Estimating the Economic Value of Specific Characteristics Associated with Angus Bulls Sold at Auction

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The genetic traits of a purebred bull convey the reproductive and economic value to buyers. This study examines and compares the value of actual production weights (birth, weaning, and yearling weight), production expected progeny differences (EPDs) (birth, weaning, milk, and yearling), and ultrasound EPDs (carcass quality predictors) for purebred Angus bulls sold at auction. One EPD, birth weight, was valued by buyers more than its corresponding actual weight, though both actual weights and EPDs significantly impact price. Predictors of carcass quality were important in determining price. Finally, several individual animal factors and sale characteristics were significant in determining price.

Key Words: Angus bulls, carcass characteristics, EPDs, marketing factors, production factors

JEL Classifications: Q10, Q12

The purebred cattle industry has undergone a period of significant informational change in the past 20 years. The development and use of expected progeny differences (EPDs) has been a primary component of this change. EPDs are complex statistical estimates of performance for a given animal's progeny (Beef Improvement Federation).[1] Since their introduction in the 1980s, EPDs have been increasingly accepted and used by purebred producers selling breeding stock. However, the impact EPDs have had in the marketplace and on commercial cattle producers is less clear. Research in this field has demonstrated that some EPDs (i.e., birth weight) are valued by producers when they purchase bulls; however, the magnitudes of the economic value of EPDs relative to the corresponding actual underlying phenotypic measures have been found to be surprisingly small (Chvosta, Rucker, and Watts).

Value-based marketing has increased the interest in genetic estimation of carcass traits by many cow/calf producers. Producers desire measurements that provide reasonable expectations as to the carcass quality of an animal (Greer and Trapp; Schroeder and Graff). Thus, the need for more accurate carcass-related information has become increasingly important to producers in recent years. Carcass EPDs, ultrasound EPDs, and actual ultrasound scan measurements are information technologies being utilized as predictors of carcass quality.

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[1] See Quaas and Pollak or Benyshek et al. for a detailed discussion of EPD calculation techniques.

Purebred bulls are bought and sold primarily at private auctions where buyers assign a value for an animal based on both its observed physical characteristics and on information that is disseminated to the buyer through the seller. Physical characteristics for an animal include conformation and frame scores, structural soundness, and other valuations of the animal's observable qualities. Information that is provided through the seller often includes actual or adjusted animal weights, EPDs, and ultrasound scan measurements as well as some information pertaining to the pedigree of the bull. Physically observed traits, as well as an animal's various weights, have been used as evaluation techniques since the inception of purebred bull sales; EPDs, however, are a newer tool available to producers. Production EPDs are now routinely reported for purebred bulls sold in the United States. Although not yet as common as the production EPDs, carcass and ultrasound information is increasingly being provided to potential buyers. It is certainly plausible that both actual weights (birth, weaning, and yearling) and their corresponding EPDs are viewed as important predictors of the performance of a bull's future offspring. From a statistical standpoint it could be argued that EPDs "should" be a better predictor, though earlier mentioned previous research suggests that the market may not value the EPDs as highly as the actual measurements. In addition, there are obvious costs associated with collecting and reporting each additional piece of information. Sorting out these important issues is important for the purebred cattle industry as the marketing environment and information technologies continue to evolve.

Objectives of this study are to reexamine the role of performance EPDs and other information in determining value for purebred Angus bulls. Specific consideration is given to carcass quality predictors in an attempt to define their role in breeding stock selection. These aspects, along with other measures, such as actual weights, regional issues, and marketing factors, are examined as they pertain to the value of purebred Angus bulls.

Previous Research

Dhuyvetter et al. examined EPDs as a determinant of a bull's value. They collected data from 26 multibreed Kansas bull sales during the spring of 1993 and modeled bull price as a function of physical and genetic characteristics, expected performance characteristics, and marketing factors. Results showed that in Angus bulls, both EPDs and actual weights were significant, as were age, sale order, pictures, and semen retention. Dhuyvetter et al. were able to compare the parameter values of actual weights with those for EPDs, but their findings left questions of the relative value of EPDs largely unanswered.

Following Dhuyvetter et al., Chvosta, Rucker, and Watts compared values for EPDs and simple performance measures (SPMs), that is, physically observed traits, for purebred Angus bulls. Data were collected from animals raised on a single Montana ranch from 1982 to 1997 and for bulls sold on 11 ranches in South Dakota and Nebraska from 1986 to 1996. They modeled bull price as a function of beef price, feed price, age, and performance measures. Variables that were significant in explaining price included 205-day weight, 365-day weight, birth and yearling-weight EPDs, and age and age squared.[2] Based on their results, Chvosta, Rucker, and Watts concluded that, although both EPDs and SPMs are significant in explaining price, SPMs may hold relatively more economic information pertaining to price.

Wallburger examined the relationship between price and attributes of bulls sold in Alberta, Canada. Data on price, birth and sale weight, average daily gain, back fat, scrotal circumference, ribeye area, and lean meat yield were collected on nearly 800 bulls of various breeds sold at a single bull test auction in 1989 and 1993 and from 1996 to 2000.[3] A tobit

[2] Dhuyvetter et al. did not include yearling weight or yearling-weight EPDs in their evaluation, as they contended that these variables were highly correlated with weaning weight and its corresponding EPD.

[3] This is the only study found that examined the relationship of bull price and carcass characteristics. No study to date that the authors are aware of has related price to ultrasound or carcass EPDs.

regression model was used, and tests for structural change were conducted. Results of these tests showed three structurally distinct time periods: 1989 and 1993, 1996–1997, and 1998–2000. Birth weight, sale weight, and scrotal circumference were significant in all three periods. Ribeye area and back fat were significant in the last time period. Walburger interpreted this as a sign of producer adoption of genetic technology.

Data

Data for this study were collected over a 4-month period from purebred Angus producers across the Midwest, Rocky Mountain, and Northwest regions of the United States. Producers were contacted by phone, written correspondence, and e-mail requesting sale catalogs and price data from their most recent production sale. Data were collected on 8,285 bulls from 60 sales in 11 states. Variables included sale price, registration number, and various marketing factors specific to each sale. Data relating to actual weights and EPDs were not recorded at this time, although animals found to have incomplete production records were noted for each sale.

The collection of all actual weights, EPDs, and pedigrees was done in cooperation with the American Angus Association (AAA). Registration numbers for all bulls were forwarded to AAA, which then generated a database with all relevant genetic information with respect to each bull. This database was combined with the existing record of prices and marketing factors to create a complete summary of variables for each bull. Table 1 provides definitions of variables used in this study, and Table 2 provides summary statistics for the price, actual weights, EPDs, and marketing variables.

It is important to note that AAA has access to and provided more information for several of the bulls in our data set than what was reported to buyers at the time of sale. Although AAA encourages breeders to provide as much information to buyers as possible, there is not a standard reporting system followed by every producer. No two sales in this study reported exactly the same amount or types of information in their sale catalogs. These discrepancies were noted and are accounted for in the forthcoming models but at first glance may appear misleading. An example of this problem appears in Table 2. Even though AAA provided over 7,000 observations on adjusted yearling weight, the actual number of observations reported by breeders was far lower. Therefore, in order to avoid creating models that included information that was unavailable to buyers, details regarding variables reported at each specific sale were tracked and models specified using only data that were available to buyers at the time of the sale (i.e., data reported in the sale catalog). As a result of this "missing data" issue, the usable number of observations out of the initial 8,285 bulls varied depending on which variables were included in the model. For example, the number of observations used in the first estimated model was 4,150, representing 41 of the 60 surveyed sales. Similarly, the usable number of observations for the second estimated model, which included EPDs, was 3,760, representing 29 different bull sales. Clearly, not all sellers are reporting ultrasound EPDs in their sale catalogs.

Methods

Following a hedonic price determination framework (Ladd and Martin; Rosen) and expanding on earlier purebred bull price studies (Chvosta, Rucker, and Watts; Dhuyvetter et al.), actual production measures, EPDs, and marketing factors form the basis for a model of bull prices that can be generally specified as

$$\begin{aligned}\text{Bull Price} = (&\text{Age, Actual Weights,}\\ &\text{Ultrasound Scans,}\\ &\text{Production Ultrasound EPDs,}\\ &\text{Marketing Factors,}\\ &\text{Sire, States/Sales}).\end{aligned} \tag{1}$$

Actual production measures include age, birth weight, and adjusted weaning and yearling weight. Production EPDs include

Table 1. Description of Independent Variables

Variable	Abbreviation	Expected Sign	Definition
Age	*Age*	+	Age in days of a bull at the time of sale.
Age squared	*age2*	−	Age squared.
Birth weight	*Birthwt*	−	Weight of a bull at birth, expressed in pounds.
Adjusted 205-day weaning weight	*adjweanwt*[a]	+	Weaning weight of animals between the ages of 160 and 250 days adjusted to a standard age of 205 days.
Adjusted 365-day yearling weight	*adjyearwt*[a]	+	Yearling weight of animals between the ages of 320 and 410 days adjusted to a standard age of 365 days.
Adjusted percent intramuscular fat	*Adjpctimf*	+	Percent fat in the ribeye, as measured by ultrasound and adjusted to a common age.
Adjusted ribeye area	*Adjribeye*	+	Ribeye area in square inches, as measured by ultrasound and adjusted to a common age.
Adjusted rib fat	*Adjribfat*	−	A measurement of the fat depth, in inches, of an animal over the 12th rib, as measured by ultrasound and adjusted to a common age.
Birth-weight EPD	*airthepd**	−	A predictor of a bull's ability to transmit birth weight, expressed in pounds, to his progeny compared to that of other bulls.
Weaning-weight EPD	*weanepd**	+	A predictor of a bull's ability to transmit weaning growth, expressed in pounds, to his progeny compared to that of other bulls.
Milk EPD	*milkepd**	+	A predictor of a bull's genetic merit for milk and mothering ability, expressed in pounds, as expressed in his daughters compared to daughters of other bulls.
Yearling-weight EPD	*yearepd**	+	A predictor of a bull's ability to transmit yearling growth, expressed in pounds, to his progeny compared to that of other bulls.
Carcass-weight EPD	*cwtepd**	+	A predictor of the differences in hot carcass weight, expressed in pounds, of a bull's progeny at a given end point compared to progeny of other bulls.
Marbling EPD	*marbepd**	+	A predictor of the difference in a subjective USDA marbling score, expressed as a fraction, of a bull's progeny at a given end point compared to the progeny of other bulls.
Ribeye area EPD	*ribepd**	+	A predictor of the difference in ribeye area, expressed in square inches, of a bull's progeny at a given end point compared to the progeny of other bulls.
Fat thickness EPD	*fatepd**	−	A predictor of the differences in external fat thickness, expressed in inches, at the 12th rib (as measured between the 12th and 13th ribs) of a bull's progeny at a given end point compared to the progeny of other bulls.
Percent retail product	*prpepd**	+	A predictor of the difference in pounds of salable retail product of a given bull's progeny compared to the progeny of other bulls.

Table 1. (Continued)

Variable	Abbreviation	Expected Sign	Definition
Ultrasound percent intramuscular fat EPD	*uimfepd**	+	A predictor of the difference in a bull's progeny for percent intramuscular fat in the ribeye muscle compared to other bulls (based on ultrasound measurements).
Ultrasound ribeye area EPD	*uribepd**	+	A predictor of the difference in square inches of ribeye area of a bull's progeny compared to the progeny of other bulls (based on ultrasound measurements).
Ultrasound fat thickness EPD	*ufatepd**	+	Expressed in inches, is a predictor of the difference in external fat thickness at the 12th rib of a bull's progeny compared to the progeny of other bulls. It includes the weighted average of 60% of the rib fat measurement and 40% of the rump fat measurement (based on ultrasound measurements).
Ultrasound percent retail product EPD	*uprpepd**	+	A predictor of the difference in pounds of salable retail product of a bull's progeny compared to the progeny of other bulls (based on ultrasound measurements).
Sale order	*Saleorder*	–	Order of the sale that a bull was sold in percent.
Percent of semen retained	*semenpct*	+	Percent of semen rights that are retained by the seller.
Season of the sale	*seasonofsale*	?	Dummy variable denoting the season (fall or spring) that the sale was held. Fall is the base.
Picture of the bull	*picture*	+	Dummy variable denoting bulls whose picture appeared in the sale catalog.
Embryo transfer	*et*	?	Dummy variable denoting bulls who are listed as embryo transfers in the sale catalog.
Full brother	*fullbrother*	?	Dummy variable denoting bulls who have a full brother, either through embryo transfer or as a twin, in the sale.
Pathfinder dam	*pathfinder*	?	Dummy variable denoting bulls whose dam is a pathfinder.
Female in the sale	*femaleinsale*	?	Dummy variable denoting sales selling females as well as bulls.
Sire	*sr(i)*	?	Dummy variable denoting bulls whose sire was ranked in top 25 for number of progeny registered in 2002.
Sale	*sale(i)*	?	Dummy variable denoting individual sales.

Note: Definitions are taken from www.angus.org/sireeval/howto.html (Accessed June 28, 2007).
a Definitions are taken from Beef Improvement Federation.

Table 2. Summary Statistics

Variable	*N*	Mean	Standard Deviation	Minimum	Maximum
price	8,285	2,564.8100	1,908.1000	875.000	51,500.000
Production measures					
age	8,285	447.211	124.726	98.000	1,829.000
age^2	8,285	215,552.320	144,818.150	9,604.000	3,345,241.000
birthwt	7,986	83.470	9.894	40.000	124.000
adjweanwt	8,063	659.967	71.860	378.000	988.000
adjyearwt	7,380	1,168.310	113.814	636.000	1,742.000
adjpctimf	7,255	3.706	0.859	0.810	10.450
adjribeye	7,243	12.368	1.569	6.500	18.800
adjribfat	7,259	0.269	0.100	0.010	0.770
EPDs					
birthepd	8,227	2.553	1.562	−3.800	9.600
weanepd	8,253	38.256	6.688	11.000	71.000
milkepd	8,253	20.284	4.622	0.000	36.000
yearepd	8,252	72.592	11.358	19.000	125.000
cwtepd	4,575	5.185	6.327	−16.000	30.000
marbepd	4,575	0.182	0.121	−0.130	0.750
ribepd	4,575	0.129	0.127	−0.350	0.590
fatepd	4,575	0.002	0.015	−0.045	0.054
prpepd	4,575	0.059	0.242	−0.870	0.770
uimfepd	7,814	0.065	0.135	−0.400	0.740
uribepd	7,814	0.123	0.212	−0.620	1.000
ufatepd	7,814	0.004	0.015	−0.059	0.064
uprpepd	7,814	0.020	0.279	−0.960	1.200
Marketing factors					
saleorder	8,285	0.501	0.289	0	1
sementhird	8,285	0.197	0.398	0	1
semenhalf	8,285	0.078	0.267	0	1
seasonofsale	8,285	0.771	0.421	0	1
picture	8,285	0.108	0.311	0	1
et	8,285	0.214	0.410	0	1
fullbrother	8,285	0.101	0.301	0	1
pathfinder	8,285	0.058	0.234	0	1
femaleinsale	8,285	0.456	0.498	0	1

birth, weaning, milk, and yearling weights. Carcass EPDs include carcass weight, marbling, ribeye area, fat thickness, and percent retail product, while ultrasound EPDs include intramuscular fat, ribeye area, fat thickness, and percent retail product. The marketing factors recorded from each sale are sale order, semen retention, seasonality of the sale, picture, embryo transfer, pathfinder dam, and the inclusion of full brothers in the sale. Sire is a series of dummy variables used to capture bulls who are the progeny of highly ranked Angus sires. States/sales are dummy variables used to identify bulls sold in a particular state or sale.

Visual observation and a Jarque–Bera test indicated that the raw bull prices were not normally distributed. Following Dhuyvetter et al., prices were transformed to natural log form, resulting in a visually more normally distributed data series. A nonnested *J*-test of competing models failed to indicate that either model (raw data or natural log) was superior to the other. Therefore, following previous research that utilized data of this nature, this analysis was conducted using the natural log price data. Ordinary least squares (OLS) regression models were applied to the data to determine the contribution of each of the variables presented in the conceptual model to purebred Angus bull prices. Heteroscedasticity concerns were tested for using the approach suggested by Breusch and Pagan and were addressed by estimating the models using White's Correction procedure.

Results

Here we present specific empirical models and report the results obtained from the estimation of the models. The parameter estimates reported represent changes in the dependent variable, natural log of price, for a one-unit change in the respective independent variable. As an alternative, the reader may choose to view the parameter estimates as percentage changes in the linear form of the dependent variable, price. This interpretation of the results is helpful but fails to provide dollar values for changes in the variables.

One way to address this issue is to multiply the parameter estimates for the continuous variables in each model by the average price for that model. This procedure resulted in dollar values for each continuous variable, representing the marginal effect for one-unit changes. We include these results for comparison with previous research; however, the marginal effects must be interpreted with caution. For example, large absolute values can result from variables that are by nature small in magnitude (i.e., a "one-unit" change is unlikely). In addition, different distributions (higher or lower degrees of variability) can impact the likelihood of a one-unit change in a particular variable, making it difficult to compare the marginal effects across variables. As a second alternative, elasticities were calculated for each of the continuous variables by multiplying the parameter estimates by the average of each continuous variable. Elasticities are commonly used and easily interpreted (percentage impact of a 1% change in the respective variable); however, they suffer some of the same shortcomings as the marginal effects calculations. That is, different distributions of alternative variables result in dissimilar likelihoods of a 1% change. In addition, elasticity estimates depend on the point of calculation (in this case the means of the respective variables). Elasticity results must be interpreted with these caveats in mind, prompting us to explore another approach to examining relative impacts (discussed later).

Shifts for discrete (i.e., dummy) variables were also calculated using the procedure suggested by Halvorsen and Palmquist for the interpretation of discrete variables in semilogarithmic equations. The values calculated for each variable show the effect of including the variable when all other discrete variables are equal to zero. The results are reported in dollars and provide a useful means of comparing between discrete variables.

Model of Actual and EPD Physical Performance Measures

The first model specification included actual performance measures (birth, adjusted weaning, and adjusted yearling weights) and their corresponding EPDs. Restricting the model to include adjusted weights decreased the number of usable observations to 4,150, primarily because of missing values for adjusted yearling weights. The model is specified as

$$
\begin{aligned}
\text{ln}\, price = {} & \beta_0 + \beta_1 age + \beta_2 age^2 + \beta_3 birthwt \\
& + \beta_4 adjweanwt + \beta_5 adjyearwt \\
& + \beta_6 birthepd + \beta_7 weanepd \\
& + \beta_8 milkepd + \beta_9 yearepd \\
& + \beta_{10} saleorder + \beta_{11} picture \\
& + \beta_{12} et + \beta_{13} sementhird \\
& + \beta_{14} semenhalf + \beta_{15} fullbrother \\
& + \beta_{16} pathfinder + \beta_{17} seasonofsale \\
& + \sum_{k=1}^{25} \alpha_k sr_k + \sum_{j=1}^{40} \gamma_j sale_j + \text{e}.
\end{aligned}
\tag{2}
$$

Results are reported in Table 3, and summary statistics for variables included in this model specification are included in Table 4. The model R^2 of 0.6363 indicates reasonable explanatory power for a cross-sectional study.

Table 3. Regression Results for Actual Weights and Production EPDs by Sale (Equation [2])

Variable	Parameter Estimate	Standard Error	*t*-Statistic	*p*-Value	Marginal Effect at Average Price	Discrete Variable Shifts	Elasticities at Variable Averages
Intercept	4.824690	0.240200	20.09	0.0000			
Production measures							
*age****	0.003220	0.000443	7.28	0.0000	8.61		1.44
*age2****	−0.000002	0.000000	−4.76	0.0000			
*birthwt****	−0.001810	0.000700	−2.59	0.0100	−4.84		−0.15
*adjweanwt****	0.000588	0.000124	4.75	0.0000	1.57		0.39
*Adjyearwt****	0.001330	0.000098	13.57	0.0000	3.56		1.59
EPDs							
*Birthepd****	−0.052010	0.005043	−10.31	0.0000	−139.06		−0.13
Weanepd	0.000048	0.001622	0.03	0.9760	0.13		0.00
*Milkepd****	0.004490	0.001234	3.64	0.0000	12.00		0.09
*Yearepd****	0.005110	0.000998	5.12	0.0000	13.66		0.38
Marketing factors							
*Saleorder****	−0.345070	0.019870	−17.37	0.0000	−922.60		−0.16
*picture****	0.226080	0.020790	10.88	0.0000		989.25	
*et***	0.045310	0.018190	2.49	0.0130		180.76	
*sementhird****	0.163960	0.031120	5.27	0.0000		694.79	
*Semenhalf****	0.519760	0.099390	5.23	0.0000		2,658.11	
fullbrother	0.011270	0.023210	0.49	0.6270		44.20	
*pathfinder**	0.044420	0.024870	1.79	0.0740		177.13	
*seasonofsale***	−0.266420	0.104600	−2.55	0.0110		−912.07	
Sires							
Sr1	0.018420	0.028560	0.64	0.5190		72.50	
Sr2	−0.014670	0.027070	−0.54	0.5880		−56.79	
*sr3***	−0.051540	0.023470	−2.20	0.0280		−195.90	
*sr4**	0.051590	0.029210	1.77	0.0770		206.46	
*sr5**	0.072590	0.038750	1.87	0.0610		293.61	
Sr6	0.073330	0.047860	1.53	0.1260		296.71	
Sr7	−0.009380	0.058940	−0.16	0.8740		−36.41	
*sr8***	0.056620	0.025650	2.21	0.0270		227.17	
*sr9***	0.087860	0.039680	2.21	0.0270		358.13	
sr10	−0.003350	0.035720	−0.09	0.9250		−13.04	
sr11	0.019470	0.040780	0.48	0.6330		76.67	
sr12	−0.004200	0.030680	−0.14	0.8910		−16.34	
*sr13****	0.200030	0.060010	3.33	0.0010		863.54	
*sr14****	0.119590	0.043130	2.77	0.0060		495.39	
*sr15***	0.090250	0.043900	2.06	0.0400		368.32	
sr16	−0.094660	0.113900	−0.83	0.4060		−352.21	
sr17	−0.085420	0.071980	−1.19	0.2350		−319.28	
*sr18****	0.166290	0.041150	4.04	0.0000		705.51	
*sr19****	0.289240	0.042380	6.83	0.0000		1,308.00	
sr20	0.000708	0.036330	0.02	0.9840		2.76	
sr21	0.016050	0.057230	0.28	0.7790		63.09	
*sr22****	0.167700	0.040670	4.12	0.0000		712.01	
*sr23**	0.063780	0.034550	1.85	0.0650		256.82	
sr24	0.077310	0.057430	1.35	0.1780		313.44	

Table 3. (Continued)

Variable	Parameter Estimate	Standard Error	*t*-Statistic	*p*-Value	Marginal Effect at Average Price	Discrete Variable Shifts	Elasticities at Variable Averages
sr25	−0.013770	0.061070	−0.23	0.8220		−53.33	
Sales							
*sale2****	−0.299080	0.050090	−5.97	0.0000		−1,008.07	
Sale6	0.018690	0.050590	0.37	0.7120		73.57	
Sale7	0.006470	0.048430	0.13	0.8940		25.31	
*sale10****	−0.502890	0.065620	−7.66	0.0000		−1,541.23	
*sale11****	−0.289390	0.109800	−2.64	0.0080		−979.91	
*sale12****	−0.292490	0.038960	−7.51	0.0000		−988.95	
*sale13***	−0.256520	0.110100	−2.33	0.0200		−882.34	
*sale15****	−0.353470	0.136100	−2.60	0.0090		−1,161.14	
*sale16***	−0.134510	0.056110	−2.40	0.0170		−490.80	
*sale18****	0.190250	0.054960	3.46	0.0010		817.19	
*sale19****	0.162840	0.055410	2.94	0.0030		689.65	
*sale20****	0.305420	0.055740	5.48	0.0000		1,392.95	
*sale21****	0.257810	0.047080	5.48	0.0000		1,146.87	
*sale22****	0.321280	0.046780	6.87	0.0000		1,477.56	
*sale23****	0.202470	0.046370	4.37	0.0000		875.18	
*sale24****	0.184600	0.046570	3.96	0.0000		790.61	
*sale26****	0.160090	0.042750	3.75	0.0000		677.05	
*sale28**	0.108910	0.056110	1.94	0.0520		448.70	
sale29	0.045880	0.044600	1.03	0.3040		183.09	
sale30	−0.021650	0.053200	−0.41	0.6840		−83.52	
*sale34***	−0.099870	0.045830	−2.18	0.0290		−370.64	
*sale36****	−0.352000	0.055990	−6.29	0.0000		−1,157.11	
*sale37****	0.140290	0.047200	2.97	0.0030		587.32	
*sale38**	−0.215630	0.120400	−1.79	0.0730		−756.41	
*sale39****	−0.598000	0.118800	−5.03	0.0000		−1,755.20	
*sale41****	−0.394050	0.046030	−8.56	0.0000		−1,270.05	
*sale42****	−0.349330	0.044880	−7.78	0.0000		−1,149.78	
*sale43****	0.263350	0.060250	4.37	0.0000		1,174.90	
*sale44****	−0.145100	0.036420	−3.98	0.0000		−526.71	
sale46	0.046980	0.059790	0.79	0.4320		187.58	
sale48	0.018100	0.045950	0.39	0.6940		71.23	
sale49	−0.037320	0.062010	−0.60	0.5470		−142.85	
*sale51****	−0.487100	0.116500	−4.18	0.0000		−1,503.69	
*sale52****	0.366290	0.069070	5.30	0.0000		1,725.11	
sale53	0.079720	0.049260	1.62	0.1060		323.61	
*sale54***	−0.154150	0.073800	−2.09	0.0370		−557.09	
sale55	0.043340	0.049880	0.87	0.3850		172.73	
*sale58****	0.219500	0.046120	4.76	0.0000		957.19	
*sale59****	−0.196740	0.049820	−3.95	0.0000		−696.47	
*sale60****	0.256410	0.046410	5.53	0.0000		1,139.81	
R^2	0.6363						
Observations	4,151						

*** Denotes significance at the 0.01 level.
** Denotes significance at the 0.05 level.
* Denotes significance at the 0.10 level.

Table 4. Summary Statistics for Equation (2)

Variable	*N*	Mean	Standard Deviation	Minimum	Maximum
price	4,151	2,673.66	2,089.56	950.00	45,000.00
age	4,151	446.31	108.51	298.00	1,107.00
birthwt	4,151	83.05	10.14	45.00	120.00
adjweanwt	4,151	666.97	72.22	408.00	988.00
adjyearwt	4,151	1,192.17	104.03	784.00	1,676.00
birthepd	4,151	2.49	1.51	−2.50	7.80
weanepd	4,151	38.53	6.84	11.00	71.00
milkepd	4,151	20.48	4.59	5.00	34.00
yearepd	4,151	73.44	11.82	19.00	125.00
saleorder	4,151	0.46	0.28	0.00	1.00

The *age* and age^2 results are consistent with expectations and with previous research (Chvosta, Rucker, and Watts; Dhuyvetter et al.). Older bulls bring premiums relative to younger bulls, though the premium decreases for progressively older bulls. An *F*-test confirmed the joint significance of the three actual weights, *birthwt*, *adjweanwt*, and *adjyearwt*. Similarly, an *F*-test confirmed the joint significance of the four production EPDs, *birthepd*, *weanepd*, *milkepd*, and *yearepd*. Individually, all three physical performance measures were significant and exhibited the expected signs. The four production EPDs also exhibited the expected signs, and all were statistically significant except *weanepd*. As birth weight increases, it is expected that calving difficulties will increase, thus increasing costs. Therefore, buyers are likely to pay less for bulls expected to produce higher birth weights (either based on the actual birth weight of that particular bull or based on the birth-weight EPD). Adjusted weaning and yearling weights (and their corresponding EPDs) provide buyers with a measure of a bull's ability to produce offspring that will more quickly (and perhaps efficiently) produce pounds of marketable gain.

Similarly, *milkepd* provides an indication of a particular bulls' progeny's milk production potential, which translates directly into rapid calf gains. The lack of statistical significance of the *weanepd* variable could be attributed to the strong correlation between it and other performance-predicting variables as revealed in Table 5.

The *saleorder* results confirmed prior expectations that bulls selling later in the auction bring less than those that are placed near the beginning. Bulls whose pictures appear in the sale catalog receive premiums relative to bulls without pictures, indicating a buyer perception that bulls that are "showcased" with a picture in the catalog are of higher quality. Embryo transfer bulls (*et*) and bulls whose dam is a pathfinder were on average valued more highly because of those traits.[4] Bulls that have a portion of their semen rights retained bring a premium relative to those that do not. Retaining semen rights may be perceived to have a high value, or this may be an indication that the bull has genetic potential (value) above that revealed by the other available information. Having a full brother in the sale did not significantly impact the value of a particular bull.[5]

The final marketing variable, *seasonofsale*, shows that animals sold in the spring are discounted relative to animals sold in the fall. Reasons for this are unclear, though one possible explanation for this may lie in the fact that most sales in this study occurred in the spring, indicating a limited supply of bulls in the fall. If demand for bulls holds constant throughout the year, then the limited number

[4] In alternative model specifications, these two parameters were not statistically significant.

[5] Results of alternative model specifications that were less restrictive (i.e., utilized a larger number of observations) suggested that having a full brother in the sale might slightly negatively impact an individual animal's value.

Table 5. Correlation Coefficients for Production EPDs and Actual Measures

	birthwt	*adjweanwt*	*Adjyearwt*	*birthepd*	*weanepd*	*milkepd*	*yearepd*
birthwt	1.0000	0.0983	0.1176	0.6331	0.0797	0.0279	0.0473
		(<0.0001)	(<0.0001)	(<0.0001)	(<0.0001)	(0.0720)	(0.0023)
adjweanwt		1.0000	0.6448	0.1984	0.5274	0.1523	0.4162
			(<0.0001)	(<0.0001)	(<0.0001)	(<0.0001)	(<0.0001)
adjyearwt			1.0000	0.1667	0.5014	0.1547	0.5837
				(<0.0001)	(<0.0001)	(<0.0001)	(<0.0001)
birthepd				1.0000	0.3891	0.0016	0.3299
					(<0.0001)	(0.9171)	(<0.0001)
weanepd					1.0000	0.1044	0.8543
						(<0.0001)	(<0.0001)
milkepd						1.0000	0.1220
							(<0.0001)
yearepd							1.0000

Note: *p*-values are in parentheses. Number of observations = 4,151.

of bulls selling in the fall would bring a premium relative to bulls sold in the spring. Several of the sire variables significantly impact price, indicating that genetic linkages to top registered Angus bulls can be important. The significance of several individual sale variables is also of interest, as it suggests that the reputation of the seller can have an impact on price and that buyers are likely to pay premiums/discounts for similar bulls sold at different sales.[6,7]

One of the primary objectives for this research was to reexamine the relationship between production EPDs and actual weights, following up on the research conducted by Chvosta, Watts, and Rucker. Comparing the parameter estimates for the EPDs and actual weights reveals larger estimates for the EPDs relative to their related actual weights. However, this comparison does not tell the whole story because of the varying units involved. Elasticities provide a unitless comparison between the two genetic measures and offer a measurement that is readily comparable across variables. The elasticities for the actual weights are greater than the elasticities for the EPDs. The results from the comparison of elasticities are similar to those reached by Chvosta, Rucker, and Watts and at first glance would suggest that actual weights receive a higher value from buyers relative to EPDs.

However, a problem with the elasticities is that they show the effect of the variable only at a certain point, here the mean. This technique ignores the true behavior of most variables by assuming that a 1% change in all variables occurs with equal likelihood. Therefore, it may be more insightful to examine the effect a variable has on price across a standardized range of likely changes. This provides a means for comparing the realistically expected relative impact between variables of differing units.

We were particularly interested in comparing the relative expected impact of actual birth weight and birth-weight EPD from our first model. In order to make this comparison, premiums were calculated in log form by multiplying the parameter estimates for all the continuous variables by their mean value. Sensitivity of price to the variable of interest (e.g., *birthwt* or *birthepd*) was calculated across a range of two standard deviations above and below the mean of the variable. The calculated

[6] Data collected from some specific breeders (sales) were not utilized in this model specification because they did not report all the information used in this analysis.

[7] An alternative model specification replaced the individual sales variables with individual state dummy variables. Production, marketing, and genetic factor results were very consistent across models. Relative to bulls sold in Kansas (the base), bulls sold in Colorado, Montana, North Dakota, Nebraska, South Dakota, and Texas received premiums, while bulls sold in Missouri and Oregon received discounts (Turner).

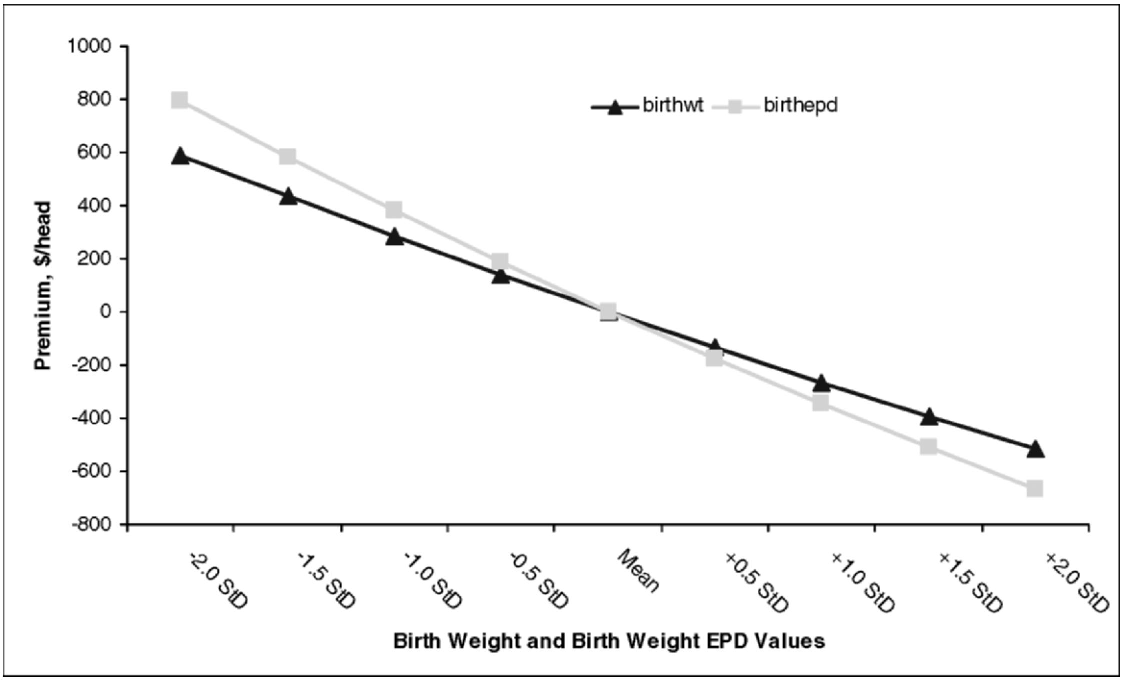

Figure 1. Predicted Premiums for Birth Weight and Birth-Weight EPD

premiums were then transformed from log to linear form, as suggested by Miller.

When calculating this sensitivity analysis for a variable, such as *birthwt*, typically all other continuous variables are held constant at their mean. However, it is not appropriate in this case to hold *birthepd* constant because of the high statistical correlation between *birthepd* and its associated physical characteristic *birthwt*. Specifically, as *birthwt* moves away from its mean, it is unlikely that *birthepd* will remain at its mean. To account for this, relationships between these two variables were estimated using OLS (regressing *birthepd* on *birthwt* and vice versa, *yearepd* on *adjyearwt* and vice versa, and so on). These estimated relationships were then used in the calculation of the sensitivity of price to each variable of interest. As an example, when calculating expected premiums for *birthwt* across a range of ±2 standard deviations of birth weight, the mean value for *birthepd* is replaced by the estimated regression equation (which is a function of birth weight) to more accurately reflect the true relationship between price and birth weight as *birthwt* changes over the two-standard-deviation range.

Figure 1 depicts the comparison of the premiums for *birthwt* and *birthepd*. For example, the calculated average premium for a bull with an actual birth weight that is one standard deviation below the mean is $284, while the calculated average premium for a bull with a birth-weight EPD that is one standard deviation below the mean is $380. Calculated in this manner, *birthepd* has slightly larger premiums associated with it relative to *birthwt* for equally likely changes of each variable. On the basis of this criterion, it can be argued that *birthepd* is the more significant genetic measure despite the higher elasticity of *birthwt*.

The same argument cannot be made for *yearepd*, however. Figure 2 shows that premiums associated with *adjyearwt* are larger relative to *yearepd* premiums across two standard deviations when the relationship between these two variables is accounted for. As an illustration, the calculated premium for a bull with an adjusted yearling weight one standard deviation above the mean is $766, while the calculated premium for a bull with a yearling-weight EPD one standard deviation above the mean is only $613. Thus, while buyers may pay higher premiums for the

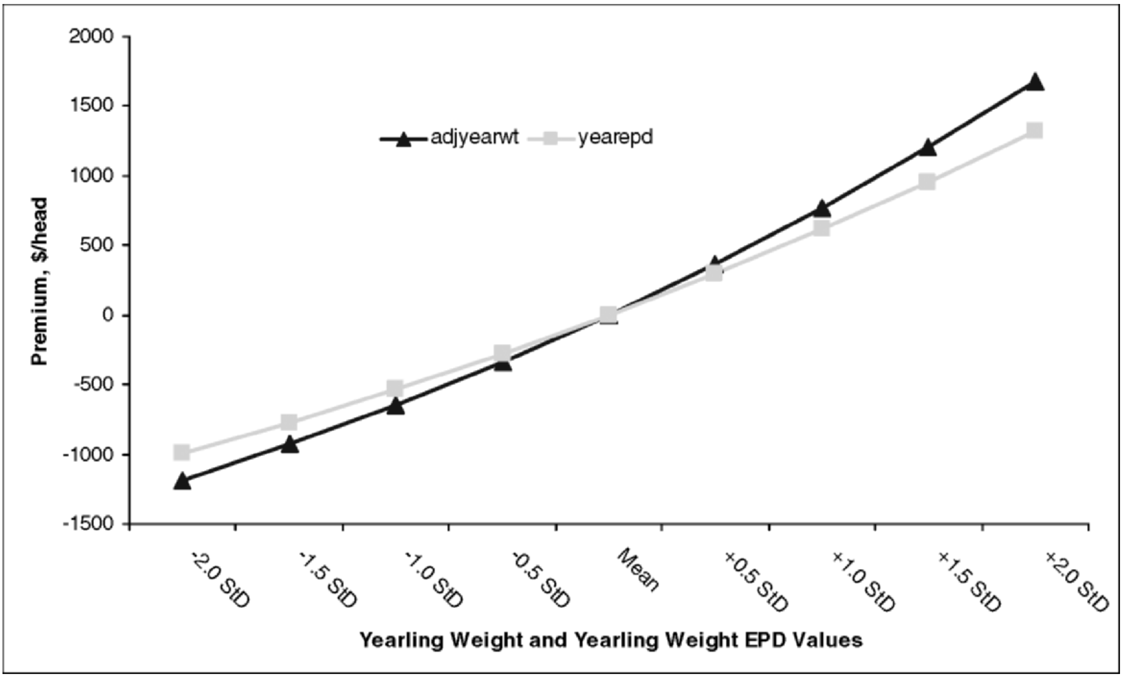

Figure 2. Predicted Premiums for Adjusted Yearling Weight and Yearling-Weight EPD

genetic information in *birthepd* relative to *birthwt*, it appears they are unwilling to do so for *yearepd*.

Reasons for the difference in these results are not entirely clear. A possible explanation may lie in the accuracy of the EPDs at the time of sale. Bulls are typically sold at 1 year of age or older. Buyers may believe that the *yearepd* values for yearling bulls are in fact unreliable. Because *yearepd* is based solely on records of related animals (parents, grandparents, and siblings), they may believe that the possible variation in the EPD is quite large and thus place more confidence in the actual weight. Table 6 shows expected changes in the value for EPDs over a two-standard-deviation range as the accuracy of the EPDs increases. The expected accuracy value for *yearepd* on a year old bull would likely be 0.05. At this level, the possible range of change for this variable would be ± 16.17 pounds from the current value of the EPD. This represents a large change and gives cause for buyers paying larger premiums for *adjyearwt*, an observable trait. Another possible explanation is that actual yearling weight is nearly observable at the time of sale (i.e., the bull is either heavy or not), whereas *birthepd* is perceived as the better indicator of birth weight of offspring.

Model Including Carcass Ultrasound EPDs

A second model specification including carcass ultrasound EPDs was estimated to explore the value that buyers place on carcass quality. Age, actual weights, production EPDs, marketing factors, and sale dummy variables were included in the model, while sire rankings were excluded because of limited data. The model is specified as

$$\begin{aligned} \ln price = {} & \beta_0 + \beta_1 age + \beta_2 age^2 + \beta_3 birthwt \\ & + \beta_4 adjweanwt + \beta_5 adjyearwt \\ & + \beta_6 birthepd + \beta_7 weanepd \\ & + \beta_8 milkepd + \beta_9 yearepd \\ & + \beta_{10} uimfedp + \beta_{11} uribepd \\ & + \beta_{12} ufatepd + \beta_{13} uprpepd \\ & + \beta_{14} saleorder + \beta_{15} picture + \beta_{16} et \\ & + \beta_{17} sementhir + \beta_{18} semenhalf \\ & + \beta_{19} fullbrother + \beta_{20} pathfinder \\ & + \beta_{21} seasonofsale + \sum_{j=1}^{28} \gamma_j sale_j + e. \end{aligned} \tag{3}$$

Table 6. Changes Associated with EPD Accuracy Values

Accuracy	Production EPDs				Carcass EPDs					Ultrasound EPDs			
Value	*Birth*	*Wean*	*Milk*	*Year*	*Carcass*	*Marbling*	*Ribeye*	*Fat*	*%Retail*	*%IMF*	*Ribeye*	*Fat*	*%Retail*
0.05	2.73	11.01	9.21	16.17	15.42	0.25	0.27	0.03	0.53	0.18	0.30	0.02	0.35
0.10	2.59	10.43	8.73	15.32	14.61	0.23	0.26	0.03	0.51	0.17	0.29	0.02	0.33
0.15	2.44	9.85	8.24	14.47	13.80	0.22	0.25	0.03	0.48	0.16	0.27	0.02	0.32
0.20	2.30	9.27	7.76	13.62	12.99	0.21	0.23	0.03	0.45	0.15	0.26	0.02	0.30
0.25	2.15	8.69	7.27	12.77	12.17	0.19	0.22	0.03	0.42	0.15	0.24	0.02	0.28
0.30	2.01	8.12	6.79	11.92	11.36	0.18	0.20	0.03	0.39	0.14	0.22	0.02	0.26
0.35	1.87	7.54	6.30	11.06	10.55	0.17	0.19	0.02	0.36	0.13	0.21	0.01	0.24
0.40	1.72	6.96	5.82	11.21	9.74	0.16	0.17	0.02	0.34	0.12	0.19	0.01	0.22
0.45	1.58	6.38	5.33	9.36	8.93	0.14	0.16	0.02	0.31	0.11	0.18	0.01	0.20
0.50	1.44	5.80	4.85	8.51	8.12	0.13	0.14	0.02	0.28	0.10	0.16	0.01	0.19
0.55	1.29	5.22	4.36	7.66	7.30	0.12	0.13	0.02	0.25	0.09	0.14	0.01	0.17
0.60	1.15	4.64	3.88	6.81	6.49	0.10	0.12	0.01	0.22	0.08	0.13	0.01	0.15
0.65	1.01	4.06	3.39	5.96	5.68	0.09	0.10	0.01	0.20	0.07	0.11	0.01	0.13
0.70	0.86	3.48	2.91	5.11	4.87	0.08	0.09	0.01	0.17	0.06	0.10	0.01	0.11
0.75	0.72	2.90	2.42	4.26	4.06	0.06	0.07	0.01	0.14	0.05	0.08	0.01	0.09
0.80	0.57	2.32	1.94	3.40	3.25	0.05	0.06	0.01	0.11	0.04	0.06	0.00	0.07
0.85	0.43	1.74	1.45	2.55	2.43	0.04	0.04	0.01	0.08	0.03	0.05	0.00	0.06
0.90	0.29	1.16	0.97	1.70	1.62	0.03	0.03	0.00	0.06	0.02	0.03	0.00	0.04
0.95	0.14	0.58	0.48	0.85	0.81	0.01	0.01	0.00	0.03	0.01	0.02	0.00	0.02

Source: www.angus.org/sireeval/accuracy.html (Accessed June 28, 2007).

The results of this model are presented in Table 7, with summary statistics of model variables reported in Table 8. The R^2 of 0.6286 again indicates that the model exhibits a large degree of explanatory power. The age, weight, production EPD, and marketing variable results are consistent with the earlier model. The only notable exceptions are that the *fullbrother* and *pathfinder* coefficients are not statistically significant in this model. The coefficient signs and magnitudes on all the statistically significant sale variables are consistent with the earlier model as well.[8] Each of the ultrasound EPDs in this model were significant, indicating that buyers value the information they provide. The variables *uimfepd* and *uribepd* were positive, indicating that additional units of intramuscular fat and ribeye increased the price paid for a bull. The coefficient for *ufatepd* was negative, implying that increases in fat thickness decreased value. The sign for *uprpepd* was expected to be positive, given that a bull's ability to sire progeny that yield greater quantities of retail product would be desirable to a buyer; however, the estimated coefficient was negative, a result that is difficult to explain.[9]

Because of the small magnitude of these variables, nominally large parameter estimates were generated. Thus, elasticities for each variable provide a much clearer picture of the effect of changes in the variable on *price*. This is evident by the elasticity for *ufatepd*. The large parameter estimate, −3.758, for this variable is reduced to an elasticity measure of −0.015.

[8] There are some differences in the particular sales that are included in the models due to data restrictions, and there are some notable differences in parameter estimates for sale variables that are not statistically significant in either model.

[9] An alternative model specification that included *marbepd*, *ribepd*, *fatepd*, and *prpepd* instead of the corresponding ultrasound measurements yielded results consistent with those reported here. Similarly, a model specification utilizing the actual ultrasound scores (*adjpctimf*, *adjribeye*, and *adjribfat*) yielded very consistent results (Turner). The authors chose to report results of the specification with the largest number of usable observations.

Based on elasticities, the variable *uribepd* is found to have the greatest effect on *price* among the ultrasound EPDs, although its effects are much smaller than any of the actual measures or production EPDs. This shows that the ultrasound EPDs provide additional information to buyers but, based on simple elasticities, may not be as important as other factors used in purchasing decisions. The argument would be that producers are most concerned with producing pounds of beef while becoming somewhat concerned with improving the carcass quality of their animals.

Figure 3 compares the estimated premiums received for *uribepd*, *birthepd*, and *adjyearwt* across a two-standard-deviation range of equally likely changes, calculated using the sensitivity approach outlined earlier. Based on this calculation technique, an ultrasound rib EPD observation that is one standard deviation above the mean would on average yield a premium of $440, while an adjusted yearling-weight measure that is one standard deviation above the mean would yield an average premium of $234, and a birth-weight EPD that is one standard deviation above the mean would result in an average discount of $186 for the bull. These results indicate that the relative premiums received for *uribepd* are considerably higher than those received by *birthepd* or *adjyearwt* at sales that report all three measures. This alternative method of interpreting the results provides insight regarding the effects of specific variables based on equally likely changes in these variables. Based on the findings in Figure 3, the inclusion of ultrasound EPDs should be considered by sales that failed to report them, given the high premiums received for bulls possessing large ultrasound ribeye EPDs.

Conclusion

The two primary objectives of this study were to reexamine the economic values of production EPDs and how they compare to the values assigned to actual weights and to assess the impact that various carcass trait predictors (e.g., ultrasound EPDs) have on Angus bull prices. Although the elasticities associated with actual weights were consistently higher than those associated with their corresponding production EPDs (similar to the findings of Chvosta, Rucker, and Watts), sensitivity calculations suggest that the predicted premiums/discounts for *birthepd* are greater than those associated with *birthwt* after accounting for the likelihood of change. These results indicate that on a relative scale, buyers consider *birthepd* more important than its related actual measure when selecting bulls. This relationship did not always hold true when comparing EPDs with actual underlying measures, however, indicating the continued importance of actual measures in bull selection.

Marketing factors were also examined in this study. These factors were found to yield premiums or discounts in addition to those received for production characteristics and predictors. An examination of the discrete variable shifts offers several interesting conclusions. Across model specification, pictures, embryo transfers, semen rights, and pathfinder dams are found to positively impact bull prices. Retention of semen rights yields a premium in all models. Bulls sold in the spring are consistently discounted relative to bulls sold in the fall. The significance of several of the sire variables suggests that the pedigree of the bull is important to buyers. Several sale variables were also found to be significant, indicating that buyers consider the reputation of the breeder when purchasing purebred bulls.

This study also examined the value of carcass quality predictors. All four ultrasound EPDs were highly significant, with three out of the four exhibiting the expected sign. Comparisons between premiums or discounts associated with ultrasound and production EPDs and actual weights showed one ultrasound EPD, *uribepd*, to have significantly larger price responses than either *birthepd* or *adjyearwt* when evaluated on an equally likely basis. This finding is significant because it suggests that buyers understand and place a high value on ultrasound data when making purchasing decision. On the basis of this finding, breeders that currently fail to report these data may want to consider its inclusion

Table 7. Regression Results for Ultrasound EPDs (Equation [3])

Variable	Parameter Estimate	Standard Error	*t*-Statistic	*p*-Value	Marginal Effect at Average Price	Discrete Variable Shifts	Elasticities at Variable Averages
Intercept	5.663660	0.153	37.020	0.0000			
Production measures							
*age****	0.001950	0.000208	9.375	0.0000	5.17		0.891
*age2****	−0.000001	0.000000	−5.431	0.0000			
*birthwt****	−0.002760	0.000735	−3.753	0.0000	−7.32		−0.230
*adjweanwt****	0.000437	0.000122	3.602	0.0000	1.16		0.291
*adjyearwt****	0.000807	0.000098	8.238	0.0000	2.14		0.961
EPDs							
*Birthepd****	−0.048550	0.005034	−9.645	0.0000	−128.78		−0.125
Weanepd	0.000470	0.001691	0.278	0.7810	1.25		0.018
*Milkepd****	0.006460	0.001148	5.625	0.0000	17.14		0.134
*Yearepd****	0.004080	0.001111	3.672	0.0000	10.82		0.301
*Uimfepd****	0.279700	0.042070	6.649	0.0000	741.90		0.020
*uribepd****	0.695340	0.086760	8.014	0.0000	1,844.39		0.098
*ufatepd****	−3.758050	0.799200	−4.703	0.0000	−9,968.23		−0.015
*Uprpepd****	−0.365540	0.074640	−4.898	0.0000	−969.59		−0.014
Marketing factors							
*Saleorder****	−0.270650	0.020260	−13.360	0.0000	−717.90		−0.134
*picture****	0.246400	0.022100	11.150	0.0000		723.75	
*et****	0.055660	0.017660	3.152	0.0020		148.26	
*sementhird***	0.091100	0.039600	2.301	0.0210		247.06	
*semenhalf****	0.390340	0.075680	5.157	0.0000		1,236.82	
fullbrother	−0.012560	0.021370	−0.588	0.5570		−32.33	
pathfinder	0.040890	0.026990	1.515	0.1300		108.11	
Sales							
*sale2****	−0.284630	0.039270	−7.249	0.0000		−641.63	
*sale4****	−0.282470	0.059190	−4.773	0.0000		−637.42	
*sale10****	−0.537660	0.064810	−8.296	0.0000		−1,077.26	
*sale11***	−0.205610	0.090510	−2.272	0.0230		−481.40	
*sale12****	−0.242700	0.037440	−6.482	0.0000		−558.19	
sale15	−0.081500	0.071990	−1.132	0.2580		−202.73	
*sale16****	−0.140600	0.054610	−2.575	0.0100		−339.75	
*sale23***	0.101810	0.049930	2.039	0.0420		277.61	
*sale24****	0.156120	0.050670	3.081	0.0020		437.67	
*sale27***	−0.143670	0.069380	−2.071	0.0380		−346.65	
*sale28**	0.101730	0.054170	1.878	0.0600		277.38	
sale29	−0.039970	0.049270	−0.811	0.4170		−101.49	
*sale34****	−0.101940	0.042710	−2.387	0.0170		−251.04	
*sale36****	−0.261310	0.051270	−5.097	0.0000		−595.66	
*sale37****	0.131130	0.050080	2.619	0.0090		362.94	
sale38	0.045470	0.060710	0.749	0.4540		120.50	
*sale39****	−0.364370	0.059440	−6.130	0.0000		−790.98	
*sale41****	−0.367990	0.042380	−8.683	0.0000		−797.49	
*sale42****	−0.354450	0.037730	−9.393	0.0000		−773.05	
*sale44****	−0.138050	0.034070	−4.052	0.0000		−334.00	
sale46	0.033910	0.057060	0.594	0.5520		89.34	

Table 7. (Continued)

Variable	Parameter Estimate	Standard Error	t-Statistic	p-Value	Marginal Effect at Average Price	Discrete Variable Shifts	Elasticities at Variable Averages
sale48	−0.030620	0.047150	−0.649	0.5160		−78.11	
*sale51****	−0.234240	0.055340	−4.233	0.0000		−540.92	
*sale52****	0.387810	0.052840	7.339	0.0000		1,227.15	
sale53	0.081670	0.055170	1.480	0.1390		220.43	
*sale54****	−0.275670	0.058180	−4.738	0.0000		−624.09	
sale55	0.037280	0.052180	0.715	0.4750		98.39	
*sale60****	0.250160	0.052150	4.797	0.0000		736.24	
R^2	0.6286						
Observations	3,768						

*** Denotes significance at the 0.01 level.
** Denotes significance at the 0.05 level.
* Denotes significance at the 0.1 level.

in future production sales. In fact, as the purebred bull market continues to evolve, more emphasis will likely be placed on EPD information.

The results of this study facilitate the estimation of relative bull prices. It is important to note, however, that other considerations, such as physical appearance and structural soundness, are often used by buyers to determine price and that these factors are not included in our models. These subjective measures may be as important to buyers as the genetic information contained in EPDs and actual weights and, at times, are certainly significant in determining value. This does not imply that the exclusion of this information damages the results of this study. The large sample sizes used in the models provide enough variation among the observations to provide reliable estimates.

This study has furthered our knowledge of the value of EPDs and other animal characteristics but should not be considered an end point for research in this field. Additional work is warranted to further explore the role of various carcass measures as a component of a bull's value. This study was somewhat limited by inconsistencies in the reporting of variables between sales, especially variables pertaining to carcass quality prediction. These

Table 8. Summary Statistics for Equation (3)

Variable	*N*	Mean	Standard Deviation	Minimum	Maximum
price	3,768	2,652.50	2,157.25	875.00	40,000.00
age	3,768	456.91	121.22	285.00	1,829.00
birthwt	3,768	83.29	10.14	45.00	120.00
adjweanwt	3,768	664.07	70.92	408.00	930.00
adjyearwt	3,768	1,190.09	103.53	842.00	1,742.00
birthepd	3,761	2.58	1.48	−2.50	7.80
weanepd	3,761	38.53	6.34	14.00	59.00
milkepd	3,761	20.77	4.50	1.00	34.00
yearepd	3,761	73.86	11.18	29.00	108.00
uimfepd	3,768	0.07	0.14	−0.40	0.74
uribepd	3,768	0.14	0.22	−0.58	1.00
ufatepd	3,768	0.00	0.02	−0.06	0.06
uprpepd	3,768	0.04	0.28	−0.87	1.20
saleorder	3,768	0.50	0.29	0.00	1.00

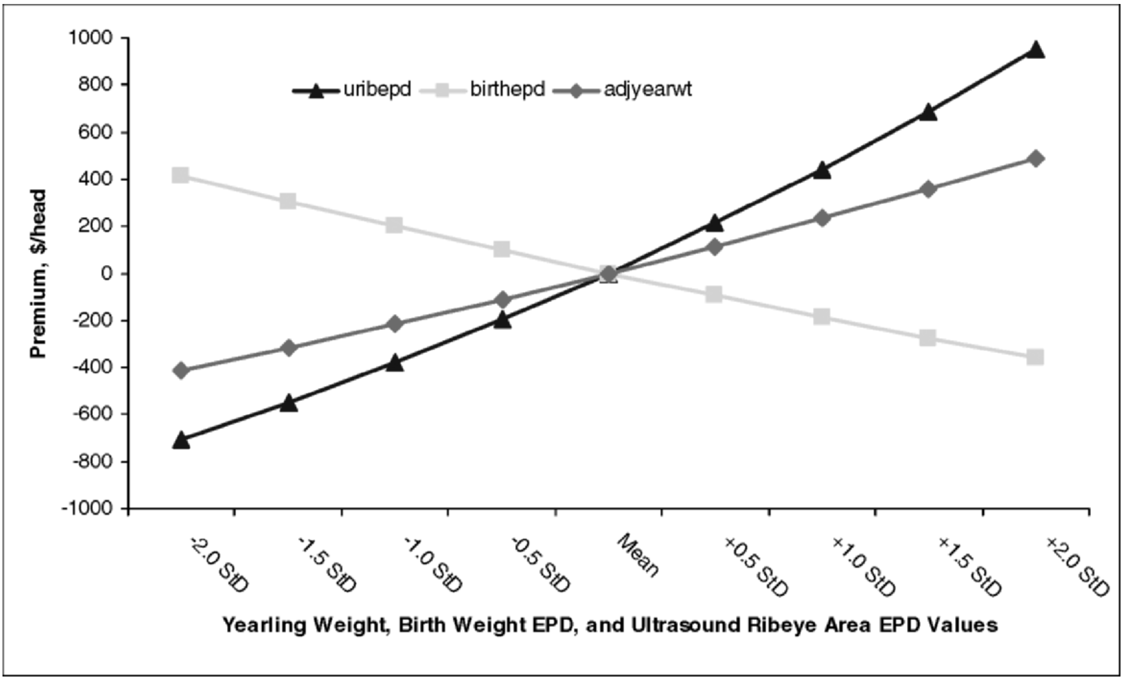

Figure 3. Predicted Premiums for Ultrasound Ribeye EPD, Birth-Weight EPD, and Adjusted Yearling Weight

inconsistencies restricted the number of observations used in specific models and prevented the examination of multiple carcass quality predictors simultaneously. With that said, this research does suggest that carcass performance predictors are important to buyers. Improving the efficiency associated with conveying the genetic carcass potential of a bull will further the cattle industry's drive to improve carcass quality.

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