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Christopher Boyer
University of Tennessee, cboyer3@utk.edu

Andrew P. Griffith
University of Tennessee, agriff14@utk.edu

Jada M. Thompson
University of Tennessee, jada.thompson@utk.edu

Justin Rhinehart
University of Tennessee, jrhinehart@utk.edu

Kenneth H. Burdine
University of Kentucky, kburdine@uky.edu

See next page for additional authors

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Bred Heifer Price Determinants in the Southeast

Christopher Boyer (University of Tennessee), Andrew P. Griffith (University of Tennessee), Jada M. Thompson (University of Tennessee), Justin Rhinehart (University of Tennessee), Kenneth H. Burdine (University of Kentucky), and Kevin Laurent (University of Kentucky)

ABSTRACT

Price determinants for bulls, cows, and feeder cattle are well established in the literature but there has been little research on bred heifer price determinants and specifically the impact of feeder cattle prices on the purchase price of bred heifers. We estimated the impact of reproductive characteristics and feeder cattle prices on bred heifer prices for beef production. Data were obtained from a May and November bred heifer sale located in Kentucky and hedonic pricing models were estimated for bred heifers for each sale month. Prices for fall-calving heifers were influenced by number of months bred or expected calving date with longer bred heifers priced the highest. Purchase price of spring-calving heifers did not vary from five to seven months bred, but heifers four months bred were priced lower. Pregnancies resulting from artificial insemination did increase the value of fall-calving heifers but did not impact spring-calving heifer prices. Heifer feeder cattle prices the day of the sale positively influenced the price of spring- and fall-calving bred heifers. This extends previous research by considering the impact of feeder cattle prices on the price of bred heifers. The results can help cow-calf producers in making a more informed purchasing decision of replacement breeding animals.

KEYWORDS

beef cattle, heifer, hedonic modeling, cow replacement

INTRODUCTION

Identifying beef cows to replace with heifers is an annual decision for cow-calf producers that is complex and critical for their long-term profitability. Financial investment into replacement heifers can be substantial, and the future value of the replacement heifers, which comes from annually weaning a calf over their productive life, is uncertain. This fundamental production decision has resulted in numerous economic studies on the optimal strategies for replacing cows (Bentley et al., 1976; Burt, 1965; Ibendahl et al., 2004; Mackay et al., 2004; Mathews & Short, 2001; Meek et al., 1999; Melton, 1980). Results show the profit-maximizing decision primarily depends on cattle prices and development costs (Clark et al., 2005; Ibendahl et al., 2004; Mackay et al., 2004; Mathews & Short, 2001; McFarlane et al., 2018). Mackay et al. (2004) reported, when cattle prices are high, profits increased by selling bred yearlings and retaining heifers to develop. Conversely, when cattle prices were low, profits were maximized by selling open heifers and retaining bred yearlings. Ibendahl et al. (2004) reported during times of high feed costs keeping open cows would be advantageous to developing heifers to replace cows. However, this could result in poor fertility and studies have shown that heifers or cows that fail to produce a calf early in their reproductive life will likely have a negative return on the investment and decreased long-term profitability (Boyer et al., 2020; Ibendahl et al., 2004; Mathews & Short, 2001).

While most producers raise their own replacement heifers (United States Department of Agriculture [USDA], 2009), heifers can also be purchased. There are several advantages to purchasing replacement heifers. For example, purchasing these animals provides producers an opportunity to introduce improved genetics into the herd to increase productivity and profitability (Schulz & Gunn, 2014). Additionally, developing replacement heifers can require a substantial amount of labor and different nutritional requirements would likely mean these animals would need to be managed separately.

Many studies have investigated factors impacting the price of purchasing bulls, feeder cattle, and bred cows using hedonic pricing models (Elliott et al., 2013; Hagerman et al., 2017; Jones et al., 2008; Mitchell et al., 2018; Parcell et al., 1995; Tang et al., 2017), but research on price determinants of bred heifers is limited. Parcell et al. (2006) analyzed the impact of sire expected progeny differences (EPDs), which attempt to estimate relative expected performance of calves from a sire of the same breed, and other characteristics on bred heifer prices. They found that heifers with expected calving dates that fell earlier in the spring season (January and February) were more valuable than heifers that were expected to calve later in that same season (March and April). They also reported that prices were impacted by calf performance and carcass quality EPDs. Parcell et al. (2010) extended their hedonic pricing study by estimating buyers' willingness to pay for certain reproductive management practices. Buyers were willing to pay a premium for heifers confirmed pregnant to artificial insemination (AI). They explained this premium as being due to the assumption that AI-sires have better genetics than bulls used for natural service. Additionally, these heifers would be expected to calve in a 30-day time period if estrous synchronization and timed AI were used.

These studies are insightful on factors impacting bred heifers, but more work is needed. One limitation of these studies is the lack of consideration of how changes in feeder cattle prices influence bred heifer price. Studies investigating price determinants for bred cows have demonstrated a positive correlation with feeder cattle prices at the time of the sale (Mitchell et al., 2018). This can be explained by the expectation of the resulting calf value being higher. Understanding the impact of feeder cattle prices at time of bred heifer purchases could influence producers' optimal purchasing decision. For example, if there is a strong correlation between feeder cattle prices and bred heifer prices, periods of high feeder cattle prices will mean the investment cost of bred heifers will be higher. Buying replacement heifers when prices are high can increase the financial risk associated with the investment. Since future prices and calf performance are unknown, producers are likely increasing their risk of the heifer being profitability over her productive life.

Therefore, the objective of this research was to determine whether reproductive management characteristics and feeder cattle prices influence bred heifer prices for buyers. We estimated hedonic price determinant equations using data from a bred heifer sale located on the Tennessee and Kentucky state line. The results indicate valuable characteristics for marketing bred heifers and assist cow-calf producers in making a more informed purchasing decision of those replacements.

DATA

Data come from the West Kentucky Select Bred Heifer sale from 2008 to 2017 at Guthrie, Kentucky. This sale started in 2000 and occurred annually in November until 2005. After 2005, the sale occurred biannually in November and May. The November sale is for spring-calving cows and the May sale is for fall-calving cows. The number of buyers has ranged from 17 to 39 with an average of 29 buyers. The total number of heifers sold at one time ranged from 112 to 233 with an average of 187 head. Heifers must meet six requirements to qualify for the sale. These requirements include vaccination against specific diseases, treated for internal and external parasites, reproductive tract score, visual inspection for structural soundness, tested for persistently infected bovine viral diarrhea, and bred to a calving-ease Angus bull. Each lot was offered for bidding through a public auction method where the bid was based on individual heifer price and the lot sold to the highest bidder for the high bid multiplied by number of heifers in the lot.

Individual animal data included breed or breed type, expected calving month, whether the heifer was pregnant to AI, price sold, and lot number. Table 1 shows the summary statistics for lots by sale month. More lots were sold in the November than May sale, but average heifer price in the May sale was on average higher than in the November sale. Marketing fall-born calves typically occurs in months within the year that feeder cattle prices are highest, thus, the value of the fall-born calf will likely be higher than the spring-born calf. This

Table 1. Summary Statistics of Bred Heifer Lots Sold from 2008 to 2017 at the West Kentucky Select Bred Heifer Sale

Variable	Number of Observations (Lots Sold)	Mean	Standard Deviation	Minimum	Maximum
	May Sale or Fall Calving				
Price ($/head)	511	1,941	567.49	944	3,657
Percent Three-Month Bred	511	0.04	0.18	0	1
Percent Four-Month Bred	511	0.38	0.49	0	1
Percent Five-Month Bred	511	0.55	0.50	0	1
Percent Six-Month Bred	511	0.04	0.19	0	1
Percent Artificially Inseminated	511	0.09	0.29	0	1
Percent Black Hide	511	0.92	0.24	0	1
Pen Size	511	3.31	1.23	1	6
	November Sale or Spring Calving				
Price ($/head)	574	1,878	551.11	944	3,793
Percent Four-Month Bred	574	0.06	0.23	0	1
Percent Five-Month Bred	574	0.31	0.46	0	1
Percent Six-Month Bred	574	0.52	0.50	0	1
Percent Seven-Month Bred	574	0.11	0.31	0	1
Percent Artificially Inseminated	574	0.06	0.24	0	1
Percent Black Hide	574	0.82	0.37	0	1
Pen Size	574	3.18	1.21	1	6

can result in fall-calving being more profitable than spring-calving (Henry et al., 2016) and might explain why the average price of bred heifers in the May sale was higher relative to bred heifers in the November sale. In the May sale, heifers ranged from three to six months pregnant with an average of 4.5 months pregnant; only 9% were pregnant to AI. In the November sale, heifers ranged from four to seven months pregnant with an average of 5.5 months bred and only 6% were bred using AI.

It is important to note that these are real-world sales data and not generated from a controlled experiment. This creates challenges in isolating effects of factors on sale price, but provides useful economic insight into making production decisions. For example, heifers were sold in lots, ranging from one to six heifers per lot with an average lot size of three heifers for both the May and November sales. However, some lots included a mix of breeds or breed types as well as a mix of registered and commercial heifers. Studies using similar data address this issue by examining the hide color impact on the value of cattle instead of breed (Hagerman et al., 2017; Mitchell et al., 2018; Williams et al., 2012). We followed Williams et al. (2012) by defining a lot as black-hided heifers if 75% of the animals in the lot were black.

Monthly Kentucky and Tennessee price data were collected for 500 to 600 lb heifers over this same time period (USDA Agricultural Marketing Service, 2017). All weanling heifer prices as well as the purchased price for bred heifers were adjusted into 2017 dollar values using the Implicit Gross Domestic Product Price Deflator (United States Bureau of Economic Analysis, 2018). Weanling heifer prices during the month of retention for

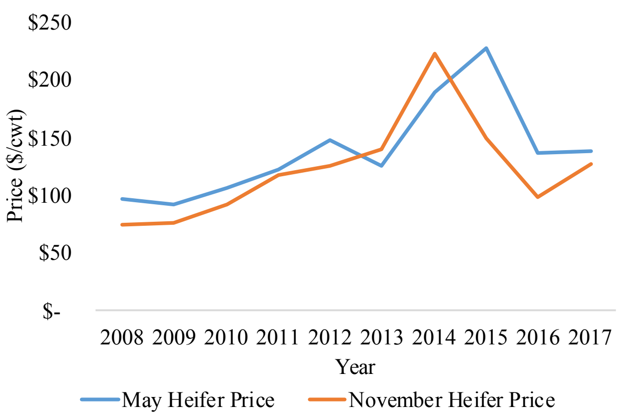

Figure 1. Average Kentucky and Tennessee Prices ($/cwt) for 500 to 600 Pound Heifers at the time of the May and November sales from 2008 to 2017

a given calving season would be the most relevant prices for gauging the opportunity cost of selling the heifer. Weanling heifer prices during the month when bred heifers are purchased will be the most relevant to determine the impact of feeder cattle prices on bred heifer prices. Weanling heifer prices during the month of November were analyzed for the spring-calving herd (November sale), and May weanling heifer prices were analyzed for the fall-calving herd (May sale). Figure 1 shows average 500 to 600 lb feeder heifer prices from 2008 to 2017.

ESTIMATION

A hedonic pricing model was used to determine the impact of weanling heifer prices and reproductive characteristics on the sale price of a bred heifer. This is a common approach to estimating price determinants of cattle (Bekkerman et al., 2013; Boyer et al., 2019; Chvosta et al., 2001; Dhuyvetter et al., 1996; Jones et al., 2008; Kessler et al., 2017; Vanek et al., 2008; Vestal et al., 2013). We specify a log-level model by taking the log of sale price, correcting the non-normality issue (Wooldridge, 2013). Since heifers were sold in lots, we estimate the model using the lot as the observation for the May and November sales individually. Heifer sales data used in Parcell et al. (2006) were also from a May and November sale, but these calving seasons (fall and spring) were combined in their estimation. Analyzing individual sale data in separate months will provide further insight into producers' value of bred heifers for each calving season.

The model is written as

(1)

$$\log(Purchase_{tlb}) = \beta_0 + \sum_{k=1}^{K-1} \beta_k X_{ik} + \beta_K AI_i + \beta_{K+1} BL_i + \beta_{K+2} HP_t + \beta_{K+3} L_i + \beta_{K+4} L_i^2 + v_t + w_b + \varepsilon_{tb}$$

where X_k indicator variables are for the number of months pregnant the heifer is at the time of the sale ($k = 1, \ldots, K$) (6 months pregnant was the reference for the May sale and 7 months pregnant was the reference for the November sale); AI is an indicator variable equal to one if the pregnancy was AI-sired, and zero if natural service pregnancy; BL is an indicator variable equal to one if hide color is black and zero if nonblack; HP_t is the weanling heifer price ($/cwt) at the time of the sale (May or November); L is the pen or lot size (in head) and L^2 is lot size squared; $\beta's$ are parameters to be estimated; $v_t \sim N(0, \sigma_v^2)$ is the year random effect; $w_b \sim N(0, \sigma_w^2)$ is the random effect for breed; and $\varepsilon_{it} \sim N(0, \sigma_\varepsilon^2)$ is the random error term. Independence is assumed across all four random components. Parameter estimates can be converted to dollars change in the price of a bred heifer by multiplying the parameter estimated by the average predicted selling price of the heifers in the sample. This is an approximation of the value impact of the independent variables on the bred heifer price at the mean price.

Previous studies have assumed a quadratic functional form for lot size and found it to be more appropriate than a linear functional form (Parcell et al., 2006). We assume the same functional form, which allows us to determine if there is a lot size that maximizes sale price. We can solve for the lot size (L^*) that maximizes sale price by taking the first-order conditions of equation (1) with respect to lot size and solving for lot size and solving for L.

Heteroscedasticity is a common problem for estimating cattle hedonic pricing models (Jones et al., 2008; Mitchell et al., 2018). The likelihood ratio test was used to determine if heteroscedasticity was present from year and breed. If heteroscedasticity was present, we corrected it using multiplicative heteroscedasticity in the variance equation (Wooldridge, 2013).

The models were estimated using maximum likelihood with the MIXED procedure in SAS 9.3 (SAS Institute, 2011).

HYPOTHESIZED VARIABLES

Table 2 shows the definitions and hypothesized sign of the parameter estimates for each of the independent variables by sale month. Mitchell et al. (2018) showed pregnant cow prices increased until they were eight months pregnant. Cows further along in pregnancy (sometimes called long bred) were assumed to be less likely to lose a calf, have a lower production cost to calving, and create revenue more quickly. Moreover, producers desire heifers to calve earlier in the calving season. This gives them more time for uterine repair (involution) and return to positive energy balance to occur before the next breeding season. Shortening the postpartum anestrous, the time from calving until return to normal estrous cycles, is critical to ensure early rebreeding for first-calf heifers (lactating two-year-olds) and managing that is made easier when heifers calve early in their first calving season. Parcell et al. (2006) found earlier calving was more valuable than later calving for spring-calving heifers. We also hypothesize the value of bred heifers increases as months pregnant increases. The base, or reference, for stage of gestation was six and seven months pregnant for the May and November sales, respectively. Therefore, since these averages at the time of their respective sale were skewed toward relatively early calving, we expect the parameter estimates to be negative for months pregnant.

Parcell et al. (2006) and Parcell et al. (2010) reported AI-sired pregnancies were more valuable to producers than natural service pregnancies for bred heifers. This is likely due to sires used for AI having more desirable, and more accurately predicted, genetic potential than sires used in natural service. Also, buyers have shown they are willing to pay a premium for heifers that were expected to calve in a 30-day time period. AI breeding provides buyers with more accurate information about the time of calving and, since the application of this

Table 2. Definitions, Average, and Hypothesized Sign of the Parameter Estimates by Independent Variables and Sale Month

Variables	Definition	Expected Sign for May Sale	Expected Sign for November Sale
Three-Month Bred	= 1 if heifer is three months bred; zero otherwise	-	n/a[a]
Four-Month Bred	= 1 if heifer is three months bred; zero otherwise	-	-
Five-Month Bred	= 1 if heifer is three months bred; zero otherwise	-	-
Six-Month Bred	= 1 if heifer is three months bred; zero otherwise	Base	-
Seven-Month Bred	= 1 if heifer is three months bred; zero otherwise	n/a[a]	Base
Artificial Inseminated (*AI*)	= 1 if heifer is artificial inseminated; zero otherwise	+	+
Black Hide (*BL*)	=1 if the heifer is black; zero otherwise	+	+
Heifer Price (HP_t)	500 to 600 lb Heifer Price ($/cwt)	+	+
Lot Size (*L*)	Number of head in each lot	+	+
Lot Size Squared (L^2)	Square of the number of head in each lot	-	-

[a] Animals were not sold in this sale.

technology is most often accompanied by estrus synchronization for timed AI, those pregnancies would be established on essentially the same day, and at the beginning of the breeding season, within management groups. Research has shown hide color does impact the value of cattle (Hagerman et al., 2017; Mitchell et al., 2018; Williams et al., 2012). Williams et al. (2012) found black-hided feeder cattle brought a higher price than nonblack feeder cattle, and Mitchell et al. (2018) reported black-hided bred cows sold for a higher price than non-black-hided cows. We also expect the parameter estimate for black hide to be positive.

Increasing feeder cattle prices at the time of the sale have been found to increase the price of the bred cows (Mitchell et al., 2018). Therefore, we hypothesize that an increase in weanling heifer prices at the time of purchasing a bred heifer will be associated with an increase in the price of the purchased heifer. Finally, pen size was assumed to be quadratic following what Parcell et al. (2006) observed and seems to be a logically functional form for these data. Like buyers in the Parcell et al. (2006) study, most Tennessee and Kentucky buyers will average about 30 head of cows per operations. Assuming a 10% or 15% replacement rate, producer would likely be looking to replace around three to five head annually. Thus, pens smaller than three would likely be discounted as well as pens larger than four.

RESULTS

Parameter estimates for the hedonic pricing models are shown in Table 3. Heteroscedasticity was detected in the data across years. Therefore, results are estimated using multiplicative heteroscedasticity in the variance equation, correcting for unequal variances.

For the May sale, months pregnant were significant price determinants of individual heifers within the lot. Purchase prices increased as the number of months bred increased with the six-month bred heifers bringing a higher purchase price (p < 0.01). Three-month bred heifers were valued $159/head less than six-month bred heifers and a five-month bred heifer was $85/head less than six-month bred heifers (p < 0.01). This is

Table 3. Parameter Estimates for Hedonic Pricing Model by Sale Month

Variables	May Sale [a] Parameter Estimate	May Sale [a] Dollar Value per Head [b]	November Sale [a] Parameter Estimate	November Sale [a] Dollar Value per Head [b]
Intercept	6.5386***		6.8291***	
Three-Month Bred	–0.08543***	–$159	n/a [c]	
Four-Month Bred	–0.0721***	–$134	–0.0301**	–$54
Five-Month Bred	–0.0457***	–$85	–0.0091	
Six-Month Bred	–		–0.0073	
Seven-Month Bred	n/a [c]		–	
Artificial Inseminated (*AI*)	0.0791***	$148	0.0178	
Black Hide (*BL*)	0.0076		–0.0149	
Heifer Price (HP_t)	0.0064***	$12	0.0059***	$11
Lot Size (*L*)	0.0567***		–0.0312	
Lot Size Squared (L^2)	–0.0058**		0.0052***	

Asterisks (***, **) denote significance at the 0.01 and 0.05 levels, respectively.
[a] Number of observations for the May sale was 511 lots and for the November sale the number of observations was 574.
[b] Parameter estimates were converted to dollars by multiplying the parameter estimated by the average predicted selling price of the heifers in the sample. This is an approximation of the value impact of the independent variables on the bred heifer price at the mean price.
[c] Animals were not sold in this sale.

consistent with Parcell et al.'s (2006) finding that earlier calving heifers were more valuable than later calving heifers. Heifers pregnant to AI sold for $148/head higher than natural service pregnant heifers, which is higher than the $18 and $25/head premium reported by Parcell et al. (2006) and Parcell et al. (2010), respectively. This finding indicates that sellers could consider AI breeding if the cost was less than $148/head.

A one dollar per hundredweight increase in weanling heifer prices at the time of sell resulted in the purchase price of bred heifers in this data set increasing $12/head. This is consistent with other studies on bred cows (Mitchell et al., 2018). Lot size was found to increase sale prices until lot size was approximately five head and then prices decreased. Prices increased by $30/head when going from selling three to four head, $8/head when going from selling four to five head, and decreased $13/head when going from five to six head per pen. This indicates that buyers might be able to purchase heifers at a lower price per head by targeting the purchase of smaller pen sizes.

For the November sale, the purchase price of bred heifers was not different if the heifer was five to seven months pregnant. But prices decreased $54/head for four-month relative to seven-month pregnant heifers. Similar to the May sale, weanling heifer price on the day of sell influenced the price of bred heifers. A one dollar per hundredweight increase in weanling heifer prices on the date of the sale was associated with increased bred heifer prices of $11/head. However, unlike the May sale, prices of bred heifers decreased as pen sizes approached three head in pen size. For a pen including three or more heifers, purchase prices increased. This result is interesting and the opposite of what we hypothesized. More research is needed to further understand this result and why the effect of lot size of bred heifer purchase prices is different across sale dates.

The difference in the value of heifers pregnant to AI might be explained by fall-calving occurring when producers who also produce crops will be harvesting and would likely have limited labor availability, while spring-calving typically occurs before planting. Producers with a fall-calving herd might have specific demand for expected calving date and the potential calving season length. That is, bred heifers expected to calve before harvest (earlier calving or longer bred) and in a shorter calving period (i.e., less than 30 days) could be more valuable for a fall-calving producer if they have limited labor availability. Moving fall-calving to earlier dates, within reasonable seasonal restrictions by early fall heat and humidity in the region, could allow producers to better allocate management and labor resources during the fall. Parcell et al. (2010) showed that buyers were willing to pay a premium for AI-sired heifers because they were expected to calve in a 30-day time period.

Another interesting finding was that black hide color did not impact the sale price of bred heifers. This is counter to what was expected and what has been observed in previous studies (Hagerman et al., 2017; Mitchell et al., 2018; Williams et al., 2012). Traditionally, black-hide cattle were valued higher because of their potential performance in the feedlot and marketability as Angus-type. One possible area of future research is to survey producers on stated values of hide color to better understand the impact of this variable on prices.

CONCLUSIONS

Investing in replacement heifers for a cow-calf operation is a challenging annual decision for producers that is vital in their long-term profitability. However, little research exists on bred heifer price determinants and specifically the impact of feeder cattle prices on the purchase price of bred heifers.

Therefore, the objective of this research was to determine the influence of feeder cattle prices and reproductive characteristics on bred heifer prices for beef production. Data comes from a bred heifer sale located on the Tennessee and Kentucky state line. Hedonic pricing models were developed for bred heifers sold in May and November. The results can help sellers know valuable characteristics of a bred heifer and will assist cow-calf producers in making a more informed purchasing decision of replacement breeding animals. This study builds on previous work by demonstrating the impact feeder cattle prices have on the purchase price of bred heifers. The study also presents results for bred heifer price determinants of both spring- and fall-calving heifers.

Results show that months pregnant, or expected calving date, influenced fall-calving bred heifer prices where prices increased as the number of months pregnant increased. Purchase price of spring-calving bred heifers did not vary across five to seven months pregnant, but four-month pregnant heifers were priced significantly lower. AI-sired pregnancies increased the value of fall-calving heifers, but did not impact the sell price of spring-calving heifers. For both the November and May sales, heifer feeder cattle prices at the day of the sale and at retention positively influenced the price of bred heifers. Next steps from this study would be to further investigate lot size effect on the sale price and adapt this model to compare purchasing verses retaining bred heifers for a cow-calf producer.

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