Lancaster University Management School
Working Paper
2007/046

The allocation of rewards in athletic contests

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1. Introduction

Similar to most top-tier matches in professional basketball, baseball and soccer, high-level competitions in individualistic sports, such as the tennis tournaments of Wimbledon and Flushing Meadows, the golf tournaments of Augusta and St. Andrews, as well as the marathons of New York and London attract not only thousands of spectators, but also a TV audience of millions of fans. Moreover, these (and other) individualistic sports have recently received increased attention also from economists trying to test a number of hypotheses that can be derived from "tournament theory" or – as a synonym – from "contest theory".

The chapter is structured as follows: We first provide a brief description of the development of prize money levels and structures in the three different individual sports mentioned in the previous paragraph (and, consequently, athletes' incomes over the last years section 2). We then summarize the basic insights and the core predictions of tournament/contest theory (section 3) and review the available literature on the incentive effects of tournament pay systems in athletic contests (section 4). Finally, section 5 concludes and raises some of the questions that have not been answered yet and that should, therefore, be dealt with in future research.

2. The Development of Prize Money Levels and Structures

The top events in tennis, golf and – to a much lesser extent – in distance running offer considerable purses to the successful contestants. Moreover, all three sports are organized like a pyramid with different series of tournaments not only for the top athletes, but

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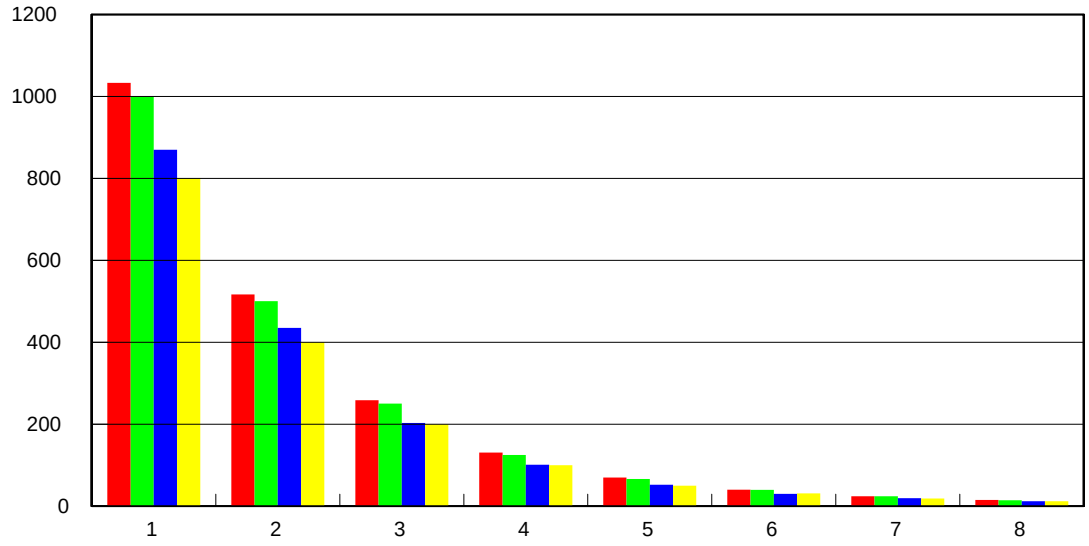
also for less talented/less successful players as well as for developing talent.

The ATP (Association of Tennis Professionals) tour calendar for 2007 includes 63 different tournaments that vary considerably in the prize purses they offer, ranging from 332.000$ to 3.7 Mio. $[3]. Nine of these tournaments belong to the "Masters Series", offering between 2.5 and 3.2 Mio. $ each. This series is crowned by the "Masters Cup", to which the eight highest ranked players in the preceding year are invited. The prize purse of this tournament currently stands at 3.7 Mio. $. The remaining 53 tournaments belong to the "International Series" with nine of them having "Gold" status due to the higher prize money they offer (more than 1.0 Mio. $). The most prestigious tournaments, however, are the four "Grand Slam" events (Melbourne, London, Paris, New York) that are organized by the ITF (International Tennis Federation). In 2007, the total prize purses offered by these four tournaments vary between 15 and 23 Mio. $.

Figure 1
Prize Money Levels and Structures in the "Grand Slam" Tennis Tournaments, 2007



red: Wimbledon; green: Paris; blue: Flushing Meadows; yellow: Melbourne

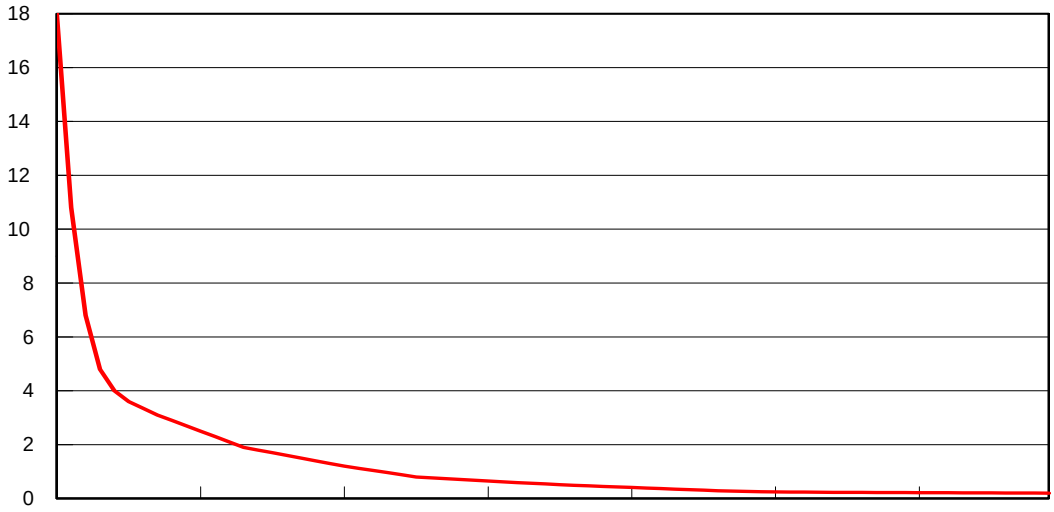
In these latter tournaments, the winners of the two singles competitions, for example, receive between 800,000 and 1 Mio. $ while the runner-up is paid approximately 50% of that amount (see Figure 1). In the tournaments offering lower purses, the distribution

3 Depending on the size of the prize purse these tournaments admit either 32 or 64 players (sometimes players have to compete successfully in an elimination round to be admitted). Only the Grand Slam tournaments start with a field of 128 players.

of the prize money is slightly different, with the winner receiving a larger "share of the pie". Players failing to qualify for the ATP events can in 2007 participate in either one of the 174 different "challenger tournaments" that offer considerably lower prize purses (ranging from 25,000 to 125,000 $), trying to accumulate the ranking points that are required to get admission to the (better paying and more prestigious) ATP tournaments. Moreover, nearly 4,200 different "futures tournaments" are played all over the world, offering purses that vary between 10,000 and 15,000 $.

In professional golf, the total prize purse in the most prestigious competition, the PGA Tour, reached 295 Mio. $ in 2007. The purse per tournament (there are about fifty of them) varies between 3.5 and 9.0 Mio. $ with the percentage breakdown being identical regardless of the total purse. The winner of a tournament always receives 18.0% of the total purse, the runner-up is awarded 10.8% and the player finishing third receives 6.8% (see Figure 2)[4]. Thus, as in the case of tennis, we observe a highly nonlinear distribution of rewards to performance with the top performers receiving disproportionately large shares of the money that is at stake.

Figure 2
Prize Money Distribution in the PGA Tournaments



Again, as in the case of tennis, a "super tournament" to which the most successful play-

4 A virtually identical structure exists, for example, in Europe with the European PGA, the "Seniors Tour" and the "Challenge Tour". On average, these tours offer considerably smaller purses than their US counterparts: In 2007, the purses vary between 0.5 and 6.2 Mio. € (European PGA), 0.19 and 1.5 Mio. € (European Seniors) and 0.12 and 0.605 Mio. € (Challenge Tour).

ers are invited at the end of the season (Tour Championship), links the different contests together. Moreover, there are two minor professional tours in the US, the "Champions Tour" for players aged 50 and more[5] and the "Nationwide Tour" for younger and/or less successful players trying to qualify for the PGA Tour. Both tours consist of slightly more than 30 tournaments offering prize purses that vary between 1.6 and 2.6 Mio. $ (Champions Tour) and 0.450 and 0.775 Mio. $ (Nationwide Tour). Here again, the distribution of the purse is identical across all tournaments.

A quite different picture emerges if we look at the purses of the five city marathons forming the "World Marathon Majors" (the races in Berlin, Boston, Chicago, London, and New York)[6]. Contrary to the top-tier tournaments in tennis and golf where entry is restricted to athletes who have qualified for the respective event (more on that below), participation in either of these races - as well as in other city marathons - is open. The five events, along with the Olympic Marathon and the IAAF World Championships Marathon, serve as the qualifying races in the series. At the conclusion of each qualifying race, the top five male and female finishers are awarded points based on their finish place. At the conclusion of each two-year series, a $1 million prize purse will be split equally between the top male and female point earners, providing each champion with $500,000. The total score for each athlete in a series will consist of points earned from a maximum of four qualifying races during that two-year cycle. Athletes earn points by placing among the top five in qualifying races. Points are allocated following each race as follows: First place results in twenty-five points, second place in fifteen points, third place in ten points, fourth place in five points and fifth place in one point. Points from a maximum of four qualifying races will be scored. If an athlete earns points in more than four events, the athlete's best four finishes will be scored.

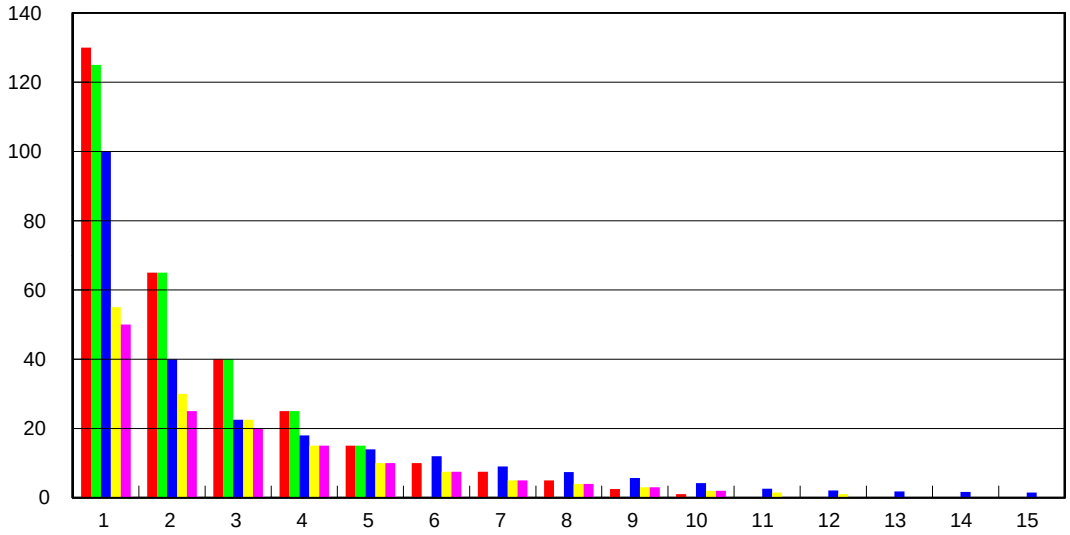
It appears from Figure 3 that the winner usually receives twice the amount that goes to the runner-up, while the second placed finisher receives about 30% more than the per-

5 A large fraction of the players on this tour have been active on the PGA's main tour already and continue to play after they became eligible for the Champions Tour. However, many of the seniors have never played as professionals when they were younger.

6 According to "Spiridon" – the most popular running magazine in the German speaking world – there are at least 1,000 city marathons in the world (most of them either in Europe or in the United States). While some of them draw up to 35,000 runners, others have less than 100 finishers.

son finishing in third place. Contrary to tennis and golf tournaments, the number of athletes who receive a share of the pie varies considerably. In Chicago, only the top 5 finishers are getting paid while in Boston the top 15 are rewarded (the remaining three races are somewhere in the middle between these two extremes).

Figure 3
Prize Money Levels in the World Marathon Majors, 2006-2007



red: New York; green: Chicago; blue: Boston; yellow: London; pink: Berlin

Moreover, in the case of distance running events, the prize purse is usually considerably extended by performance-related bonuses. If athletes break certain barriers (such as 2 hours and 10 minutes (men) or 2 hours and 30 minutes (women)) or run a new course or even a world record, they can considerably increase their revenues (Table 1).

Table 1
Bonus Payments in Major City Marathons (Men)

Required Performance	Berlin	Boston	Chicago	London	New York
Sub 2:10:00	2,500*	-	7,500	3,000	25,000
Sub 2:08:30	7,500	-	15,000	15.000	40,000
Sub 2:07:30	15,000	-	30,000	25.000**	70,000
Sub 2:06:30	30,000	-	55,000	-	-
Course record	n.d.	25,000	200,000	25,000	60,000
World record	n.d.	50,000	300,000	125,000	n.d.

* required time: 2:09:30
** required time: 2:08:00
- no bonus available; n.d. bonus not disclosed

Obviously, the bonus payments are not correlated with the prize purse or the amount of money that can be earned by the winner, but are related to the difficulty of the course. The men's current as well as the previous world record have been set in Berlin, suggesting that Berlin is the fastest of the five courses. New York, on the other hand, is clearly the most difficult one.

Table 2
Top Earners in Selected Individual Sports

Overall Money Rank	Sport / Gender			
	2006 Earnings*		Career Earnings	
	Road Running / Women**			
	Name	Amount	Name	Amount
1	Berhane Adere	237,500	Paula Radcliffe	1,842,835
10	Meseret Defar	126,000	Susan Chepkemei	768,095
50	Nataliya Volguina	29,165	Nuta Olaru	292,175
Road Running / Men**				
1	Robert Cheruiyot	266,000	Haile Gebrselassie	2,343,883
10	Daniel Njenga	80,000	Moses Tanui	553,395
50	Evans Cheruiyot	29,820	Sammy Korir	275,070
Tennis / Women***				
1	Justine Henin	4,204,810	Steffi Graf	21,895,277
10	Patty Schnyder	883,685	Kim Clijsters	14,764,295
50	Iveta Benesova	251,563	Nathalie Dechy	3,514,709
Tennis /Men***				
1	Roger Federer	8,343,835	Pete Sampras	43,280,489
10	Jonas Bjorkman	1,221,485	Lleyton Hewitt	17,215,012
50	Nicolas Kiefer	456,005	Thomas Johansson	6,535,842
Golf / Women***				
1	Lorena Ochoa	2,592,872	Annika Sorenstam	20,641,936
10	Pat Hurst	1,128,662	Christie Kerr	7,752,263
50	Nancy Scranton	274,304	Janice Moodie	3,066,135
Golf / Men***				
1	Tiger Woods	9,941,563	Tiger Woods	65,712,324
10	Brett Wetterich	3,023,185	Kenny Perry	20,335,031
50	Richard S. Johnson	1,555,376	Shigeki Maruyama	12,241,561

* Annual earnings in nominal US $.
** Complete through August 2007.
*** Complete through December 2006.

Sources: www.rrm.com, www.pgatour.com ,www.lpga.com. www.tennisessentials.com, www.tennis.bravehost.com, www.nascar.com

These differences in total prize purses and prize distributions translate into different annual and lifetime earnings of the respective groups of athletes. Table 2 reveals that the annual as well as the career earnings of golf and tennis players are about 20 times higher than the ones of long distance runners who, in general, earn more than most other track and field athletes (with the notable exception of sprinters[7]). This finding holds irrespective of whether one looks at number one, number ten or number fifty of the respective earnings list.

It is, of course, quite likely that the figures presented in Table 2 underestimate the earnings of the distance runners because their "incomes … are generally a mysterious mix of shoe-contract money and appearance fees, which for the top performers can total far more than $ 1 million a year. Yet in a marketplace in which celebrity is often measured by salary, these invisible niches have no promotional value" (Layden 1998)[8]. However, since the endorsement contracts signed by the top golf and tennis players (remember the multi-million and multi-year contracts of Tiger Woods and the Williams sisters with Nike) are generally much higher than the ones granted to distance runners, the figures presented above grossly underestimate the earnings differentials between the three groups of individual athletes.

3. Athletic Contests as Rank-Order Tournaments

Athletic contests, such as golf tournaments and long-distance foot races, are invariably rank ordered because most of the social interest and value of these events lies in ascertaining the "best" contestant. The contests themselves represent a test of abilities and motivations among the individual participants; the common and binding "rules of the game" allow relative evaluations. Athletes entering a particular contest choose their

7 „Track and field pays a lot more for sprinters than it does for top distance runners. That's not the injustice, though. If the top distance runners start griping about money, … the women's throwers would consider killing them and burying them in shallow graves near minor European villages. And if the women's throwers start griping … the racewalkers would have a legitimate grudge" (Hollobaugh 2003).

8 According to various press reports, sprinter Carl Lewis was able to command an appearance fee of $ 100,000 in the mid 1980s already. The average athlete, however, will be happy already if the organizers pay his/her travel costs. Tyson Gay, the current 100 and 200m World Champion, receives 50,000 $ in appearance fees for his starts after he won three titles in Osaka in August 2007.

effort levels and other actions (such as their strategies) to optimize against the efforts of opponents, given the rules of the game and the costs and rewards of winning[9].

From an economic point of view, the structure of athletic contests can be described as follows: First, prizes are fixed in advance and are – with the exception of performance-related bonuses in marathon races – independent of absolute performance. This means that the winner receives the first prize not for being good, but for being (slightly) better than the runner-up. The amount of money that goes to the winner is not affected by the amount by which he beats the runner-up. Even if both athletes do extremely well neither the total prize money nor its distribution will be affected. Second, the level of effort with which each athlete tries to win the contest he has entered depends on the size of the (potential) prize. This implies that the larger the spread between the winner's and the loser's prize, the higher the effort exerted by both athletes. Thus, prize structures are designed to induce individual contestants to put forth more effort which, in turn, increases the interest of sports fans in that competition (with the likely consequence that the profits of the organizer increase, too). This does not mean, however, that contest organizers should implement a winner-take-all tournament, because there clearly is a limit to spread. Although additional spread induces more effort, the average prize money must be high enough to attract athletes to enter the event in the first place.

Athletes typically receive feedback during the competition about their relative positions. Since final payoffs usually depend only on rank order and not on absolute performance, contestants will adjust their behavior in response to that intermediate information: A golf player who on the last day of a tournament knows that he is ten strokes behind he leader has less incentives to put forth effort that a player who is just one stroke behind. Similarly, a marathon runner who is informed by his coach that at km 30 he is two minutes behind the leader is less likely to speed up than a runner who is just 20 seconds behind. Moreover, if athletes can choose between "risky" and "safe" strategies, they are

9 The following sections draw heavily from Rosen (1988) and Lazear (1998: 223-257). For a more formal discussion of the concept see, inter alia, Alchian (1988), Bognanno (2001), Clark and Riis (1996), Cooper, Graham and Dyke (1993), Dye (1984), Green and Stokey (1983), Konrad (2007), Lazear and Rosen (1981), McLaughlin (1988), Moldovanu and Sela (2001, 2006), Nalebuff and Stiglitz (1983), O'Keefe, Viscusi and Zeckhauser (1984), and Rosen (1986). Szymanski (2003) provides a review of contest theory with particular reference to team sports.

likely to alter their choice of strategy in response to intermediate information, i.e. a tennis player who is three points behind in the final set of a match is likely to play with more risk by, for example, serving harder. Thus, in a tournament the leader has an incentive to pursue a "safe" strategy while the trailer usually pursues a "risky" strategy (see Hvide 2002, Hvide and Kristiansen 2003, Kräkel and Sliwka 2004).

Apart from the "incentive function" described above, athletic contests also serve a "sorting function". By having a pyramidal structure of events it is possible to let individuals compete with one another and then have winners compete with other winners to get admission to the top-tier tournaments where higher prize purses are at stake. In the end, such a structure is equivalent to a multiple-round elimination tournament. Both systems try to ensure that only the most able competitors make it to the final round or the final contest[10]. Summarizing, the function of minor tournaments is not only to identify particularly able athletes, but also to avoid "contamination" of the professional elite. This is important insofar as, for example, the prize money that is being paid to a first-round loser in a Grand Slam tournament often exceeds the amount of money he can earn in a minor tournament. Moreover, as the number of contestants increases, the individual's probability of winning decreases. Since with too many participants contestants are discouraged to put forth effort, free and open entry is generally not the optimal participation policy.

Thus, organizers of top events usually try to limit the number of entries. In tennis, for example, 96 of the 128 spots at a Grand Slam tournament are filled according to the actual world ranking with the remaining 32 slots being filled by players who have to qualify immediately before the tournament in a particular "elimination round". In golf, entry to most PGA tournaments is limited to 144 or 156 players with a few tournaments restricting entry much more severely. Again, the rationing device is a player's past performance. The highest priority category consist of golfers who have either won a tournament in the recent past or who finished among the top 125 money winners in the previous years. The middle category consists of players who were among the top 15 money

10 Fullerton and McAfee (1999) discuss a „contest selection auction" as a potential device to prevent adverse selection of less able participants into a tournament offering high prize money.

winners on the PGA's minor league golf tour or finished among the top 35 at the annual PGA qualifying tournament before the start of the season. The lowest priority category consists of players who do not qualify for either one of the first two groups. While golfers in the first category have guaranteed slots in any tournament they wish to enter, players from the second category are occasionally denied access by the rationing rule. Finally, players from the third category are most of the time not admitted to a tournament they wish to enter[11]. In distance running access to a particular race is usually not restricted by eligibility or performance, but by the local organizer's willingness to pay for an athlete's travel costs and accommodation. Since the organizers of the more renowned races have an incentive to assemble the best athletes, recent top performers have a much higher probability of being invited, i.e. the selection procedure is in the end quite similar to the one described above for golf and tennis.

Effort usually suffers when heterogeneous athletes compete against each other[12]. Effort has the largest effect on changing the probability of winning when the contestants are of similar ability. If ability differs among contestants, then both the talented and the less talented ones tend to slack off. To maintain high levels of effort it is important to group athletes so that they are evenly matched with those against which the will directly compete. Another possibility is to implement "handicap rules" that compensate the weaker athletes' disadvantage or to offer additional rewards to the weaker athletes[13]. Thus, heterogeneity is another reason not to implement a winner-take-all prize money structure: In order to motivate weaker athletes to put forth effort, prizes for the runner-up, the third finisher, etc. are clearly warranted (see Szymanski and Valletti 2005)[14].

11 For a further description of the structure of the "professional golf circus" see, inter alia, Cottle (1990) and Shmanske (2004: 193-210).

12 In this situation, the "underdog" may wish to sabotage the other contestants instead of putting forth more effort. In order to avoid such behaviour, contestants have to be monitored (see Kräkel 2005).

13 If it is difficult to determine the athletes' ability levels, it is advisable to repeat the competition. Take as an example a golf tournament where the contestants have to complete 18 holes a day over a period of four days. Under these circumstances it is very unlikely that a lucky (instead of an able) athlete wins (see Gürtler 2006).

14 In some individualistic sports, such as gymnastics, figure skating and ski jumping, the athletes ranking at the end of the competition is not only determined by their "objective" performance", but also by the "subjective impression" of (impartial?) judges (Zitzewitz (2006) documents a "nationalistic bias" in the evaluations of judges in figure skating). This introduces an element of luck (or "noise") into the competition which, in turn, leads to a lower level of effort. The reason is that noise reduces the value of effort by reducing the probability of winning. When luck is important it is, therefore, important to offset the decline in effort by using a larger prize spread.

The asymmetric prize structure in a single athletic contest is very often supplemented by a "super contest" that links together the single events. The "option value" of competing in that latter contest provides additional motivation to athletes to perform well in the individual tournaments they enter over the course of a season. When the athlete reaches the final round, there is no longer any option value, i.e. winning the "super contest" is the end of the story. Therefore, the prize money in that final contest is usually particularly high. The three individualistic sports that are of particular interest in this chapter have all introduced such a super contest – the "Tour Championship" in golf, the "Masters Cup" in tennis and the "World Marathon Majors" in distance running,.

The research agenda discussed in the previous section can be summarized under three different headings: First, the impact of prizes and prize spreads on incentives to perform, second, the impact of the structure of the contest on the individual athlete's strategic behavior and, third, the different responses of "risk-loving" and "risk-averse" athletes to tournament incentive systems.

4. Tournament Incentives and Athletic Performance: A Review of the Evidence

In an extensive survey of labor markets in professional (team) sports, Kahn (2000: 89) concluded that "some of the most intriguing evidence on the links from incentives to performance comes from sports … like golf and marathon running". In these sports it is possible to collect data on individual performance and to relate that data to the prize money offered in individual tournaments.

4.1. Sorting vs. Motivation: What Explains Athletes' Behavior?

Golf

Ehrenberg and Bognanno (1990a, 1990b) were the first to analyze the prize money-performance relationship examining the scores in American and European PGA golf tour-

naments. Their first important finding is that scores are lower (indicating that performance is better) when the prize purse is higher. Second, they looked at the impact of a player's position after the third day on his performance on the last day of the tournament. The expectation here is that players who are trailing one or more of their opponents very closely have a larger incentive to perform well as the marginal returns to effort are higher. This expectation is again strongly supported by the data. Finally, since the prize spread decreases with rank (the differences between to adjacent ranks are getting smaller; see Figure 2 above) effort is expected to be higher (and scores lower) in the final round when a player has a better placing at the beginning of this round. Again, the expectation is strongly confirmed by the data[15]. Focusing on the sorting effects of tournaments, Ehrenberg and Bognanno (1990a, 1990b) also show that exempt players (i.e. those who are allowed to enter any tournament they wish to play) are more likely than non-exempt players to enter tournaments that offer particularly high prize money[16]. This latter finding is extended to yet another aspect: In a recent study Rhoads (2007) who finds that players' annual entry decisions change as their exemption status changes: Players enjoying a lengthy exemption status enter significantly fewer events per year compared to players whose exemption status is about to expire[17]. McFall, Knoeber and Thurman (2006) examine the incentive effects of a "grand prize" by comparing player performance on the PGA tour before and after the introduction of the season-ending "Tour Championship". They find considerable changes particularly in the behavior of the most successful players: Since entry into the final tournament is restricted to those 30 players who win the most money during the regular season, players who win early in the year face incentives to try harder and perform better than they otherwise would (and the reverse for those who lose early). Towards the end of the season, when those who have won early are assured of a spot in the finals, they will try less hard compared to

15 Using data from the season 1992, Orszag (1994) was unable to replicate these findings. He attributes this unexpected result to increased media coverage since the 1980s which might have led to increased nervousness among players, thus distorting the relationship between effort and performance. Using data from the 2000 Ladies PGA tour, Matthews, Sommers and Peschiera (2007) find that a higher prize purse has a negative impact on players' performance, i.e. it increases (instead of decreases) the number of strokes required to complete the course.

16 Using longitudinal data covering five consecutive seasons (1996-2000) with 12,700 player-tournament-observations Bronars and Oettinger (2001) confirm this result.

17 In another recent paper, Hood (2006) shows that on the PGA tour an increase in the participation of top players leads to a significant increase in the prize purse in the following year and that a change in the purse has again a positive impact on the entry decisions of the top players.

those still competing for a spot (i.e. those around the "cut-off-rank" on the money list).

Tennis

Using data from the semi-finals and the finals of men's and women's major tennis tournaments played in the years 1990-2002 and 2002-2004, respectively, Sunde (2003) and Lallemand, Plasman and Rycx (2005) try to separate the incentive effects of prize money from the impact of ex ante heterogeneity in players abilities. Both studies find that the incentive effect on effort resulting from playing a final, where the prize to be won is about twice as high as the prize for winning the semi-final, is positive and statistically highly significant. Thus, women and men seem to react to prize incentives in a very similar way. The remaining results for men and women, however, are completely different: While for women uneven contests lead favorites to win more games and underdogs to perform poorer, the exact opposite seems to be true for men. These results, although incompatible at first sight, can easily be reconciled: If the difference in the number of games won by the favorite and the underdog increases with the difference in the individual players' ranking position, it is the "capability aspect" of heterogeneity that dominates. If, on the other hand, the difference in the number of games won by the favorite and the underdog decreases as the difference in the ranking positions increases, the "incentive aspect" of heterogeneity seems to dominate. Surprising as they may be, do these results certainly not suggest that men and women behave differently in a highly competitive environment (more on that below). A plausible interpretation is that the heterogeneity measures used in the two studies – the absolute difference in the ranking points of the contestants – more accurately reflects heterogeneity in the abilities of women than in those of men. Coate and Robbins (2001) analyze the long-run effect of prize money on player careers by looking, first, at the number of tournaments played per year and, second, the timing of retirement. They use a sample of some 240 male and 220 female tennis players who attained a singles ranking in the top 50 at least once on their respective tours between 1979 and 1994 and find that a $50,000 reduction in real tournament earnings increases the probability of retiring in the following year by 15%. Moreover, the higher the prize money a player has one in the previous season, the more tournaments she is entering in the current season. Obviously, both findings are in line

with the incentive story outlined above[18].

Distance Running

Maloney and McCormick (2000) use data from 115 foot races ranging in distance from one mile to full marathon that were held in the southeastern United States between 1987 and 1991. They find that both the average prize paid and the prize spread have the predicted negative and statistically significant influence on finish times: Doubling the average prize leads to a fall in average times by about 2% and doubling the prize spread leads to a fall in average times by about 4%. They interpret their findings to be consistent with the "sorting hypothesis" as well as the "incentive hypothesis". Using data from 135 different races ranging in distance from 5k to full marathon Lynch and Zax (2000) also confirm the hypothesis that times are faster in races offering higher prize money. However, when controlling for runner ability by including a measure of the athletes' recent race history in the regression, the incentive effects of the prize level and spread completely disappear. The authors therefore attribute the impact of prize spread to the sorting effects of tournaments rather than the incentive effects. Frick (1998) and Frick and Klaeren (1997) use data from 57 different city marathons run worldwide between 1983 and 1995 and involving much larger prize money (around 135,000 $ per race in 1993 dollars). They find that (a) doubling the average prize reduces average times by one percent; (b) doubling the spread improves average times by two percent; (c) doubling bonus payments improves average finish times by about .75 percent. Moreover, an increase in prize fund, spread and bonus payments also increases the closeness of the race (measured as the time difference between the winner the next four finishers). Finally, race times are decreasing in the number of "in the money" ranks (i.e. the number of prizes). Thus, all the characteristics of the prize fund seem to influence the elite runners' performance in the way predicted by tournament theory. However, when controlling for the endogeneity of the prize purse as well as for runner abilities, it turns out that the prize purse becomes insignificant while the spread variables retain their statistical significance (Frick and Prinz 2007). This seems to suggest that the selection effect of

18 Garin and von Allmen (2005) show that in Grand Slam tournaments an increase in the prize purse between two rounds induces players to put forth considerably more effort in the sense of hitting more aces and more "winners", i.e. shots that cannot be returned by the opponent.

tournament pay systems dominates the incentive effect.

Horse Racing

Fernie and Metcalf (1999) analyze the influence of alternative remuneration systems on the performance of a sample of British jockeys. They find that replacing incentive contracts by non-contingent retainer payments introduces moral hazard into a payment system which had proved to be very successful at overcoming such behavior: Jockeys who signed contracts that guaranteed them a fixed instead of a variable income showed a dramatically deteriorating performance. Not surprisingly, therefore, none of these contracts was renewed – with the interesting consequence that most of the jockeys returned to their previous performance levels once they were paid strictly according to their results again. Moreover, analyzing data from Arabian horse races in the U.S. and Canada, Lynch (2005) finds that jockeys increase their efforts (lower their times) in the second half of races when the amount of prize money lost by dropping one place is greater and when there is less distance between them and their closest competitor[19]. Finally, Lynch and Zax (1998) demonstrate that races with the highest prize purses attract contestants of varying ability. This "contamination effect" can be eliminated by increasing the prize spread which, in turn, will induce contestants to self-select into tournaments based on their individual abilities.

Other Individualistic Sports

Apart from foot and horse races as well as golf and tennis tournaments, a number of other individualistic sports have produced empirical studies on the prize money-performance relationship, too:

- Using a three-year panel from the US Professional Bowlers Association Bognanno (1990) finds a consistently positive and generally significant influence of total prize

19 Boyle, Guthrie and Gorton (2006) demonstrate that client-owned horses perform significantly better than the horses that are owned by their trainers. Trainers have an incentive to devote more effort to horses they own themselves, but in doing so they run the risk that horses owned by clients will be transferred to other stables in the future. Thus, reputational incentives seem to be very important in this context.

money on bowlers' performance (as measured by the number of pins per round). This supports the main prediction of tournament theory that higher prize levels and, hence, dispersion among prizes lead to higher output. However, he also finds that the percentage of prize money allocated to first place has a significantly negative influence, suggesting that greater skewness reduces the rewards to winning – a finding that presents a contradiction to the theory under test.

- Becker and Huselid (1992) draw on two different panels from auto racing (NASCAR and IMSA) to study the influence of prize money differentials on both driver performance and safety. They find that the prize spread has indeed the expected incentive effects on individual performance and that these effects peak at rather high spreads and then level off. Perhaps most important is yet another finding: Driver safety is adversely affected by increasing the prize spread, suggesting that tournaments may produce "undesirable" behavior as well.[20]

- Prinz (1999) uses data from 44 different long-distance triathlons ("Ironman") held in nine different places (1989-1999) all over the world. Ironman contests are interesting insofar as purses are rather low compared to sports like golf and tennis (the average purse a top ten finisher takes home is slightly more than 3.000 US$) while the training requirements by far exceed those in most other sports[21]. Nevertheless, the author finds that both a higher purse and a greater spread result in faster finish times. Moreover, the smaller the difference between the prize money attached to a specific rank and the preceding rank, the slower the finish times. These findings are robust on further controls, such as athlete quality (measured by the personal records of the athletes),

20 Von Allmen (2001) shows that the reward structure in NASCAR is efficient, because of the linearity of the reward structure of individual races that is accompanied by highly nonlinear end-of-season rewards. The analysis shows that the need to maintain sponsorship exposure, combined with drivers' willingness to take risks (and the possible catastrophic result of negative outcomes of such behavior), creates a competitive environment where winner-take-all would be inefficient (empirical evidence in support of these assumptions is provided by Depken and Wilson (2004)). In a companion paper, von Allmen (2002) shows that neither in NASCAR nor in CART (Championship Auto Racing Team) do drivers respond to the possibility of increases in marginal winnings or losses. Moreover, Terkun and Maloney (2000) find evidence supportive of tournament theory by using data from the motorcycle industry.

21 On average, professional iron(wo)men train eight hours a day approaching 35k of swimming, 1.000k of biking and 100k of running per week.

Summarizing, it appears that the amount of prize money offered induces considerable selection effects while the distribution of the purse induces the participants to put forth effort in an attempt to maximize their individual revenues.

4.2. Incentives, Risk-Taking and Strategic Behavior

Identifying the most able athletes by rank-order tournaments is problematic if the contestants are able to choose strategies of different risk. First, the tournaments' outcomes are then mainly determined by luck or random components and, therefore, do not provide much information about the athletes abilities. Second, athletes preferring high risk strategies often choose low effort levels. Since risk-taking behavior is likely to bias the results of a contest, it is of interest, first, to explore to what extent athletes make use of risky strategies and, second, whether the choice of such strategies pays off for the athlete[22].

Grund and Gürtler (2005) study the risk-taking behavior of head coaches in the German "Bundesliga" in 2003/04 by looking at the positions of players who are substituted during a match[23]. In principle, a coach can undertake a risk neutral substitution (the player taken off the field and the player sent on the field have the same tactical position), a risk-taking substitution (a defender is replaced by either a midfielder or a forward or a midfielder by a forward) or a risk-reducing substitution (a midfielder or a forward is replaced by a defender or a forward by a midfielder). A risk-taking substitution in-

22 Abrevaya (2002) studies individual performance in ladder tournaments, using data from professional bowling competitions. He finds that "underdogs" win more often than expected and explains this not by differing individual responses to (financial) incentives, but by "hot-hand" and "regression-to-the-mean" theories. Moreover, when analyzing data from sumo wrestling, Duggan and Levitt (2002) are less interested in testing predictions derived from tournament theory than finding evidence for corruption. Nevertheless, they can show that wrestlers' effort apparently increases when the marginal returns to winning increase. Willoughby and Kostuk (2005) examine the choice between taking a single point or blanking an end in the latter stages of a curling game. It turns out that blanking an end is the better alternative, but it is usually only chosen by Americans, but not by Europeans. Laband (1990) finds that tournament wins are concentrated among a small number of top players in tennis, but not in golf. He does not explain this by referring to differences in risk-taking, but by emphasizing the importance of the match-play structure of competition and the practice of seeding the top players against weaker players in the early rounds of a tennis tournament.

23 A soccer team consists of 11 players. The players are specialized in one of the following positions: They are either goalkeeper, defender, midfielder or forward (only one goalkeeper is allowed in the team). Up to three substitutions per team are allowed during a match.

creases the probability to score a goal, but also increases to possibility that a goal is scored against the team. As expected, the probability of risk-taking (risk-reducing) substitutions decreases (increases) with the difference in goals: Coaches replace defensive players by offensive one when their team is behind and substitute offensive players by defensive ones when their team is ahead. However, risk-taking behavior does not pay: The increase in the probability of scoring an additional goal is more than offset by the increasing probability of conceding a (further) goal.

Studying videotapes of all middle and long-distance races at the 1992 Olympic Games in Barcelona, Boyd and Boyd (1995) show that in the men's races (but not in the women's) the "underdogs" moved first and the "favorites" tended to wait: While the pre-race favorites (measured by prior performance) usually start out conservatively and then move up past other runners as the race develops, the underdogs tend to start quickly but see their performance and relative race position deteriorate as the event transpires. The fact that the men's races are considerably more strategic than the women's is apparently due to the fact that the talent pool is more concentrated for men than for women (see also Deaner 2006)[24]. Not surprisingly, risky strategies pay off for the underdog only on the middle distances. The longer the race is, the less likely the underdog is to win.

A further study that deserves being mentioned in this context is the one by Bronars and Oettinger (2001). They test for effects of golf tournaments on risk-taking by analyzing whether players who appear to have an incentive to take (avoid) risks over the last holes of the final round are more (less likely to shoot scores that deviate considerably from par (i.e. the "normal" result for a professional). Surprisingly, their results are in accordance with tournament theory, but are not statistically significant.

Assuming for a moment that the card game "Poker" is indeed a sport, a study by Lee (2004) is quite interesting. Poker tournaments are particularly suitable to study risk-taking behavior, because risk-taking is the essential component of an individual's strategy

24 Munasinghe, O'Flaherty and Danninger (2001) compare the development of local (high school) and world records in track and field to separate the overlapping effects of technical change (better equipment, better training methods etc.) and globalization (increased competition) and find that the former is more is more important than the latter to explain the observed pattern. Moreover, Scully (2000) documents the decreasing returns to training.

while the problem of effort choice is trivial. Moreover, poker tournaments provide a unique opportunity to evaluate risk-taking behavior under well-defined rules in the face of high monetary incentives – something that cannot be achieved in a laboratory experiment. Apart from that, players are homogenous in quality and are unlikely to make systematic mistakes in statistical calculations. Using data from 27 tournaments of the "World Poker Tour" in 2002/03-2003/04 it is found that risk-taking behavior is completely in line with the predictions of tournament theory: Players choose the degree of risk depending on monetary incentives, i.e. if a player is trailed by the nearest leader by a larger gap or if he leads the nearest follower by a larger gap, be usually bets more, suggesting that risk taking is clearly dependent on chip spread. Moreover, a larger expected gain or a smaller expected loss strengthens the incentives for risk-taking.

4.3. Do Male and Female Athletes Respond Differently to Incentives?

Recently, a number of primarily experimental studies have tried to answer the question whether women respond differently to competitive pressure than men. While Gneezy, Niederle and Rustichini (2003) reveal the existence of a significant gender gap in a tournament setting (men's performance increases significantly with the competitiveness of the environment but women's performance does not)[25], Paarsch and Shearer (2007) reach the opposite conclusion. Using data from a tree-planting company in British Columbia they find that there is no difference in the reaction to incentives between male and female workers. The productivity differential of male planters is exclusively due to differences in ability[26].

A closer look at the findings presented by Frick (1998) and Frick and Klaeren (1997) suggests that women respond much more than men to an increase of the prize purse as well as to changes in the prize spread. However, women seem not to respond to bonus payments (i.e. additional rewards for absolute performance). While at odds with the

25 In a laboratory setting, Niederle and Versterlung (2005) find that twice as many men as women choose a tournament compensation system over a fixed salary. However, there seem to be no gender differences under either remuneration system.

26 This is consistent with a finding reported in Vandegrift and Brown (2005), that although women are more risk-.averse than men, the former are no less likely to adopt a high-variance strategy in a tournament competition.

traditional tournament model at first sight, there is a rather simple explanation for the different behaviors of men and women: With regard to their performances, the male marathon elite is much more homogeneous than the female elite. In 1996 for example, the difference between the fastest runner of the year and no. 50 on that list was 2:39 minutes in the men's field and 4:37 in the women's. Given the same number of races for men and women, this implies that members of the female elite can (and indeed do) avoid competing against each other. Such a behavior is not possible for men, who (due to the homogeneity of the competition) will always face other runners of similar strength. Given these specific conditions it is hardly surprising that bonus payments do not induce higher effort levels in the women's races.

Due to the heterogeneity among the female elite, it was (and still is) quite possible for a woman to win a marathon with a sub-optimal performance, while this is entirely impossible for a male runner. While this may sound strange to most people (sports fans as well as economists), the authors present ample evidence for this proposition: The female winners of the races in their sample were on average more than six minutes slower than the then actual world record (2:21:06) while the male winners were only about three minutes above the record (then 2:06:50). Moreover, in 1995 the fastest 50 times in the women's races have been clocked by 42 different runners while 48 different men were needed to deliver the 50 best performances of that year. Apparently, it is rational for female elite runners to participate in more than two marathons per year and to try to finish "within the money" several times instead of running only two marathons per year (as most of the male athletes do) with the goal of winning prize money as well as a bonus for an especially noticeable performance[27].

Paserman (2007) studies the response of male and female tennis players to competitive pressure in nine different Grand Slam tournaments played between 2005 and 2007, i.e. in a setting with large monetary rewards. Her major finding is that men's performance

27 In 2001, exactly 88 men finished a marathon in less than 2:11 while an equal number of women were faster than 2:30. While a time of 2:10:59 is only 4,2% slower than the existing world record of 2:05:44, a 2:29:59 is already 8,1% slower than the 2001 world record of 2:18:47 (in 2003 it has been improved to 2:15:45). Also in 2001, only 19 female, but 135 male athletes finished a marathon within 105% of the then current world record (see Deaner 2006 for an explanation why more men than women are running fast).

(measured by either unforced errors or winners) does not vary much depending on the performance of the point while women's performance deteriorates significantly as points become more important. The results of a number of estimations suggest that women play a more conservative and less aggressive strategy as points become more important, i.e. men hit faster first serves as importance rises while women hit significantly lower first serves as the stakes become higher

5. Summary and Implications for Further Research

Summarizing the available evidence it appears that virtually all of the predictions of tournament theory are unequivocally supported by data from a variety of contests (footraces, golf and tennis tournaments, horse races, auto racing, triathlons and bowling competitions).

Although monetary rewards do have the incentive and selection effects predicted by tournament theory, several qualifications seem to be warranted: First, in situations, where the abilities of the contestants differ, bonuses for absolute performance may be an adequate instrument to induce the more able persons not to reduce their effort levels. However, if these persons have outside options in the sense of being able to enter additional competitions, it is very likely that they will choose a less risky strategy by competing more often at a level well below their abilities.

Second, if cooperation requirements are crucial for the performance of the contestants, increasing the number of prizes awarded may be a helpful strategy, because this will reduce the opportunity costs of contestants who fear that otherwise they will end up without any compensation. Thus, if it is in the interest of the organizer "to keep the field together", it may be wise to pay prizes to a larger number of the contestants.

Moreover, two important puzzles remain to be solved: First, a convincing separation of the incentive and the selection effects of tournaments has not been performed yet, but should be possible given the data that is available from, for example, track and field: Since the IAAF's "Grand Prix Circuit" consists of three different series of events with

prize money levels that differ between the series, but are identical across the meetings in any one of the series (but not over time), empirical tests of the relative contribution of incentive and (self) selection effects to explain the observed patterns of performance are now possible in a quasi-experimental setting. Second, the introduction of prize money in 1993 (in the form of a car) and the subsequent changes in the level as well as the distribution of the prize money at the IAAF's World Championships in Athletics provides yet another quasi-experimental setting to study the impact of financial rewards on the behavior of utility-maximizing agents.

In his survey of tournament theory, Rosen (1988: 89) argues that "there is a large gap in formulating … testable empirical hypotheses. Much could be gained by studying the details of real organizations …, where many of the forces suggested by theory can be observed and new observations that will enrich the theory can be discovered". Future research should take up this challenge and add further evidence to the already existing body of literature. Given the availability of excellent data and the interests of many economists in professional sports in general and in track and field in particular this goal should be accomplished very soon.

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