Hedonic prices of yearling bulls: Estimating the value of a pulmonary arterial pressure score

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ABSTRACT

Producers look for various traits in seedstock bulls to enhance their herds and will often pay a premium for those traits. One particular physical characteristic that is of interest to producers in the mountainous western United States is for cattle that can thrive at a high altitude. Cattle in this environment can be prone to developing high altitude disease, which has been shown to cause weakness, lethargy, and death. Pulmonary arterial pressure is a test used to detect the likelihood of an animal developing high altitude disease. Between 2011 and 2014 an annual auction was held at high elevation offering yearling bulls that had certain performance measurements and genetic characteristics. A hedonic price regression framework was used to determine the marginal implicit value of the simple performance measurements, EPD, and marketing factors of the yearling bulls. The results suggest that producers were willing to pay more for bulls with lower pulmonary arterial pressure scores (P < 0.05). The analyses also suggest that producers were willing to pay for other performance measurements (e.g., birth weight, weaning weight, dam age, and ADG) and EPD (e.g., yearling weight, milk, and stayability). Although buyers are willing to pay more for several other traits (e.g., ADG, birth weight), pulmonary arterial pressure score appears to be an important trait on which producers place significant value.

Key words: bull prices, expected progeny difference, hedonic model, pulmonary arterial pressure, performance measurements

INTRODUCTION

High altitude disease (HAD), also known as brisket disease, dropsy of high altitudes, and high mountain disease, affects cattle living at altitudes of 1,524 m (5,000 ft) or more and is commonly found in herds in Colorado, New Mexico, Utah, and Wyoming. High altitude disease is one of the top causes of morbidity and mortality in cattle raised at a high altitude and accounts for significant loss in growth and reproductive performance. Holt and Callen (2007) estimated that among the 1.5 million cattle raised at high elevation, HAD accounted for a 5% annual death loss in those herds. McCormick (2011) reported the disease had a 0.5 to 5% occurrence rate in cattle native to high elevations, but jumped to 30 to 40% in cattle transported from low to high elevations or in the offspring of untested sires. This resulted in an estimated annual financial loss of $60 million.

Cattle today are frequently tested to determine susceptibility to HAD. The test, pulmonary arterial pressure (PAP), provides a score that is an indicator trait of an animal’s genetic ability to tolerate high altitudes (Holt and Callen, 2007). To perform a PAP test, the animal is restrained, a catheter is inserted into the jugular vein, and it is threaded through the right ventricle and into the pulmonary artery, where the pressure is measured (Holt and Callen, 2007). An animal’s PAP score is the average of diastolic and systolic blood pressures and is a reliable predictor when performed at high altitudes. The scores typically range from mid-30s to 130 mmHg, with scores over 45 indicating a greater risk of developing HAD (Ahola et al., 2006). The PAP score has been shown to be heritable in cattle (Schimmel et al., 1981; Enns et al., 1992; Shirley et al., 2008), suggesting the PAP may be reduced in future generations of herds through retaining bulls with lower, more desirable scores.

The objective of this study was to assess the implicit value of PAP scores and performance in yearling bulls sold at auctions in a high altitude environment. Specifically, a hedonic model was used to estimate the intrinsic value of simple performance measures (SPM) and EPD. The additional performance measures included other traits such as birth weight (BRW), growth, and maternal ability. With a significant number of cattle raised in higher elevations in the western United States, an economic assessment of a PAP score and other traits can potentially provide value to the cattle ranchers and breeders in this region.
MATERIALS AND METHODS

Hedonic Modeling

One of the most common ways to estimate the value of attributes of agricultural products is through the use of hedonic price modeling. A hedonic model shows the relationship between the price of a product and its various attributes (Studenmund, 2006). By using partial derivatives, it isolates each attribute to determine its influence on the price (Oczkowski, 2001).

Model

The model used in this study follows the conceptual model used by Duyvotteder et al. (1996) and Jones et al. (2008):

\[
\text{Bull Price} = f(\text{SPM, EPD, Marketing Factors}).
\]  

Equation (1) states the bull price is a function, \( f \), of SPM, EPD, and Marketing Factors. Simple performance measurements refer to the bull’s own performance for commonly recorded traits (Table 1), whereas EPD refers to expected performance of offspring based on a genetic evaluation. The marketing factors, or year of the sale, were included to account for temporal factors that could affect the bull sale price. The SALE_PRICE is the purchase price of bull \( i \) and can be specified in the following empirical model:

\[
\text{SALE}_i \text{PRICE}_i = \beta_0 + \beta_1 \times \text{PAP}_i + \beta_2 \times \text{BRW}_i + \beta_3 \times \text{BRW}^2_i + \beta_4 \times \text{WW}_i + \beta_5 \times \text{SALE}_AGE_i + \beta_6 \times \text{SALE}_AGE^2_i + \beta_7 \times \text{DAM}_AGE_i + \beta_8 \times \text{FRAME}_i + \beta_9 \times \text{ADG}_i + \beta_{10} \times \text{SC}_i + \beta_{11} \times \text{EPD}_\text{BRW}_i + \beta_{12} \times \text{EPD}_\text{WW}_i + \beta_{13} \times \text{EPD}_\text{YW}_i + \beta_{14} \times \text{EPD}_\text{MILK}_i + \beta_{15} \times \text{EPD}_\text{CED}_i + \beta_{16} \times \text{EPD}_\text{CETM}_i + \beta_{17} \times \text{EPD}_\text{STAY}_i + \beta_{18} \times \text{YR2012}_i + \beta_{19} \times \text{YR2013}_i + \beta_{20} \times \text{YR2014}_i + \epsilon_i, \quad (2)
\]

where PAP is pulmonary arterial pressure, BRW is birth weight, \( \text{BRW}^2 \) is BRW squared, WW is weaning weight, \( \text{SALE}_AGE \) is the age of the bull at the sale date, \( \text{SALE}_AGE^2 \) is \( \text{SALE}_AGE \) squared, \( \text{DAM}_AGE \) is the age of the dam at calving, FRAME is the frame score, ADG is average daily gain, and SC is scrotal circumference. The variables \( \text{EPD}_\text{BRW}, \text{EPD}_\text{WW}, \text{EPD}_\text{YW}, \text{EPD}_\text{MILK}, \text{EPD}_\text{CED}, \text{EPD}_\text{CETM}, \) and \( \text{EPD}_\text{STAY} \) represent the EPD for BRW, WW, and YW, milk (MILK), calving ease direct (CED), calving ease total maternal (CETM), and stayability (STAY), respectively. The marketing years for 2012, 2013, and 2014 were YR2012, YR2013, and YR2014, respectively. Additional description of the variables is provided in the text below. The estimated coefficients (\( \beta_i \)) are the partial derivatives of the sale price with respect to the characteristic and measure the marginal implicit price of the characteristic. For example, \( \beta_1 \) is the partial derivative of the sale price with respect to the PAP score. This parameter indicates the marginal change in the sale price for each one-unit increase in PAP score. Table 1 provides the variable name, description, and summary statistics for variables listed in Equation (2).

Issues with Hedonic Models

Two common issues that arise with hedonic modeling are multicollinearity and heteroskedasticity. The effect of multicollinearity is a high R² with few or no statistically significant regression coefficients, which results in the increased likelihood of making a Type II error (Gujarati, 2003). Although there is no formal statistical test for detecting multicollinearity, the general rule of thumb is that a variance inflation factor over 10 is problematic (Ott and Longnecker, 2001). This corresponds to an R² greater than 0.9 when each independent variable is regressed on the remaining independent variables. In prior studies, EPD for BRW, WW, and YW were found to be collinear (Vanek et al., 2008; McDonald et al., 2010). This study did not find any multicollinearity with these variables; thus, all 3 variables were retained.

A variance inflation factor of 11.0 was found for the EPD for CED. The models used to calculate CED, which is a predictor of a sire’s ability to produce calves born unassisted, and CETM, which reflects the ability of a sire’s daughters to calve as first-calf heifers, both use BRW and calving ease score as outlined in the Beef Improvement Federation guidelines (BIF, 2010) in a multitrait mixed, animal model to calculate CED and CETM EPD. Because the input received to calculate CED is retained within the BRW and CETM variables, it was determined that the EPD for CED could be omitted without compromising accuracy; thus, it was dropped from the final model.

Heteroskedasticity is another issue that has been detected in prior studies (Jones et al., 2008). Heteroskedasticity can lead to incorrect hypothesis testing and erroneous conclusions because the variances are no longer the minimum and no longer efficient (Gujarati, 2003). White’s test was used, and no evidence of unequal variances was found (White, 1980).

Data

Data used in this study were collected at the John E. Rouse Beef Improvement Center located near Saratoga, Wyoming, at an elevation of 2,103 m (6,900 ft). The bull sales occurred in March 2011, March 2012, April 2013, and April 2014. The bull test data were distributed to potential buyers through presale catalogs, and actual purchase prices were obtained directly from Colorado State University personnel after each sale. There were 35, 39, 17, and 41 bulls listed at the 2011, 2012, 2013, and 2014 sales, respectively. Bulls scratched before the sale and those
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