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Hedonic Pricing of Race-Bred Yearling Quarter Horses Produced by Quarter Horse Sires and Dams

Notie H. Lansford, Jr., David W. Freeman, Donald R. Topliff, and Odell L. Walker

Yearling quarter horse prices are dependent upon a number of characteristics. Quantifiable genetic and macroeconomic variables for 5,295 sales from 1982–92 are used in a hedonic price model. Marginal values and discrete incremental prices are determined for 23 characteristics, 21 of which are found to be significant. The model's fit implies it may be helpful for maximizing breeder returns. Overall, buyers pay substantial premiums if the yearling's first dam or sire was a champion and if the sire or first dam previously produced a champion. Likewise, yearlings whose second and third dams are winners and producers of winners receive higher prices. Prices paid for fillies and older yearlings exceed those paid for colts, geldings, and younger horses.

Key Words: genetic characteristic, hedonic model, marginal price, quarter horse, race-bred, yearling

Prices of yearling quarter horses are a major focus of breeders and prospective buyers looking for yearlings with racing and breeding potential. Yearling sales prices are highly variable among individual animals within and across sale years (Rentfro). This variability may lead breeders and investors to ask such questions as: (*a*) What can be learned from these prices concerning preferences of buyers? and (*b*) What are the effects of macroeconomic conditions on the yearling horse market? Breeder profitability will hinge, in part, on knowledge of marginal values and costs of various characteristics. The objective of this analysis is to determine the price placed on various yearling quarter horse characteristics in the marketplace.

Quarter horse investors have access to a vast amount of information on the ancestry of yearlings being sold. However, little research has been conducted to investigate the value placed on individual ancestral (genetic) characteristics. In addition, there are phenotypic and environmental factors that are more difficult to quantify and for which

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Lansford is an associate professor in the Department of Agricultural Economics, Freeman and Topliff are professors in the Animal Science Department, and Walker is professor emeritus, Department of Agricultural Economics, all at Oklahoma State University, Stillwater.

historic data are less accessible. These may include such factors as physical condition and appearance of the horse, professional assessment of the animal's soundness, demeanor and mannerisms of the animal, weather conditions before and during the sale, sale time of day, marketing strategies such as use of a reputable agent, and interactions with auctioneers and ring crews (Rentfro). Finally, national and international economic conditions impact horse investor decisions and, indirectly, yearling horse prices.

Because sales data containing phenotypic and environmental information are not available, and because macroeconomic factors are problematic and beyond the scope of this research, we include primarily genetic variables in this analysis. The study proceeds with a background discussion of the equine industry and a review of relevant literature. Next, the hedonic pricing model and the analytical framework used in the investigation are reported. The results of the regression model, including comparisons of three case scenarios, are then presented, followed by a final section offering our summary and conclusions.

Background

In studies focusing on the equine industry, the considerable size of the industry sometimes may be overlooked. There are approximately 5.25 million horses in the United States, and 15 states have in excess of 100,000 (Peat, Marwick, Mitchell, and Co.). Manson reported that in 1988, revenues to state governments from equine pari-mutuel wagering alone were approximately $600 million. For Oklahoma in 1989, Walker et al. estimated the value of horse production by the breeding segment of the Oklahoma Bred Program at approximately $63 million. Moreover, the Oklahoma Bred Program includes only a fraction of Oklahoma's total race-bred quarter horse market.[1] About [illegible]0% of the 42,000 horses involved in race horse production in Oklahoma are quarter horses. Race horse owners number about 3,700, and 1,850 Oklahomans train horses for races at the three pari-mutuel tracks. Over 900 Oklahomans are employed at racetracks (Freeman, Woods, and Walker). Thus, race-bred yearling horse production and sales make a significant contribution to the Oklahoma economy. In addition, the Oklahoma Heritage Place Sale is the primary U.S. auction for race-bred quarter horses. The national and international market for quarter horses may be said to be centered in Oklahoma.

Knowledge of the characteristics that significantly impact yearling price can help breeders maximize their earnings. Breeders can identify and produce yearlings with characteristics that maximize the spread between price received for and cost of the specific characteristics. In an earlier study, Commer investigated price-determining factors in the thoroughbred yearling market. Factors found to significantly, positively impact price included black-type progeny from sire, dam, and second dam; colts

[1] The Oklahoma Bred Program is a voluntary incentive program funded through a portion of the handle at Oklahoma tracks. Only a portion of the breeders choose to participate.

over fillies; nomination or registration in the Breeder's Cup, Maryland Million, or Maryland Bred Program; and sale in a "select" sale as compared to an "open" sale. The factors in the Commer model explained 40% of the variability in prices paid for thoroughbred yearlings.

Karungu, Reed, and Tvedt addressed the importance of macroeconomic factors on thoroughbred prices in addition to yearling-specific variables. The 1986 federal tax law changes and international exchange rates both were found to be highly significant influences. Intermediate-term loan rates were also statistically significant, but (unexpectedly) positively signed.

Neibergs and Thalheimer also considered tax policy and international exchange rate in their estimated supply and demand equations for thoroughbreds. Based on their analysis, the 1986 tax law change was found to be significant, and exchange rate was nonsignificant. Interest rate was not included in their study. Purse size ranked as the most significant factor in explaining thoroughbred prices.

Buzby and Jessup included macroeconomic and yearling-specific variables in their investigation of thoroughbred yearling prices. Stud fee of the yearling's sire was found to be the variable of greatest effect on price. Gross dollar purchases by foreign investors (foreign demand) and the 1986 tax law change were also significant factors. Interest rate was statistically significant (at the $\alpha = .06$ level) and was positively signed. The researchers concluded that both macroeconomic and yearling-specific factors are important in explaining yearling price. They further concluded that additional phenotypic characteristics may improve the model (the R^2 value was 0.26).

Comparable research has not been conducted for the quarter horse market. Our investigation builds on Rentfro's 1993 analysis of Oklahoma quarter horse yearling sale prices. Heritage Place Sale prices and nonphenotypic characteristics were gathered from sales session catalogs between January 1978 and September 1992. Rentfro's analysis, using descriptive statistics by subgroups, revealed many key characteristics of yearling sales over this time period. Among his findings were that horses sold by agents (rather than by owners) were of superior pedigree, on average, and brought an average of $1,051 more. Categorized by sex, the average filly sold for $7,694, while the average colt and gelding sold for $6,576 and $2,183, respectively. Ninety percent of the yearlings had no direct lineage from a champion in the dam's family. Those that did, however, appeared to command a substantial premium. Yearlings descended from a champion sire also commanded a substantial premium. Furthermore, yearlings whose sires had produced more race winners received a premium. Likewise, those having more paid-up engagements for future races brought a higher price.

Rentfro examined one macroeconomic variable, the structural change in income tax law. Prices paid for yearlings before the Tax Reform Act of 1986 were higher than average prices paid after the change. Finally, the prices were found to be positively skewed. With few very high prices and numerous lower prices, the median and modal prices reported in Rentfro's analysis were shown to be lower than the average price.

Analytical Framework and Procedure

A hedonic (implicit) pricing model is used to estimate the price of individual characteristics of yearlings. The hedonic hypothesis states that "goods are valued for their utility-bearing attributes or characteristics" (Rosen, p. 34). Under assumptions of the model, summing the price placed on each attribute gives the total price paid for the "composite" good. In other words, a buyer considers all facets of a horse to arrive at the bid price. The theoretical underpinnings of the hedonic approach were developed by Lancaster; Rosen; Freeman; and others.

The hedonic model has been applied to a wide variety of goods, from farm implements and breeding bulls to housing and quality-of-life indices. Likewise, a wide variety of mathematical functional forms have been employed ranging from simple linear regression to quadratic Box-Cox models. As cautioned by Halvorsen and Pollakowski:

> A hedonic price equation is a reduced-form equation reflecting both supply and demand influences. Therefore, the appropriate functional form . . . cannot in general be specified on theoretical grounds (p. 37).

Care must be taken, therefore, in functional form specification.

This analysis focuses on Oklahoma yearling quarter horse sales occurring in the "select" and "regular" sessions of the Heritage Place Sales from 1982 through 1992. These sales are conducted annually, during the third week of September. Heritage Place Sales represent the largest market for quarter horses in the United States, and probably in the world. Yearlings included in the "select" sale must meet quality standards in pedigree. However, there is no clear delineation in quality between horses offered in the two sales. Some horses sold in the "regular" sale will have equal or better pedigree and other quality characteristics when compared to their yearling counterparts marketed in the "select" sale. Because there is no clear division in the quality continuum, no dummy variable for sale is included here. Rather, the assumption is made that quality differences will be reflected in the various characteristics included in the model.[2]

For similar reasons, a variable for agent is not included in the model. Approximately 17% of the yearlings were represented by an agent. The preparation and marketing services provided by an agent, plus agent reputation, may add appreciably to the price received. Given sufficient information, the impact an agent has on price can be measured. It was not possible with the current data set to separate the value of an agent from the quality of the horse represented by the agent. Adding a dummy variable would introduce bias (see footnote 2).

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[2] There are several aspects of quality which likely are not measured. Horses with higher quality, for example, would be more likely to have an agent. If an agent (or sale) dummy were included in the model, the coefficient would be biased upward due to simultaneous equation bias. We estimate the reduced form to avoid the bias.

Sales of 5,295 quarter horse yearlings with quarter horse sires and dams were recorded from 1982–92 Heritage Place Sales. This subset of Rentfro's data was selected due to completeness (all years represented) and consistency (relatively large number) of yearlings sold in each of these years. Further, these sales are held at the same time each year. The sales data are cross-sectional time series (panel data). Means analysis of sale prices and the positive skew coefficient found by Rentfro led to specification of a semi-log model for our study, where the dependent variable is the natural log of price, ln(*PRICE*). The implication is that as the combination of preferred attributes in an animal increases, the price increases exponentially. Simply put, the sale price of a yearling from high performance sire and dam families may be a factor of 10, 20, or even 100 greater than that of a yearling with a pedigree judged inferior. A benefit of the semi-log functional form is the ease of interpretation and use of the parameter estimates. Parameter estimates represent the percentage change in the dependent variable for a unit change of a given independent variable.

Independent variables included in the model come largely from the sales catalogs. Data in the catalogs are recognized as relevant market information. To these yearling-specific characteristics, it might be desirable to add some macroeconomic variables suggested by the literature and economic theory—e.g., interest rate, currency exchange rate, and 1986 tax law changes. However, adequately accounting for these factors that change over time is difficult, and failure to correctly specify the model will result in biased estimates. To avoid misspecification, dummy variables are used for each time period.[3]

The model is specified as follows: ln(*PRICE*), the dependent variable, is a function of sex of the yearling, yearling age, characteristics of first, second, and third dams, characteristics of the sire, and year dummy. The model contains 16 continuous variables and 19 indicator (noncontinuous) variables. Table 1 provides a listing of the model's variables and their definitions, and table 2 gives descriptive statistics for these variables. The model is specified in equation (1) as follows:

$$\ln(PRICE) = \alpha + \sum_{i=1}^{19} \beta_i D_i + \sum_{k=1}^{16} \delta_k C_k + \varepsilon. \tag{1}$$

The parameters to be estimated are α, the intercept, β_1–β_{19}, and δ_1–δ_{16}; D_i denotes the indicator (noncontinuous) variables; C_k represents the continuous variables; and ε is a random error term.

Most parameter estimates are expected to be positively signed. The coefficient for geldings should be negative (relative to colts, the base, due to breeding potential for the latter). There is no a priori expectation for fillies. Older, more mature yearlings are assumed to be preferred to younger animals. Better pedigree is assumed to be preferred to lesser quality indicators, and thus more race wins, good breeding history, and speed indexes for sire and dams (first, second, and third) are expected to

[3] Annual dummy variables capture variation due to the macroeconomic factors listed and due to inflation. Yearling prices are not found to correlate with the typical price indices; hence, annual dummy variables are preferred.

Table 1. Definitions of Variables Included in the Model Equation

Variable	Definition
PRICE	Quarter horse yearling sale price in dollars
ln(*PRICE*)	Natural log of *PRICE*
SEXF	Sex dummy variable for filly, where *SEXF* = 1 if a filly, 0 otherwise
SEXG	Sex dummy variable for gelding, where *SEXG* = 1 if a gelding, 0 otherwise
D1CHAMP	If the dam is or has produced an American Quarter Horse Association champion, *D1CHAMP* = 1, 0 otherwise
DAM1STAK	Number of stakes races the yearling's dam has won (Min. = 0, Max. = 15)
DAM1WIN	Number of races the yearling's dam has won (Min. = 0, Max. = 28)
DAM1PRST	Number of stakes winners the dam has produced (Min. = 0, Max. = 5)
DAM1PROD	Number of race winners the dam has produced (Min. = 0, Max. = 12)
D2CHAMP	If the 2nd dam is or has produced an American Quarter Horse Association champion, *D2CHAMP* = 1, 0 otherwise
DAM2STAK	Number of stakes races the 2nd dam has won (Min. = 0, Max. = 14)
DAM2WIN	Number of races the 2nd dam has won (Min. = 0, Max. = 37)
DAM2PRST	Number of stakes winners the 2nd dam has produced (Min. = 0, Max. = 5)
DAM2PROD	Number of race winners the 2nd dam has produced (Min. = 0, Max. = 13)
D3CHAMP	If the 3rd dam is or has produced an American Quarter Horse Association champion, *D3CHAMP* = 1, 0 otherwise
DAM3STAK	Number of stakes races the 3rd dam has won (Min. = 0, Max. = 14)
DAM3PRST	Number of stakes winners the 3rd dam has produced (Min. = 0, Max. = 7)
SCHAMP	If the sire is an American Quarter Horse Association champion, *SCHAMP* = 1, 0 otherwise
SPCHAMP	If the sire has produced an American Quarter Horse Association champion, *SPCHAMP* = 1, 0 otherwise
SIRSTK	If the sire has won a stakes race, *SIRSTK* = 1, 0 otherwise
SIREWIN	Number of races won by the yearling's sire (Min. = 0, Max. = 28)
SPSPW	If the sire has produced a stakes placed winner, *SPSPW* = 1, 0 otherwise

(continued)

Table 1. (Continued)

Variable	Definition
SPSW	Number of stakes winners produced by the sire (*SPSW* = 0 if no stakes winners; *SPSW* = 1 if 1–5 stakes winners; *SPSW* = 2 if > 5 stakes winners)
SI_SIRE	Speed index of the yearling's sire (Min. = 50, Max. = 117)
*SI_DAM*1	Speed index of the yearling's dam (Min. = 0, Max. = 118)
YRLAGE	The yearling's age (in days) based on date of birth up through September 20 of the following year (since the Heritage Place annual sale is the 3rd week of September, age can be closely estimated by using September 20) (Min. = 446 days, Max. = 628 days)
ENGAGE	Number of paid-up engagements (i.e., the number of future races for which the yearling's initial fees and registration requirements have been met) (Min. = 0, Max. = 5)

Notes: Unless specified otherwise, the data source is the Oklahoma Heritage Place Sale catalogs. Colts (*SEXC*) are not listed above, but constitute the "base" sex for the regression model. As such, *SEXC* does not appear in the model equation.

positively influence price. A positive coefficient is expected for paid-up engagements (the number of future races for which initial fees and registration have been paid prior to the sale). More paid-up engagements are expected for yearlings judged by a breeder as having greater potential; otherwise the breeder is unlikely to incur the expense.

The nature of the data (cross-section over time) suggests the potential statistical problems of heteroskedasticity and degrading collinearity. Heteroskedasticity is addressed by use of the Breusch-Pagan-Godfrey test and correction technique. (Homoskedasticity is tested by expressing the squared residuals of the ordinary least squares regression as a linear function of the independent variables.) Statistical Analysis System (SAS) computer software collinearity diagnostics (SAS Institute, Inc.) are used to detect degrading collinearity.

Estimation of the model and identification of potential data problems is followed by interpretation of coefficients and calculation of the marginal value of each characteristic. For a continuous variable, the marginal value is the first derivative of the regression model with respect to that variable. In order to take the first derivative of equation (1), we must first take the anti-log of equation (1) to derive equation (2). (Note that the anti-log of a natural logarithm is e^x, where x is the value or expression that was in log form.) Equation (2) is then specified as follows:

$$PRICE = e^{\alpha + \sum_{i=1}^{19} \beta_i D_i + \sum_{k=1}^{16} \delta_k C_k} \quad (2)$$

Table 2. Descriptive Statistics for 5,295 Yearling Quarter Horse Sales, Select and Regular Sessions, Heritage Place Sale, 1982–92

Variable	Mean	Std. Dev.	Min.	Max.	Sum
PRICE	7,111.470	12,848.860	500	300,000	37,655,250
ln(*PRICE*)	8.342	0.947	6.215	12.612	44,170.660
SEXF	0.482	0.500	0	1	2,551
SEXC	0.494	0.500	0	1	2,615
SEXG	0.024	0.154	0	1	129
D1CHAMP	0.007	0.081	0	1	35
DAM1STAK	0.216	0.917	0	15	1,144
DAM1WIN	2.191	3.002	0	28	11,601
DAM1PRST	0.151	0.420	0	5	802
DAM1PROD	1.414	1.779	0	12	7,486
D2CHAMP	0.040	0.197	0	1	214
DAM2STAK	0.344	1.237	0	14	1,824
DAM2WIN	2.923	3.970	0	37	15,475
DAM2PRST	0.558	0.800	0	5	2,955
DAM2PROD	4.102	2.451	0	13	21,721
D3CHAMP	0.054	0.226	0	1	287
DAM3STAK	0.291	1.197	0	14	1,542
DAM3PRST	0.669	0.955	0	7	3,540
SCHAMP	0.256	0.436	0	1	1,355
SPCHAMP	0.278	0.448	0	1	1,470
SIRSTK	0.376	0.484	0	1	1,989
SIREWIN	8.544	5.987	0	28	45,243
SPSPW	0.062	0.241	0	1	328
SPSW	0.662	0.790	0	2	3,506
SI_SIRE	82.534	20.793	50	100	437,020
*SI_DAM*1	58.193	39.193	0	100	308,130
YRLAGE	547.099	35.986	446	628	2,896,891
ENGAGE	2.153	1.639	0	5	11,401
*YR*83	0.118	0.322	0	1	623
*YR*84	0.085	0.279	0	1	449
*YR*85	0.100	0.300	0	1	531
*YR*86	0.099	0.299	0	1	524
*YR*87	0.102	0.302	0	1	538
*YR*88	0.019	0.137	0	1	101
*YR*89	0.104	0.306	0	1	552
*YR*90	0.122	0.328	0	1	647
*YR*91	0.086	0.280	0	1	455
*YR*92	0.090	0.286	0	1	476

Equation (3) is the first partial derivative of equation (2) with respect to one of the continuous variables, C_k:

$$(3) \qquad \frac{\partial PRICE}{\partial C_k} = \delta_k \times e^{\alpha + \sum_{i=1}^{19} \beta_i D_i + \sum_{k=1}^{16} \delta_k C_k}$$

For a noncontinuous variable, D_i (such as sire was or was not a champion), the marginal or incremental value is the difference between the predicted price of the yearling if the sire was a champion and the predicted price of the yearling if the sire was not a champion, as illustrated in equation (4):

$$(4) \qquad \Delta PRICE = \left[e^{\alpha + \sum_{i=1}^{19} \beta_i D_i + \sum_{k=1}^{16} \delta_k C_k} \middle| D_i = 1 \right] - \left[e^{\alpha + \sum_{i=1}^{19} \beta_i D_i + \sum_{k=1}^{16} \delta_k C_k} \middle| D_i = 0 \right].$$

These "marginal" prices may aid a producer with breeding decisions. Marginal prices indicate how much value a buyer places on another unit of a given characteristic, given any set of initial characteristics. The marginal prices of a semi-log model are dependent upon the value of each and every characteristic (or variable) included in the model. Hence, the marginal price of a particular characteristic, such as sex, will vary as the total set of characteristics of the yearling changes. This functional form causes and reflects a degree of interaction and complementarity among the various price factors. This is expected for many of the pedigree factors.

Results

Heteroskedasticity was detected, and correction was made using the SAS "weight" procedure. Degrading collinearity was not indicated. SAS PROC Univariate was employed to check for distribution of the residuals. The normal distribution hypothesis was rejected, with positive skewness and kurtosis indicated. Given the range of yearling prices present in the market and in this data set, these conditions are not surprising. The kurtosis appears to be relatively small. Based on the size of the data set and significance of the estimated coefficients, violation of the assumption of normal distribution is not believed to negate use of the results.

The adjusted R^2 value is 0.424, indicating the model explains 42.4% of the variation in the log of sales price. This result is similar to the Commer model, where the R^2 was 0.40. As shown in table 3, all but three of the parameter estimates are statistically significant at the 95% confidence level ($\alpha = .05$). Furthermore, all coefficients have the expected arithmetic sign except those on *SIRSTK* (sire has or has not won a stakes

Table 3. Summary Statistics of Results from the Model Estimation

Variable	Parameter Estimate	Standard Error	Avg. for Yearling Characteristic	Marginal Value ($)
INTERCEPT	6.394*	0.153	1.000	
SEXF	0.115*	0.019	0.482	798.36
SEXG	-0.373*	0.058	0.024	-2,590.35
D1CHAMP	0.689*	0.180	0.007	4,790.94
DAM1STAK	0.038*	0.015	0.216	263.56
DAM1WIN	0.019*	0.004	2.191	133.51
DAM1PRST	0.323*	0.028	0.151	2,244.78
DAM1PROD	0.044*	0.006	1.414	304.35
D2CHAMP	0.117*	0.060	0.040	810.31
DAM2STAK	0.026*	0.011	0.344	183.17
DAM2WIN	0.013*	0.003	2.923	87.66
DAM2PRST	0.061*	0.014	0.558	423.42
DAM2PROD	0.021*	0.005	4.102	145.84
D3CHAMP	0.193*	0.048	0.054	1,343.45
DAM3STAK	0.027*	0.008	0.291	190.17
DAM3PRST	0.052*	0.011	0.669	363.28
SCHAMP	0.294*	0.038	0.256	2,041.60
SPCHAMP	0.609*	0.029	0.278	4,233.33
SIRSTK	-0.039	0.026	0.376	-274.21
SIREWIN	0.015*	0.002	8.544	100.88
SPSPW	-0.007	0.040	0.062	-47.26
SPSW	0.105*	0.015	0.662	730.64
SI_SIRE	-0.0004	0.0005	82.534	-2.59
SI_DAM1	0.002*	0.0003	58.193	10.90
YRLAGE	0.002*	0.0003	547.099	16.13
ENGAGE	0.089*	0.007	2.153	619.50
YR83	-0.329*	0.041	0.118	-2,287.26
YR84	-0.331*	0.048	0.085	-2,298.85
YR85	-0.551*	0.045	0.100	-3,830.41
YR86	-0.539*	0.041	0.099	-3,748.80
YR87	-0.609*	0.044	0.102	-4,237.97
YR88	-0.204*	0.066	0.019	-1,421.59
YR89	-0.491*	0.042	0.104	-3,417.36
YR90	-0.559*	0.040	0.122	-3,888.37
YR91	-0.460*	0.045	0.086	-3,201.82
YR92	-0.349*	0.043	0.090	-2,426.74

Notes: An asterisk (*) denotes statistical significance at the 95% confidence level (α = .05). Parameter estimates represent the percentage change in the price for a unit change of a given independent variable. Marginal values are calculated at the means.

race) and *SI_SIRE* (speed index of the sire). The parameter estimates for *SIRSTK* and *SI_SIRE* are not statistically significant, and so the sign is inconsequential.

Characteristic marginal prices are evaluated at the means of each independent variable (table 3). Further, the functional form of the model allows direct interpretation of coefficients as percentage change in price. Physical attributes of the yearlings—sex and age—significantly impact price paid. Fillies (*SEXF*) are found to sell for 12% more than colts ($798 more on average). This contrasts with Commer's finding that thoroughbred colts bring a higher price. Quarter horse fillies, however, have no disadvantage relative to colts. Anecdotal evidence also suggests that many breeders do not sell their best colts, but personally race them. It also might be that quarter horse fillies maintain more breeding potential relative to colts if the fillies become incapacitated for racing. Geldings (*SEXG*), on the other hand, are found to sell for almost $2,600 less than a colt at the means, or 37% less. The older the yearling (*YRLAGE*), the higher the price received; the marginal value per day is 0.2% ($16.13 at the means). Yearlings with paid-up engagements (*ENGAGE*) receive an additional 9% increase in price per engagement.

As seen from table 3, attributes of the first, second, and third dams have a significant impact on yearling price. If the first dam is or has produced a champion (*D1CHAMP* = 1), the estimated premium paid for the yearling is almost 69%. By comparison, if the second or third dam is or has produced a champion, the estimated premiums are 12% and 19%, respectively. We would expect a substantial premium when the first dam is or has produced a champion. However, our finding that the premium on the third dam is greater than that on the second dam is somewhat unexpected. This may be due to unexplained variation in the model and to the fact that the number of characteristics available regarding third dams is more limited. Additionally, in the data set, the champion designation does not differentiate between the dam being a champion or producing a champion.

If a yearling's dam is not a champion and has not produced a champion, she still may significantly influence price paid. The marginal value if the average yearling's dam won just one stakes race (*DAM1STAK*) is 3.8% ($264 at the means) (table 3). However, if the yearling's dam produced a stakes winner (*DAM1PRST*), the estimated premium is 32%. The average number of non-stakes races won (*DAM1WIN*) by a first dam is just over two. Yearlings whose dam won a third race bring another 2% ($134 at the means). The average first dam produced 1.4 winners (*DAM1PROD*) prior to the yearling in question. If a dam produced an additional winner, the price is estimated to increase 4.4%. These last four marginal price evaluations strongly suggest that buyers pay more for yearlings whose first dam produced winners of stakes and other races, compared to yearlings whose first dam won the races but did not produce winners. This observation is supported by the results for second and third dams as well.

The marginal value if the average yearling's second dam won just one stakes race (*DAM2STAK*) is a 2.6% increase ($183), and if the yearling's second dam produced a stakes winner (*DAM2PRST*), the estimated premium is 6% ($423 at the means) (table 3). The average number of non-stakes races won by a second dam (*DAM2WIN*) is 2.9. Yearlings whose second dam won another race bring, on average, an additional \$88, or a marginal price increase of 1.3%. The average second dam produced four winners (*DAM2PROD*) prior to the yearling in question. If the second dam produced five winners, the price is estimated to increase by \$146, or 2%. The additional price paid for a yearling whose third dam won a stakes race (*DAM3STAK*) is 2.7%. The additional price paid for a yearling whose third dam produced one more stakes winner (*DAM3PRST*) is indicated to be 5.2%. Finally, the dam's speed index (*SI_DAM*1) has an impact on prices of yearlings. Each additional integer increase in the speed index results in a marginal price increase of 0.2%. Thus, yearlings from first, second, or third dams with good productive histories command higher prices than those whose first, second, or third dams were race winners but not producers of race winners. Dams who are champions or who have produced a champion quarter horse, however, have by far the largest impact on yearling price. Producers may compare the marginal value to marginal cost of increasing each characteristic in order to evaluate increased return potential.

A sire's racing and breeding history are also important in predicting the price paid for a yearling. If the yearling's sire is a champion (*SCHAMP*), the model suggests the average yearling will command a 29% premium over yearlings from nonchampion sires (table 3). If the sire produced a champion (*SPCHAMP*), the average yearling will command about a \$4,230 premium (a 61% increase). The average yearling's sire produced between one and five stakes race winning offspring (*SPSW* = 0.7). If a sire had previously produced more than five stakes winners, the premium for the sire's yearling is estimated to be about 11%. The average sire won 8.5 races (*SIREWIN*). The model estimates an additional 1.5% for each additional win. Sire speed index (*SI_SIRE*) is not shown to have a significant impact on price paid.

Finally, every annual dummy variable parameter estimate is statistically significant and negative. Because interpretation of these results is not germane to the specific objectives of this study, only brief analysis is offered. The base year for this evaluation is 1982. Our findings indicate that prices have been relatively lower in all years since then, with 1987 showing the lowest price levels. These results appear to reflect general economic conditions and observed yearling quarter horse prices over the years.

Three Cases for Comparison

As indicated by the descriptive statistics in table 2, most yearlings are not "average." Rather, there is wide variation in the set of characteristics possessed by the yearlings at Heritage Place Sales. Therefore, to enhance understanding of the results of the regression model, yearling characteristics are shown and marginal values computed for three sample situations: (*a*) yearlings from lower quality mares, (*b*) yearlings from mid-range quality mares, and (*c*) yearlings from higher quality mares. In order to isolate the effect of dams only, the characteristics of the sire are held constant at the mean values.

Table 4. Effect of Mare Quality on Yearling Price, Based on Results for Three Case Scenarios

	CASE ONE: Low-Quality Mare		CASE TWO: Mid-Quality Mare		CASE THREE: High-Quality Mare	
Characteristic	Yearling	Marginal Value ($)	Yearling	Marginal Value ($)	Yearling	Marginal Value ($)
SEXF		434.84		641.96		1,306.64
D1CHAMP		2,609.50		3,852.33		7,841.12
DAM1STAK		143.56		211.93	1	431.36
DAM1WIN		72.72	3	107.36	5	218.51
DAM1PRST		1,222.67		1,804.99	1	3,673.92
DAM1PROD		165.77	2	244.72	3	498.11
D2CHAMP		441.35		651.56		1,326.19
DAM2STAK		99.77	1	147.28	2	299.79
DAM2WIN		47.75	4	70.49	7	143.47
DAM2PRST		230.62	1	340.46	1	692.99
DAM2PROD	2	79.44	4	117.27	7	238.69
D3CHAMP		721.74		1,080.25		2,198.76
DAM3STAK		103.58		152.92	1	311.25
DAM3PRST		197.87	1	292.11	2	594.56
SCHAMP		1,112.01		1,641.62		3,341.39
SPCHAMP		2,305.78		3,403.96		6,928.49
SIRSTK		−149.35		−220.49		−448.79
SIREWIN	9	54.95	9	81.12	9	165.10
SPSPW	0	−25.74	0	−38.01	0	−77.36
SPSW	1	397.96	1	587.49	1	1,195.80
SI_SIRE	83	−1.41	83	−2.08	83	−4.23
SI_DAM1	50	5.94	58	8.77	97	17.85
YRLAGE	547	8.79	547	12.97	547	26.40
ENGAGE	2	337.43	2	498.13	2	1,013.91
Estimated Yearling Price:	$3,787.55		$5,591.46		$11,380.90	

Notes: For all case scenarios, the yearling is a 547-day-old colt. Marginal values are calculated at the means.

Table 4 shows the effect of mare quality on yearling price, as illustrated by the three case scenarios discussed below. The respective marginal value column in table 4 for each of the three case scenarios indicates the price increase a breeder can expect by increasing the associated characteristic. A breeder can compare the expected additional return with the expected additional cost of obtaining each characteristic to determine the characteristic or set of characteristics that may be enhanced in order to increase net returns on yearling production.

CASE ONE: *Yearling from Lower Quality Mare.* In this scenario, the average sire and yearling characteristics are maintained, but the characteristics of the first, second, and third dams are diminished such that the dams' values are either zero, one standard deviation below the average value, or at a minimum. The sire has a speed index (*SI_SIRE*) of 83, has won nine races (*SIREWIN*), and has produced one to five stakes race winners (*SPSW*). The yearling is 547 days old (*YRLAGE*) and is a colt. But the first, second, and third dams have not been, nor have they produced, stakes winners or champions. The dam's speed index (*SI_DAM*1) is at a minimal level (50). The only "track record" is that the second dam previously produced two race winners (*DAM2PROD*). ("Two race winners" is one standard deviation below the average number.) Under this scenario, the yearling price is estimated to be $3,788 (last row of table 4).

CASE TWO: *Yearling from Mid-Range Quality Mare.* In this scenario, the average sire and yearling characteristics are held constant, but the characteristics of the first, second, and third dams are increased (relative to the lower quality mare) such that the dams' values are close to the averages shown in table 2. The first dam won three races (*DAM*1 *WIN*) and produced two race winners (*DAM*1*PROD*). In addition to non-stakes races, the second dam won a stakes race (*DAM2STAK*) and produced a stakes race winner (*DAM2PRST*). The third dam produced a stakes race winner also (*DAM*3*PRST*). The dam's speed index (*SI_DAM*1) is 58. In this case, the yearling price is estimated at $5,591 (table 4). Marginal values for this mid-range case are larger than those in the first case. If this yearling, for example, had a third dam that was a stakes race winner (*DAM*3*STAK*), an estimated $153 would be added to its sale price. More significantly, if the third dam had been a champion or had produced a champion (*D*3*CHAMP*), the model estimates the sale price would rise by $1,080. If the first dam had produced a previous stakes race winner (*DAM*1*PRST*), the incremental increase in price is $1,805. Additional ancestral traits may have a cost, but these projected revenues can help the breeder determine if the net result will be greater returns on investment.

CASE THREE: *Yearling from Higher Quality Mare.* In this scenario, the average sire and yearling characteristics again are maintained, but the characteristics of the first, second, and third dams are increased such that the dams' values are approximately one standard deviation above the average. All dams have been and have produced race winners and stakes winners. The dam's speed index (*SI_DAM*1) is 97. The only characteristic not present in these dams is the "champion" designation. Under this scenario, the yearling price is estimated at $11,381 (table 4). Decision information is contained in the marginal values. The breeder with higher quality mares can compare the marginal returns of adding additional quantities of desirable characteristics with the costs in order to maximize net income. Note that the marginal values are considerably greater under this scenario than for the "lower" or "mid-range" mares. Logically, this reflects the evaluations of investors looking for top race horses. The better horses command substantial premiums. As shown in table 4, a

$7,841 premium is paid for a yearling whose first dam is or has produced a champion (*D1CHAMP*).

Based on the three cases detailed above, increasing marginal values for all characteristics are evidenced in this model as one compares lower to mid-range to higher quality mares. For example, the premium for a sire that produced a champion (*SPCHAMP*) increases from $2,306 to $6,928 across the three cases (table 4). This reflects the synergy or complementarity among the characteristics as quality increases. Although this is a natural result of the semi-log functional form, it also corresponds to actual market prices.

Numerous realistic scenarios could be presented. However, since each brood farm operation is somewhat unique, it may be useful to apply the model presented here to investigate various scenarios of interest. Since the parameter estimates are also the estimated flexibilities, marginal changes in management decisions are easily investigated.

Summary and Conclusions

This analysis identifies several genetic or ancestral characteristics of yearling quarter horses that significantly influence prices paid in the marketplace. A semi-log, hedonic price model is used on 5,295 observations over an 11-year period from 1982–92. Eighteen of 21 ancestral characteristics were statistically significant. In addition, yearling sex, age, and paid-up engagements were found to be significant factors. Yearlings from champion sires and/or dams command relatively large premiums over other traits. At the mean values, premiums range from 12% (if the second dam is or previously has produced a champion) to 69% (if the first dam is or previously has produced a champion). A yearling from a sire that previously produced a champion is expected to bring twice the premium of a yearling from a champion sire that had not previously produced a champion. Likewise, yearlings from sires with a proven history of stakes race winners are estimated to bring 10–11% more.

Generally speaking, marginal values are identified based on ancestral and yearling characteristics. Yearlings from sires and/or dams with more wins receive higher prices, and those from sires and/or dams with a history of producing winners receive even higher prices. Both are expected results. This study quantifies the additional value for many individual situations, i.e., sets of characteristics.

To illustrate the synergy of desirable characteristics grouped together, three specific case situations are presented: yearlings from lower quality, mid-range, and higher quality mares. The illustrations clearly demonstrate the increasing premiums and marginal values placed on higher quality as indicated by more desirable ancestral and preferred physical characteristics.

It is acknowledged that buyers consider many phenotypic characteristics that are, as yet, nonquantifiable. Furthermore, several environmental factors surrounding sales, as well as macroeconomic variables, may have an impact. Such factors are not explicitly captured in the semi-log model used in this study. Many structural and unidentified factors, however, are captured by the annual dummy variables.

Despite the usual caveats, the conformity of the results to observed market phenomena adds validity to the estimated hedonic price equation and the marginal prices of each identified characteristic. Yearling quarter horses produced by sires and dams who previously have produced winners bring higher prices. First-dam attributes add more to price than the same attributes in second and third dams. Previous research findings for thoroughbred pricing are largely corroborated here. Our model, therefore, may be directly applicable and useful to quarter horse breeders.

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