ABSTRACT

Objective: The objective of this analysis was to determine whether an online bidding format affects the price of female beef cattle along with several factors such as age, months bred, and sire’s EPD.

Materials and Methods: This analysis uses annual sales data from 2017 to 2022 from a registered Angus cow and heifer sale in Crossville, Tennessee, that occurs in November at the University of Tennessee Plateau Research and Education Center. A hedonic pricing model was used to determine the value of these factors on sale price.

Results and Discussion: The results indicate heifer lots were sold for less than cows lots. The sale price of bred females increases until they are approximately 5 and 6 mo bred, and then the prices start declining. These results were expected based on the literature. The primary finding of this analysis is that having a sale to have online bidding increased the sale price by approximately $379 per head.

Implications and Applications: This research extends the literature by considering the effects of an online bidding presence on female sale prices. This article also builds on the growing literature examining how various factors affect female sale prices in the southeastern United States. These results are useful for producers with small- and medium-sized herds who market cattle in their farm; they might consider implementing an online bidding component when marketing their cattle.

Key words: online auction, beef cattle, hedonic pricing, JEL codes: Q12

INTRODUCTION

Historically, cattle auctions first began with cattle being marketed on the hoof and in person at a sale barn, stockyard, or in the farm, but over time, these auctions have evolved from in-person bidding to include video auctions, where bidding can occur in person, on the phone, and online. The transition and inclusion of phone and online bidding encouraged research focusing on the effects of the various forms of cattle marketing under traditional in-person sales, video sales with telephone bidding, and video sales with online bidding (Bailey and Peterson 1991; Bailey et al., 1991; Zimmerman et al., 2012; Williams et al., 2014; Blank et al., 2016). In general, research conclusions indicate prices can be greater in video auctions than prices in regional markets and can attract a larger pool of buyers than traditional auctions (Bailey et al., 1991; Blank et al., 2016). Video auctions with online bidding can reduce transaction costs for bidders and improve animal health regarding the commingling of cattle (Bailey and Peterson, 1991).

Online bidding through video cattle auctions has similar protocols to in-person and live bidding. Whether in person or online, cattle auctions have a set start time and date, and cattle are sold one lot at a time, and in a sequential order. Online bidding auctions are commonly used for large, regional cattle sales throughout the United States, and most of the literature has analyzed online bidding for cattle through video sales and has focused on large feeder cattle sales (Zimmerman et al., 2012; Blank et al., 2016; Li and Shonkwiler, 2021).

Little is known about how online bidding could affect the price of cattle sold in small or farm-specific sales despite this being a common marketing method in regions such as the southeastern United States. Studies have used hedonic pricing models to evaluate how various factors could affect bull (Boyer et al., 2019; Tang et al., 2020, 2022) and female prices (Parcell et al., 2006, Boyer et al., 2020a,b, 2021). However, to our knowledge, no analysis has examined how female beef cattle prices are affected by allowing online bidding. Therefore, the objective of this research was to determine whether online bidding affected the price of female beef cattle along with several factors such as age, months bred, and dam’s EPD. This analysis is a hedonic pricing model with a sale lot as the observational unit. These results can be used to demonstrate to producers the value of using online bidding and adds to the hedonic pricing literature for cattle.
MATERIALS AND METHODS

Because no human or animal subjects were used, this analysis did not require approval by an Institutional Animal Care and Use Committee or Institutional Review Board.

Data

Data came from an annual registered Angus cow and heifer sale in Crossville, Tennessee, that occurs in November at the University of Tennessee Plateau Research and Education Center from 2017 to 2022. The data contain information on the animal age and pregnancy status, along with the dam’s EPD. This sale started in 2008 and has been conducted annually in November, but in 2019, the auction went from using the live sale mechanism to completely online. The catalog was placed online, and bidders could simultaneously bid on all lots of cattle over a 15-d period. In 2019 the sale occurred from 10 a.m. central time starting on November 5 to 10 a.m. central time on November 19, and in 2020 the sale occurred from 10 a.m. central time on November 3 to 10 a.m. central time on November 17. Each lot had a soft closing, meaning any bid within the last 3 min of a lot closing, within the sale, would extend the bidding time of the sale by 3 min. For example, if an auction ending at 10 a.m. has a bid at 9:59 a.m., the bidding is extended to 10:02 a.m. Additionally, bidders could enter a proxy bid or reservation bid, and the auction would incrementally increase in prices by $50 per head.

Figure 1 contains the average sale price by year and number of lots sold each year. Each year the sale had between 30 and 32 lots. Minimum prices ranged from a low of $700 per head in 2018 to $1,700 per head in 2022. The average annual sale price ranged from $1,195 in 2018 to $2,049 in 2022. Table 1 contains the summary statistics for the variables included in the model. The average months bred was 4.7 mo, with some females being open and others being 7 mo bred. The average lot size was 2.65 head ranging from 1 to 4. Furthermore, about 66% of all the lots were sold online, and about 68% of all the lots were heifers.

Figure 1. Average price ($/head), SD (shown in error bars), and number of lots sold by year.

Method

A hedonic pricing regression was used to determine the effects of the various factors on sale price. We specify a log-level model by taking the log of sale price, correcting the nonnormality issue (Wooldridge, 2013). This specific is common for cattle hedonic pricing models (Martinez et al., 2021; Jones et al., 2023). The model is estimated using the lot as an observation. The model is written as

\[
\ln(\text{Price}_i) = \beta_0 + \beta_1 H_i + \beta_2 B_i + \beta_3 B^2_i + \beta_4 \text{CED}_i + \beta_5 \text{WW}_i + \beta_6 \text{MK}_i + \beta_7 O_i + \beta_8 L_i + \beta_9 T + \beta_{10} T^2 + u_i + \epsilon_i,
\]

where Price is the log of the purchased price of the ith lot in year t; H is an indicator variable equal to one if the lot is heifers and zero otherwise; B is the months bred the female is when sold; CED is the average calving ease direct EPD for the lot; WW is the average sire’s weaning weight EPD for the lot; MK is the average sire’s expected milk EPD for the lot; O is an indicator variable equal to one if the lot was sold online and zero otherwise; L is the lot size in head; T is the year trend variable; u is the sale order random effect; and $\epsilon_i \sim N(0, \sigma^2_\epsilon)$ is the random error term with mean zero and variance $\sigma^2_\epsilon$. Parameter estimates are translated to a sale price change by multiplying the parameter esti-
mates by the average predicted sale price of the cattle (Wooldridge, 2013). This transformation shows the marginal effect of a change in the independent variable at the average price.

Heteroscedasticity is sometimes a problem in hedonic pricing models for cattle (Kessler et al., 2017; Mitchell et al., 2018). A likelihood ratio test was used to determine whether heteroscedasticity was present from year, and if heteroscedasticity was found, a multiplicative heteroscedasticity variance equation was used to correct for this issue (Wooldridge, 2013). Equation [1] was estimated using the MIXED procedure in SAS 9.4 (SAS Institute Inc.).

The variables in this regression were based on the literature of other female sale data. Parcell et al. (2006) found the sire EPD affected bred heifer prices. Others have also shown that calving date or months bred is also important (Parcell et al., 2006; Mitchell et al., 2018; Boyer et al., 2020a,b, 2021). We also include lot size and time trend variables, which are commonly used in these models (Thompson et al., 2022; Key et al., 2023). We followed a similar approach to Thompson et al. (2022) to control year-to-year effects. We did not include a time dummy variable because the online variable is based on year. Including both a year dummy variable and online variable would result in a multicollinearity issue.

## RESULTS AND DISCUSSION

Parameter estimates for the hedonic pricing models are contains in Table 2. Heteroscedasticity was found across years and months. Results, therefore, are estimated using multiplicative heteroscedasticity in the variance equation, correcting for unequal variances.

The model indicates that several factors affected female cattle prices and that the signs of the coefficients were as expected. We found that heifer lots sold for less than the bred female lots. Translating the estimated parameter to a price, the per head price discount for heifer lots was $151. This is aligned with what both Mitchell et al. (2018) and Boyer et al. (2021) found, which is that 5-yr-old bred cows sold for the highest price. The price of female cattle in this sale increased at a decreasing rate, which is also what Boyer et al. (2021) found. Boyer et al. (2021) reported the sale price increased until females were between 4 and 5 mo pregnant, whereas Mitchell et al. (2018) found pregnant cow sale prices increased until they were 8 mo pregnant. This analysis found that the price was maximized when females were sold between 5 and 6 mo pregnant.

The calving ease direct EPD and milk EPD were insignificant, but weaning weight EPD was positive and significant. A one-unit increase in the weaning weight EPD resulted in the sale price increasing $10 per head. Parcell et al. (2006) analyzed the effect of sire EPD on bred heifer prices and found birthweight EPD and carcass quality EPD did influence prices. The time trend was significant, but lot size was not. Finally, opening this sale up to have

<table>
<thead>
<tr>
<th>Variable</th>
<th>Mean</th>
<th>SD</th>
<th>Minimum</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heifer¹</td>
<td>0.68</td>
<td>0.47</td>
<td>0.00</td>
<td>1.00</td>
</tr>
<tr>
<td>Months bred</td>
<td>4.72</td>
<td>2.48</td>
<td>0.00</td>
<td>7.00</td>
</tr>
<tr>
<td>Calving ease direct EPD</td>
<td>5.39</td>
<td>3.67</td>
<td>-6.50</td>
<td>14.33</td>
</tr>
<tr>
<td>Weaning weight EPD</td>
<td>54.53</td>
<td>7.22</td>
<td>33.50</td>
<td>79.00</td>
</tr>
<tr>
<td>Milk EPD</td>
<td>26.58</td>
<td>3.29</td>
<td>16.50</td>
<td>35.00</td>
</tr>
<tr>
<td>Online sold²</td>
<td>0.66</td>
<td>0.48</td>
<td>0.00</td>
<td>1.00</td>
</tr>
<tr>
<td>Steer price ($)</td>
<td>141.68</td>
<td>10.62</td>
<td>132.88</td>
<td>163.76</td>
</tr>
<tr>
<td>Lot size (head)</td>
<td>2.66</td>
<td>0.65</td>
<td>1.00</td>
<td>4.00</td>
</tr>
</tbody>
</table>

¹Heifer = 1 if lot was heifers.  
²Online sold = 1 if lot was sold with online bidding.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Estimate</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>6.8149</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Heifer¹</td>
<td>-0.0650</td>
<td>0.0195</td>
</tr>
<tr>
<td>Months bred</td>
<td>0.1713</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Month bred squared</td>
<td>-0.0151</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Calving ease direct EPD</td>
<td>0.0005</td>
<td>0.8304</td>
</tr>
<tr>
<td>Weaning weight EPD</td>
<td>0.0045</td>
<td>0.0062</td>
</tr>
<tr>
<td>Milk EPD</td>
<td>-0.0015</td>
<td>0.5599</td>
</tr>
<tr>
<td>Online sold²</td>
<td>0.2541</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Lot size (head)</td>
<td>0.0090</td>
<td>0.4753</td>
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<tr>
<td>Time</td>
<td>-0.2736</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Time squared³</td>
<td>0.0534</td>
<td>&lt;0.0001</td>
</tr>
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</table>

¹Heifer = 1 if lot was heifers.  
²Online sold = 1 if lot was sold with online bidding.  
³We also ran the model with cattle price; the results did not change.
online bidding increased sale prices. The estimated per head price increase because of online sales was $379. This is a similar conclusion to those found in studies focused on larger sales, most focused on feeder cattle (Bailey et al., 1991; Blank et al., 2016). Since shifting to online sales in 2019, the sale has averaged 31 lots per year, with an average lot size of 2.66 head per lot. About 82 head were sold online per year or 330 head total. At an estimated premium of $379 per head, online sales have increased sale revenue by an estimated $125,009 over the last 4 yr or around $31,100 per year. Obviously, if the cost of the online bidding service were less than the added revenue, this was a profitable investment. This estimate is also useful for other producers to consider how many head they need to sell to pay for the online bidding opportunity. It should be noted that in-person bidding might also have benefits that go beyond the dollars. There might be certain cases where an in-person sale might benefit the sale more than online.

APPLICATIONS

The objective of this analysis was to determine whether online bidding affected the price of female beef cattle along with several factors such age, months bred, and sire’s EPD. Data came from a registered Angus cow and heifer sale in Crossville, Tennessee, that occurs in November at the University of Tennessee Plateau Research and Education Center, from 2017 to 2022. A hedonic pricing model was used to determine the value of these factors on sale price. The key finding from this analysis was that adding an online auction sales component to an on-farm sale of females can increase revenue. As noted in the introduction, the positives of using the online bidding mechanism can reduce transactions costs while also allowing for more potential buyers. Given the significant price increase for cattle via online bidding, a producer could consider this as an alternative to the traditional marketing of cattle via a live auction. Moreover, given that the average lot size is below 5 head, producers marketing through a traditional auction market might not achieve a volume premium that exceeds the increased revenue due to the online bidding alternative. These results can be used to demonstrate to producers the value of allowing online bidding and add to the hedonic pricing literature for cattle. If a producer chooses to use online bidding, there is a service or commission fee for this alternative. These results will also allow a producer to analyze the added value from including online bidding against the cost of the service or commission. More research is needed to understand whether an online option increases bidders and the number of bids.

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LITERATURE CITED


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