Price Determinants of Bred Cows in Oklahoma Auctions

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1.0 Introduction

Bred cows are an input into beef production. Often producers are directly marketing their bred cows as beef replacement animals. Alternatively, many producers are capitalizing on alternative marketing opportunities and are selling their cull cows as bred. Research has determined that cull cow retention and marketing as bred has the potential to be a profitable opportunity for cow-calf producers (Amadou). Past research has also identified several other replacement cow marketing and procurement strategies (Trapp; Lawrence). However, in auctions across the state of Oklahoma quality variation in the bred cows sold is noticeable. No previous research has considered the contribution bred cow traits have on their total value.

Bred cow price differentials are a consequence of many factors including their physical characteristics. The variability in bred cow prices suggests that producers are considering production decisions and are purchasing bred cows based on the perceived value of specific traits. A standard methodology to quantify product differentiation and price variability is the hedonic approach.

Numerous studies have implemented hedonic analysis to examine the relationship between the characteristics of agricultural commodities and their corresponding prices. Specifically, a considerable amount of effort has been devoted towards identifying factors that impact feeder cattle prices. Results from these academic studies provide producers with valuable information on the linkage between specific characteristics and their accompanying premiums and discounts.

This paper addresses the question of: how physical characteristics, temporal, and marketing factors influence the price of bred cows sold in auctions across the state of Oklahoma. Research on bred cow price determinants will provide sellers with information on which traits buyers find desirable. Furthermore, buyers will be able to make use of these results and make more efficient production decisions as it relates to replacement cow procurement.

2.0 Literature Review

Hedonic models have become a standard approach for evaluating the value of product characteristics. There is a variety of literature in the development and application of hedonic analysis. There is no known work that investigates the value of bred cow characteristics, however, there are a number of studies that employ hedonic regression to evaluate livestock characteristics of different classes of cattle in the beef industry.

2.1 Historical Studies

Literature on the hedonic approach dates back as far as the early 1900's. Frederick Waugh was one of the first to present research on the impact physical characteristics have on product prices. Among the studies that advanced our knowledge of hedonic analysis, Lancaster, Rosen, and Ladd and Martin are cited as being significant contributors to the topic.

Lancaster argues that utility is derived not from the goods being consumed; instead, utility is derived from the characteristics of the goods being consumed. While Lancaster's research had implications for consumer theory, Rosen's work had more general implications for hedonic pricing methods. Rosen proposes that product prices are equal to the summation of their implicit hedonic prices.

Ladd and Martin employ a product characteristic approach to farm production inputs. The significant findings from their input characteristic model (ICM) illustrate how the value of production inputs are equal to the sum of the implicit marginal value of the input characteristics. The conceptual framework developed in Ladd and Martin has been implemented in numerous academic papers to estimate the value of livestock traits.

2.2 Empirical Livestock Studies

Several studies have quantified the effect of various animal characteristics and market influences on feeder cattle prices. The relative premiums and discounts attributed to these characteristics is well documented in the academic literature (e.g., Buccola; Marsh; Faminow and Gum; Baily, Peterson, and Brorsen; Schroeder, Mintert, Brazle, and Grunewald; Coatney, Menkhaus, Schmitz; Barham and Troxel; Avent, Ward, and Lalman; Williams, Raper, DeVuyst, Peel, and McKinney; Zimmerman, Schroeder, Dhuyvetter, Olson, Stokka, Seeger, and Grotelueschen). As production and marketing practices have continued to evolve researchers have continued to refine the research on feeder cattle price determinants.

Fewer academic studies have determined the impact of animal characteristics on the value of cows. The studies that have investigated the price determinants of breeding stock and cull cows provide insight towards characteristics and an overview of a methodology that should be considered in an analysis of bred cow price determinants. Prior to Parcell, Schroeder, and Hiner, no previous studies had determined the implicit value of cow-calf pair characteristics. Since, cow-calf pairs are sold as one product the characteristics each animal possesses are bundled together, making them one input into beef production. In the study, the price paid for each pair is a function of the sum of the values of marginal yields of characteristics in beef production (Parcell, Schroeder, and Hiner). Their results show that cow age has a nonlinear effect, with two-year-olds receiving the highest premiums. Relative to average condition, very thin cows received $37.81/ pair discounts. Unhealthy cows are discounted $69.69/pair. Relative to healthy calves, unhealthy calves received $132.29/pair discounts. The article concludes that young, healthy cows with a large, healthy calf received the highest premiums.

Mintert et al. explain cull cow short-run price variability by estimating a comprehensive model of cull cow physical characteristics. Physical characteristics and market factors included in the model are: weight, dressing percentage, lot size, health, breed, time, location, age, and pregnancy. Results from their study demonstrate that a major portion of variability in Kansas cow prices is attributed to lot size, health, and dressing percentage (Mintert et al., 1999).

3.0 Bred Cow Pricing Model

The total value of a bred cow depends upon their physical characteristics. The characteristics bred cows possess contribute to their total value as an input and later their contribution to future beef production. When producers invest in bred cows they must consider both the discounted returns from that animal as well as the salvage value. As a result, we include cull value as a proxy for the salvage value of a bred cow. The total value of a bred cow is equal to their salvage value plus the value of their desirable characteristics as an input into beef production.

Ladd and Martins Input characteristic model (ICM) provides a framework for researchers to model livestock price determinants. Through previous extensions of ICM (Schroeder et al; Dhuyvetter et al.; Parcell, Schroeder, and Hiner; Williams et al;), the price of a lot of bred cows can be specified as a function of physical characteristics (C), Salvage Value (S), and market forces (M), formulated as:

$$Price_{it} = \sum_k V_{ikt}C_{ikt} + \sum_h R_{ht}M_{ht} + G_tS_t \qquad (1)$$

where *i* refers to a lot of bred cows sold in week *t*, *k* refers to a specific bred cow trait, and *h* refers to a market force. The value of each bred cow physical characteristic specified as *V*, and *G* represents their underlying salvage value. The effect of market forces is represented by *R*. In the livestock marketing literature, researchers have used feeder cattle futures prices as proxy for expected output prices to reflect market forces and price expectations (Schroeder et al.). When producers consider investing in bred cows as an input, they do so with the expectation that each cow bought will produce one calf per year over the course of their useful life. We use a cow-calf returns series to measure expectations about input prices and output prices on an annual basis. Equation (1) states that the price per head of a lot of bred cows sold equals the sum of the marginal implicit values of each lots characteristics (Ladd and Martin), the price effect of each market force (Mintert et al.; Schroeder et al.), and salvage value.

Equation (1) is estimated using multiple regression to determine the marginal implicit value of bred cow characteristics. Previous research has included random effects for sale location and use a mixed model approach to estimate the hedonic model (Williams et al.). Similarly, we include a random effect for each sale location for each observed time period to estimate equation (1). The mixed model can be expressed as:

$$Price = X\beta + Z\theta + \varepsilon \tag{2}$$

where *Price* is a vector of observations on the dependent variable, *X* is matrix of independent variables, β is a vector of fixed effects parameters to be estimated, *Z* is a matrix of variables identifying each sale location for each time period, θ is a vector of random effects to be estimated, and ε is the random error term.

4.0 Data and Methods

This paper uses fifteen years of Agricultural Marketing Service (AMS) auction reports for seven Oklahoma auctions. The Agricultural Marketing Service has reporters present at each of the seven Oklahoma auctions on the day of the sale. Sale reports are typically created on the day of the sale and released to the public the following day. We were granted access to the AMS archive system to collect sale reports from the years 2000 to 2015. Within AMS auction reports, bred cows are aggregated into homogenous groups and reported as lots with an unknown head count for each lot. Animals sold that do not accurately reflect the market for bred cows are not reported in the sale reports. For example, if a bred cow with a bad eye was sold, it would not be reported with bred cows of similar physical characteristics. The Livestock Marketing Information Center Staff developed an automated Excel program to process the AMS text files, totaling close to 6,000 individual files.

The auction reports include: date, price, age, weight, months bred, quality, location, and sale volume. All replacement cows are pre-tested for pregnancy, bangs, and age. The seven auctions included are Oklahoma City, Woodward, Apache, Ada, Tulsa, El Reno, and McAlester. The reports from the seven Oklahoma auctions are combined to create weekly cross-sections. Reports that are not reported correctly or have inconsistencies are dropped from the data set. The final data set includes 776 weeks comprised of 14,811 individual lots from January 5, 2000 to May 21, 2015. The price of a bred cow ranges from \$330/head to \$3400/head. Weights range from 700 pounds to 1700 pounds. Complete summary statistics are included in Table 1.

To estimate the mixed model expressed in equation (2) a semi-log functional form is specified, which is common in the hedonic literature. Traditionally researchers include weight and age as linear terms and often include a quadratic term. In doing so, researchers impose a functional form, which is convenient when data limitations are a concern. We include separate age and weight binary variables, so to not impose a functional form that may not necessarily fit their corresponding relationships with price. We use sine and cosine functions to account for seasonality because monthly dummy variables would not be suitable for weekly data. The empirical model to estimate is:

$$\ln(Price_{ity}) = \beta_0 + \sum_{j=1}^{9} \beta_1 Age_{ijt} + \sum_{j=1}^{8} \beta_2 MBred_{ijt} + \sum_{j=1}^{9} \beta_3 Wt_{ijt} + \sum_{j=1}^{4} \beta_4 Qlty_{ijt}$$

$$+\beta_5 Hcolor_{it} + \sum_{j=1}^{6} \beta_6\, Loc_{ijt} + \beta_7 Cycle_{iy} + \beta_8 ln(CPrice_{it}) + \beta_9 Sin\left(\frac{2\pi t}{T}\right) \qquad (3)$$

$$+\beta_{10} Cos\left(\frac{2\pi t}{T}\right) + \theta_{it} + \varepsilon_{ity}$$

where $Price_{ity}$ is the price of a lot of bred cows i at week t in year y, T denotes the frequency ($T=52$), θ_{it} is the random effect for each sale location for each time period, and ε is the random error term. Description of variables are presented in Table 2.

The hedonic pricing model was estimated using Maximum Likelihood Estimation (MLE) in SAS Enterprise Guide 5.1 using PROC MIXED. In order to estimate equation (3) a reference lot of bred cows was selected in order to avoid perfect multicollinearity. Three years of age was selected as the base age, while 901 to 1000 pounds was selected as the base weight class. Six months bred was selected as the base. Average quality was chosen as the base quality. Oklahoma City was chosen as the base sale location. In the semi-log functional form, coefficients for characteristics included as binary variables represent a percent price effect relative to the base level of each characteristic. Coefficients for variables included as continuous represent a percentage change in price for a 1 unit change in the characteristic.

There are two major concerns associated with the time-series, cross-sectional nature of the data set under investigation. The first being auto-correlation. Research interested in the determinants of livestock has most commonly been concerned with auto-correlation across pens of animals and across the time of the sale on a given day. While these could be major concerns in this paper, the data we were granted access to does not report when each pen sold and the lots themselves are aggregated into homogenous groups and are not necessarily the lots that were sold. The second concern is heteroscedasticity. We employ a likelihood ratio test, which indicated the presence of heteroscedasticity resulting from the variables: sale volume, average weight, average age, and average months bred per lot. Heteroscedasticity is corrected for by specifying multiplicative heteroscedasticity in the variance equation for the four variables, defined in (Judge et al. 1985) as:

$$E[e_{it}^2] = \sigma_{it}^2 = exp[\alpha_1 + \alpha_2 Vol_{it} + \alpha_3 AvgWt_{it} + \alpha_4 AvgAge_{it} + AvgMBred_{it}] \quad (4)$$

5.0 Results

Parameter estimates for equation 3 are reported in Table 3. Parameter estimates explain the variation in logged bred cow prices. Most variables are significant at the 1% level. There was not a significant difference between a lot of four-year-old and a lot of three-year-old bred cows. One month bred was significant at the 5% level. There was not a significant difference between nine months bred and six months bred. All coefficients have the expected sign. The magnitude of some of the parameter estimates was not as expected.

5.1 Effect of Age

Bred cows that were younger than three had a positive impact on price while those that were older than three had a negative effect on price. Bred cows sold as one-year-olds had the greatest positive impact on price; their respective price was 3.17% higher than a lot of three-year-olds. Ten-year-old bred cows received a price that was 23.20% below the price of a lot of three year olds. Eight and nine year olds brought 11.20% and 16.97% discounts respectively. Producers should aim to sell bred cows that are three years of age or younger. While there is risk associated with buying first calf heifers and young bred cows, the risk is outweighed by the expected useful life of a young bred cow.

5.2 Effect of Weight

Weight appears to have a positive but diminishing impact on price (Figure 2). All of the parameter estimates for the different weight ranges are significant at the 1% level. Cows in weight ranges below 901 to 1000 pounds received discounts. The heaviest weight range, 1601 to 1700 pounds, received the highest premium, 14.32%, relative to the base weight range. It is difficult to draw conclusions about cow size and cow weight. We suspect that there is an interaction between months bred and cow weight. In recent years, there has been a lot of discussion in the academic literature and popular press about optimal cow size and moderating cow weight. Our results suggest that buyers still place the highest value on cows weighing well above the average. However, the small marginal change in the value for cow weight greater than 1400 pounds suggests that value reaches a maximum at higher weights.

5.3 Effect of Months Bred

All coefficients had the expected sign. All cows that were less than six months bred received a reduction in price. Bred cows that were one month bred received a price that was 13.41% below the price of a six-month bred cow. While eight months received the greatest premiums. Producers purchasing bred cows prefer late gestating cows. There is less risk associated with losing a calf. Furthermore, less time has to be devoted to feeding a cow before a calf is born. Figure 3 illustrates the effect of months. The coefficients for months bred indicate that the value increases at a decreasing weight up to a maximum at eight months bred.

5.4 Effect of Hide Color and Quality

All coefficients for hide color and quality were significant and had the expected sign. The coefficient for hide color suggests that black bred cows bring a price 6.74% higher than nonblack cows. High-quality cows brought 13.76% premiums while low-quality cows brought 15.01% discounts. Cow quality has breeding, calving, and health implications. Producers purchasing cows that will be placed into herds prefer black, high-quality cows. The substantial discounts for low and low-average cows indicates that producers should consider improving the quality of their cows before sale.

5.5 Effect of Location and Seasonality

Estimates for location and seasonality were significant suggesting there is a location effect across sales in Oklahoma as well as a seasonal effect. Relative to Oklahoma City all cows sold in all other locations received premiums ranging from 2.42%, at El Reno, to 6.69%, at Woodward. Oklahoma City is a well-known market for feeder cattle. However, results suggest that Oklahoma City is not where buyers go to invest in breeding animals. Producers looking to invest in breeding stock prefer to do so closer to where the majority of the ranches in Oklahoma are. Figure 4 illustrates the seasonal pattern in prices. Bred cow prices are at their lowest in May and June. Producers pay premiums for late gestating cows. Cows sold in the summer months of May and June fall in between the two traditional calving seasons, which would explain why prices are at their lowest during this period.

5.6 Effect of Cull Cow Value and Price Expectations

We use the average Oklahoma City boning cull cow price as a proxy for the expected salvage value of bred cows. Of the 776 weeks used, 26 weeks did not have an Oklahoma City sale. When Oklahoma City is missing the six sale average boning cull value is used. The estimate for cull value is positive and significant at the 1% level. For every 10% increase in the value of cull cows, the value of bred cows increases by 6.92%. In addition to cull value, we use an annual cow-calf returns series to model price expectations. The returns series represents expected returns from calves as well as expected costs. For every expected dollar increase in annual returns, the value of bred cows increases by 0.05%.

6.0 Conclusions

This paper estimates the determinants of bred cows sold in seven Oklahoma auctions. Previous studies have found that livestock characteristics have a significant role in determining livestock prices. The main objective of this paper was to examine the impact various factors had on bred cow prices. Physical characteristics, expected salvage value, and market forces all help to determine bred cow prices. Results presented in this paper will provide producers with valuable information regarding cow marketing and will help improve production decisions relating to cow procurement.

Bred cow traits had a significant impact on bred cow prices. First calf heifers and young bred cows received significant premiums. Relative to nonblack cows, black cows received 6.7% premiums. Producers should attempt to improve the quality of their cows and market them as average-high and high quality. Producers paid significant premiums for bred cows weighing more than 1000 pounds with cows between 1601 and 1700 bringing the greatest premiums. Producers place the greatest value on late gestating cows.

The hedonic model estimated in this paper accounts for market forces, which include sale location and price expectations. All six sales received significant premiums relative to Oklahoma City. This result suggests that Oklahoma City is not a location buyers go to when investing in breeding animals and herd replacement cows. We use an annual cow-calf returns series as a proxy for input and output price expectations. For every dollar increase in expected returns, bred cow values increase by 0.05%.

The average Oklahoma City boning cull cow price is used to represent the salvage value of a bred cow. As cull cow values in by 1% bred cow values are expected to increase by .7%. Finally, bred cow prices have a seasonal pattern, with the lowest prices occurring in the summer months. The results found in this paper suggest that producers will receive premiums by improving the quality of the cows they market in Oklahoma auctions.

Table 1. Descriptive Statistics (N=14811)

Variable	Mean	Std Dev	Minimum	Maximum
Price	936.67	390.41	330.00	3400.00
Age	5.58	2.38	1.00	10.00
Weight	1126.35	118.87	700.00	1700.00
Months Bred	5.41	1.35	1.00	9.00
Volume	267.29	234.58	8.75	2343.00
Cull Price	638.29	237.66	317.00	1302.55

Table 2. Description of Variables

Variable	Definition
$Price_{ity}$	The average price of lot *i* at week *t* in year *y* ($/head)
Age_{ijt}	Ten binary variables (0 or 1) for age *j*=1,…,10 base=3
$MBred_{ijt}$	Nine binary variables (0 or 1) for months bred Base=6 months bred *j*=1,…,9 base=6
Wt_{ijt}	Ten binary variables (0 or 1) for weight Weight is included as hundred pound ranges *j*=1,…,10 1=700-800 2=801-900 3=901-1000 4=1001-1100 5=1101-1200 6=1201-1300 7=1301-1400 8=1401-1500 9=1501-1600 10=1601-1700 base=901-1000
$Qlty_{ijt}$	Binary variables (0 or 1) for quality *j*=1,…,5 1=Low 2=Low-Average 3=Average 4=Average-High 5=High Base=Average
$HColor_{it}$	Hide color of each lot 0=nonblack 1=black
Loc_{ijt}	Binary variables (0 or 1) for sale location *j*=1,…,7 1=Ada 2=Apache 3=El Reno 4=Oklahoma City 5=Tulsa 6=McAlester 7=Woodward base=Oklahoma City
$Cycle_{iy}$	The annual returns in year *y* for a cow-calf operation
$CPrice_{it}$	The average Oklahoma City boning cull cow price in week *t*

Table 3. Hedonic Model Parameter Estimates

Variable	Estimate	t-value	p-value	Variable	Estimate	t-value	p-value
Intercept	2.2024	59.00	<.0001	Months Bred (Base=6)			
Cull Price	0.6920	115.70	<.0001	1	-0.1341	-2.33	0.0198
Cycle	0.0005	39.40	<.0001	2	-0.0795	-10.99	<.0001
Hide Color	0.0674	39.10	<.0001	3	-0.0674	-23.31	<.0001
Cos52	0.0385	18.85	<.0001	4	-0.0410	-15.54	<.0001
Sin52	-0.0204	-10.60	<.0001	5	-0.0155	-7.46	<.0001
Age (Base=3)				7	0.0192	9.24	<.0001
1	0.0317	7.33	<.0001	8	0.0388	11.93	<.0001
2	0.0144	3.09	0.0020	9	-0.0043	-0.07	0.9481
4	0.0044	1.37	0.1715	Quality (Base=average)			
5	-0.0087	-2.79	0.0054	average-high	0.0836	28.32	<.0001
6	-0.0329	-11.68	<.0001	high	0.1376	71.65	<.0001
7	-0.0710	-21.62	<.0001	low	-0.1501	-27.28	<.0001
8	-0.1120	-32.83	<.0001	low-average	-0.0592	-7.77	<.0001
9	-0.1697	-46.83	<.0001	Location (Base=Oklahoma City)			
10	-0.2320	-67.87	<.0001	El Reno	0.0242	5.08	<.0001
Weight (Base=901-1000)				McAlester	0.0265	5.08	<.0001
1001-1100	0.0345	12.44	<.0001	Tulsa	0.0639	11.95	<.0001
1101-1200	0.0656	22.54	<.0001	Woodward	0.0669	14.08	<.0001
1201-1300	0.0884	27.08	<.0001	Ada	0.0365	7.40	<.0001
1301-1400	0.1054	25.21	<.0001	Apache	0.0493	9.91	<.0001
1401-1500	0.1317	19.18	<.0001				
1501-1600	0.1187	7.54	<.0001	Variance of Error term			0.0224
1601-1700	0.1432	3.56	0.0004	Week*Location Random Effect			0.0061
700-800	-0.1151	-10.15	<.0001	-2 Log Likelihood			-28395.20
801-900	-0.0479	-9.84	<.0001				

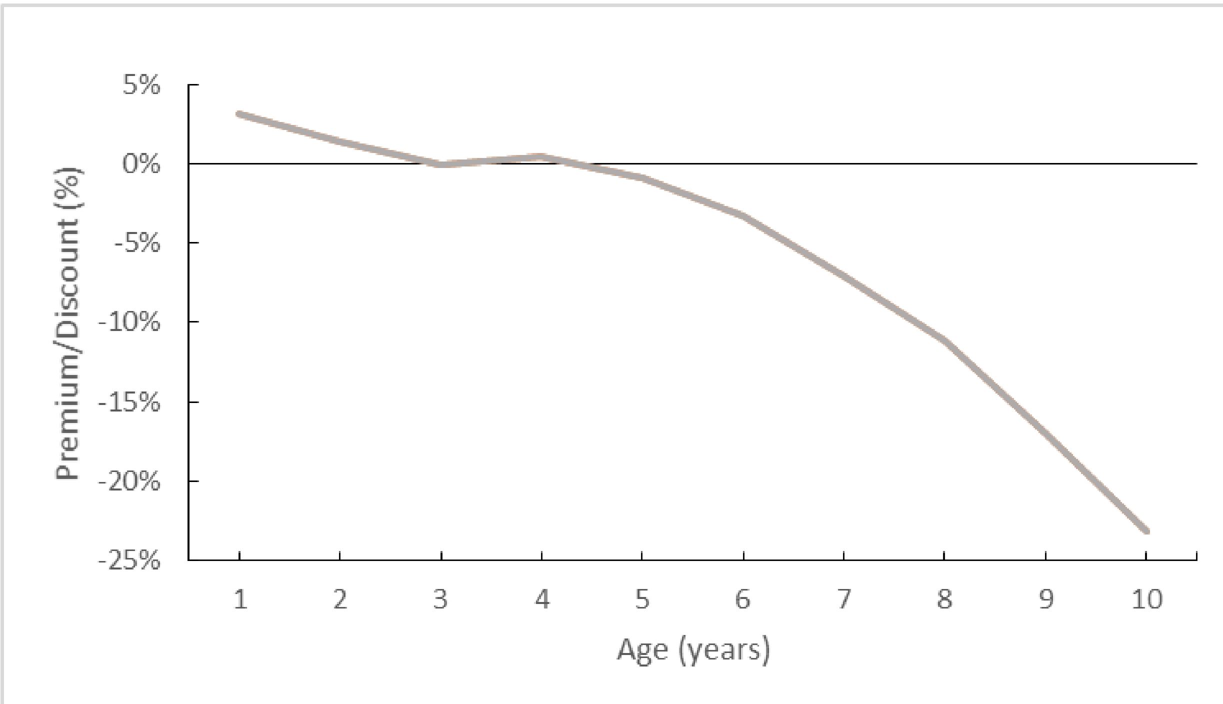

Figure 1. Effect of age, base age is 3 years

Figure 2. Effect of weight, base weight 901 to 1000 lbs.

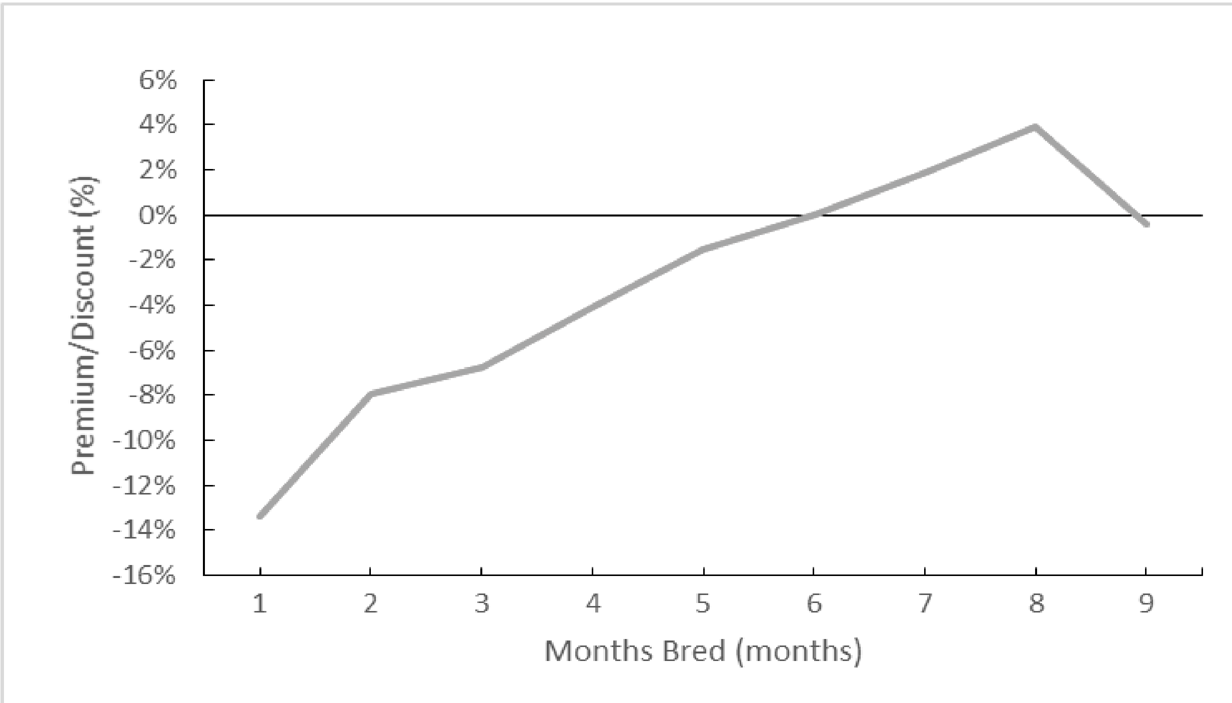

Figure 3. Effect of months bred, base months bred is 6 months

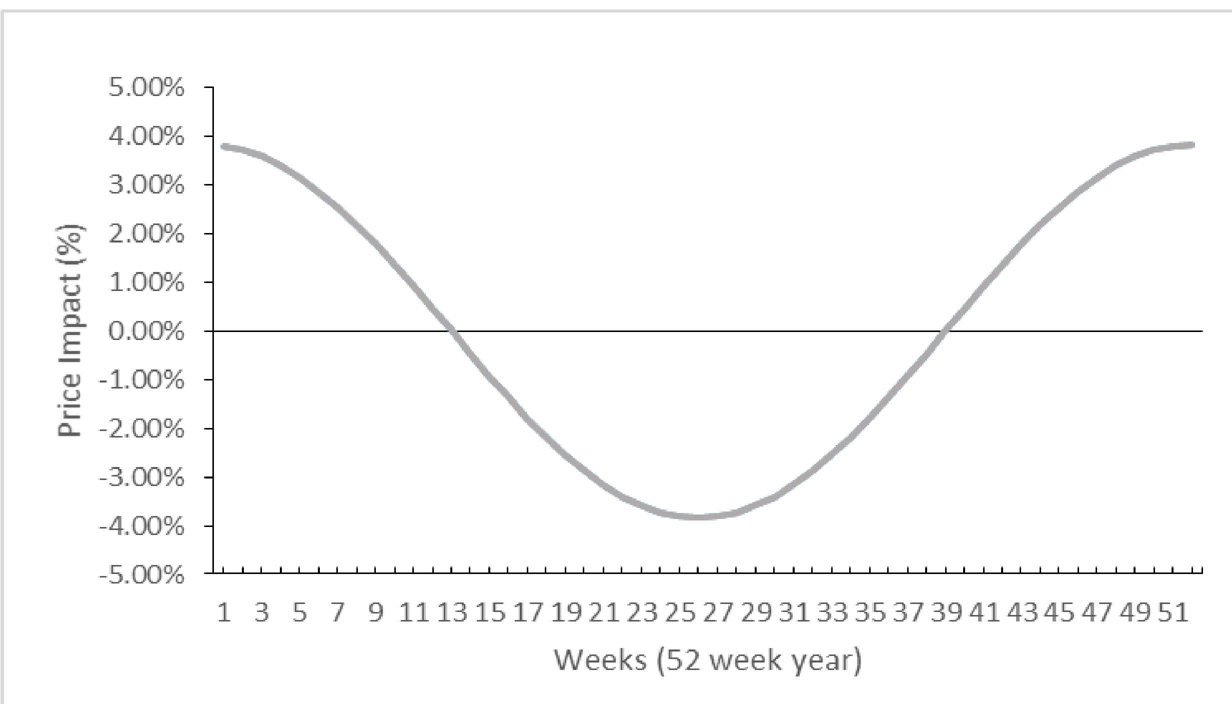

Figure 4. Seasonality of bred cow prices

References

Amadou, Z. 2012. "Value Enhancement Marketing Strategies for Cull Beef Cows." PhD dissertation, Oklahoma State University.

Avent, R. K., C. E. Ward, and D. L. Lalman. 2004. "Market Valuation of Preconditioning Feeder Calves." *Journal of Agricultural and Applied Economics* 36(1):173-183.

Bailey, D. M. C. Peterson, and B. W. Brorsen. 1991. "A Comparison of Video Cattle Auction and Regional Market Prices." *American Journal of Agricultural Economics* 73(2):465-475.

Buccola, S. T. 1980. "An Approach to the Analysis of Feeder Cattle Price Differentials." *American Journal of Agricultural Economics* 62(3):674-580.

Barham, B. L., and T.R. Troxel. 2007. "Factors Affecting the Selling Price of Feeder Cattle Sold at Arkansas Livestock Auctions in 2005." *Journal of Animal Science* 85(12):3434-3441.

Coatney, K.T., J.D. Schmitz, and D.J. Menkhaus. 1996. "Feeder Cattle Price Determinants: An Hedonic System of Equations Approach." *Review of Agricultural Economics* 18(2):193-211.

Dhuyvetter, K. C., T. C. Schroeder, D. D. Simms, R. P. Bolze, and J. Geske. 1996. "Determinants of Purebred Beef Bull Price Differentials." *Journal of Agricultural and Resource Economics* 21(2):396-410.

Faminow, M. D. and R. L. Gum. 1986. "Feeder Cattle Price Differentials in Arizona Auction Markets." *Western Journal of Agricultural Economics* 11(2):156-163.

Judge, G. G., W. E. Griffiths, R. C. Hill, H. Lutkepohl, and T. Lee. 1985. *The Theory and Practice of Econometrics*, 2nd. Ed. New York: John Wiley & Sons.

Ladd, G.W., and M.B. Martin. 1976. “Prices and Demands for Input Characteristics.” *American Journal of Agricultural Economics* 58(1):21-30.

Lancaster, K.J. 1966. “A New Approach to Consumer Theory.” *Journal of Political Economy* 74(2):132-157.

Lawrence, J.D. 2001. “Profiting From the Cattle Cycle: Alternative Cow Herd Investment Strategies.” Iowa Beef Center Publication, Iowa State University.

Marsh, J. M. 1985. “Monthly Price Premiums and Discounts between Steer Calves and Yearlings.” *American Journal of Agricultural Economics* 67(2):307-314.

Mintert, J.R., J. Blair., T.C. Schroeder., and F. Brazle. 1990. “Analysis of Factors Affecting Cow Auction Price Differentials.” *Southern Journal of Agricultural Economics* 22(2): 23-30.

Parcell, J.L., T.C. Schroeder, and F.D. Hiner. 1995. “Determinants of Cow-Calf Pair Prices.” *Journal of Agricultural and Resource Economics* 20(2):328-340.

Rosen, S. 1974. “Hedonic Prices and Implicit Markets: Product Differentiation in Pure Competition.” *Journal of Political Economy* 82(1):34-55.

Schroeder, T.C., J. Mintert, F. Brazle, and O. Grunewald. 1988. “Factors Affecting Feeder Cattle Price Differentials.” *Western Journal of Agricultural Economics* 13(1):71-81.

Trapp, J. N. 1986. “Investment and Disinvestment Principles with Nonconstant Prices and Varying Firm Size Applied to Beef Breeding Herds.” *American Journal of Agricultural Economics* 68(3):691-703.

Waugh, F. V. 1928. “Quality Factors Influencing Vegetable Prices.” *Journal of Farm Economics* 10(2):185-196.

Williams, G. S., K. C. Raper, E. A. DeVuyst, D. S. Peel, and D. McKinney. 2012. “Determinants of Price Differentials in Oklahoma Value-Added Feeder Cattle Auctions.” *Journal of Agricultural and Resource Economics* 37(1): 114-127.

Zimmerman, L. C., T. C. Schroeder, K. C. Dhuyvetter, K. C. Olson, G. L. Stokka, J. T. Seeger, and D. M. Grotelueschen. 2012. “The Effect of Value-Added Management on Calf Prices at Superior Livestock Auction Video Markets.” *Journal of Agricultural and Resource Economics* 37(1):128-143.