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Cow–Calf Producer Preferences for Bull Genomic Enhanced Expected Progeny Differences

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Genomic enhanced expected progeny differences (GE-EPDs) combine expected progeny differences (EPDs) with DNA information to improve EPD accuracy values. In 2020, Tennessee cattle producers completed a between-subjects choice experiment for bulls marketed with either EPDs or GE-EPDs. Panel Tobit regression results indicate that, on average across all considered EPDs, producers were not willing to pay significantly more for GE-EPDs than for EPDs. However, producers were willing to pay more for the calving ease direct EPD if it was genomic enhanced. This is the first known study to evaluate producers' value of improved accuracy scores associated with GE-EPDs.

Key words: beef cattle, choice experiment, producer survey

Introduction

In 2020, there were approximately 94 million head of cattle and calves in the United States, and the sector recorded cash receipts of approximately \$63 billion (US Department of Agriculture, 2021b, 2017b). Additionally, the United States was the third-largest beef exporter in the world, with exports of \$7.6 billion (US Meat Export Federation, 2021; US Department of Agriculture, 2021a). While several factors have contributed to the growth of the US beef industry, improved herd genetics through breeding management has been an important contributor to increasing the efficiency of the US beef industry (Rowan, Martinez, and Rhinehart, 2021; University of Tennessee Institute of Agriculture, 2021).

The breeding process begins with cow–calf producers selecting sires and dams with physical and genetic traits that they hope will maximize profits through improved performance and enhanced quality. According to Dhuyvetter et al. (1996), bulls introduce most of the new genetic attributes into a typical beef cow herd. Kilpatrick (2015) explains that the last three sires used in an operation could account for as much as 87% of the genetic makeup of the calf crop if the replacement heifers are retained. The collection of bull genetic information is valuable to producers because it can improve their decision-making process when purchasing bulls. For example, through improved selection of bulls, cattle producers can improve animal efficiency, sustainability, and profitability (Kilpatrick, 2015; Rowan, Martinez, and Rhinehart, 2021; University of Tennessee Institute of Agriculture, 2021).

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Expected progeny differences (EPDs) indicate the performance potential of a bull's progeny by using all animal performance data on its ancestors and progeny to calculate the animals' associated EPDs (Greiner, 2005). EPDs can be used to select cattle for specific traits (e.g., birth weight, weaning weight, and carcass quality). While these measurements have been around for 3 decades, studies have shown that producers' valuation of EPDs when purchasing bulls varies depending on the time frame and location of the study (Dhuyvetter et al., 1996; Chvosta, Rucker, and Watts, 2001; Vestal et al., 2013; Boyer et al., 2019).

First introduced by the American Angus Association (AAA) in 2009 (Scharpe, 2016), genomic-enhanced EPDs (GE-EPDs) combine genomic test results with pedigree, performance, and progeny data, resulting in increased EPD accuracy (American Angus Association, 2018; Hoffman, 2014). Thus, GE-EPDs differ from regular EPDs by having performance-improved accuracy values associated with the selected EPD traits. While research has examined cow-calf producer preferences for bull EPDs, no known research has examined how cow-calf producers value bull GE-EPDs. The goal of this research is to determine how producers value GE-EPDs and their associated improved accuracy scores.

To accomplish this, a between-subjects choice experiment was administered on Tennessee cow-calf producers. Respondents participating in the choice experiment bid on bulls with varying traits; half of the participants saw bulls marketed with EPDs, while the other half saw bulls marketed with GE-EPDs. Results provide insights into cow-calf producer preferences for bull EPDs, and their price valuation of bulls marketed with GE-EPDs compared to EPDs, while controlling for the influence of producer and farm characteristics.

This research represents a unique contribution since prior research has been limited to studying cattle producer willingness to pay (WTP) for bull EPDs (Dhuyvetter et al., 1996; Chvosta, Rucker, and Watts, 2001; Vestal et al., 2013; Boyer et al., 2019) and has not incorporated the estimation of GE-EPDs. Therefore, we extend the bull genetic literature by providing an analysis of how GE-EPDs are valued by producers and how they compare to EPDs. By utilizing a between-subjects experimental design we can directly measure the effect of improved accuracy scores associated with GE-EPDs on producer WTP for bulls while holding other relevant factors constant, including their stated relevance of traits in their decision. Results of this research are informative to understanding how producers value EPDs, GE-EPDs, and the associated accuracy of these traits.

Producers in Tennessee were surveyed since beef cattle production is a critical component of the Tennessee economy, accounting for approximately 17% of all agriculture cash receipts, with cow-calf production being the largest component of the state's cattle industry (Tennessee Department of Agriculture, 2020). Behind soybeans, the cattle industry is the second-highest valued commodity in Tennessee's agricultural sector (US Department of Agriculture, 2020). With approximately 909,000 head of beef cattle, Tennessee ranks 12th in the nation in total beef cows and is known as a cow-calf producing state (US Department of Agriculture, 2017c).

McBride and Mathews (2011) estimated that 70% of Tennessee calves are sold at weaning, which is the highest of all considered cattle regions, and calves were reported, on average, to be sold at a much lighter weight (480 lb/head) than in other regions. Asem-Hiablie et al. (2018) reported similar production practices for other Southeast producers. Southeast producers sold calves at weaning with an average age of 7.9 months old. Thus, Tennessee and Southeast producers are frequently purchasing bulls, and this analysis will be useful to inform Extension programs across the Southeast on using GE-EPDs for bull evaluation.

Literature Review

Several studies have examined producer preferences for bull EPDs and physical traits by using bull auction data throughout various regions of the United States and Canada (e.g., Dhuyvetter et al., 1996; Chvosta, Rucker, and Watts, 2001; Walburger, 2002; Irsik et al., 2008; Jones et al., 2008; McDonald et al., 2010; Franken and Purcell, 2012; Brimlow and Doyle, 2014; Kessler, Pendell, and

Enns, 2017; Boyer et al., 2019). These studies found a variety of factors influenced bull sale prices ranging from physical characteristics to specific EPD traits (e.g., weaning weight, birth weight, ribeye area). For example, Jones et al. (2008) examined data from purebred Angus bull sales across the Midwest, Rocky Mountain, and Northwest regions of the United States. Their study compares values of production weights, production EPDs, and ultrasound EPDs. Results found that actual weights and EPDs significantly impacted the sale prices of bulls.

Evaluating bull auction data from Montana, McDonald et al. (2010) found that EPDs such as birth weight, birth to yearling gain, and ribeye area significantly affected the sale price of bulls. Franken and Purcell (2012) reviewed studies evaluating bull EPDs and evaluated data from bull auctions encompassing multiple breeds of beef cattle held in Missouri from 2000–2010. Their findings indicated that EPDs such as birth weight, yearling weight, maternal milk, ribeye area, and marbling contribute to the value buyers placed on bulls at auction.

Brimlow and Doyle (2014) studied Nevada bull test auction data spanning 2007–2009 and 2012 to assess bull buyer valuation for both genetic and phenotypic measures of carcass and growth characteristics. Like the aforementioned studies (Jones et al., 2008; McDonald et al., 2010; Franken and Purcell, 2012), Brimlow and Doyle concluded that birth weight EPD was an important factor in determining the value buyers place on bulls at auction. EPDs such as birth to yearling gain and ribeye area were also found to be significant in determining bull sale prices. Other important characteristics were the performance measures of final average daily gain, the bull's actual birth weight, ultrasound adjusted ribeye area, ultrasound marbling, the bull's final weight, residual feed intake, and total conformation score.

Kessler, Pendell, and Enns (2017) analyzed data from 2011–2014 for bull sales in Wyoming. Their research indicated buyers paid significantly more for bulls with increased performance measurements (e.g., the bull's actual birth weight, weaning weight, and average daily gain). Buyers also paid significantly more for bulls with increased EPD values for yearling weight and stayability.

Boyer et al. (2019) used bull sale data from 2006–2016 to estimate Tennessee cow–calf producers' value of phenotypic traits, performance measures, and EPDs. Their study also evaluated the effects of Tennessee's partial-cost reimbursement program on bull prices. Results showed that producers valued projected growth EPD, calving ease direct EPD, milk EPD, average daily gain, sale weight, and frame score. These researchers also found that the partial-cost reimbursement program increased bull prices in some years.

This previous literature focused solely on auction data. Vestal et al. (2013), however, implemented a combined revealed and stated preference approach to evaluate and compare bull buyers' survey stated WTP values along with auction data. Vestal et al. distributed a mail survey to previous Oklahoma Beef Incorporated (OBI) bull buyers in 2010 to elicit information regarding preferences for EPDs, Igenity scores, and ultrasound results. The revealed preference data (actual auction data) was collected from three OBI performance-tested bull sales spanning 2009–2010. When the two datasets were compared, results showed that bull buyers significantly valued EPD information, test performance, and ultrasound information, while newer DNA profile information (Igenity scores) was unrelated to buyers' preferences. We build on this previous research regarding producer preferences for bull EPDs by surveying Tennessee cow–calf producers to determine their stated WTP for bulls with varying EPDs and GE-EPDs.

Materials and Methods

Survey Design

In June 2020, email invitations to complete an online Qualtrics survey (www.qualtrics.com) were sent to cattle producers participating in the Tennessee Agricultural Enhancement Program (TAEP). TAEP, which is funded by the Tennessee Department of Agriculture (TDA), is a cost-share program established in 2005 to assist Tennessee farmers in making long-term investments (Tennessee Department of Agriculture, 2021). Second invitations were sent to nonrespondents a few weeks later.

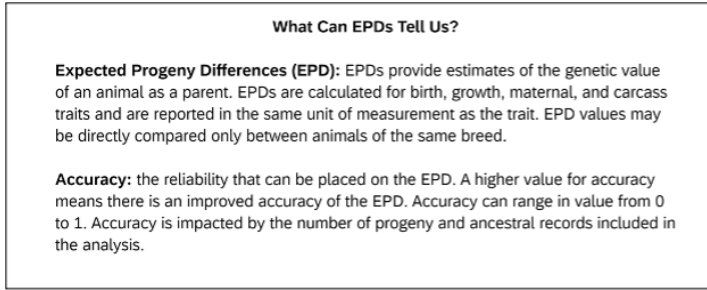


Figure 1. EPD Treatment Information Screen

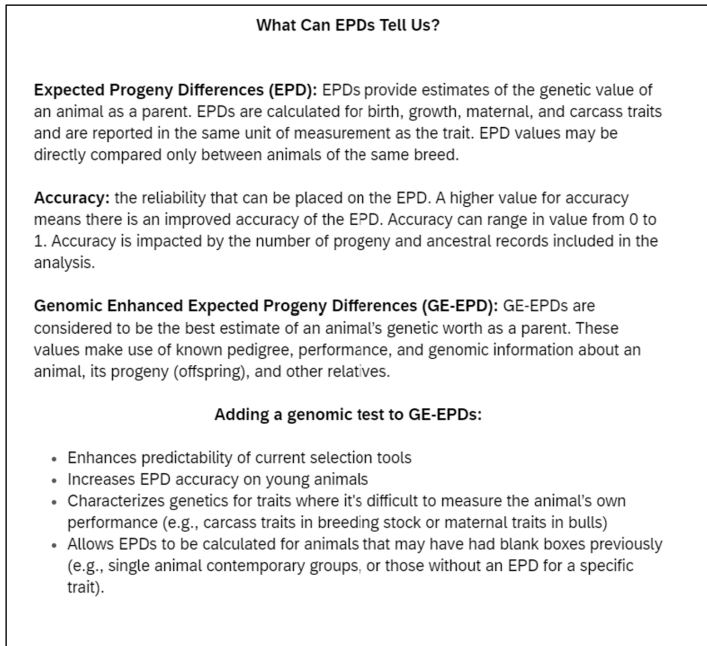


Figure 2. GE-EPD Treatment Information Screen

Producers were required to be 18 years of age or older to complete the survey. Prior to distribution, the survey was pretested by Tennessee cow–calf producers and industry experts.

Producers were first asked to indicate in which segment of the beef cattle industry they were primarily involved. Participants who selected purebred breeder, commercial producer by natural service, or commercial producer by artificial insemination were then directed into either the EPD treatment or the GE-EPD treatment. Similar to Vestal et al. (2013), participants in both treatments were provided the following instructions prior to bidding on the bulls:

We would like to ask you about your willingness to pay for bulls with differing EPD's. In the next series of questions, you will be asked to choose from 9 bulls with differing EPD's. This will help us better understand your preferences, as a cattle producer, for these traits in bulls.

Directions: Imagine you are at a bull auction, and you are only going to purchase one of the nine bulls which are available for sale. At the bottom of each bull's information is a place for you to list your maximum bid for each bull. This is the most you would be willing to pay for the bull. You will be able to look at all nine bulls and scroll through them and enter your bids for them.

EPDs That Will Appear on the Bid Sheet:															
<p>Calving Ease Direct EPD (CED): is expressed as a difference in percentage of unassisted births, with a higher value indicating greater calving ease in first-calf heifers. It predicts the average difference in ease with which a sire's calves will be born when he is bred to first-calf heifers.</p> <p>Weaning Weight EPD (WW): expressed in pounds, is a predictor of a sire's ability to transmit weaning growth to his progeny compared to that of other sires.</p> <p>Docility EPD (DOC): is expressed as a difference in yearling cattle temperament, with a higher value indicating more favorable docility. It predicts the average difference of progeny from a sire in comparison with another sire's calves. In herds where temperament problems are not an issue, this expected difference would not be realized.</p> <p>Maternal Milk EPD (MILK): is a predictor of a sire's genetic merit for milk and mothering ability as expressed in his daughters compared to daughters of other sires. In other words, it is that part of a calf's weaning weight attributed to milk and mothering ability.</p> <p>Mature Weight EPD (MW): expressed in pounds, is a predictor of the difference in mature weight of the daughters of a sire compared to the daughters of other sires.</p> <p>Carcass Weight EPD (CW): expressed in pounds, is a predictor of the differences in hot carcass weight of a sire's progeny compared to progeny of other sires.</p> <p>Ribeye Area EPD (RE): expressed in square inches, is a predictor of the difference in ribeye area of a sire's progeny compared to progeny of other sires.</p> <p>Weaned Calf Value (\$W): An index, expressed in dollars per head, to predict profitability differences in progeny due to genetics from birth to weaning. Included traits are birth weight, weaning weight, milk, and mature cow weight.</p> <p>The highlighted EPDs (described above) will vary among the bulls you are to bid on, while all others are assumed to be at the averages provided in the table below.</p>															
Spring 2020 Angus Breed Averages															
Non-Parent Bulls															
Production								Maternal							
CED	WW	DOC	BW	YW	RADG	DMI	YH	SC	Milk	MW	HP	CEM	MH	\$EN	
6	54	16	1.3	96	0.24	0.81	0.5	0.76	25	51	11.1	9	0.3	-11	
Carcass								\$Values							
				CW	RE	Marb	Fat	\$W	\$M	\$F	\$G	\$B	Claw	Angle	
				40	0.55	0.54	0.011	54	56	83	46	129	0.51	0.5	

Figure 3. EPD Definitions Provided in the Survey

Participants in the EPD treatment next saw the information provided in Figure 1; participants in the GE-EPD treatment saw the information provided in Figure 2. Both treatments were provided with definitions of EPDs and EPD accuracy values (Figures 1 and 2). The GE-EPD treatment also provided information regarding GE-EPDs (Figure 2).

Participants in both treatments were then asked to bid on nine bulls with varying EPD traits: calving ease direct (*CED*), weaning weight (*WW*), docility (*DOC*), maternal milk (*MILK*), mature weight (*MW*), carcass weight (*CW*), ribeye area (*RE*), and weaned calf value (*\$W*) (Table 1). Participants in both treatments were provided with information defining each of these EPDs as well as the AAA breed EPD averages for all EPDs (the highlighted EPDs being the ones presented for the nine bulls they were asked to bid on) (Figure 3). These EPDs were identified as the most relevant and important based on literature and conversations with Tennessee beef cattle producers and industry experts. All possible EPDs were not included in the choice experiment design to

Table 1. Attribute Levels of Survey Bulls

EPD	Description (units)	Levels	Average	EPD Accuracy	GE-EPD Accuracy
CED	Calving ease direct (percentage of unassisted births)	14	6	0.29	0.44
		8		0.29	0.44
		5		0.29	0.44
WW	Weaning weight (lb)	74	54	0.28	0.43
		59		0.28	0.43
		50		0.28	0.43
DOC	Docility (temperament score)	29	16	0.26	0.41
		20		0.26	0.41
		13		0.26	0.41
MILK	Maternal milk (milk and mothering ability score)	34	25	0.17	0.32
		27		0.17	0.32
		23		0.17	0.32
MW	Mature weight (lb)	98	51	0.27	0.42
		62		0.27	0.42
		40		0.27	0.42
CW	Carcass weight (lb)	63	40	0.17	0.32
		46		0.17	0.32
		35		0.17	0.32
RE	Ribeye area (square inches)	0.98	0.55	0.21	0.36
		0.64		0.21	0.36
		0.45		0.21	0.36
\$W	Weaned calf value (index in dollars)	79	54	n/a	n/a
		60		n/a	n/a
		49		n/a	n/a

guarantee a reasonable number of bulls for participants to bid on. Participants had access to the Figure 3 information sheet as they bid on the bulls.

The bull choice set was generated using an orthogonal sequential design, which was programmed using Ngene (ChoiceMetrics, 2018). The design consisted of three blocks with nine bulls in each block, for a total of 27 bulls. Respondents were asked for their maximum bid on each of the nine bulls as if they were purchasing them at an auction. They were able to see all nine bulls at once and were able to revise their bids as needed. The order of the bulls was randomized across participants.

Table 1 shows the eight EPD attributes that appeared on the bull bid sheets, the three levels by which they varied in the choice set, and the Angus breed EPD average for each respective EPD. The EPD average values and selected EPD attribute levels were obtained from the AAA's Breed Percentile Breakdown for 2020 Non-Parent Bulls (American Angus Association, 2020). The low, middle, and high EPD levels in Table 1 are the 65th, 35th, and 5th percentiles of the AAA Breed Percentile Breakdown for 2020, respectively. These percentiles were chosen as the most realistic range to use based on discussion with cattle producers and from examination of the University of Tennessee (UT) Bull Test data.

Average EPD accuracy values were found by examining accuracy values for bulls sold through the UT Bull Test. The accuracy values were the same for each EPD level but varied across each EPD.

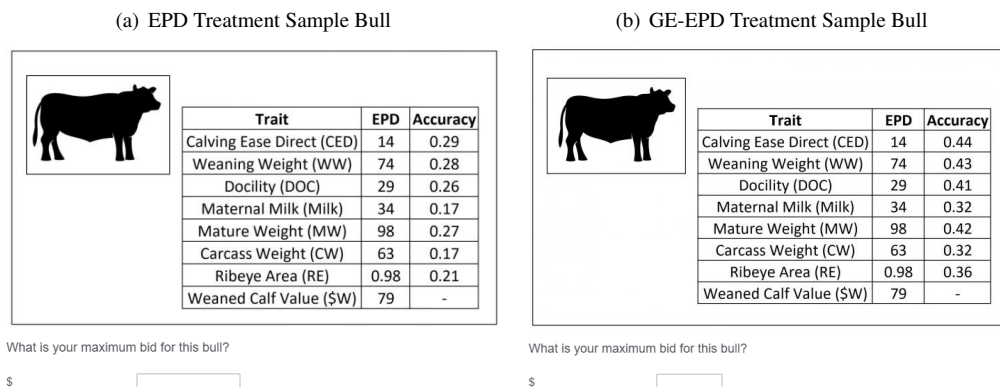


Figure 4. Sample Bulls upon Which Producers in the Survey Bid

Moving from the EPD treatment to the GE-EPD treatment, accuracy values increase by a factor of 0.15. This decision came from analyzing accuracy values of the UT Bull Test between EPDs and GE-EPDs of bulls sold, which were improved by a factor of 0.15 compared to EPD accuracy values. An increase in accuracy value indicates less variation of the actual EPD value from the average or expected value of the EPD.

Figure 4 shows an example of a bull upon which producers bid in the EPD and GE-EPD treatments. The only difference between bulls sold in the GE-EPD and EPD treatments was that the accuracy values were increased by a factor of 0.15 for the GE-EPD treatment; the EPDs were all kept at the same levels between the two treatments. Thus, only the impact of improved accuracy values associated with GE-EPDs is evaluated through this design.

It should be noted that improved accuracy scores are not the only benefit of GE-EPDs compared to EPDs. The bottom of Figure 2 outlines additional benefits of GE-EPDs, which include being able to calculate EPDs for cattle which may not have previously had EPD scores. GE-EPDs also have the potential to change EPD values (and in turn make the EPDs more accurate) because the genetic information provides ancestry information. The American Angus Association (2018) explains this:

For example, if a newly tested animal shows to have a strong genomic relationship to an animal who is proven to excel for a trait like Marbling, then the newly tested animal will increase for Marbling EPD. On the contrary, if an animal is found to be more related to a low performing animal in the pedigree, its EPDs will adjust accordingly.

Our experimental design isolates whether producers place a greater value on EPDs if they are more accurate through the addition of genomic testing.

Conceptual Framework and Hypothesized Results

Each respondent's bid in the choice experiment represents their WTP for each of the nine bulls offered in the choice experiment. We hypothesize that each bull's value (WTP) is a function of the bull's provided EPDs, which appear in Table 1. Other variables likely to impact bull WTP are producer and farm characteristics (*Characteristics*), the importance of EPDs and GE-EPDs in producers' bull selection decision (*EPD_Importance*), and the sources of information that producers use in making their beef cattle business decisions (*Info*). Finally, we expect that bull WTP is affected by producers being in the GE-EPD treatment or the EPD treatment, since producers in the GE-EPD treatment bid on bulls with increased EPD accuracy scores (*GE_Treatment*).

Thus, we hypothesize that producer i 's WTP for bull k (wtp_{ik}) can be expressed as a function (f) of the following factors:

$$(1) \quad wtp_{ik} = f(EPDs_{ik}, Characteristics_i, EPD_Importance_i, Info_i, GE_Treatment_i),$$

where wtp_{ik} is the price (\$/head), $EPDs_{ik}$ represents EPDs associated with the choice set of hypothetical bull k (Table 2), $Characteristics_i$ refers to producer and farm characteristics of producer i , $EPD_Importance_i$ is producer i 's stated importance of EPDs and GE-EPDs in their bull selection decision on a scale from 1 (not important) to 7 (very important); and $Info_i$ reflects the sources from which producer i obtained information used in making beef cattle business decisions. The variable $GE_Treatment_i$ is a binary variable indicating whether producer i was assigned to the GE-EPD treatment or the EPD treatment (1 = GE-EPD treatment, 0 = EPD treatment). In the first model specification (Model I), we include $GE_Treatment$ as a variable to examine whether producers in the EPD treatment bid significantly more for bulls than producers in the GE-EPD treatment. In the second model specification (Model II), we interact the $GE_Treatment$ variable with each EPD (e.g., $GE_Treatment \times CED$) to examine whether producers bid significantly more for bulls with specific EPDs that were GE. The specific names and definitions of the variables in these categories appear in Table 2.

The EPDs included in the choice set were hypothesized to have a significant impact on WTP (Table 2) because discussion with Tennessee producers and industry experts identified them as important in bull purchasing decisions. Further, the literature has found several of these EPDs to be positive and significant determinants of bull auction sale prices (e.g., Boyer et al., 2019; Franken and Purcell, 2012; Brimlow and Doyle, 2014; Vestal et al., 2013).

Boyer et al. (2019) found that an increase in CED EPD positively impacted bull purchase price. Kessler, Pendell, and Enns (2017) did not find the WW EPD to significantly impact bull auction prices. However, we expect that the WW EPD will positively impact WTP, since cow-calf producers in the Southeast United States are known to market their calves at weaning (Tang et al., 2017; McBride and Mathews, 2011), and a higher weaning weight generally leads to increased revenue.

An increase in the MILK EPD has been found to increase bull auction prices (Jones et al., 2008; Franken and Purcell, 2012; Boyer et al., 2019), but other studies have found that the MILK EPD was not significant in determining bull prices or that an increased MILK EPD decreased bull prices (Brimlow and Doyle, 2014; Vestal et al., 2013; Kessler, Pendell, and Enns, 2017). We expect the MILK EPD to positively impact WTP. The RE EPD has been found to be significant and positive in determining bull prices (e.g., Vanek, Watts, and Brester, 2008; Franken and Purcell, 2012); therefore, we expect the RE EPD to positively impact WTP. Producer preferences for DOC, MW, CW, and the \$W index EPDs have not previously been examined. Therefore, our results will be of interest to breed associations and contribute to the literature by evaluating these EPDs.

Producers with at least \$100,000 of household income (*HighIncome*) and at least 40% of their household income originating from farming (*FarmIncome40%*) are hypothesized to pay more for bulls (Table 2). Older producers (*Age*) are hypothesized to be willing to pay less for bulls, as research shows that they are typically resistant to change (Weiss and Maurer, 2004). Research shows that higher levels of education promote producer willingness to adopt new management strategies (Kilpatrick, 2000); thus, we hypothesize that producers with a bachelor's degree or higher (*CollegeDegree*) might bid more for the bulls.

It is unknown whether producers who are primarily involved in the beef cattle industry as a purebred breeder (*Purebred*), commercial producers of feeder calves and yearlings by natural service (*Commercial Natural*), or commercial producers of feeder calves and yearlings by artificial insemination (*Commercial AI*) would bid differently on the bulls. However, these variables were included in the model as controls since it is possible these producer types may value bulls differently. Additional control variables were *Herd Size*, the use of Angus sires in their herd, the level of financial risks related to their beef cattle business (*BeefFinanceRisk*) and the price a producer paid for their last bull (*PreviousPrice*).

Producers' stated importance of EPDs and GE-EPDs in their bull selection decisions were included as control variables. Producers were asked to rank how important EPDs and GE-EPDs were in their bull selection decisions on a scale from 1 (not important) to 7 (very important). It is likely that producers who place more importance on EPDs and GE-EPDs will pay more for bulls

Table 2. Names and Definitions of Dependent and Independent Variables

Variable	Description	Hyp. Sign
Dependent variable		
<i>Bull WTP</i>	Stated willingness to pay/bid (\$)	n/a
Expected progeny differences (EPDs)		
<i>CED</i>	Calving ease direct (percentage of unassisted births)	+
<i>WW</i>	Weaning weight (lb)	+
<i>DOC</i>	Docility (temperament score)	+
<i>MILK</i>	Milk (milk and mothering ability score)	+
<i>MW</i>	Mature weight (lb)	+
<i>CW</i>	Carcass weight (lb)	+
<i>RE</i>	Ribeye area (square inches)	+
<i>\$W</i>	\$W index (\$)	+
GE treatment		
<i>GE_Treatment</i>	1 if provided GE-EPD block, 0 otherwise	+
<i>GE_Treatment</i> × <i>EPDs</i>	Interaction variables for each EPD × <i>GE_Treatment</i>	+
Producer and farm characteristics		
<i>Age</i>	Age of the producer (years)	–
<i>CollegeDegree</i>	1 if the producer had at least a bachelor's degree; 0 otherwise	+
<i>HighIncome</i>	1 if the producer had household income of at least \$100,000; 0 otherwise	+
<i>FarmIncome40%</i>	1 if at least 40% of household income is from farming; 0 otherwise	+
<i>Purebred</i>	1 purebred breeder; 0 otherwise	+/-
<i>Commercial Natural</i>	1 if commercial producer by natural service; 0 otherwise	+/-
<i>Commercial AI</i>	1 if commercial producer by artificial insemination; 0 otherwise	+/-
<i>Herd Size</i>	Total number of cattle on farm	+/-
<i>Angus</i>	1 if uses Angus sires in their herd; 0 otherwise	+/-
<i>BeefFinanceRisk</i>	Willingness to take risks in beef cattle business financial matters ^a	+/-
<i>PreviousPrice</i>	Price respondent paid for the last bull purchased (\$)	+/-
EPD importance		
<i>EPDs</i>	Importance of EPDs in bull selection decision ^b	+
<i>GE-EPDs</i>	Importance of GE-EPDs in bull selection decision ^b	+
Information sources		
<i>UT Extension</i>	1 if obtain information from University of Tennessee Extension; 0 otherwise	+/-
<i>National</i>	1 if obtain information from national producer groups; 0 otherwise	+/-
<i>Popular Press</i>	1 if obtain information from popular press articles; 0 otherwise	+/-
<i>RegBeefAssociations</i>	1 if obtain information from registered beef cattle associations; 0 otherwise	+

Notes: ^a On a scale from 1 (not at all willing to take risks) to 10 (very willing to take risks).

^b On a scale from 1 (not important) to 7 (very important).

with certain EPDs. These variables also control for producers' prior knowledge and use of EPDs and GE-EPDs: If producers consider them important, they likely use and are knowledgeable about them.

Studies have found a variety of information sources to be important in explaining various farm outcomes (e.g., DeLong et al., 2017; McKay et al., 2019; McLeod et al., 2019; Ellis et al., 2020). McLeod et al. (2019) used a multiple indicator, multiple causes (MIMIC) modeling framework to evaluate farmer use of information sources and found that beef cattle farmers use information from a

variety of sources (e.g., extension service, producer groups, popular press articles, USDA, internet, and other farmers) when making decisions for their beef operations. DeLong et al. (2017) reported if dairy producers obtained information from veterinarians and extension personnel, they had lower bulk tank somatic cell counts on their dairy farm. Ellis et al. (2020) found that dairy producers were 5% less likely to have an operational dairy if they had received information about mastitis from farm journals.

Similarly, we expect the sources of information that producers utilize to inform their beef cattle business decisions to impact their WTP for bulls. However, it is unknown how obtaining information from UT Extension services (*UT Extension*), national producer groups (*National*), and popular press articles (*Popular Press*) might impact their WTP for bulls. Producers obtaining information from registered beef associations (Reg Beef Associations) are hypothesized to be willing to bid more on bulls since they are likely most interested in bulls with specific EPDs (Table 2).

We hypothesize that producers would bid more for bulls marketed with GE-EPDs compared to EPDs since they have higher associated accuracy values. Thus, we expect the *GE_Treatment* and the *GE_Treatment* \times *EPDs* variables to be positive and significant (Table 2). Accuracy values refer to the reliability that can be placed on an EPD, with a higher value for accuracy denoting improved accuracy of the EPD. Accuracy values can range in value from 0 to 1. Accuracy is impacted by the number of progeny and ancestral records included in the analysis (Figure 2).

Econometric Model

We use a random effects panel Tobit regression to estimate factors influencing producers' bids for bulls in the choice experiment (Tobin, 1958). This model was selected due to 6.43% of the bull bids being 0. The panel Tobit regression is represented by

$$(2) \quad y_{ik}^* = \beta_0 + \sum_{j=1}^{25} \beta_j X_{ijk} + \beta_{26} \times GE \text{ EPD Treatment} + v_i + \mu_{ik},$$

where y_{ik}^* is the unobserved latent variable for producer i 's WTP for bull k ; X_{ijk} represents the j th *EPD*, *Producer and Farm Characteristics*, *EPD_Importance*, and *Information Source* explanatory variables; and *GE_Treatment* is an indicator variable equal to 1 if the participant was in the GE-EPD treatment and 0 otherwise. In Model II, equation (2) is modified by dropping the *GE_Treatment* variable and including the interaction of the *GE_Treatment* variable with each of the EPDs (*GE* \times *CED*, *GE* \times *WW*, *GE* \times *DOC*, *GE* \times *MILK*, *GE* \times *MW*, *GE* \times *CW*, *GE* \times *RE*, *GE* \times *\$W*). The β s are the parameter coefficients to be estimated. The random effects, v_i , are independent and identically distributed (*i.i.d.*), and distributed normally with mean 0 and variance of σ_v^2 (i.e., $v_i \sim N[0, \sigma_v^2]$); the error term, μ_{ik} , is also *i.i.d.*, distributed normally with mean 0 and variance of σ_μ^2 (i.e., $\mu_{ik} \sim N[0, \sigma_\mu^2]$), independent of v_i . The subscript $i = 1, 2, \dots, N$ indicates the observation from individual i who is bidding on bulls $k = 1, 2, \dots, 9$. For each bid from individual $i = 1, 2, \dots, N$ for bull k ,

$$(3) \quad y_{ik} = \max(0, y_{ik}^*).$$

The lower bound for the panel Tobit regression is set to 0 due to the presence of 0 bids:

$$(4) \quad y_{ik} = \begin{cases} 0 & \text{if } y_{ik}^* \leq 0 \\ y_{ik}^* & \text{if } y_{ik}^* > 0. \end{cases}$$

Average marginal effects for discrete and continuous variables were calculated as described in StataCorp (2022b) when dealing with a censored outcome (e.g., a clustering of 0 bids). The Tobit regression and marginal effects were estimated with StataCorp (2019) using the *xtTobit* and *margins*

commands, respectively. StataCorp's *coldiag2* command was used to estimate multicollinearity. An estimated condition index for the variables of less than 30 is considered free of collinearity issues (Belsley, 1991).

In Model I, the null hypothesis is that producers in the EPD treatment will bid the same for bulls as producers in the GE-EPD treatment ($\beta_{26} = 0$). However, if we reject the null hypothesis ($\beta_{26} \neq 0$), then the GE-EPD treatment is found to have a significant impact on participants' bids for bulls and increased accuracy values caused producers to bid differently on the bulls. However, if we fail to reject the null, then producers did not bid more for the bulls in the GE-EPD treatment.

Similarly, in Model II, the null hypothesis is that the estimated coefficients for the *GE_Treatment* \times EPDs interaction variables will equal 0. Rejecting this null hypothesis indicates that producers bid significantly different among bulls with EPDs when they were genomic enhanced compared to not being genomic enhanced. The robustness of Model II was also examined by estimating separate regressions following equation (2) using only (i) the EPD treatment observations and (ii) the GE-EPD treatment observations. The StataCorp (2022a) seemingly unrelated estimation procedure (*suest*) was then used to determine whether there were significant differences between the EPD coefficients in the two treatments.

Results

Survey Descriptive Statistics

Of the 6,858 producers contacted, 18% (1,245) responded to the survey. This is similar to other surveys of Tennessee cattle producers, which have had response rates of 11% (McKay et al., 2019) and 18% (McLeod et al., 2019). It is slightly lower than the 28% response rate for Tonsor's (2018) national cattle survey but higher than the 1.9% email response rate of McKendree, Tonsor, and Wolf (2018). Of the 1,245 survey respondents, 1,059 were purebred breeders, commercial producers by natural service, or commercial producers by artificial insemination and invited to participate in the bull choice sets. Of these producers, 754 answered the bull choice sets and a total of 563 answered all questions included in the Tobit regression (283 producers from the GE-EPD treatment and 280 producers from the EPD treatment). The final percentage of observations used in the analysis is consistent with McKendree, Tonsor, and Wolf (2018): of the 723 producer responses to their survey, only 372 answered all questions used in the analysis.

Table 3 presents dependent and independent variable means, standard deviations, and *t*-test results for differences in variable means between each treatment. Very few variables were significantly different between treatments, and all variable mean values between treatments are similar. Additionally, all listed variables are included as independent variables in the regression to control for these factors in the analysis.

On average, producers bid \$2,294.65 for bulls in the EPD treatment and \$2,294.74 for bulls in the GE-EPD treatment. These values were not significantly different from one another, despite the fact that the bulls in the GE-EPD treatment had accuracy values that were 0.15 higher than in the EPD treatment. This result may be explained by producers identifying EPDs (5.8 out of 7 mean Likert score) as being more important than GE-EPDs (4.84 out of 7 mean Likert score) in their bull selection decision (Table 3). The percentage of 0 bids for the bulls in the EPD and GE-EPD treatments was 4% and 8%, respectively. The maximum bids in the EPD and GE-EPD treatments were \$20,000 and \$35,000 per bull, respectively.

The average price paid for the last bull purchased (*PreviousPrice*) by producers was \$3,470 and \$3,080 in the GE-EPD and EPD treatment, respectively. These values were consistent with the average sale price of bulls sold through the UT Bull Test, which ranged from \$3,000 to \$3,500 (Boyer et al., 2019). Producers bid less for the bulls in the choice experiment (\$2,295) than their last bull purchased and bid less than the average sale price of bulls purchased through the UT Bull Test. This justifies the validity of our data and indicates that hypothetical bias is likely not an issue

Table 3. Dependent and Independent Variable Means, Standard Deviations, and Differences of Means for GE-EPDs and EPDs

Variable	EPDs (N = 280)		GE-EPDs (N = 283)		t-Test Statistics
	Mean	Std. Dev.	Mean	Std. Dev.	
Dependent variable					
<i>Bull WTP</i>	2, 294.65	1, 075.25	2, 294.74	1, 534.30	−0.002
Independent variables					
EPDs					
<i>CED</i>	9.02	3.76	8.96	3.74	0.572
<i>WW</i>	61.04	9.96	60.89	9.89	0.547
<i>DOC</i>	20.67	6.55	20.67	6.55	0.00
<i>MILK</i>	28.01	4.54	27.96	4.57	0.332
<i>MW</i>	66.71	24.02	66.73	24.06	−0.024
<i>CW</i>	48.05	11.65	48.00	11.52	0.154
<i>RE</i>	0.69	0.22	0.69	0.22	0.557
<i>\$W</i>	62.72	12.47	62.53	12.38	0.552
Producer and farm characteristics					
<i>Age</i>	56.37	13.21	55.39	12.61	0.94
<i>CollegeDegree</i>	60.00%	0.49	51.24%	0.50	2.05**
<i>HighIncome</i>	57.50%	0.49	53.00%	0.50	1.11
<i>FarmIncome40%</i>	13.21%	0.34	13.47%	0.35	−0.21
<i>Purebred</i>	27.14%	0.44	34.28%	0.47	−1.87*
<i>Commercial Natural</i>	84.64%	0.36	79.51%	0.40	1.61
<i>Commercial AI</i>	14.64%	0.35	13.07%	0.34	0.52
<i>Herd Size</i>	109.55	125.49	111.23	107.06	−0.13
<i>Angus</i>	81.07%	0.39	76.68%	0.42	1.30
<i>BeefFinanceRisk</i>	5.66	2.20	5.93	2.06	−1.38
<i>PreviousPrice</i>	3, 080.30	1, 689.80	3, 469.61	2, 341.90	−2.24**
EPD importance					
<i>EPDs</i>	5.80	1.59	5.88	1.57	−0.62
<i>GE-EPDs</i>	4.84	1.81	5.12	1.87	1.76*
Information sources					
<i>UT Extension</i>	83.31%	0.37	84.10%	0.37	−0.26
<i>National</i>	23.93%	0.43	26.50%	0.44	−0.63
<i>Popular Press</i>	54.64%	0.50	47.00%	0.50	1.78*
<i>RegBeefAssociations</i>	38.93%	0.49	42.76%	0.49	−0.87

Notes: Single, double, and triple asterisks (*, **, ***) indicate significance at the 10%, 5%, and 1% level.

in the survey since average stated bull prices of respondents in the survey are in line with realized bull prices in Tennessee.

The average producer age (*Age*) in both treatments was approximately 55 years old, which is slightly below the average age (59 years) of Tennessee farmers (US Department of Agriculture, 2017a). A little over half of producers in both treatments had household income over \$100,000 (*HighIncome*), consistent with the average US household income for farms, \$115,588 in 2019 (Schnepf, 2019). Only 13% of producers had at least 40% of their household income originate from farming (*FarmIncome40%*). In 2019, approximately 18% of total farm household income reportedly came from farm production activities (Schnepf, 2019). The average herd size (*Herd Size*) for respondents was about 110 head of cattle, compared to an average herd size in Tennessee of 48 head (US Department of Agriculture, 2017a).

About 30% of respondents in both treatments were primarily involved in the beef cattle industry as purebred breeders (*Purebred*), about 80% identified as commercial producers of feeder calves and yearlings by natural service (*Commercial Natural*), and about 14% identified as commercial producers of feeder calves and yearlings through using artificial insemination (*Commercial AI*).

Panel Tobit Regression Results

Appendix Table A1 reports the estimated coefficients of the panel Tobit regression for Models I and II, and Table 4 reports the associated marginal effects. We limit our discussion of results to the estimated marginal effects since they provide an approximation of the amount of change in WTP that will be produced by a 1-unit change in an independent variable. The estimated condition index number was 27.31 for Model I. Thus, no evidence of multicollinearity was found (Belsley, 1991; Hendrickx, 2004; StataCorp, 2019). For Model II, the average condition number was higher at 55.07 because the interaction variables were included ($GE_Treatment \times EPDs$). Given the main effects of Model I were like Model II, multicollinearity was not considered to be an issue for Model II. Further, the robustness of Model II is confirmed in Appendix Table A2. When estimating separate models for each treatment and comparing the EPD coefficients across treatments, the results are the same as Model II. Thus, we limit the discussion of results below to the marginal effects of Models I and II.

In both models, the EPDs included in the choice set significantly and positively impacted WTP (Table 4). In Model I, which measures the average effect of the EPDs across both treatments, a 1% increase in the *CED* EPD increased WTP by \$34 per bull ($p < 0.01$). As the RE EPD increased by 0.1 square inches, WTP increased by \$35 ($p < 0.01$). In Model II, for the EPD Treatment, a 1% increase in the *CED* EPD increased WTP by \$27 per bull ($p < 0.01$); however, if a participant saw increased accuracy levels for the *CED* EPD (GE-EPD treatment), a 1% increase in the *CED* EPD increased WTP by nearly \$41 per bull ($p < 0.10$). While producers were willing to pay nearly \$19 more for a 0.1-square-inch increase in the RE EPD in the GE-EPD treatment than the EPD treatment, this amount was not significantly different between treatments (Model II). Thus, besides the *CED* EPD result, which was only significant at the 10% level, there were no significant differences for producer preferences for EPDs with increased accuracies (i.e., no significant differences were found for EPDs between treatments other than for the *CED* EPD at the 10% significance level).

Overall, all of the other EPDs were of similar magnitude in both treatments, suggesting that increased accuracy scores did not affect producer WTP for bulls for any of the EPDs except *CED*. This result is confirmed by Model I, where the *GE-EPD Treatment* dummy was not significant. This indicates that on average, across all considered EPDs, producers did not bid more for bulls in the GE-EPD treatment compared to the EPD treatment. Thus, we fail to reject our null hypothesis ($\beta_{26} = 0$), and producers did not bid significantly more for bulls if the EPDs had increased accuracy values in Model I. We also fail to reject our null hypothesis of the coefficients on the interaction variables in Model II being 0 for all EPDs, except *CED* ($p < 0.10$).

Variables significant in both models at the 1% level include producers with at least 40% of their income originating from farming (*FarmIncome40%*), the price producers paid for their previous bull (*PreviousPrice*), and producers' stated importance of EPDs in their bull purchasing decision (*EPDs*). If producers received at least 40% of their income from farming, they bid about \$450 more for the bulls. Intuitively, as a producer receives more farm income from their operation, they are willing to pay more for a bull that they believe will generate more return on the bull purchase price (investment). As a producer paid \$100 more for the last bull they purchased (*PreviousPrice*), bull WTP increased by \$11. If a producer considered EPDs more important in their bull purchasing decision, they bid more for the bulls, which is expected since the bulls were marketed with EPDs. However, the importance of GE-EPDs in producers' bull purchasing decisions was not significant. This may suggest there is an educational gap in how producers use GE-EPDs and improvements in EPD accuracy. This is also consistent with our result that GE-EPDs were generally not valued significantly more by producers than EPDs. Other variables that increased producer WTP for bulls

Table 4. Marginal Effects from Willingness to Pay (WTP) Panel Tobit Regression (N = 563)

Variable	Model I		Model II	
	Marginal Effects	Std. Error	Marginal Effects	Std. Error
EPDs				
<i>CED</i>	34.42***	3.67	27.49***	5.10
<i>WW</i>	12.89***	1.39	14.14***	1.82
<i>DOC</i>	14.94***	2.06	14.28***	2.86
<i>MILK</i>	7.95***	2.99	10.86***	3.95
<i>MW</i>	1.47***	0.56	2.22***	0.79
<i>CW</i>	3.73***	1.17	3.59**	1.60
<i>RE</i>	350.78***	62.61	254.23***	86.51
<i>\$W</i>	9.89***	1.11	9.64***	1.48
<i>GE_Treatment</i>	-108.71	77.97		
<i>GE × CED</i>			13.60*	7.15
<i>GE × WW</i>			-2.32	2.39
<i>GE × DOC</i>			1.24	3.99
<i>GE × MILK</i>			-5.59	5.17
<i>GE × MW</i>			-1.49	1.10
<i>GE × CW</i>			0.34	2.22
<i>GE × RE</i>			188.93	120.37
<i>GE × \$ W</i>			0.49	1.99
Producer and farm characteristics				
<i>Age</i>	-3.85	3.09	-3.84	3.09
<i>College_Degree</i>	-66.17	80.21	-62.98	80.21
<i>HighIncome</i>	-39.32	81.55	-36.15	81.57
<i>FarmIncome40%</i>	454.15***	123.29	456.66***	123.33
<i>Purebred</i>	-110.86	140.68	-114.98	140.72
<i>Commercial Natural</i>	287.20*	150.81	286.38*	150.84
<i>Commercial AI</i>	241.49*	123.28	245.28**	123.32
<i>Herd Size</i>	0.41	0.37	0.41	0.37
<i>Angus</i>	-167.03*	95.97	-164.55*	96.00
<i>BeefFinanceRisk</i>	-9.26	18.73	-9.84	18.73
<i>PreviousPrice</i>	0.11***	0.02	0.11***	0.02
EPD importance				
<i>EPDs</i>	135.57***	30.44	135.55***	30.44
<i>GE-EPDs</i>	33.72	26.26	32.89	26.27
Information sources				
<i>UT Extension</i>	229.41**	109.70	227.99**	109.72
<i>National</i>	173.60*	92.89	170.77*	92.92
<i>Popular Press</i>	-31.01	82.23	-26.63	82.24
<i>RegBeefAssociations</i>	137.15	99.98	137.43	100.00

Notes: Single, double, and triple asterisks (*, **, ***) indicate significance at the 10%, 5%, and 1% level.

included receiving information from UT Extension and national producer groups and if producers were commercial producers by artificial insemination or natural service. Producers with Angus cattle, meanwhile, bid about \$160 less for bulls ($p < 0.10$).

Discussion and Conclusions

The beef industry is constantly seeking to improve in terms of animal efficiency, sustainability, and profitability through innovation. Improvement in animal genetics through natural breeding and the use of EPDs, and now GE-EPDs, is one innovation the beef cattle industry has adopted. While previous research shows producers value EPD information when selecting a bull, this is the first study to examine how producer WTP for increased accuracies associated with GE-EPDs compares to EPDs. This study utilized an experimental design which enabled a *ceteris paribus* comparison of cow-calf producers' WTP for bulls with GE-EPDs compared to EPDs.

This research provided further information on the value producers place on several previously studied and unstudied EPDs. All eight EPDs chosen for the choice set (CED, WW, DOC, MW, CW, RE, and \$W) influenced producer WTP. Several producer and farm characteristics were also significant in determining WTP for bulls. As producers considered EPDs more important, they bid more on the bulls; however, as producers considered GE-EPDs more important, there was no significant relationship with WTP for bulls.

This research found that beef cattle producers, on average, were willing to pay the same for bulls regardless of whether they were marketed using GE-EPDs or EPDs. With the exception of the CED EPD, producers were also not willing to pay more for individual EPDs if they had greater accuracy scores due to being GE-EPDs. Several possible factors may explain this finding. When deciding what to bid on a bull, participants are clearly searching for specific EPD values, as shown by the significance of all the EPD traits in our analysis. Once a producer identifies a bull with their desired EPD values, we revealed through our experimental design that their bull decision may not include any emphasis on the associated accuracy of those EPDs (except for CED). This may be because they simply do not know how to "value" accuracy levels and the increased accuracy provided by GE-EPDs. However, producers do consider accuracy scores important since we did ask producers how important EPD accuracy is in their bull purchase decisions on a scale from 1 (not important) to 7 (very important); the average response was 5.6 in both treatments. While producers consider accuracy important, we did not find this importance translated to any dollar value when bidding on the bulls. Future Extension education on the value of GE-EPDs and the value of the accurate information that they provide could help producers when valuing bulls.

Future research is needed to corroborate the result of our study that while producers value specific EPDs, they do not adjust their bids for bulls based on their associated accuracy levels. As noted by a reviewer, this research employed a between-subjects experimental design while the research could have incorporated a within-subjects design which would allow for learning effects through treatment rounds. For example, producers could have first bid on bulls in the EPD treatment and then be asked to again bid on bulls in the GE-EPD treatment (where the EPDs were associated with higher accuracy levels). Hence, future research might additionally incorporate a within-subjects experimental design to test the effect of information about EPD accuracy levels. However, the between-subjects experimental design brings to light that producers either do not pay as much attention to accuracy as they may should or that producers do not fully understand the how accuracy values factor into EPD information. Thus, the between-subjects design identifies a need for education on EPD accuracy values and their information contribution.

As noted by another reviewer, it is also possible that producer risk preferences play a role in how accuracy levels affect their preferences for bulls. Both EPDs and increased EPD accuracies reduce the risks associated with buying bulls since they provide additional information about how a bull's progeny is expected to perform. Essentially, increased EPD accuracy reduces the risks associated with expected bull performance. Future research could further evaluate whether more risk-averse producers place a value on EPD accuracy levels. However, in our current study, we did not find the *BeefFinancialRisk* variable significant in determining bids for bulls in any model.

This research does not suggest that GE-EPDs are not an important innovation. Rather, it indicates that producers may not understand how to properly evaluate and value increased accuracy values.

Future research could further investigate this issue by more drastically varying accuracy levels to determine if there is a threshold for an “acceptable” accuracy value. In this current study, we only increased accuracy levels by 0.15 because that was consistent with how GE-EPDs appear to be increasing accuracy levels. However, a future study could determine how low accuracy levels would have to be for producers to not consider the EPD of value and whether a certain accuracy level constitutes an “acceptable” threshold and all accuracy levels past that are equally valued.

An additional research approach could use eye-tracking technology to quantify a producer’s fixation duration time on EPD accuracy values. Through eye-tracking, one could conduct a choice experiment and determine how much time is spent by producers looking at associated accuracy values and whether this impacts bull bids. If it is found that producers only fixate on EPD values and not accuracy values, this would further suggest that producers do not consider accuracy levels in their purchasing decision. Finally, this study only evaluated cow–calf producer preferences for EPDs within Tennessee. Future research using a nationally representative survey would be beneficial to understanding cow–calf producer preferences for EPDs nationally.

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Appendix

Table A1. Parameter Estimates from Willingness-to-Pay Panel Tobit Regression ($N = 563$)

Variable	Model I		Model II	
	Marginal Effects	Std. Error	Marginal Effects	Std. Error
EPDs				
<i>CED</i>	36.78***	3.92	29.37***	5.45
<i>WW</i>	13.77***	1.48	15.11***	1.95
<i>DOC</i>	15.96***	2.20	15.26***	3.06
<i>MILK</i>	8.49***	3.19	11.60***	4.22
<i>MW</i>	1.57***	0.60	2.37***	0.84
<i>CW</i>	3.99***	1.25	3.84**	1.71
<i>RE</i>	374.79***	66.92	271.62***	92.44
<i>\$ W</i>	10.57***	1.18	10.30***	1.59
<i>GE_Treatment</i>	-116.15	83.34		
<i>GE × CED</i>			14.53*	7.64
<i>GE × WW</i>			-2.48	2.55
<i>GE × DOC</i>			1.32	4.27
<i>GE × MILK</i>			-5.98	5.53
<i>GE × MW</i>			-1.59	1.18
<i>GE × CW</i>			0.36	2.37
<i>GE × RE</i>			201.85	128.61
<i>GE × \$ W</i>			0.52	2.13
Producer and farm characteristics				
<i>Age</i>	-4.12	3.30	-4.11	3.30
<i>College_Degree</i>	-70.70	85.70	-67.29	85.70
<i>HighIncome</i>	-42.01	87.14	-38.62	87.15
<i>FarmIncome40%</i>	485.23***	132.19	487.89***	132.23
<i>Purebred</i>	-118.45	150.32	-122.84	150.37
<i>Commercial Natural</i>	306.86*	161.23	305.96*	161.26
<i>Commercial AI</i>	258.02*	131.83	262.06**	131.83
<i>Herd Size</i>	0.44	0.39	0.44	0.39
<i>Angus</i>	-178.46*	102.60	-175.80*	102.61
<i>BeefFinanceRisk</i>	-9.89	20.01	-10.51	20.01
<i>PreviousPrice</i>	0.12***	0.023	0.12***	0.02
EPD importance				
<i>EPDs</i>	144.85***	32.65	144.82***	32.66
<i>GE-EPDs</i>	36.03	28.07	35.14	28.07
Information sources				
<i>UT Extension</i>	245.11**	117.30	243.58**	117.31
<i>National</i>	185.49*	99.30	182.44*	99.31
<i>Popular Press</i>	-33.13	87.86	-28.45	87.87
<i>RegBeefAssociations</i>	146.54	106.85	146.83	106.87
Constant	-2,248.85***	384.18	-2,308.84***	382.31
Log-likelihood	-40,380		-40,397	

Notes: Single, double, and triple asterisks (*, **, ***) indicate significance at the 10%, 5%, and 1% level.

Table A2. Marginal Effects from Willingness to Pay Panel Tobit Regression for the EPD Treatment and the GE-EPD Treatment and Associated Significance of Differences between the EPD Coefficients

Variable	EPDs (<i>N</i> = 280)		GE-EPDs (<i>N</i> = 283)		<i>suest</i> Difference between Treatments χ^2 Stat.
	Mean	Std. Dev.	Mean	Std. Dev.	
EPDs					
<i>CED</i>	26.66***	4.06	41.48***	5.95	2.87*
<i>WW</i>	13.22***	1.53	12.76***	2.25	0.01
<i>DOC</i>	13.79***	2.29	15.95***	3.33	0.30
<i>MILK</i>	8.12**	3.33	8.01*	4.82	0.03
<i>MW</i>	2.07***	0.63	0.94	0.91	0.25
<i>CW</i>	2.93**	1.29	4.51**	1.90	0.63
<i>RE</i>	230.55***	69.36	460.15***	101.58	1.68
<i>\$ W</i>	9.09***	1.22	10.62***	1.80	0.33
Producer and farm characteristics					
<i>Age</i>	-0.56	3.70	-7.83	5.04	
<i>CollegeDegree</i>	-110.44	97.30	-70.38	128.58	
<i>HighIncome</i>	54.36	100.14	-98.80	127.64	
<i>FarmIncome40%</i>	110.99	150.51	752.81***	203.42	
<i>Purebred</i>	40.91	166.79	-309.25	234.43	
<i>Commercial Natural</i>	158.58	189.38	390.95*	234.21	
<i>Commercial AI</i>	6.35	142.60	463.67**	208.66	
<i>Herd Size</i>	0.49	0.40	-0.03	0.66	
<i>Angus</i>	-124.73	126.33	-86.73	144.57	
<i>BeefFinanceRisk</i>	-12.90	22.37	7.74	30.56	
<i>PreviousPrice</i>	0.10***	0.03	0.14***	0.03	
EPD importance					
<i>EPDs</i>	77.25**	35.56	195.97***	50.19	
<i>GE-EPDs</i>	37.39	31.63	41.05	42.42	
Information sources					
<i>UT Extension</i>	83.28	131.87	317.93*	175.44	
<i>National</i>	106.94	113.89	242.68*	144.70	
<i>Popular Press</i>	82.04	100.16	-76.88	129.43	
<i>RegBeefAssociations</i>	160.95	117.00	137.25	165.49	

Notes: Single, double, and triple asterisks (*, **, ***) indicate significance at the 10%, 5%, and 1% level. Stata's *suest* post-estimation procedure can only be used after *Tobit* and not *xtTobit*. Thus, the panel specification of our data was not taken into consideration when estimating the *suest* χ^2 stat; however, parameter estimates are robust whether estimating the models with *Tobit* or *xtTobit* and results confirm Model II. Presented parameter estimates for both treatments are from the *xtTobit* specification.