Determinants of Weanling Thoroughbred Auction Prices

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Abstract

Determinants of prices of 1,302 weanling Thoroughbreds sold at the 2010 November Breeding Stock Sale at the Keeneland Association, Inc. are investigated. Weanlings, who are less than one-year-old, are of unknown breeding and racing quality; still, prices at auctions display high variability. A hedonic price analysis is utilized to identify the determinants of weanling sales prices, and the corresponding marginal values of those determinants are estimated. Prices were highly responsive to variables related to pedigree quality, including the sire's stud fee, whether the sire was relatively new in his breeding career or not, and whether the dam or the dam's progeny had earned black type. In addition, prices were influenced by individual characteristics such as gender, age, state of birth. The weanling's placement in the sale and pinhooked weanlings also influenced price. Results can be used as a decision tool by both buyers and sellers.

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I. Introduction

Auctions are a common mechanism used to trade heterogeneous goods such as fine art, antiques, wines, and the focus of this paper, Thoroughbred horses. Historically, yearlings have been the most common age group among Thoroughbreds to be traded in auction; however, Thoroughbreds of other ages are also sold in auction. One example is the Keeneland November Breeding Stock Sale, which occurs every fall in Lexington, Kentucky. During this sale, Thoroughbreds of all ages are sold, but the primary focus of the sale is on weanlings, broodmares and broodmare prospects[1]. The market for Thoroughbred broodmares and broodmare prospects has already been studied (Maynard & Stoeppel (2007), Neibergs (2001)), but the market for weanlings has not yet been explored. The objective of this paper is to fill this gap; more specifically, the determinants of Thoroughbred weanling auction prices are investigated.

Weanling Thoroughbreds represent an interesting segment of the market because as horses less than one-year-old and possibly as young as five months old at the time of auction, they are immature in their growth process, meaning that their conformation upon maturity is even more difficult to assess than their yearling or two-year-old counterparts. This makes it even more difficult to predict future racing or breeding quality, and accordingly, it becomes more difficult to assess the value of that individual. In spite of this, the weanling auction market is very active; between 2006 and 2013, about 7.5% of the Northern American Thoroughbred foal crop was sold as weanlings, which represents about 2,000 weanlings sold every year.

The weanling market may attract a different type of horse and buyer than the more common yearling market. Weanlings are typically at least 16 months from starting their first race, which, for a buyer, is a significant time span before realizing a return on investment.

Additionally, there is greater risk for these buyers as there is a greater time span in which the horse could injure itself and never make it to the track. On the other hand, selling a horse as a weanling allows the seller to reduce risk for the same reason risk increases for buyers. Horses are often sold as weanlings for different reasons than yearlings, from a farm needing to liquidate some of its assets before winter to those whose sire (the father of a horse) or dam (the mother of a horse) has become "hot," or more commercially desirable, due to outstanding progeny racetrack performance earlier in the year. Additionally, the weanling market is popular for one type of market participant, the pinhooker. A pinhooker is someone who buys weanlings and sells them the next year as yearlings (there is also a market for yearling to two-year-old pinhooks).

The results suggest that like other age groups, pedigree quality is a key factor in determining prices. On the sire's side, the market value of the sire as measured by his stud fee is a main determinant of weanling prices. On the dam's side, the dam's racing quality and the ability of the dam to produce successful racehorses are key factors in determining prices. However, individual qualities such as age and gender are also factors, along with the placement of the weanling in the sale, and if the weanling is pinhooked for future sale.

This article proceeds as follows. Section II provides more information on the background of Thoroughbred auctions and discusses related literature. Section III presents the empirical model. Section IV describes the data used in the analysis. Section V presents the results and discussion. Section VI concludes and offers agricultural implications.

II. Background

Thoroughbreds are sold in auctions at a number of different ages. As seen in Table 1, most often, as prospective racehorses, Thoroughbreds are sold as yearlings; however, they are also sold as weanlings and as two-year-olds in-training.

[Table 1 about here]

At the two-year-old in-training sales, prospective buyers can watch a horse “breeze” a short distance on the racetrack, observing its speed and running form. Both weanlings and yearlings, however, are too young to have begun training. At these sales, prospective buyers are limited to observing an individual’s conformation, or physical build, as well as evaluate the quality of its walk; industry experts suggest that the quality of a horse’s walk is indicative of the quality of its gallop. It is on this basis, along with information available on a horse’s pedigree in the sales catalog, that buyers make their pricing decisions. However, due to their immaturity, weanlings are the most difficult age group to predict future racing ability. Not only is it difficult to assess their conformation at racing age, but in addition, they are young enough that any conformation problems that exist may be improved or entirely grown out of as the horse ages (McIlwraith, Anderson, & Sanschi (2003).

The determinants of weanling Thoroughbred sales prices have not been studied before, which makes this paper of particular interest not only in understanding this segment of the market, but also in how the entire market has developed to diversify risky investments. Other segments of Thoroughbred auction markets are better understood; several studies have investigated the determinants of yearling prices (see Plant & Stowe (2013) for an overview), broodmare prices (Maynard & Stoeppel (2007); Neibergs (2001)), and recent research has investigated the determinants of prices for Thoroughbreds sold at the two-year-old in-training auctions (Robert & Stowe (2016)). While not traded in auction markets, the determinants of advertised stud fees of Thoroughbred stallions have also been examined (Stowe & Ajello (2010); Stowe (2013)). Hedonic price analysis is the analytical tool of choice in these studies to estimate the value of certain attributes of horses.

We anticipate that price determinants for weanling Thoroughbreds will be most similar to those of yearlings. The vast body of research in that area show that yearling prices are influenced by pedigree quality and individual-specific characteristics of the horse such as age and gender (Buzby & Jessup (1994); Chezum & Wimmer (1997); Neibergs & Thalheimer (1997); Parsons & Smith (2007); Plant & Stowe (2013); Poerwanto & Stowe (2010); Robbins & Kennedy (2001); Vickner & Koch (2001)). Pedigree quality is measured in a number of ways. The quality of a horse's sire is best represented by his advertised stud fee, which is the price a mare owner pays for one breeding to a stallion. Stud fee seems to collect available information regarding a stallion's ability to produce successful race horses and commercially attractive progeny. The quality of a horse's dam is measured by her own racing performance as well as her ability to produce successful racehorses.

III. Empirical Model

Hedonic pricing models have been the primary tool of analysis in investigating price determinants in the Thoroughbred industry. In a hedonic pricing model, the price of a product is a function of the quantity and quality of its attributes or characteristics. The coefficient estimates for these attributes can be used to predict the marginal value of the characteristics of a product.

In this study, the "product" is a weanling Thoroughbred. The hammer price of a weanling serves as the dependent variable.[2] Demand is assumed to depend on attributes of that weanling, including individual characteristics (such as age, gender, whether the weanling was foaled in Kentucky, and whether the weanling is Breeders' Cup eligible), pedigree variables (such as the sire's stud fee, whether a weanling's sire is a freshman sire, and whether the dam and her progeny have earned black type), a sale variable (the placement of the weanling in the sale), and a pinhook variable (whether the weanling was pinhooked for sale as a yearling in 2011).

Two models are estimated to analyze price determinants for weanling Thoroughbred prices, and they differ in the way they account for sire pedigree. The first model is a log-linear ordinary least squares model (OLS), with the general model to be estimated being represented by

$$ln(y_i) = \alpha + \boldsymbol{x}_i\beta + \varepsilon_i,$$

where $\ln(y_i)$ is the hammer price of weanling i during the 2010 November Breeding Stock Sale, x_i is an $n \times k$ matrix of explanatory variables (n is the total number of observations and k is the number of regressors), and ε_i is the error term. All monetary variables included in this analysis (hammer price and sire's stud fee) are modified using the natural log transformation to normalize their distributions. In this model, the effect of sire pedigree is controlled for by the sire's stud fee and a measure of the number of foal crops he has produced.

An alternative to accounting for sire pedigree in this manner is to control for each individual sire in the data set with a dummy variable. Thoroughbred sires can be thought of as "brand names," and what is included in that brand may encompass more than just his stud fee and the number of crops he has produced. In general, this could be modeled as follows:

$$ln(y_i) = \alpha + \boldsymbol{x}_i\beta + \gamma_1 d_1 + \gamma_2 d_2 + \ldots \gamma_{j-1} d_{j-1} + \varepsilon_i,$$

where d_j represents a dummy variable for each of the $j - 1$ sires in the data set.

There are 212 individual sires represented in this data set[3], creating a large number of dummy variables and drastically reducing the degrees of freedom. The `areg` procedure in Stata handles this approach by “absorbing” the dummy variables (specific coefficient estimates for each of the dummy variables are not available), but the coefficients on the remainder of the explanatory variables are estimated. The estimation tests for the joint significance of the dummy variables.

Had we excluded the sire specific-variables in Model 1 and rather included 211 dummy variables to control for sire, the coefficient estimates for the remaining variables would be the same, as well as the same R^2 values and root mean squared error. However, the model F tests would not be the same.

The first model is tested for multicollinearity by using the Variance Inflation Factor test, the Breusch-Pagan/Cook-Weisberg test for heteroskedasticity, and the Ramsey RESET test for omitted variables. The highest VIF is 3.46, indicating no concern of multicollinearity. The results of the Breusch-Pagan/Cook-Weisberg test cannot reject the null hypothesis of constant variance. The results from the Ramset RESET test cannot reject the null hypothesis that the model has no omitted variables.

After the models are estimated, marginal values are computed to illustrate the effect of a one-unit increase in the independent variable on weanling hammer price. Marginal values are calculated at the sample mean (for continuous variables) and at zero for all dummy variables except the variable under consideration.

IV. Data

The Keeneland Sales website (accessible at https://www.keeneland.com/sales) and the 2011 *American Produce Records,* which contains pedigree and racing records of dams and foals between 1960-2010, are used to compile the dataset used in this study. Information provided in these resources include information on the weanling’s pedigree, color, gender, age, state of birth, Breeders’ Cup eligibility, seller, buyer, and other auction details. In addition, advertised sale-year stud fees for a weanling’s sire are obtained from the December 2009 *BloodHorse MarketWatch*.

Data were collected from the Keeneland 2010 November Breeding Stock Sale in Lexington, Kentucky. Of the 4,772 total horses cataloged at this sale, 1,786 were weanlings. 443 of the weanlings were removed from consideration prior to the sale by the seller, leaving 1,343 weanlings that were presented for sale. Among these, 29 weanlings did not receive a bid, and there was missing information for an additional 12 weanlings; these 41 weanlings were excluded from this analysis. Accordingly, the final sample size for this study is 1,302 weanling Thoroughbreds.

Variables used in the models are described below. Table 2 enumerates the variables and provides their definitions and expected influence on hammer price. Table 3a reports the summary statistics for these variables.[4]

[Tables 2, 3a, and 3b about here]

The dependent variable used in this study is the natural log of the hammer price (*LNPRICE*). The minimum and maximum hammer prices in the sample are $1,000 and $450,000, respectively, with a mean hammer price of $37,466.51.

Independent variables include the weanling’s individual characteristics such as gender, age, Breeders’ Cup eligibility, and whether it was foaled in the state of Kentucky. Gender is represented by the variable *COLT*, which is set equal to one if the weanling is an uncastrated male and zero if the weanling is a filly (there were no geldings, or castrated males, in this sample). In most studies, when gender is significant, colts sell for more than fillies on average.

Just over half of the sample (50.8%) are colts. Age is represented by the variable *DPF*, which stands for "days past foaling" calculated on the first day of the sale. It is expected that older weanlings will sell for more on average, as they will be more mature than their younger counterparts as they head into race training. The average age of weanlings in the sample is about 233 days, or nearly 8 months old. The youngest weanling in the sale is about 5.5 months, while the oldest is over 10 months. If a weanling has been nominated to compete in the Breeders' Cup championships when it is older, the variable *BC* equals one and is zero otherwise. The nominator pays a fee of $400 to $1,500 to nominate a foal, and all nominated foals are eligible to compete in all Breeders' Cup World Championships.[5] About 75% of the weanlings in the sample are Breeders' Cup eligible. State of birth is represented by the variable *KY*, an indicator variable equal to one if the weanling was foaled in the state of Kentucky and zero otherwise. Evidence from previous research in yearling and two-year-old pricing studies are mixed as to the sign and significance of this variable, although we expect it to be positive if it is significant. Almost 85% of the sample was foaled in Kentucky.

Other independent variables relate to pedigree quality of the weanling's sire and dam. Sire quality is measured by the sire's advertised sale-year stud fee (*STUDFEE*); the natural log transformation of this variable is used in the model (*LNSTUDFEE*). The minimum and maximum stud fees in the sample are $2,500 and $150,000, with an average of $23,377.41. All previous pricing studies in which stud fee is included find a positive and highly significant relationship between stud fee and prices. In addition, we control for whether the weanling is part of its sire's first crop (*FIRSTCROP*), second crop (*SECONDCROP*), or third crop (*THIRDCROP*) of foals. Each of these indicator variables equals one if the weanling is from that foal crop and zero otherwise. There is some evidence in both yearling and two-year-old pricing studies that buyers are willing to pay a premium for progeny by first crop sires. Moreover, according to market participants, foals in a sire's second and third crops are less desirable as the market waits to see how a sire's first crop of foals perform on the racetrack. In this sample, 18.3% of the weanlings are by first crop sires, 13.4% by second crop sires, and 12.1% by third crop sires. The quality of the weanling's dam is measured by whether she earned black type during her racing career (*DAMBT*) and whether she has produced any progeny earning black type (*DAMPBT*). A horse earns "black type" when it places first, second, or third in a stakes race (literally, a horse's name is listed in bold, black font in the sales catalog). 27.3% of the weanling's dams in the sample have earned black type, and 27.0% have produced at least one foal that earned black type.

We also include a variable indicating whether or not the hammer price met the seller's reserve price; when a horse does not meet its reserve price, "reserve not attained" is indicated in the sales results. The variable *RNA* equals one if a weanling's hammer price does not meet the reserve price and zero otherwise. About 24% of the weanlings in the sale did not meet their reserve price. As in Plant and Stowe (2013) and Neibergs (2001), we expect the coefficient on this variable to be negative, indicating that buyers undervalue the horse relative to the seller (or that the seller overvalues the horse relative to the market).

The pinhook variable indicates whether a weanling was re-sold the following year as a yearling. A weanling that is pinhooked is bought at a lower price with the intention of making a return on investment. The variable *PINHOOK* equals one if a weanling was bought and pinhooked the following year as a yearling, and zero if they were not sold the following year as a yearling. 55% of weanlings were pinhooked.

Finally, a set of indicator variables is included to control for the weanling's placement in the sale. Placement is categorized by the "book" in which the weanling appears. In this sale, there is a book for each day of the sale, which lasted 14 days. Therefore, indicators variables are included for *BOOK2 – BOOK14*, with *BOOK1* being omitted to avoid multicollinearity.

Variables included in the final model are chosen based on statistical significance, overall fit of the model, tests for multicollinearity and other model specification tests.

The first model to be estimated is the standard ordinary least squares model (OLS), with sire pedigree controlled for by *LNSTUDFEE*, *FIRSTCROP*, *SECONDCROP*, and *THIRDCROP*. The specific form of the model being estimated is:

Model 1

$$LNPRICE_i = \alpha + \beta_1 COLT_i + \beta_2 DPF_i + \beta_3 BC_i + \beta_4 KY_i + \beta_5 LNSTUDFEE_i + \beta_6 FIRSTCROP_i + \beta_7 SECONDCROP_i + \beta_8 THIRDCROP_i + \beta_9 DAMBT_i + \beta_{10} DAMPBT_i + \beta_{11} PINHOOK_i + \beta_{12} RNA_i + \beta_{13} BOOK2_i + \beta_{14} BOOK3_i + \beta_{15} BOOK4_i + \beta_{16} BOOK5_i + \beta_{17} BOOK6_i + \beta_{18} BOOK7_i + \beta_{19} BOOK8_i + \beta_{20} BOOK9_i + \beta_{21} BOOK10_i + \beta_{22} BOOK11_i + \beta_{23} BOOK12_i + \beta_{24} BOOK13_i + \beta_{25} BOOK14_i + \varepsilon_{it}$$

The second model to be estimated "absorbs" the effects of individual sires. With this approach, the sire-specific variables (*LNSTUDFEE*, *FIRSTCROP*, *SECONDCROP*, and *THIRDCROP*) are wiped out since they do not vary by sire, similar to in a fixed-effects regression model. Thus, the specific form of the second model being estimated is:

Model 2

$$LNPRICE_i = \alpha + \beta_1 COLT_i + \beta_2 DPF_i + \beta_3 BC_i + \beta_4 KY_i + \beta_5 DAMBT_i + \beta_6 DAMPBT_i + \beta_7 PINHOOK_i + \beta_8 RNA_i + B_9 BOOK2_i + \beta_{10} BOOK3_i + \beta_{11} BOOK4_i + \beta_{12} BOOK5_i + \beta_{13} BOOK6_i + \beta_{14} BOOK7_i + \beta_{15} BOOK8_i + \beta_{16} BOOK9_i + \beta_{17} BOOK10_i + \beta_{18} BOOK11_i + \beta_{19} BOOK12_i + \beta_{20} BOOK13_i + \beta_{21} BOOK14_i + \varepsilon_{it}$$

Results are presented in the next section.

V. Results and Discussion

Results from Model 1 are presented in the first two columns of Table 4. The adjusted R^2 of the model is 0.56, which lies within the range of measures of fit in other pricing models for yearlings and two-year-olds (0.37 – 0.72).

[Table 4 about here]

The individual-specific explanatory variables are significant at the 5% or better. On average, colts sell for more than fillies ($p < 0.05$); the estimated marginal value of this effect is about $4,100. Age is also positively correlated with hammer price ($p < 0.01$); each additional day of age is worth $150 dollars; this can represent a difference of over $20,000 between the youngest and oldest weanlings in the sale. A surprising result is that the Kentucky-bred weanlings sell for less than those foaled elsewhere ($p < 0.01$). This contradicts results in other pricing papers (when the variable is significant, its sign is positive). This result may suggest that on average, the lower-quality Kentucky-bred foals are culled at the November sale. Finally, weanlings that have been nominated for the Breeders' Cup sell for higher prices on average ($p < 0.01$); buyers pay a premium of about $5,000 for this attribute. The magnitude of this effect is interesting. According to the Breeders' Cup Limited, the fee for nominating a foal in the year it is born ranges from $400 to $1,500.[6] The marginal value exceeds the nomination fee, which suggests that this variable may also serve as an expected quality signal on the part of the nominator.

As expected, pedigree variables are highly significant. The stud fee of the weanling's sire is significant at the 1% level. A $1 increase in stud fee results in a $0.82 increase in average price; to put into more realistic terms, a $1,000 increase in stud fee is reflected in an $820 increase in sales price. Other papers have also found this "overinvestment" result, where a $1 investment in stud fee is rewarded by a less than $1 increase in hammer price. Weanlings by first-crop sires receive a premium of over $9,000 ($p < 0.01$), while weanlings by second-crop sires are discounted by an average of over $5,400 ($p < 0.01$). There is no significant difference between prices of weanlings by third-crop sires and all of the more established sires, all else equal. The result on first-crop sires supports anecdotal evidence that progeny by an unproven sire may be fashionable because of his recent racing success and is in higher demand by buyers. We suspect its influence may depend on market conditions (paying a premium for foal by an unproven sire might signal willingness to take greater risk) as well as the quality of the sire crop. In addition, there appears to be value in correctly predicting that a new sire is going to be successful, only in terms of increasing social capital among market participants.

There is a trend toward significance that weanlings by broodmares who had earned black type during their racing careers sell for about $3,500 more than those who are not ($p < 0.1$). However, weanlings by broodmares who have already produced black-type earning progeny sell for over $13,300 more ($p < 0.01$). Clearly, buyers expect that a history of producing winners on the racetrack improves the odds that a weanling might itself experience success on the racetrack.

The pinhook variable yielded an interesting result. Instead of a negative coefficient, the coefficient was positive and pinhooked weanlings sold for about $11,300 more than those who were not pinhooked. To explore the result of the *PINHOOK* variable, a logit model was created and the results explained the positive coefficient (see Appendix 1 and Appendix 2). The results showed younger horses(*DBF*) are less likely to be pinhooked, but weanlings whose sire's stud fee is in the lowest commercial range (*SIRE3*), who are by a sire with more weanlings at the sale (*SIREREP)*, and whose sale price/stud fee ratio (*SPSF)* is greater are all more likely to be pinhooked. A lower priced weanling by a "hot" sire would be less likely to be pinhooked because the low price is due to low quality. In Poerwanto and Stowe (2010), it is shown that sires with more yearlings at a sale had higher average prices, so progeny by these stallions are in higher demand. Of the pinhooked weanlings, 59% had sale prices higher than their sire's stud fee, and 99.9% of weanlings had sale prices higher than the average sale price for that sire.

Many of the variables representing the weanling's placement in the sale are also significant. There is a general declining trend in prices throughout the sale. The difference in prices on any particular day differs from Book 1 prices by an average of nearly $15,000 to over $30,000. The differences between average prices between Book 3 and 5 – 14 are all significantly less than Book 1 prices at the 1% level, and the marginal values increase in absolute value until Book 13, were it falls slightly. Interestingly, the marginal value of being placed in Book 14 is closer to the marginal values of Books 5 and 6 than of books later in the sale. There are a few possible reasons for this overall declining trend in prices across books. The first is that higher quality weanlings may be placed near the front of the sale by the auction company, similar to in yearling sales. The second may be a budget-constraint effect; as the sale goes on, buyers may be nearing or have completely exhausted their allotted budget with which to purchase weanlings.

In general, the results in Model 2 are robust to the change in specification, although there are a few differences. The overall fit of the model has improved; the adjusted R^2 is 0.63. The significance of the variable controlling for dam black type has improved from 10% to 5%, and the variables *RNA* and *BOOK3* are no longer significant. *BOOK5* and *BOOK14* dropped in significance from 10% to 5%.

The results from both models suggest that information regarding the quality of a Thoroughbred weanling's pedigree is highly significant in determining the hammer price of a weanling. In addition, some individual characteristics such as age, gender, and place of birth are important, as well as placement in the sale, and if they are a pinhook weanling. The fit of the models lie within the range of model fits from pricing studies of Thoroughbreds of different ages.

VI. Conclusion and Implications

The value of a Thoroughbred weanling is difficult to assess based on its relative immaturity. However, buyers utilize information available on the expected quality of the weanling according to sire and dam pedigree variables.

The analysis conducted in this paper provides important and new insight to the value of a segment of the Thoroughbred auction market that has not been studied before. In doing so, this research fills a gap in the price analysis research for Thoroughbreds and can serve as a decision tool for both sellers in establishing reasonable reserve prices and buyers in determining fair purchase prices.

In addition, a few of the results provide insight into how the ability to sell prospective racehorses as weanlings may help diversify risk in the market. The time between conception to a

Thoroughbred's first start on the racetrack is at least three years, meaning that the mare owner is spending significant amounts of money on board and daily care, stud fees, and later, in training fees, before the opportunity for a return on investment is realized. Therefore, the presence of more frequent sales allows breeders to sell some of their stock to (somewhat) smooth the stream of income. That the Kentucky-bred weanlings were discounted relative to others suggests that some breeders may cull their lower quality weanlings to cut costs. Moreover, the "premium" for weanlings that did not reach their reserve price also suggests that owners of foals whose pedigrees have suddenly become desirable may use the sale as an opportunity to "strike while the iron is hot" and capitalize on their good fortune.

Future research includes examining profitability for the pinhook market as well as determining the extent to which purchase prices predict career racing performance.

Footnotes

[1] Broodmares are female horses which have produced a foal.

[2] The hammer price refers to the last bid called with the auctioneer ends the sale with the strike of the gavel. The hammer price may be the sale price, but it is possible that the hammer price does not meet the reserve price set by the seller so that no sale takes place. However, the hammer price represents the highest bid placed on an individual horse.

[3] Of the 212 sires in the data set, they are represented by a minimum of one and a maximum of 26 weanlings in the sale, with each sire having an average of about 6.1 weanlings in the sale.

[4] Table 3b reports summary statistics for the 29 excluded weanlings that did not receive a bid. Variables identified with [***], [**], and [*] had means which differed significantly from those weanlings with positive hammer prices.

[5] Information retrieved from members.breederscup.com/nominations/foal/information.aspx.

[6] Horses can be nominated for the Breeders' Cup after the year in which they are born, but the fees increase significantly; late nomination fees range from $12,000 to $200,000.

[7] Data on foal crop sizes comes from The Jockey Club Fact Book (http://jockeyclub.com/default.asp?section=FB&area=2), and auction data come from the *Blood-Horse* State of the Market statistics (http://www.bloodhorse.com/horse-racing/thoroughbred-sales/state-of-the-market).

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Table 1. Percent of 2006-2013 North American registered foal crop sold as weanlings, yearlings, and two-year-olds[7]

Year	NA Registered Foal Crop	# sold as weanlings	% sold as weanlings	# sold as yearlings	% sold as yearlings	# sold as two-year-olds	% sold as two-year-olds
2006	34,905	2,848	8.16%	12,284	35.19%	4,182	11.98%
2007	34,357	2,948	8.58%	11,707	34.07%	3,667	10.67%
2008	32,330	2,447	7.57%	10,411	32.20%	3,127	9.67%
2009	29,609	1,912	6.46%	9,776	33.02%	3,342	11.29%
2010	25,948	1,868	7.20%	8,515	32.82%	3,006	11.58%
2011	22,644	1,576	6.96%	7,785	34.38%	2,887	12.75%
2012	21,440	1,673	7.80%	8,062	37.60%	3,447	16.08%
2013	21,377	1,418	6.63%	8,722	40.80%	3,312	15.49%
Total	*27,826*	*2,086*	*7.50%*	*9,658*	*34.71%*	*3,371*	*12.12%*

Table 2. Definitions of variables and expected signs

Variable	Sign	Definition of Variable
LNPRICE	n/a	The natural log of the hammer price for the weanling; this serves as the dependent variable
COLT	+	*COLT*=1 if the gender of the weanling is an uncastrated male and 0 otherwise
DPF	+	The age of the weanling in days on the first day of the sale
KY	+	*KY*=1 if the weanling was foaled in Kentucky as 0 otherwise.
BC	+	*BC*=1 if the weanling has been nominated to compete in the Breeders' Cup and 0 otherwise
LNSTUDFEE	+	The natural log of the 2010 advertised stud fee of the weanling's sire
FIRSTCROP	+	*FIRSTCROP*=1 if the weanling was produced in its sire's first crop of foals and 0 otherwise
SECONDCROP	+	*SECONDCROP*=1 if the weanling was produced in its sire's second crop of foals and 0 otherwise
THIRDCROP	+	*THIRDCROP*=1 if the weanling was produced in its sire's third crop of foals and 0 otherwise
DAMBT	+	*DAMBT*=1 if the weanling's dam earned black type in her racing career and 0 otherwise
DAMPBT	+	*DAMPBT*=1 if the weanling's dam has produced other foals that have earned black type in their racing careers and 0 otherwise
PINHOOK	-	*PINHOOK*=1 if the weanling was sold the following year at the 2011 September Yearling Sale
RNA	-	*RNA*=1 if the hammer price did not meet the weanling's
BOOK2 – BOOK14	-	Categorical variables representing the weanling's placement in the sale by Book; the omitted variable is Book 1

Table 3a. Summary statistics for weanlings with a positive price (n = 1,302)

Variable	Mean	Std. Dev.	Min	Max
PRICE	$37,466.51	$56,816.39	$1,000	$450,000
COLT	0.508	0.500	0	1
DPF	232.558	31.53	162	304
KY	0.847	0.359	0	1
BC	0.751	0.435	0	1
STUDFEE	$23,377.41	$22,618.27	$2,500	$150,000
FIRSTCROP	0.183	0.387	0	1
SECONDCROP	0.134	0.341	0	1
THIRDCROP	0.121	0.326	0	1
DAMBT	0.270	0.444	0	1
DAMPBT	0.270	0.444	0	1
PINHOOK	0.545	0.498	0	1
RNA	0.240	0.427	0	1
BOOK2	0.051	0.221	0	1
BOOK3	0.087	0.281	0	1
BOOK4	0.101	0.301	0	1
BOOK5	0.099	0.299	0	1
BOOK6	0.113	0.317	0	1
BOOK7	0.088	0.283	0	1
BOOK8	0.101	0.302	0	1
BOOK9	0.049	0.216	0	1
BOOK10	0.071	0.258	0	1
BOOK11	0.065	0.247	0	1
BOOK12	0.068	0.251	0	1
BOOK13	0.035	0.185	0	1
BOOK14	0.021	0.143	0	1

Table 3b. Summary statistics for weanlings with no bid (n = 29)

Variable	Mean	Std. Dev.	Min	Max
COLT	0.414	0.501	0	1
DPF	231.52	36.67	167	295
KY	0.793	0.412	0	1
BC***	0.517	0.509	0	1
STUDFEE***	$8,604.00	$5,136.42	$2,500	$25,000
FIRSTCROP	0.138	0.351	0	1
SECONDCROP	0.103	0.310	0	1
THIRDCROP	0.172	0.384	0	1
DAMBT**	0.103	0.310	0	1
DAMPBT**	0.069	0.258	0	1
RNA***	1	0	1	1
BOOK2	0	0	0	0
BOOK3*	0	0	0	0
BOOK4*	0	0	0	0
BOOK5	0.034	0.186	0	1
BOOK6*	0	0	0	0
BOOK7*	0	0	0	0
BOOK8	0.034	0.186	0	1
BOOK9	0.034	0.186	0	1
BOOK10	0.138	0.351	0	1
BOOK11***	0.276	0.455	0	1
BOOK12***	0.414	0.501	0	1
BOOK13	0.069	0.258	0	1
BOOK14	0	0	0	0

Table 4. Coefficients, St. Error, and Marginal Values for Models 1 and 2

	Model 1 – OLS		Model 2 – Absorb Sire Effects	
	Coeff. Est. (Std Err)	Marginal Value	Coeff. Est. (Std Err)	Marginal Value
COLT	0.114** (0.054)	$4,112.57	0.153*** (0.054)	$5,630.63
DPF	0.004*** (0.001)	$149.87	0.005*** (0.001)	$187.33
KY	-0.234*** (0.076)	-$6,945.44	-0.240*** (0.078)	-$7,103.03
BC	0.267*** (0.067)	$5,090.10	0.212*** (0.072)	$3,927.64
LNSTUDFEE	0.513*** (0.050)	$0.82	--	--
FIRSTCROP	0.238*** (0.074)	$9,005.42	--	--
SECONDCROP	-0.214*** (0.082)	-$5,428.99	--	--
THIRDCROP	-0.023 (0.087)	--	--	--
DAMBT	0.100* (0.061)	$3,551.88	0.154** (0.061)	$5,622.80
DAMPBT	0.362*** (0.062)	$13,370.92	0.340*** (0.062)	$12,412.97
PINHOOK	0.284*** (0.057)	$11,372.77	0.191*** (0.058)	$7,287.66
RNA	0.036 (0.064)	--	0.089 (0.066)	--
BOOK2	0.136 (0.168)	--	0.150 (0.167)	--
BOOK3	-0.277*** (0.153)	-$8,379.62	0.012 (0.154)	--
BOOK4	-0.229 (0.151)	--	-0.064 (0.154)	--
BOOK5	-0.557*** (0.154)	-$15,555.55	-0.347** (0.159)	-$10,679.17
BOOK6	-0.629*** (0.155)	-$17,373.72	-0.459*** (0.161)	-$13,697.45
BOOK7	-1.175*** (0.166)	-$26,631.94	-0.884*** (0.172)	-$22,612.84
BOOK8	-1.376*** (0.165)	-$29,309.39	-1.173*** (0.173)	-$27,080.03
BOOK9	-1.492*** (0.187)	-$29,471.50	-1.190*** (0.200)	-$26,456.24
BOOK10	-1.470*** (0.177)	-$29,793.64	-1.268*** (0.185)	-$27,802.37
BOOK11	-1.460*** (0.182)	-$29,800.58	-1.271*** (0.194)	-$27,925.26
BOOK12	-2.131*** (0.187)	-$34,624.62	-1.745*** (0.206)	-$32,427.33
BOOK13	-1.947*** 0.226	-$32,480.52	-1.606*** (0.237)	-$30,283.55
BOOK14	-0.707*** (0.226)	-$18,457.30	-0.606** (0.228)	-$16,548.96
Constant	4.115*** (0.600)	--	8.973*** (0.268)	--
	n	1,302	*n*	1,302
	F(25,1276)	68.29	*F*(21,1069)	16.89
	Prob > *F*	0.0000	Prob > *F*	0.0000

	Adj. R^2	0.5639	Adj. R^2	0.6307

***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively

Appendix 1.
Table 5. Definitions of variables and expected signs

Variable	Sign	Definition of Variable
COLT	+	*COLT*=1 if the gender of the weanling is an uncastrated male and 0 otherwise
DPF	+	The age of the weanling in days on the first day of the sale
KY	+	*KY*=1 if the weanling was foaled in Kentucky as 0 otherwise.
BC	+	*BC*=1 if the weanling has been nominated to compete in the Breeders' Cup and 0 otherwise
FIRSTCROP	+	*FIRSTCROP*=1 if the weanling was produced in its sire's first crop of foals and 0 otherwise
SECONDCROP	+	*SECONDCROP*=1 if the weanling was produced in its sire's second crop of foals and 0 otherwise
THIRDCROP	+	*THIRDCROP*=1 if the weanling was produced in its sire's third crop of foals and 0 otherwise
SIRE1	+	*SIRE1*=1 if the weanling was produced by a sire whose stud fee is greater than $100,000
SIRE2	+	*SIRE2*=1 if the weanling was produced by a sire whose stud fee is between $50,000 and $100,000
SIRE3	+	*SIRE3*=1 if the weanling was produced by a sire whose stud fee is between $25,000 and $50,000
SIREREP		*SIREREP* is the number of weanlings represented by the same sire at the sale
SPSF		*SPSF* is the weanling's sale price divided by its sire's stud fee
DAMBT	+	*DAMBT*=1 if the weanling's dam earned black type in her racing career and 0 otherwise
DAMPBT	+	*DAMPBT*=1 if the weanling's dam has produced other foals that have earned black type in their racing careers and 0 otherwise

Appendix 2.
Table 6. Coefficients and Standard Errors of the Pinhook Logistic Regression

	Coeff. Est. (Std Err)
COLT	0.135 (0.116)
DPF	-0.006*** (.002)
KY	0.232 (0.161)
BC	0.170 (0.139)
FIRSTCROP	0.079 (0.167)
SECONDCROP	-0.139 (0.176)

THIRDCROP	0.138 (0.183)
SIRE1	0.275 (0.334)
SIRE2	0.315 (0.210)
SIRE3	0.319** (0.151)
SIREREP	0.046*** (0.010)
SPSF	0.081** (0.035)
DAMBT	0.125 (0.130)
DAMPBT	0.108 (0.134)
CONSTANT	0.301 (0.465)
n	1,302
LR chi2 (14)	72.38
Prob > *chi2*	0.0000
Pseudo R2	0.0403

***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively