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Understanding Factors That Influence Breeders to Sell Bulls at Performance Tests

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Breeders of purebred bulls have multiple avenues to market their bulls, including consignment at public auctions associated with performance tests. Purebred breeders often have the opportunity to withdraw bulls that are eligible to sell in these auctions. We examine sales data from a public auction held in conjunction with a performance bull test in Tucumcari, NM, to gain insights on breeder decisions to withdraw bulls prior to entering the sales ring. Specifically, we use a binary logit model to identify relevant characteristics that affect a breeder's decision to withdraw a sale eligible bull from the auction.

Key Words: breeder decisions, livestock, performance bull test

JEL Classifications: C31, D23, D44, D83, M31, Q13

Performance bull tests are a well-known means of facilitating market interaction between sellers of purebred cattle and buyers (e.g., cow-calf producers). Performance tests bring together bulls from varied genetic and environmental backgrounds at one testing facility to compare growth performance against bulls of the same breed. In many cases, on completion of the performance test, breeders may elect to sell their eligible bulls at after-test auctions. Eligibility may vary from test to test but generally requires the bull to be healthy and to have met minimum test performance standards.

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Auctions like those associated with performance bull tests are particularly effective, as traits of the auction commodity (i.e., purebred bulls) can be highly variable (Tomek and Robinson). In addition to facilitating market interaction between seller and buyer, the combination of performance test and the ensuing auction can improve market efficiency. For example, information on a specific animal collected during the test is often published in a presale catalog, providing important information to potential buyers. The disseminated information can effectively lower search costs and reduce product uncertainty for potential buyers.

In order for performance tests and after-test auctions to operate effectively, managers must be attentive to a variety of concerns; among these is the assurance that an adequate number of animals are available for sale in the auction. Consistent shortages of animals available for sale at these auctions reduce search cost savings for potential buyers. As costs savings decrease, fewer buyers will participate in the auction, as other costs (e.g., transportation costs) may begin to

outweigh search cost savings. Left uncorrected, a shortage of quality animals available for sale can eventually result in long-term failure of these auctions and ultimately their associated performance test programs.

In this paper we use a binary logit regression framework and data from New Mexico's Tucumcari Bull Test and Sale to examine factors that influence breeders to withdraw eligible bulls from a performance test auction prior to entering the sales ring. Specifically, we examine bull-related variables (bull test performance, breed, and age), seller-related variables (seller's previous experience at the test), and macroeconomic variables (cattle prices and production costs) to determine their marginal effect on a breeder's decisions to enter a bull into an after-test auction. By better understanding factors that influence breeders to forego opportunities to sell bulls at the auction, auction and test facility managers can better manage test auctions.

While a number of researchers have examined management elements of livestock auctions as they related to auction mechanisms, information, and prices (e.g., Buccola; Chvosta, Rucker, and Watts; Dhuyvetter et al.; Mintert et al.; Turner, Dykes, and McKissick), little applied research has been done relative to seller decisions to sell animals, specifically bulls, at auction. One area, related to the work presented here, is that of "buyback decisions.[1]" Theoretical and empirical work has been done relative to buyback practices (sellers bidding and buying back their own auctioned goods) in other industries (e.g., Beckmann; Chakraborty and Kosmopoulou; Greenleaf), but only one study, to the authors' knowledge, has examined buyback practices associated with livestock auctions.

Taylor et al., examining price determinants of show quality quarter horses, explored buyback practices associated with the World Championship Show held in Oklahoma City. The authors found that from 1995 to 2002, approximately 20% of the horses entered into the sale (actually entered the ring and were bid on) were bought back by their owners. They suggest three possible reasons why horses were bought back: lack of information conveyed to potential buyers, difficulty in measuring a young horse's potential, or an overvaluation by the seller. While examining a different phenomenon, these explanations for tendencies to buy back horses after they have entered the sale ring may provide some insight into why purebred bull breeders may choose not to sell bulls in a test-related auction.

We proceed with the presentation of our analysis by providing a brief general description of performance test programs and ensuing auctions. We then describe specific attributes of New Mexico's Tucumcari Bull Test and Sale and data obtained from the sale that were used to examine the decision of breeders to withdraw eligible bulls. The regression methodology used in the study is then presented, followed by a presentation of our results and summary of the analysis

Performance Bull Tests

Bull performance tests generally begin in the fall when weanling calves are delivered to a centralized testing facility. These calves may be "preconditioned" to accustom them to the ration and new location before beginning the 112-day test. Most facilities follow the Beef Improvement Federation (BIF) guidelines for testing procedures. Performance measures (e.g., average daily gain [ADG] and weight per day of age [WDA]) are recorded for each bull in the test. Throughout the test, sick or injured bulls are removed.

[1] It is important to make the distinction between "pulled out" and "buy back." Breeders who have "pulled out" their bulls do so before the bull enters the auction ring (these breeders generally do not face penalties for withdrawing their bulls from the sale). Breeders who "buy back" their bulls enter their bulls into the auction. These bulls are presented to buyers in both preauction catalogs and at the auction itself. While there may be differing reasons why a breeder may choose to buy back a bull that has entered the auction ring, it is often the case that the bull fails to meet the breeder's preauction price expectations. Breeders often face penalties (e.g., no-sale fees, auctioneer commissions, and so on) associated with their decision to "buy back" their bulls.

At the conclusion of the testing period, underperforming bulls are culled from the test, usually the bottom-performing 20% to 25%. Culling criteria vary from test to test but usually involve an individual bull's ADG, WDA, or other measure of performance, such as a composite index. Bulls that fail a final physical or breeding soundness evaluation can also be removed from the test and ensuing auction. Bulls that have ''made the grade'' are then eligible for public sale. Often the test facility incorporates its own public auction that is held on the conclusion of the performance test. Between the end of the test and sale day, breeders are allowed to pull their eligible bulls from the sale. These breeders pass on the opportunity to sell their bull at the sale, even though the bull has met all the requirements to sell.

The number of bulls ''pulled out'' or withdrawn prior to an auction associated with a performance test can differ substantially from year to year and from one test to another. For example, in the Tucumcari Bull Test (TBT) data set used in this analysis, the number of qualifying bulls that were pulled out from the auction ranged from a low of 0% to a high of 31% over the 17-year examination period.

The Tucumcari Bull Test and Sale

Since its first sale in 1961, the TBT has evaluated the performance of over 5,000 yearling bulls representing 24 different breeds. The TBT is sponsored by the New Mexico Beef Cattle Performance Association, the New Mexico Cooperative Extension Service, and the New Mexico State University Agricultural Experiment Station. The test attempts to (1) compare gain ability and feed conversion of bulls, (2) encourage herd improvement through the use of performance tested bulls, and (3) demonstrate relationships between measured production traits in order to develop better methods of selection (Garcia et al.).

Purebred producers bring weaned bull calves to the testing facility in October where they are preconditioned and adapted to test rations for three weeks. Incoming bulls must be born between January 5 and April 5 of the testing year, be registered purebreds, and meet minimum growth requirements. Currently, the test's growth requirements are set at 2.2-pound weight gain per day of age and 475 pounds adjusted 205-day weaning weight (WW).

Beginning-of-test data are collected on all bulls, including weight, scrotal circumference, and height. The bulls are placed on test for a 112-day period using testing procedures specified by the BIF (prior to 1987, bulls were on test for a 140-day test period). After the bulls finish the test in March, end-of-test data are collected, including final weight, scrotal circumference, back-fat thickness, pelvic area, WDA, and ADG. The test also examines the amount of feed needed for each pound of gain (feed efficiency) on a per pen and per group (i.e., breed) basis.

Bulls are sorted in pens according to their breeder and group. A group constitutes a bull's contemporaries (i.e., other bulls of the same breed on test). Each bull is indexed according to its growth performance; the top 80% of each group are declared eligible to be sold in an auction held at the bull test facility in Tucumcari.[2] After final performance measures are recorded, breeders decide whether to enter their bulls into the auction. On the day of the auction, buyers are able to talk with breeders and examine the bulls offered for sale. Bulls are sold by breed, with sale order within breed being determined by the bull's test index score. Breed sale order rotates by year; the last breed sold during the current year becomes the first to be sold the following year.

Data

Data used in the analysis were collected from 1990 to 2006 for 1,995 bulls representing 19 different breeds (Figure 1). During the 17-year

[2] In recent years (i.e., 2003–2006), the TBT management with urging of sellers and buyers has relaxed the index eligibility requirement. Breeders are now allowed to enter any bull that passes health and soundness requirements.

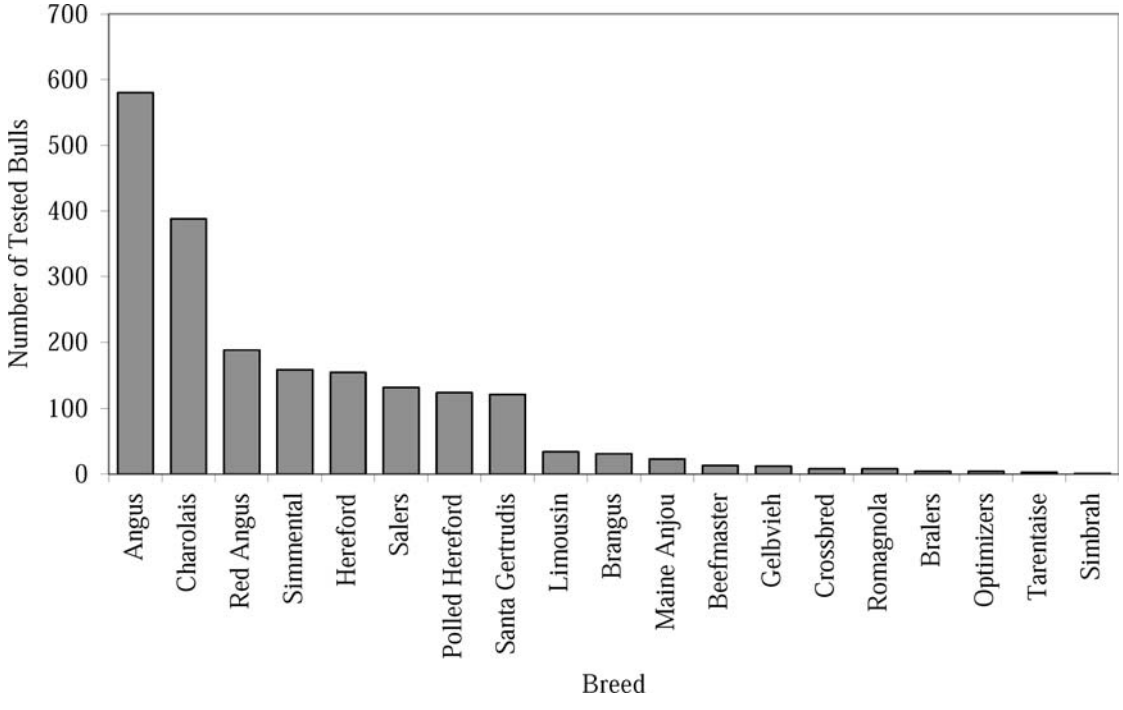

Figure 1. Bulls Tested at the Tucumcari Bull Test, by Breed, 1990–2006

period, 1,312 bulls entered the auction. Nine hundred eighty-three of these bulls were sold, hereafter referred to as "sold bulls." Three hundred twenty-nine bulls entered the entered the sale but did not sell. We refer to these bulls as "no-sale" bulls. An additional 281 bulls were eligible to sell (met all auction requirements) but were removed by their owners prior to the auction. These bulls are referred to as "pulled-out" bulls. These observations—sold bulls, no-sale bulls, and pulled-out bulls, totaling 1,593 bulls—were used in our analysis.

The majority of the remaining 402 observations represented bulls that were not eligible to be sold in the auction. These bulls failed to meet the auction's performance standard (were in the bottom 20% of their breed in terms of performance) or failed health and soundness standards. A small fraction of the initial 1,995 observations were not used because of missing information or incomplete records. Table 1 shows a breakdown of bulls that entered the sale ring and those that did not. Tables 2 and 3 provide summary statistics for the 1,593 bulls used in the analysis and the breeders who entered the bulls into the test.

Methodology

Two methods of analyzing the TBT sales data were adopted for this study. First, simple descriptive analysis is used to compare differences in variable means and proportions between bulls that went through the ring and those that were pulled prior to the sale at the TBT. The statistical significance of these differences was evaluated using appropriate *t*- and chi-square statistics. While differences between the two groups are interesting, the simple descriptive analysis has several shortcomings. First, simple descriptive statistics fail to control for other factors that might lead to statistically significant spurious correlations. Second, the method does not allow an examination of the marginal effects of key variables on the probability that a particular bull will be entered into the auction. For this analysis, we turn to binary logit analysis.

Binary Logit Estimation

Binary logit analysis is a common regression methodology used to examine the marginal

Table 1. Tucumcari Bull Test Bull Disposal Summary, 1990–2006

	Number of Head	Percent of Total
Bulls that entered the sales ring		
Sold bulls	983	49.3
No-sale bulls[a]	329	16.5
Bulls that did not enter the sales ring		
Pulled out (eligible for sale but breeder refused entry)	281	14.1
Indexed out (failed index score eligibility requirement)	270	13.5
Removed from test or sale (e.g., failed soundness evaluation)	110	5.5
Missing data	22	1.1
Total	1,995	100.0

[a] Bulls that entered the sales ring but failed to meet breeder set minimums and did not sell.

impact of explanatory variables on the probability that a particular result for a dichotomous dependent variable is observed. In the binary logit model, the analyst assumes the existence of an underlying latent variable for which a dichotomous realization is observed (Maddala). In this case the choice model is presented as

$$(1) \quad y_i^* = x'_i\beta + \varepsilon_i,$$

where the sign of the observed dichotomous variable is

$$(2) \quad y_i = \begin{cases} 1 & \text{if } y^* > \phi \\ 0 & \text{otherwise}, \end{cases}$$

where ϕ is an unobserved threshold level and the disturbance term, ε_i, is distributed with a standard logistic distribution. The cumulative density function for the error distribution is written as

$$(3) \quad \Lambda(x) = \frac{1}{(1 + \exp(-x))}.$$

With these assumptions and specificationsm the probability that a particular event occurs within the model, that is, $y^* > \phi$ and $y = 1$, is

$$(4) \quad P_i = G(z'_i\beta) = \frac{1}{(1 + \exp(x'_i\beta))}.$$

The likelihood function used to estimate the model parameters is written as

$$(5) \quad \ell = \sum_{i=1}^{N} \{y_i \log[G(x'_i\beta)] + (1 - y_i)\log[1 - G(x'_i\beta)]\}.$$

Table 2. Summary Statistics for Tucumcari Bull Test Auction-Eligible Bulls, 1990–2006

Breed	Average Number of Bulls	Average Number of Breeders	Years Bulls Available	Average Price[a]
Hereford	8	2.18	17	$1,450
Charolais	19	3.18	17	$1,945
Red Angus	8	1.94	15	$1,591
Angus	27	6.41	17	$1,733
Polled Hereford	6	0.88	14	$1,189
Santa Gertrudis	5	1.00	14	$1,283
Simmental	8	1.94	14	$1,422
Saler	6	1.35	12	$1,305
Other	6	2.28	14	$1,336

[a] Price for bulls that entered the sale and were sold.

Table 3. Summary Statistics for Tucumcari Bull Test Breeders with Auction-Eligible Bulls, 1990–2006

	Average	Maximum	Minimum	Standard Deviation
Bulls per breeder	4.57	13	1	2.73
Breeders per year	20.00	28	5	6.62

The probability model stated previously is a nonlinear function of the unknown parameters that requires maximum likelihood procedures to estimate the parameters. Using a maximum likelihood procedure with appropriate regularity conditions, a logit estimator that accounts for the heteroscedasticity of the error terms is consistent and asymptotically normal (Capps and Kramer). The model used in the study was corrected for heteroscedasticity using the hetero command in the "QLIM" procedure of SAS (SAS Institute).[3]

Model

A total of 15 variables believed to influence a decision to withdraw a particular TBT auction–eligible bull from the sale were used in the model. These variables can be categorized into three general areas: bull-specific, seller-specific, and macroeconomic variables. Bull-specific variables include those variables that identify characteristics of a particular bull. Included in this category are the bull's index value, breed, and age.

The second classification of variables includes those variables that are unique to an individual seller. This category includes variables that describe a seller's previous experience at the auction. Variables included in this category were the percentage of bulls pulled out by the breeder (relative to their eligible bulls) from the previous 5 years as a percentage of the breed average pulled-out percentage and the dollar premium or discount, per performance index point, as a percentage of the breed average, again where the premium or discount per index point is averaged over the previous 5 years. Both bull-specific and seller-specific categories include variables that are either directly or indirectly under the control of the seller (e.g., a bull's performance index value may not be directly under the control of a seller, but over time genetic selection can be used to enhance performance traits that can influence the index; Mears and Kozub; Prayaga and Henshall; Schenkel, Miller, and Wilton)

The third classification of variables, macroeconomic variables, includes variables that are external to the seller (i.e., outside their control) but that may influence their decision to withdraw a particular bull from a posttest auction. Variables included in this classification include those that may embody a buyer or seller's expectation regarding future output prices (e.g., cattle prices or input prices, e.g., feed prices). The 1-year-out futures price for March feeder cattle is used to represent output prices. The Producer Price Index (PPI) and Palmer Drought Severity Index (PDSI) are used to measure input prices. Justification for inclusion and a discussion of expected impacts of each of these explanatory variables are provided next. A summary of the explanatory variables (names, measurement, and expected marginal impacts) is provided in Table 4.

Bull-Specific Variables

Performance index. A number of variables are often used to describe a particular bull's

[3] Because the exact form of heteroscedasticity was unknown and difficult to observe graphically, the hetero command in the QLIM procedure was used to test for heteroscedasticity. Different functional relationships for the heteroscedasticity were examined. In some cases, variables exhibited statistically significant heteroscedasticity in more than one functional relationship. In this case, the functional relationship link (exp) in the QLIM procedure that provided the greatest log likelihood was adopted. In this case, the variance is modeled as

$$E(\varepsilon_i^2) = \sigma_i^2 = \exp(\mathbf{z}'_i\gamma).$$

Table 4. Explanatory Variable Summary

Variable Name/Description	Measurement	Expected Sign
Bull specific		
Performance index	Tucumcari Bull Test auction defined index	Negative
Breed	Dummy variable	Unknown
Age	Age (in days)	Negative
Seller specific		
Historical price premium	Percentage above breed average	Positive
Historical pulled-out percentage	Percentage above breed average	Negative
Macroeconomic		
Futures price	1-year-out March feeders futures price	Negative
Production costs	Farm product Producer Price Index	Unknown
Drought	Palmer Drought Severity Index	Unknown

performance or quality, such as ADG, back fat, pelvic area, physical appearance. The TBT has developed a performance index that combines ADG, WDA, and feed efficiency to rate a particular bull relative to the average test bull for that breed. Recognizing that many factors may influence an evaluation of a bull's quality but understanding that the performance index score encompasses many of these measures, we use the performance index score as a general measure of bull quality.[4] Because a higher-quality bull is more likely to obtain a higher price, it is expected that bulls with higher performance index scores will be less likely to be pulled out from the sale.

Breed. Breed popularity or the relative number of bulls offered for sale versus the number of buyers looking for a particular breed may influence the probability that a particular bull is offered for sale. While this is especially true of purebred breeders, many commercial buyers may have strong preferences for a particular bull breed (Walburger). Because information regarding buyer preferences is unknown, prior expectations regarding the impacts of breed on the probability that a particular bull is pulled out from the sale are not possible.[5]

Age. Breeders with young bulls may pull a bull from the sale, even though it is sound for breeding purposes. While age alone does not seem to influence breeding capability, age can affect dominance, which in turn can affect fertility (Petherick). Age can also affect libido, which in turn may affect fertility (Chenowith). If a potential seller feels that buyers will discount the price they are willing to pay for a young bull for these or similar reasons, they may choose to withhold their bull for sale until it has matured.

Seller-Specific Variables

Previous sales experience/reputation. Breeders who have been successful in marketing their bulls through recent TBT auctions are more likely to enter their bulls into the sale. We measured breeder experience, positive or negative, by the price premium they have received for their bulls during the previous 5 years. In order to account for price differences associated with a specific bull, the premium or discount is measured in dollars per bull performance index point. This experience variable is normalized across breeds by

[4] The TBT performance index is calculated as

$$Index = 0.40 \times \frac{Individual\ \text{Bull ADG}}{\text{Group Average ADG}} + 0.40 \times \frac{Individual\ \text{Bull WDA}}{Group\ \text{Average WDA}} + 0.20 \times \frac{Group\ \text{Average Feed Gain}}{\text{Pen Feed Gain}}.$$

[5] A possible method of measuring the buyer preferences for particular breeds in the sale might be to measure the premium received for a particular breed sold at the TBT auction as compared to the regional average for the same breed, but that information was not readily available.

calculating the premium or discount per index point as a percent of the average sale dollar per index point for the breed. This price premium measure might be considered a measure of breeder reputation (Quagrainie, McCluskey, and Loureiro).

Bulls pulled out. A record of withdrawing bulls from the auction may indicate a seller who has developed alternative marketing options. This also could encompass breeders who lack facilities needed to "feed out" or measure performance of their own bulls or who have high opportunity costs associated with feeding weanling bulls at home. These breeders may want to take advantage of the test's other benefits (e.g., comparing gain ability, developing genetic selection criteria, or documenting performance characteristics from a third party) before selling their bulls via private treaty or another sale method. We measure breeder tendency to pull out bulls prior to the sale as a continuous variable. Specifically, we use the percentage of bulls pulled out (as a percentage of eligible bulls) over the past 5 years as a percentage of the breed average percentage withdraw. We expect that the probability a bull will be pulled out from the sale increases with this measure of bulls previously pulled from the auction.

Macroeconomic Variables

Futures price. Cattle breeders, both purebred and commercial, are cognizant of feeder cattle markets and prices. Feeder cattle futures prices capture industry expectations about the calf's value as both a feedlot operation input and a cow-calf operation output. For cow-calf operators, the price received for their output (e.g., a calf) can influence how much they are willing to pay for a new bull (Chvosta, Rucker, and Watts; Schroeder et al.; Walburger). If a seller believes the feeder calf market will be strong in the future, they may expect strong demand from buyers at the posttest auction as these buyers may attempt to increase herd size to take advantage of positive expectations regarding future prices. If this is the case, buyers may be more likely to enter their bull into the auction. March Chicago Mercantile Exchange feeder calf futures data were obtained from the Livestock Marketing Information Center.

Production costs. Input costs for breeders may also affect their decision to pull a bull from the sale. If inputs such as feed are expensive, the breeder may be more willing to sell their bull rather than bear the costs of additional care. At the same time, the breeder may recognize that commercial breeders face the same increasing production cost and will be less willing to pay higher prices for breeding bulls. The marginal effect of production costs on the probability of withdrawing a bull is unknown. The PPI, with a base year of 1982–1984, for farm product commodities (U.S. Department of Labor) was used to measure input costs.

Drought. Because of the extensive grazing nature of cow-calf production in New Mexico and surrounding states, we include drought as a variable influencing breeder decisions to enter their test bulls into the TBT auction. Similar arguments made for marginal impacts of increased production costs on breeder decisions to withdraw bulls from a posttest sale can be made for the drought variable.[6] Commercial breeders face increased costs when drought conditions occur, as they must often subsidize extensive grazing with purchased feed. Often in persistent drought conditions, commercial herd sizes decline, reducing the need for breeding bulls and thus reducing demand at the auction. At the same time, the purebred breeder faces increased feeding costs if bulls are not sold in the auction. The marginal effect of drought on the probability of withdrawing a bull is unknown.

The PDSI is used as a measure of drought. The index ranges from a value of negative 6

[6] It should be noted that drought can be a local or a regional phenomenon and may disproportionately affect sellers or buyers depending on their geographical location. While detailed information for buyers was not readily available, individuals familiar with the auction suggest that the majority of buyers are located within New Mexico. This anecdotal evidence is supported by recent sales reports. In the 2005 and 2006 sales, 83% of the bulls sold through the sale were to breeders and ranchers in New Mexico. Those bulls sold outside the state were generally sold to breeders in west Texas and southwest Oklahoma.

Table 5. Significance Tests for Continuous Variables

Variable	Pulled Out		Through Ring			
	Mean	Standard Error	Mean	Standard Error	*t*-Value	*p*-Value
Bull specific						
Performance index	99.72	0.499	103.07	0.221	−6.34	<0.001
Age	370.85	1.320	368.85	0.683	1.35	0.180
Seller specific						
Percentage pulled out	−0.163	0.041	−0.243	0.026	1.64	0.103
Sales premium	0.034	0.010	0.016	0.005	1.66	0.097
Macroeconomic						
Futures price	79.88	0.598	79.91	0.290	−0.05	0.957
Production costs	107.39	0.343	107.68	0.184	−0.75	0.452
Drought	0.618	0.124	0.341	0.054	2.13	0.034

(extremely dry) to a value of 6 (extremely wet), with an index value of zero being considered "normal." The index for the study area ranged from a low of −3.23 to a high of 5.06 during the study years. The PDSI was obtained from the National Oceanic and Atmospheric Administration's Satellite and Information Service (http://cdo.ncdc.noaa.gov/CDO/cdo).

Results

Descriptive Statistics

Mean and proportion comparisons between bulls that were pulled out from the auction and those that went through the ring for the key variables identified previously are shown in Tables 5 and 6. Statistically significant differences (at the 5% level) between "through-the-ring" and pulled-out bulls were found in the average performance index score and drought conditions as measured by the PSDI. Independence between breed and whether a bull was pulled out from the auction was rejected with a chi-square statistic of 151.62. Red Angus, Santa Gertrudis, and breeds in the "other" category were pulled out of the sale more often than expected (under a null hypothesis of independence), while Angus and Simmental bulls were pulled out less frequently than expected.

Logit Regression Results

Parameter estimates for the logit regression model described previously were obtained

Table 6. Significance Tests for Dummy Variables

Variable	Total Number	Pulled Out		
		Number	Proportion	Chi-Square Statistic
Bull breed				
Hereford	136	25	18.38	0.043
Charolais	320	25	7.81	17.519
Red Angus	141	39	27.66	8.025
Angus	457	68	14.88	1.964
Polled Hereford	102	22	21.57	0.893
Santa Gertrudis	91	53	58.24	85.045
Simmental	132	10	7.58	7.579
Salers	104	13	12.50	1.557
Other breed	110	26	23.64	2.243

Table 7. Percent Correct Predictions

	Predicted		
Observed	Pulled Out	Entered Sale	Percent Correct
Pulled Out	239	42	85.1
Entered Sale	40	1,272	97.0

using the proc QLIM procedure in the SAS statistical software package. Numerous statistics have been proposed to evaluate overall model fit, a majority of these relying on the log-likelihood function value. The model had a log-likelihood value of −652.50. The likelihood ratio statistic, distributed as a chi-square, was statistically significant at the 5% level with a value of 179.31, rejecting the null hypothesis that all model parameters are equal to zero.

Another measure of the model's predictive ability is the ''percent-correct-predictions'' measure. The percent-correct-predictions statistic was calculated by assuming that if the model estimated probability is greater than or equal to 0.5 then the event would occur (i.e., a bull would be pulled out from the auction). For this model, the percent correct predictions is defined the number of times the model correctly predicted the outcome of a bull entering or failing to enter the auction ring. The logit model described previously predicted an event (either a bull being pulled out from the sale or being sold) correctly 94.9% of the time. Table 7 shows the number of times the model predicted an event relative to the event's actual occurrence.

An additional measure of a model's overall performance is the number and the strength of statistically significant parameters (Hurd). Seven of the 15 estimated coefficients (not including the intercept) in the model were statistically significant at the 1% level with an additional coefficient significant at the 5% level (Table 8). The coefficients for production costs (measured by the PPI), the feeder cattle futures price, the percentage of eligible bulls previous pulled over the past 5 years compared to the breed average pulled-out percentage, the bull's age, and the coefficients for three dummy variables representing bull breed did not enter into the regression equation in a statistically significant fashion.

Considering the significant log-likelihood statistic, the percent correct predictions, and the number of statistically significant coefficients, it appears that, in general, the model performed well. In the discussion that follows, we examine the model's predicted effects and compare those predictions to our expectations.

Effect of Bull-Specific Variables

Consistent with our expectations, as a bull's performance index decreases, the likelihood that the bull is pulled out from the test auction decreases. The average marginal effect on the probability that a bull is pulled out from the sale was −0.674, suggesting that an increase in a bull's performance index by 1 point would decrease the probability that it was pulled out from the sale by 0.674%.

The marginal effect of a particular breed on the probability that a bull was pulled out from the sale varied across breeds. Relative to Angus bulls (reference breed left out of the regression to avoid singularity), Charolais, Red Angus, Santa Gertrudis, and bulls from breeds categorized as ''other'' were more likely to be pulled from the sale. Simmental bulls were less likely to be pulled out from the auction.

Age's influence on the probability that a bull is pulled out from the sale was not statistically significant, suggesting that for the data set used in this analysis the final age of a bull in the test does not contribute to the probability that a bull is or is not entered into the sale. This finding is likely due to the fact that age differences for all bulls eligible to be sold were minimal given testing requirements.

Table 8. Logit Regression Results

Variable	Estimated Parameter	*t*-Value	*p*-Value	Marginal Effect (%)[a]
Intercept	7.215	2.34	0.020	
Bull specific				
Performance index	−0.075	−5.70	<0.001	−0.67
Breed				
Hereford	0.535	1.40	0.160	4.83
Charolais	−1.012	−2.89	0.004	9.14
Red Angus	0.874	2.58	0.010	7.89
Polled Hereford	0.467	1.17	0.242	4.21
Santa Gertrudis	3.080	8.18	<0.001	27.81
Simmental	−0.943	−1.86	0.063	−8.51
Salers	−0.058	−0.12	0.903	−0.53
Other breed	0.954	2.41	0.016	8.61
Age	−0.003	−0.58	0.559	−0.02
Breeder specific				
Dollar per index premium	3.234	4.15	<0.001	29.25
Withdraw percent	0.018	0.15	0.882	0.17
Macroeconomic				
Futures price	−0.011	−1.08	0.280	−0.10
Production costs	−0.004	−0.26	0.796	−0.04
Drought	0.169	3.34	0.001	1.53

[a] Marginal effect on the probability that a bull is pulled out from the sale.

Effect of Breeder-Specific Variables

The marginal effect for the percentage of bulls pulled out over the past 5 years (as a percentage of breed average) was consistent with researcher expectations in sign, but the variable did not enter into the regression equation significantly, suggesting that previously exhibited willingness to pull bulls from the sales does not affect the probability that a breeder will do so in the future.

The marginal effect of previous sales experience, as measured by the price that premium breeders had received during the previous 5 years (adjusted for bull quality using the performance index), was not consistent with researcher expectations. Rather, we found that breeders who have received positive price premiums from previous sales are more likely to pull their bulls from the current sale. This finding suggests that as breeders build reputations (as proxied by price premiums received from past sales), other sales opportunities may develop for their bulls (e.g., private ranch sales).

Effect of Macroeconomic Variables

Only drought, one of the three macroeconomic variables used to understand breeder decisions to pull bulls from the after-TBT auction, proved to be statistically significant in explaining breeder decisions. As drought conditions decrease, as measured by increases in the PSDI, the probability that a breeder withdrew bulls from the sale increased. In the estimated logit model, the marginal impact of an increase in the PSDI by 1 point resulted in a 1.53% increase in the probability that a particular bull was not entered into the TBT auction. Reduced drought conditions decrease the opportunity cost of holding bulls for use in a breeder's own herd or for later sale.

Summary

Performance bull tests and their associated auctions are a well-used method of facilitating market interaction between buyers and sellers of purebred cattle. The combination of a well-functioning test and associated auction offer

important search cost savings and improved marketing efficiency. In order for these efficiency gains to occur, however, it is important that test and auction managers ensure that an adequate number of bulls are available for sale in the auction. An important component of this management concern is to understand why some sale-eligible bulls, bulls that successfully completed the performance test and meet all requirements for sale, are pulled out from posttest sales prior to entering the sale ring.

Using a binary logit regression framework and data from New Mexico's Tucumcari Bull Test and Sale, we examined factors that influence breeders to withdraw eligible bulls from performance test auctions. Generally consistent with expectations, we found that attributes associated with the bull, the bull's breeder, and economic conditions played important roles in a breeder's decision to withdraw an eligible bull from the sale. The following factors were related to an increased probability of sale withdrawal by bull breeders: poor bull performance measures (as measured by the performance index), lower production costs associated with reduced drought, and breeder receipts of price premiums (premiums adjusted for bull quality compared to breed averages). In addition, we found differences in the propensity to withdraw bulls among different breeds of cattle. Specifically, Charolais, Red Angus, Santa Gertrudis, and "other breeds" that included other more exotic breeds of cattle were more likely to be pulled out from the sale compared to Angus bulls.

By better understanding the factors that influence breeders to forgo opportunities to sell bulls in postperformance test auctions, auction managers can better manage their auctions and thus improve the overall efficiency and value of the test and auction. While some of the factors that we found to influence breeders to pull their bulls from after-auction sales cannot be directly influenced by the sales manager (e.g., drought), by understanding these factors the manager can more effectively use available tools to manage the sale.

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