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The Relationship Between Sire Representation and Average Yearling Prices in the Thoroughbred Industry

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Many Thoroughbred stallions are being bred to increasing numbers of mares. This practice raises the question of how progeny value is affected by an increased supply of foals by the same sire, which ultimately influences the sire's value. This paper addresses that question. Three of the four models presented in our study find that the average price of a sire's yearlings is increasing in sire representation. In addition, greater sire representation decreases the likelihood that a yearling is removed from the sale, but may increase the likelihood that it does not meet its reserve price.

Key Words: agribusiness, equine, hedonic price analysis, Thoroughbred industry

From the late 1950s through the 1990s, Thoroughbred stallions had a relatively limited book of mares.[1] Because the number of mares a sire covers is highly correlated with the size of his annual foal crop, this strategy was intended to boost the value of a stallion's foals by limiting their supply. More recently, however, book sizes have been relaxed; stallions have been covering larger numbers of mares. This shift in breeding strategies regarding the size of a sire's book is important for the following reasons. Limiting a sire's book to a small number of mares may be beneficial because that stallion's progeny are relatively scarce, increasing the value of the foals and hence the long-term value of the sire, but at the expense of gains in short-term revenues. In contrast, allowing larger books of mares increases short-term revenue for the stallion owner/manager, but potentially risks the long-term value of the stallion.

The optimal stallion book size depends on many factors, and addressing all of them is outside the scope of this paper. Instead, we investigate one integral piece of the puzzle. More specifically, we examine how the number of progeny by one sire at a sale influences the average price of that sire's progeny. This relationship is of particular interest because the value of the sire, as represented by his stud

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[1] A sire's book is the number of mares he covers in one year.

fee,[2] depends in part on the value of his progeny—especially for some classes of sires. Stowe and Brown (2009) find that among elite Thoroughbred sires in the United States, the ability of a sire to produce progeny selling for high average prices is the single most important factor in determining future stud fees. Thus, understanding the relationship between supply of same-sired foals at a sale, which is highly correlated with book size, and average price is of vital importance in determining the optimal breeding strategy.

A related issue of interest is whether the supply of same-sired yearlings at a sale affects the likelihood that the yearling sells or not. To that end, we also investigate the relationship between the number of same-sired progeny at the sale and (*a*) the likelihood that a yearling does not meet its reserve price, or is classified as "reserve not attained" (RNA), as well as (*b*) the likelihood that a yearling is an "out" (removed from the sale grounds before ever entering the sales ring).

Economic theory is ambiguous regarding the direction of the relationship between the number of same-sired progeny at the sale and average price. All else equal, the greater the supply of a sire's progeny, the lower the average price. Yet, if the increase in book sizes is a response to an increase in demand for a sire's progeny, the number of same-sired progeny at the sale may be positively related to average sales price. Since the trend in breeding sires to large books of mares persists, we anticipate the latter result—i.e., a larger number of same-sired progeny at the sale would result in a higher average price.

To investigate this relationship, we utilize a hedonic pricing model. Hedonic pricing studies are common in the Thoroughbred industry and have focused mainly on estimating the market value of attributes for individual Thoroughbred yearlings sold at public auction. These studies estimate a value for individual-specific characteristics (pedigree, gender, and date of birth) and also show that macroeconomic variables, such as the exchange rate and interest rate, are significant predictors of prices (Karungu, Reed, and Tvedt, 1993; Buzby and Jessup, 1994; Chezum and Wimmer, 1997; Neibergs and Thalheimer, 1997; Vickner and Koch, 2001; Robbins and Kennedy, 2001).

Notably, while investigating the absence or presence of adverse selection, Vickner and Koch (2001) include a variable to account for the number of same-sired progeny represented at the auction. The authors find that it is significantly negatively related to individual yearling hammer prices[3] at the 10% level. However, the coefficient estimate is only marginally economically significant; each additional same-sired progeny at the auction reduces an individual yearling's price by an average of $38.

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[2] A stud fee is the price paid by a mare owner for one breeding season to a stallion.

[3] The "hammer price" refers to the last price called by the auctioneer before the gavel strikes the wood. This may or may not result in a sale, depending on whether the yearling's reserve price was met. In our paper, we also use hammer price (rather than sales price), for consistency with Vickner and Koch (2001).

As alluded to earlier, we examine the impact of the number of same-sired progeny on a sire's average yearling price, whereas Vickner and Koch (2001) focus on individual yearling prices. This departure from Vickner and Koch is salient for the following reasons. First, from a marketing standpoint, stallion owners/managers often use average progeny sales price in advertising the merits and value of breeding to their stallion. Second, commercial breeders (mare owners who breed with the intent of selling the offspring) would consider the average value of a sire's progeny a useful metric in selecting sires to breed to their mares. Third, there is evidence that the market has changed dramatically in the past decade, and the relationship discovered by Vickner and Koch, whose study occurred before the time in which large book sizes became commonplace, may no longer be relevant.[4]

Empirical Model and Estimation Procedure

To determine the relationship between the number of same-sired progeny at a sale and average yearling price, a hedonic pricing model is employed. In such a model, the price of a good is a function of the quantity and quality of its attributes. In the context of this model, the value of a sire's yearlings, measured here by average price, is a factor of both sire quality and the (average) quality of the yearlings' dams as measured by a number of different attributes.

The general form of model to be estimated is

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

where y_i is the average hammer price for all progeny by sire i, $\mathbf{x}_i$ 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. The set of explanatory variables includes measures related to sire racing quality, sire progeny quality, dam racing quality, and dam progeny quality. In addition, we include individual-specific variables for sires; these variables indicate whether the yearlings at the sale are from the sire's first crop or second crop of foals as well as whether the sire stands outside the United States.

The next section identifies and defines the variables used in this study and presents the specific structural models to be estimated.

Data

Data from the 2008 Keeneland September yearling sales are obtained from the "Keeneland Sales Results" online database (Keeneland Association, Inc.). The database specifies whether each yearling was sold or not, the hammer price, and

[4] Finally, the change in specification should not influence the results; if the number of same-sired progeny at the sale affects an individual yearling's expected sales price by a given amount, it also affects the average sales price for all progeny from one sire by that same amount.

Table 1. Definitions of Variables and Their Expected Signs

Variable	Definition of Variable	Expected Sign
Dependent Variables:		
MEANHP	Mean of all hammer prices for all yearlings by one sire	N/A
MEDHP	Median of all hammer prices for all yearlings by one sire	N/A
Independent Variables:		
TOTAL	Total number of yearlings representing a sire at the sale	+/−
%OF_FOALCROP	*TOTAL* divided by the size of a sire's 2007 foal crop	+/−
STUDFEE	Sire's 2008 stud fee	+
EARN2008	Total progeny earnings for the 2008 racing season by sire	+
WNRS	Total number of progeny winning at least one race produced by a sire over the course of his breeding career	+
SWNRS	Total number of progeny winning at least one stakes race produced by a sire over the course of his breeding career	+
*GR*1*_2008*	Total number of Grade 1 stakes races that a sire's progeny have won in 2008	+
INTERNATIONAL	Dummy variable equal to 1 if the sire stands outside the U.S.	−
FIRSTCROP	Dummy variable equal to 1 if the sire's first crop of foals are yearlings	+
SECONDCROP	Dummy variable equal to 1 if the sire's second crop of foals are yearlings	+
SIRESW	Dummy variable equal to 1 if the sire won at least one stakes race	+
%DAMSW	The percentage of each sire's mares that have won at least one stakes race	+
%SIBSSW	The percentage of each sire's mares that have produced at least one stakes winner	+

the buyer and seller. At this sale, 5,555 Thoroughbred yearlings were listed in the sales catalog, with 3,605 ultimately selling. Supporting data are obtained from the Keeneland sales catalogs. The catalogs consist of detailed information for each yearling being sold and are made available, free of charge, to all visitors. The sales catalog page includes information regarding the yearling's foaling date, extended pedigree, racing performance of the sire and dam, and racing performance of related siblings. The *Blood-Horse Stallion Register Online* was used to collect data on advertised stud fees and progeny earnings. The *2009 American Produce Records* provided data regarding the racing performance of the yearlings' dams as well as the yearlings' siblings. The Jockey Club Online Publications and Resources publishes data on the number of mares bred and the number of live foals born each year. Names, definitions, and expected signs of variables used in the model are presented in table 1.

The dependent variable in models 1 and 2 is the natural log of the mean yearling hammer price for a given stallion, ln(*MEANHP*). The dependent variable in models 3 and 4 is the natural log of the median yearling hammer price for a given stallion, ln(*MEDHP*).

The independent variables of interest are measures which capture how prolific a sire is at the time of a sale in terms of how many progeny represent him. We consider two related measures: *TOTAL* and *%OF_FOALCROP*. *TOTAL* is simply the absolute number of a sire's progeny at the sale; this variable includes progeny which were sold, RNA, or out. The second measure, *%OF_FOALCROP*, considers the absolute number of progeny at the sale divided by the size of the sire's 2007 live foal crop.[5] We analyze this variable as well because it may not be that the absolute number of progeny at the sales matters. Instead, the relevant measure may be the percentage of a sire's foal crop presented for sale. Figures 1 and 2 illustrate the distribution of *TOTAL* and *%OF_FOALCROP*; both exhibit positive skew.

The remaining control variables have been used in other yearling pricing studies and include sire quality, dam quality, and individual sire characteristics. Measures related to sire quality include *STUDFEE*, which is the advertised stud fee for a sire in 2008. *EARN2008*, *GR*1*_2008*, *WNRS*, and *SWNRS* all correspond to the performance of a sire's progeny on the track. *EARN2008* constitutes the total earnings for all of a sire's progeny running in 2008, and *GR*1*_2008* represents the number of Grade 1 stakes races won by the sire's progeny in 2008. Both variables measure how well the sire's progeny have performed in the recent past. Cumulative measures of progeny racetrack performance include the number of race winners a sire has produced in his career at stud (*WNRS*), and the number of stakes winners a sire has produced in his career at stud (*SWNRS*). We expect all of these measures to be positively related to average price.

Mare quality variables include whether a dam is a stakes race winner and whether she has produced any stakes race winners. Since the unit of measurement here is by sire, these measures are averaged. More specifically, for the yearlings by one sire at the sale, *%DAMSW* is the percentage of their dams that won at least one stakes race. Similarly, for yearlings by one sire at the sale, *%SIBSSW* is the percentage of their dams which have produced at least one stakes winner. It is expected that these performance and quality indicators will be positively related to average price.

Finally, we incorporate individual-specific variables for each sire. The variable *INTERNATIONAL* indicates whether a stallion stands outside the United States. The sign on this variable is predicted to be negative; those in the Thoroughbred industry believe that the best sires (at least for U.S. racing) stand in the United States. One variable for the sire's own racetrack performance is included: *SIRESW*, which indicates whether a sire won at least one stakes race during his racing career. We also include *FIRSTCROP*, a dummy variable equal to 1 if a sire's first crop of foals are yearlings, and *SECONDCROP*, a dummy variable equal to 1 if a sire's second crop of foals are yearlings. We expect the coefficient estimates on these variables to be positive because, at least anecdotally, buyers of Thoroughbreds are willing to pay a premium for progeny by young sires. Summary statistics for these variables are presented in table 2.

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[5] Yearlings of 2008 are foals born in 2007.

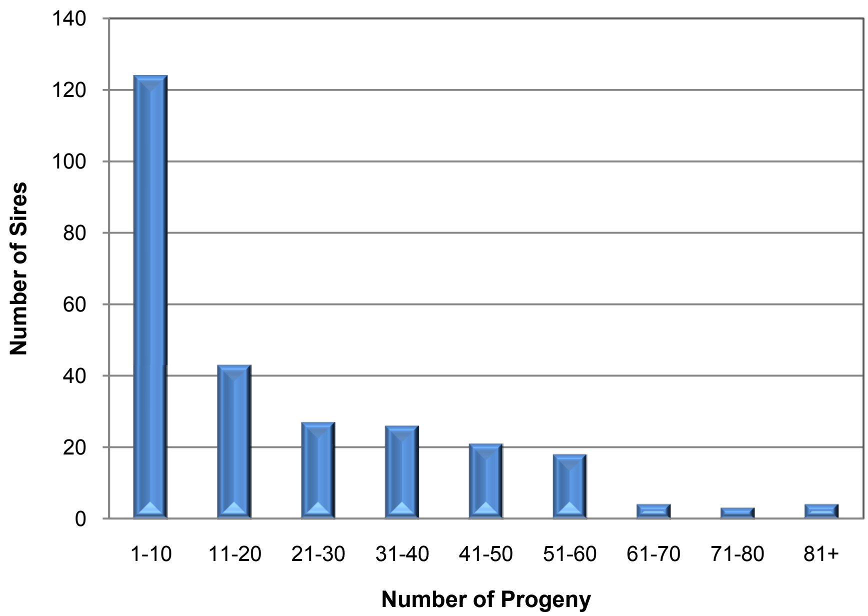

Figure 1. Distribution of same-sired progeny at 2008 Keeneland September yearling sales

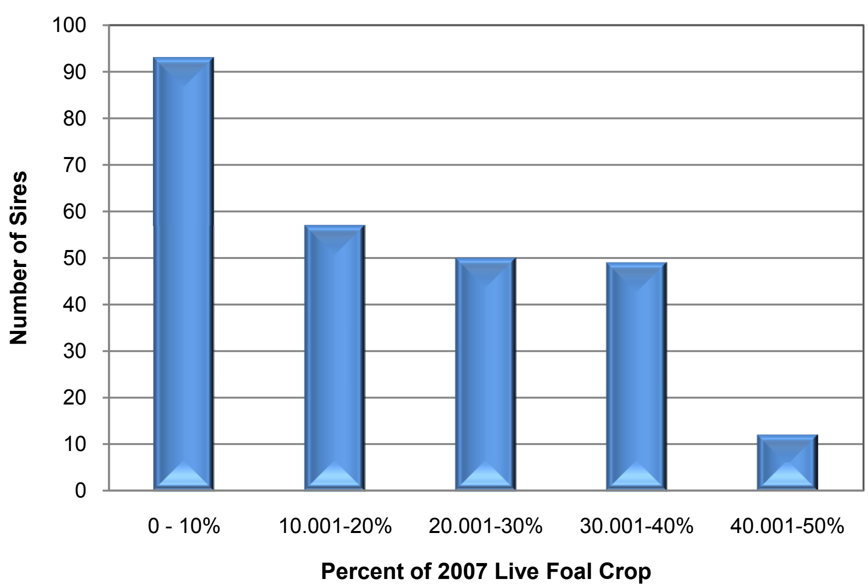

Figure 2. Distribution of same-sired progeny relative to 2007 live foal crop at 2008 Keeneland September yearling sales

Table 2. Summary Statistics for Dependent and Independent Variables

Variable	No. of Observs.	Mean	Std. Dev.	Minimum	Maximum
MEANHP	270	$53,950.69	$84,830.14	0	$736,250
MEDHP	270	$40,965.56	$69,986.04	0	$600,000
TOTAL	270	20.3	20.3	1	85
%OF_FOALCROP	261	18.4%	12.8%	0	50%
STUDFEE	270	$26,633.09	$43,856.63	$1,250	$300,000
EARN2008	270	$2,238,421	$2,508,479	0	$12,413,093
GR1_2008	270	0.17	0.55	0	4
WNRS	270	46.1	41.6	0	152
SWNRS	270	3.8	4.5	0	24
INTERNATIONAL	270	0.07	0.25	0	1
FIRSTCROP	270	0.16	0.37	0	1
SECONDCROP	270	0.17	0.38	0	1
SIRESW	270	0.93	0.26	0	1
%DAMSW	270	14.4%	16.6%	0	100%
%SIBSSW	270	18.9%	21.1%	0	100%

The mean of a sire's progeny's *mean* yearling hammer price (*MEANHP*) is $53,950.69, and the median is $26,525. The mean of a sire's progeny's *median* yearling hammer price (*MEDHP*) is $40,965.56, and the median is $18,250. These findings suggest the distribution of both mean and median hammer prices is positively skewed, which is typical for such data in this industry.

The 270 sires included in the data set are represented by a mean of 20 progeny (and a median of 12) at the 2008 Keeneland September yearling sales, with a minimum of 1 and a maximum of 85 progeny. On average, the number of progeny at the sale relative to the sire's 2007 live foal crop (*%OF_FOALCROP*) is 18%; one sire was represented by 50% of his foal crop at this sale.[6] Figures 1 and 2 illustrate the distribution of these two measures of sire representation at the 2008 Keeneland September yearling sales; both are positively skewed.

The average stud fee of the sires in the sample is over $26,000 (*STUDFEE*), and their progeny earned an average of over $2.2 million on the racetrack in 2008 (*EARN2008*). This includes about 46 winners (*WNRS*) and four stakes winners per sire (*SWNRS*). Ninety-three percent of the sires in the data set are stakes winners themselves (*SIRESW*), 7% stand internationally (*INTERNATIONAL*), 16% are represented by their first yearling crop (*FIRSTCROP*) at the 2008 Keeneland September yearling sales, and 17% are represented by their second yearling crop (*SECONDCROP*). On average, 14% of the mares bred to each sire had themselves

[6] The sample size is reduced to 261 sires when we use *%OF_FOALCROP* due to missing observations in the size of the 2007 foal crop.

won at least one stakes race (*%DAMSW*), and 19% of mares bred to each sire had produced at least one stakes-winning foal (*%SIBSSW*).

Given these variables, models 1–4 are specified as follows:

$$\begin{aligned}(1)\quad \ln(MEANHP_i) = {} & \beta_0 + \beta_1 TOTAL_i + \beta_2 \ln(STUDFEE_i) + \beta_3 EARN2008_i \\ & + \beta_4 GR1\_2008_i + \beta_5 WNRS_i + \beta_6 SWNRS_i \\ & + \beta_7 INTERNATIONAL_i + \beta_8 FIRSTCROP_i \\ & + \beta_9 SECONDCROP_i + \beta_{10} SIRESW_i \\ & + \beta_{11} \%DAMSW_i + \beta_{12} \%SIBSSW_i + \varepsilon_i ,\end{aligned}$$

$$\begin{aligned}(2)\quad \ln(MEANHP_i) = {} & \beta_0 + \beta_1 \%OF\_FOALCROP_i + \beta_2 \ln(STUDFEE_i) \\ & + \beta_3 EARN2008_i + \beta_4 GR1\_2008_i + \beta_5 WNRS_i \\ & + \beta_6 SWNRS_i + \beta_7 INTERNATIONAL_i + \beta_8 FIRSTCROP_i \\ & + \beta_9 SECONDCROP_i + \beta_{10} SIRESW_i + \beta_{11} \%DAMSW_i \\ & + \beta_{12} \%SIBSSW_i + \varepsilon_i ,\end{aligned}$$

$$\begin{aligned}(3)\quad \ln(MEDHP_i) = {} & \beta_0 + \beta_1 TOTAL_i + \beta_2 \ln(STUDFEE_i) + \beta_3 EARN2008_i \\ & + \beta_4 GR1\_2008_i + \beta_5 WNRS_i + \beta_6 SWNRS_i \\ & + \beta_7 INTERNATIONAL_i + \beta_8 FIRSTCROP_i \\ & + \beta_9 SECONDCROP_i + \beta_{10} SIRESW_i + \beta_{11} \%DAMSW_i \\ & + \beta_{12} \%SIBSSW_i + \varepsilon_i ,\end{aligned}$$

$$\begin{aligned}(4)\quad \ln(MEDHP_i) = {} & \beta_0 + \beta_1 \%OF\_FOALCROP_i + \beta_2 \ln(STUDFEE_i) \\ & + \beta_3 EARN2008_i + \beta_4 GR1\_2008_i + \beta_5 WNRS_i + \beta_6 SWNRS_i \\ & + \beta_7 INTERNATIONAL_i + \beta_8 FIRSTCROP_i \\ & + \beta_9 SECONDCROP_i + \beta_{10} SIRESW_i + \beta_{11} \%DAMSW_i \\ & + \beta_{12} \%SIBSSW_i + \varepsilon_i .\end{aligned}$$

In our data, heteroskedasticity may be a problem due to factors unobservable to the econometrician, such as general conformation of each sire's progeny. Moreover, the dependent variable in all regressions is an average measure. We employ weighted OLS, where the weights are equal to the number of progeny used in calculating the average price for each sire, to account for heteroskedasticity. Results from models 1–4 are presented in the next section.

Results and Discussion

Results from the four regression models are reported in table 3. First, we examine the independent variables of interest: *TOTAL* in models 1 and 3 and *%OF_FOALCROP* in models 2 and 4. The coefficient estimates are positive and significant at

Table 3. Regression Results for Weighted OLS Regressions in Models 1–4

Variable	**Model 1** DV: ln(*MEANHP*)	**Model 2** DV: ln(*MEANHP*)	**Model 3** DV: ln(*MEDHP*)	**Model 4** DV: ln(*MEDHP*)
TOTAL	0.004**	—	0.003	—
	(0.002)		(0.002)	
%OF_FOALCROP	—	1.083***	—	0.942***
		(0.275)		(0.316)
ln(*STUDFEE*)	0.695***	0.615***	0.783***	0.700***
	(0.050)	(0.054)	(0.057)	(0.063)
EARN2008 [a]	0.003	0.004	0.002	0.004
	(0.004)	(0.004)	(0.004)	(0.004)
GR1_2008	0.072	0.057	0.062	0.044
	(0.053)	(0.052)	(0.060)	(0.060)
WNRS	−0.000	−0.000	−0.001	−0.001
	(0.002)	(0.002)	(0.002)	(0.002)
SWNRS	0.021*	0.023**	0.018	0.020
	(0.011)	(0.011)	(0.012)	(0.012)
INTERNATIONAL	0.066	−0.013	0.040	−0.107
	(0.273)	(0.317)	(0.311)	(0.365)
FIRSTCROP	0.282**	0.351***	0.116	0.152
	(0.123)	(0.113)	(0.140)	(0.130)
SECONDCROP	0.279**	0.306***	0.228*	0.243*
	(0.112)	(0.109)	(0.127)	(0.125)
SIRESW	0.013	−0.109	−0.037	−0.152
	(0.254)	(0.256)	(0.289)	(0.294)
%DAMSW	0.579**	0.698**	0.616*	0.706**
	(0.288)	(0.289)	(0.328)	(0.332)
%SIBSSW	0.928***	0.955***	0.892***	0.932***
	(0.274)	(0.275)	(0.312)	(0.316)
Constant	3.020***	3.547***	1.920***	2.493***
	(0.492)	(0.502)	(0.560)	(0.577)
No. of observations	270	261	270	261
Adjusted R^2	0.8009	0.8133	0.7757	0.7860
F-statistic	91.19	95.39	78.54	80.59
Prob > F	0.000	0.000	0.000	0.000

Notes: Single, double, and triple asterisks (*,**,***) denote statistical significance at the 10%, 5%, and 1% levels, respectively. Values in parentheses are standard errors.

[a] The variable *EARN2008* was scaled by a factor of 10^{-5}.

the 5% level or better in models 1, 2, and 4, but insignificant in model 3. Taken together, these results suggest that, in contrast to Vickner and Koch (2001), measures related to the number of same-sired progeny at the sale are *positively* related to the average hammer price of those progeny. One explanation for this divergence in results may be due to changes in the market. The greater number of progeny by sires may be a signal of increased demand for the progeny of those sires and, moreover, that the increase in demand dominates the increase in supply, thus driving up average prices.

Of particular interest is that *TOTAL* is a significant predictor only of mean hammer prices (model 1), whereas *%OF_FOALCROP* is a significant predictor of both mean and median hammer prices (models 2 and 4). This raises the question as to why the relationship between *TOTAL* and median hammer prices is insignificant. To understand this result, it is first helpful to recall how *TOTAL* and *%OF_FOALCROP* differently capture the extent to which a sire is represented at the sale. *TOTAL* represents the absolute number of same-sired progeny at the sale, while *%OF_FOALCROP* represents the number of same-sired progeny at the sale relative to a sire's total foal crop in the relevant year. For example, for a sire with 25 yearlings at the sale out of a foal crop of 75, *TOTAL* = 25 and *%OF_FOALCROP* = 33%, whereas for a sire with 10 yearlings at the sale out of a foal crop of 20, *TOTAL* = 10 and *%OF_FOALCROP* = 50%.

TOTAL is significantly correlated with the size of a sire's foal crop ($r = 0.827$, $p < 0.0001$), as is *%OF_FOALCROP* ($r = 0.4638$, $p < 0.0001$). Clearly, however, the former relationship is stronger. As observed in table 4, *TOTAL* and the size of the 2007 live foal crop (as well as *%OF_FOALCROP*) are also increasing in stud fee. Those sires at the upper end of the stud fee distribution, with the largest foal crop sizes, are known as commercial sires; they attract a larger number of mares, and the progeny are often produced with the intent of being sold at auction. As such, these sires have higher odds of attracting the highest quality mares, and consequently, these sires are more likely to produce one or two "home-run" foals that sell well above their average. Hence, producing one or two outliers affects the mean but not the median measure of average hammer price.

Next, we note that the natural log of *STUDFEE* is positive and highly significant in all four models. This result is common in the literature. All else equal, the quality of the sire positively contributes to the average hammer price of his progeny. However, in all four models, the estimated elasticities are significantly less than one at the 5% level, indicating that a 1% increase in a sire's stud fee results in a less than 1% increase in average prices.

Both recent and cumulative racing quality of a sire's progeny are insignificant with the exception of the total number of stakes winners produced. Coefficient estimates are positive and significant at the 10% level or better in predicting mean hammer prices. When examining individual characteristics of the sire, *FIRSTCROP* is positive and significant in models 1 and 2, but are nowhere near conventional levels of significance in models 3 and 4. *SECONDCROP* is positive and significant at the 10% level or better in all four models. As noted earlier, at least anecdotally, some buyers of Thoroughbreds are willing to pay a premium for sires of unknown quality. These results support that notion. Interestingly, the variable *FIRSTCROP* is significant in predicting mean prices but not median prices. One possible explanation for this finding is that a buyer may be willing to pay a relatively high price for one or two of the best foals from a sire's first crop, because usually only

Table 4. Means for *TOTAL*, *%OF_FOALCROP*, and 2007 Live Foal Crop by Stud Fee Category

Stud Fee Category	No. of Observs.	*TOTAL*	*%OF_FOALCROP*	2007 Live Foal Crop
< $5,000	38	1.71	9.8%	25.4
$5,000–$9,999	109	6.61	14.2%	48.3
$10,000–$14,999	44	16.7	23.4%	68.4
$15,000–$24,999	33	27.8	35.9%	71.5
$25,000–$49,999	51	31.7	43.6%	79.8
$50,000–$99,999	19	42.1	52.5%	88.6
≥ $100,000	18	37.6	47.0%	92.1

the most fashionable new sires are represented by their progeny at the Keeneland September yearling sales. Again, this influences mean but not median prices. The premium indicated by the *SECONDCROP* coefficient is consistent across all four models and may exist due to an especially attractive set of sires (in particular, the entering sires of 2005).

The average quality of mares bred to each sire is also significant in predicting both mean and median prices. Coefficient estimates for %*DAMSW* are positive and significant at the 10% level or better in all four models, and estimates for %*SIBSSW* are positive and significant at the 1% level in all models.

Results from models 1 and 3 suggest that a greater absolute supply of same-sired progeny at the sales does not diminish the average value of a sire's yearlings, and may actually increase the mean hammer price for a sire's progeny. Findings from models 2 and 4 reveal that a greater supply of same-sired progeny relative to foal crop sizes results in higher mean and median hammer prices of a sire's yearlings. Taken together, we can infer that the demand for those sires' progeny must have increased more than supply to yield a higher mean price.

Results from models 1 and 3, which are comparable to those in Vickner and Koch (2001), contradict their finding of a negative and significant relationship (at the 10% level) between the number of progeny at the sale and the expected hammer price for an individual yearling. Our model 3 indicates an insignificant relationship between sire representation and median prices, and our model 1 indicates a positive and significant relationship (at the 5% level) between sire representation and mean prices. Moreover, our result implies slightly greater economic significance. Vickner and Koch estimate that each additional same-sired progeny at the auction reduces an individual yearling's expected price by $38. In contrast, our result suggests that each additional same-sired progeny increases the mean hammer price for a sire's yearlings by over $215. One potential reason for the divergence in results is, as noted earlier, Vickner and Koch use 1999 Keeneland September yearling sales data. The landscape of the Thoroughbred industry may have changed sufficiently in the past decade such that the relationship identified in their research no longer exists and may even have been reversed.

Table 5. Sample Correlations Between Sire Representation, RNAs, and Outs

		Measure of Representation	
		TOTAL	*%OF_FOALCROP*
Measure of Outs and RNAs	*OUT%*	−0.1061 ($p < 0.05$)	−0.2065 ($p < 0.01$)
	RNA%	0.2421 ($p < 0.0001$)	0.0503 ($p < 0.42$)

Impact of Sire Representation on RNAs and Outs

In the previous sections, we have considered the relationship between sire representation and average prices of yearlings that either were sold or did not meet their reserve prices. A related question is if the number of same-sired progeny at the sale influences whether a yearling does not meet its reserve price or is taken out of the sale. Let *RNA* be the number of yearlings for each sire that do not meet their reserve price, and let *OUT* be the number of yearlings for each sire that are taken out of the sale. Dividing both variables by *TOTAL* (denoted *RNA%* and *OUT%*) yields an estimate of the probability a progeny by one sire will not meet its reserve price or will be taken out of the sale, respectively.

Table 5 presents the sample correlations and significance of those correlations. *OUT%* is negatively correlated with both measures of representation, *TOTAL* and *%OF_FOALCROP*, at the 5% level and better. Hence, based on this sample, we find that the more prolific a sire is at the September sale, the less likely one of his yearlings will be removed from the sale. The results on *RNA* are different, however. The sample correlation between *RNA%* and *TOTAL* is 0.2421 ($p < 0.0001$), which suggests there is a positive relationship between the number of same-sired progeny at the sale and the likelihood that a yearling by that sire will not meet its reserve price. The correlation between *RNA%* and *%OF_FOALCROP* is not significant.

To summarize this brief analysis, yearlings by more well-represented sires, as measured by *TOTAL* and *%OF_FOALCROP*, are less likely to be taken out of the sale, thus providing the breeder a greater opportunity to realize a return on investment. However, the likelihood of a yearling not meeting its reserve price is more likely among these same sires. Since *TOTAL* is positively related to hammer prices, this may be due to overestimation by the yearling owners of the demand for and hence the market value of their horse, which then causes the owners to set reserve prices too high.

Summary

Stallion owners and managers, who need to maximize profit from their breeding operation, and commercial breeders, who need to maximize return on investment from the foals they breed and sell, should be interested in how the number of same-sired progeny at a sale affects the value of the foal. In this paper, we investigate this relationship and find that three of our four models support the notion that greater sire representation at the sale increases the average price of that sire's yearlings. There is no significant relationship in the fourth model. Further, more same-sired progeny at the sale decreases the likelihood that a yearling is removed from the sale but may increase the likelihood that it does not meet its reserve price.

Because a greater supply of foals by the same sire does not reduce their value, and in most cases actually increases their value, the emergence and persistence of breeding policies over the past decade at many Thoroughbred stallion farms in which sires cover increasingly large numbers of mares is better understood. Therefore, to the extent the market for Thoroughbreds has remained stable, one would expect stallion owners/managers to continue breeding their sires to large numbers of mares.

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