Methodology

The producer's choice in maximizing net returns from retaining a cull cow j for i feeding periods relative to culling revenue at weaning (i=0) can be defined as:

$$\text{Max } NR_{ij} = \begin{cases} P_{oj}W_{oj}, \text{ for } i = 0 \\ P_{ij}W_{ij} - P_{oj}W_{oj} - \sum_{i=1}^{5} C_{ij}, \text{ for otherwise} \end{cases} \tag{3.1}$$

where NR_{ij} is total net return from selling cull cow j at feeding interval i (where $i \epsilon$ (1, 2, 3, 4, 5), P_{ij} represents the price for cow j at feeding interval i, W_{ij} is the ending weight for cow j at feeding interval i, P_{oj} is the price for cow j at culling, W_{oj} is the weight for cow j at the time of culling, and C_{ij} is the cumulative retention cost from the culling point to the marketing period for cow j at feeding interval i.

For an individual cow j, the optimal marketing period i (at culling or at the end of a subsequent feeding interval) is that period in which net return over retention cost is maximized.

If net return for each feeding interval, i, is known, the producer's decision is simplified. Since that is not the case, we estimate the adjusted mean net returns that take into account the fixed effects in the experiment. Specifically, maximum likelihood estimation is employed to estimate adjusted (least squares) means for net returns at the culling period and for alternative marketing periods with both random and fixed effects. Fixed effects include beginning BCS category at culling (thin, medium, and heavy), management system (pasture or dry lot), and feeding interval (0, 35, 63, 91, 126, and 155 days), while cow and year are considered as random effects. The general model can be expressed as follows:

$$NR_{ijk} = \mu + \alpha_i + \beta_j + \theta_k + \alpha\beta_{ij} + \alpha\theta_{ik} + \beta\theta_{jk} + \alpha\beta\theta_{ijk} + \mu_t + \varepsilon_{ijk} \qquad (3.2)$$

where NR_{ijk} is the adjusted mean for net return for a given cow with body condition score i (i= thin, medium, and heavy) on treatment level j (j=pasture or dry-lot) at time k (k=0, 35, 63, 91, 126, and 155), μ is a constant representing the overall mean, α_i is the beginning BCS i effect, β_j is the management system j effect (pasture, dry lot), θ_k is the feeding period k effect, $\alpha\beta_{ij}$ is the body condition score and treatment interaction, $\alpha\theta_{ik}$ is the body condition score and marketing period interactions, $\beta\theta_{jk}$ is management system and marketing period interaction effect, $\alpha\beta\theta_{ijk}$ is the body condition score, feeding period and treatment interaction effect, μ_t is the year random effect with $\mu_t \sim (0, \sigma^2_\mu)$, and ε_{ijk} is the random error with $\varepsilon_{ijk} \sim N(0, \sigma^2_\epsilon)$

3.3 Data

This cull cow retention and marketing experiment was conducted at the Samuel Roberts Noble Foundation in Ardmore, Oklahoma. Spring calving cows culled from a herd of black-hided Angus cows were retained either in a grazing environment (pasture) or in a low-cost dry lot environment (dry lot). Ranch managers made culling decisions based on cow performance and breeding history. Data were collected at culling and then at approximately monthly intervals for cows culled in October 2007 and marketed in April 2008, for cows culled in October 2008 and marketed in March 2009, and for cows culled in October 2009 and marketed in March 2010. A total of 162 cows included in the study across the three year period were randomly assigned to a management system. In the low-cost dry lot system, 81 cows were fed rye hay and protein cubes (10% crude protein from mid-October to December changing to 25% crude protein cubes in December). The 81 cows in the pasture system were fed on stockpiled native grass pasture (350 acres) supplemented with hay and cubes only during icy periods. Both groups received mineral supplement. Physical data collected on individual cows includes weight, estimated USDA slaughter cow grade, estimated dressing percentage, and body condition score. To minimize bias in subjective measures across time periods, the same USDA Agricultural Marketing Services (AMS) staffs were utilized to assign USDA grade, dressing percentage and body condition scores at each weigh period when data were collected, including at culling.

Cost components include feed, pasture, labor, and operating interest. Feed quantity data was collected on a pen basis and includes protein range cubes (pounds fed), mineral supplement (pounds fed), and hay (tons fed). Cube and mineral prices were charged at the rate offered by the local feed milling company during the feeding period. Rye hay cost is based on tons fed and it is priced at the purchase price, which is consistent with prices reported in the Oklahoma Market Report, Oklahoma Department of Agriculture, Food and Forestry for grass hay, east region. Pasture costs were assessed a per acre cash rental rate based on local rates and are within the range reported by Doye and Sahs (2011) during the study period. Feed costs for each feeding period are converted to a per cow average for individual cows based on management system and number of animals in the pen. Labor is tracked in hours per feeding period for each system and assigned a wage rate consistent with that offered locally for hourly ranch hands during the study period as reported by Oklahoma Department of Commerce (2009). Operating interest is charged at the annual rate of 7.5% on the estimated value of the cow at the initial culling.

Price data for cull cows is taken from the Slaughter Cow portion of Agricultural Marketing Service's (AMS) price reports KO-LS155 and KO-LS795 for Oklahoma National Stockyards, Oklahoma City, as summarized by the Livestock Market Information Center. Two methods are used to assign individual cow prices. The first method is an actual price. Estimated USDA grade and dressing percentage are used in conjunction with the nearest in time weekly AMS price report to identify a specific price per hundredweight for each cow at each of the five feeding intervals in a culling year. The second method is an estimated price obtained from a price response function. Monthly AMS price data from 2003 to 2010 is used to generate a price response function for slaughter cows, which then assigns individual cow prices ($/cwt) based on the marketing period and the animal's USDA grade.

The beginning BCS of an individual cow at culling is used to assign the cow to one of three BCS categories. Cull cows are classified as thin (beginning BCS < 5), medium ($5 \leq$ beginning BCS ≤ 6) or heavy (beginning BCS > 6). This division of BCS scores, particularly with respect to the thin category, is supported by Encinias and Lardy (2000) and as well as Steward (2000) . Anecdotally, discussions with ranch managers also suggest that they sort cows in a manner similar to these classifications when assessing nutritional needs and adjusting feeding regimens of the cow herd. Beginning BCS was not collected in the first year of the experiment. However, BCS was collected in the initial culling periods for the second and third experiment years, as well as for three other periods during the study. The relationship of BCS, cow weight, dressing percentage, fill and quality grade is estimated using data from the five available periods as follows:

$$BCS_j = \beta_1 + \beta_2 W_{oj} + \beta_3 DP_j + \beta_4 \text{Boner} + \beta_5 \text{Breaker} + \beta_6 \text{Fill} + \eta_j \tag{3.3}$$

where DP is dressing percentage, Boner and Breaker are dummy variables representing quality grade, $\eta \sim N(0, \sigma_\eta^2)$, and other variables are as previously defined. The resulting equation is used to predict beginning BCS score, and thus BCS category (thin, medium and heavy), for cows included in the first year of the experiment.

3.4 Results

Two possibilities were considered for the functional form of the price response. A model using the dummy variables for monthly and quality grade impacts was compared to a trigonometric model. The simple dummy variable for price response is expressed as follows:

$$P_{mgt} = \beta_0 + \sum_{m=1}^{11} \beta_m M_m + \sum_{g=1}^{2} \alpha_g Q_g + \mu_t + \varepsilon_{mgt} \tag{3.4}$$

where P_{mgt} is the price at month m (m=1,...,12) at given quality grade g (g=lean, Boner, or Breaker) in year t, M = month, Q_g quality grade, μ_t is the year random effect with $\mu_t \sim N(0, \sigma_t^2)$, ε_{mgt} is a random error term where $\varepsilon_{mgt} \sim N(0, \sigma_\epsilon^2)$. The trigonometric price response function may be written as:

$$P_{mgt} = \beta_0 + \beta_1 \mathrm{M_m} + \sum_{\mathrm{n=1}}^{3} \sum_{\mathrm{T=4}}^{12} [\mathrm{a_n} \cos\left(\frac{2\pi \mathrm{M}}{\mathrm{T}}\right) + \mathrm{b_n} \sin\left(\frac{2\pi \mathrm{M}}{\mathrm{T}}\right)] + \sum_{\mathrm{g=1}}^{2} \alpha_{\mathrm{g}} \mathrm{Q_g} + \mu_{\mathrm{t}} + \varepsilon_{\mathrm{mgt}} \tag{3.5}$$

where T is the frequency and other variables are as previously defined. The two models can be compared using a likelihood ratio test.

The chi-square value for the likelihood ratio test is calculated as $\chi_4^2 = -5360_U + 5386.7_R = 26.7$, where the trigonometric model (10 parameters) is a restricted version of the dummy variable model (14 parameters). Comparing the test value of $\chi_4^2 = 24.8$

to the critical chi-square value ($\chi_c^2 = 9.48$) concludes that the dummy variable model is more appropriate than the trigonometric model. Price response function parameter estimates are reported in table 3.1 below. Coefficient estimates capture the significant seasonality typically present in the slaughter cow market. Figure 3.2 illustrates that the predicted price response function generates a similar seasonal price pattern to that reflected by the seasonal price index in Figure 3.1. While the actual market price reflects short run market dynamics, the price response function deals with the long run dynamics of price. Relative to the October price, the November coefficient is negative and significant, representing the seasonal low in the fall when cow culling decisions are typically made resulting in high supply. Price effects for February through September are positive and significant, peaking in April. Coefficients for yield grades of Boner and Breaker are also positive and significantly related to price, relative to a yield grade of Lean. The coefficients in table 1 are used to estimate price per hundredweight for each cow at each possible marketing period. For example, a cow marketed in December 2007 classified as a Breaker is assigned an actual price of \$39.50/cwt as reported in the nearest AMS marketing report. However, using the price response function, that same cow would be assigned an estimated price of

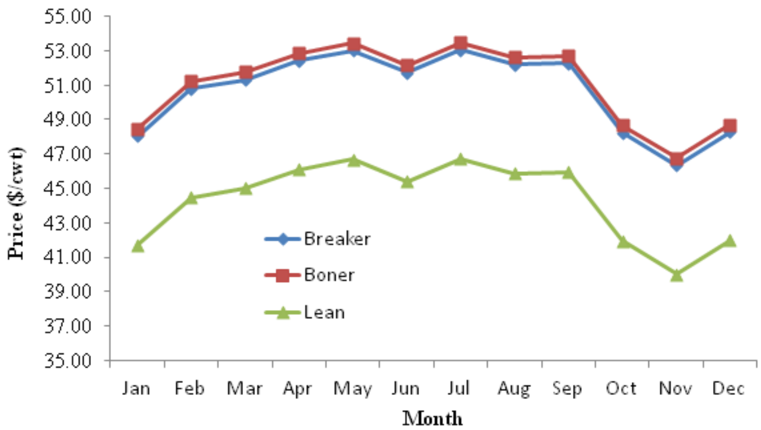

Figure 3.2: Slaughter cow price response as a function of month and quality grade

Table 3.1: Estimated slaughter cow price as function of month and quality grade.

Parameters	Independent variables	Estimates	Standard Errors	p-values
β_0	Intercept	41.610	0.5508	< 0.0001
β_1	Jan	1.090	0.7832	0.1644
β_2	Feb	3.599	0.7472	< 0.0001
β_3	Mar	4.146	0.7348	< 0.0001
β_4	Apr	4.619	0.7396	< 0.0001
β_5	May	4.604	0.7196	< 0.0001
β_6	June	3.311	0.7396	< 0.0001
β_7	July	4.600	0.7472	< 0.0001
β_8	Aug	3.634	0.7196	< 0.0001
β_9	Sept	3.808	0.7325	< 0.0001
β_{10}	Nov	-1.669	0.7136	0.0196
β_{11}	Dec	-0.989	0.8326	0.2353
α_1	Breaker	6.308	0.3823	< 0.0001
α_2	Boner	6.740	0.3826	< 0.0001
σ_t^2	Year Random effect	11.144		
σ_ε^2	Variance of error term	23.681		
-2LL	Loglikelihood	5360		

\$46.95/cwt at marketing.

Parameter estimates for equation 3.3 represent the body condition score relationship to specific physical condition variables. The resulting equation is as follows, with p-values reported in parentheses:

$$\begin{aligned} \text{BCS}_j &= -3.14 + 0.30 \text{ Boner} + 0.74 \text{ Breaker} + 0.02\ W + 0.01\ W^2 + 0.15 \text{ Fill} + 0.16 \text{ DP} \\ &\quad (0.0460) \quad (0.0400) \quad (0.0001) \quad (0.8480) \quad (0.2530) \quad (< 0.0001) \quad (0.0001) \end{aligned} \tag{3.6}$$

Quality grade, dressing percentage, and fill are positive and significantly related to body condition scores. The resulting equation is used to estimate initial body condition scores for each cow in year one. Summary statistics of the beginning BCS and the distribution of cull cows across beginning BCS categories, treatment groups, and across years are presented in table 3.2. In general, a disproportionate number of cows are classified as medium across the study years. The percentage of cows in each study year classified as medium ranged from 51 percent to 78 percent, suggesting that the source herd is well-managed with respect to optimal body condition scores at weaning. A mixed model is used to estimate equation 3.2 with Proc Mixed in SAS 9.2. Likelihood ratio tests indicated that the unstructured covariance matrix was most appropriate for modeling the data.

Table 3.2: Cull cow BCS distribution and treatment group summary statistics across years

Variables	Characteristics	Pooled average	Year one	Year two	Year three
Mean	BegBCS	5.5	5.4	5.9	5.32
Standard Deviation		0.86	0.72	0.99	0.77
Minimum		4	4	4	4
Maximum		8	6.5	8	7.5
Distribution of Cows					
N		162	48	43	71
Management System					
Pasture		81	24	21	36
Drylot		81	24	22	35
BCS Category					
Thin		32	8	6	18
Medium		99	32	22	45
Heavy		31	8	15	8

Table 3.3 below reports adjusted mean change in net returns relative to revenue at culling for the three BCS categories across management systems, years and weigh periods using actual market price. The most striking results from table 3.3 is the lack of positive changes in net returns in the dry lot management system. In all cases under the dry lot system, net returns relative to revenue at culling are either negative and significant ($p \leq 0.10$) or not significantly different from zero. In the pasture management system change in net returns for cows classified as thin were positive and significant ($p \leq 0.10$) at 63 days ($50.60), 91 days ($39.73), and 126 days ($64.10). Net returns peaked at 126 days, but require holding cows sixty days

Table 3.3: Change in net returns relative to revenue at culling by body condition score category, management system, and marketing interval with ± 10% change in input costs using actual market price

		Thin			Medium			Heavy		
Systems	Days	Pooled	-10%FC	+10%FC	Pooled	-10%FC	+10%FC	Pooled	-10%FC	+10%FC
Revenue at Culling	0	522.26			589.27			721.49		
Pasture		1.41	4.87	-0.13	-14.33*	-10.90	-15.85*	-88.48*	-85.24*	-89.9*
	35	(0.9168[a])	(0.7186)	(0.9924)	(0.0728)	(0.1723)	(0.0472)	(< 0.0001)	(< 0.0001)	(< 0.0001)
		50.60*	53.52*	49.63*	26.36*	29.42*	25.31*	-49.45*	-45-48*	-51.01*
	63	(0.0050)	(0.0026)	(0.0065)	(0.0129)	(0.0049)	(0.0181)	(0.0099)	(0.0158)	(0.0085)
		39.73*	44.09*	37.42*	47.93*	52.45*	45.6*	-33.13	-27.82	-35.50
	91	(0.0625)	(0.0361)	(0.0819)	(0.0002)	(< 0.0001)	(0.0004)	(0.1436)	(0.2119)	(0.1206)
		64.10*	68.42*	61.75*	65.88*	70.99*	63.10*	-67.74*	-61.35*	-70.68*
	126	(0.0123)	(0.0133)	(0.0275)	(< 0.0001)	(< 0.0001)	(0.0002)	(0.0223)	(0.0366)	(0.0180)
		35.82	40.35*	33.44	38.82*	43.82*	36.30	-27.2	-19.82	-30.50
	155	(0.1557)	(0.0994)	(0.1937)	(0.0095)	(0.0026)	(0.0173)	(0.3119)	(0.4456)	(0.2606)
Revenue at Culling	0	527.48			596.97			719.45		
Dry lot		-43.8*	-36.8*	-47.5*	-53.23*	-46.04*	-57.12*	-88.67*	-81.45*	-92.65*
	35	(0.0006)	(0.0036)	(0.0002)	(< 0.0001)	(< 0.0001)	(< 0.0001)	(< 0.0001)	(< 0.0001)	(< 0.0001)
		-32.10*	-21.55	-38.86*	-52.25*	-41.53*	-58.9*	-110.79*	-98.52*	-118.23*
	63	(0.0520)	(0.1840)	(0.0204)	(< 0.0001)	(0.0002)	(< 0.0001)	(< 0.0001)	(< 0.0001)	(< 0.0001)
		-6.07	5.25	-13.5	-29.29*	-17.01	-37.10*	-92.75*	-77.07*	-102.51*
	91	0.7560)	(0.7849)	(0.4941)	(0.0258)	(0.1863)	(0.0053)	(< 0.0001)	(0.0004)	(< 0.0001)
		23.19	34.85	15.06	-10.3	3.54	-19.65	-88.83*	-68.76*	-101.84*
	126	(0.3629)	(0.16870)	(0.5569)	(0.5440)	(0.8330)	(0.2510)	(0.0021)	(0.0158)	(0.0005)
		-21.62	-8.80	-30.06	-49.62*	-34.17*	-59.64*	-133.21*	-110.24*	-147.84*
	155	(0.3519)	(0.6953)	(0.2050)	(0.0016)	(0.0237)	(0.0002)	(< 0.0001)	(< 0.0001)	(< 0.0001)
-2Log-likelihood		8945.5	8954.5	8934.4						

[a]Numbers in parentheses are p-values and $*$ denotes statistically significant at $p \leq 0.10$

longer to capture the additional $13.50 in net returns. Changes in net returns for cows in the pasture system classified as medium were positive and significant at 63 days ($26.36), 91 days ($47.93), 126 days ($65.88), and 155 days ($38.82), again peaking at 126 days. By contrast pooled net returns for cows classified as heavy retained in the pasture system were negative and significant at all weigh periods . Table 3.3 also reports sensitivity of net returns to ± 10% change in feed cost using actual market price. Results show that a ± 10% change in feed cost is not enough to influence producers' decisions on cull cow retention strategies based on net return measures.

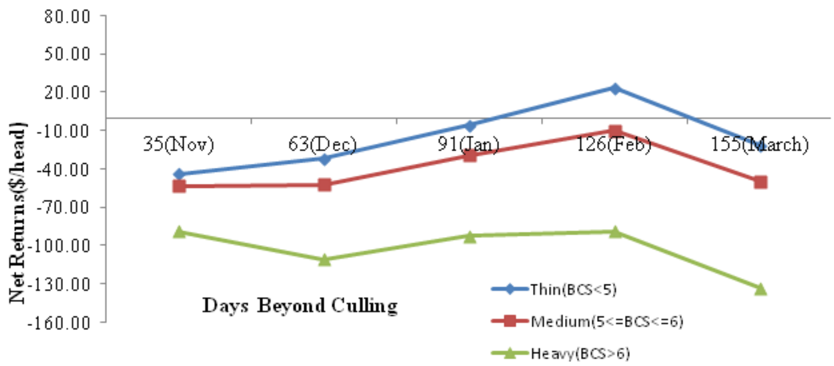

Figure 3.3: Change in net returns compared to revenue at culling for cull cows in dry lot system using actual market price: comparison across beginning BCS categories

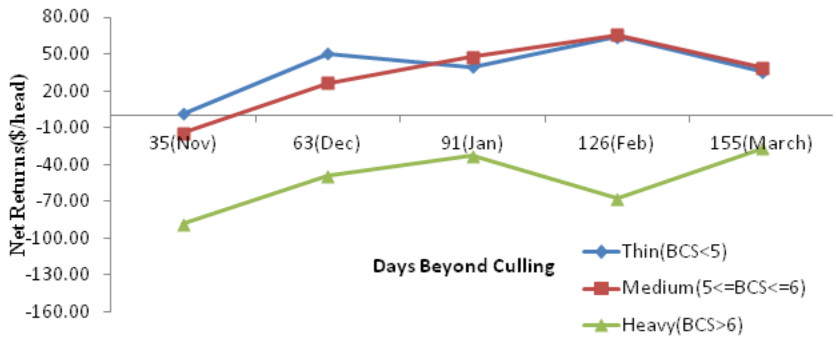

Figure 3.4: Change in net returns compared to revenue at culling for cull cows in the pasture system using actual market price: comparison across beginning BCS categories

Figures 3.3 and 3.4 above illustrate pooled net returns across BCS categories for the dry lot system and pasture system, respectively, using actual market price. Figure 3.3 illustrates that changes in net returns above revenue at culling for dry lot system cows were only positive at 126 days in the case of thin cows. However, as seen in Table 3.3, this result is not statistically different from zero. Figure 3.4 shows that changes in pooled net returns are positive beyond 35 days for both thin and medium cows in the pasture system using actual market price. Together, figures 3.3 and 3.4 emphasize that cows classified as heavy at culling do not generate positive changes in net returns over revenue at culling in either retention setting.

A direct statistical comparison of differences in net returns between categories as measured with actual market price is presented in table 3.4. Results show that, in general, the difference between net returns of thin versus medium cows retained on both pasture and dry lot were not significantly different from each other. Results also reveal that the difference between pasture system net returns of both thin and medium cows versus heavy cows were positive and statistically significant. Thin and medium cows retained on pasture at 35 days produced \$89.90 ($p < 0.0001$) and \$74.15 ($p < 0.0001$) higher net returns, respectively, than heavy cows on pasture. At 63 days, medium and thin cull cows on pasture respectively generated \$100.06 ($p=0.0002$) and \$75.82 ($p=0.0162$) higher net returns than heavy cull cows retained on pasture. At 91 days, net returns of thin and medium cows on pasture were \$72.85 ($p=0.0197$) and \$81.05 ($p=0.0020$) higher than heavy cows held on pasture. The largest difference in net returns come at 126 days where thin and medium cows on pasture produced \$131.85 ($p=0.0013$) and \$133.62 ($p=0.0001$) higher net returns respectively, than heavy cows. Results are similar for cull cows held in pasture system for 155 days. Overall, cows classified as thin or medium by BCS score generated higher net returns in either retention setting as compared to those classified as heavy.

Table 3.4: Change in net returns relative to culling revenue by alternative marketing interval, body condition score category, and management systems using actual market price.

			Pasture				Dry lot			
Days	BCS		Pooled	Year1	Year2	Year3	Pooled	Year1	Year2	Year3
35	Thin	Medium	15.74 (0.3155)	44.62* (0.0935)	-7.48 (0.8024)	3.4 (0.8264)	9.42 (0.5287)	24.63 (0.2783)	5.26 (0.8602)	-12.63 (0.4252)
	Thin	Heavy	89.9* (< 0.0001)	130.17* (0.0002[a])	47.25 (0.1417)	23.92 (0.3671)	44.87* (0.0172)	77.27* (0.0267)	18.22 (0.5586)	-16.25 (0.4634)
	Medium	Heavy	74.15* (< 0.0001)	85.54* (0.0020)	54.74 (0.0177)	20.52* (0.3995)	35.44 (0.0298)	52.93 (0.1052)	12.95 (0.5447)	-3.62 (0.8544)
63	Thin	Medium	24.24 (0.2420)	43.34 (0.1762)	-12.33 (0.7990)	23.34 (0.3724)	20.15 (0.3081)	17.74 (0.5174)	10.49 (0.8285)	20.19 (0.4486)
	Thin	Heavy	100.06* (0.0002)	130.21* (0.0015)	60.12 (0.2456)	67.38 (0.1332)	78.69* (0.0017)	66.96 (0.1094)	33.08 (0.5122)	76.12* (0.0441)
	Medium	Heavy	75.82* (0.0162)	86.86* (0.0086)	72.46* (0.0496)	44.05 (0.2832)	58.54* (0.0068)	49.22 (0.2108)	22.59 (0.5143)	55.93* (0.0956)
91	Thin	Medium	-8.19 (0.7391)	-6.11 (0.8427)	-87.46 (0.1590)	17.59 (0.4992)	23.20 (0.3240)	18.53 (0.4870)	11.91 (0.8459)	12.24 (0.6444)
	Thin	Heavy	72.85* (0.0197)	126.41* (0.0015)	-4.83 (0.9407)	86.33* (0.0549)	86.68* (0.0032)	61.03 (0.1328)	53 (0.4074)	56.81 (0.1290)
	Medium	Heavy	81.05* (0.0020)	132.52* (< 0.0001)	82.63* (0.0754)	68.33* (0.095)	63.47 (0.0135)	42.5 (0.2655)	41.09 (0.3500)	44.57 (0.1811)
126	Thin	Medium	-1.77 (0.9558)	5.33 (0.8525)	-26.28 (0.7639)	13.35 (0.6103)	33.49 (0.2745)	22.81 (0.3592)	8.37 (0.9238)	35.10 (0.1912)
	Thin	Heavy	131.85* (0.0013)	81.31* (0.0237)	274.8* (0.0050	95.98* (0.0346)	112.02* (0.0038)	70.51* (0.0641)	98.40 (0.2828)	84.38* (0.0276)
	Medium	Heavy	133.62* (0.0001)	75.98* (0.0109)	301.09* (< 0.0001)	82.62* (0.0472)	78.54 (0.0188)	47.69 (0.1812)	90.03 (0.1547)	49.27 (0.1425)
155	Thin	Medium	-3.02 (0.9174)	-50.51 (0.2004)	-52.76 (0.2740)	40.18 (0.1582)	28.01 (0.3156)	26.83 (0.4276)	26.72 0.5773)	-6.57 (0.8195)
	Thin	Heavy	62.94* (0.0881)	69.09 (0.1502)	33.20 (0.5136)	76.37 (0.1165)	111.6* (0.0016)	94.71* (0.06750	29.37 (0.5557)	98.28* (0.0171)
	Medium	Heavy	65.97* (0.0324)	119.61* (0.0036)	85.97* (0.0197)	36.19 (0.4149)	83.59* (0.0062)	67.88 (0.1625)	2.64 (0.9382)	104.86* (0.0047)

[a]Numbers in parentheses are p-values and $*$ denotes statistically significant at $p \leq 0.10$

Table 3.5 reports net returns by BCS category across management systems and weigh periods using the price response function. Pooled net returns for thin cows compared to revenue at culling in a dry lot setting were all negative, but significantly different from zero only at 35 days. Changes in net returns for cows classified as thin and retained in the pasture system were positive and statistically significant at each marketing period, peaking at 155 days ($72.92). Changes in net returns for cows classified as medium and retained in the pasture system were also positive and significant for each marketing period, peaking at 155 days ($66.07). Table 3.5 also reports the sensitivity of net returns to a 10% change in feed cost. Results suggest that only the magnitudes of net returns have changed, but the direction of coefficients remains unchanged as a result of 10% change in feed cost. In this scenario, the 10% change in input costs has little impact on producers' decision to retain and feed cull cows beyond culling.

Table 3.5: Change in net returns relative to revenue at culling by body condition score category, management system, and marketing interval with ± 10% change in input costs using price response function.

		Thin			Medium			Heavy		
Systems	Days	Pooled	-10%FC	+10%FC	Pooled	-10%FC	+10%FC	Pooled	-10%FC	+10%FC
Revenue at Culling	0	522.26			589.27			721.49		
Pasture		19.05*	20.59*	17.52*	18.98*	20.48*	17.46*	-10.25	-8.82	-11.67
	35	(0.0402[a])	(0.0264)	(0.0599)	(0.0006)	(0.0002)	(0.0016)	0.1698)	(0.3679)	(0.1374)
		33.36*	34.34*	32.38*	40.22*	41.26*	39.17*	11.8	13.37	10.24
	63	(0.0361)	(0.0296)	(0.0437)	(< 0.0001)	(< 0.0001)	(< 0.0001)	(0.3884)	(0.4232)	(0.3431)
		58.20*	60.52*	55.89*	57.52*	59.85*	55.18*	11.93*	14.3	9.55*
	91	(0.0015)	(0.0009)	(0.0027)	(< 0.0001)	(< 0.0001)	(< 0.0001)	(0.0070)	(0.4515)	(0.0054)
		61.07*	63.42*	58.72*	58.88*	61.67*	56.11*	-35.37*	-32.44	-38.32
	126	(0.0088)	(0.0057)	(0.0134)	(< 0.0001)	(< 0.0001)	(< 0.0001)	(< 0.0001)	(0.1797)	(0.1272)
		72.92*	75.3*	70.55*	66.07*	68.6*	63.54*	35.24*	38.62*	31.86
	155	(0.0014)	(0.0007)	(0.0028)	(< 0.0001)	(< 0.0001)	(< 0.0001)	(0.0058)	(0.0962)	(0.1981)
Revenue at Culling	0	527.48			596.97			719.45		
Dry lot		-14.63*	-10.92	-18.33*	-11.72*	-7.82	-15.62*	-27.88*	-31.87*	-23.89*
	35	(0.0870)	(0.1988)	(0.0330)	(0.0401)	(0.1680)	(0.0067)	(0.0038)	(0.0010)	(0.0126)
		-12.43	-5.67	-19.17	-24.9*	-18.25*	-31.55*	-92.25*	-99.69*	-84.82*
	63	(0.3943)	(0.6945)	(0.1936)	(0.0112)	(0.0595)	(0.0015)	(< 0.0001)	(< 0.0001)	(< 0.0001)
		-7.49	-0.06	-14.92	-12.08	-4.27	-19.9*	-62.5*	-72.25*	-52.74*
	91	0.6534)	(0.9969)	(0.3786)	(0.2776)	(0.6970)	(0.0798)	(0.0010)	(0.0002)	(0.0046)
		19.2	327.4	11.16	10.58	19.92	1.22	-51.13*	-64.15*	-38.13
	126	(0.3648)	(0.1905)	(0.6066)	(0.4557)	(0.1534)	(0.9327)	(0.0326)	(0.0088)	(0.1038)
		2.10	10.55	-6.34	-6.28	3.74	-16.29	-113.41*	-128.05*	-98.77*
	155	(0.9190)	(0.5983)	(0.7666)	(0.6489)	(0.7795)	(0.2541)	(< 0.0001)	(< 0.0001)	(< 0.0001)
-2Log-likelihood		8570.7	8587.3	8555.4						

[a]Numbers in Parentheses are P-values and $*$ denotes statistically significant at $p \leq 0.10$

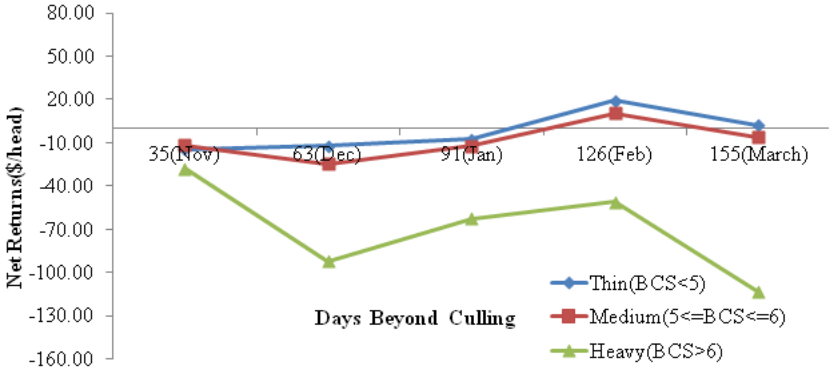

Figure 3.5: Change in net returns compared to revenue at culling for cows in dry lot system using price response function: comparison across beginning BCS categories.

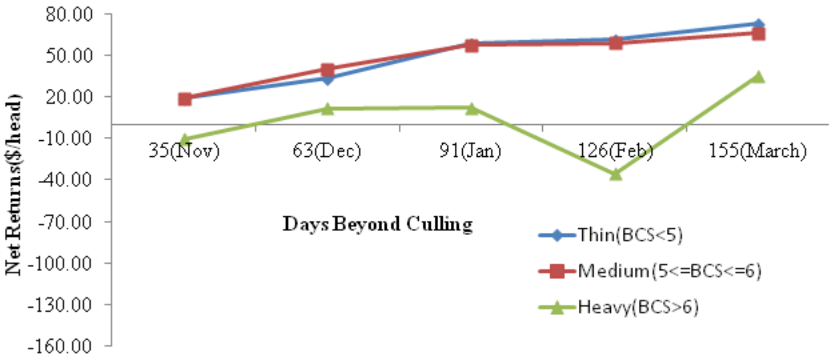

Figure 3.6: Change in net returns compared to revenue at culling for cows in the pasture system using price response function: comparison across beginning BCS categories

Figures 3.5 and 3.6 above illustrate pooled net returns estimated using the price response function. Figure 3.5 illustrates that change in net returns for dry lot systems were slightly positive for thin and medium cows at 126 days, though Table 3.5, indicates neither is significantly different from zero. Figure 3.6 shows that changes in net returns are positive beyond 35 days for both thin and medium cows in the pasture system using the price response function. Figures 3.5 and 3.6 again highlight that cows classified as heavy at culling produce little or no positive changes in net returns over revenue at culling in either feeding program. Table 3.6 reports pairwise BCS comparisons of the change in net returns relative to revenue at culling across all alternative marketing intervals for both retention systems when prices are estimated using the price response function. At each period, the difference between net returns of thin and medium cows held on pasture is not statistically significant. The same holds true for cull cows retained in the dry lot system. However, results do suggest significant differences in net returns for both thin versus heavy and medium versus heavy cows in the pasture system at multiple periods. The largest differences come at 126 days where thin and medium cows produced \$96.44 and \$94.25 higher, respectively, than net returns of heavy cows retained on pasture.

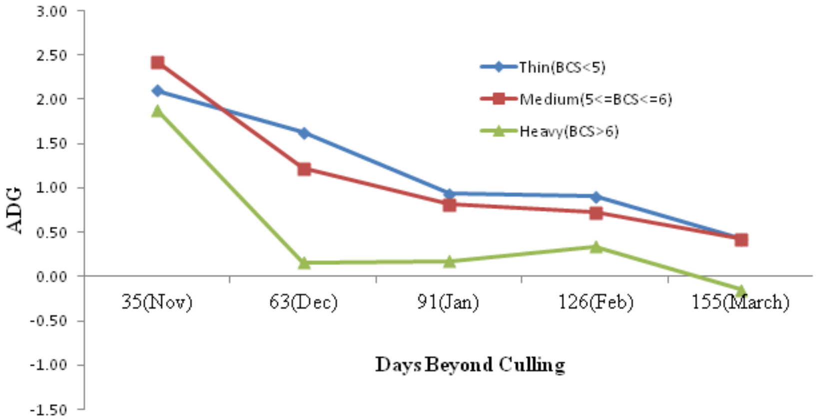

Figure 3.7: Change in ADG compared to ADG at culling for cull cows in dry lot across beginning BCS categories

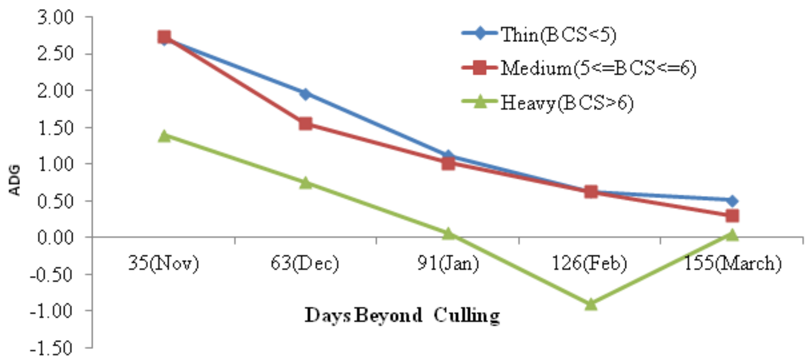

Figure 3.8: Change in ADG compared to ADG at culling for cull cows in pasture system across beginning BCS categories.

Figures 3.7 and 3.8 illustrate average daily gain (ADG) for thin, medium and heavy cull cows in the dry lot management system and on pasture. Figure 3.7 shows that ADG of thin, medium and heavy cull cows in the dry lot setting decreased over time, but the ADG of thin cull cows was higher than for medium and heavy cows

Table 3.6: Change in net Returns relative to culling revenue by alternative marketing interval, BCS categories, and management systems using price response function.

Days	BCS		Pasture				Dry lot			
			Pooled	Year1	Year2	Year3	Pooled	Year1	Year2	Year3
35	Thin	Medium	0.07 (0.9942)	-10.08 (0.1843)	-1.06 (0.8970)	6.45 (0.7472)	-2.9 (0.7761)	2.76 (0.1220)	1.58 (0.8472)	-2.44 (0.4767)
	Thin	Heavy	29.30* (0.0309)	29.98 (0.4458[a])	12.92 (0.1432)	33.4 (0.3296)	13.25 (0.2996)	20.51 (0.2453)	13.97 (0.1077)	-16.99 (0.5524)
	Medium	Heavy	29.22* (0.0100)	40.06* (0.0046)	13.99* (0.0265)	26.95 (0.3915)	16.16 (0.1457)	17.75 (0.2873)	12.39* (0.0228)	16.6 (0.1457)
63	Thin	Medium	-6.85 (0.7088)	-8.7 (0.5862)	-63.54* (0.0322)	8.32 (0.7849)	12.47 (0.4766)	1.98 (0.8855)	14.88 (0.5874)	19.92 (0.5222)
	Thin	Heavy	21.55 (0.3511)	40.34* (0.0424)	-68.67 (0.0224)	52.48* (0.3148)	79.82 (0.0003)	34.15 (0.1052)	60.98* (0.0375)	96.18* (0.0300)
	Medium	Heavy	28.4 (0.1410)	49.04* (0.0035)	-8.12 (0.6896)	44.15 (0.3569)	67.34* (0.0005)	32.17 (0.1067)	46.09* (0.0228)	76.26* (0.0529)
91	Thin	Medium	-8.19 (0.7391)	-6.11 (0.8427)	-87.46 (0.1590)	17.59 (0.4992)	23.20 (0.3240)	18.53 (0.4870)	11.91 (0.8459)	12.24 (0.6444)
	Thin	Heavy	72.85* (0.0197)	126.41* (0.0015)	-4.83 (0.9407)	86.33* (0.0549)	86.68 (0.0032)	61.03 (0.1328)	53 (0.4074)	56.81 (0.1290)
	Medium	Heavy	81.05* (0.0020)	132.52* (< 0.0001)	82.63* (0.0754)	68.33* (0.095)	63.47* (0.0135)	42.5 (0.2655)	41.09 (0.3500)	44.57 (0.1811)
126	Thin	Medium	-1.77 (0.9558)	5.33 (0.8525)	-26.28 (0.7639)	13.35 (0.6103)	33.49 (0.2745)	22.81 (0.3592)	8.37 (0.9238)	35.10 (0.1912)
	Thin	Heavy	131.85* (0.0013)	81.31* (0.0237)	274.8* (0.0050	95.98* (0.0346)	112.02* (0.0038)	70.51* (0.0641)	98.40 (0.2828)	84.38* (0.0276)
	Medium	Heavy	133.62* (0.0001)	75.98* (0.0109)	301.09* (< 0.0001)	82.62* (0.0472)	78.54* (0.0188)	47.69 (0.1812)	90.03 (0.1547)	49.27 (0.1425)
155	Thin	Medium	-3.02 (0.9174)	-50.51 (0.2004)	-52.76 (0.2740)	40.18 (0.1582)	28.01 (0.3156)	26.83 (0.4276)	26.72 0.5773)	-6.57 (0.8195)
	Thin	Heavy	62.94* (0.0881)	69.09 (0.1502)	33.20 (0.5136)	76.37 (0.1165)	111.6* (0.0016)	94.71* (0.06750	29.37 (0.5557)	98.28 (0.0171)
	Medium	Heavy	65.97* (0.0324)	119.61* (0.0036)	85.97* (0.0197)	36.19 (0.4149)	83.59* (0.0062)	67.88 (0.1625)	2.64 (0.9382)	104.86* (0.0047)

[a]Numbers in parentheses are p-values and $*$ denotes statistically significant at $p \leq 0.10$

in all but the first weigh period. Similarly, Figure 3.8 illustrates that ADG of thin, medium and heavy cows generally decreased over time with ADG of thin cull cows again higher than those of medium and heavy cows[2]. This corresponds with the notion that as cows get heavier, more feed goes to weight maintenance as opposed to weight gain and feed efficiency decreases. Here, evidence supporting that theory is seen in both the dry lot and pasture management systems. In the first 35 days of feeding, costs between the dry lot and pasture systems are similar. However, in the periods following, dry lot costs increase more rapidly across marketing periods than do the costs for holding cull cows in a pasture/forage system.

3.5 Conclusions and Implications

Beginning body condition score appears to be an important factor in determining net returns from retaining and feeding cull cows beyond the culling date. As such, the beginning body condition scores should also play an important role in the decision of whether to sell cull cows at the time of culling or to retain and feed them for a period of time. In this study, cows classified as heavy at culling (beginning BCS >6.0) generally yielded negative and significant net returns relative to revenue at culling regardless of the retention system or pricing method. Cows with lower beginning BCS scores generally yielded positive net returns above revenue at culling in a pasture retention system, though net returns were typically negative in the dry lot system. Recall that ADG decreased over time for each BCS category in each management system, but thin and medium cows tended to have a higher ADG than heavy cows in each system. From a practical management perspective, together these results suggest that heavy cows should be sold immediately after culling, while pro-

[2]The exception is heavy cows at the day 155 weigh period. However, ADG is calculated for the days between weigh periods. The fact that heavy cows lost weight in the previous period and then had increased pasture available from spring green up likely influenced ADG measures in this period.

ducers should consider their own resources, including feed cost, when determining whether to retain cows with lower BCS scores for delayed marketing.

In this study, results favor a pasture system over low cost dry lot retention. Net returns relative to revenue at culling are higher for pasture system cows than dry lot at each marketing interval for each BCS category. That is, the potential for positive net returns is higher in a pasture based system than in a dry lot based system. This would suggest that an accurate assessment of relative feed costs of retention systems, along with predicting the likely magnitude of seasonal price movements in cull cow markets, is particularly important in the decision to hold cows beyond culling.

The beginning BCS appears to be an important factor in determining which cull cows to retain and feed. In the context of producer decisions regarding feeding cull cows, the results suggest that producers should carefully consider the body condition score of cows when making the decision to retain and feed versus marketing cows at culling. While our study suggests that a pasture system was generally more profitable for retention than a dry lot system, cows with a beginning BCS less than 6.0 generated higher net returns relative to marketing at culling than cows with a beginning of BCS 6.0 or higher, regardless of the feeding system.

CHAPTER 4

PROFITABILITY OF MARKETING CULL COWS AS BRED COWS

4.1 Introduction

Several studies have consistently indicated that retaining cull cows for delayed marketing provides a potential source of increased income to U.S cow-calf producers (Amadou et al 2009, Feuz et al 2006). However, most cow-calf producers traditionally sort out and sell cull cows when both body condition scores and prices are low. Relatively little attention is given by producers to increasing returns from marketing cull cows despite the fact that they account 15-30% of cow-calf revenue (Feuz 1996, Spreen and Simpson 1992). The profitability of fall marketing of cull cows from spring calving herds is potentially limited by both physical and economic factors. Poor body condition score in the fall resulting from the effect of lactation combined with poor quality forage is the key limiting physical factor. Seasonal price lows generated from a large cull cow supply in the fall is the key limiting economic factor to profitability if marketing cows at culling. Alternative timing of cull cow marketing has the potential to increase net revenue that slaughter cows bring to the cow-calf operation, thus increasing the salvage value of that cow as a capital asset. Managing cull breeding stock by improving body condition score with a cost-effective feeding program and selling them in the spring as prices seasonally increase may significantly improve net returns from the sale of cull cows (Little et al 1990, Feuz 1996, Spreen et al 1992, Peel and Meyer 2002). Additionally, it presents an opportunity to breed back cull cows to be marketed as bred cows. Most cows sold from a cow-calf operation would be open cull cows. For those cows in good health, adding a bull to a retention system for cull cows may result in bred cows, presenting an alternative marketing option.

Calving seasons in Oklahoma for cow-calf operations include year-round, fall calving, spring calving, and spring and fall calving. A limited survey of Oklahoma producers suggests that the most common is year-round calving, with 44.6% of producers practicing this. Spring calving follows at 25.6%, with fall and spring calving at 20.6% and fall calving at 9.2% (Peel and Doye 2008). The existence herds with alternative calving seasons provides a potential market for cull cows from spring-calving herds that breed back after culling and can be marketed as bred cows rather than as slaughter cows.

Most previous research has focused on determining how physical attributes such as weight and grade categories impact market price for cull cows sold as slaughter cows, finding that healthy cows in desirable lot sizes at higher dressing percentages were significantly related to higher cow price (e.g. Mintert et al 1990, Apple 1999). Research has also shown that there is potential to add value to cull cows from spring calving herds when retained on pasture for delayed marketing (Amadou et al 2009). Retaining and feeding cull cows for delayed marketing to take advantage of potentially better condition, higher slaughter grade, and seasonal price upswings may add value to cull cows, but producers have to consider potential added benefits against average added costs for alternative marketing programs (Ward et al 2008).

The average bred cow is typically valued about 8 percent higher per head than an average cull cow (Peel et al 2008). This average is further affected by age and quality of the cow, with younger cows and higher quality cows earning higher prices Putting bulls with cows assumed to be open at culling may result in some percentage of them being bred. The determination of cull cows' re-breeding rates similarly involves the interaction of many factors. For example, genetic and environmental factors such as nutritional level, body condition, climatic conditions, diseases, breeding season and breed differences generally affect the rebreeding performance of cows (Corah and

Lusky 1999). Any cull beef cows that become bred in the retention period have the potential to be sold as bred cows.

To better understand both bred and slaughter cow market dynamics over time, bred and slaughter cow price series are analyzed. Figures 1 and 2 illustrate slaughter cow and bred cow price series over time. Figure 1 shows that slaughter cow prices follow a relatively consistent pattern over time. Figure 2 shows that the bred cow price pattern fluctuates more over time, with price trends driven by the influence of expansion and liquidation phases. Herd expansion generally results in higher demand and higher prices for cows, while herd liquidation leads to excess supply and lower prices for cows. Post-drought rebuilding may provide a potential market for cows marketed as bred. While the potential to capture the seasonal price upswing makes delayed marketing of cull cows as slaughter cows attractive, the overall price difference that typically exits between bred cows and slaughter cows suggests that marketing cull cows from spring-calving herds as bred cows that fit into and alternative breeding season may be a viable alternative.

The overall objective of this paper is to determine whether the salvage value of cull cows can be increased when cull cows are retained beyond culling and marketed later as bred cows instead of slaughter cows. The specific objective is to compare the profitability of marketing cull cows as bred cows and slaughter cows under two retention systems.

4.2 Conceptual Framework

The producer must consider the trade-off between potential returns and anticipated costs before deciding to retain and feed cull cows in any delayed marketing scenario. Profitability of delayed marketing for marketing cull beef cows either as slaughter or bred cows is not only influenced by weight gain, but also by input and output prices, length of feeding, and seasonal price changes. Assuming the producer owns or has access to a bull, penning the bull with retained cull cows may increase the number of cull cows available to market as bred cows instead of slaughter cows. The producer's choice in maximizing net returns from retaining cull cow c for i feeding periods to be marketed as a slaughter or bred cow relative to culling revenue at weaning (i=0) can be mathematically expressed as follows:

$$\text{Max } NR_{ijc} = \begin{cases} P_{ojc}W_{ojc}, \text{ for } i = 0 \\ P_{ijc}W_{ijc} - P_{ojc}W_{ojc} - \sum_{i=1}^{5} C_{ij}, \text{ for otherwise} \end{cases} \tag{4.1}$$

where NR_{ijc} is total net return from selling cull cow j sold as c bred or slaughter cows at feeding interval i (where $i \epsilon$ (1, 2, 3, 4, 5), P_{ojc} is the price for cow c at culling sold as slaughter, W_{ojc} is the weight for cow c at the time of culling sold as slaughter P_{ijc} represents the price for cull cow c at marketing period i at feeding system j, W_{ijc} is the ending weight for cow c at marketing interval i on feeding system j, and C_{ij} is the cumulative retention cost from the culling point to the marketing period for cow c at feeding interval i. For an individual cow c, the optimal marketing period i (at culling or at the end of a subsequent feeding interval) is that period in which net return over retention cost is maximized.

4.3 Data

Study data is the result of a three year experiment conducted at the Samuel Roberts Foundation in Ardmore, Oklahoma from October 2007 to March 2010. The experiment included a total of 162 cull cows equally assigned to low-cost dry lot and native grass pasture systems. Data were collected for cull cows in October 2007 and marketed in April 2008 cows collected in October 2008 and marketed in March 2009, and finally cows culled in October 2009 and marketed in March 2010. The study specifically included 48 cull cows in year 1, 43 cull cows in year 2 and 71 cull cows in year 3. In each year, individual cow data were measured at approximately monthly intervals on weight, USDA grade, dressing percentage, and cost components.

Note that during each experiment period, a bull was assigned to each group of cull cows (dry-lot and pasture). In the dry-lot system, cows were fed on hay and protein cubes. From mid-October to December, cow in the dry-lot system were fed 10% crude protein and then switched to 25% protein cubes for the rest of the retention period. Cows maintained in the pasture system grazed on stockpiled native grass pasture supplemented with hay and cubes only during icy periods. Each group additionally received mineral supplement.

Price data series for both slaughter and bred cows reported by Agricultural Marketing Service's (AMS) are collected. Price data for cull cows is taken from the Slaughter Cow portion of AMS price reports $KO - LS155$ and $KO - LS795$ for Oklahoma National Stockyards, Oklahoma City, as summarized by the Livestock Market Information Center from 2003 to 2010. Similarly, price data for bred cows classified as medium-large and middle aged (4-6 years) are taken from the bred cow portion of Agricultural Marketing Service's (AMS) price report $LS-214$ for Oklahoma National Stockyards, Oklahoma City, as summarized by Livestock Market Information Center from 2004 to 2011. Price response functions for both slaughter and bred cows were estimated and used to assign market value for individual cows at each period under the two alternative marketing scenarios. The first scenario assumes that cull cows are marketed as slaughter cows while the second scenario assumes cull cows are marketed as bred cows.

The cost components including feed, pasture, labor and operating interest were considered in this study. Feed cost data are assigned as per a cow average by marketing interval and management systems for an individual cow and is the same under the slaughter cow scenario and the bred cow scenario. Feed data includes protein range cubes (pounds fed), mineral supplement (pounds fed), and hay (tons fed). Rye hay cost is based on tons fed and priced as Grass hay East as reported by the Oklahoma Market Report, Oklahoma Department of Agriculture, Food and Forestry. Pasture costs were charged a per acre cash rental rate based on local rates and consistent with rates reported by Doye and Sahs (2011) for native pasture in the East region of Oklahoma. Labor is tracked in hours per feeding period for each system and assigned a wage rate comparable to that offered locally for hourly ranch hands during the study period as reported by Oklahoma Department of Commerce (2009). Operating interest is charged at the annual rate of 7.5% on the estimated value of the cow at the initial culling. Mineral and cubes were charged a price per pound consistent with prices reported by the local mill.

4.4 Methods and Procedures

Monthly data reported by Agricultural Marketing Services (AMS) are used to estimate price response functions for both slaughter and bred cows. As shown in the equation in 3.4, slaughter cow price measured as function of month and quality grade can be expressed as follows:

$$P_{smgt} = \beta_0 + \sum_{m=1}^{11} \beta_m M_m + \sum_{g=1}^{2} \alpha_g Q_g + \mu_t + \varepsilon_{mgt} \tag{4.2}$$

where P_{smgt} represents slaughter cow price at month m (m=1...12) at given quality grade g (g=1, 2, 3), Q_g are dummy variables for quality grade, μ_t is a year random variable with $\mu_t \sim N(0, \sigma_t^2)$, ε_{mgt} is a random error term with $\varepsilon_{mgt} \sim N(0, \sigma_\epsilon^2)$, and β_m, α_g are parameters to be estimated.

Similarly, the price response function for bred cows can be mathematically described as follows:

$$P_{bwt} = \alpha_0 + \sum_{m=1}^{11} \alpha_m M_m + \sum_{l=1}^{2} \alpha_l W_l + v_t + \mu_{bmt} \tag{4.3}$$

where P_{bwt} is the bred cow price b at month m in year t, M_m is a dummy variable for month m, W_l is the weight in pounds of cow i at month m, W_l is a dummy variable for weight l (l=medium, heavy) with W < 1100 as small weight, medium as

1100 $\leq$ W $\leq$ 1200, and heavy weight as W >1200, v_t is the year random variables, and $v_t \sim N(0, \sigma_t^2)$, μ_{bmt} is random error term where $\mu_{bmt} \sim N(0, \sigma_t^2)$, and α_m and α_l are parameters to be estimated. Alternatively, a trigonometric form for the price response function for bred cows is also considered and can be expressed as follows:

$$P_{bwt} = \alpha_0 + \alpha_1 \mathrm{M} + \sum_{n=1}^{3} \sum_{T=4}^{12} [\mathrm{a_n} \cos\left(\frac{2\pi \mathrm{M}}{\mathrm{T}}\right) + \mathrm{b_n} \sin\left(\frac{2\pi \mathrm{M}}{\mathrm{T}}\right)] + \sum_{l=1}^{2} \alpha_l \mathrm{W_l} + \mathrm{v_t} + \mu_{\mathrm{bwt}} \quad (4.4)$$

where P_{bwt} is the price of bred cow b at month m in year t, M is dummy variable for month m, W_l is the dummy variable weight for l (l=light, medium, and heavy) with weight categories as previously defined, T is the frequency (T=4, 6, 12), n=1, 2, 3, v_t is the year random variables, and $v_t \sim N(0, \sigma_t^2)$, μ_{bmt} is random error term where $\mu_{bmt} \sim N(0, \sigma_t^2)$, and α_0, α_1, α_l, a_n, and b_n are parameters to be estimated. The estimated price response functions are used to calculate net returns relative to culling for each feeding period under each marketing scenarios as described in equation 4.2.

To determine optimal marketing scenarios, net returns are regressed on marketing period defined by retention beyond culling (35, 63, 91, 126, and 155), management system (dry lot and pasture), and cow market (slaughter and bred). This relationship can be written as follows:

$$NR_{ijk} = \mu + \alpha_i + \beta_j + \theta_k + \alpha\beta_{ij} + \alpha\theta_{ik} + \beta\theta_{jk} + \alpha\beta\theta_{ijk} + \mu_t + \varepsilon_{ijk} \quad (4.5)$$

where NR_{ijk} is the adjusted mean for net return for a given cow type i (i= slaughter and bred) on treatment level j (j=pasture or dry-lot) at time k (k=0, 35, 63, 91, 126, and 155), μ is a constant representing the overall mean, α_i is cow type i effect, β_j is the management system j effect(pasture, dry lot), θ_k is the feeding period k effect, $\alpha\beta_{ij}$ is the cow type and treatment interaction, $\alpha\theta_{ik}$ is the cow type and marketing period interactions, $\beta\theta_{jk}$ is management system and marketing period interaction effect, $\alpha\beta\theta_{ijk}$ is the cow type, feeding period and treatment interaction effect, μ_t is the year random effect with $\mu_t \sim N(0, \sigma_\mu^2)$, and ε_{ijk} is the random error term with $\varepsilon_{ijk} \sim N(0, \sigma_\epsilon^2)$. The model shown in equation 4.5 has both fixed and random effects.

Therefore, a restricted maximum likelihood estimation technique with unstructured covariance matrix is used to fit the model.

4.5 Results

Table 4.1 reports coefficients for slaughter cow price and for bred cow price as function of monthly dummy variables and quality grade(slaughter) or weight category (bred). Price response function coefficient estimates for bred cow price as a trigonometric function are reported in table 4.2. Recall that in section 3.4, the monthly dummy variable model was shown to best represent the slaughter cow price. A comparison of the two functional forms for the bred cow price response results in $\chi^2_4 = -2701.1_U + 2746.7_R = 45.6$, where the trigonometric model (10 parameters) is a restricted version of the dummy variable model (14 parameters). Comparing the test value $\chi^2_4 = 45.6$ to the critical chi-square value ($\chi^2_c = 9.48$) concludes that the dummy variable model is also more appropriate for the bred cow price than the trigonometric model.

Bred cow price function coefficients for January, February, March, April, May, August and December are positive and statistically significant when compared to the base month of October, indicating that the seasonal low price occurs in October. Coefficients for medium and heavy weight cows are positive and significant related to weight, indicating that medium and heavy weight bred cows tend to bring higher prices relative to low weight bred cows. Results for the slaughter cow price response function show that dummy variables for February through September are positive and and significant relative to October, with the seasonal price upswing peaking in May. November is negative and significantly different from zero, indicating that the seasonal low price typically occurs in November. Results also show that breaker and boner categories are positive and significant as compared to price for the lean category.

Table 4.1: Bred cow price and slaughter cow price as function of monthly dummy variables and and quality grade (slaughter) or weight categories(bred)

		Bred Cows		Slaughter Cows	
Parameters	Independent variables	Estimates	P-values	Estimates	P- values
β_0	Intercept	700.05	< 0.0001	41.64	< 0.0001
β_1	Jan	30.54	0.0893	1.09	0.1644
β_2	Feb	66.29	0.0003	3.599	< 0.0001
β_3	Mar	68.24	0.0002	4.146	< 0.0001
β_4	Apr	60.64	0.00067	4.1619	< 0.0001
β_5	May	37.40	0.0307	4.604	< 0.0001
β_6	June	25.82	0.1449	3.311	< 0.0001
β_7	July	17.13	0.3317	4.600	< 0.0001
β_8	Aug	41.10	0.0248	3.634	< 0.0001
β_9	Sept	17.18	0.3241	3.808	< 0.0001
β_{10}	Nov	15.06	0.33877	-1.669	0.0196
β_{11}	Dec	33.75	0.0572	-0.989	< 0.0001
α_1	Medium Weight(D2)	29.50	0.0010		
α_2	High Weight(D3)	42.27	< 0.0001		
α_3	Breaker			6.308	< 0.0001
α_4	Boner			6.740	< 0.0001
-2LogLikelihood		2701.1		5807.5	

Table 4.2: Estimated bred cow price as a function of month and weight category using the trigonometric function.

Parameters	Independent variables	Estimated coefficients	Standard Errors	p-values
β_0	Intercept	713.18	29.1143	< 0.0001
β_1	Month	3.2570	3.0748	0.2906
β_2	Cosine1	3.9414	6.0531	0.5156
β_3	Sine1	0.5977	5.9334	0.9198
β_4	Cosine2	-12.9800	6.0310	0.0324
β_5	Sine2	11.5578	7.3607	0.1177
β_6	Cosine3	-6.0138	6.0127	0.3182
β_7	Sine3	36.2446	12.6190	0.0044
α_1	Medium Weight(D2)	29.4475	8.7803	0.0009
α_2	Heavy Weight(D3)	42.5468	9.0221	< 0.0001
σ_t^2	Year Random effect	3315.76		
σ_ε^2	Variance of error term	3368.16		
-2LL	Loglikelihood	2746.7		

Table 4.2 presents results of the bred cow price response function as described in equation 4.4. Medium weight and heavy weight categories are positive and significant related to price compared to the light weight category.

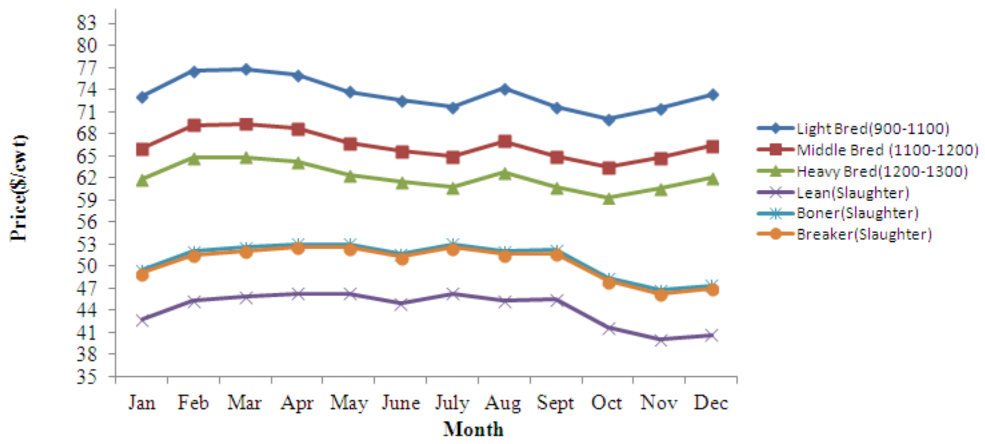

Figure 4.1: Seasonal price patterns of slaughter and bred Cows, 2004-2010

Figure 4.1 illustrates the seasonality of both slaughter and bred cows by plotting the respective price response functions. Seasonal patterns of the two price series are similar. Note that for the purpose of comparison only, bred cow prices are converted to a \$/cwt basis rather than \$/head. Bred cow price peaks in March with prices lowest in October. Slaughter cow price peaks in May with prices lowest in November. Bred cow prices are higher on a \$/cwt basis than slaughter cow prices for all time periods. This relationship further illustrates the potential for higher salvage values in marketing cull cows as bred cows.

Table 4.3 reports adjusted mean net returns to retaining beyond culling for the two cow categories across management systems and weigh periods. Results indicate that net returns for cows marketed as slaughter and retained in a dry lot are negative and significant, while net returns for cows marketed as bred and retained in the dry lot system are positive and significant for all periods. Results showed that net returns for cows marketed as slaughter and retained on pasture are positive and significant at marketing period, ranging from \$13.57 at 35 days to a peak of \$61.80 at 155 days, peaking at 155 days beyond culling. Those same cows retained on pasture and marketed as bred cows result in higher net returns, with a range of \$131.20 (155 days) to a peak of \$174.14 at 63 days beyond culling. Results further indicate that the change in net returns for retaining cows on dry lot and marketing as bred is positive and significant ($p \leq 0.10$) at each marketing period with the low at 155 days (\$56.58) and high at 35 days (\$127.06). This implies that there is potential to increase net returns by retaining cull cows beyond for delayed marketing as slaughter or potential bred cows on pasture. Results also highlight the potential to increase net returns for cows marketed as bred, regardless of marketing periods and management systems. We also examine the sensitivity of net returns to a $\pm$ 10% change in cost in table 4.3. This change affects only the magnitude of net returns, but signs of net returns remain changed, leaving the general result unchanged.

Table 4.3: Revenue at culling and net returns from delayed marketing by management systems and cow types across alternative marketing intervals.

		Marketed as Slaughter Cows			Marketed as Bred Cows		
Systems	Days Beyond Culling	Pooled	-10 % Cost	+10 % Cost	Pooled	-10 % Cost	+10 % Cost
Revenue at Culling	0	599.70			599.70		
Pasture	35	13.57* (0.0525[a])	15.07* (0.0312)	12.07* (0.0848)	135.38* (< 0.0001)	136.89* (< 0.0001)	133.88* (< 0.0001)
	61	33.52* (< 0.0001)	34.64* (< 0.0001)	32.38* (0.0001)	174.14* (< 0.0001)	175.27* (< 0.0001)	173.01* (< 0.0001)
	91	49.22* (< 0.0001)	51.55* (< 0.0001)	46.88* (< 0.0001)	142.79* (< 0.0001)	145.13* (< 0.0001)	140.45* (< 0.0001)
	126	41.89* (< 0.0001)	44.6* (< 0.0001)	39.17* (0.0005)	3150.50* (< 0.0001)	153.21* (< 0.0001)	147.78* (< 0.0001)
	155	61.8* (< 0.0001)	64.45* (< 0.0001)	59.14* (< 0.0001)	131.20* (< 0.0001)	133.86* (< 0.0001)	128.54* (< 0.0001)
Revenue at Culling	0	604.00			604.00		
Dry lot	35	-15.63* (0.0258)	-11.76* (0.0924)	-19.49* (0.0056)	126.06* (< 0.0001)	130.92* (< 0.0001)	123.19* (< 0.0001)
	63	-35.12* (< 0.0001)	-28.29* (0.0005)	-41.95* (< 0.0001)	72.02* (< 0.0001)	78.85* (< 0.0001)	65.19* (< 0.0001)
	91	-20.91* (0.0327)	-12.80* (0.1850)	-29.01* (0.0035)	83.20* (< 0.0001)	91.31* (< 0.0001)	75.10* (< 0.0001)
	126	0.54 (0.9604)	10.30 (0.3276)	-9.23 (0.4059)	58.67* (< 0.0001)	68.44* (< 0.0001)	48.89* (< 0.0001)
	155	-25.37* (0.0184)	-14.83* (0.1513)	-35.90* (< 0.0001)	56.58* (< 0.0001)	67.12* (< 0.0001)	46.04* (< 0.0001)
-2LogLikelihood		18379.9	18346.5	18414.4			

[a]Numbers in parentheses are p-values and ∗ denotes statistically significant at p $\leq$ 0.10

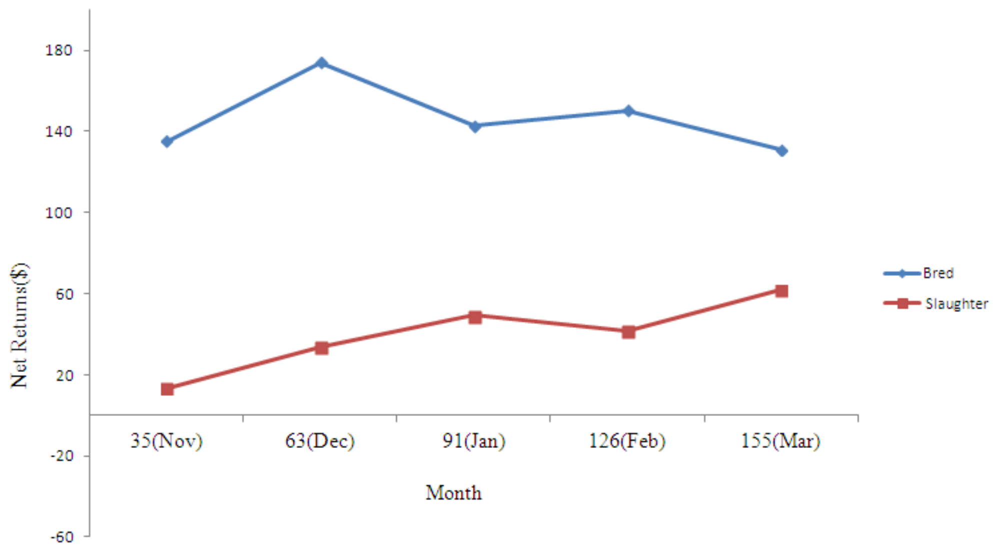

Figure 4.2: Net returns comparison for cull cows retained on pasture marketed as slaughter versus bred Cows

Figure 4.3: Net returns comparison for cull cows retained on dry lot marketed as slaughter versus bred Cows

Figures 4.2 and 4.3 illustrate net returns for bred and slaughter cows retained in pasture and dry lot. Net returns for bred cows on pasture appear higher than those same cows marketed as slaughter cows, regardless of marketing periods (Figure 4.2). The same is true for cull cows retained in the dry lot setting (Figure 4.3). Table 4.4 compares the change in net returns from delayed marketing of cull cows relative to revenue if sold at culling across cow marketing category, alternative marketing intervals, and feeding systems. Coefficients estimates compare bred cow net returns relative to marketing as culls as slaughter cows. Positive net returns favor marketing cows as bred, while negative net returns favor marketing cows as slaughter. Change in net returns beyond culling for pasture cows marketed as bred are significantly higher than that of pasture cows marketed as slaughter, regardless of feeding periods and management systems. The difference is highest at 63 days beyond culling where net returns relative to revenue at culling for marketing pasture cows are \$140.62 significantly higher than when marketing them as slaughter cows. The difference in net returns is smallest at 155 days (\$69.40) for pasture cows marketed as bred rather than as slaughter cows. Results also indicate changes in net returns relative to revenue at culling for cows retained in a dry lot and marketed as bred cows are significantly higher than changes in net returns when those same cows are marketed as slaughter cows. The result holds for all periods. The highest difference in net returns occurs at 35 days where marketing as bred is \$142.68 more than marketing as slaughter. However, the more likely scenario is that the cow would be marketed as bred at the 63 days period or beyond, since she was presumably open at culling. The exception would be a cull cow that was a late breeder and incorrectly presumed open at culling. The smallest changes in net returns relative to revenue at culling for dry lot cows marketed as bred compared to those for dry lot marketed as slaughter occur at 126 days beyond culling (\$58.13)

A comparison of net returns from retention of cull cows on dry lot and pasture

Table 4.4: Change in net returns from delayed marketing relative to revenue at culling by alternative marketing interval, management systems, and cow marketing category.

			Pasture system	Dry lot system
Days Beyond Culling	Cow types		Pooled	Pooled
0	Revenue at Culling		599.70	604
35	Bred	Slaughter	121.81* (< 0.0001[a])	142.68* (< 0.0001)
63	Bred	Slaughter	140.62* (< 0.0001)	107.14* (< 0.0001)
91	Bred	Slaughter	90.57* (< 0.0001)	104.12* (0.0112)
126	Bred	Slaughter	108.61* (< 0.0001)	58.13* (0.0002)
155	Bred	Slaughter	69.40* (< 0.0001)	81.95* (< 0.0001)
35-63	Slaughter	Slaughter	-19.94* (0.0545)	19.49* (0.0600)
63-91	Slaughter	Slaughter	-15.70* (0.0965)	-14.21* (0.1324)
91-126	Slaughter	Slaughter	7.33 (0.5244)	-21.44* (0.0632)
126-155	Slaughter	Slaughter	-19.90* (0.0372)	25.90* (0.0068)
35-63	Bred	Bred	-38.75* (0.0002)	-47.08* (< 0.0001)
63-91	Bred	Bred	31.34* (0.0010)	-11.18 (0.2360)
91-126	Bred	Bred	-7.70* (0.5034)	-67.28* (< 0.0001)
126-155	Bred	Bred	19.29* (0.0434)	2.08 (0.8265)
	-2LogLikelihood	18379.9		

[a]Numbers in parentheses are p-values and $*$ denotes statistically significant at $p \leq 0.10$

across adjacent feeding intervals in the same system is also reported in table 4.4. When comparing time intervals, negative net returns favor the second time period in the interval, while positive net returns favor the earlier time period in the interval. The change in net returns for pasture cows marketed as slaughter is statistically higher at 63, 91, and 155 days as compared to net returns in the immediately previous period. There is no statistical difference in net returns from retaining cows on pasture from 91 to 126 days to market as slaughter. There is, however, a significant increase in net returns in marketing pasture cows at 155 days rather than 126 days. When cows are retained in the dry lot setting and marketed as slaughter, results favor marketing at 126 days. When marketing cows as bred, pasture cows peak in net returns at 63 days. Marketing pasture cows as bred beyond 63 days results in a negative change in net returns. Dry lot cows marketed as bred reach peak net returns at 35 days, with zero or statistically negative changes in net returns for holding bred cows in a dry lot setting beyond 35 days.

4.6 Conclusions and Recommendations

This research sought to determine whether the salvage value of cull beef cows is increased when cull cows are retained and marketed as bred cows instead of as slaughter cows. This three-year study included 162 cull cows equally assigned to dry lot and pasture retention systems at the Samuel Roberts Noble Foundation, Ardmore, Oklahoma. Results suggest that marketing cows as bred cows is significantly higher than those generated when marketing cows as slaughter cows. However, net returns for slaughter cows on pasture are more profitable than net returns of slaughter cows retained on dry lot. Net returns of bred cows retained on pasture suggest that it is most profitable to market bred cows after retaining them for about 63 days. However, positive net returns over value at culling persist throughout the retention period. Net returns of bred cows held on dry lot are highest at 35 days, but this would presume that the cow was incorrectly assumed open at culling. The potential to add value to cull cows that breed back relative to value if marketed at culling persists in both retention systems throughout the periods analyzed. Ranchers should consider potential weight gain, seasonal price movements, bull accessibility and cost, and potential for inexpensive gain when considering whether and how long to retain cull cows before marketing them. In general, producers must know their cost and available resources in both slaughter and bred cow retention programs to add potential value and take advantage of the market dynamics.

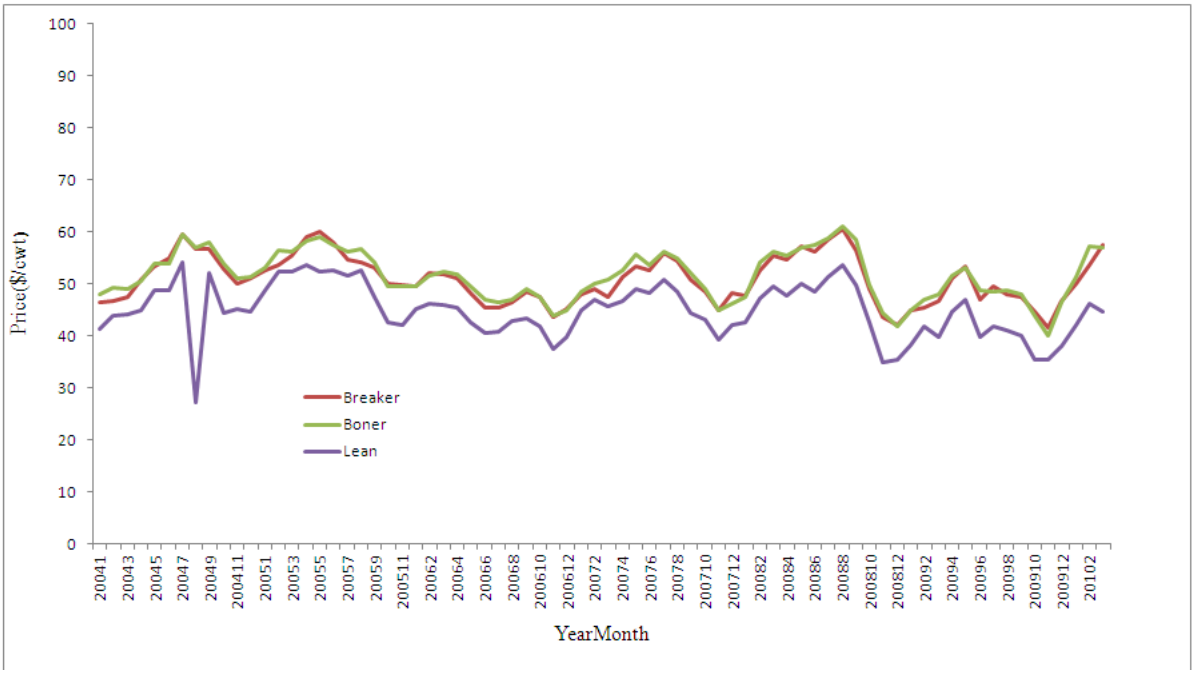

Figure 4.4: Slaughter cow price series as reported by AMS from 2004 to 2010

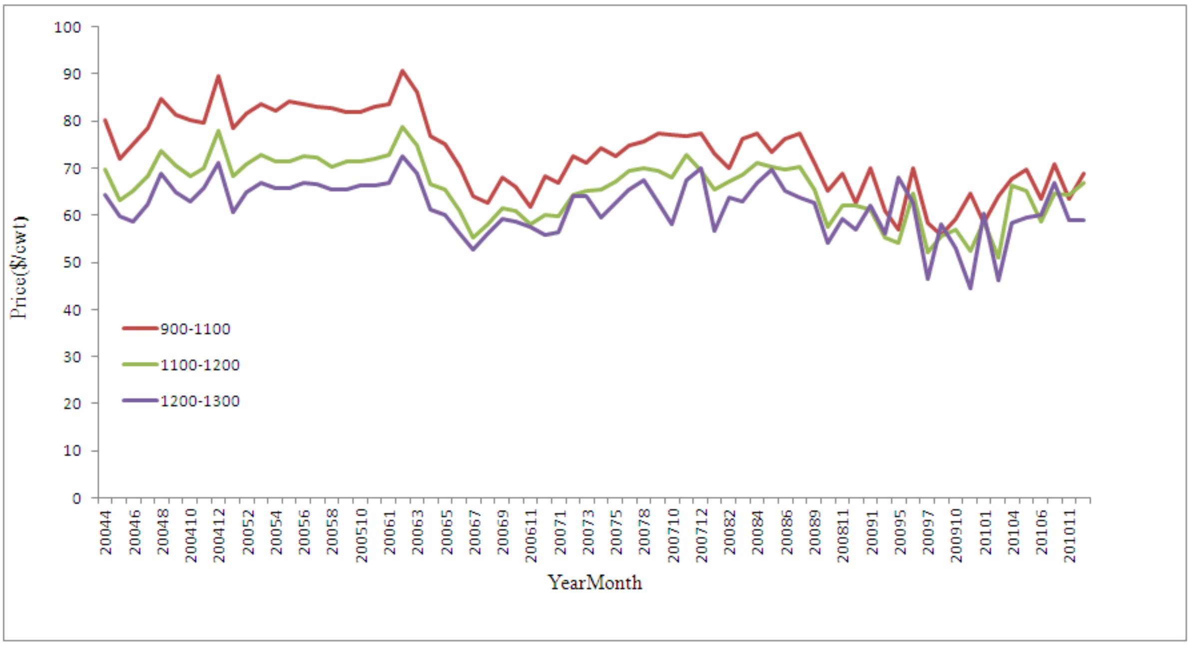

Figure 4.5: Bred cow price series as reported by AMS from 2004 to 2010

CHAPTER 5

SUMMARY and CONCLUSIONS

This dissertation adds to the literature of cull beef cow management and marketing by assessing alternative marketing strategies for cull cows, influence of body condition scores on net returns, and the economics of marketing cull cows as bred cows instead of slaughter cows using production and cost data from three year experiment

For objective 1, this study investigated whether net returns are higher if cull cows are sold immediately after being culled from the herd or kept and fed on native grass pasture or a low-cost dry lot for alternative periods of time. Estimated USDA grade and dressing percentage were used to assign a price to each cow at each feeding interval, based on prices reported by the Agricultural Marketing Systems (AMS). In addition, price response function as a function of yield and months were also used to assign value to each cow at each weigh period.

Cows in both treatments initially gained weight. Cows in the pasture system lost weight beyond 91 days while the dry lot cows generally maintained weight. However, net returns of dry lot cows as compared to revenue if sold at culling were generally negative regardless of the marketing period. That is, the cull cows retained in the dry lot would be more profitable; therefore they should be sold at culling. Net returns for cows retained on pasture were generally profitable if held beyond culling, with net returns over revenue at culling peaking at 155 days beyond culling. ADG for both pasture and dry lot peaked at the beginning then progressively declined as the feeding length increases. ADG of pasture cows were generally less than ADG of dry lot. This implies that the profitability of retaining cull cows depends more on seasonal price increases than weight gain. The average cost per cow for the retention system is also a crucial factor. Therefore, producers should consider the weight, the body condition scores of cows at culling, potential for gain at reasonable cost, results at various potential end points, and the normal seasonal price pattern when considering how long to feed cull cows before marketing them. In sum, producers should consider their own available resources and how to best use these resources.

Next, the second objective of the the study investigated the influence of beginning body condition score on net returns from retaining cull cows. Overall, beginning body condition scores appear to be an important factor in determining net returns from retaining cull cows beyond the culling date. As such, beginning body condition scores should also play an important role in the producer's decision of whether to market cull cows at the time of culling or to retain and feed them for a period of time. In this study, cows classified as heavy at culling (beginning BCS > 6) generated negative and significant net returns for the pasture management system at all weigh periods using both the actual price and the estimated price. Cows with lower beginning BCS scores(≤ 5.0) generally yielded higher net returns than heavy cows. Regarding physical performance measures, ADG decreased over time for each BCS category in each management system, but thin and medium cows tended to have a higher ADG than heavy cows in each system. This can likely be attributed to the fact that for heavier more conditioned animals, more energy goes to weight maintenance relative to energy contributing to weight gain. From a practical management perspective, together these results suggest that heavy cows be sold immediately after culling.

As with objective 1, results favor a pasture retention system over a low cost dry lot retention system. Net returns relative to revenue at culling are higher for pasture system cows than dry lot cows at each marketing interval for each BCS category. That is, the potential for positive net returns compared to revenue at culling is higher in the pasture system than in the dry lot system. This would suggest that an accurate assessment of relative feed costs of available retention systems, along with predicting the likely magnitude of seasonal price movements in the cull cow market is particularly important in the decision to hold cows beyond culling.

The beginning BCS appears to be an important factor in determining which cull cows to retain and feed. In the context of producer decisions regarding feeding cull cows, results suggest that producers should carefully consider the body condition score of cows when making the decision to retain and feed versus marketing cows at culling. While our study suggests that a pasture system was generally more profitable than a dry lot system, thin and medium cows generated higher net returns than cows with higher BCS, regardless of the feeding system. Producers may significantly improve the salvage value of cows at weaning by retaining and feeding thin and healthy cows on underutilized, low-cost, and low-quality forages.

Finally, objective 3 analyzed the economics of marketing cull cows as bred cows. This research component sought to determine whether the salvage value of cull cows is improved when cull cows are retained and marketed as bred cows rather than as slaughter cows. Net returns are compared when cull cows marketed as bred as compared to revenue at culling if marketed as a slaughter cows. Results suggest that there is potential to increase net returns of marketing cows as either bred or slaughter when retained on pasture, but net returns generated from marketing cull cows as bred cows were significantly higher than those when culls were marketed as slaughter cows. However, net returns for slaughter cows retained on pasture were higher than net returns of slaughter cows retained in a dry lot. Marketing cull cows as bred cows rather than slaughter cows generated higher net returns above marketing as slaughter at culling for both retention systems and for all marketing periods.

In any retention and delayed marketing decisions for cull cows, ranchers should consider weight gain, seasonal price movements, body condition scores and potential for low-cost gain. Additionally, producers should consider their own cost, available resources including availability of bulls and retention space, and how to best use those resources in adding value using a cull cow retention program. Forage production, highly dependent on rainfall and soil moisture, may influence producers' decisions from year to year.

5.1 Limitations and Directions for Future Research

Several limitations of this research also are worth highlighting. The main limitations of this research include equal cost assigned to cows whether marketed as slaughter or bred cows, relatively short price data series used to estimate price response functions, comparison of the opportunity cost of using these resources to feed cull cows relative to more productive cows excluded from the analysis, the cost component related to pregnancy-test is not included in the analysis, unequally spaced marketing periods, and skewed body condition score distribution. Assigning equal cost to cows with different weight and BCS may over or under estimate the cost component, thereby increasing or decreasing net returns. Short price data series may have low variability, leading to less variation in revenue among cows. The cost for pregnancy testing ($6/head)is insignificant when expense of carrying an open cow for a year is considered and it is less likely to affect initial analyses.

Further research comparing retaining and marketing cull cows as cow-calf pairs instead of as bred cows or slaughter cows could be useful. In addition, assigning individualized feeding cost based on body condition and weight basis (actual feed intake) may help producers better assess resource needs, thereby enhancing decision-making for the cow-calf operation.

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This study compares alternative marketing strategies with the traditional practice of marketing spring-calving cull cows in the fall immediately after weaning. Specifically, this dissertation investigates value-added marketing strategies for cull cows, with particular attention on how alternative feeding systems, beginning body condition scores and marketing cull cows as bred cows instead of as slaughter cows improve the salvage value. First, this work examines the profitability of delayed marketing of cull cows held in two different retention feeding systems. In each of three culling years, net returns based on physical performance data and financial data were measured at five approximately monthly intervals for cull cows retained on stockpiled native pasture versus a low-cost dry lot setting. Results favor the lower-cost, forage-based feeding program with spring marketing over fall marketing. Low-cost weight gain coupled with seasonal increases in slaughter cow prices combined to increase net returns for retaining and feeding cows on lower-cost forage for about four months. The impact of beginning body condition scores on net returns from marketing cull cows at culling or retaining cull cows for delayed marketing is also investigated. Net returns are examined across marketing periods relative to the use of body condition score at culling as a sorting trigger. While a pasture system was generally more profitable than a low-input dry lot system, cows with lower beginning BCS were more profitable than cows with higher beginning BCS, regardless of the feeding system. Finally, this study examines whether the salvage value of cull cows can be improved by retaining cows with a bull and marketing them as bred cows instead of as slaughter cows. Results reveal that marketing cull cows as bred cows was more profitable than marketing them as slaughter cows, regardless of retention systems or retention period length, assuming the producer has the resources to do so. Additionally, while results indicate that retaining cull cows in the dry lot system was not profitable if cows were marketed as slaughter cows, the retention system becomes profitable if cull cows can be marketed as bred cows.

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