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The effort effects of prizes in the second half of tournaments

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Abstract

The theory of tournaments predicts that a worker's effort depends on the difference between the winning and losing prizes, as well as the degree that increases in effort affect the probability of winning. This paper tests these predictions using a data set from Arabian horse racing. Jockeys increase their efforts (lower their times) in the second half of races when the amount of prize money lost by dropping a place is greater and when there is less distance between them and their closest competitors. These findings are consistent with the theory.

JEL classification: J33; J4

Keywords: Tournaments; Compensation; Incentives

1. Introduction

This paper uses a new data set from Arabian horse racing to examine the incentive effects of prize money in tournaments, compensation schemes where workers are paid based on their performance relative to their co-workers' performance. By providing an incentive

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structure for workers, tournaments align the interests of the agents (employees) with those of the principal (employer).

While a horse race is a good example of a tournament, the theory has applications for more conventional labor markets. For example, in corporations vice presidents compete for a single CEO position. In this example the much higher salary of the CEO may be more of a prize for winning the promotion than a reflection of the CEO's higher productivity. Similarly, in law firms, associates compete to make partner, at universities assistant professors compete to make tenure, and architecture firms compete for contracts to design public buildings and monuments.[1]

The theory of tournaments predicts that workers' efforts will be greater when (i) the difference between the winning and losing prizes is greater, and (ii) increases in effort have a larger positive effect on the probability of winning. This paper uses a new and unique data set from Arabian horse racing to test these predictions. The main conclusion of the paper is that jockeys increase their efforts (lower their times) in the second half of races when (i) the amount of prize money lost by dropping a place is greater and (ii) there is less distance between them and their closest competitors. These findings support the tournament model and add to a growing empirical literature on tournaments.

The paper proceeds as follows. Section 2 outlines the main results from the theoretical and empirical literatures on tournaments. Section 3 describes the data set, and Section 4 contains the empirical results. Concluding remarks appear in the final section.

2. Tournament literature

The theoretical literature on tournaments is replete with testable hypotheses.[2] First, Lazear and Rosen show that while the decision to enter a tournament depends on the absolute level of prize money, the decision of how much effort to exert during the tournament does not. The level of effort depends, instead, on the difference between the prizes awarded to the various places as well as the degree to which the worker's effort affects the worker's probability of winning or improving a place. In the context of horse racing, a jockey in first or second place during a race will exert more effort when the difference between first place prize money and second place prize money is greater. Furthermore, this jockey's effort will be greater in a race where the horses are bunched together and less in a race where the field is more spread out.

A second hypothesis from the theory is that mixed or uneven tournaments that match workers of different abilities are inefficient. Here, if worker ability is known to all workers, both the low-ability worker and the high-ability worker will put forth less effort.[3]

Horse racing organizers have recognized the inefficiencies of uneven tournaments and use handicapping, sorting and race restrictions to make races more competitive. Most horse

[1] These examples are outlined in more detail in Lazear (1998, pp. 237–242).

[2] Only the hypotheses relevant to this paper are presented here. For more on the theory of tournaments, see Lazear and Rosen (1981), Green and Stokey (1983), Nalebuff and Stiglitz (1983), Rosen (1988), O'Keeffe et al. (1984), or for a nice survey of this literature see McLaughlin (1988).

[3] See McLaughlin (1988).

races are designed to attract a more homogeneous field of entrants. For example, in some races horses are assigned different weight burdens to give slower horses a better chance of winning. In others races all the horses entered are for sale for a pre-specified amount. There are also races that are exclusively for horses that have never won a race.[4] Finally, many races are restricted to horses of a particular gender or age. This also ensures that the horses within a race are of similar quality.

There is also a growing empirical literature that tests the theory of tournaments.[5] The results of these tests are mixed. For example, in experiments using economics students as volunteers, Bull et al. found that in even tournaments the amount of effort put forth by the players was consistent with the theory. However, in uneven tournaments the low-ability players put forth too much effort.

Several of the tests of the theory have used data from professional sports. Ehrenberg and Bognanno (1990a,b) find golf scores in professional tournaments to be inversely related to total prize money that is proportional to prize spreads. However, Orszag uses the Ehrenberg and Bognanno model and a different data set and finds no relationship between golf scores and total prize money. The results of a study by Becker and Huselid showing a positive relationship between driver performance and prize spreads in auto racing support the theory. However, an empirical analysis of professional road racing by Lynch and Zax is generally not supportive of the theory; their results suggest that races with larger prizes record faster times because they attract faster runners, not because the larger prize spreads encourage all runners to run faster.

As indicated above, the results of the empirical studies are quite mixed, demonstrating that further tests of the theory in different settings with new data would be desirable. This paper provides such a test using a new and unique data set to add to the growing empirical literature on tournaments.

3. The data

The data used in this paper come from the Arabian Jockey Club, a national non-profit organization that promotes Arabian Horse Racing in the United States. The original data set contains data on all Arabian horse races in the U.S. and Canada in 1991–1995.

For each horse in each race the data set includes, among other variables, the horse's name, the jockey's name, the horse's age, weight carried, finishing time, finishing place, winnings, and odds of winning. In addition to finishing times and places, the data set also includes each horse's time and place at the 1/4 and 1/2 mile points of each race. The distances, in horse lengths, between horses at the 1/4 and 1/2 mile points are also included in the data.

For each race the data include the name of the race, the total amount of prize money, the name of the racetrack, track conditions, the distance of the race, race restrictions and the type of race.

[4] The different race types are described in more detail in Section 3.

[5] See, for example, Becker and Huselid (1992), Bull et al. (1987), Ehrenberg and Bognanno (1990a,b), Knoeber and Thurman (1994), Orszag (1994) and Lynch and Zax (2000).

There are five different types of races: stakes, allowance, handicap, claiming, and maiden. The stakes race is the most prestigious type of race and pays the highest prizes. In these races, owners pay an entry fee to nominate and run their horses. The Kentucky Derby is an example of a stakes race for thoroughbred horses.[6]

Allowance races pay lower prizes and are less prestigious than stakes races. To make these races more competitive, horses are required to carry more or less weight depending on their age or racing record.[7] These weight adjustments are made by placing or removing lead weights from the saddle.

Similar to allowance races, in a handicap race the racing secretary evaluates the past performance of the each entrant individually and assigns weights to burden the faster horses.[8]

In a claiming race, all of the horses entered are for sale for a pre-specified amount. A claimed horse becomes the property of the new owner once the race begins. However, any prize money won goes to the previous owner.

Finally, a maiden race is a race for horses that have never won a race. These different types of races are designed to reduce the inefficiencies of uneven tournaments.

Race organizers also use race restrictions to make races more competitive. All of the different types of races outlined above may be restricted to horses of a particular age or gender or both. For example some races are restricted to horses that are four year olds and older. Others may be restricted to colts and geldings or fillies and mares of different age groups.[9]

Table 1 presents the descriptive statistics, by race distance, for the samples used in this paper. One furlong is equal to one-eight of a mile. The samples only include observations for the race distances shown at the top of Table 1 because the number of observations at the other distances are too small for the analyses in the following section. Each observation in Table 1 represents a particular horse and jockey in a particular race. The races occurred over 1991–1995.

The times, ages and weights are measured in seconds, years and pounds, respectively. The weight carried by the horse includes the weight of the jockey, the saddle, and lead bars placed inside the saddle to burden faster horses.

The odds of winning are expressed as the dollar return on a one-dollar bet. The variables ‘number of previous races by horse,’ ‘number of previous races by jockey,’ ‘number of top three finishes by horse,’ and ‘number of top three finishes by jockey’ include all races from the beginning of 1991 until the race in question.

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[6] Thoroughbred horses are generally faster than Arabians. These two types of horses often race at the same racetracks on the same day but always in separate races.

[7] For example, in a recent allowance race three years olds that had won a race in the last month were required to carry at least 117 pounds while those over three years old that had won a race in the last month were required to carry at least 122 pounds. Horses that had not won a race in the past month were allowed a reduction of three pounds while those that had not won in the last two months were allowed a reduction of five pounds.

[8] Each racetrack has a track secretary. In addition to assigning weights in handicap races the track secretary prepares the condition book, which is a list of proposed future races, including the race type and distance, that owners may enter their horses.

[9] A colt is a young male horse and a gelding is a castrated horse. A filly is a young female horse and a mare is a mature female horse.

Table 1
Sample means for horses

	5.5 Furlong	6 Furlong	7 Furlong	8 Furlong
Quarter-mile time	25.84 (1.485)	25.71 (1.507)	25.84 (0.8405)	27.16 (0.9597)
Half-mile time	53.12 (1.623)	53.05 (1.756)	52.72 (1.200)	54.28 (1.676)
Finishing time	76.62 (2.373)	83.92 (2.780)	97.71 (2.597)	115.4 (3.114)
Weight carried	119.3 (3.040)	118.0 (3.651)	118.4 (3.513)	115.7 (4.360)
Age	4.872 (1.657)	4.852 (1.725)	5.409 (1.695)	4.938 (1.732)
Odds of winning	15.21 (18.60)	17.29 (23.51)	14.74 (18.02)	14.35 (15.42)
Number of previous races by horse	9.060 (10.27)	11.65 (12.24)	18.31 (14.01)	16.95 (15.20)
Number of top three finishes by horse	3.745 (4.994)	5.011 (6.096)	9.562 (8.288)	6.937 (7.085)
Number of previous races by jockey	84.80 (105.2)	108.3 (139.6)	124.2 (143.5)	103.2 (108.0)
Number of top three finishes by jockey	35.07 (46.09)	44.96 (63.29)	52.60 (66.07)	41.45 (43.37)
Prize money lost (1/4 mile)	300.6 (500.1)	363.2 (1210)	492.1 (1144)	309.4 (689.8)
Prize money gained (1/4 mile)	445.5 (611.1)	541.3 (1470)	749.9 (1464)	529.6 (1169)
Prize money lost (1/2 mile)	253.3 (453.0)	301.7 (1002)	445.4 (1027)	305.9 (709.9)
Prize money gained (1/2 mile)	345.7 (546.9)	415.8 (1207)	645.5 (1163)	442.1 (829.0)
Number of horses	522	1595	357	171
Number of jockeys	213	522	173	98
Number of observations	1905	10657	1337	532

Note: Standard deviations are in parentheses.

'Prize money lost (1/2 mile)' is how much prize money horse *i* and jockey *j* would lose in race *t* if they dropped back two horse lengths from their 1/2 mile position relative to the rest of the field. For example, suppose horse *i* and jockey *j* are in first place at the 1/2 mile mark in race *t*. If the second and third place horses in race *t* are one and three horse lengths behind horse *i* and jockey *j* respectively, then the value of 'prize money lost (1/2 mile)' for horse *i* and jockey *j* in race *t* is the difference between first and second place prize money. Similarly, 'prize money gained' is how much prize money a horse and jockey would gain if they improved their position by two horse lengths relative to the rest of the field.

It follows that 'prize money lost (1/4 mile)' and 'prize money gained (1/4 mile)' are based on the position of, and the distance between, the horses at the 1/4-mile mark.[10] For all four distances, the mean of 'prize money lost (1/4 mile)' is greater than the mean of 'prize money lost (1/2 mile)' because the horses start the race bunched together and tend to spread out as the race progresses. This same relationship exists between the means of the prize money gained variables, for the same reason.

[10] These marginal return to effort variables, which I will also refer to as the prize difference variables, are similar to those used by Ehrenberg and Bognanno (1990a,b) in their analysis of the incentive effects in professional golf.

Table 2
Means of race-specific variables by distance

	5.5 Furlong	6 Furlong	7 Furlong	8 Furlong
Quarter-mile time of first place horse	25.19 (1.645)	24.91 (1.298)	25.14 (0.5863)	26.13 (0.6154)
Half-mile time of first place horse	52.32 (1.594)	51.98 (1.549)	51.91 (0.9701)	53.42 (2.825)
Finishing time of first place horse	74.77 (1.663)	81.84 (1.885)	95.89 (1.895)	112.8 (2.006)
Total prize money	3194 (1255)	4947 (12020)	5628 (5438)	5751 (6158)
Herfindahl index of prizes	0.3907 (0.02154)	0.3904 (0.03345)	0.3866 (0.03177)	0.3971 (0.04933)
Number of races	321	1374	229	113

Note: Standard deviations are in parentheses.

Table 2 contains descriptive statistics for race-specific variables. The average times in Table 2 which are for first place horses only are lower than those in Table 1 which include all horses. Total prize money is the total dollar amount of prize money awarded to all the places in each race. The Herfindahl index of prizes is the sum of the square of the percentage of total prize money awarded to each place. This index measures dispersion in the entire prize structure of a race and is bound by zero and one.

4. Results

Tables 3–5 present estimates of several different versions of Eq. (1) for four different distances.

$$\begin{aligned}\text{finishing time}_{ijt} = {} & \alpha_0 + \alpha_1 \text{ split time}_{ijt} + \alpha_2 \text{ previous races jockey}_{jt} \\ & + \alpha_3 \text{ top 3 finishes jockey}_{jt} + \alpha_4 \text{ previous races horse}_{it} \\ & + \alpha_5 \text{ top 3 finishes horse}_{it} + \alpha_6 \text{ weight carried}_{ijt} \\ & + \alpha_7 \text{ odds of winning}_{ijt} + \alpha_8 \text{ total prize money}_t \\ & + \alpha_9 \text{ Herfindahl index}_t + \alpha_{10} \text{ prize money lost}_{ijt} \\ & + \alpha_{11} \text{ prize money gained}_{ijt} + \beta' D + u_{ijt}. \end{aligned} \tag{1}$$

In these tables the dependent variable is finishing time$_{ijt}$, which is horse i and jockey j's finishing time in race t.[11] However, in the specification in Table 3 the variables split time, prize money lost and prize money gained are based on the 1/4 mile time, and the place and position of the horse and jockey in question. In Table 4 these variables are based on the horse and jockey's time, place and position at 1/2 mile. Table 5 adds quadratic terms for prize

[11] The split time could be subtracted from the finishing time making the dependent variable the time elapsed between the 1/4 mile or 1/2 mile mark and the end of the race. However, this restricts the coefficient on split time to be one. In the model in Eq. 1 the coefficient on split time is unrestricted.

Table 3
Regression results for 1/4 mile split times linear specification

	5.5 Furlong	6 Furlong	7 Furlong	8 Furlong
Quarter-mile time	0.1244*** (6.51)	0.07882*** (12.34)	0.1825*** (3.92)	0.3394*** (3.27)
Number of previous races by jockey	−0.00394 (0.84)	−0.00169 (1.13)	0.00424 (0.97)	0.01717 (1.47)
Number of top three finishes by jockey	0.01391 (1.43)	0.003984 (1.27)	−0.00705 (0.76)	−0.0348 (1.28)
Number of previous races by horse	−0.03893** (1.97)	−0.04089*** (6.04)	−0.00514 (0.28)	−0.1051** (1.98)
Number of top three finishes by horse	−0.02432 (0.72)	0.01161 (0.99)	−0.02561 (0.91)	0.0609 (0.71)
Weight carried	0.003276 (0.13)	−0.00833 (1.10)	0.02302 (1.1)	0.07837* (1.78)
Odds of winning	−0.00081 (0.29)	0.005886*** (6.22)	0.005316 (1.4)	−0.00883 (0.76)
Total prize money	−0.00023* (1.96)	−0.00000338* (1.94)	0.000007592 (0.45)	−0.00019 (1.28)
Herfindahl index of prizes	−23.07 (0.96)	−1.909** (2.04)	−4.086 (1.30)	−2.459 (0.15)
Prize money lost	−0.00010** (2.10)	−0.00001 (1.58)	−0.00002 (0.65)	−0.00018 (1.40)
Prize money gained	−0.00004 (1.18)	−0.00000459 (0.84)	0.000002005 (0.11)	0.000037 (0.58)
Track conditions (omitted condition: ‘Fast’)				
Good	1.647*** (7.24)	1.723*** (12.60)	2.430*** (8.52)	−0.1860 (0.35)
Heavy		5.865*** (6.04)		
Muddy	1.460*** (5.03)	0.8073*** (5.78)	1.396*** (2.89)	−0.9464 (1.13)
Slow		2.866*** (6.83)		3.682* (1.76)
Sloppy	0.7997*** (3.07)	1.261*** (13.94)	2.529*** (7.51)	0.6439 (1.16)
Types of races (omitted race type: ‘Stakes’)				
Alowance	−2.641 (1.63)	0.09028 (0.86)	−0.2163 (1.05)	−1.995** (2.51)
Claiming	−3.010* (1.75)	0.2857** (2.41)	−0.5202** (1.99)	−3.072*** (3.34)
Handicap		−0.4180 (0.43)		
Maiden	−2.870* (1.68)	0.6075*** (5.07)	0.3412 (0.77)	−2.357** (2.37)
Race restrictions (omitted restriction: ‘Three Year Olds and Up’)				
3 year olds	0.4325 (1.37)	0.5472*** (3.81)		−0.03611 (0.03)
3–4 year olds		−0.1282 (0.12)		
3–5 year olds	−3.317*** (4.21)	1.075 (1.35)		
3 year olds Fillies and Mares	0.5543 (1.24)	0.3470** (2.06)	1.062 (0.83)	0.8755 (0.42)
3 year olds and up Fillies and Mares	−0.07443 (0.35)	−0.05994 (0.65)	0.1716 (0.54)	−1.043 (1.15)
3 year olds Colts and Geldings		0.7199*** (3.73)	−1.483** (2.46)	2.367 (1.30)
3 year olds and up Colts and Geldings		0.5703** (2.04)	1.088 (1.21)	4.593 (0.91)
4 year olds		0.2554 (0.87)	0.2822 (0.57)	−2.425 (0.97)
4 year olds and up	−0.3452 (1.48)	0.3434*** (2.71)	0.4276* (1.77)	−0.7963 (0.92)
4 year olds Fillies and Mares		0.5545 (0.77)	−0.3105 (0.57)	
4 year olds and up Fillies and Mares	−0.2687 (0.54)	−0.0509 (0.17)		
4 year olds Colts and Geldings			−1.458** (2.22)	
5 year olds and Up				−0.1679 (0.04)

Table 3 (*Continued*)

	5.5 Furlong	6 Furlong	7 Furlong	8 Furlong
Years (omitted year: '1991')				
1992	−0.2905 (1.31)	−0.1249 (1.20)	0.09400v	2.921*** (2.78)
1993	0.001548 (0.00)	0.3377** (2.37)	−0.02024 (0.05)	3.964** (2.54)
1994	1.225** (2.22)	1.364*** (7.48)	1.043* (1.90)	4.873** (2.52)
1995	0.9133 (1.32)	1.130*** (4.91)	0.6445 (0.97)	4.651** (2.02)
N	1,905	10,657	1,337	532

Note: Parentheses contain *t*-statistics. Regressions include jockey and horse effects.
* Indicate significance at the 10% level.
** Indicate significance at the 5% level.
*** Indicate significance at the 1% level.

Table 4
Regression results for 1/2 mile split times linear specification

	5.5 Furlong	6 Furlong	7 Furlong	8 Furlong
Total prize money	−0.00022** (2.13)	−0.00000305* (1.93)	0.000007203 (0.49)	−0.00016 (1.23)
Herfindahl index of prizes	−16.59 (0.78)	−1.759** (2.05)	−3.631 (1.30)	−4.074 (0.28)
Prize money lost	−0.00012*** (2.63)	−0.00002*** (2.68)	−0.00003 (1.32)	−0.00015 (1.49)
Prize money gained	−0.00003 (1.00)	−0.0000044 (0.76)	−0.00001 (0.54)	0.000043 (0.54)
Correlation of residuals	0.9152	0.9384	0.9146	0.9242
Breusch–Pagan test of independence: χ^2 (1)	1,595.6***	9,384.5***	1,118.4***	4,54.4***
N	1,905	10,657	1,337	532

Note: Parentheses contain *t*-statistics. Regressions include horse and jockey effects as well as all control variables listed in Table 3. The estimates for these controls are qualitatively similar to those in Table 3 and, therefore, omitted from this table.
* Indicate significance at the 10% level.
** Indicate significance at the 5% level.
*** Indicate significance at the 1% level.

money lost and prize money gained to the specifications in Tables 3 and 4. The estimates for the control variables in the regressions in Tables 4 and 5 are qualitatively similar to those in Table 3 and are omitted from those tables.

D, in Eq. 1, is a vector of dummy variables. In order to control for unobserved differences in horse and jockey quality that are invariant across races, the estimated equation includes dummy variables for horses and jockeys.[12] The samples used in the regression analyses only include horses and jockeys that appear in at least two races.

D also includes dummy variables for racetracks and track conditions since these race-specific variables influence finishing times. There are 34 different racetracks in the data, and six different track conditions that are listed in Table 3.

[12] Not all of the horse and jockey effects are identified. That is, there are jockeys in the samples that only ride one horse and that horse is only ridden by that jockey. In the largest of the four samples, the 6 furlong sample, there are two such exclusive horse and jockey combinations representing 4 observations. While the individual horse and jockey effects in these cases are not separately estimable, their inclusion does control for horse and jockey quality.

Table 5
Regression results for quadratic specification

	5.5 Furlong	6 Furlong	7 Furlong	8 Furlong
Quarter-mile split times				
Total prize money	−0.00024** (1.99)	−0.0000034** (1.96)	0.000006238 (0.36)	−0.00019 (1.35)
Herfindahl index of prizes	−23.25 (0.97)	−1.913** (2.05)	−4.287 (1.36)	−3.517 (0.22)
Prize money lost	−0.00017** (1.96)	−0.00003** (2.42)	−0.00004 (0.80)	−0.00034 (1.39)
Prize money lost^2	3.753×10^{-8} (0.97)	5.95×10^{-10}* (1.83)	3.009×10^{-9} (0.66)	4.95×10^{-8} (0.90)
Prize money gained	−0.00006 (0.95)	−0.00000853 (0.94)	0.00000677 (0.21)	0.000072 (0.46)
Prize money gained^2	1.456×10^{-8} (0.48)	2.21×10^{-10} (0.78)	-3.26×10^{-10} (0.11)	-2.98×10^{-9} (0.14)
Half mile split times				
Total prize money	−0.00023** (2.15)	−0.00000306* (1.94)	0.000004928 (0.33)	−0.00013 (1.07)
Herfindahl index of prizes	−16.54 (0.78)	−1.771** (2.07)	−3.797 (1.36)	−3.213 (0.23)
Prize money lost	−0.0002** (2.46)	−0.00005*** (4.25)	−0.00009* (1.77)	−0.00058*** (3.06)
Prize money lost^2	3.943×10^{-8} (1.14)	1.097×10^{-9}*** (3.15)	9.279×10^{-9} (1.26)	1.048×10^{-7}** (2.38)
Prize money gained	−0.00006 (0.94)	−0.00002* (1.69)	−0.00003 (0.81)	−0.00006 (0.33)
Prize money gained^2	1.519×10^{-8} (0.58)	4.98×10^{-10}* (1.67)	3.231×10^{-9} (0.65)	4.423×10^{-8} (0.92)
Correlation of residuals	0.9128	0.9360	0.9104	0.8770
Breusch–Pagan test of independence: χ^2 (1)	1,587.3***	9,336.8***	1,108.1***	409.2***
N	1,905	10,657	1,337	532

Note: Parentheses contain *t*-statistics. Regressions include horse and jockey effects as well as all control variables listed in Table 3. The estimates for these controls are qualitatively similar to those in Table 3 and, therefore, omitted from this table.

* Indicate significance at the 10% level.

** Indicate significance at the 5% level.

*** Indicate significance at the 1% level.

To control for the quality of the field, the regression equation also includes dummy variables for the type of race and race restrictions. Section 3 contains a discussion of the various types of races and different race restrictions. These are also listed in Table 3. Furthermore, dummy variables for years appear on the right-hand side of Eq. (1) to control for any long-run trends in finishing times. Finally, u_{ijt} is the random disturbance term for horse i and jockey j in race t.

A logical next step, at this point, would be to estimate Eq. (1) using ordinary least squares (OLS). However, because the error terms in the 1/4 and 1/2 mile versions of Eq. (1) belong to the same set of horses and jockeys in the same races, they are most likely correlated. Therefore, to increase the efficiency of the estimates, these two versions of Eq. (1) are estimated together as a system of seemingly unrelated equations rather than by OLS.[13] The results of these seemingly unrelated regressions appear in Tables 3 and 4.

In Table 3 the coefficients on quarter-mile time are positive and significant for all of the four distances, indicating that higher 1/4-mile times lead to higher finishing times.

In almost all cases the number of previous races and number of previous top three finishes by the horse and the jockey are not significant. The exception is that the number of previous races by the horse is negative and significant at three of the four distances. This indicates that at these distances more experienced horses run faster. One reason for the lack of significance of these quality control variables is the presence of dummy variables for both horses and jockeys.[14]

Weight carried is significant only for the 8 furlong sample in Table 3. The general lack of significance here actually indicates that weight handicapping is working. The weight allowances increase the variation in weight carried while reducing the variation in finishing time.

The sign on the odds of winning variable, which measures the dollar return on a one-dollar bet, is positive and significant only at the 6 furlong distance. This demonstrates that, at this distance, horses that are more likely to win, according to the odds, are also more likely to

[13] In addition to OLS and seemingly unrelated regressions (SURE) there is a third method of estimation that warrants consideration. If the split times and prize difference variables in Eq. 1 are not exogenous, then an instrumental variable (IV) estimation technique would be more appropriate. The split times may be endogenous because they depend on, among other things, the prize structure, track conditions and the efforts of other competitors. The prize difference variables also may not be exogenous since they depend on the horse's split time, which depends in turn on the variables just mentioned. The appendix to this paper (available on the *Journal of Economic Behavior* & *Organization* website only) summarizes two-stage least squares and OLS estimates of the equations specified in Tables 3–5 and compares these estimates to the SURE estimates used in the body of the paper. The results of Hausman specification tests permit the rejection of the null hypothesis that the prize difference variables and split time are exogenous for 9 of the 16 equations estimated in Tables 3–5. Because of the mixed results of these tests and because of the questionable nature of the available instruments (i.e., they are probably correlated with both the regressor and the error term), only the SURE results are presented in the body of this paper.

[14] In Table 3 regressions that omit horse and jockey effects, the significance of these horse and jockey quality variables increases markedly. For example, at the 6 furlong distance the number of previous races by the jockey and the number of previous races by the horse become negative and significant at the 1% level. The number of top 3 finishes by the horse and number of top three finishes by the jockey both become positive and significant at the 1% level. Together these results indicate that a horse or jockey is expected to be slower with the more races the horse or jockey has to enter in order to achieve a given number of top three finishes.

run faster. One possible explanation for the lack of significance at the other distances is that the odds of winning variable is a measure of expected relative performance, not absolute performance. Therefore, it may be a good predictor of finishing places but not always a good predictor of finishing times.

Total prize money is negative and significant at the 5.5 and 6 furlong distances. At first this result may seem to contradict the theory of tournaments where the difference in prizes, not the level of prizes, affects the level of effort. However, when the Herfindahl index of prizes, which measures the dispersion of prizes, is held constant, increases in total prize money reflect larger prize differences. For the 5.5 and 6 furlong distances these larger prize differences produce faster times as predicted by the theory.

In the 5.5 furlong distance, the coefficient on prize money lost in Table 3 is negative and significant. This result is consistent with the theory of tournaments. This variable represents the amount of prize money that would be lost if a horse and jockey dropped 2 horse lengths from their 1/4-mile position. For the 5.5 furlong distance an increase in prize money lost of US$ 10,000 decreases finishing times by one second or 1.3% of the average 5.5 furlong finishing time. While prize money lost is not significant at the remaining distances in Table 3, it is negative and significant for both the 5.5 and 6 furlong distances in Table 4, which presents the results for the 1/2 mile version of Eq. (1). Together, these two distances makeup 87% of the total number of observations for all four distances.

Prize money gained, on the other hand, is not significant at any distance in Table 3 or Table 4. This implies that jockeys respond more to potential losses than they do to potential gains. While this result may not be completely consistent with the theory of tournaments, it is consistent with diminishing marginal utility where utility falls more when a dollar is lost than it rises when a dollar is gained.

The sign, magnitude and significance of the remaining control variables in Table 3 seem mostly plausible. For example, most of the coefficients for track conditions are positive and very significant, indicating that these track conditions, especially 'heavy' and 'slow,' are slower than the omitted track condition which is 'fast.' Furthermore, at the 6 furlong distance, which represents 74% of all the observations, the coefficients for the claiming and maiden race types are both positive and significant. This result suggests that, all else equal, times in these types of races are slower than in the omitted race type, which is the more prestigious stakes race. Finally, the horse and jockey dummy variables included in Table 3 regressions are both jointly significant for all of the distances.[15]

The correlations of the residuals of the 1/4 and 1/2 mile versions of Eq. (1) reported in Table 4 are all large, positive and significant. The significance of the Breusch–Pagan test

[15] One interesting question worth examining is how much of the variation in finishing times is explained by differences in horses and how much is explained by differences in jockeys. This analysis is along the lines of work done by Abowd et al. (1999) in which they decompose wage variation into the portion explained by firm effects and the portion explained by person effects. For the 6 furlong distance, three OLS regressions (one with horse effects only, one with jockey effects only and one with both horse and jockey effects) produce R^2 of 0.5912, 0.2031 and 0.6577 respectively. This result, which is similar to those at the other race distances, indicates that more of the variation in finishing times is explained by differences in horses than by differences in jockeys. However, the fact that the R^2 do not "add up" demonstrates that the jockey and horse effects are correlated.

statistic allows the rejection of the null hypothesis that there is no correlation between the equation errors and indicates that seemingly unrelated regressions (SURE) is an appropriate estimation technique.

Table 5 reports SURE results with quadratic terms for prize money lost and prize money gained for both the 1/4 mile and 1/2 mile specifications.[16] For the 1/4 mile specification the linear and quadratic terms for prize money lost are negative and positive respectively for all four distances. Both terms are significant at the 6 furlong distance and jointly significant at the 5.5 furlong distance.

For the 1/2 mile specification, the signs on the linear and quadratic terms for prize money lost are also negative and positive, respectively as well as individually or jointly, significant at all four distances. Furthermore, the sign and significance of the prize money gained variables at the 6 furlong distance show that jockeys also respond to potential gains.

To summarize Table 5, an increase in prize money lost from US$ 0 to 1000 decreases finishing times by between 0.04% and 0.41% of average finishing times. The positive quadratic terms indicate that these effects diminish as the amount of prize money at stake increases.[17] That is to say, any attempt by race organizers to induce greater effort by increasing the differences between prizes, or by taking measures to make the race “tighter,” is subject to diminishing returns.

5. Conclusion

This paper uses a new and unique data set to examine the incentive effects of tournament reward structures in Arabian horse racing. The data confirms two predictions from the theory of tournaments. First, effort in tournaments is greater when the prize differences are larger. Moreover, this effect is independent of the level of prizes. Second, effort is greater when increases in effort significantly increase the probability of winning or improving a place. For example, a potential loss of US$ 10,000 in prize money lowers finishing times by 1.6% in races of 5.5 furlongs. Furthermore, regressions with nonlinear specifications suggest that these effort effects increase at a diminishing rate as the prize spread increases. These results add to a growing literature testing the theory of tournaments and may have implications for organizations using tournament reward structures.

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[16] Other nonlinear functional forms, including the use of discrete prize variable classes, yield results that are qualitatively similar to those in Table 5.

[17] The coefficients in Table 5 imply that at very large levels, increases in prize money lost actually increase finishing times. However, these levels occur outside of the range of over 98% of the data points.

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Appendix A

Table A.1 presents OLS and two-stage least squares (2SLS) estimates of the split time and prize difference variables for the specification in Table 3. In the 2SLS regressions instruments for split times and the prize difference variables were created from the remaining right-hand side variables in Eq. (1) and the number of previous races by the horse's trainer, the number of previous top three finishes by the horse's trainer, the horse's post position, post position squared, pre-race prize difference, and pre-race prize difference squared.

The post position is the position of the stall in the starting gate from which a horse starts a race. A horse with a post position of one, which is the position closest to the inside of the racetrack, has a slight advantage over horses in higher post positions. These later horses start further away from the inside of the racetrack and, therefore, must travel a slightly greater distance to get to the finish line. The post position for each horse is determined by chance through a drawing before each race.

The pre-race prize difference is the amount of money that would be lost if a horse and jockey finished one place below their pre-race ranking. The pre-race ranking is based on the odds of winning. For example, if horse *i* and jockey *j* in race *t* are the most likely to win, according to the odds, then horse *i* and jockey *j* are assigned a pre-race prize difference equal to the difference between first and second place prize money in race *t*.

In the majority of cases in Table A.1 the OLS estimates of the prize difference variables are both more significant and smaller in magnitude than the 2SLS estimates. However, the results of the Hausman specification tests shown in Table A.1 permit the rejection of the null hypothesis that the prize difference variables and split time are exogenous for two of the four distances.

The OLS and 2SLS results for the remaining 12 specifications from Tables 4 and 5 are similar to those in Table A.1 (i.e., most of the OLS estimates of the prize difference variables are more significant and smaller in magnitude than the 2SLS estimates), and in roughly half the cases, 7 out of the 12 specifications, the null hypothesis that the split time and prize variables are exogenous can be rejected. These results, which are not displayed in tables, are available from the author upon request.

The SURE estimates of the prize difference variables presented in Tables 3–5 are more similar in sign, magnitude, and significance to the OLS estimates. While the standard errors of the SURE estimates are mostly lower, the OLS estimates are larger in magnitude and more significant. Nevertheless, both sets of results support the theory of tournaments.

Because of the increased efficiency of the SURE estimates, along with the mixed results of the Hausman specification tests and the questionable nature of the available instruments (i.e., they are probably correlated with both the regressor and the error term), only the SURE results are presented in the body of the paper.

Table A.1
OLS and 2SLS results for quarter-mile split times linear specification

		5.5 Furlong	6 Furlong	7 Furlong	8 Furlong
OLS	Quarter-mile split time	0.2338*** (6.39)	0.1280*** (8.96)	0.5305*** (5.45)	0.7106*** (3.54)
	Prize money lost	−0.0003619*** (3.59)	−0.00008797*** (5.07)	−0.0001311** (2.21)	−0.0002883 (1.13)
	Prize money gained	0.00003830 (0.49)	−0.00001840 (1.29)	0.00002011 (0.48)	0.0002020 (1.26)
2SLS	Quarter-mile split time	−0.2211 (0.31)	0.2365 (1.31)	0.6250 (0.81)	1.532** (2.00)
	Prize money lost	−0.00255** (2.08)	−0.00041*** (3.42)	−0.00016 (0.96)	0.001604 (1.44)
	Prize money gained	−0.00391** (2.14)	0.000188 (0.46)	−0.00045 (0.99)	0.000661 (0.59)
Hausman test for exogeneity	*F*-value	6.120***	4.639***	1.001	1.335
	Prob. > *F*	0.0004	0.0030	0.3915	0.2637
N		1,905	10,657	1,337	532

Note: Parentheses contain *t*-statistics. The null hypothesis that the split time and prize variables are exogenous is rejected for statistically significant *F*-values. Regressions include horse and jockey effects as well as all control variables listed in Table 3.
** Indicate significance at the 5% level.
*** Indicate significance at the 1% level.

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