2019

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economies

Article

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Received: 5 August 2019; Accepted: 19 September 2019; Published: 2 October 2019

Abstract: The predictions that emerge from tournament theory have been tested in a number of sports-related settings. Since sporting events involving individuals (golf, tennis, running, auto racing) feature rank order tournaments with relatively large payoffs and easily observable outcomes, sports is a natural setting for such tests. In this paper, we test the predictions of tournament theory using a unique race-level data set from NASCAR. Most previous tests of tournament theory using NASCAR data used either season level data or race level data from a few seasons. Our empirical work uses race and driver level NASCAR data for 1114 races over the period 1975–2009. Our results support the predictions of tournament theory: the larger the spread in prizes paid in the race, measured by the standard deviation or interquartile range of prizes paid, the higher the average speed in the race. Our results account for the length of the track, number of entrants, number of caution flags, and unobservable year- and week-level heterogeneity.

Keywords: NASCAR; tournament theory; nonlinear prize structure

JEL Classification: J22; J33; L83

1. Introduction

A substantial body of literature testing the predictions of tournament theory in the context of sport exists. Sport represents a natural setting for testing these predictions because the nonlinear prize structure of many sporting events clearly follows the model's predictions, the prizes are often large, and contestant performance can readily be observed. Tests from golf, bowling, foot races, motorcycle races, tennis, and team sports generally confirm the predictions of the model: effort depends on the prize structure put in place by the tournament organizer.

Curiously, one setting with relatively few tests of tournament theory is stock car racing, a popular form of automobile racing that grew from relatively humble roots in the southern United States into an extremely popular form of car racing. Stock car racing originally referred to races featuring vehicles that had not been modified from the original factory form. It now refers to races involving any production-based vehicles, in contrast to cars, for example Formula 1 or drag racing, custom built for racing purposes. Many stock car racing circuits exist in the US, Mexico, Canada, the UK, New Zealand, and Brazil. The most popular, and most visible, stock car racing circuit is the National Association for Stock Car Racing (NASCAR); NASCAR's Sprint Cup Series (formerly called the NEXTEL Cup Series and Winston Cup Series) is the premier stock car racing series in the world and has been in existence since 1949.

von Allmen (2001) laid out one key theoretical issue associated with the reward structure in NASCAR, noting that the presence of large revenues generated by advertising, the season long NASCAR points competition generating monetary incentives that extend beyond single races, some NASCAR drivers earning significant sponsor bonuses without winning races, and also sharing race winnings with their team, and the relatively compressed nature of race winnings in NASCAR suggest that standard contest theory might not apply.

Instead, von Allmen argued that the "sabotage effect" model developed by Lazear (1989) in the context of winner take all contests where one competitor in a tournament can engage in behavior detrimental to other competitors could also apply to NASCAR races. In this context, Lazear (1989) showed that the prize structure for eliciting maximum effort is compressed relative to the optimum prize stricture when sabotage is not possible. Alternatively, von Allmen (2001) posited that the large sponsorship revenues from car advertising generate incentives for consistent driver performance rather than maximum driver effort to win races. Subsequent empirical literature focused primarily on analyzing sabotage and consistency in NASCAR driver performance.

We perform a test of the standard contest theoretic model applied to NASCAR. Several previous papers test the predictions of contest theory using NASCAR data. Becker and Huselid (1992) used data from a single NASCAR racing season which limited their ability to capture variability in effort. O'Roark et al. (2012) used data from the NASCAR post season ("the Chase") over the 2003–2006 seasons and individual driver data. They focus on risk taking, and explain observed wrecks during races, not driver effort. O'Roark et al. (2012) takes a similar approach. Rishel et al. (2015) analyze variation in season points earned by individual drivers and discuss the implications of tournament theory for this outcome, but do not estimate regression models containing a variable reflecting the nonlinearity of the prize structure.

We argue that the prize structure of NASCAR races is sufficiently non-linear to generate contest incentives for drivers to put forth maximum effort, despite the potential for sabotage effects during races. We analyze the outcomes of more than 1100 NASCAR races from the 1975 to 2009 seasons. The sample ends in 2009 because of substantial rule changes made prior to the 2010 season, including restrictor plate changes that increased cars' horsepower and elimination of rules against bump drafting that substantially affected drivers' aggressiveness on the track. These rule changes make comparisons difficult across the two rule regimes.

Yaskewich (2017) provides a second reason for not extending the sample beyond the 2009 or 2010 NASCAR season. Prior to 2011 NASCAR allowed drivers to compete in any or all of the three NASCAR-sponsored race series: the top Spring Cup series and the lower tier Nationwide series and Truck series. Beginning in 2011, NASCAR required drivers to compete in only one series in any season. Yaskewich (2017) showed that this rule change substantially changed driver behavior.

Estimates of a reduced form econometric model of driver effort show that the prize structure in NASCAR races generates incentives for drivers to put forth more effort. The empirical results indicate that a one standard deviation increase in the spread of the prize distribution increases the average speed of the winning car by about 2.5 miles per hour over the course of the race, controlling for unobservable track-specific heterogeneity, week of season and year effects, and other characteristics of races. Speed of the winning competitor represents a common proxy variable for effort in research using data from races. As tournament theory predicts, NASCAR drivers supply more effort in races with a larger spread in the prize distribution, other things equal.

Predictions and Tests of Tournament Theory

Frick (2003) summarized the key predictions of contest theory and surveyed the empirical tests of the predictions of contest theory based on data from athletic contests. The basic idea behind contest theory is that participants in a contest possess endowments of ability and talent and choose an optimal amount of effort to put forth in the contest given the endowment of ability and talent of their competitors and the prize structure of the contest. The contest is assumed to be rank ordered—prizes are awarded based on relative performance only—and the prizes known in advance are increasing in rank.

Performance in the contest depends on both the optimal effort chosen by all participants and a random component attributed to luck and other random factors outside the control of the participant. Since the contest has multiple competitors, the optimal choice of effort depends on the distribution of talent and ability across the competitors and each competitor's expectation of the effort put forth by other participants, as well as the prize structure.

Three key testable predictions emerge from contest theory. First, optimal effort depends positively on the size and spread of the prize distribution; second, optimal effort depends negatively on the marginal cost of effort; third, optimal effort depends on the effect of changes in effort on the probability of winning the tournament.

In general, empirical tests of the predictions of tournament theory focus on the relationship between the size and structure of the prize pool in tournaments and the effort put forth by the contestants. Sporting events represent a natural setting for testing the predictions of tournament theory because both the effort put forth by the contestants and the size and structure of the prize pool can easily be observed. Previous tests of the predictions of tournament theory in a sports setting include tests using data from professional golf (Ehrenberg and Bognanno 1990a, 1990b; Orszag 1994; Melton and Zorn 2000), professional bowling (Bognanno 1990), horse racing (Fernie and Metcalf 1999; Coffey and Maloney 2010), tennis (Lallemand et al. 2008; Sunde 2009), motorcycle racing (Maloney and Terkun 2002), and foot races (Maloney and McCormick 2000; Lynch and Zax 2000; Frick and Prinz 2007; Frick 2011). Feuillet et al. (2018) perform a comparative test using data from golf and tennis and find no impact of the prize distribution on effort in either sport.

von Allmen (2001) posited that other alternative models could be applied to NASCAR race outcomes, documenting a number of features of NASCAR races that differ from other sporting events. NASCAR drivers compete for three types of awards in each race: cash winnings based on rank order of finish in the race, points that accrue over the course of the season and count toward a season-long competition with a sizable monetary reward to the driver who accumulates the most points over the course of the season, and other bonus payments for in-race accomplishments like the number of laps lead or winning the pole position in the race. Also, many NASCAR drivers are members of multi-car teams, and compensation from individual events can be shared with the team owner and other team members. In addition to team membership, sponsorship revenues paid by companies who place corporate logos on the cars also contribute heavily to the revenues earned by teams.

Each race offers a standard non-linear rank order prize structure. Beyond this standard prize structure, several types of bonuses also apply to each race, including incentives for leading the race for a number of laps, bonuses paid by certain equipment manufacturers if a car using their equipment finishes among the top positions, and incentives paid to the current leader in the season-long points competition if he wins the current race and other bonuses. Points that count toward the season long total points competition are also awarded for rank order finish in each race. The distribution of points awarded for order of finish in each race is relatively compressed compared to the monetary prize structure of the race, although the payout awarded at the end of the season based on total points earned is highly nonlinear.

In 2007, the winner of the season-long points competition, Jimmie Johnson, won $7.3 million for finishing first in the points competition (he also won $7.6 million in individual races), the second-place finisher in the points competition won $3.2 million and the third place finisher $2.3 million. von Allmen (2001) pointed out that these factors, and the presence of large sponsorship revenues derived from placing logos on cars that depend on the visibility of the car during the race and not on the rank order finish in each race, flatten the overall reward structure over the course of a NASCAR season, reducing the incentive for drivers to provide additional effort in specific races and also reducing the applicability of standard tournament theory to NASCAR outcomes.

Because of the compressed nature of the overall NASCAR reward structure and the possibility of sabotage in races, von Allmen (2001) argued that Lazear (1989) model of tournaments with sabotage can be applied to NASCAR, that the compensation structure in NASCAR was unable to generate sufficient incentives to generate additional effort on the part of NASCAR drivers.

A small but growing literature analyzes the outcomes of car races.[1] Becker and Huselid (1992) used data from 28 races organized by NASCAR in 1990 to test the predictions of tournament theory. Becker and Huselid (1992) analyzed the performance of 44 individual drivers in each of the 28 contests. Their measure of effort reflected both the normalized average speed of the winning driver in each race, where the fastest average winning speed was set equal to 1 and slower average winning speeds assigned higher index values, and the rank order of finish for each driver. The index of average winning speeds was multiplied by the rank order finish to generate an effort measure that is equal to 1 for the first place finisher with the highest average speed; all other drivers have effort scores larger than one, with the value depending on both their finishing position in each race and the winning driver's average speed in that race relative to the fastest average winning speed in the season.

Note that this measure of effort, while varying across participants, is difficult to interpret because it mixes absolute (average speed of the winning driver) and relative (rank order of finish) measures of effort. It also does not preserve within-race rank ordering. Their measure of the prize structure in NASCAR races included a variable reflecting the average difference in prizes awarded to the first 20 finishers in each race compared to drivers who finished outside the top 20. Becker and Huselid (1992) concluded that the larger the difference in average winnings of the top 20 finishers compared to finishers outside the top 20 in each race, the more effort put forth by drivers, holding race-specific factors and driver ability constant. These results are consistent with the predictions of tournament theory, in that a more unequal distribution of prize money induces greater effort by participants.

Despite the obvious limitations of the results in Becker and Huselid (1992), in terms of the dependent variable and the use of race data from a single season, subsequent research did not focus on testing the predictions of tournament theory using data from NASCAR races. Additional empirical research focused on the applicability of alternative models to NASCAR race outcomes. Depken and Wilson (2004) analyzed end of season outcomes in NASCAR over the period 1949–2001 and concluded that the relationship between the concentration of performance points and the concentration of prize winnings supported the sabotage hypothesis.

Schwartz et al. (2007) analyzed race level NASCAR data from the 2003 and 2004 seasons to look for additional evidence supporting the sabotage hypothesis and the inefficiency of the NASCAR compensation scheme. They found evidence of heterogeneity in driver skills, and evidence that less skilled drivers generate more accidents during races, supporting the sabotage hypothesis. Groothuis et al. (2011) claimed that the monetary prize structure in NASCAR is linear, and investigated the role of sponsorship in NASCAR; they rejected the idea that the monetary prize structure in NASCAR is insufficient to generate incentives for NASCAR drivers to supply additional effort in races, and instead explore the idea that consistency, providing sustained periods of camera exposure for sponsors, drives the behavior of NASCAR drivers.

Much of the existing empirical research on outcomes in NASCAR races focuses on the idea that the prize structure of NASCAR cannot generate sufficient contest incentives to induce drivers to supply increased effort in races. These studies posit that the compressed prize structure, presence of the end of season points competition, importance of sponsorship revenues, and negative consequences of supplying additional effort in contests, either through recklessness generated by higher speeds or sabotage, leads NASCAR drivers to pursue a goal of consistency instead of supplying maximum effort.

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[1] Economists have also examined the effects of uncertainty of outcome on interest in NASCAR (Berkowitz et al. 2011), risk taking in NASCAR racing (O'Roark and Wood 2004; Sobel and Nesbitt 2007; Dole 2007; Bothner et al. 2007), the role of sponsorship and status (Bothner et al. 2012; Groothuis et al. 2011), strategic interaction in pit stops (Deck et al. 2014), and momentum and consistency in driver performance (Depken et al. 2017).

In the context of the model of Lazear and Rosen (1981), in equilibrium in races with drivers of equal ability and identical cars, all NASCAR drivers supply a similar amount of effort. Heterogeneous driver ability or car performance will lead to different levels of effort supplied. The empirical literature on the effects of tournament incentives on NASCAR drivers has focused on the lack of incentives to increase effort, and the negative consequences of increases in incentives in this setting.

We return to the fundamental questions raised when applying standard tournament theory to NASCAR racing: does NASCAR have a non-linear prize structure, and does the existing NASCAR prize structure generate sufficient incentives for drivers to supply additional effort? Using a comprehensive data set from 1114 NASCAR races over the period 1975–2009, we find that the monetary prize structure of individual NASCAR races is non-linear, and that drivers appear to supply additional effort as the prize structure becomes more dispersed, consistent with the predictions of tournament theory.

2. Materials and Methods

Our data come from all 1114 NASCAR races run in the 1975 through 2009 racing seasons. We collected data on the outcomes of each race, including the money and points earned by each participant, from the NASCAR web site (www.nascar.com). The NASCAR web site contains the official results of all races since 1975, including the starting position, finishing position, status, points earned, winnings, and laps raced by each driver in each race. It also contains other race-related data including the average speed of the winning car, the margin of victory of the winner, the number of lead changes in the race, the number of caution flags, and the number of laps raced under caution flags during each race. We augmented these data with information about the tracks that each race took place on, in terms of the length and configuration.

Table 1 summarizes the relevant variables from these 1114 NASCAR races. We deflated winnings to real 2009 dollars using the Consumer Price Index (CPI) for All Urban Consumers. We use the average speed of the winning car in miles per hour as our measure of effort in NASCAR races.

Table 1. Summary statistics.

Variable	Mean	SD	Min	Max
Average Speed Winning Car	118.41	27.11	66.10	188.35
Total Winnings	2,207,711	2,262,556	115,172	16,900,000
Interquartile Range Winnings	23.43	15.12	2.01	84.80
Standard Deviation of Winnings	3.07	3.27	0.45	43.98
Number of Entrants	40	4.5	22	50
Number of Caution Flags	7	3.5	0	22
Length of a Lap	1.519	0.721	0.533	2.66
Oval Track Shape	0.34	-	-	-
D or Quad Oval Track Shape	0.44	-	-	-
Tri Oval Track Shape	0.09	-	-	-
Road Course Track	0.07	-	-	-

Other empirical research testing the predictions from tournament theory using data from racing also use variables related to the speed of the winning participant as an effort proxy. Becker and Huselid (1992) use average winning speed as the effort proxy in their study using NASCAR data. Lynch and Zax (2000), Maloney and McCormick (2000), and Frick and Prinz (2007) all use winning time or time per mile for the winning runner in foot races as an effort proxy.

The average speed of the winning car exhibits quite a bit of variation. This is due in part to the number of caution—or yellow—flags that take place during NASCAR races and the number of laps raced under a caution flag. A yellow caution flag is signaled during a NASCAR race when there is some hazard on the course. The most common reason for a caution flag is an accident, but it may also be due to debris on the track or inclement weather. Under a yellow flag all cars slow down and follow a pace car; passing is not permitted under caution flags. The race continues at a reduced speed until the reason for the caution flag is removed. Only 11 races in the sample, about 1%, featured no caution flags.

The median margin of victory in this sample is 1.19 s, and the margin of victory at the 75th percentile is just 3.84 s, so the leaders in almost all races finish very close to each other. The mean margin of victory is 5.9 s, but this is skewed by a small number of races (86) decided by more than two minutes.

The average real purse size in the sample is just over $2.2 million. Purse size has clearly grown over time; the average real purse in 1976 was $430,000 and the average real purse in 2006 was $5.43 million. We use two different measures of the dispersion of winnings in races: the interquartile range of winnings and the standard deviation of winnings. Both will increase as the prize structure of the race becomes more non-linear. We measure the interquartile range in 1000s of dollars, and the standard deviation in 10,000s of dollars in order to generate easy to express parameter estimates. Note that both the interquartile range and the standard deviation of the prize structure vary considerably within the sample. This variation occurs because the average purse size has grown and because different races use different prize structures and change these prize structures over time.

The number of cars participating in a race will affect the speed, both because of the physical space occupied by the cars and because of strategic interaction among competitors. The number of entrants in each race varies both over time, and within seasons. The average field size in the 1970s was about 35 cars; this number has increased steadily over time; since the late 1990s most NASCAR race fields have contained 43 cars.

The average speed of the winning car is clearly influenced by driver effort. It can also be affected by characteristics of the track that the race takes place on. NASCAR race tracks vary in terms of length and configuration. The average length of a NASCAR track is 1.5 miles. The shortest track, Bristol International Speedway, is just over a half mile in length; the longest track, Talladega Superspeedway, is nearly five times as long. The length of the track determines how many turns are in the race, which tends to slow speeds.

NASCAR tracks have four basic forms: a standard oval with two equal length straight stretches, a D oval with one long straight stretch, a quad oval with one long straight stretch and three shorter straight stretches, a tri-oval with three equal length straight stretches, and 'road course' tracks with many irregular turns. Only three 'road course' tracks have been used in NASCAR: Riverside International Raceway, Sears Point/Infineon Raceway, and Watkins Glen International. The three tri oval tracks are Phoenix International Raceway, Pocono Raceway, and Talladega Superspeedway. Most NASCAR tracks are either ovals or D or Quad ovals. Each basic form provides different combinations of turns and straightaways, which will affect the speed of the cars.

Our data come from a large number of NASCAR seasons. The tracks in use changed somewhat over the sample period. We analyze data from 29 different racetracks. Twelve racetracks were in use continually, or nearly continually, in the sample period accounting for 73% of the sample observations. Eight appear only in the second half (post-1990) of the sample, accounting for 10% of the observations. Four were in use only in the first half of the sample, accounting for 6% of the observations. An additional five hosted races in both halves of the sample, but hosted a large majority of their races in the earlier or later period.

2.1. NASCAR Prize Structure

A number of previous papers argued that NASCAR races have a compressed prize structure. We have data on the prize structure, expressed in constant 2009 dollars, of all 1114 NASCAR races run over a 34 year period, a long enough period to assess the non-linearity of the prize structure. Table 2 summarizes the average amount won by place for the first 10 finishers in NASCAR races over this period. Over this period, the winner of NASCAR races took home just under $190,000. This figure includes all bonuses earned by drivers in each race. The second place driver took home almost $124,000 on average, about $65,500 less. Put another way, the first place driver in a NASCAR race earned more than 50% more than the second place driver, and the second place driver earned almost 25% more than the third place driver. The third place driver earned about half the amount that the winning driver earned.

Table 2. NASCAR prize structure 1975–2009.

Place	Average Amount Won	Difference	% Increase
1	$189,244	$65,535	53%
2	$123,709	$23,997	24%
3	$99,712	$15,584	19%
4	$84,129	$8855	12%
5	$75,274	$9247	14%
6	$66,027	$4282	7%
7	$61,745	$3357	6%
8	$58,388	$1893	3%
9	$56,495	−$481	−1%
10	$56,976		

The "bumpiness" in prize structure noted by von Allmen (2001) can clearly be seen in Table 2. The percentage increase in winnings from moving up one place in the standings does not diminish uniformly, and due to bonuses the 10th place drivers actually earned a bit more than the 9th place drivers in this sample. Beyond 10th place the prize structure in NASCAR levels out considerably, much like in other settings like professional golf. However, Table 2 clearly indicates that the actual monetary prize structure of individual NASCAR races held over the period 1975–2009 was non-linear, with the returns to moving up one place in the standings increasing significantly in the top five positions.

While sponsorship, team contracts, and other factors might erode the effective prize structure, the information provided in Table 2 suggests that NASCAR has a non-linear prize structure for individual races. The key empirical issue focuses on the incentives generated by this non-linear prize structure: does it provide enough of an incentive to get drivers to increase their effort over the course of a NASCAR race?

2.2. Empirical Analysis

We examine the relationship between the effort put forth by NASCAR drivers and the prize structure of individual races. In order to investigate this relationship, we estimate a linear reduced form model of the determination of effort put forth in NASCAR races, e, in season t in race i during week j at track k. The empirical model is

$$e_{ijkt} = \alpha_1 \mathrm{a_t} + \alpha_2 \mathrm{b_j} + \beta_1 \mathrm{TC_k} + \beta_2 \mathrm{RC_{ijt}} + \mu_{ijkt} \quad (1)$$

where e_{ijkt} is the effort put forth in the race, captured by the average speed of the winning car. $\mathrm{a_t}$ is a vector of year dummy variables capturing all factors that affect the outcome of all NASCAR races in season t. NASCAR has undergone numerous rule changes over the 1979–2009 period, and this year dummy variable captures the overall environment facing NASCAR drivers in each season. For example, technological changes over time have increased the average speed in NASCAR races, and improvements in equipment and pit crews may keep more cars in races, compressing the distribution of finishing times. The average speed of the winning car in our sample was under 115 miles per hour (MPH) in the 1970s and early 1980s and increased to well over 120 MPH in the late 1990s.

NASCAR frequently implements rules to enhance uniformity in equipment that may also change racing speeds over time. Any rules or conditions that apply to all NASCAR races in a particular season will be captured by these year indicator variables. $\mathrm{b_j}$ is a vector of week-of-season indicator variables that captures systematic changes in incentives for drivers to provide effort over the course of the NASCAR season.

The season-long points competition evolves over time, and the standings in the point competition might affect the incentives to put forth effort systematically from week to week. In addition, other factors could change systematically over the course of the NASCAR season, like the amount of time that elapses from one race to the next and the distance between racetracks. The week dummy variables capture the effects of these factors on effort.

TC_k is a vector of track-specific characteristics. The characteristics of tracks, including their layout and length, affect the speed of races that take place on these tracks. This vector includes the length of a lap at each track and indicators for the general shape of each track. The standard oval shape is the omitted category.

RC_{ijt} is a vector of characteristics of the individual races that affect effort. This vector includes measures of the dispersion of the real monetary prize structure of each race, and other characteristics of each race like the number of entrants and the number of caution flags that occurred during the race. α_1, α_2, β_1, and β_2 are unknown parameters to be estimated.

μ_{ijkt} is an unobservable random error term that captures all other factors that affect the effort put forth by NASCAR drivers. These factors include the inherent random component of effort postulated by tournament theory as well as other random and unobservable factors affecting effort. We assume that this random error term is independent and identically distributed with mean zero, although we allow the variance of this random error term to vary across races. We estimate the unknown parameters of Equation (1) using the Ordinary Least Squares estimator with the usual Huber–White 'sandwich' correction for heteroscedasticity. The standard F-statistic from a Breusch–Pagan test for heteroscedasticity rejected the null of homoscedasticity with a p-value of 0.06. Technically, we estimate a two-way fixed effect model, since we control for unobservable heterogeneity across seasons and across weeks of the season.

3. Results

Table 3 contains parameter estimates, asymptotic t-statistics on a two-tailed test of the null hypothesis that the estimated parameter is equal to zero for each parameter, and other standard regression diagnostics for several versions of Equation (1). Again, these results correct for heteroscedasticity using the standard Huber–White 'sandwich' correction. The measure of the dispersion of the monetary prize structure in each race is the interquartile range of the monetary prize structure of each race. This is the difference between the first and third quartiles of the real monetary prize distribution, in thousands of 2009 dollars.

Models 1 and 2 establish the basic relationship between the dispersion of the monetary prize structure and effort, as measured by the average speed of the winning car in each race. All of the parameter estimates are statistically different from zero at the 5% level and the models explain between 75% and 85% of the observed variation in average speed of the winning car. The estimated parameters on the track characteristics have plausible and intuitively appealing signs. The longer each lap at a track is, the higher the average speed of the winning car, other things being equal. Longer tracks have longer straight sections of track, which allow drivers to drive faster. The omitted track shape is a standard oval, and the results suggest that D or Quad oval tracks and tri-oval tracks produce higher average winning speeds, other things equal. Race Course tracks like Watkins Glen, with their many curves and irregular setup, produce markedly lower average winning speeds, roughly 50 miles per hour slower than those on oval tracks.

The parameters of interest in Table 3 are the ones on the interquartile range of the monetary prize structure, and these parameter estimates reflect the effect of the incentives generated by a non-linear prize structure on effort, as reflected by the average speed of the winning car in each race. These parameter estimates are all positive and significantly different from zero at the 5% level, suggesting that the more variable the prize structure in a NASCAR race, the more effort drivers put forth in that race. We interpret this as supporting the predictions of tournament theory.

The estimated sign and significance of the parameter on the interquartile range variable is not sensitive to the inclusion of other race specific control variables, the number of entrants and the number of caution flags during the race. The estimated parameters on these two race characteristics have appropriate signs and are statistically different from zero. Each additional entrant in a NASCAR race is associated with an increase in the average speed of the winning car in that race of between 1.7 and 2.2 miles per hour. The expansion of NASCAR field size over time appears to have increased the effort put forth by drivers. Each additional caution flag during the course of a race was associated with a decrease in the average speed of the winning car by about 2.1 miles per hour. Since caution flags require drivers to slow down and not to pass, this should clearly reduce the average speed in the race.

Table 3. Dispersion of prize structure affects average winning speed.

Dependent Variable: Average Winning Speed						
Variable	**Model 1**	**Model 2**	**Model 3**	**Model 4**	**Model 5**	**Model 6**
Interquartile Range	0.233	0.279	0.161	0.184	0.173	0.143
	3.30	3.45	2.51	2.55	3.05	2.25
Lap Length	27.84	30.43	24.01	25.82	19.66	22.02
	37.74	30.70	29.63	24.49	14.21	22.70
D or Quad Oval Track	11.87	10.11	10.28	8.953	8.032	7.096
	11.41	8.89	10.53	8.53	9.46	7.74
Tri Oval Track	9.29	9.64	7.01	7.834	4.299	4.669
	5.94	4.83	4.08	3.71	2.61	2.33
Race Course Track	−49.69	−49.70	−49.54	−48.88	−52.62	−52.77
	−33.32	−29.60	−31.61	−29.00	−35.13	−32.68
# of Entrants	-	-	1.771	1.653	2.235	2.135
	-	-	10.14	9.01	14.21	12.85
# of Caution Flags	-	-	-	-	−2.151	−2.114
	-	-	-	-	−17.19	−17.77
Year Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Week Fixed Effects	No	Yes	No	Yes	No	Yes
R^2	0.752	0.786	0.782	0.807	0.832	0.853
N	1114	1114	1114	1114	1114	1114

Asymptotic robust *t*-statistics shown below parameter estimates.

Interquartile range is not the only possible measure of the non-linearity of the monetary prize structure of NASCAR races. To assess the robustness of the results reported in Table 3, we used an alternative measure of the dispersion of the monetary prize structure of each race, the standard deviation of the winnings paid to each participant in the race. Table 4 contains the results from estimating Equation (1) using this alternative measure of the dispersion of the monetary prize structure of races.

The results displayed in Table 4 are qualitatively similar to those in Table 3. The larger the dispersion of the prize structure, as measured by the standard deviation of the prize money for each race, the more effort is put forth by drivers in that race, other things being equal. The only difference between the results in Table 4 and those in Table 3 is that the estimated parameter on the standard deviation of the prize structure for Model 1 is not statistically different from zero.

We also estimated all the models reported on Tables 3 and 4 including a variable reflecting the total value of the prize pool for each race. The size of the total purse could also induce more driver effort in races. The results are robust to the inclusion of this variable. The estimated parameters on the total purse variable in these models were generally not statistically different from zero.

Table 4. Alternative dispersion of prize structure measure.

Dependent Variable: Average Winning Speed						
Variable	**Model 1**	**Model 2**	**Model 3**	**Model 4**	**Model 5**	**Model 6**
Standard Deviation	0.159	0.321	0.282	0.358	0.291	0.249
of Prize Structure	1.19	1.87	2.01	2.27	2.53	1.95
Lap Length	28.56	31.37	24.19	26.13	19.88	22.29
	38.78	32.66	29.98	25.20	26.52	23.40
D or Quad Oval Track	11.99	10.28	10.28	8.999	8.033	7.134
	11.54	9.12	10.52	8.57	9.46	7.76
Tri Oval Track	8.633	8.949	6.708	7.451	3.961	4.345
	5.52	4.52	3.91	3.55	2.41	2.19
Race Course Track	−50.77	−50.82	−49.98	−49.27	−53.12	−53.13
	34.02	−30.40	−32.48	−29.56	−36.14	−33.35
# of Entrants	-	-	1.820	1.709	2.288	2.178
	-	-	10.34	9.31	14.38	13.09
# of Caution Flags	-	-	-	-	−2.147	−2.117
	-	-	-	-	−17.23	−17.84
Year Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Week Fixed Effects	No	Yes	No	Yes	No	Yes
R^2	0.749	0.783	0.782	0.807	0.832	0.853
N	1114	1114	1114	1114	1114	1114

Asymptotic *t*-statistics shown below parameter estimates.

4. Conclusions

While the estimated parameters on the interquartile range variable are statistically significant, their relative size compared to the size of the estimated parameters on some other variables might lead readers to question the economic significance of these parameters. To illustrate the economic significance of these results, consider the estimated contribution made by the spread of the prize structure to the average speed in two races held at Talladega Superspeedway, a tri-oval racetrack. In 1980, the interquartile range of this race was $9724, roughly one standard deviation below the mean displayed in Table 1; in 1989 the interquartile range had increased to $23,313, which is roughly at the mean in Table 1. Based on the results from Model 4 of Table 3, which contains both year and week fixed effects and a control for the number of entrants, the interquartile range of the prize distribution in that range contributed to an increase in the average speed of the winning car of about 1.79 miles per hour in 1980. The interquartile range of the prize structure in the 1989 race contributed to an increase in the average winning speed of about 4.29 miles per hour. The difference, which shows the effect on the average winning speed of a move from about one standard deviation below the mean interquartile range to the mean, is 2.5 miles per hour.

Becker and Huselid (1992) treated the number of caution flags in the race as uncorrelated with the equation error term. However, a case can be made that the number of caution flags in a race depends on incentives to supply effort during a race, and thus could be correlated with the unobservable error term in Equation (1). The idea is that the more effort is supplied by drivers, the greater the potential for an accident, which would lead to a caution flag. This concept is closely related to the sabotage incentive posited by von Allmen (2001). If the number of caution flags is correlated with the unobservable error term, then the OLS estimator used here is neither unbiased nor consistent. The usual remedy for this problem is to identify an instrument that is correlated with the number of caution flags and uncorrelated with the unobservable error term in Equation (1) and use the instrumental variables (IV) estimator. However, finding an appropriate instrument may be difficult in this context. Note that the significance of the estimated parameter on the prize spread variable does not change when the number of caution flags is dropped from the regression model, suggesting that any existing correlation between the number of caution flags and the equation error term does not lead to severe econometric problems in this case.

Beginning in the 2004 season, NASCAR introduced a form of post-season competition, called "the Chase" into the racing schedule. This 10-race postseason competition might generate different incentives throughout the season. We estimated all of the model specifications shown above with an indicator variable for racing seasons that included "the Chase" at the end of the season. The inclusion of this indicator variable did not have any effect on the estimated parameters on the prize distribution spread displayed in Tables 3 and 4 above.

The results above support the idea that the prize structure in NASCAR races generates incentives for drivers to provide more effort in races, confirming one of the main predictions of tournament theory. As noted by von Allmen (2001) and others, the prize structure in NASCAR races is more compressed than the prize structure in professional golf, tennis, and some other individual sports. The results presented here suggest that NASCAR drivers respond to incentives generated by prize structures with less dispersion than found in professional golf and tennis. This leads to the question of how much spread is required in a prize distribution to induce increased effort by participants. Since NASCAR drivers respond to a smaller spread than professional golfers, a further examination of prize structure and effort in order to determine how much spread is required in the prize money distribution to induce contest effects appears warranted.

Since NASCAR drivers respond to the incentives generated by the prize structure of races, and a large amount of detailed data on these races exist, further research in this area would be fruitful. We use the average speed of the winning car as a measure of effort. Institutional characteristics of NASCAR races provide alternative methods of measuring effort. For example, drivers qualify for races during preliminary competitions the week before the race. These qualifying competitions take place on the same track, with no other competitors present; the top speed recorded by each driver during qualifying is used to seed the drivers at the start of the main race. These qualifying times and places provide a measure of the ability of the driver and car going into the race in absolute terms and relative to the other competitors. These qualifying times and starting positions could be used to construct a driver-specific measure of effort in each race and used to test similar predictions from tournament theory. Also, NASCAR sponsors five other stock car racing series in addition to the Sprint Cup Series, and prize structures and outcomes from these series could also be analyzed.

Finally, the NASCAR Sprint Cup Series features both prizes for individual races and a season long points competition. In this competition, points are awarded based on order of finish; the distribution of points is quite compressed, but the prize distribution for the point competition is highly non-linear. The existence of two different prize payouts in NASCAR generates a race-within-a-race that may provide different incentives to drivers. To date, only Depken and Wilson (2004) and Schwartz et al. (2007) have examined the interaction between prizes in individual races and the season long points competition. Given the evidence developed here that drivers respond to the prize structure in individual races, a closer look at the relationship between these two competitions and the incentives generated by them appears warranted.

Author Contributions: Data curation, B.F.; Formal analysis, B.H.; Methodology, B.H. and B.F.; Writing—original draft, B.H. and B.F.; Writing—review & editing, B.H. and B.F.

Funding: This research received no external funding.

Conflicts of Interest: The authors declare no conflicts of interest.

References

Becker, Brian E., and Mark A. Huselid. 1992. The Incentive Effects of Tournament Compensation Systems. *Administrative Science Quarterly* 37: 336–50. [CrossRef]

Berkowitz, Jason, Craig A. Depken, and Dennis P. Wilson. 2011. When Going in Circles is Going Backwards: Outcome Uncertainty in NASCAR. *Journal of Sports Economics* 12: 253–83. [CrossRef]

Bognanno, Michael L. 1990. An Empirical Test of Tournament Theory. Ph.D. Thesis, Department of Economics, Cornell University, Ithaca, NY, USA.

Bothner, Matthew S., Jeong-Han Kang, and Toby E. Stuart. 2007. Competitive Crowding and Risk Taking in a Tournament: Evidence from NASCAR Racing. *Administrative Science Quarterly* 52: 208–47. [CrossRef]

Bothner, Matthew S., Young-Kyu Kim, and Edward B. Smith. 2012. How Does Status Affect Performance? Status as an Asset versus Status as a Liability in the PGA and NASCAR. *Organization Science* 23: 416–33. [CrossRef]

Coffey, Bentley, and Michael T. Maloney. 2010. The Thrill of Victory: Measuring the Incentive to Win. *Journal of Labor Economics* 28: 87–112. [CrossRef]

Deck, Alan, Cary Deck, and Zhen Z. Zhu. 2014. Decision-Making in a Sequential Game: The Case of Pitting in NASCAR. *Journal of Sports Economics* 15: 132–49. [CrossRef]

Depken, Craig A., and Dennis P. Wilson. 2004. The Efficiency of the NASCAR Reward System: Initial Empirical Evidence. *Journal of Sports Economics* 5: 371–86. [CrossRef]

Depken, Craig A., Matthew Hood, and Ernest King. 2017. Consistency and Momentum in NASCAR. *Journal of Sports Economics* 18: 601–21. [CrossRef]

Dole, C. A. 2007. Risk Taking in NASCAR: An Examination of Compensating Behavior and Tournament Theory in Racing. *Journal of Economics and Economic Education Research* 8: 47–64.

Ehrenberg, Ronald G., and Michael L. Bognanno. 1990a. Do Tournaments have Incentive Effects? *Journal of Political Economy* 98: 1307–24. [CrossRef]

Ehrenberg, Ronald G., and Michael L. Bognanno. 1990b. The Incentive Effects of Tournaments Revisited: Evidence from the European PGA Tour. *Industrial and Labor Relations Review* 43: 74–88. [CrossRef]

Fernie, Sus, and David Metcalf. 1999. It's Not What You Pay It's the Way that You Pay it and that's What Gets Results: Jockeys' Pay and Performance. *Labour* 13: 385–411. [CrossRef]

Feuillet, Antoine, Nicolas Scelles, and Christophe Durand. 2018. Revenus et Superstars dans les sports individuels: Le cas du tennis et du golf masculins [Revenue and Superstars in individual sports: The case of men's tennis and golf]. *Revue Française de Gestion* 44: 45–60. [CrossRef]

Frick, Bernd. 2003. Contest Theory and Sport. *Oxford Review of Economic Policy* 19: 512–29. [CrossRef]

Frick, Bernd. 2011. Gender differences in competitiveness: Empirical evidence from professional distance running. *Labour Economics* 18: 389–98. [CrossRef]

Frick, Bernd, and Joachim Prinz. 2007. Pay and Performance in Professional Road Running: The Case of City Marathons. *International Journal of Sport Finance* 2: 25–35.

Groothuis, Peter A., Jana D. Groothuis, and Kurt W. Rotthoff. 2011. Time on Camera: An Additional Explanation of NASCAR Tournaments. *Journal of Sports Economics* 12: 561–70. [CrossRef]

Lallemand, Thierry, Robert Plasman, and Francois Rycx. 2008. Women and Competition in Elimination Tournaments: Evidence from Professional Tennis Data. *Journal of Sports Economics* 9: 3–19. [CrossRef]

Lazear, Edward P. 1989. Pay Equality and Industrial Politics. *Journal of Political Economy* 97: 561–80. [CrossRef]

Lazear, Edward P., and Sherwin Rosen. 1981. Rank-Order Tournaments as Optimum Labor Contracts. *Journal of Political Economy* 89: 841–64. [CrossRef]

Lynch, James G., and Jeffrey S. Zax. 2000. The Rewards to Running: Prize Structure and Performance in Professional Road Racing. *Journal of Sports Economics* 11: 606–28. [CrossRef]

Maloney, Michael T., and Robert E. McCormick. 2000. The Response of Workers to Wages in Tournaments: Evidence from Foot Races. *Journal of Sports Economics* 1: 99–123. [CrossRef]

Maloney, Michael T., and Kristina Terkun. 2002. Road Warrior Booty: Prize Structures in Motorcycle Racing. *Contributions to Economic Analysis & Policy* 1. [CrossRef]

Melton, Michael, and Thomas S. Zorn. 2000. An Empirical Test of Tournament Theory: The Senior PGA Tour. *Managerial Finance* 26: 16–32. [CrossRef]

O'Roark, J. Brian, and William C. Wood. 2004. Safety at the Racetrack: Results of Restrictor Plates in Superspeedway Competition. *Southern Economic Journal* 71: 118–29. [CrossRef]

O'Roark, J. Brian, William C. Wood, and Benjamin Demblowski. 2012. Tournament Chasing NASCAR Style: Driver Incentives in Stock Car Racing's Playoff Season. *Eastern Economic Journal* 38: 1–17. [CrossRef]

Orszag, Jonathan. 1994. A New Look at the Incentive Effects of Golf Tournaments. *Economics Letters* 46: 77–88. [CrossRef]

Rishel, Tracy D., Elizabeth W. Baker, and C. Barry Pfitzner. 2015. Finishing or Winning? The Variables that Impacted the NASCAR Championship in the Chase I Format (2004–2013). *The Coastal Business Journal* 14: 26–41.

Schwartz, Jeremy, Justin Isaacs, and Anthony Carilli. 2007. To Race or Place? An Empirical Investigation of Efficiency of the NASCAR Points Competition. *Journal of Sports Economics* 8: 633–41. [CrossRef]

Sobel, Russell S., and Todd M. Nesbitt. 2007. Automobile Safety Regulation and the Incentive to Drive Recklessly: Evidence from NASCAR. *Southern Economic Journal* 74: 71–84.

Sunde, Uve. 2009. Heterogeneity and Performance in Tournaments: A Test for Incentive Effects Using Professional Tennis Data. *Applied Economics* 41: 3199–208. [CrossRef]

von Allmen, Peter. 2001. Is the Reward System in NASCAR Efficient? *Journal of Sports Economics* 2: 62–79. [CrossRef]

Yaskewich, David M. 2017. Heterogeneous Ability and Risk Taking in a Rank-Order Tournament: An Analysis of NASCAR's Pick-A-Series Rule. *Journal of Sports Economics* 18: 803–30. [CrossRef]