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Asymmetric Information in the Market for Thoroughbred Yearlings

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In 2007, nearly 3,800 thoroughbreds were sold at the Keeneland September Yearling Sale for a total sum of $385,018,600 (International Horse Breeding 2007). This annual sale, held in Lexington, Kentucky, is restricted to registered thoroughbred horses one year of age ("yearling" is an industry-specific term for horses one year of age; see Appendix B for a glossary of additional terms). These horses, months away from beginning their racing careers, commanded an average sales price of $101,347. Even more extraordinary, the sales topper was purchased for $3.7 million.

Thoroughbred horses are bred for the purpose of racing, however formal competition does not commence until horses are at least two years of age. Lacking the aid of performance records or speed trials, potential buyers must predict the racing potential of yearlings using only pedigree and biological characteristics (age, sex and appearance). Further adding to the difficulty is the fact that only 50% of thoroughbreds ever win a race and less than 1% emerge the victor in a stakes race, the highest class of race and desired level of competition for the majority of Keeneland buyers (Gutner 2003). The task undertaken by bidders is similar to watching children play in a park and picking out the next LeBron James or Serena Williams. Just as observers likely know the probability of a child becoming a professional athlete (i.e. slim to none), thoroughbred yearling buyers know only the distribution of yearling quality and, this study hypothesizes, use seller signals to better predict true racing potential.

I. Survey of Literature

The effects of adverse selection in markets have been a popular topic for research by economists, beginning with Akerlof's 1970 paper on the "market for lemons." He finds evidence of adverse selection in markets, such as those for used cars and insurance, where sellers know the true value of a good while buyers are only able to determine the distribution of quality. Rational buyers will offer a price no higher than the market average, driving sellers of high-quality goods out of the market.

Since then, Akerlof's adverse selection hypothesis has been applied to a variety of markets. Genesove (1993) finds a substantial price differential between used cars sold at auction by used car dealers and those sold by dealers who operate only new car dealerships. He hypothesizes the existence of a signal between buyers and sellers in used car auction markets. Sellers who operate purely new car dealerships must send all used cars they receive in trade-in to auction. However, dealers of new and used car dealerships have other outlets from which to sell their used cars. By sending a used car to auction, sellers suggest the car is unable to be sold otherwise and signal to buyers the unsatisfactory quality or defective nature of the car (such cars are termed "lemons").

Chezum and Wimmer (1997) apply a similar principle to the market for thoroughbred yearlings. Using a random sample of 304 yearlings sold at the 1994 Keeneland September Yearling Sale, Chezum and Wimmer hypothesize sellers who breed and race horses receive lower prices for their animals than those received by sellers who only breed horses. Their hedonic pricing model, used to control for variables that determine the expected potential of yearlings, establishes hammer price as a function of pedigrees of sire and dam (father and mother, respectively), racing performance of dam, age, sex, geographic origin and other industry statistics.

Chezum and Wimmer hypothesize that the greater degree to which a seller races thoroughbreds, the larger price discount his yearlings receive. They find their variable, racing intensity [(seller's previous year racing starts)/(his breeding starts + 1 in the previous year)], statistically significant at the 95% confidence level[1]. Thus, they conclude adverse selection does play a role in determining the price of thoroughbred yearlings.

Vickner and Koch (2001) expand upon the research of Chezum and Wimmer, testing the same hypothesis but attempting to strengthen the hedonic pricing model by including other measures of the knowledge buyers have of yearling sold at auction. Variables such as date of sale (yearlings sold in the "select session" of the Keeneland sale are assumed to be of higher quality), performance of same-sired progeny, buyer visits to view a yearling's health records, advertising, dam's age, supply of similarly bred yearlings and individual seller reputation are introduced to the model[2]. However, out of seven introduced variables, only three are found statistically significant at a confidence level exceeding 90%. Further, Vickner and Koch fail to find evidence suggesting adverse selection does affect the sale prices of thoroughbred yearlings.

A few recent papers have explored equine markets, increasing economists' understanding of yearling buyer behavior. Robbins and Kennedy (2001) study the formulation of a hedonic pricing model for yearling thoroughbreds. Many of the aforementioned variables were included, and found to be significant, however the role of the stud fee and dam's racetrack performance are noteworthy[3]. Past researchers had included sire performance, performance of same-sired progeny and stud fee in their pricing models. Robbins and Kennedy find evidence that current stud fee compromises the total value of a sire and its progeny, thereby leaving the other two variables redundant and unnecessary. They also find the success of an individual dam's produce, not the dam's racetrack performance, suggestive of a high quality yearling[4]. These discoveries help to increase the strength of the hedonic pricing model utilized in this study.

In her study of the applications of taxes and asset prices to thoroughbreds, Key (2008) formulates two hedonic pricing models, one for yearlings and one for broodmares[5]. Her yearling model is similar to that employed in previously outlined research. However, her broodmare model is unique and sheds light on the role dams play in the value of yearlings. Using dummy variables, Key finds a positive relationship statistically significant at the 95% confidence level based upon whether a dam is the product of a high quality winner (i.e. its dam produced winners of stakes races), if its progeny are high quality winners and if its siblings are high quality winners. Key's findings, along with those of Robbins and Kennedy, are noteworthy achievements that help economists to better understand buyer behavior in thoroughbred markets.

[1] Racing starts refers to the number of races entered by horses owned by the seller. Breeding starts refers to the number of races entered by horses bred by the seller.
[2] The Keeneland "Select Sale" was discontinued in 2003, thus such a variable is not utilized in this study.
[3] Stud fee is the fee paid by an owner for the opportunity to breed a mare (female horse) to a stallion (male horse).
[4] Produce refers to the offspring of a dam; offspring of a sire are termed "get".
[5] Broodmares are mares that are primarily used for breeding.

II. Theoretical Model

Buyer behavior is challenging for economists to model, partially because it is difficult for buyers to predict a yearling's racing potential with complete accuracy and offer bids accordingly. With thousands or even millions of dollars on the line, the stakes are high and rational buyers will try to learn as much as they can about any horse before bidding. Just as tee-ball coaches and gym teachers of children in the park have an informational advantage over first time observers; owners of young horses are more able than buyers to accurately predict the racing potential of their yearlings. Owners have the opportunity to oversee their stock from birth until the sale and benefit from access to full medical records and the chance to observe the athletic abilities and "heart" of their yearlings6. Any rational buyer will look to the owner of an available horse for additional information before bidding.

However, just as a used car dealer is not likely to speak negatively of a car on his lot, owners are likely to give only glowing reviews of every thoroughbred on their farm. Yet, some owners unintentionally signal to buyers which yearlings they feel lack potential for racing. By keeping some of their yearlings to race themselves, owners signal that the yearlings they offer for sale may be of lower quality. Buyers are able to intercept this signal and, this paper hypothesizes, offer discounted prices for those yearlings.

Owners of thoroughbred yearlings can be categorized as two types: "breeders" and "racers". Breeders only breed and do not train or condition horses for races. Outside of future breeding, they have no use for their yearlings, so they sell all, or nearly all, of their stock at yearling sales[7].

In contrast, racers both breed and race thoroughbreds. They breed and prepare their yearlings for races and profit from purses (prize money) won by their horses. Thus, racers can choose between sending a yearling to a sale and retaining it for their own racing operations. Racers recognize that buyers do not know the true racing potential of a yearling (no one does), but do know the distribution of that potential among all thoroughbred yearlings. Buyers will likely offer bids no greater than the market average for yearlings of similar breeding and biological characteristics. Thus, racers profit by retaining the yearlings they feel have more promise than indicated by their pedigree and biological characteristics, and racing these horses themselves. They will offer for sale the yearlings they feel have less potential than suggested by pedigree and characteristics, as buyers will again offer the market average and racers will profit. The costs and benefits of racers are outlined in Figure 1 (an * denotes a profitable decision).

[6] While owners can sell their young stock at any age, it is common in the industry for owners to not sell horses until they are at least one year old. Thus, it is safe to assume that yearlings offered for purchase at the Keeneland September Yearling Sale have had the same owner since birth.

[7] It is important to note that some breeders may retain an occasional yearling for future breeding purposes; however, the statistical likelihood of this occurring is small enough to not affect the results of this study.

Figure 1: Racer's decision

Racer's decision		**Type of yearling**	
		Racing potential less than market average	Racing potential greater than market average
Decision	Offer yearling for sale	**Likely profit: yearling commands market average price which is greater than its discounted future racing value*	*Likely loss: yearling commands market average price which is less than its discounted future racing value*
	Retain yearling	*Likely loss: discounted future racing value is less than the current market average for the yearling*	**Likely profit: discounted future racing value is greater than the current market average for the yearling*

If buyers are able to determine seller type, they can offer discounted prices for yearlings owned by racers and avoid buying a lemon. In this study, seller type is determined by classifying owners who entered a horse in at least one race the previous year as racers and those who did not race at all as breeders. This sample contains a nearly even split of breeders and racers (49% of sellers are racers). After controlling for detectable variations in expected potential with a hedonic pricing model, finding a statistically significant difference between the sale prices of yearlings sold by racers and those sold by breeders will suggest that adverse selection does affect the prices offered for thoroughbred yearlings. Thus, the evidence will support that seller type serves as a signal of the expected quality of a yearling. The hypothesized decision-making process of a buyer is captured in Figure 2 (an * denotes a likely profitable outcome).

Figure 2: Buyer's decision

Buyer's decision		**Type of seller**	
		Racer	Breeder
Decision	Offer market average bid	*Likely to purchase a lemon: racers stand to profit only by offering yearlings of less than potential quality*	**Likely to purchase a horse of market average potential quality*
	Offer discounted bid	**Likely to avoid overpaying for a horse of unsatisfactory quality*	*Likely to not achieve the high bid: other bidders will bid to the market average and the buyer will not win the horse*

The goals of this study are to expand upon previous research and determine the role played by adverse selection in the market for thoroughbred yearlings. Recent research, such as that by Robbins, Kennedy and Key, has increased understanding of the variables that affect sales prices of yearlings sold at auction and will be applied to improve upon the hedonic pricing model. Strengthening the model will increase accuracy in detecting adverse selection.

This study also uses a variable not relied upon in past models to test for the presence of adverse selection. Chezum, Wimmer, Vickner and Koch all hypothesized that the greater the degree to which an owner races, rather than breeds, the greater the price discounts his yearlings will receive. In both papers, the economists hypothesized that finding a statistically significant negative value for a variable comprised of the ratio of racing starts to breeding starts would signal that adverse selection was present in the market.

Chezum and Wimmer found their adverse selection variable statistically significant at the 95% confidence level, however they only found evidence of a price discount due to seller type of less than one percent. In other words, a one unit increase in the ratio resulted in a $317 decrease in sales price. Vickner and Koch, on the other hand, were unable to find any evidence suggestive of adverse selection. This study hypothesizes that the degree to which a seller races does not define seller type; rather, seller type is determined by whether or not the seller races at all.

If a seller races at all, it can be assumed that he has the resources to adequately train and condition a yearling for racing. As discussed earlier, a rational racer stands to lose money by offering for sale those yearlings he feels have substantially more potential than their pedigree and biological characteristics suggest. Only 50% of all thoroughbreds win a race and just 1% win a stakes race, thus only a very small percentage of yearlings should be expected to have much more potential than suggested by their breeding and characteristics. A seller who races at all will certainly retain such yearlings and should receive discounted prices for his yearlings as a result. Determining seller type by a ratio of racing starts to breeding starts could have clouded this simplistic relationship, causing the inconsistency in hypothesis testing observed in previous papers.

III. Data and Empirical Model

Data for this study was collected from a random sample (every fifteenth hip number) of 370 yearlings offered for sale at the 2007 Keeneland September Yearling Sale (253 observations remained after omitting those with missing values). The mean hammer price of all yearlings sold at the sale was $101,347, compared to $105,393 in the sample used in this study (International Horse Breeding 2007). The Keeneland Sale was chosen as it is arguably the sale for the upper tier of thoroughbred yearlings bred for racing. The sale is responsible for 37% of all yearlings sold at auctions in 2007 (The Jockey Club Fact Book: Auction Sales in North America) and 69% of all revenues from yearling auction sales (The Jockey Club Fact Book: Average/Median Price per Yearling).

The Keeneland Sale is a standard English (ascending-bid) auction in which horses must be nominated by their selling agent at least three months prior to the sale. Sellers may choose to set a reserve price for any yearling and will retain ownership if the yearling does not meet its reserve. Additionally, Keeneland collects a 4.5% commission from the hammer price of any horse sold for more than $20,000 (Keeneland Thoroughbred Racing and Sales).

To control for detectable predictors of expected racing potential, a hedonic pricing model fashioned hammer price as a function of variables including pedigree, date of birth, sex and seller type. Data on hammer price was retrieved from the Keeneland Sales webpage and yearling quality variables were collected from industry sources, *The Thoroughbred Time's Buyer's Guide: 2007, The Thoroughbred Times Racing Almanac: 2008,* and *The American Racing Manual: 2007.* The equation utilized in this study, (1), and the expected coefficient signs are as follows[8]:

(1) LN(*HAMMER PRICE*) =

$$\beta_0 + \beta_1 RACER + \beta_2 COLT + \beta_3 AGE + \beta_4 \text{LN}(STUD\ FEE) + \beta_5 \text{LN}(DAM\ PURSE) + \varepsilon$$

(-) (+) (-) (+) (+)

Individual variables are defined as,

HAMMER PRICE Final auction price (dependent)

RACER =1 if seller's 2006 racing starts > 0, and 0 otherwise.

Racing starts is the number of races entered by horses owned by the seller.

COLT =1 if the yearling is male, and 0 otherwise

AGE Date the yearling was born, ranging 1-157

A birth date of January 1st=1, January 2nd=2, and so forth.

STUD FEE 2007 stud fee for the sire of the yearling

Stud fee is the amount paid by a mare owner to breed his mare to a stallion.

DAM PURSE Average purse of earnings per start for all progeny of the yearling's dam, given by (total progeny earnings/total progeny starts).

The variable *RACER*, a dummy using 0 to represent breeders (those who did not race in 2006) and 1 to represent racers (those who raced at least one horse the previous year), is used to test for the presence of adverse selection. As discussed earlier, it is expected that potential buyers will recognize the two distinct seller types and offer discounted prices for horses owned by racers. Thus, a negative coefficient is expected for the variable *RACER.*

To test for the effects of adverse selection, other characteristics affecting the expected quality of a yearling are held constant. The hedonic pricing model controls for expectations derived from biological characteristics (sex and age) and the success of a yearling's sire and dam.

Colts have historically been more successful racehorses than their female counterparts and should

[8] The natural logarithm was taken of *Hammer price*, *Stud fee* and *Dam purse* to account for scale effects and avoid heteroskedasticity.

draw higher bids as a result[9]. Colts can also command large stud fees (in this study, stud fees were as high as $500,000) in the future, further adding to their value. This preference should yield a positive coefficient for the dummy variable, *COLT*.

Buyers also place value on yearlings born earlier in the year, as older yearlings have additional time to grow and mature prior to the start of their racing career[10]. Such yearlings are expected to begin racing earlier and have more success, leading to an expected inverse relationship between *HAMMER PRICE* and the coefficient of *AGE*.

The role of the sire is captured in the variable *STUD FEE*. *STUD FEE* is the price paid by an owner for the right to breed a mare to a sire in 2007 and can be thought of as the market value of the hereditary capabilities of the sire, established by a combination of its and its offspring's racing success. Sires produce multiple foals in one breeding season (in this study, an average of 41 foals annually), while dams are restricted to a single offspring[11]. Thus, fewer stallions than mares are needed for breeding and the average quality of sires is higher than that of a dams. This, together with the added difficulty in studying the larger quantity of mares, creates an emphasis in the industry on sires rather than dams. More valuable sires produce more valuable progeny, resulting in a positive expected relationship between *HAMMER PRICE* and *STUD FEE*.

The value of the dam is summarized in *DAM PURSE*. While stud fees are paid for the opportunity to breed to a sire, breeders and racers own their mares and are not accessed a fee for the right to breed them. Thus, dams do not have a published breeding value. With relatively few offspring (in this sample, the number of offspring produced by a dam ranged from 1 to 14), it is more difficult and costly to determine the effects of the Dam on potential offspring performance. *DAM PURSE* was chosen as the most accurate measure, as it captures both the level of racing undertaken by a dam's produce and their success (higher placing horses earn a larger percentage of the purse). Again a positive coefficient should be observed, as higher average purses signify success of progeny on the racetrack.

IV. Empirical Results

Table 2 lists the regression results for the equation and shows that all variables have the expected signs and all but one are statistically significant. The F-statistic is significant at the 99% confidence level, suggesting the model fits the data well. Overall, the model explains 40% of the variation in the natural logarithm of *HAMMER PRICE*. Similar models achieved adjusted R^2s as high as 0.55; nonetheless, 0.400 is an acceptable R^2 for a cross-sectional study of a market where buyers must predict an untried juvenile animal's future athletic performance. Undoubtedly, buyers, and thus their bids, are influenced by the perceived attractiveness of a horse, the "look" in a horse's eye, its behavior in the auction ring, buyer mood and other immeasurable factors which could easily determine a large percentage of the sales price of a yearling.

[9] In 134 runnings of the Kentucky Derby, a colt has emerged the winner over 97% of the time. (Statistics: Kentucky Derby 134)

[10] In the Thoroughbred industry, all horses celebrate their first birthday on January 1st of the next year. Thus a horse born January 20, 2008 and a horse born May 10, 2008 will both turn one year of age on January 1, 2009. Here lies the inherent advantage of horses born earlier in the year that have had more time to grow and mature in preparation for racing.

[11] Foals are horses less than one year of age.

Table 1: Descriptive Statistics

	Mean	Median	Stand. Dev.	Minimum	Maximum
HAMMER PRICE	105393	47000	184035.55	1000	1700000
RACER	0.490	0	0.42	0	1
AGE	80	79	34.62	2	157
COLT	0.520	1	0.50	0	1
STUD FEE	45651	25000	65489.89	3500	500000
DAM PURSE	4413	2453	9234.23	0	115251

Table 2: OLS Regression Results

Dependent variable: LN(*HAMMER PRICE*)	
Variable	Coefficient (T-statistic)
RACER	-0.353** (2.085)
AGE	-0.002 (0.827)
COLT	0.270** (1.955)
LN(*STUD FEE*)	0.856*** (12.405)
LN(*DAM PURSE*)	0.025* (1.368)
CONSTANT	1.559*** (2.140)
R^2	0.408
Adjusted R^2	0.400
F-statistic	34.114***
Observations	253

*Notes: Levels of significance *=10% **=2.5% ***=1%*
T-statistics are provided in absolute value format and use one-tailed test

The coefficient of *RACER*, the variable used to test for presence of adverse selection, is significant at the 97.5% confidence level and shows that sellers who race should expect a 35.33% discount in the prices offered for their yearlings at auction. Using the mean hammer price in the sample, this coefficient represents a decrease of $37,236.05 in hammer price for yearlings owned by those actively racing. The coefficient provides evidence of adverse selection in the market and the existence of a signal between buyers and sellers which relays the true expectations of racing potential of a yearling by the seller.

The coefficient of *AGE* is not statistically significant, suggesting buyers do not find an extra few days for a young horse to mature particularly valuable. However, the range of birth dates was small (covering just six months, January 2nd to June 6th), so there is the possibility a stronger correlation could be detected if birth dates spanned all twelve months. Also, entering dates as weeks or months could have improved the variable.

The coefficient of the variable *COLT* is significant at the 97.5% confidence level and implies colts fetch prices 27% (in this study, $28,456.11) greater than those of fillies, ceteris paribus. Colts are typically more successful on the racetrack and present profitable breeding opportunities later on, so it is expected they will net higher bids[12].

The coefficient of the natural logarithm of *STUD FEE* is significant at the 99% confidence level and shows that the marginal value of *STUD FEE* in this sample is $90,248.08 (85.63%). The strong relationship between *STUD FEE* and *HAMMER PRICE* could explain the willingness of breeders to pay stud fees which ranged between $3,500 and $500,000 in this study.

The coefficient of the natural logarithm of *DAM PURSE* is also statistically significant and shows a marginal value of $2,634.83 (2.5%) in this study. The strength of the relationship between *DAM PURSE* and *HAMMER PRICE* is consistent with that of similar studies and reflects the industry emphasis on sires, yet it is still interesting to note the lack of impact a dam has on the expected racing potential of its foal. Sires have no contact with their get, while foals spend 11 months in the wombs of their dams and an additional few months on the ground. There is reason to conclude that purchasers of thoroughbred yearlings are believers in the power of nature, not nurture.

Tests for heteroskedasticity and multicollinearity (the White Test and use of variance inflation factors, respectively) found no evidence of either classical assumption violation. See Appendix A for full test results.

V. Concluding Remarks

This paper hypothesizes that the market for thoroughbred yearlings sold at auction is affected by adverse selection. Asymmetric information plays a large role in the market, as buyers are at an informational disadvantage as compared to sellers. However, by identifying the type of seller, either breeder or racer, offering a yearling for purchase, buyers are able to interpret seller behavior as a signal of

[12] The current world record for selling price of a broodmare or broodmare prospect is $10.5 million, set by Playful Act in 2007 at the Keeneland Breeding Stock Sale. (Biles 2007) In comparison, the record stud or stud prospect price is $60 million, set by Kentucky Derby winner Fusaichi Pegasus in 2000. (Ackman 2005)

the seller's true expectations of racing potential.

Breeders send all of their yearlings to auction, no matter how talented they feel a yearling might be. Racers, however, operate their own racing stables and have the incentive to retain the yearlings they feel are the most talented for their own use. A racer knows buyers will bid only up to the market average for a yearling of similar breeding and biological characteristics. As a result, racers retain all horses they feel possess more talent than their pedigree and appearance suggest (because buyers will not offer proportionate bids) and sell those that appear to be less talented than others of similar breeding and biological characteristics (racers know they will profit from these sales). Thus, this paper hypothesizes, rational buyers should offer discounted prices for yearlings owned by racers.

This hypothesis is tested by sampling a group of 253 yearlings sold at the 2007 Keeneland September Yearling Sale, a sale representative of the market for upper-tier racehorses. The natural logarithm (used to control for scale effects) of the final selling price of a yearling is modeled as a function of date of birth, sex, sire and dam quality and seller type. The coefficients of sex, sire and dam quality and seller type are all found to be statistically significant at a confidence level exceeding 90%. The coefficient of seller type (significant at the 97.5% confidence level) is negative and suggests yearlings owned by racers fetch prices 35.33% ($37,236.05) less than those netted by yearling owned by breeders. Thus, the data provides evidence that seller type is used by buyers as a signal of a racer's true expectations of a yearling's racing potential. Hence, there is reason to believe adverse selection is present in the market for thoroughbred yearlings sold at auction.

Equine economics is a relatively new field and there is much room for further study. Specifically relating to adverse selection in the market for yearling thoroughbreds, there are a variety of other ways sellers signal their expectations of a yearling's racing potential. Finding whether the seller retained previous foals of similar pedigree and biological characteristics and whether he chose to breed his dam back to the same sire could both capture signals offered by sellers. Additionally, finding ways to quantify more of the subjective determinants of hammer prices would improve the hedonic pricing model.

VI. References

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VII. Appendix A: Heteroskedasticity and Multicollinearity Tests

Table 3: White heteroskedasticity test results

F-statistic	0.834	
Observations*R^2	15.2576[+]	
Dependent variable	*Residual*^{2}	
Variable	Coefficient	T-statistic
RACER	0.440	-0.175
*RACER*COLT*	-0.385	0.732
*RACER**LN(*DAM PURSE*)	0.038	-0.567
*RACER**LN(*STUD FEE*)	0.028	-0.112
*RACER*AGE*	-0.001	0.157
COLT	1.262	0.558
*COLT**LN(*DAM PURSE*)	0.030	0.534
*COLT**LN(*STUD FEE*)	-0.164	-0.764
*COLT*AGE*	0.001	0.118
LN(*DAM PURSE*)	0.334	1.096
L(*DAM PURSE*)^2	0.009	0.573
LN(*DAM PURSE*)*LN(*STUD FEE*)	-0.030	-1.046
LN(*DAM PURSE*)**AGE*	-0.001	-1.238
LN(*STUD FEE*)	0.393	0.216
LN(*STUD FEE*)^2	-0.005	-0.055
LN(*STUD FEE*)**AGE*	-0.002	-0.666
AGE	0.023	0.608
AGE^2	1.27E-05	0.150
CONSTANT	-1.873	-0.193
R^2	0.060	
Adjusted R^2	-0.012	
Observations	253	

[+] Observations*R^2 is less than 26, the critical chi-square value at the 1 percent level. Thus the null hypothesis of homoskedasticity cannot be rejected.

Table 4: Variance inflation factors multicollinearity test results

Dependent variable in auxiliary regression	R^2	Variance inflation factor
RACER	0.036	1.037
AGE	0.033	1.034
COLT	0.010	1.010
STUD FEE	0.040	1.042
DAM PURSE	0.056	1.059

Using a common rule of thumb, the number 2 is the critical VIF value in this study. All VIF(β_i)<5, thus multicollinearity is not found to compromise the regression results.

VIII. Appendix B: Glossary of terms

Breeder: 1) In this study, an owner who only breeds and does not race horses.

2) Industry-wide, the owner of the mare at the time of breeding.

Breeding starts: In this study, the number of races entered by horses bred by a breeder.

Broodmare: A female horse used primarily for breeding.

Colt: A male horse less than one year of age.

Dam: The female parent of a horse.

Filly: A female horse less than one year of age.

Foal: A young horse less than one year of age.

Gelding: A castrated male horse, incapable of breeding.

Get: The progeny of a sire.

Hammer price: The final sale price of an animal sold at auction.

Heart: The desire and competitiveness of a racehorse.

Hip number: Number affixed to the hip of a horse at an auction; used for record-keeping and identification purposes.

January 1st: The official birthday of all thoroughbreds.

Jockey Club: The registry of thoroughbreds.

Keeneland Select Yearling Sale: Annual auction open to invited thoroughbred yearlings, discontinued in 2003.

Keeneland September Yearling Sale: Annual ascending-bid auction for thoroughbred yearlings. The sale is responsible for 37% of all yearlings sold at auctions in 2007 and 69% of all revenues from yearling auction sales. Keeneland is located in Lexington, Kentucky.

Mare: A female horse five years or older.

Produce: The progeny of a female horse.

Progeny: The offspring of a horse.

Purse: The prize money awarded to the top-three finishers in a horse race.

Racer: In this study, an owner who both races and breeds thoroughbreds.

Racing starts: In this study, the number of races entered by horses owned by a racer.

Sire: The male parent of a horse.

Stakes race: A class of race more prestigious than allowance and claiming races. In stakes races, owners usually must pay a fee to run a horse. The fees can be for nominating, maintaining eligibility, entering and starting, to which the track adds more money to make up the total purse. Some stakes races are by invitation and require no payment or fee.

Stallion: A male horse capable of breeding; commonly referred to as a stud.

Stud: Shorthand for a stallion.

Stud fee: The price paid for the right to breed a stallion to a mare.

Thoroughbred: Developed in England in the 17th century, Thoroughbreds are bred for racing and are noted for their tremendous speed and athleticism.

Yearling: An industry-wide term used to refer to horses one year of age. Thoroughbreds turn one on January 1st of the year following their birth and age an additionally year every following January 1st.