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Maximum-Likelihood Estimates of Racehorse Earnings and Profitability

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Thoroughbred racehorses are commonly characterized as unprofitable investments. Previous studies, grouping all racehorses together, estimate that over 80% of all racehorses in training fail to earn enough to recover the variable costs of training. However, these studies are not truly representative, because they fail to account for a number of factors affecting profitability. This study estimates expected purse earnings and profitability of claiming horses in Kentucky. Maximum-likelihood estimates of probability distribution parameters show that expected purse earnings follow an exponential distribution with a mean of $25,267. Profitability is best described by a Gamma distribution with a mean of $4,824. Of the 305 claims analyzed for profitability, 61% were profitable. The results indicate substantial financial risk associated with claiming race horses, but conclude that there are positive economic returns on average.

Key Words: claiming horses, financial risk, maximum likelihood, probability, profitability, thoroughbred

Racehorse ownership has long been characterized as a high-risk, unprofitable investment. The negative profitability expectation has been enhanced by industry analyses that group all horses together and conclude that over 80% of all horses in training fail to earn enough to recover the variable costs of training (Simon). However, these analyses fail to account for the fixed costs of investment, the terminal value of the racehorse, the length of ownership, differences in racehorse quality, and differences in regional purse structure—each of which may dramatically affect profitability. Typically, the economic justification of a racehorse investment is the expected utility gained from racehorse ownership.

Many equine consultants recommend to a prospective racehorse investor that, as a conservative estimate, if the investor cannot risk the entire initial investment and variable cost of training, then potential racehorse ownership should be reconsidered (Green and Green). This is a primary concern for the thoroughbred industry. Owners are the central economic agent as consumers of thoroughbred blood-stock, and they

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provide the primary input in producing horse races—the horses. It has been shown that field size (the number of horses running in a race) is a primary wagering determinant. As field size increases, there are more betting opportunities, which increases handle (the amount of parimutuel wagers) (Thalheimer and Ali). This, in turn, increases purses—a factor which is a primary demand determinant of thoroughbred blood-stock (Neibergs and Thalheimer).

Potential owners would be best served by providing them an accurate profitability analysis to better identify the level of risk, and the potential profitability associated with a racehorse investment. The business objective of most racehorse owners is to increase their investment to purchase higher class[1] horses in order to race for the higher purses associated with higher quality races. However, there is limited empirical analysis examining the profitability of thoroughbred racehorses, or the financial feasibility of investing in higher class horses. The objective of this study is to use probability analysis to estimate the purse earnings and profitability of claiming racehorses in Kentucky.

The Claiming Rule and Claiming Purses

Claiming races/horses represent a quality classification. A claiming race requires, as a condition of entering the race, that every horse be offered for sale at a claiming price stipulated in the race conditions. For example, if the claiming price for a given race is set at $10,000, all horses entered in the race can be purchased (i.e., claimed) for $10,000 by an eligible buyer. All claims are made prior to the start of the race, and the track does not reveal which, if any, of the horses have been purchased until after the finish of the race. If a horse is claimed, transfer of ownership occurs when the horse starts the race, but any purse money the horse wins in the race is paid to the original owner who entered the horse in the race.

Claiming races/horses are considered to be lower quality. A ranking of races/horses from highest to lowest quality would be: (*a*) graded stakes, (*b*) stakes, (*c*) allowance, (*d*) maiden, and (*e*) claiming races. Quality of claiming races/horses can be further classified by claiming price. A lower claiming price reflects lower quality. Claiming races serve two important functions. They provide a racehorse market which allows investors to purchase/liquidate racehorse investments, and claiming races are a market-based method of handicapping[2] horses to create an even field.

[1] Class refers to the quality of a horse. As a horse increases in class, it increases in quality and competes in higher quality races that correspond to higher purses. Class is directly correlated with the value of a horse.

[2] Handicapping in this instance refers to a racing official specifying race conditions that match horses of equal caliber to create an "even" field for wagering purposes. The more even the field, the less variation in wagering odds between the horses most likely and least likely to win the race. An even field improves parimutuel wagering, because one horse will not dominate wagering patterns and the race results. For exotic wagering where the bettor selects multiple horses, an even field increases the number of likely wagering combinations, which increases both handle and payoffs to winning bettors. The word handicap is also used to refer to the analysis of factors in past performances of horses to determine their likelihood of winning the race in which they are currently entered.

In Kentucky, the majority of horse races are claiming races (see figure 1). Claiming races comprise 54% of all races run, or about twice the number of allowance races, which account for 28% of the number of races. Maiden races and stake races comprise 14% and 5%, respectively, of the number of races run. As identified in figure 1 (panel B), the distribution of the number of races does not match the purse distribution. Allowance and stake races have a disproportionately larger share of purses (40% and 25%, respectively) relative to the number of races. Claiming races comprise 20% of the purse distribution, followed by maiden races at 15%. The large number of claiming races and the relatively small distribution of purses means that claiming races have relatively small per race purses.

The distribution of claiming races and purses across claiming price is illustrated in figure 2. Purse levels are directly correlated with race class. The lowest range of claiming price has the largest number of races (576), and the lowest average purse per race ($7,668). As claiming price increases, purses increase. Claiming races with a claiming price range of $10,000–$15,000 have an average purse of $11,633, with 331 races. The highest group of claiming prices (greater than $15,000) has 498 races and an average purse per race of $16,154.

A Model of Claiming Horse Profitability

Claiming horses provide a unique opportunity to analyze profitability. All of the data necessary to calculate profitability are publically disclosed: the initial purchase price of the horse, purse earnings of each horse, the terminal value of the horse, and the number of days the horse was owned between the initial claim and the ending claim terminating the horse investment. The earning potential of a claiming horse is from earning purse money by finishing the race as one of the top five finishers in the race plus the probability of being claimed at the specified claiming price of the race in which the horse is entered. The expected earnings, *E*, of a claiming horse can be specified as:

$$E = bPS + cCP_t. \tag{1}$$

Here, *bPS* is purse earnings, where *b* is the probability of earning purse money (*P*) times the number of starts the horse makes (*S*). *P* varies dependent on the class of the race and the finishing position of the horse. Expected earnings also include the terminal value of the investment, defined as the probability of being sold (*c*) at investment terminating claiming price (CP_t). Earnings are constrained by two factors. First, the number of starts (*S*) a horse can make is limited, because horses require some time following a race to regain their strength. Second, a horse is constrained by its class, which limits *P* and CP_t. Because of the very low probability of winning *P* and earning CP_t while sacrificing *S*,[3] a horse is not raced at a higher

[3] Parameters *b* and *c* approach zero.

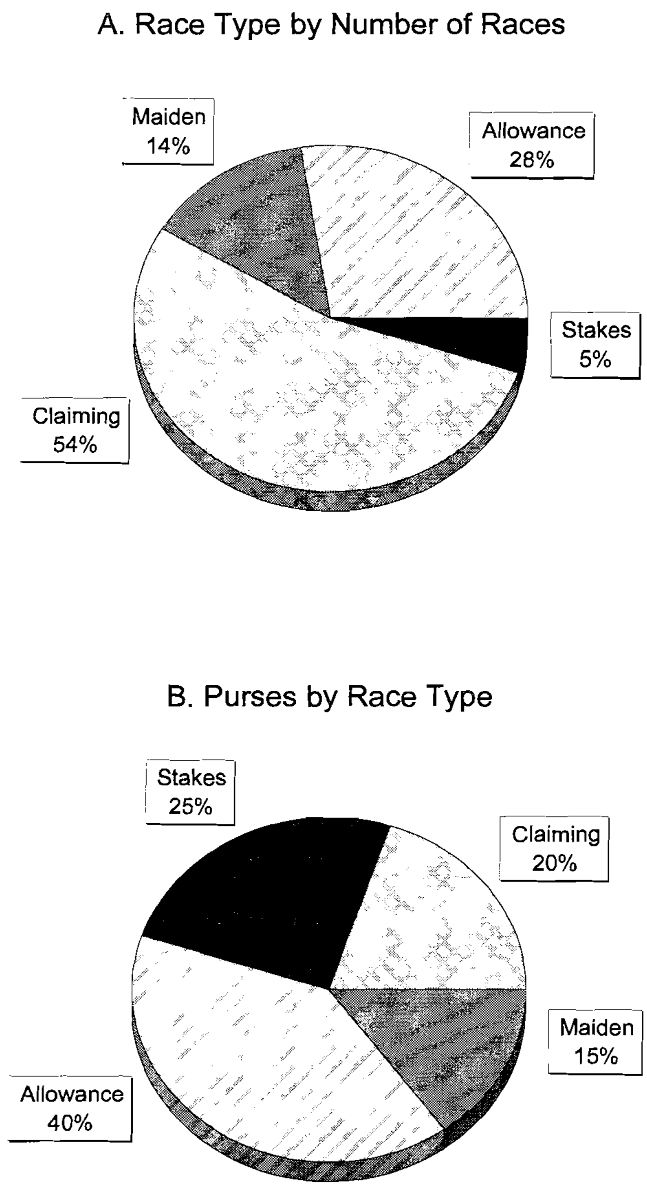

Figure 1. Distribution of race type and purses by quality class in Kentucky (1995)

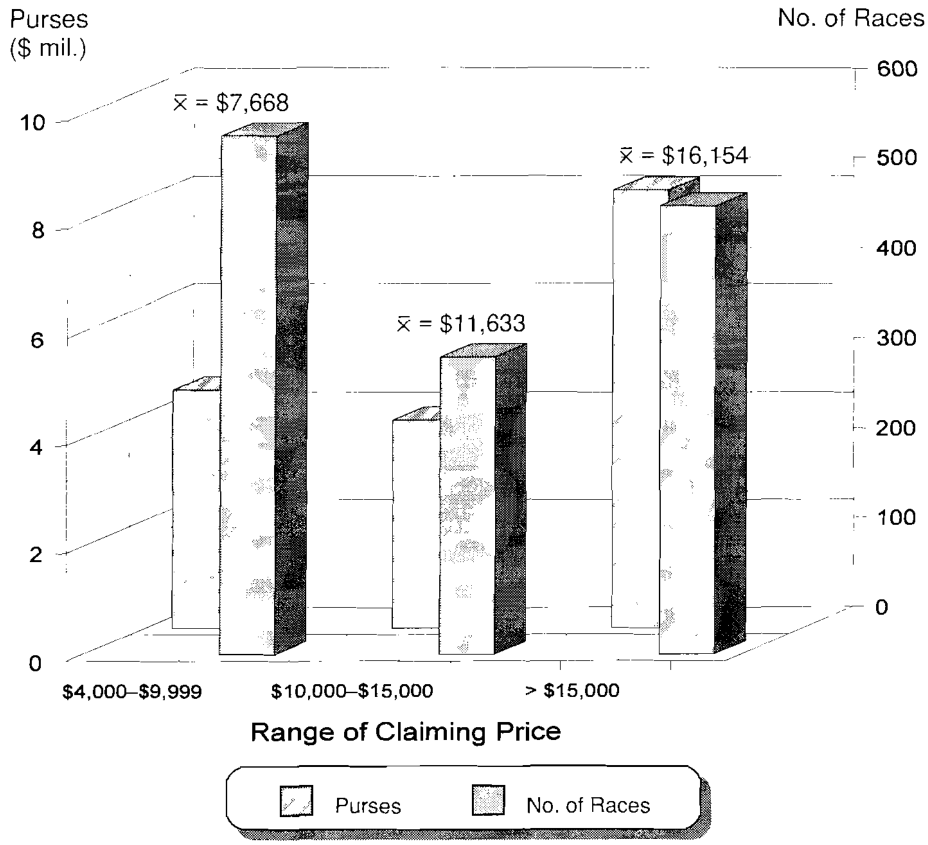

Figure 2. Distribution of claiming races and purses by claiming price in Kentucky (1995)

class than its ability. Conversely, a higher class horse running in a lower class race has a high probability of earning P, but due to the astute nature of the market, that horse has a high probability of being claimed at a lower CP_t than its potential; thus, the owner sacrifices terminal value and potential future purse earnings.

The profitability of a claiming horse investment can be specified as follows:

$$\pi = E - CP_i - DR, \qquad (2)$$

where the initial investment to purchase the claiming horse (CP_i), and the number of days the horse is owned (D) times the cost per day of maintaining the racehorse (R), are subtracted from expected earnings to calculate claiming horse profitability.[4]

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[4] The cost per day (R) used in this study is $50. This is comparable to the average daily training fee of $41.77 for thoroughbreds in Kentucky over a similar time frame of data analysis (Lawrence and Thalheimer).

Data Sources and Analysis Procedures

The *Daily Racing Form* charts provide a complete summary of each race run in North America. The charts provide data on the conditions of the race such as the claiming price, purse level, the names of all horses making a start in the race, any horses that were claimed in the race, and the earnings of the top finishing horses. By tracking the charts over time, a database of all horses claimed in Kentucky in 1995 was developed. The claiming horse database was merged with the *Daily Racing Form*/KIII Data Services database to determine claiming horse purse earnings (*bPS*). There were 559 horses claimed over the year which were used to estimate a probability density function (pdf) describing *bPS* using maximum-likelihood methods. A maximum-likelihood estimate (MLE) of pdf parameters maximizes the probability of obtaining the sample actually observed (Judge et al.). Of the 559 horses claimed, 305 were claimed more than once. This provides all data necessary to estimate the pdf describing π. MLE parameters for 26 alternative pdf's for *bPS* and π were evaluated and ranked for goodness of fit using χ^2, Kolmogorov-Smirnov, and Anderson-Darling test statistics.

Results and Discussion

MLE pdf parameters are presented in table 1. The results indicate that *bPS* is best described by an exponential distribution, and π is best described by a Gamma distribution.[5] Figure 3 (panels A and B) presents the data and the estimated pdf for both expected purse earnings and expected profitability, respectively. The exponential distribution for purse earnings is consistent with expectations for racehorse purse earnings, i.e., there is a high probability of low purse earnings, and a low probability of high purse earnings. Purse earnings ranged from $0 to $220,050. Both the mean of the sample data and the first moment of the distribution are $25,267. The parameter b in earnings equation (1) averaged over all horses in the study is 0.69. This indicates that, on average, the claiming horses in this study earned some purse money by placing in the top five finishing positions in 69% of their starts.[6] Purse money earned per start per individual varies greatly based on place of finish and the purse of the race. The likelihood of being claimed in each start is relatively low. The parameter c in equation (1) is 0.11.[7] Given the large difference in likelihoods of

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[5] The exponential pdf is $f(x) = \frac{e(-x/\beta)}{\beta}$; the Gamma pdf is $f(x) = \frac{\beta^{-\alpha}x^{\alpha-1}e(-x/\beta)}{\Gamma(\alpha)}$.

The domain requirement for Gamma distribution is $x \geq 0$. Since π has negative observations, the data were shifted. The pdf's were fit with respect to the shifted data, and the appropriate shift factor is appended to the estimated distribution parameters (Palisade Corporation).

[6] The 559 claiming horses analyzed made 8,197 starts and earned purse money in 5,668 starts, resulting in a 0.69 purse earning rate per start.

[7] The 8,197 starts made by the horses in the data set resulted in 864 claims (559 + 305), resulting in a 0.105 claiming rate per start.

Table 1. Maximum-Likelihood Parameter Estimates of Claiming Horse Purse Earnings and Profitability

Description	Purse Earnings (bPS)	Profitability (π)
Sample Data:		
Number of observations (n)	559	305
Mean	25,267	4,840
Standard deviation	23,084	15,910
Variance	5.3e+08	2.5e+08
Minimum	0	−26,979
Maximum	220,050	100,250
Density Function Parameters:		
Type of distribution	Exponential	Gamma
alpha (α)	NA	3.542
beta (β)	25,267.110	8,984.669
Domain shift factor[a]	NA	−27,000
Goodness-of-Fit Statistics:		
χ^2	25.877**	17.810**
Kolmogorov-Smirnov	2.238	1.347*
Anderson-Darling	1.278*	3.682**
Estimated Distribution Moments:		
Mean	25,267	4,824
Variance	6.4e+08	2.9e+08

Note: Single and double asterisks (*) denote significance at the 0.10 and 0.05 levels, respectively.

[a] To adhere to the pdf domain requirements, the sample data are shifted and MLE calculations performed on the shifted data. The shift factor must be accounted for in calculating distribution moments. For example, the distribution mean $\alpha\beta$ is calculated as $(3.542 * 8{,}984.7) - 27{,}000$.

earnings versus being claimed, we feel that b and c are sufficiently independent to be analyzed in the manner specified.

Of the 305 claiming horses evaluated for profitability, 185, or 61%, were profitable ($\pi > 0$). The sample data on claiming horse profitability averaged $4,840, and ranged from a loss of $26,979 to a profit of $100,250. The first moment of the estimated Gamma distribution is $4,824. The results identify substantial financial risk associated with claiming racehorses, but conclude that there are positive economic returns on average.

These findings are imperative to the thoroughbred industry, because they identify a class of racehorses with a relatively high probability of profitability. The results

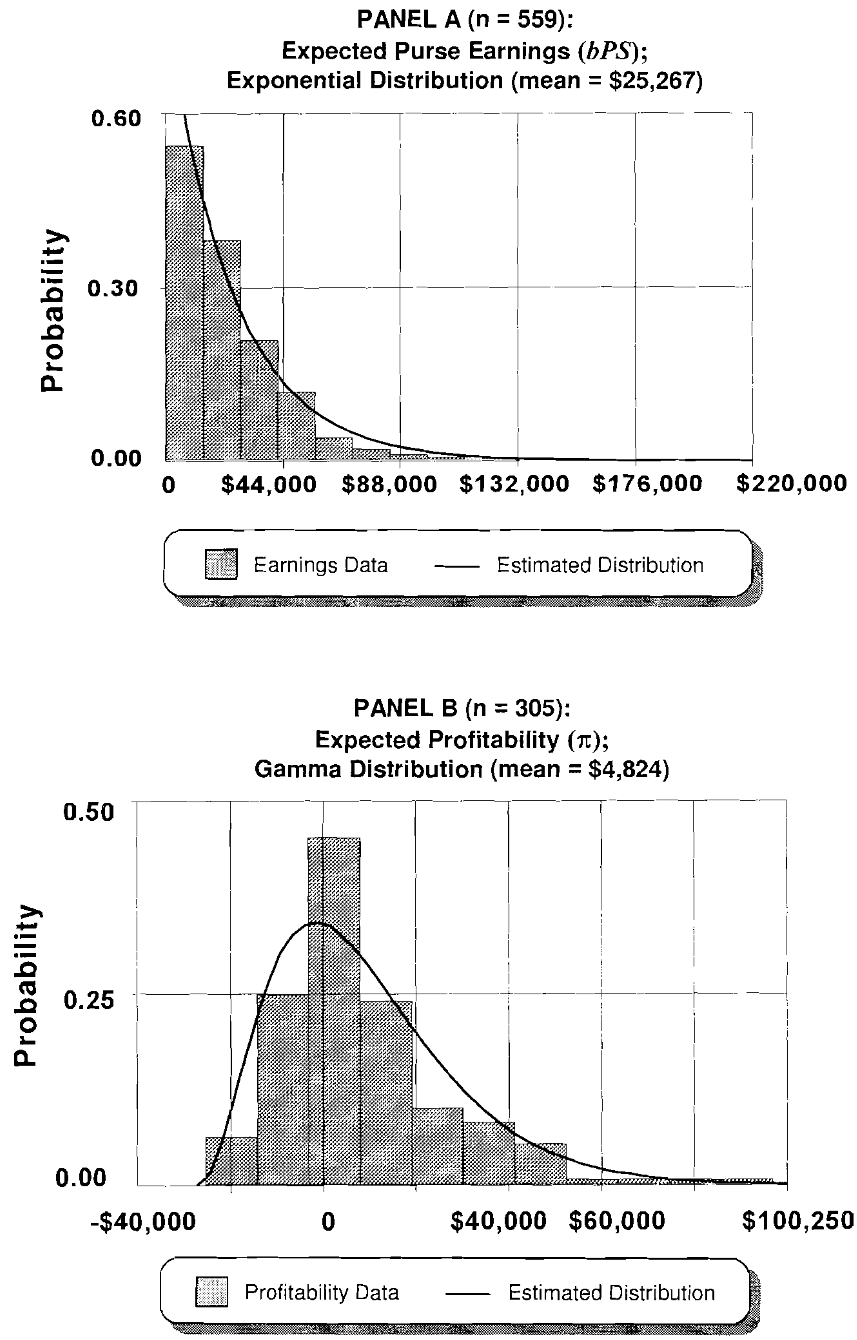

Figure 3. MLE earnings and profitability probability density graphs

Table 2. Claiming Horse Profitability by Claiming Class

Claiming Horse Class (CP_i)	n	Average Earnings (bPS)	Average Profitability (π)	Probability of Profitability	Purse-to-CP_i Ratio	ANOVA Results[a] (H_0: $\pi = 0$)
\$4,000–\$9,999	128	\$9,122	\$4,173	68%	1.32	$\chi^2 = 5.33$**
\$10,000–\$15,000	98	\$11,989	\$4,740	59%	1.01	$\chi^2 = 4.92$**
> \$15,000	79	\$21,813	\$6,046	51%	0.79	$\chi^2 = 2.91$*

Note: Single and double asterisks (*) denote significance at the 0.10 and 0.05 levels, respectively.

[a] ANOVA results are based on the likelihood-ratio test.

provide a quantitative tool for investors to develop a financial risk analysis of probable claiming horse purse earnings and profitability. Statistically the results are interesting, given the unique relationship between the Gamma and exponential density functions. Using the notations provided in footnote 5, the exponential pdf is a special case of the Gamma pdf where $\alpha = 1$.

Table 2 further breaks down the analysis of profitability by looking at three classes of claiming horses: (*a*) the lowest quality class, where CP_i ranges from \$4,000 to \$9,999; (*b*) a middle class of \$10,000 to \$15,000; and (*c*) the highest class, where CP_i is greater than \$15,000. There are a number of interesting points concerning claiming horse profitability. First, ANOVA results show that the profitability of each of the three classes is significantly greater than zero. ANOVA results are based on the likelihood-ratio test.[8] The calculated χ^2 for each claiming class (5.33, 4.92, and 2.91, respectively) shows that π is significantly greater than zero.

Second, average earnings increase from \$9,122 to \$21,813, and profitability increases from \$4,173 to \$6,046 as claiming class increases (table 2). For the claiming horses in this study, this provides a justification for the recommendation to invest in a higher class of horse to improve profitability as a result of the higher purses for higher class horses, although the gain is relatively small. The lowest class of claiming horses has the greatest probability of profitability, because the purse-to-CP_i ratio of 1.32 is greatest for the lowest claiming class. This means that purses relative to the initial investment cost of the horse are greater for the lowest claiming class, which allows investors in this class of horse a greater opportunity to recapture their investment through purse earnings. Risk-averse investors would be best advised to invest in this class of horse.

Table 3 provides additional information for racehorse investors who would like to know how many times their horse is likely to start, the number of days they will own the horse, and if their investment is likely to increase or decrease in value. A

[8] The likelihood-ratio test statistic (LR) is given by: $LR = -2[L(\pi = 0) - L(\pi)] \sim \chi^2$ to test the restriction H_0: $\pi = 0$, where $L(\cdot)$ is the maximum value of the log-likelihood function for the restricted or unrestricted model evaluated for each class of claiming horses (Judge et al.).

Table 3. Average Number of Starts, Days Between Claims, and Change in Claiming Price, by Claiming Class

Claiming Horse Class (CP_i)	n	Starts Between Claims (S)	Days Between Claims (D)	Change in Claiming Price (CP_t - CP_i)
\$4,000–\$9,999	128	5	114	\$773
\$10,000–\$15,000	98	6	130	-\$768
> \$15,000	79	8	186	-\$6,487

primary motivation of a racehorse investor is to watch the horse compete in races. The number of starts ranges from five to eight, which directly corresponds to the number of days the horse is owned between claims (114 to 186 days). For each claiming class, each horse on average made about one start for each 23 days of ownership. A longer period of ownership, 72 days, is associated with the highest claiming class in comparison to the lowest claiming class. There appears to be no advantage to owning one claiming class of horse over another relative to the number of starts a horse makes.

A primary economic motivation of investing in claiming horses is the speculation that they will increase in value. The success of this speculation is measured, on average, by the change in claiming price. The lowest claiming horse class is the only class that shows an increase in value, but only \$773. The highest claiming class reflects a loss in value of \$6,487. However, this loss may be overstated, because horses in this class are the most likely to increase in class to an allowance/stake horse. The variable CP_t is unavailable for allowance/stake horses, and those horses are therefore not included in the data.

Conclusions

Our investigation of the profitability of claiming horses found that there is a relatively high probability of profitability for this class of horses. ANOVA results show that average claiming horse profitability is significantly greater than zero. Furthermore, the lowest quality class of claiming horses, where CP_i ranges from \$4,000 to \$9,999, maximizes the likelihood of profitability due to a high purse-to-CP_i ratio, and an increase in speculative value of \$773. This information is useful to the thoroughbred industry in addressing one of its most challenging problems—attracting new owners. It is difficult to entice investors into this industry because of the perceived barriers to entry of high capital investment and unprofitability. This analysis shows that a relatively low capital investment provides a relatively high probability of profitability in which both variable and fixed costs are recovered.

There are a number of limitations associated with this study, as well as recommendations for future research. First, the profitability of a claiming horse is determined by the individual horse's performance. The results presented in this study are averages based on the range of profitable and unprofitable individual horses' performance. The results identify substantial financial risk associated with individual horses, although on average claiming horses were profitable. Second, these findings are unique to Kentucky, because the horses' earnings were based on Kentucky's purse distribution. As the purse distribution varies between classes of horses across states, so too will profitability. Also, the profitability analysis was limited to the 305 horses claimed more than once, out of the possible 559 horses claimed in Kentucky in 1995. Further research is needed to identify the factors that contribute to a horse being claimed multiple times. The 254 horses that were not evaluated for profitability (because CP_t was not available) have a number of potential outcomes: (*a*) the claiming horse improved to an allowance/stakes class; (*b*) the claiming horse is still in training, but has not been reclaimed; or (*c*) the claiming horse was retired for breeding or because of poor performance. Each outcome has alternative potential for profitability.

Subsequent to the time period analyzed in this study, Kentucky revised its claiming regulations so that a claimed horse may not make a start for 30 days in which the claiming price is less than 25% more than the price for which the horse was claimed.[9] This regulation may affect a claiming horse's number of starts, earnings, and its likelihood of being claimed. The effects of the change in regulation could be tested against the results from this study when data become available.

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[9] The Kentucky Racing Commission voted to amend the claiming regulations on April 8, 1998, with the new regulations becoming effective October 12, 1998.

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