Journal of Agricultural and Resource Economics 31(3):595–615

Show Quality Quarter Horse Auctions: Price Determinants and Buy-Back Practices

Mykel R. Taylor, Kevin C. Dhuyvetter, Terry L. Kastens, Megan Douthit, and Thomas L. Marsh

This study estimates the price determinants of show quality quarter horses sold at auction. Several characteristics including genetic and physical traits, quality of pedigree, and performance record of the horse, as well as the horse's offspring, were found to significantly impact selling price. Sale order positively affected price and appears to be driven by buyers rather than intentional ordering of the horses. A common practice at horse auctions is for the seller to reject the final bid offered and buy back the horse. Model-predicted prices for these buy-back horses indicate they are not undervalued by the final bids, based on their characteristics.

Key words: auction, equine, hedonic pricing, quarter horses

Introduction

Limited economic research has been conducted pertaining to the show horse industry. Researchers typically have overlooked the show horse industry in favor of the racehorse industry. An attraction to researchers regarding thoroughbred and quarter horse racehorses is the amount of money spent on the gambling aspect of the sport. However, the show horse industry also has a significant economic impact on society. There are over 6.9 million horses in the United States and 7.1 million people involved in the horse industry. Of the $25.3 billion in total goods and services directly produced by the horse industry, horse showing contributes over 25% (Barents Group, 1996). Typical expenses include money spent on the horse, tack, hotel, food, entry fees, gas, vehicles, and the general care of the horse. In 2003, the American Quarter Horse Association (AQHA) sanctioned over 2,500 horse shows. Points earned at AQHA sanctioned shows allow riders to qualify for the World Show held each November in Oklahoma City, Oklahoma. One of the major events at the World Show is the World Championship Sale. This consignment sale of AQHA show horses regularly grosses over $3 million in sales annually (table 1).

Horses are entered in the World Championship Sale as consigned animals by the seller. The seller pays a $400 entry fee for every horse entered in the sale and agrees to

---

Mykel R. Taylor is a graduate research assistant, Department of Agricultural and Resource Economics, North Carolina State University. Kevin C. Dhuyvetter and Terry L. Kastens are professors and Megan Douthit is a former graduate student, all in the Department of Agricultural Economics, Kansas State University. Thomas L. Marsh is associate professor, School of Economic Sciences, Washington State University.

The authors would like to thank Barry Goodwin and participants of the North Carolina State University Ag Seminar Series and two anonymous reviewers for constructive comments and suggestions during the editing of this paper.

Review coordinated by DeeVon Bailey.

Table 1. Summary Statistics of AQHA World Championship Sale (1995–2002)

	Sale Price[a]					
Year	Gross ($)	Average ($)	Minimum ($)	Maximum ($)	Count (No.)	Percent Sold (%)
Sale Horses:						
2002	2,886,200	6,666	800	145,000	433	84.9
2001	3,055,300	7,507	700	73,500	407	79.6
2000	3,004,225	7,586	1,000	77,000	396	77.2
1999	3,173,250	8,074	750	90,000	393	79.9
1998	3,437,800	8,552	550	80,000	402	79.9
1997	3,118,100	7,894	700	85,000	395	77.9
1996	3,033,100	7,878	800	77,000	385	77.0
1995	2,019,150	7,237	950	170,000	279	80.4
No-Sale Horses:						
2002	N/A	5,247	900	14,500	77	15.1
2001	N/A	8,904	1,200	75,000	104	20.4
2000	N/A	9,059	1,400	80,000	117	22.8
1999	N/A	7,560	1,400	27,000	110	20.1
1998	N/A	8,494	1,400	49,000	101	20.1
1997	N/A	8,791	1,500	40,000	112	22.1
1996	N/A	9,083	500	103,000	115	23.0
1995	N/A	7,264	1,200	58,000	68	19.6

[a] Final bid received for no-sale horses.

pay 8% of the final sale price of each horse as a commission to the auction company. The seller is responsible for providing information on the horse to be sold to the auction company for use in the sale catalog. Sale catalogs typically include detailed information on the horse's performance record, pedigree, and genetic and physical characteristics. In addition to the sale catalog, which is available approximately one month prior to the sale, buyers and sellers have the opportunity to interact prior to the sale in the barns and riding arenas located at the World Show. Many buyers use the days prior to the sale to see prospective horses and inquire about the horses from owners and trainers.

A common practice at many horse sales, including race horses, is the use of reserve prices, or "buying back" horses. Depending on the auction company, a seller may either enter a minimum (reservation) price for the horse with the auctioneer prior to the sale or buy the horse back from the sale ring after all bids have been offered by potential buyers by entering a final "buy-back" bid. In either case, the seller determines a minimum acceptable price for the horse and does not have to sell the horse if bidding does not meet or exceed this minimum price. The World Championship Show uses the "buy-back" method and requires sellers to enter the final bid for their horse if they do not want the horse to sell for the last bid offered by a potential buyer. In this case, the horse is referred to as a "no-sale" horse, and there is no transfer of ownership. The seller, however, is still required to pay the 8% commission on the final bid. The average number of no-sale horses at this sale is 20% per year over the period 1995–2002.

Given the above discussion, two objectives were established for this study. The first is to quantify the price determinants of show-quality quarter horses sold at public auction.

The factors affecting show horse prices include genetic traits of the horse, pedigree, performance in the show ring, and economic conditions. The second objective is to determine if there is a systematic difference in the horses that sell versus the horses that do not sell, which might help explain the frequency of the buy-back method observed at the World Championship Sale.

Literature Review

Early work using the basic hedonic pricing framework proposed the hypothesis that goods can be considered as bundles of attributes, and consumers value these goods based on their individual attributes (Lancaster, 1966; Griliches, 1971). The hedonic model considered here follows Rosen's (1974) specification of an implicit pricing model. To avoid the identification problem noted by Rosen, it is assumed that the supply of horses at auction is fixed, and therefore demand for heterogeneous characteristics of horses determines the sale price.

Hedonic models have been widely used to evaluate the implicit prices of many agricultural commodities, especially livestock. There are many similarities between cattle and horse auctions, including an emphasis by sellers on genetic and phenotypic (physical) descriptions of animals to potential buyers. Thus, a review of the hedonic literature for cattle provides insight into the application of a hedonic model to horse auctions. Faminow and Gum (1986) considered short-run price differentials for feeder cattle sold at Arizona auctions. They argued that the supply of cattle at a given auction is fixed, and therefore price is determined by demand for the individual characteristics of the cattle. Their findings showed that sex, weight, pen size, breed, sale year, and location, as well as interaction terms between sex and weight, affected sale price.

Schroeder et al. (1988) used Kansas cattle auction data to analyze the effects of physical characteristics on price differentials between lots of feeder cattle. While the price differentials among lots reflect differences in supply and demand for cattle at different weight and grade categories, price premiums and discounts were also expected to reflect the demand for specific characteristics of each pen of cattle. Several attributes were found to affect price differentials including sex, weight, pen size, breed, and several conformation and health characteristics. Finally, sale order of the pen was found to positively affect price as the sale progressed. In an earlier study, Buccola (1982) also tested the effect of sale order, but found a negative price impact as the sale progressed. However, the sale order for these pens was not random; rather, sales were ordered according to weight, grade, and breed.

Dhuyvetter et al. (1996) estimated a hedonic pricing model for bulls which included bull attributes, information on expected progeny differences (EPDs), and bull sale marketing efforts. The EPDs considered in the model were not significant in explaining price variability for all breeds. Chvosta, Rucker, and Watts (2001) also included EPDs in their model of pre-sale data at bull auctions, and reported that older, simpler measures of performance provide more information on prices than the newer and more sophisticated EPDs.

Hedonic pricing models have also been used extensively for determining the value of characteristics of thoroughbred racing horses. A recent study by Robbins and Kennedy (2001) reviews the existing literature on hedonic pricing models of thoroughbred yearling auctions. As the authors note, however, much of the literature uses data from elite sales in Kentucky. Horses sold at these sales must meet strict guidelines for lineage and veterinary exam requirements, making the range in quality observed in the data very small. Because these sales also have a high number of foreign buyers, macroeconomic variables such as exchange rates can influence sale prices. Robbins and Kennedy use data from a regional horse market in British Columbia, Canada, to analyze a wider quality distribution of yearling horses and to avoid the factors that affect Kentucky horse markets exclusively. Their results indicate that the effect of the sire on sale price is captured well by the stud fee, and male yearlings bring higher prices than female yearlings. Further, race horses bought in this regional market do not appear to win back their purchase price, and therefore could be described as consumption rather than investment goods.

Lansford et al. (1998) used a semi-log hedonic pricing model to estimate the price of individual and ancestral characteristics of yearling quarter horses bred for racing. They note there has been little research pertaining to genetic and ancestral characteristics of quarter horses (i.e., pedigree) despite vast record keeping of ancestral information. The ancestral characteristics of the yearlings were described by racing performance of the yearling's sire and dam, as well as the racing performance of other offspring of the sire and dam. Racing performance was described as both number of races won and total race winnings. The authors concluded that several genetic and ancestral characteristics influence the price paid for race-bred yearling quarter horses.

Vickner and Koch (2001) extended the work of Lansford et al. by considering a hedonic hammer price model for thoroughbred yearlings. The final auction hammer price included horses that did not reach the reservation price set by the consignor. Their hedonic model considered several variables including date of sale, influence of same-sired progeny, buyer visits to an on-site repository for health records, advertising, consignor size, and individual seller reputation effects. Only the first three variables were statistically significant in explaining hammer price at auction.

Using a semilog hedonic pricing model, Neibergs (2001) analyzed thoroughbred broodmare characteristics. The characteristics examined were described as breeding, racing, genetic, and marketing factors. Breeding factors included stud fee of covering sire and earnings of foals produced by the mare. Genetic factors in the model were identified as the racing record of siblings and a quality index for the mare's sire. Marketing factors included whether or not the sale was a dispersal sale and a binary variable (*RNA*) if the horse failed to reach the reserve price (i.e., no-sale). For horses failing to reach the reserve price, the last competitive bid was used as the dependent variable. If the *RNA* binary variable is negative, this implies the broodmare would have a higher expected sale price based on its characteristics than the final competitive bid. However, the *RNA* binary variable coefficient was not statistically significant. Neibergs therefore concluded there is no evidence that sale horses and no-sale horses differ, and consequently there is no support for the seller setting a reserve price above the final bid.

Theoretical Model

As noted previously, ownership of some of the horses in the World Championship Sale did not actually change due to sellers who "buy back" their horses by entering the final bid. The final bid on a no-sale horse provides some information about the demand for that horse at auction because it is only slightly higher than the last bid offered by a potential buyer.[1] Based on the relative frequency of the buy-back method observed for this horse sale, it could be argued that sellers have some justification for buying back certain horses. This reasoning may be a consequence of the seller not conveying enough information about the horse to the buyers, resulting in the buyers not valuing the horse sufficiently to meet the seller's reservation price. In the case of young horses, it could be especially difficult for sellers to provide measurable evidence of a horse's potential for performance in the arena or for breeding to potential buyers. The buy-back method may also simply be the result of an overvaluation by the seller, given the demand for certain characteristics by buyers at this auction. In this case, the no-sale horses are not innately different from the horses that sold, and the market prices offered should be consistent with the value of individual attributes measured by the hedonic model.

For these reasons, we investigate the potential for observations on sale and no-sale horses to be generated by two different data processes. This is done by considering a Heckman sample selection model (Heckman, 1979). Following Greene (2003, pp. 782–784), the Heckman procedure first requires the estimation of a probit model where the dependent variable is an indicator variable equal to one if the horse sold and equal to zero if it did not sell. Therefore, the first-step equation for determining the sample selection is written as:

$$z_i = \mathbf{w}_i'\gamma + u_i, \tag{1}$$

where z_i is a binary variable indicating if the horses sold, and $\mathbf{w}_i$ is a vector of characteristics of each horse. Sale price is only observed when z_i is greater than zero so that the observations used in the hedonic pricing model are "selected" by equation (1).

The equation for the second-step hedonic model is given by:

$$p_i = \mathbf{x}_i'\beta + \varepsilon_i, \tag{2}$$

where p_i is the sale price, and $\mathbf{x}_i$ represents a vector of characteristics for each horse that includes at least one regressor not contained in $\mathbf{w}_i$ to ensure identification (Maddala, 1983, p. 229). The characteristics included in $\mathbf{w}_i$ and $\mathbf{x}_i$ are specified below in the empirical model section. The regressors excluded from the first-step estimation are those measuring sale order and sale order squared. These variables are dropped because, while they may affect the sale price, it is not expected that they will impact the probability of selling. Therefore, they do not appear in equation (1), but they do appear in the second-step estimation of equation (2). Table 2 provides a listing of variable names and descriptions, and reports their summary statistics.

Equation (2) is estimated using information on the sample selection from the estimation of equation (1). Therefore, the sale price observed, given z_i is greater than zero, is modeled as follows:

$$p_i \mid z_i^* > 0 = \mathbf{x}_i'\beta + \beta_\lambda \lambda_i(\alpha_u) + \nu_i, \tag{3}$$

where $\alpha_u = -\mathbf{w}_i'\gamma/\sigma_u$, $\lambda(\alpha_u) = \phi(\mathbf{w}_i'\gamma/\sigma_u)/\Phi(\mathbf{w}_i'\gamma/\sigma_u)$, and Φ and ϕ denote the cumulative and probability density functions, respectively, of the standard normal distribution.

[1] Recall the seller must pay a commission on the final bid price of 8%, and therefore has no incentive to bid any higher than necessary to buy the horse back.

Table 2. Variable Descriptions and Summary Statistics (*N* = 3,894)

Variable Name	Description	Mean	Std. Dev.	Min. Value	Max. Value
ln(*REALP*)	Log of real sale price (real final bid price for no-sale horses)	8.71	0.77	6.21	12.04
Gelding	Binary variable equal to 1 if horse is a gelding	0.14	0.35	0	1
Mare	Binary variable equal to 1 if horse is a mare	0.70	0.46	0	1
Stallion	Binary variable equal to 1 if horse is a stallion	0.16	0.37	0	1
Age	Age of horse (years)	5.11	4.64	0.50	23.50
*G*Age*	Gelding and age interaction term	0.38	1.21	0	14.50
*G*Age2*	Gelding and age squared interaction term	1.60	9.08	0	210.25
*M*Age*	Mare and age interaction term	4.31	5.03	0	23.50
*M*Age2*	Mare and age squared interaction term	43.83	78.35	0	552.25
*S*Age*	Stallion and age interaction term	0.43	1.43	0	15.50
*S*Age2*	Stallion and age squared interaction term	2.22	13.44	0	240.25
$Color_i$	Binary variable for color of horse[a]	—	—	0	1
Bred	Binary variable equal to 1 if horse is marketed as breeding stock	0.38	0.49	0	1
Incentive	Enrolled in or eligible for AQHA Incentive Fund	0.70	0.46	0	1
*H*NoTest*	Halter class and horse not tested for HYPP interaction term	0.07	0.26	0	1
*H*NN*	Halter class and horse is homozygous negative for HYPP interaction term	0.23	0.42	0	1
*H*NH*	Halter class and horse is heterozygous for HYPP interaction term	0.11	0.32	0	1
Halter	Halter class	0.41	0.49	0	1
HUS	Hunter under saddle class	0.11	0.32	0	1
WP	Western pleasure class	0.36	0.48	0	1
Allaround	One or more classes	0.07	0.26	0	1
ClassOther	Other class	0.04	0.19	0	1
Points	AQHA points earned/year	2.06	6.20	0	85.07
NonPoints	Non-AQHA points earned/year	0.18	3.17	0	112.62
ROM	Registers of merit earned/year	0.04	0.13	0	1.33
Superior	Superior ratings earned/year	0.01	0.06	0	0.86
WorldC	AQHA World Show championships/year	0.01	0.05	0	1.26
WorldP	AQHA World Show placings/year	0.03	0.13	0	2
Futurity	Championships or placings at AQHA futurities/year	0.05	0.33	0	10
NonCP	Championships or placings at non-AQHA shows/year	0.01	0.07	0	2
OffspringP	Offspring that have won points	0.34	1.19	0	20
OffspringWC	Offspring with AQHA World Show championship	0.04	0.52	0	15
OffspringWP	Offspring with AQHA World Show placing	0.12	0.73	0	13
OffspringOther	Offspring with ROM, SUP, or futurity championship or placing	0.30	1.31	0	25
SireWPRank	Rank of sire for western pleasure	9.74	20.72	0	100
SireWPRankBV	Binary variable equal to 1 if sire is ranked for western pleasure	0.33	0.47	0	1
SireHUSRank	Rank of sire for hunter under saddle	7.38	20.51	0	99
SireHUSRankBV	Binary variable equal to 1 if sire is ranked for hunter under saddle	0.18	0.38	0	1

(continued . . .)

Table 2. Continued

Variable Name	Description	Mean	Std. Dev.	Min. Value	Max. Value
SireHALTRank	Rank of sire for halter	5.68	16.19	0	100
SireHALTRankBV	Binary variable equal to 1 if sire is ranked for halter	0.25	0.43	0	1
DSireWPRank	Rank of dam's sire for western pleasure	3.62	13.61	0	99
DSireWPRankBV	Binary variable equal to 1 if dam's sire is ranked for western pleasure	0.13	0.33	0	1
DSireHUSRank	Rank of dam's sire for hunter under saddle	3.19	13.91	0	97
DSireHUSRankBV	Binary variable equal to 1 if dam's sire is ranked for hunter under saddle	0.07	0.25	0	1
DSireHALTRank	Rank of dam's sire for halter	1.64	9.80	0	100
DSireHALTRankBV	Binary variable equal to 1 if dam's sire is ranked for halter	0.07	0.25	0	1
SSireWPRank	Rank of service sire for western pleasure	2.29	10.55	0	99
SSireWPRankBV	Binary variable equal to 1 if service sire is ranked for western pleasure	0.08	0.27	0	1
SSireHUSRank	Rank of service sire for hunter under saddle	1.78	10.29	0	97
SSireHUSRankBV	Binay variable equal to 1 if service sire is ranked for hunter under saddle	0.04	0.20	0	1
SSireHALTRank	Rank of service sire for halter	3.21	12.07	0	98
SSireHALTRankBV	Binary variable equal to 1 if service sire is ranked for halter	0.13	0.33	0	1
SOClass	Sale order within class	128.74	79.98	1	327
SOClass2	Sale order within class, squared	22,968.94	23,625.66	1	106,929
YEAR	Sale year (binary variable used in model)	1998.66	2.23	1995	2002
SALE	Binary variable equal to 1 if horse sold	0.79	0.40	0	1

[a] Color categories are *Bay, Black, Brown, Chestnut, Gray, Palomino, Redroan, Sorrel,* and *ColorOther.*

Statistical significance of the β_λ coefficient in this model is evidence in favor of sample selection and the hypothesis that observations on no-sale and sale horses are coming from different data-generating processes.

The Heckman model was estimated using LIMDEP (Econometric Software, Inc., 2002). The results from the first-step probit model estimation of equation (1) are presented in table 3. The second-step estimation results are not presented to conserve space. However, the results of the second-step estimation reveal the sample selection hypothesis proposed for the auction data is not supported because the coefficient on the lambda term (β_λ) is not statistically significant. This finding suggests the no-sale horses are not statistically different from the sale horses. Given that sample selection is not necessary, a simple ordinary least squares (OLS) regression including all the data is sufficient to estimate the hedonic pricing model. However, the intuitive arguments mentioned above do provide some support for the hypotheses of systematic differences between the two groups of horses. Based on these arguments, the no-sale horses are set aside during the OLS estimation. With a relatively large number of observations on sale horses, it is then possible to perform out-of-sample predictions of the sale price for the no-sale horses, given their individual attributes.

Table 3. Probit Model Regression Results (first step of Heckman model) [dependent variable = *SALE*]

Variable	Parameter Estimate	Standard Error	*t*-Statistic	*p*-Value
Constant	0.8583	0.1327	6.4660	0.000
Genetic and Physical Characteristics:				
*G*Age*	0.0705	0.0956	0.7380	0.4606
*G*Age2*	-0.0110	0.0086	-1.2690	0.2044
*M*Age*	-0.0134	0.0292	-0.4600	0.6457
*M*Age2*	0.0005	0.0014	0.3610	0.7179
*S*Age*	-0.0664	0.0707	-0.9380	0.3481
*S*Age2*	0.0045	0.0061	0.7360	0.4616
Gelding	0.0117	0.1894	0.0620	0.9506
Stallion	-0.0625	0.1425	-0.4390	0.6610
Bay	0.0189	0.0654	0.2890	0.7729
Black	0.3275	0.1424	2.2990	0.0215
Brown	-0.1350	0.1062	-1.2710	0.2036
Chestnut	-0.1303	0.0653	-1.9970	0.0459
Gray	-0.0140	0.1108	-0.1260	0.8998
Palomino	0.0152	0.1803	0.0840	0.9329
Redroan	0.0894	0.1855	0.4820	0.6298
ColorOther	-0.0565	0.1411	-0.4000	0.6890
Bred	0.0208	0.1058	0.1960	0.8442
*H*NoTest*	-0.1748	0.1016	-1.7200	0.0855
*H*NH*	-0.0398	0.0859	-0.4630	0.6431
Performance Characteristics:				
Incentive	0.0186	0.0627	0.2970	0.7663
HUS	-0.0618	0.1075	-0.5750	0.5654
WP	-0.1308	0.0930	-1.4080	0.1593
Allaround	-0.1195	0.1107	-1.0790	0.2804
ClassOther	-0.2448	0.1328	-1.8440	0.0652
Points	-0.0158	0.0096	-1.6400	0.1010
NonPoints	0.0091	0.0095	0.9540	0.3401
ROM	0.0866	0.2535	0.3420	0.7325
Superior	1.4984	0.8866	1.6900	0.0910
WorldC	-0.1689	0.5162	-0.3270	0.7435
WorldP	0.0037	0.2090	0.0180	0.9857
Futurity	0.0611	0.0818	0.7460	0.4554
NonCP	-0.4950	0.3412	-1.4510	0.1469
OffspringP	-0.0280	0.0324	-0.8660	0.3862
OffspringWC	-0.0317	0.0467	-0.6780	0.4978
OffspringWP	-0.0148	0.0398	-0.3710	0.7107
OffspringOther	-0.0007	0.0280	-0.0240	0.9807

(continued . . .)

Table 3. Continued

Variable	Parameter Estimate	Standard Error	t-Statistic	p-Value
Pedigree Characteristics:				
SireWPRank	-0.0030	0.0015	-1.9440	0.0519
SireWPRankBV	0.0001	0.0857	0.0010	0.9995
SireHUSRank	-0.0019	0.0018	-1.0380	0.2993
SireHUSRankBV	0.1588	0.1091	1.4560	0.1455
SireHALTRank	-0.0026	0.0018	-1.4330	0.1518
SireHALTRankBV	0.2247	0.0852	2.6360	0.0084
DSireWPRank	-0.0007	0.0025	-0.2960	0.7675
DSireWPRankBV	0.0535	0.1162	0.4610	0.6450
DSireHUSRank	0.0056	0.0033	1.6990	0.0893
DSireHUSRankBV	-0.3648	0.1921	-1.8990	0.0575
DSireHALTRank	0.0013	0.0030	0.4360	0.6629
DSireHALTRankBV	-0.1344	0.1251	-1.0740	0.2828
SSireWPRank	-0.0024	0.0036	-0.6660	0.5057
SSireWPRankBV	0.2023	0.1846	1.0960	0.2731
SSireHUSRank	-0.0017	0.0039	-0.4460	0.6557
SSireHUSRankBV	0.0360	0.2215	0.1630	0.8708
SSireHALTRank	0.0002	0.0026	0.0590	0.9532
SSireHALTRankBV	-0.0954	0.1072	-0.8900	0.3736
Economic Conditions:				
Year1995	0.4336	0.1094	3.9650	0.0001
Year1996	0.1236	0.0907	1.3620	0.1733
Year1997	0.0923	0.0892	1.0350	0.3008
Year1998	0.0817	0.0896	0.9120	0.3619
Year1999	0.0961	0.0897	1.0710	0.2843
Year2000	0.1643	0.0897	1.8310	0.0672
Year2002	0.1265	0.0893	1.4170	0.1565

Empirical Model Specification

The hedonic pricing function used in this study considers the influence of a vector of characteristics of a horse on the sale price at public auction. Sale price is a function of genetic and phenotypic (physical) characteristics, pedigree, performance, sale order, and economic conditions. Physical characteristics of a horse, such as conformation, demeanor, and general appearance, are not easily recorded in a sale catalog and must be determined upon inspection of the horse prior to or during the sale. For this reason, not all physical characteristics are included in the model. The general specification of the model is:

$$\ln[REALP] = f(\textit{Genetic and Physical Traits, Individual Performance, Performance of Offspring, Quality of Pedigree, Sale Order, Year}), \tag{4}$$

where *REALP* is the real sale price of the horse and ln denotes natural logarithm.

Genetic and Physical Traits denotes a group of variables that describe the genetic makeup and physical characteristics of the horse including age, color, sex, whether or not it is a bred mare (in foal), and the presence of genetic diseases. To allow for a nonlinear age effect by sex, variables measuring age and age squared enter the empirical model as interaction terms with sex (mare, stallion, or gelding). This allows for the differences in breeding potential between mares and stallions as well as the absence of breeding potential for geldings. Age is expected to be positively related to price, but at a decreasing rate. Horse color is categorized as binary variables with sorrel being the default. There is no a priori expectation of the effect of color on price. A dummy variable for mares that are currently bred is included. A bred mare is expected to bring a higher value than a mare not currently in foal. A genetic disease of concern to show horse owners and breeders is hyperkalemic periodic paralysis (HYPP).[2] This variable enters the model as a binary variable interacted with the halter class binary variable because the disease is primarily found in horses bred for halter classes. The interaction term of halter class and testing negative for HYPP (n/n gene) was the default.

Individual Performance represents a group of variables describing the show record of the horse being sold. Each horse is categorized into one of five primary classes: western pleasure, hunter under saddle, halter, all-around (multiple classes), or other (cutting, reigning, or roping). A binary variable for each class is included in the model with the exception of halter class, which is the default. There are no a priori expectations for the class variables. Continuous variables are included for points earned at AQHA shows, points earned at non-AQHA shows, number of World Show championships, number of World Show top placings, number of futurities won, and championships or placings at non-AQHA events. In addition to points earned at shows, horses can qualify for awards based on the number of points earned in specific events. Continuous variables for number of registers of merit, which require 10 points in a single event, and the number of superior ratings, which require 50 points in a single event, are included in the model. Since the age of the horses in this sale varies from yearlings to horses over 20 years old, some horses have been eligible for competition longer than others. To account for this variance in years eligible for competition, the variables for points, awards earned, and any championships or placings at shows are divided by the age of the horse to arrive at a measure of individual performance per year of competition. Each of the variables measuring *Individual Performance* is expected to positively influence a horse's value. Finally, a binary variable is included for horses that are enrolled in or eligible for the AQHA Incentive Fund. If an incentive fund horse wins at an AQHA show, the rider and owner will receive a monetary award in addition to points. The expected sign for this variable is positive.

Performance of Offspring denotes variables describing the performance record of the offspring of the horse being sold. It includes continuous variables for the number of offspring that have earned AQHA points, won World Show championships, placed at the World Show, or won championships or placed at other horse shows or futurities.

Quality of Pedigree is a measure of the strength of a horse's lineage. While the sale catalogs provide detailed information on the lineage of the horse, the strength of the

[2] HYPP is an inherited disease of the muscle, which is caused by a genetic defect. The gene occurs primarily in horses bred for halter classes (where heavy muscling is desired) and can cause sudden paralysis or death in an animal carrying the gene. Horses will carry either the n/n gene (no HYPP), the n/h gene (50% chance of passing on to offspring), or the h/h gene (100% chance of passing HYPP on to offspring). Testing for the gene has been required on new foals by the AQHA since 1998.

pedigree is hard to determine without first-hand knowledge of the reputation of the various sires and dams. Most breeders use rankings of sires based on lifetime earnings of offspring to distinguish among the reputations of various sires. These rankings are listed by class (i.e., western pleasure, hunter under saddle, and halter) and are included for the sire of the horse, the sire of the horse's dam, and the service sire's ranking.[3] Sire rankings are calculated as both a continuous variable of the actual rank and a binary variable equal to one if the sire is ranked in the top 100 horses and zero otherwise.

Sale Order is a continuous variable corresponding to the order in which the horses were sold at each year's sale. The horses are assigned a sale order or "hip number" by alphabetical listing of the first dam's name within two groups, halter and all other performance horses. Therefore, the sale order variable is the random order in which a horse was sold within one of these two groups. To allow for a nonlinear effect by sale order, the continuous variable enters the empirical model as sale order and sale order squared. Due to the random sale order of the horses at the World Championship Sale, there are no prior expectations for the signs of these variables.

The variable *Year* represents year of sale and is modeled as a series of binary variables to capture the general effect of the overall economy (2001 is the default year). (Refer to table 2 for a listing of variable names and descriptions.)

Data

Summary statistics of the prices are reported by sale year in table 1, and summary statistics for the variables used in the model are provided in table 2. Sale prices and final bids were collected for the World Championship Sale from Professional Auction Services, Inc., which conducted the sale each of the years in the data set. The sale data included 3,911 observations from the time period 1995–2002. Six observations were dropped because the horses did not show up for the sale. Eight horses in the data set were ranked themselves on the all-time sire list for one of the three classes. These horses were considered outliers and were dropped from the data set. Only three horses tested positive for the HYPP gene, so these horses were also dropped from the sample. Of the 3,894 observations remaining, 3,090 (79%) horses sold and 804 (21%) were no-sale horses. To account for inflation, sale prices and final bids were inflated to 2002 values using the Consumer Price Index (CPI).

Data on the top 100 sires ranked by lifetime earnings of offspring were collected for each sale year from Equi-Stat. The ranking data are assigned to each observation based on the sale year. This is meant to reflect the current information on sire rankings available to buyers and sellers prior to the sale. All other data used in the model were collected from the sale catalogs for the respective sale years.

Results of the Hedonic Pricing Model

The hedonic pricing function is estimated by OLS and uses only the observations on horses that sold. The results of the regression are presented in table 4. Due to the semi-logarithmic form of the regression, the coefficients for the binary variables are transformed as follows:

[3] Some of the mares sold at this auction are sold "in foal" or currently bred. The service sire is the sire to which the mare is bred.

Table 4. OLS Hedonic Model Regression Results [dependent variable = ln(*REALP*)]

Variable	Parameter Estimate	Standard Error	*t*-Statistic	*p*-Value	Transformed Parameter Est.[a]
Constant	7.8608	0.0770	102.1400	0.0001	—
Genetic and Physical Characteristics:					
*G*Age*	0.0167	0.0557	0.3000	0.7643	—
*G*Age2*	-0.0028	0.0057	-0.4900	0.6240	—
*M*Age*	0.0916	0.0150	6.1100	0.0001	—
*M*Age2*	-0.0057	0.0007	-7.7200	0.0001	—
*S*Age*	0.1865	0.0381	4.9000	0.0001	—
*S*Age2*	-0.0126	0.0033	-3.8300	0.0001	—
Gelding	-0.2485	0.1019	-2.4400	0.0148	-0.2241
Stallion	-0.3458	0.0753	-4.6000	0.0001	-0.2944
Bay	0.0979	0.0338	2.9000	0.0038	0.1022
Black	0.3793	0.0638	5.9500	0.0001	0.4582
Brown	0.1852	0.0570	3.2500	0.0012	0.2015
Chestnut	-0.0247	0.0347	-0.7100	0.4759	-0.0250
Gray	0.2589	0.0576	4.5000	0.0001	0.2934
Palomino	0.1611	0.0936	1.7200	0.0854	0.1697
Redroan	0.2291	0.0920	2.4900	0.0128	0.2522
ColorOther	0.1499	0.0752	1.9900	0.0464	0.1584
Bred	0.0638	0.0529	1.2000	0.2285	0.0643
*H*NoTest*	-0.0569	0.0521	-1.0900	0.2753	—
*H*NH*	0.1175	0.0437	2.6900	0.0072	—
Performance Characteristics:					
Incentive	0.0826	0.0321	2.5700	0.0101	0.0855
HUS	0.0951	0.0549	1.7300	0.0835	0.0981
WP	0.0483	0.0485	1.0000	0.3191	0.0483
Allaround	-0.0431	0.0570	-0.7600	0.4499	-0.0437
ClassOther	0.4249	0.0727	5.8400	0.0001	0.5254
Points	0.0187	0.0049	3.8200	0.0001	—
NonPoints	0.0055	0.0040	1.4000	0.1625	—
ROM	0.3688	0.1296	2.8500	0.0045	—
Superior	0.6400	0.4073	1.5700	0.1162	—
WorldC	0.5016	0.3056	1.6400	0.1008	—
WorldP	0.4188	0.1063	3.9400	0.0001	—
Futurity	0.0990	0.0350	2.8300	0.0047	—
NonCP	0.3863	0.1949	1.9800	0.0476	—
OffspringP	0.0393	0.0194	2.0300	0.0426	—
OffspringWC	0.0805	0.0282	2.8500	0.0043	—
OffspringWP	0.0345	0.0228	1.5100	0.1301	—
OffspringOther	0.0406	0.0167	2.4300	0.0153	—

(continued . . .)

Table 4. Continued

Variable	Parameter Estimate	Standard Error	*t*-Statistic	*p*-Value	Transformed Parameter Est.[a]
Pedigree Characteristics:					
SireWPRank	-0.0033	0.0008	-3.9900	0.0001	—
SireWPRankBV	0.3324	0.0448	7.4200	0.0001	0.3929
SireHUSRank	0.0004	0.0009	0.4100	0.6801	—
SireHUSRankBV	0.1460	0.0544	2.6800	0.0073	0.1555
SireHALTRank	-0.0020	0.0009	-2.1200	0.0345	—
SireHALTRankBV	0.1963	0.0428	4.5900	0.0001	0.2158
DSireWPRank	-0.0010	0.0013	-0.7600	0.4450	—
DSireWPRankBV	0.1104	0.0593	1.8600	0.0629	0.1147
DSireHUSRank	-0.0001	0.0018	-0.0800	0.9380	—
DSireHUSRankBV	-0.0184	0.1082	-0.1700	0.8649	-0.0240
DSireHALTRank	-0.0012	0.0016	-0.7500	0.4519	—
DSireHALTRankBV	0.0888	0.0653	1.3600	0.1742	0.0905
SSireWPRank	-0.0036	0.0019	-1.9300	0.0542	—
SSireWPRankBV	0.2056	0.0914	2.2500	0.0246	0.2231
SSireHUSRank	-0.0017	0.0020	-0.8500	0.3938	—
SSireHUSRankBV	0.0177	0.1112	0.1600	0.8733	0.0116
SSireHALTRank	-0.0047	0.0014	-3.3300	0.0009	—
SSireHALTRankBV	0.4627	0.0567	8.1600	0.0001	0.5858
Sale Order:					
SOClass	0.0015	0.0005	2.8000	0.0051	—
SOClass2	-0.000003	0.0000	-1.4400	0.1511	—
Economic Conditions:					
Year1995	0.1340	0.0527	2.5400	0.0111	0.1418
Year1996	0.0718	0.0482	1.4900	0.1364	0.0732
Year1997	0.1120	0.0481	2.3300	0.0199	0.1172
Year1998	0.1268	0.0482	2.6300	0.0085	0.1339
Year1999	0.1821	0.0481	3.7900	0.0002	0.1984
Year2000	0.0385	0.0473	0.8100	0.4161	0.0381
Year2002	-0.0944	0.0474	-1.9900	0.0464	-0.0911
R^2 = 0.2938					
RMSE = 0.6599					
Degrees of Freedom = 3,027					

[a] Binary variable coefficients transformed according to Kennedy (1981).

$$g^* = \exp\big(\hat{c} - 0.5\hat{V}(\hat{c})\big) - 1, \quad (5)$$

where $\hat{c}$ is the estimated coefficient of the binary variable, and $\hat{V}(\hat{c})$ is an estimate of the variance of $\hat{c}$ (Kennedy, 1981). These transformed coefficients for the binary variables are also presented in table 5, and the following interpretation of the estimation uses these transformed coefficients for the binary variables.

Table 5. Summary Statistics of Predicted Market Prices

Description	Average	Standard Deviation	Minimum Value	Maximum Value
Sale Horses:				
$\ln(REALP) - [\widehat{\ln(REALP)}]$	0.00	0.65	-2.52	2.90
$P - (\hat{P})$	\$135.45	\$8,465.33	-\$64,527.99	\$155,767.66
RMSE	0.65			
% Predicted Prices Above Sale Price	65.18			
No-Sale Horses:				
$\ln(REALFB) - [\widehat{\ln(REALFB)}]$	0.0858	0.61	-2.07	2.48
$FinalBid - (\widehat{FinalBid})$	\$477.24	\$7,224.01	-\$21,673.80	\$63,770.96
RMSE	0.61			
% Predicted Prices Above Final Bid	61.07			

Genetic and Physical Characteristics

The coefficients for age and age squared of mares (*M∗Age*, *M∗Age2*) and stallions (*S∗Age*, *S∗Age2*) are significant. The positive sign on the linear term and negative sign on the squared term indicate that price increases as mares and stallions get older, but at a decreasing rate. Figure 1 shows the model-predicted effect of age on market price by sex (a more detailed discussion of the model-predicted prices is presented in the following section). The signs of the coefficients may be suggesting that the value of mares and stallions increases as their show careers progress, but will eventually fall off when they are used only for breeding later in life. The coefficients for *Gelding* and *Stallion* were negative and statistically different from zero, indicating that mares receive a premium of 22.4% and 29.4% over geldings and stallions, respectively.

All of the coefficients for color were significant, except *Chestnut*, and had a positive sign, suggesting the default color (*Sorrel*) is less preferred to other colors. The coefficient for *Bred* was not statistically different from zero. The model predicts that horses registered in or eligible for the incentive fund (*Incentive*) receive a premium of 8.6% over horses that are not eligible. This program allows riders and owners/breeders to receive money for points earned at AQHA shows. Therefore, the positive effect on the sale price of a horse is expected. The only interaction term between the halter class and the HYPP gene which was significant was the term describing a halter class horse that tested n/h for HYPP (see footnote 2). The marginal effect of the *H∗NH* coefficient indicates that a halter horse with the n/h gene will bring 11.8% more than a halter horse testing negative for the HYPP gene. This marginal effect may be the result of breeders or owners who continue to take the risk of a horse getting HYPP in return for heavier muscling, which is highly valued in halter classes.

Individual Performance

Of the binary variables denoting the primary class of the horse, the coefficients for *ClassOther* and *HUS* were significant. Horses in western pleasure, or the all-around

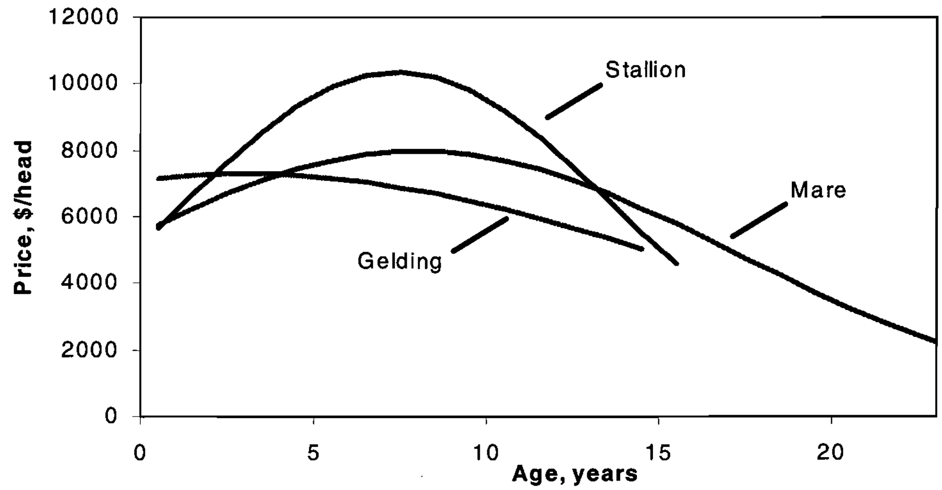

Figure 1. Model-predicted effect of age on market price by sex (all other characteristics evaluated at the mean of the series for gelding, stallion, and mare)

class do not have a significant premium or discount relative to halter horses, while horses in the hunter under saddle (*HUS*) class are predicted to have a premium of 9.8% over halter class horses. The significant and positive sign on the *ClassOther* variable indicates the possibility of a different set of buyers for the performance horses (cutting, reigning, or roping).

Several of the individual performance variables describing the horse's record per year of competition were significant. Specifically, points earned at AQHA shows (*Points*), the number of awards (*ROM*), the number of championships or top placings at the World Show, the number of futurity championships or placings, and the number of championships or placings at non-AQHA shows (*WorldC*, *WorldP*, *Futurity*, *NonCP*) were significant and positive. An additional point earned per year of competition increases sale price by 1.9%. An additional register of merit earned per year of competition, requiring 10 points in a single class, increases the sale price of a horse by 36.9%. A World Show championship (top placing) increased price by 50.2% (41.9%), while winning or placing at a futurity or non-AQHA event increased price by 9.9% and 38.6%, respectively. Based on these marginal effects, buyers consider the show record of a horse and are willing to bid higher for horses with a proven show record.

Performance of Offspring

All of the variables measuring the performance of the horses' offspring (if they had any) were positive and significant, except a top placing at the World Show. A horse having an additional offspring that has earned AQHA points at any time during its career increases the sale price by 3.9%, while an additional World Show championship increases sale price by 8.1%. Each horse's offspring that has received an award (register of merit, superior rating) or won a championship at a futurity or other event during its career increases the sale price of that horse by 4.1%.

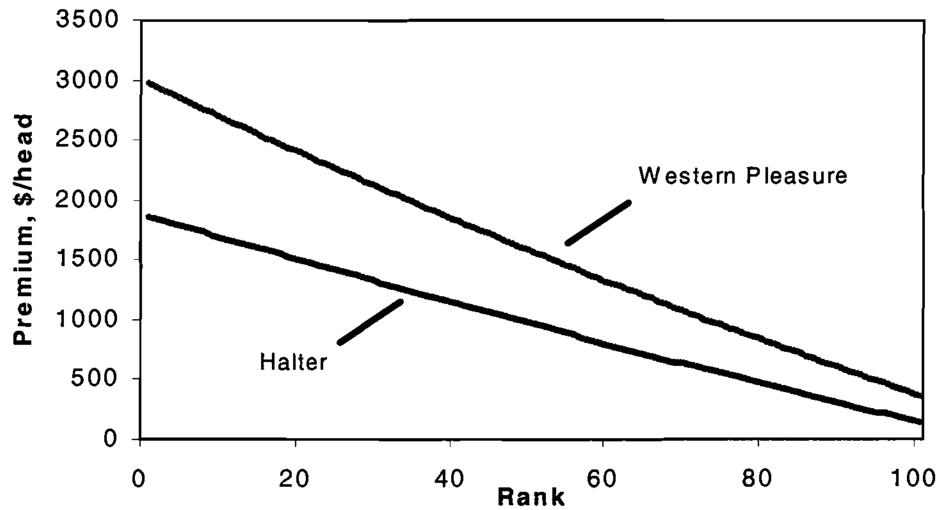

Figure 2. Model-predicted premium for a ranked sire by class (all other characteristics evaluated at the mean of the series for western pleasure and halter)

Quality of Pedigree

The ranking of a horse's sire was broken out by class: western pleasure, hunter under saddle, and halter. For western pleasure, a sire ranked in the top 100 (*SireWPRankBV*) adds 39.3% to the sale price. The continuous variable for sire rank (*SireWPRank*) shows the sale price falls by 0.33% for a one unit increase in rank (the best rank possible is 1 and the worst is 100). This relationship indicates that the premium of having a ranked sire in western pleasure is reduced from 39.3% to 6.3% as the level at which the sire is ranked falls from 1 to 100. For hunter under saddle, the binary variable (*SireHUSRankBV*) was significant and adds 15.6% to the sale price. The continuous variable was not statistically significant. For horses with sires ranked in the halter class (*SireHALTRankBV*), the added value is 21.6%. The continuous variable (*SireHALT-Rank*) reveals that the premium from having a ranked sire in halter decreases 0.20% for each decline in rank from 1 to 100, resulting in the premium being reduced to 1.6% as the sire ranking falls to 100. Figure 2 shows the change in the predicted premium for a ranked sire in western pleasure or halter classes as the rank declines from 1 to 100.

For horses whose dam's sire was ranked in the western pleasure class (*DSireWP-RankBV*), the sale price increases by 11.5%. The other variables for dam's sire ranking were not statistically different from zero.

For bred mares with service sires that were ranked in the western pleasure class (*SSireWPRankBV*), the sale price is increased by 22.3% and declines 0.36% for each fall in rank from 1 to 100 (*SSireWPRank*). The premium associated with being ranked in western pleasure is reduced to zero by the 62nd ranked horse. The ranking of a service sire in the hunter under saddle class (*SSireHUSRank*, *SSireHUSRankBV*) was not significantly different from zero. For mares with service sires ranked in the halter class (*SSireHALTRankBV*), the sale price is 58.6% higher and the price declines by 0.47% for each fall in rank from 1 to 100 (*SSireHALTRank*). The premium is reduced to 11.6% for a service sire in the halter class at the last ranking (100th).

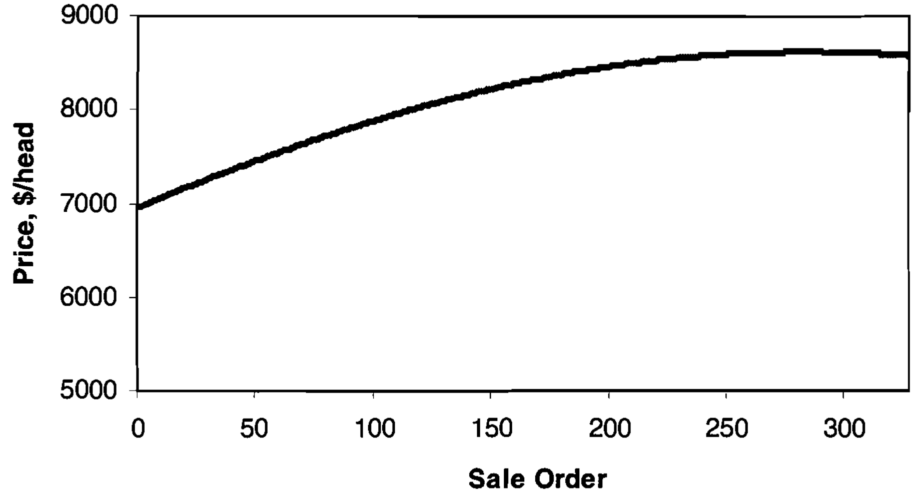

Figure 3. Effect of sale order on sale price

Sale Order

The coefficient for sale order by class (*SOClass*) was statistically significant and positive. The coefficient for sale order by class squared (*SOClass2*) was not significant. The positive sign on the linear term and negative sign on the squared term indicate that price increases the farther into a sale a horse is sold, but at a decreasing rate. This quadratic relationship likely describes the change in attitude of buyers over the duration of the sale because the order of horses sold is random and therefore not impacted by higher valued horses being placed intentionally at the end of the sale. Figure 3 presents the effect of sale order on price.

Year

The binary variables for year were included to account for general economic conditions. The coefficients for 1995, 1997, 1998, and 1999 were significant and positive. The base year for comparison is 2001, implying that horses with identical characteristics sold for 14.2%, 11.7%, 13.4%, and 19.8% more in the years 1995, 1997, 1998, and 1999, respectively, than in 2001. The coefficient for 2002 was also significant, but the negative sign reveals that horses sold in 2002 received 9.1% less than an identical horse sold in 2001. The year coefficients for 1996 and 2000 were not significant in explaining the variation in price for horses sold. The signs of the significant coefficients indicate generally good economic conditions for horse buyers until 2001, after which economic conditions were not favorable for expenditures on this type of "luxury" good.

Explaining the Buy-Back Method

Predicted Sale Prices

Using the parameter estimates from the hedonic pricing model, the expected sale prices for the no-sale horses are predicted. The summary statistics of the residuals between the observations on the sale price, ln(*REALP*), and the predicted sale price, [$\widehat{\ln(REALP)}$] of the sale horses are presented in table 5. The residuals for the no-sale horses are also presented using the observed final bid and their predicted sale price. The average residual for the no-sale horses is 0.0858, showing the observed final bid price is 8.6% larger than the predicted sale price, on average, for the no-sale sample.

It may be easier to understand these results if the predicted logs of the prices are transformed to levels for comparison to the final sale bids. Due to bias in the transformation of a semilogarithmic linear model, an adjustment is applied to the transformation (Miller, 1984). The transformation is as follows:

$$E\big(\widehat{\ln(p_i)}\big) = e^{\mathbf{x}_i\hat{\beta}} e^{0.5\hat{\sigma}^2}, \tag{6}$$

where $\hat{\sigma}^2$ is the model root mean squared error.

Once the predicted sale prices for the sale and no-sale horses are transformed, the average residuals between the observed price or final bid and the predicted sale price are $135.45 for sale horses and $477.24 for no-sale horses. While the average residuals suggest the predicted sale prices for both groups of horses are lower than the observed price, table 5 shows the percentage of all the horses predicted to have sale prices higher than the observed price or final bid. According to this measure, approximately 65% of the sale horses had predicted prices above the observed price. Similarly, for no-sale horses, approximately 61% of the observations had predicted prices higher than the observed final bid. Taken alone, this measure suggests 61% of the no-sale horses were undervalued by bidders at the auction. However, this measurement is very comparable to the model's prediction of 65% of the sale horses being undervalued as well. While these measures confirm the accuracy of the OLS model predictions, comparison of the measures between the two groups suggests there is very little difference in the predicted sale prices between the sale horses and no-sale horses. Therefore, it does not appear that the no-sale horses were consistently undervalued by the final bid, based on their characteristics.

Probit Model Results

While the predicted prices do not suggest a systematic difference between the sale and no-sale horses, it may be useful to revisit the first-step estimates of the Heckman model. The probit estimates identify characteristics of horses making them more likely to sell. Of the 63 regressors used in the probit model, only 10 were statistically significant at the 10% level or better. Of the significant coefficients, two were individual performance regressors—*Points* and *Superior*. Based on the negative coefficient for *Points*, horses with a higher number of points earned per year of competition are less likely to sell, while the positive coefficient for *Superior* suggests additional superior ratings will increase the probability of selling. There were also two annual binary variables, *Year1995* and *Year2000*, which had positive effects on the probability of selling. The relatively low number of regressors displaying explanatory power provides little insight into why some of the horses sold and others were bought back by the seller. Again, there does not appear to be a measurable, systematic difference in the characteristics of the sale versus no-sale horses.

Other Activities

While the model is unable to capture any empirical differences between the two groups of horses entering the auction ring, there are several explanations for why sellers may choose not to sell their horses at auction, beyond the value of the horse's characteristics. Some sellers may have information on the horses' expected show or breeding performance that is difficult to express to potential buyers through the catalog or pre-sale viewing. This inefficiency in the flow of information could cause buyers to undervalue a horse relative to the seller's reservation price. Conversations with individuals in the show and performance horse industry also suggest the possibility that deals are being made outside the sale ring, and some of the no-sale horses are actually being sold at a later time.[4] Another possible explanation for no-sale horses is overvaluation by sellers. Some sellers may simply ignore the market signals from buyers at the auction and decide their horse is "too valuable" to sell at the final bid price.

Conclusions

Knowing how individual characteristics of horses—ranging from genetic characteristics to performance discipline to pedigree—impact prices is critical information for both buyers and sellers of quarter horses. Buyers desire this information in order to make informed purchase decisions possibly reducing the risk associated with their investments. Likewise, sellers desire this information so they can make breeding decisions to capture the traits most demanded by buyers.

Several of the genetic traits, as well as age, color, and sex, impacted sale price. For mares and stallions, the positive relationship between age and price declines as the horse ages. The coefficients on sex revealed that mares receive a premium relative to both geldings and stallions. This likely is due to both their breeding potential, as compared to geldings, and their tendency to be easier to handle in the show ring after they have started their breeding career. Stallions tend to be much harder to work with after their breeding life has begun.

Each of the statistically significant variables measuring a horse's performance positively impacted sale price. Clearly, buyers value horses with distinguished show records not only for their potential in the show ring, but also for their future value as breeding animals. Enrollment in or eligibility for the AQHA Incentive Fund also increases the sale prices of horses.

A strong pedigree is valuable for show horses, as confirmed by the positive effect of the performance of offspring and the ranking of sires, dams' sires, or service sires. Pedigree is likely to be a significant factor in many breeding programs because it is a valuable trait desired by buyers in the market.

Horses are considered a luxury good, and expenditures in the horse industry may be affected by the condition of the economy. The binary variables used for each sale year indicate that the first five years of the sample were generally good economic years for sale prices and the last two were relatively less favorable for the purchase of show horses.

---

[4] While this type of activity is certainly possible, Professional Auction Services does have regulations in place to prohibit sales outside the auction ring. To the extent they are able to enforce these regulations, this practice may not be affecting very many of the no-sale observations in the sample.

While the effect of sale order has been considered in other studies, these particular data offer a unique opportunity to evaluate the effect of order on price when order is determined randomly. As shown by the coefficients on sale order, price increases as the sale progresses. Unlike sales where the auctioneer or sellers arrange the order to sell their best horses first, this positive effect can be attributed to buyers. It appears that buyers "hold back" somewhat at the beginning of a sale, perhaps to evaluate the market conditions for the auction as well as the characteristics of the horses themselves.

In addition to identifying the individual characteristics affecting show horse value, this study also sought to explain the use of the buy-back practice of sellers by considering differences in characteristics between horses that sold and those that were bought back. The results of the predicted sale prices for the no-sale horses suggest these horses are not systematically undervalued by the final bid at auction as compared to the horses that did sell. Also, the results of the probit model provide very little explanation of inherent differences between the two groups based on measurable characteristics.

The relative frequency of the buy-back practice is an aspect of these auctions that remains unexplained by this model, which is only able to consider characteristics of the horses. Future research could address some of the possible explanations for why sellers use the buy-back method at auction by including information on the characteristics of the sellers themselves. This approach will allow more extensive investigation into the trend of no-sale horses commonly observed at auctions for show-quality quarter horses.

[*Received July 2005; final revision received June 2006.*]

References

Barents Group, LLC. "The Economic Impact of the Horse Industry in the United States." Technical report prepared for The American Horse Council Foundation, Washington, DC, December 1996.

Buccola, S. T. "Price Trends at Livestock Auctions." *Amer. J. Agr. Econ.* 64(1982):63–69.

Chvosta, J., R. R. Rucker, and M. J. Watts. "Transaction Costs and Cattle Marketing: The Information Content of Seller-Provided Presale Data at Bull Auctions." *Amer. J. Agr. Econ.* 83(2001):286–301.

Dhuyvetter, K. C., T. C. Schroeder, D. D. Simms, R. P. Bolze, Jr., and J. Geske. "Determinants of Purebred Beef Bull Price Differentials." *J. Agr. and Resour. Econ.* 21(December 1996):396–410.

Econometric Software, Inc. *LIMDEP Reference Guide, Version 8.0.* Plainview, NY: Econometric Software, Inc., 2002.

Equi-Stat. Personal communication with Equi-Stat representative Donna Tolson, Fort Worth, TX, June 2004.

Faminow, M. D., and R. L. Gum. "Feeder Cattle Price Differentials in Arizona Auction Markets." *West. J. Agr. Econ.* 11(1986):156–163.

Greene, W. H. *Econometric Analysis*, 5th ed. Upper Saddle River, NJ: Prentice-Hall, 2003.

Griliches, Z., ed. *Price Indexes and Quality Change.* Cambridge, MA: Harvard University Press, 1971.

Heckman, J. "Sample Selection Bias as a Specification Error." *Econometrica* 47(1979):153–161.

Kennedy, P. E. "Estimation with Correctly Interpreted Dummy Variables in Semilogarithmic Equations." *Amer. Econ. Rev.* 71(1981):801.

Lancaster, K. J. "A New Approach to Consumer Theory." *J. Polit. Econ.* 74(1966):132–157.

Lansford, N. H., Jr., D. W. Freeman, D. R. Topliff, and O. L. Walker. "Hedonic Pricing of Race-Bred Yearling Quarter Horses Produced by Quarter Horse Sires and Dams." *J. Agribus.* 16(Fall 1998): 169–185.

Maddala, G. S. *Limited-Dependent and Qualitative Variables in Econometrics.* New York: Cambridge University Press, 1983.

Miller, D. M. "Reducing Transformation Bias in Curve Fitting." *Amer. Statistician* 38(1984):124–126.

Neibergs, J. S. "A Hedonic Price Analysis of Thoroughbred Broodmare Characteristics." *Agribus.: An Internat. J.* 17(2001):299–314.

Professional Auction Services, Inc. Sale data from World Championship Show, 1995–2002, PAS, Inc., Leesburg, VA.

Robbins, M., and P. E. Kennedy. "Buyer Behaviour in a Regional Thoroughbred Yearling Market." *Appl. Econ.* 33(2001):969–977.

Rosen, S. "Hedonic Prices and Implicit Markets: Product Differentiation in Pure Competition." *J. Polit. Econ.* 82(1974):34–55.

Schroeder, T., J. Mintert, F. Brazle, and O. Grunewald. "Factors Affecting Feeder Cattle Price Differentials." *West. J. Agr. Econ.* 13(July 1988):71–81.

Vickner, S. S., and S. I. Koch. "Hedonic Pricing, Information, and the Market for Thoroughbred Yearlings." *J. Agribus.* 19(Fall 2001):173–189.