Price Determinants of Show Quality Quarter Horses

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Abstract

This study estimates the price determinants of show quality Quarter Horses sold at auction. Several characteristics including genetic and physical traits, the quality of pedigree, and sale order affect price. Sale price is positively affected by a strong performance record of the horse as well as the performance record of the horse's offspring. A common practice at horse auctions is for the seller to reject the final bid offered and not sell the horse. The market prices predicted by the model for these horses indicate that they are not undervalued by the final bids, based on their characteristics.

Keywords: auction, censored regression, hedonic model, Quarter Horses

Price Determinants of Show Quality Quarter Horses

There has been limited economic research 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 percent (Barents Group). 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 $3,000,000 in sales (Table 1).

Horses are entered in the World Championship Sale as consigned animals by the seller. The seller pays a $400 entry fee and agrees to pay 8% of the final sale price 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 characteristics. In addition to the sale catalog, which is available approximately one month prior to the sale, buyers and seller 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 practice of using 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 or buy the horse back from the sale ring by entering the final 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 the seller to enter the final bid for their horse if they do not want the horse to sell for the last bid offered by a 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 to 2002.

The first objective of this study is to quantify the price determinants of show-quality Quarter Horses sold at public auction. The factors that affect show horse prices include genetic traits of the horse, pedigree, performance in the show ring, and economic conditions. A second objective is to determine if there is a market inefficiency that causes sellers to buy back their horses as opposed to letting them sell at the final bid price.

Literature Review

Rosen's hedonic pricing model is based on the hypothesis that goods are valued based on their attributes. Hedonic models have been widely used to evaluate the implicit prices of many agricultural commodities, especially livestock. Bailey and Peterson estimated factors affecting feeder cattle prices at video and traditional auctions. Dhuyvetter, et al. and Chvosta, Rucker, and Watts estimated purebred beef bull determinants and Mintert, et al. analyzed factors affecting the price for cull cows.

Lansford, et al. used a semi-log hedonic pricing model to estimate the price of individual and ancestral characteristics of yearling Quarter Horses bred for racing. They noted that 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.

Neibergs also used a semi-log hedonic pricing model to analyze Thoroughbred broodmare characteristics. The characteristics included 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 included the racing record of siblings and a quality index for the mare's sire. The marketing factors considered included whether or not it was a dispersal sale and a binary variable (*RNA*) if the horse failed to reach the reserve price (i.e., if it did not sell). The model indicated that horses that win graded stakes races have the greatest purse earning potential and the greatest value as a breeding prospect. The *RNA* binary variable coefficient was not statistically significant and the author concluded that there is no evidence that the value of these no-sale horses justifies setting a reserve price above the final bid.

Hedonic 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 that reason, many physical characteristics are not included in the model. The general specification of the model is

(1) ln*[Price]=f(genetic and physical traits, individual performance, performance of offspring, quality of pedigree, sale order, year),*

where *Price* is the 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, 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 that is not currently in foal. A genetic disease of concern to show horse owners and breeders is hyperkalemic periodic paralysis (HYPP).[1] 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 and testing negative for HYPP (n/n gene) was the default.

Individual Performance is a group of variables that describe the show record of the horse being sold. Each horse is classified in one of five primary classes: western pleasure, hunter under saddle, halter, all-round (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

[1] 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 percent chance of passing on to offspring), or the h/h gene (100 percent chance of passing HYPP on to offspring). Testing for the gene has been required on new foals by the AQHA since 1998.

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 register of merits, which require ten points in a single event, and the number of superior ratings, which require 50 points in a single event, are included in the model. The variables for points and awards earned are 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 that describe 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 events.

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 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.[2] Sire rankings are calculated as both a continuous variable of the actual rank and a binary variable that equals one if the sire is ranked in the top 100 horses and zero otherwise.

[2] 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.

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 its group. 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 as to 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). Variable names and descriptions are listed in Table 2.

Model Estimation

As mentioned previously, some of the horses in the World Championship Sale did not actually transfer ownership due to the seller "buying back" their horses. For these no-sale horses, the sale catalog provides all of the information on the independent variables, but the only information on price is the final bid recorded. Although the final bid on a no-sale horse provides some information about the demand for that horse at auction, it is not a market-clearing price. The price would have to be higher than the final bid for a transfer of ownership to occur, thus the final bids are essentially a censored value of the market-clearing price. Neibergs estimated an OLS model using the sale price as the dependent variable for horses that sold and the final bid price as the dependant variable for horses that did not sell. To account for the horses that did not sell, a binary variable for the no-sale horses (*RNA*) was included in the model. However, using an OLS model to estimate censored data will generate biased and inconsistent parameter estimates (Pindyck and Rubinfeld, pp. 325-327). Therefore, a censored regression model allowing the no-sale observations to be included in the dataset is a more appropriate modeling approach.

Crespi and Sexton used a censored regression model to recover losing bids from an auction for pens of fed cattle. Their model allowed the censored value to adjust by observation, rather than be set at a specific value for all observations. Following their model specification, we assume that the natural log of the market clearing price of $horse_i$ $(\ln P_i^*)$ is determined by a vector of characteristics, X_i, such that $\ln P_i^* = \beta_i X_i + \varepsilon_i$. Further, and assuming that $\varepsilon_i \sim N[0, \sigma_i^2]$, the observed natural log of the sale price is

(1) $\ln P_i = \ln P_i^{SP}$, if $P_i^* = P_i$,

and the censored natural log of the final bid is

(2) $\ln P_i = \ln P_i^{FB}$, if $P_i^* > P_i^{FB}$,

where $\ln P_i^{SP}$ is the natural log of the sale price for horse *i* (if the horse sold) and $\ln P_i^{FB}$ is the natural log of the final bid for horse *i* (if the horse did not sell). For an observation drawn randomly from the sample, which may or may not be censored (Greene, p. 764),

(3) $$E[\ln P_i | X_i] = \Phi\left(\frac{X_i'\beta}{\sigma}\right)\left(X_i'\beta + \sigma\lambda_i\right),$$

where

(4) $$\lambda_i = \frac{\phi(X_i'\beta / \sigma)}{\Phi(X_i'\beta / \sigma)} .$$

Data

Summary statistics of the prices are reported in Table 1 and summary statistics for the variables used in the model are listed 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 dataset. The sale data included 3911 observations from the time period 1995 to 2002.

Six observations were dropped because the horses did not show up for the sale. Eight horses in the dataset 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 dataset. Of the 3897 observations remaining, 3093 horses sold and 804 were no-sale horses.

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

The hedonic pricing function is modeled as a Tobit model and was estimated using Limdep. The coefficient estimates and marginal effects of the Tobit model are shown in Table 3. The marginal effects of the model are

(5) $$\frac{\partial \ln P_i}{\partial X_i} = [\rho_{non-\lim}]\beta ,$$

where β is the vector of estimated coefficients and $\rho_{non-\lim}$ is the probability of an observation not being censored such that

(6) $$\rho_{non-\lim} = \{\Phi_i[1-\lambda_i(\alpha_i+\lambda_i)]+\phi_i(\alpha_i+\lambda_i)\},$$

where $\alpha_i = X_i'\beta$, $\Phi_i = \Phi(\alpha_i)$, and $\lambda_i = \phi_i / \Phi_i$, with Φ and ϕ denoting the cumulative and density functions, respectively, of the standard normal distribution. Greene (pp. 674-676) recommends computing the marginal effects at each observation and reporting the sample average of the individual marginal effects due to the nonlinearities of discrete choice models.

The sample average of the marginal effect for each parameter is reported in Table 3. The interpretation of the marginal effect for each coefficient is the proportional change in price for a one unit change in the parameter, given that some sellers will not sell their horses. Taking into account the probability that a horse may not sell, the marginal effects are slightly smaller in magnitude than the estimated coefficients of the Tobit model. The following discussion of the different model variables is based on the marginal effects.

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 indicating 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 both statistically different from zero and indicate that mares receive a premium of 24.46 percent and 20.56 percent 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 6.90 percent 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 that was significant was the term describing a halter class horse that tested n/h for HYPP (see footnote 1). The marginal effect of the *H*NH* coefficient indicates that a halter horse with the n/h gene will bring 10.12 percent more than a halter horse that tested 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, only the *ClassOther* coefficient was significant. Horses in western pleasure, hunter under saddle, or some combination of these classes do not have a significant premium or discount relative to halter 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 were significant. Specifically, the number of awards (*ROM, Superior*), the number of championships or top placings at the World Show, and the number of futurity championships or placings (*WorldC, WorldP, Futurity*) were significant and positive. An additional register of merit increases the sale price of a horse by 15.20 percent, while an additional superior rating increases sale price by 14.88 percent. A World Show championship (top placing) increased price by 8.63 (7.88) percent and winning or placing at a futurity increased price by 7.97 percent. These marginal effects indicate that the show record of a horse positively impacts it value.

Performance of Offspring

All of the variables measuring the performance of the horses' offspring (if they had any) were positive and significant. A horse having an additional offspring that has earned AQHA points increases the sale price by 5.04 percent, while an additional offspring that has a World Show championship (top placing) increases sale price by 7.10 (3.26) percent. Each offspring that has received an award (register of merit, superior rating) or won a championship at a futurity or other event increases the sale price of a horse by 2.50 percent.

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 28.28 percent to the sale price. The continuous variable for sire rank (*SireWPRank*) indicates that the sale price falls by 0.23 percent 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 to almost 5.28 percent from 28.28 percent 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 added 12.65 percent 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 13.10 percent. The continuous variable (*SireHALTRank*) indicates that the premium from having a ranked sire in halter is decreased by 0.13 percent for each decline in rank from 1 to 100. This relationship indicates that the premium is reduced to less than 1 percent as the level at which the sire is ranked 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 (*DSireWPRankBV*), the sale price is increased by 10.34 percent. For a dam's sire ranked in the halter class (*DSireHALTRankBV*), the sale price is increased by 10.14 percent. 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 22.66 percent and declines by 0.41 percent for each fall in rank from 1 to 100 (*SSireWPRank*). The premium from being ranked in western pleasure is reduced to zero by the 55^{th} ranked horse and a negative 18.34 percent at the 100^{th} rank. The ranking of a service sire in the hunter under saddle class (*SSireHUSRank, SSireWPRankBV*) was not significantly different from zero. For the mares with service sires ranked in the halter class (*SSireHALTRankBV*), the sale price is 41.30 percent higher and the price declines by 0.40 percent for each fall in rank from 1 to 100 (*SSireHALTRank*). The premium is reduced to 1.3 percent for a service sire in the halter class at the last ranking (100th).

Sale Order

The coefficient for sale order by class (*SOClass*) was statistically significant and positive. The coeffienct for sale order by class squared (*SOClass2*) was significant and negative. 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 may describe the change in attitude of buyers over the duration 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 coefficient for 1999 (*Year1999*) was significant and positive. The base year for comparison is 2001, implying that horses with identical characteristics sold for 11.17 percent more in 1999 than in 2001. The coefficient for 2002 (*Year2002*) was also significant, but the sign indicates that horses sold in 2002 went for 9.47 percent less than an identical horse sold in 2001. All other year coefficients were not significant in explaining the variation in price for horses sold.

Predicting Sales Prices

While it is appropriate to evaluate individual characteristics for show horses using the marginal effects from the Tobit model, this may not be the best model to use for predicting sale prices. To predict the sale price of a horse, we used the parameter estimates β from the Tobit model (i.e., $\hat{\ln}[P_i] = X_i'\beta$), which assumes that any random horse selected will sell (i.e., the uncensored model).

The fit of the model is described by calculating a correlation coefficient for the natural log of the sale prices of horses that sold with the natural log of their predicted values. This coefficient cannot include the no-sale horses because there is no "observed" sale price to use as a comparison. The correlation coefficient is 0.294 for the log prices of the sale horses. The average difference between the log of the observed sale price and the predicted log sale price for a horse that sold was negative 0.073. The average difference between the log of the observed final bid and the predicted log sale price for no-sale horses was negative 0.007. This means that, on average, the predicted sale price for a no-sale horse was 0.7 percent higher than the final bid. Table 4 lists the summary statistics for the predictive model for both sale and no-sale horses.

It may be easier to understand these results if the predicted log prices are transformed to price for comparison to the final sale bids. Due to bias in the detransformation of a semi-log linear model, an adjustment is applied to the transformation (Miller). The transformation is as follows

$$(7) \qquad E(\hat{\ln} P_i) = e^{\hat{\beta}_i X} e^{0.5\hat{\sigma}^2} ,$$

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

Once the predicted log sale prices for the sale and no-sale horses are transformed, the average difference between the observed sale price (final bid) and the predicted sale price is negative \$478.57 for sale horses and negative \$552.49 for no-sale horses. The percentage of predicted sale prices that are above the observed sale price is 69.9 percent for sale horses. When using the model to predict the sale prices of no-sale horses, the percentage of predicted prices that are higher than the final bid is a comparable 67.0 percent. The relatively small difference in the percentages of predicted prices that are higher than the observed price (final bid) suggests that no-sale horses are not consistently undervalued by the final bid, based on their characteristics. The results also indicate that whether or not a horse sells at auction appears to be a random event.

There are several explanations for why sellers may choose not to sell their horses at auction.

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. Another possible explanation for no-sale horses is overvaluation by sellers. The seller may simply ignore the market signals from buyers at the auction and decide the 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 so they can make informed purchase decisions possibly reducing the risk associated with their investments. Likewise, sellers desire this information so they can make breeding and show decisions to capture the traits most demanded by buyers.

Several of the genetic traits, including 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. This indicates that horses with distinguished show records are valuable as show horses and possibly as breeding animals. Enrollment in or eligibility for the AQHA Incentive Fund also increases the sale prices of horses.

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

Sale order does affect the sale price of horses, with horses selling at the beginning and end of the sale receiving a slight discount relative to horses sold in between. Although horses are considered a luxury good and expenditures in the horses industry may be affected by the condition of the economy, the binary variables used for each sale year were generally not statistically significant.

In addition to understanding the individual characteristics that affect show horse value, this model also allowed the prediction of market-clearing prices for the no-sale horses. The results suggest that no-sale horses are not undervalued by the final bid at auction and that whether or not a horse sells appears to be a random event. Some explanations for why sellers may choose not to sell their horse at auction include inefficiency in the flow of information between buyers and sellers or overvaluation of the horse by the seller.

Future research will address the possible inefficiencies in the flow of information regarding the characteristics of no-sale versus sale horses. This will allow further investigation into the practice of the no-sale horses at auctions for show-quality Quarter Horses.

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Table 1. Summary Statistics of AQHA World Championship Sale

	Sale Price					
Year	Gross	Average	Minimum	Maximum	Count	% Sold
Sale Horses						
2002	$2,993,850	$7,338	$800	$170,000	408	87.0%
2001	$3,128,400	$8,063	$700	$77,000	388	79.6%
2000	$3,424,200	$8,291	$900	$85,000	413	77.9%
1999	$3,289,700	$8,328	$550	$90,000	395	78.3%
1998	$3,214,500	$8,159	$750	$77,000	394	78.5%
1997	$3,193,325	$8,084	$1,000	$73,500	395	80.5%
1996	$2,769,650	$6,959	$700	$145,000	398	75.9%
1995	$1,792,200	$5,934	$800	$45,000	302	79.5%
No-Sale Horses						
2002	n/a	$6,969	$500	$58,000	105	13.0%
2001	n/a	$9,393	$1,100	$103,000	123	20.4%
2000	n/a	$9,583	$1,500	$49,000	100	22.1%
1999	n/a	$7,539	$1,400	$26,500	108	21.7%
1998	n/a	$7,787	$1,400	$27,000	109	21.5%
1997	n/a	$10,614	$1,200	$80,000	112	19.5%
1996	n/a	$6,581	$900	$50,000	102	24.1%
1995	n/a	$5,200	$1,000	$14,500	45	20.5%

Table 2. Variable Descriptions and Summary Statistics[a]

Variable Name	Description	Mean	Standard Deviation	Minimum Value	Maximum Value
lnP	Log of sale price (final bid price)	8.63	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	4.61	4.64	0	23
*G*Age*	Gelding and age interaction term	0.31	1.08	0	14
*G*Age2*	Gelding and age squared interaction term	1.26	8.07	0	196
*M*Age*	Mare and age interaction term	3.96	4.90	0	23
*M*Age2*	Mare and age squared interaction term	39.68	73.65	0	529
*S*Age*	Stallion and age interaction term	0.35	1.31	0	15
*S*Age2*	Stallion and age squared interaction term	1.83	12.20	0	225
$Color_i$ [b]	Binary variable for color of horse	--	--	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
*H*HH*	Halter class and horse is homozygous positive for HYPP interaction term	0.00	0.03	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 in lifetime	13.82	45.96	0	837
NonPoints	Non-AQHA points earned in lifetime	1.19	25.40	0	915
ROM	Register of merit	0.19	0.57	0	5
Superior	Superior rating	0.08	0.38	0	5
WorldC	AQHA World Show champion	0.05	0.41	0	12
WorldP	AQHA World Show placing	0.15	0.73	0	10
Futurity	Championship or placing at AQHA futurity	0.14	0.69	0	9
NonCP	Championship or placing at non-AQHA show	0.02	0.18	0	6
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

[a] Total sample size n=3,897

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

Table 2. Variable Descriptions and Summary Statistics, cont.

Variable Name	Description	Mean	Standard Deviation	Minimum Value	Maximum Value
SireWPRank	Rank of sire for western pleasure	9.73	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	7.37	20.50	0	99
SireHUSRankBV	Binary variable equal to 1 if sire is ranked for hunter under saddle	0.18	0.38	0	1
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	13.60	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	1.63	9.79	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	Binary 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	129	80	1	327
SOClass2	Sale order within class, squred	22,952	23,624	1	106,929
YEAR	Binary variable for each sale year	--	--	0	1

Table 3. Hedonic Model Regression Results

Variables	Parameter Estimate	Standard Error	t-statistic	p-value	Average Marginal Effect
Constant	8.0163	0.0678	118.1770	0.0000	7.1735
G*Age	0.0211	0.0411	0.5130	0.6077	0.0189
G*Age2	-0.0032	0.0042	-0.7660	0.4437	-0.0029
M*Age	0.0781	0.0133	5.8920	0.0000	0.0699
M*Age2	-0.0057	0.0007	-8.4390	0.0000	-0.0051
S*Age	0.1431	0.0318	4.5000	0.0000	0.1280
S*Age2	-0.0123	0.0030	-4.1490	0.0000	-0.0110
Gelding	-0.2734	0.0689	-3.9700	0.0001	-0.2446
Stallion	-0.2297	0.0541	-4.2460	0.0000	-0.2056
Bay	0.0775	0.0310	2.4960	0.0126	0.0693
Black	0.3302	0.0610	5.4140	0.0000	0.2955
Brown	0.2411	0.0517	4.6590	0.0000	0.2157
Chestnut	-0.0091	0.0316	-0.2880	0.7732	-0.0082
Gray	0.3070	0.0529	5.8000	0.0000	0.2747
Palomino	0.1818	0.0864	2.1030	0.0355	0.1627
Redroan	0.1970	0.0858	2.2970	0.0216	0.1763
ColorOther	0.1481	0.0682	2.1730	0.0298	0.1326
Bred	0.0689	0.0493	1.3990	0.1618	0.0617
Incentive	0.0771	0.0296	2.6080	0.0091	0.0690
H*NoTest	-0.0325	0.0478	-0.6790	0.4974	-0.0290
H*NH	0.1131	0.0403	2.8080	0.0050	0.1012
H*HH	0.0278	0.3909	0.0710	0.9433	0.0249
HUS	0.0352	0.0506	0.6950	0.4870	0.0315
WP	0.0089	0.0443	0.2010	0.8407	0.0080
Allaround	-0.0678	0.0525	-1.2900	0.1970	-0.0607
ClassOther	0.4168	0.0656	6.3530	0.0000	0.3730
Points	0.0007	0.0006	1.1570	0.2474	0.0007
NonPoints	0.0002	0.0005	0.4890	0.6246	0.0002
ROM	0.1698	0.0249	6.8310	0.0000	0.1520
Superior	0.1662	0.0607	2.7400	0.0061	0.1488
WorldC	0.0965	0.0397	2.4300	0.0151	0.0863
WorldP	0.0881	0.0195	4.5090	0.0000	0.0788
Futurity	0.0890	0.0172	5.1830	0.0000	0.0797
NonCP	0.0857	0.0742	1.1550	0.2483	0.0767
OffspringP	0.0563	0.0169	3.3340	0.0009	0.0504
OffspringWC	0.0793	0.0241	3.2980	0.0010	0.0710
OffspringWP	0.0365	0.0199	1.8290	0.0673	0.0326
OffspringOther	0.0279	0.0143	1.9590	0.0502	0.0250
SireWPRank	-0.0026	0.0008	-3.3500	0.0008	-0.0023
SireWPRankBV	0.3161	0.0411	7.6840	0.0000	0.2828
SireHUSRank	0.0002	0.0009	0.2100	0.8340	0.0002
SireHUSRankBV	0.1413	0.0506	2.7930	0.0052	0.1265
SireHALTRank	-0.0014	0.0009	-1.6780	0.0933	-0.0013
SireHALTRankBV	0.1464	0.0395	3.7060	0.0002	0.1310

Table 3. Hedonic Model Regression Results, cont.

Variables	Parameter Estimate	Standard Error	t-statistic	p-value	Average Marginal Effect
DSireWPRank	-0.0005	0.0012	-0.4550	0.6489	-0.0005
DSireWPRankBV	0.1155	0.0553	2.0880	0.0368	0.1034
DSireHUSRank	-0.0014	0.0016	-0.8700	0.3845	-0.0013
DSireHUSRankBV	0.0644	0.0965	0.6680	0.5041	0.0577
DSireHALTRank	-0.0011	0.0014	-0.8090	0.4187	-0.0010
DSireHALTRankBV	0.1134	0.0593	1.9130	0.0557	0.1014
SSireWPRank	-0.0046	0.0017	-2.6400	0.0083	-0.0041
SSireWPRankBV	0.2533	0.0862	2.9370	0.0033	0.2266
SSireHUSRank	-0.0004	0.0018	-0.2170	0.8284	-0.0004
SSireHUSRankBV	-0.0605	0.1040	-0.5820	0.5608	-0.0542
SSireHALTRank	-0.0044	0.0013	-3.5080	0.0005	-0.0040
SSireHALTRankBV	0.4615	0.0515	8.9600	0.0000	0.4130
SOClass	0.0016	0.0005	3.3220	0.0009	0.0015
SOClass2	-0.000004	0.0000	-2.3020	0.0214	0.0000
Year1995	-0.0487	0.0492	-0.9920	0.3214	-0.0436
Year1996	-0.0380	0.0439	-0.8660	0.3866	-0.0340
Year1997	0.0680	0.0435	1.5650	0.1177	0.0609
Year1998	0.0494	0.0437	1.1300	0.2586	0.0442
Year1999	0.1248	0.0438	2.8490	0.0044	0.1117
Year2000	0.0283	0.0433	0.6530	0.5140	0.0253
Year2002	-0.1058	0.0432	-2.4480	0.0144	-0.0947

Table 4. Summary Statistics of Predicted Market Prices

	Average	Standard Deviation	Minimum Value	Maximum Value
Sale Horses				
$\ln P - \hat{\ln} P_i$	-0.073	0.65	-2.12	2.75
$P - \hat{P}_i$	-$478.57	$7,846.22	-$46,876.28	$155,214.37
RMSE	7859.54			
% predicted prices above sale price	69.87%			
No-Sale Horses				
$\ln P - \hat{\ln} P_i$	-0.0069	0.60	-2.02	2.30
$P - \hat{P}_i$	-$552.49	$7,014.18	-$54,431.83	$60,892.98
RMSE	7031.55			
% predicted prices above final bid	67.04%			

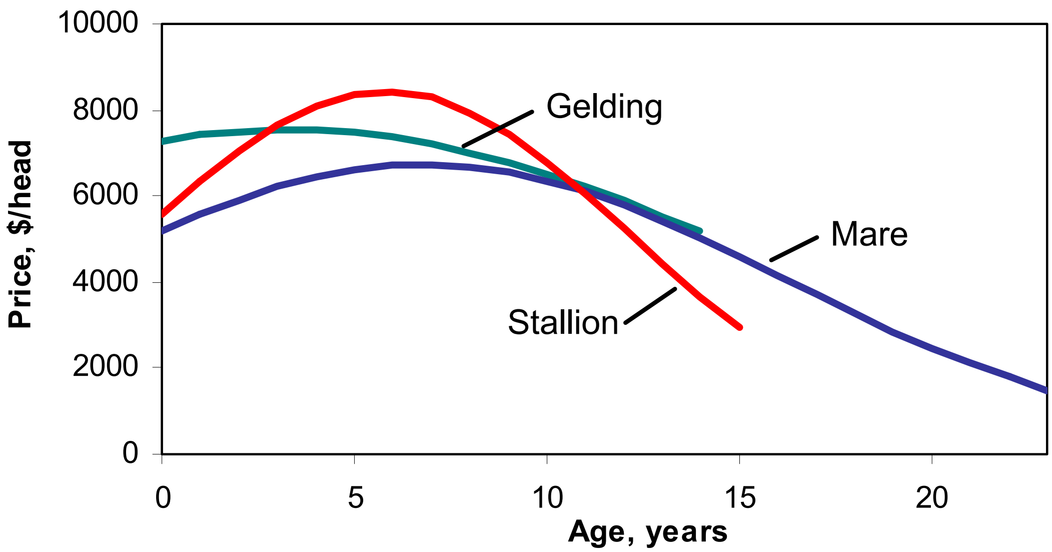

Figure 1. Model Predicted Effect of Age on Market Price by Sex (all other characteristics evaluated at the mean of the series for gelding, stallion, and mare).

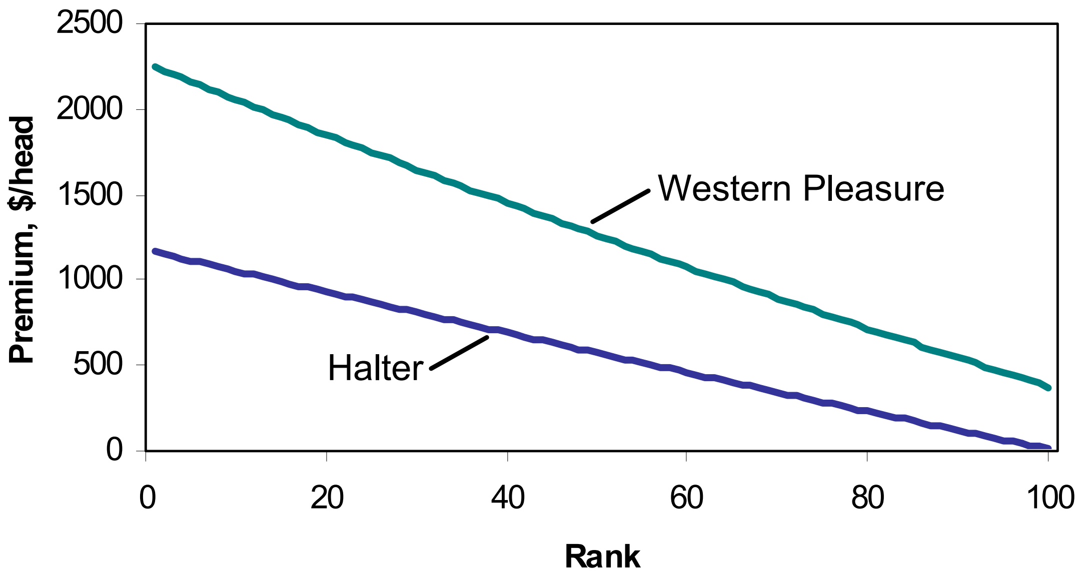

Figure 2. Model Predicted Premium for a Ranked Sire by Class (all other characteristics evaluated at the mean of the series for western pleasure and halter).

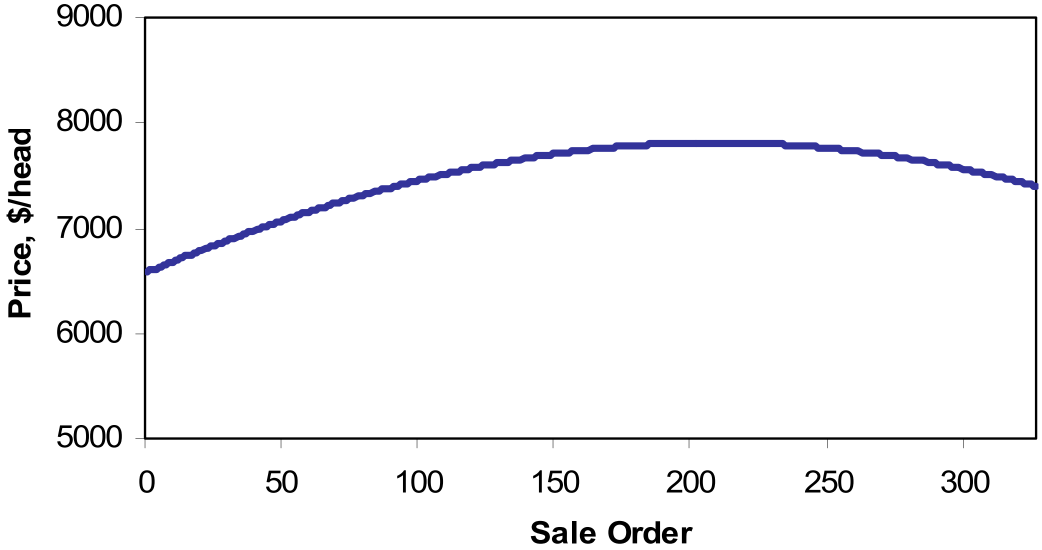

Figure 3. Effect of Sale Order on Sale Price.